WATERBIRDS OF PEEL-HARVEY ESTUARY

IN

1996-97

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Cover photograph of Grey Teal (*Anas gracilis*) by A.G. Wells, AFIAP, ARPS.

The Grey Teal was the second-most abundant bird on Peel-Harvey Estuary during 1996-97, with numbers reaching 13 000 in February 1997. Most were found on the extensive shallow feeding grounds of south-eastern Peel-Inlet. The Grey Teal travels widely throughout Australia in response to rainfall and wetland conditions.

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SUMMARY

Peel-Harvey Estuary, 70 km south of Perth, Western Australia, is listed jointly with Lakes McLarty, Mealup and the Yalgorup Lakes as a Wetland of International Importance under the Ramsar Convention. Surveys in the mid 1970s and 1980s have shown that tens of thousands of waterbirds make regular use of the estuary's extensive, shallow and highly productive waters. In early 1977, waterbird numbers exceeded 100,000.

During the 1960s to 1990s, Peel-Harvey became increasingly eutrophic due to leaching of agricultural fertilisers from its catchment. Public objections to odours emanating from decaying macro-algae and the increasing occurrence of blue-green algae blooms resulted in government and community action to alleviate these problems.

One component of the government's strategy was to increase flushing of the estuary by constructing a second entrance to the ocean. This entrance - the Dawesville Channel - was completed in April 1994.

A condition of government approval of the Channel was that monitoring be undertaken so that impacts could be assessed and, where practicable, managed.

This report presents results from one component of the Peel-Harvey Estuary monitoring program - the 1996-97 surveys of waterbird species, numbers and distributions on Peel-Harvey.

The 1996-97 data show that, 2-3 years following construction of the Dawesville Channel, Peel-Harvey Estuary remained one of the most important waterbird habitats in Western Australia. More than 50,000 birds were counted in December 1996 and at least 61,000 birds of 60 species made use of this estuary at some time during the survey period.

During 1996-97, most birds were found in southern and eastern parts of Peel Inlet, at the southern end of Harvey Estuary and in north-central parts of Peel Inlet on either side of the natural entrance channel. The first and last areas are largely within conservation reserves. The southern end of Harvey Estuary has a conservation reserve adjoining its eastern shore but is otherwise unprotected.

The 1996-97 data indicate that Peel-Harvey Estuary continues to meet the Ramsar Convention waterbird criteria under which it was listed in 1990.

Before a proper assessment can be made of possible impacts of the Dawesville Channel on Peel-Harvey waterbird species, numbers and distributions it will be necessary to report the results of baseline surveys conducted in the mid 1970s. It will also be useful to consider the results of the 1998-99 surveys. This work is proposed.

1. INTRODUCTION

Peel-Harvey Estuary, 70 km south of Perth, Western Australia, is recognised as one of the most important waterbird habitats in Western Australia. At least 86 species have been recorded, with many in great abundance. In February 1977, a survey of the estuary revealed more than 100,000 birds (J. Lane, unpublished data). In November 1982 a survey of the eastern part of Peel Inlet alone produced c. 41,000 (ANCA 1996). No other wetland in south-western Australia is known to support as many waterbirds

In recognition of its significance, Peel-Harvey has been listed, jointly with Lakes McLarty, Mealup and the Yalgorup Lakes, as a Wetland of International Importance under the Ramsar Convention (Government of Western Australia 1990, 2000).

Clearing of native vegetation, drainage works and use of agricultural fertilisers has resulted in Peel-Harvey Estuary becoming eutrophic. Complaints during the 1960s and 1970s about the accumulation of decaying algae led to efforts being made to solve the problem. Following lengthy investigation it was decided that a multi-faceted approach should be taken. Key elements were to be modification of fertilizer use in the catchment and excavation of a channel - the Dawesville Channel - to provide a second connection to the sea, thereby increasing tidal exchange and flushing.

The proposal to construct a channel at Dawesville was approved in principle by the Western Australian Government in January 1989. Works began in February 1992 and the Channel was opened in April 1994.

A condition of approval for construction of the Channel was a requirement that monitoring be undertaken so that impacts could be assessed and, where practicable, managed.

One component of the monitoring program was to be an assessment of waterbird use of the estuary following completion of the Channel. This work was to be done by the Western Australian Department of Conservation and Land Management. Funding arrangements for the Dawesville Channel monitoring program were determined by Government in February 1994, enabling studies to commence later that year.

A progress report (Lane, Pearson & Clarke 1997) completed in September 1997 gave an overview of work undertaken by the Department of Conservation and Land Management following opening of the Channel. Seven projects were described.

In relation to one of these projects - "Waterbird species, numbers and distributions" - the background, rationale and methodology were outlined and some preliminary impressions concerning the status of several waterbird species were presented. Few data were presented, however, as the process of transcribing the 1996-97 waterbird survey recordings from audiocassettes to maps and analysing these figures had not been completed. This work has now been done and the results are presented below.

2. PROJECT AIMS

The aims of the "Waterbird species, numbers and distributions" project are:

- To determine the species, numbers and distributions of waterbirds on Peel-Harvey Estuary following construction of the Dawesville Channel.
- To identify significant impacts of construction of the Dawesville Channel on waterbird species, numbers and distributions.
- To determine whether Peel Harvey Estuary continues to meet Ramsar Criteria relating to waterbirds for ongoing listing as a Wetland of International Importance.

The aims of this report are to present the data that have been collected during the first year (1996-97) of waterbird surveys following construction of the Channel and, to the extent possible with one year of data, address the project aims.

3. PROJECT DESIGN

Opening of the Dawesville Channel had the potential to affect the suitability of Peel-Harvey for use by waterbirds in a number of ways. The number of high tide roost sites, some of which are sand cays or low islets, could be reduced by an increase in tide heights. Higher tides could also cause flooding of pelican nesting grounds and the death of fringing vegetation used by waterbirds for feeding, refuge, roosting and breeding. Changes in the estuary's salinity regime, when combined with an increase in tide heights, could also contribute to the death of vegetation. Increased tide heights, particularly during summer, could result in an increase in disturbance, by permitting human access to important waterbird feeding and loafing areas that were previously too shallow for boats. Altered water levels, salinities and circulation patterns could also have largely unpredictable effects on the food webs supporting the estuary's waterbird populations. Clearly most if not all species could be affected in some way (some perhaps positively) by creation of the Channel. For this reason it was decided that comprehensive surveys to determine use of the estuary by all waterbird species should be conducted.

In order to establish a baseline it would have been preferable for surveys to have been conducted for at least two years immediately prior to the Channel being opened. This, however, was not achievable. The only baseline data on waterbird use of the entire estuary come from comprehensive surveys undertaken by the principal author (JL), with assistance from one of the co-authors (GP), in the mid-1970s. These surveys could be repeated precisely as full details of survey methodologies, routes, times etc. had been recorded and the same personnel were available. It was therefore decided to repeat the 1976-77 surveys during two of the five years programmed for post-Channel monitoring.

Two years of surveys were planned in order to obtain an indication of year-to-year variability in waterbird numbers and distribution. Post-Channel years three and five (1996-97 & 1998-99) were chosen as it was considered likely that at least some of the effects of the Channel would take several years to be expressed. Whereas in 1976-77 six surveys were conducted at two monthly intervals from August 1976 onwards, in 1996-97 and 1998-99 this was not possible, due to other demands on staff time. For this reason the 1996-97 and 1998-99 surveys were limited to October, December and February. These months were chosen because both total waterbird numbers and the number of species, particularly of transequatorial migrants, were expected to be greatest at this time of the year.

4. STUDY AREA

The study area was the entire Peel-Harvey Estuary (area c. 136 km^2, shoreline length c. 75 km) including open waters, shallows, tidal flats, tidal marshes and shorelines (Figure 1). The delta and lower reaches of the Harvey River were also included.

5. METHODOLOGY

5.1 Waterbird Species

Species typically regarded as waterbirds include swans, ducks, grebes, cormorants, pelicans, herons, egrets, ibis, spoonbills, waterhens, sandpipers, stilts, plovers, gulls and terns (Rose & Scott 1997). However, several other bird species that are not always regarded as waterbirds make substantial use of estuarine and other wetland habitats in south-western Australia. These are the Osprey, Whistling Kite, White-bellied Sea-Eagle, Swamp Harrier, White-fronted Chat and Little Grassbird. For the purposes of this study, these species were included. This approach is consistent with the suggestions of Rose & Scott (p4).

5.2 Survey Program

Surveys of all species of waterbirds throughout the Peel-Harvey Estuary were conducted in October and December 1996 and February 1997. Modes of transport (plane, boat and foot), equipment used (binoculars, audio cassette recorder, notebook, maps), survey routes, survey times and personnel were the same as, or similar to, those of surveys conducted in the same months of 1976-77. The same areas were surveyed as in 1976-77, plus additional areas described below. The date of survey of each sector, and the personnel involved, are shown in Appendix 11.

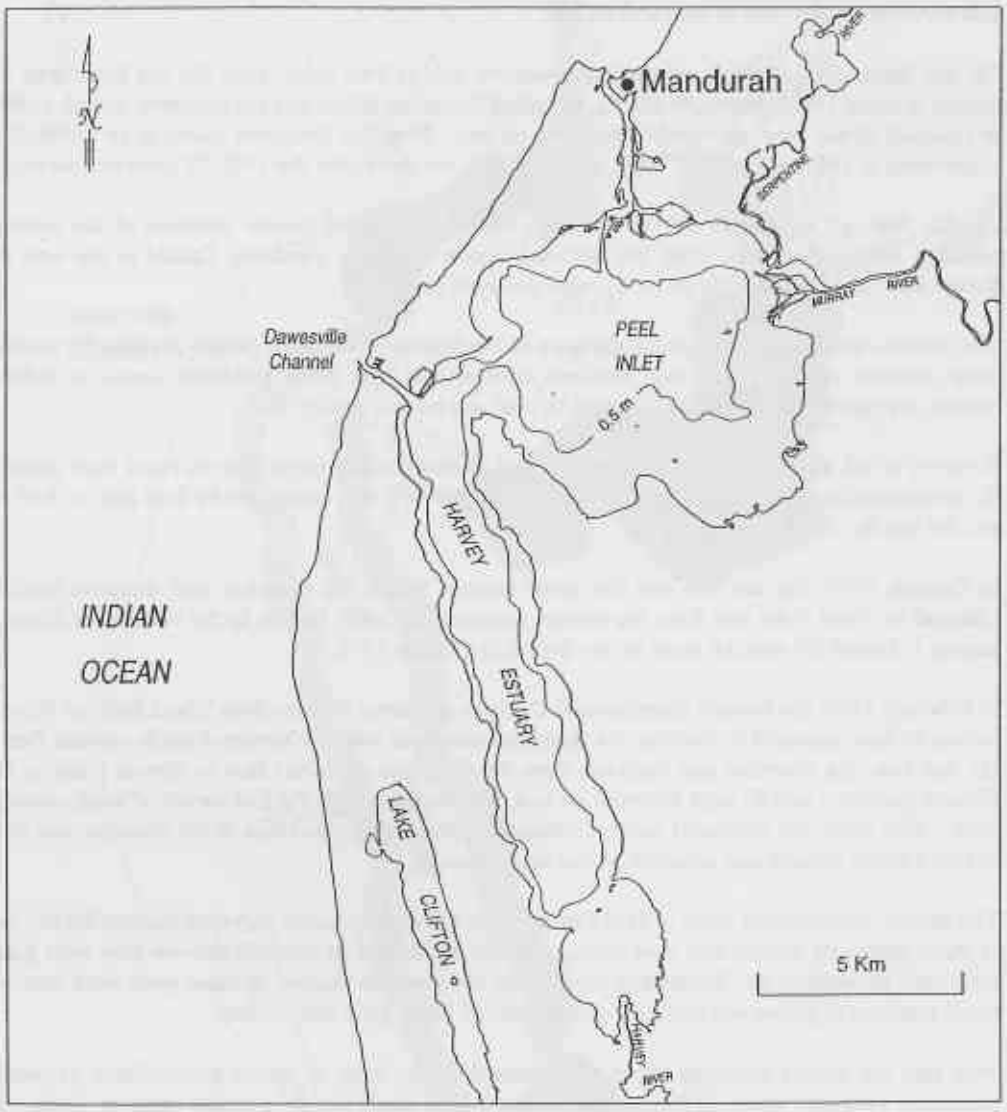

Figure 1. Peel-Harvey Estuary.

The general approach was as follows. On the first day of each survey, pelican numbers and distribution on Peel Inlet and Harvey Estuary were determined by aerial census, using a single-engine, high wing, four seater aircraft with commercial pilot and observer (JL). Black Swan numbers and distribution on Harvey Estuary were also determined during this aerial survey. Swans in south-eastern Peel Inlet could not be effectively surveyed by plane due to the breadth (several kilometres) of the shallows in this part of

the estuary, the large number (potentially) and spread of birds and the relative difficulty (compared with pelicans) of seeing the birds against the darkness of the shallows, most of which were covered by abundant submerged aquatic plants. Instead, the swans of Peel Inlet were surveyed by boat, this being a 3.5 metre, flat-bottomed punt with 15 horsepower outboard motor operated by a single observer.

On the second day, a survey was made by boat of the numbers and distributions of all waterbird species from the old Mandurah Traffic Bridge downstream to the ocean mouth (sector 1 of Figure 2). Waterbirds on the north-eastern side of Peel Inlet upstream from the same bridge to the mouth of the Serpentine River (sectors 2a and 3), including Creery and Channel Islands and the Creery marshes, were also surveyed on day two, by boat and on foot.

On day three, all waterbirds on the north-western side of Peel Inlet, from the old Mandurah Traffic Bridge to Ward Point (sectors 2b and 4), including Boundary Island and the samphire islands to the west of Channel Island, were surveyed by boat and on foot. Note that Boundary Island is an artificial island constructed in 1987 (Pszczola, J. 1998, pers. comm.), ten years after the 1976-77 waterbird surveys.

On day four, all waterbirds on the shoreline and the inner and middle shallows of the eastern and southern side of Peel Inlet, from the artificial lagoon adjoining Yunderup Canals to the west side of Robert Bay (inner and middle sector 6), were surveyed on foot.

The western shoreline and adjacent shallows of the Murray River delta (sector 5), plus the middle and outer shallows on the eastern and southern sides of Peel Inlet from Yunderup Canals to Robert Bay (middle and outer sector 6), were surveyed by boat and on foot on day five.

A survey of all waterbirds at the southern end of Harvey Estuary (from Herron Point Ford south), plus the lower reaches and delta of the Harvey River (sector 10), was conducted by boat and on foot on day six, the last day of the surveys.

In October 1996, the day two and day three surveys, minus the shoreline and shallows from Sticks Channel to Ward Point and from the eastern entrance of Creery lagoon to the Serpentine River, (thus sectors 1, 2a and 2b) were all done in one day, as in October 1976.

In February 1997, the western shoreline and shallows of Harvey Estuary from Island Point to Ward Point (sector 9) were surveyed by boat on day three, simultaneous with the survey of north-western Peel Inlet. On day four, the shoreline and shallows from the west side of Robert Bay to Herron Point in Harvey Estuary (sectors 7 and 8) were surveyed on foot, simultaneous with the foot survey of south-eastern Peel Inlet. With these two additional surveys, almost-complete survey coverage of the shoreline and shallows of Peel-Harvey Estuary was achieved in that survey month.

The central, deeper-water parts of Peel-Harvey were not systematically surveyed because ad-hoc surveys of these waters by aircraft and boat during the mid 1970s and in 1996-97 showed they were generally little used by waterbirds. Waterbirds most likely to have been missed in these parts were cormorants, small numbers of grebes and pelicans, and occasional terns, gulls and darters.

Note that the sectors described above were defined on the basis of survey practicalities, primarily the maximum area that could be thoroughly surveyed in a single day by a single observer under varying weather and tidal conditions.

On the first day of survey in October 1996, a "general air survey" was conducted to gain a broad overview of bird numbers and distributions prior to conducting ground surveys. This air survey was intended to replicate surveys conducted twenty years previously, in 1976-77. However, the October 1996 general air survey did not produce worthwhile results (see Appendix 9 for results and discussion). General air surveys were therefore not conducted in subsequent survey months of 1996-97.

5.3 Counting Techniques

Whenever possible, birds were counted individually. This was usually achievable with flocks of tens or

low hundreds of individuals, but rarely achievable with flocks of high hundreds or thousands. In these latter instances, the commonly used (Conder 1978, Bibby et al 2000) technique of counting in tens,

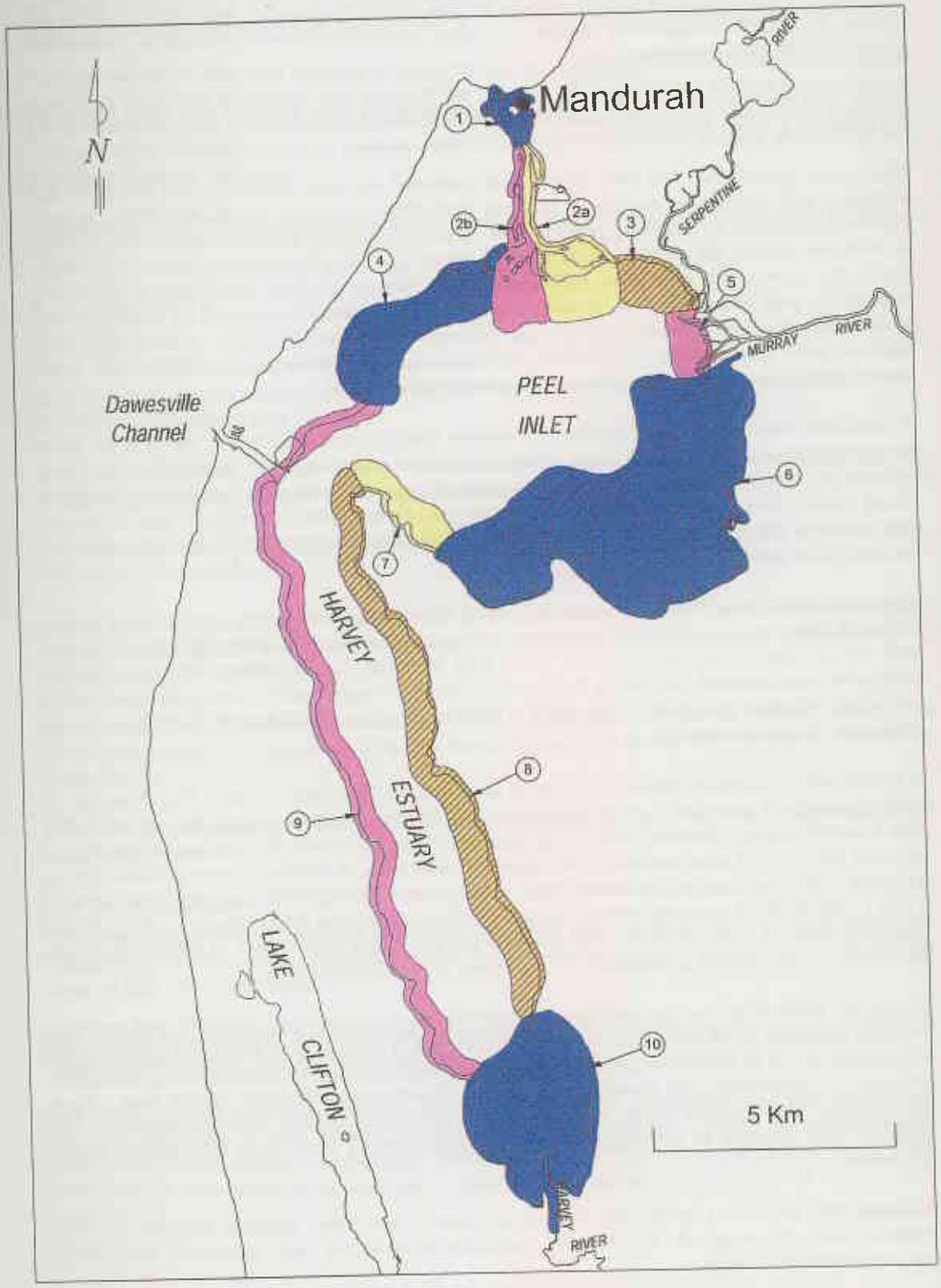

Figure 2. Survey sectors of Peel-Harvey Estuary.

twenties or larger estimated groupings was employed. Some very large flocks (thousands) were broken by eye into a number of equal-sized parts and the number in one of these parts was counted or estimated

and then multiplied by the number of parts. Where practicable this process was repeated two or more times to improve the estimate.

Sometimes it was not possible to determine the identity of birds because they were too far away for the observer to discern distinguishing features. On these occasions they were recorded as "unidentified ducks", "unidentified cormorants", etc.

Flying birds were included in sector counts except for occasions when they were seen flying high above the estuary, e.g. rising on thermals.

Because the ground (boat and foot) surveys were conducted over four (October) to six (December and February) full days, some movement of birds undoubtedly occurred during the survey periods. Allowance was made for this where possible. During each day's survey a record or mental note was kept of birds seen passing the observer, either ahead or behind, and count figures were adjusted accordingly. Day-to-day movements were more problematic. No measure of these movements was possible. Impressions were gained, however, as some previously surveyed areas were passed on subsequent days while on the way to and from new survey areas. Survey areas were also "revisited" at the margins when adjoining areas were surveyed. On this basis, the authors have confidence that most birds present on the estuary during each survey period were not double-counted or omitted.

As indicated above, Australian Pelicans were counted from an aircraft, with each survey of the entire estuary taking no more than 1-1.5 hours. These surveys were undertaken in the middle of the day, when pelicans are often resting and relatively few movements, compared with early morning or evening, are taking place. Flocks too large to count from the air were photographed and numbers later determined from prints as described in section 5.4. For these reasons there is a high degree of confidence in the accuracy of the pelican count data.

Also as indicated above, Black Swan numbers on Peel Inlet were counted during a single survey by boat, with each survey taking around 3.5 to 5 hours to complete. The swans of Harvey Estuary were counted from the air during the pelican survey. The Peel Inlet and Harvey Estuary swan surveys were undertaken simultaneously and during the day, when swans are usually quietly grazing on aquatic plants or resting with little movement taking place. There is therefore a high degree of confidence in the accuracy of the swan count data.

It will be seen in following sections that none of the count data have been rounded. This is because the authors consider it more useful, in this first reporting of survey results, to present the raw data rather than rounded figures. However, when these data are put to other uses, for example comparisons of numbers with those of other wetlands, it is suggested that all totals be rounded to two significant figures. Thus the maximum count of Red-necked Stint would become 15,000 rather than 14,672 as shown in Table 1. Similarly the maximum count of Australian Shelduck becomes 4,500 rather than 4,527 and the maximum count of Australasian Shoveler becomes 500 rather than 501. Totals of 100 or less remain unchanged. This approach is consistent with that taken in Rose & Scott (1997).

The survey methodology was not well suited to detecting secretive species of waterbirds such as crakes and rails (members of the family Rallidae). To be confident of locating these species an observer needs to spend periods of 10 minutes or more quietly observing likely habitats, e.g. rushbeds, from unobtrusive positions. Alternatively, tape recordings or humane live-trapping techniques can be used. These methods were not employed during the 1996-97 (or 1976-77) surveys due to time constraints. It is therefore quite possible, in fact highly likely, that some birds of these types were present though unrecorded.

Although bird behaviours (principally feeding or roosting) were often recorded, this was not done routinely due to the magnitude and, at times, complexity of the survey task. Behaviours are therefore not presented in this report.

5.4 Data Management

Pelican and swan count data collected on "day one" of each survey were recorded directly onto maps of the estuary or were recorded on audiotape (hand-held cassette recorder) and later transcribed to maps. A hand-held 35mm camera was used to photograph pelican flocks too large to count from the air and bird numbers were later determined from photographic prints using a dissecting microscope at low power.

All other waterbird data were recorded on audiotape or, less frequently, in notebooks. The audiotape recordings were later transcribed onto maps of the estuary. The estuary was divided into ten survey sectors and the number of birds of each species was totalled for each sector. These sector totals were then summed, using Microsoft Excel, to produce totals for Peel Inlet and Harvey Estuary individually and Peel-Harvey Estuary combined.

Copies of the 1996-97 data, including detailed distributional data, have been stored off-site for security.

6. RESULTS

6.1 Species

Sixty species of waterbirds were recorded during the 1996-97 waterbird surveys. These represented 16 families and 42 genera (Table 1).

18 were transequatorial migratory species with their breeding grounds in the northern hemisphere. All of these migrant species are "shorebirds", also commonly referred to as "waders".

50 species were recorded during the October 1996 survey; 46 were recorded in December 1996 and 48 in February 1997 (Appendix 1).

Sectors 1, 2, 6 and 10 (Figure 2) were surveyed in all three survey months. The numbers of waterbird species recorded in these four sectors in October 1996, December 1996 and February 1997 were 50, 44 and 46 respectively (Appendix 2).

Sectors 1, 2, 3, 4, 5, 6 and 10 were surveyed both in December 1996 and in February 1997. The numbers of waterbird species recorded in these sectors in these two months were 46 and 47 respectively (Appendix 3).

39 species were recorded in all three survey months; 14 species were recorded in only one of the survey months (Appendix 1).

6.2 Abundance

The minimum number of identified waterbirds that made use of Peel-Harvey Estuary at some time during 1996-97 was 60,562 (Table 1). This is the sum of the maximum monthly (Oct, Dec or Feb) count of each individual species.

The highest single monthly count (October, December or February) of all species, including waterbirds unidentified to species, was 50,776 in December 1996 (Appendix 1).

The most abundant species (13 species; each more than 1,000 individuals) were Red-necked Stint (14,672), Grey Teal (12,612), Banded Stilt (6,954), Australian Shelduck (4,527), Silver Gull (4,405), Red-necked Avocet (2,443), Black-winged Stilt (2,293), Little Pied Cormorant (1,665), Little Black Cormorant (1,368), Sharp-tailed Sandpiper (1,285), Pied Cormorant (1,096) and Black Swan (1,052) (Table 1).

Table 1. Waterbird species and maximum numbers counted on Peel-Harvey Estuary during 1996-97. (Scientific and common names are those of Christidis & Boles 1994. Transequatorial migrants are denoted by [M], JAMBA species by [J] and CAMBA species by [C]).

Family Name	Group and Scientific Names	Common Name	Max. Count
ANATIDAE	**Ducks & allies**		
	Biziura lobata	Musk Duck	4
	Cygnus atratus	Black Swan	1052
	Tadorna tadornoides	Australian Shelduck	4527
	Chenonetta jubata	Australian Wood Duck	3
	Anas superciliosa	Pacific Black Duck	749
	Anas rhynchotis	Australasian Shoveler	501
	Anas gracilis	Grey Teal	12612
	Anas castanea	Chestnut Teal	1
	Malacorhynchus membranaceus	Pink-eared Duck	1
	Aythya australis	Hardhead	9
PODICIPEDIDAE	**Grebes**		
	Poliocephalus poliocephalus	Hoary-headed Grebe	220
	Podiceps cristatus	Great Crested Grebe	3
ANHINGIDAE	**Darters**		
	Anhinga melanogaster	Darter	95
PHALACROCORACIDAE	**Cormorants**		
	Phalacrocorax melanoleucos	Little Pied Cormorant	1665
	Phalacrocorax varius	Pied Cormorant	1096
	Phalacrocorax sulcirostris	Little Black Cormorant	1368
	Phalacrocorax carbo	Great Cormorant	39
PELECANIDAE	**Pelicans**		
	Pelecanus conspicillatus	Australian Pelican	641
ARDEIDAE	**Herons, Egrets, Bitterns**		
	Egretta novaehollandiae	White-faced Heron	134
	Egretta garzetta	Little Egret	89
	Ardea alba [CJ]	Great Egret	114
	Nycticorax caledonicus	Nankeen Night Heron	1
THRESKIORNITHIDAE	**Ibises, Spoonbills**		
	Threskiornis molucca	Australian White Ibis	48
	Platalea flavipes	Yellow-billed Spoonbill	11
ACCIPITRIDAE	**Osprey, Kite, Eagles, Harriers**		
	Pandion haliaetus	Osprey	1
	Haliastur sphenurus	Whistling Kite	5
	Haliaeetus leucogaster [C]	White-bellied Sea-Eagle	1
	Circus approximans	Swamp Harrier	4
RALLIDAE	**Rails, Crakes, Water hens, Coot**		
	Porphyrio porphyrio	Purple Swamphen	4
SCOLOPACIDAE	**Sandpipers, Knots, Stint & allies**		
	Limosa limosa [CJM]	Black-tailed Godwit	28
	Limosa lapponica [CJM]	Bar-tailed Godwit	307
	Numenius phaeopus [CJM]	Whimbrel	11
	Numenius madagascariensis [CJM]	Eastern Curlew	19
	Tringa nebularia [CJM]	Common Greenshank	314
	Xenus cinereus [CJM]	Terek Sandpiper	4
	Actitis hypoleucos [CJM]	Common Sandpiper	17

Table 1 continued.

Family Name	Group and Scientific Names	Common Name	Max. Count
SCOLOPACIDAE contd.	*Heteroscelis brevipes* [CJM]	Grey-tailed Tattler	8
	Arenaria interpres [CJM]	Ruddy Turnstone	2
	Calidris tenuirostris [CJM]	Great Knot	26
	Calidris canutus [CJM]	Red Knot	39
	Calidris ruficollis [CJM]	Red-necked Stint	14672
	Calidris acuminata [CJM]	Sharp-tailed Sandpiper	1285
	Calidris ferruginea [CJM]	Curlew Sandpiper	313
HAEMATOPODIDAE	**Oystercatchers**		
	Haematopus longirostris	Pied Oystercatcher	27
RECURVIROSTRIDAE	**Stilts, Avocets**		
	Himantopus himantopus	Black-winged Stilt	2293
	Cladorhynchus leucocephalus	Banded Stilt	6954
	Recurvirostra novaehollandiae	Red-necked Avocet	2443
CHARADRIIDAE	**Plovers, Dotterels**		
	Pluvialis fulva [CJM]	Pacific Golden Plover	54
	Pluvialis squatarola [CJM]	Grey Plover	116
	Charadrius ruficapillus	Red-capped Plover	876
	Charadrius mongolus [CJM]	Lesser Sand Plover	1
	Charadrius leschenaultii [CJM]	Greater Sand Plover	11
	Thinornis rubricollis	Hooded Plover	1
LARIDAE	**Gulls, Terns**		
	Larus novaehollandiae	Silver Gull	4405
	Sterna caspia [C]	Caspian Tern	180
	Sterna bergii [J]	Crested Tern	112
	Sterna nereis	Fairy Tern	262
	Chlidonias hybridus	Whiskered Tern	736
MELIPHAGIDAE	**Honeyeaters, Australian Chats**		
	Ephthianura albifrons	White-fronted Chat	33
SYLVIDAE	**Old World Warblers**		
	Megalurus gramineus	Little Grassbird	15
TOTALS		**60 species**	**60 562 birds**

The minimum number of identified ducks that made use of Peel-Harvey Estuary during 1996-97 was 18,407 (Table 1). The highest single monthly count of all ducks, including ducks unidentified to species, was 17,710 in December 1996 (Appendix 4). The most numerous (more than 1,000 individuals) of these were Grey Teal (12,612) and Australian Shelduck (4,527). The next most abundant (more than 100 individuals) were Pacific Black Duck (749) and Australasian Shoveler (501).

The minimum number of identified cormorants that made use of Peel-Harvey Estuary during 1996-97 was 4,168 (Table 1). The highest single monthly count of all cormorants, including cormorants unidentified to species, was 3,849 in February 1997 (Appendix 5). The most numerous (more than 1,000 individuals) of these were Little Pied Cormorant (1,665), Little Black Cormorant (1,368) and Pied Cormorant (1,096). Great Cormorants were not abundant (maximum of 39 in December 1996).

The minimum number of identified terns that made use of Peel-Harvey Estuary during 1996-97 was 1,290 (Table 1). The highest single monthly count of all terns, including terns unidentified to species, was 901 in October 1996 (Appendix 8). The two most abundant species were Whiskered Tern (736) and

Fairy Tern (262).

The minimum number of identified transequatorial migratory shorebirds that made use of Peel-Harvey Estuary during 1996-97 was 17,227 (Table 1). The most numerous (more than 1,000 individuals) of these were Red-necked Stint (14,672) and Sharp-tailed Sandpiper (1,285). The next most abundant (more than 100 individuals) were Common Greenshank (314), Curlew Sandpiper (313), Bar-tailed Godwit (307) and Grey Plover (116). The highest single monthly count of knots was 166 (including 110 unidentified to species) in December 1996 (Appendix 6). The highest counts of Great Knot and Red Knot were 26 and 39 respectively.

The most recent compilation of maximum counts of individual waterbird species on wetlands across the south-west of Western Australia (Kalbarri – Cape Arid) is that of Jaensch, Merrifield & Raines (1993) and covers the period 1981-92. Maximum 1996-97 Peel-Harvey counts of ten species were greater than those reported by Jaensch, Merrifield & Raines (Table 2).

Table 2. The ten species with higher 1996-97 Peel-Harvey counts than reported for any wetland in south-western Australia for the period 1981-92.

Species	Max. 1996-97 Peel-Harvey Count	Max. 1981-92 SW Wetlands Count	Location of Maximum 1981-92 South-West Wetlands Count
Darter	95	45	West Corio Swamp (near Pinjarra)
Little Pied Cormorant	1665	1000	Carraburmup Swamp (near Peel Inlet)
Pied Cormorant	1096	519	Peel Inlet East & South
Little Egret	89	21	Creery Marshes (Peel Inlet)
Whimbrel	11	7	Creery Marshes (Peel Inlet)
Common Greenshank	314	213	Peel Inlet East & South
Red-necked Stint	14672	10000	Alfred Cove (Swan River)
Silver Gull	4405	3500	Perry Lakes (Perth)
Caspian Tern	180	60	Peel Inlet
Fairy Tern	262	102	Alfred Cove (Swan River)

The minimum number of individuals of bird species listed under JAMBA or CAMBA that made use of Peel-Harvey Estuary during 1996-97 was 17,634 (Table 1). The most numerous (more than 1,000 individuals) of these were Red-necked Stint (14,672) and Sharp-tailed Sandpiper (1,285). The next most abundant (more than 100 individuals) were Common Greenshank (314), Curlew Sandpiper (313), Bar-tailed Godwit (307), Caspian Tern (180), Grey Plover (116), Great Egret (114) and Crested Tern (112).

Seventeen of the 60 species recorded had maximum counts of less than 10 individuals (Table 1).

6.3 Distribution

In each of the three survey months, more waterbirds were recorded in south-eastern Peel Inlet (sector 6) than in any other survey sector of Peel-Harvey (Appendix 1). The highest number recorded in this sector was 28,727 in December 1996. The lowest number in this sector was 12,380 in October 1996.

The survey sectors in which waterbirds were next most abundant were the southern end of Harvey Estuary (sector 10) and north-central Peel Inlet (sector 2). The number of waterbirds counted in sector 10 ranged from 1,618 in October 1996 to 13,907 in December 1996. The number counted in sector 2 ranged from 2,531 October 1996 to 4,888 in February 1997.

The most abundant species (Red-necked Stint) was most numerous in sector 10 (8,009 birds in December 1996) and sector 6 (6,058 birds in December 1996). The second most abundant species (Grey Teal) was also most numerous in sectors 6 and 10 (9,585 and 2,241 respectively, in February 1997).

Sectors 2 and 6 had the highest diversity (40) of species in October 1996. Sector 2 had the highest diversity (36) in December 1996 and February 1997.

6.4 Breeding

Eight species of waterbirds were recorded breeding during the 1996-97 waterbird surveys. These were Black Swan, Australian Shelduck, Pacific Black Duck, Grey Teal, Australian Pelican, Pied Oystercatcher, Black-winged Stilt and Silver Gull (Appendix 10). Fairy Terns might also have bred on Peel-Harvey Estuary during 1996-97.

Only one swan nest mound was found on Peel-Harvey, in samphire marsh on the north side of Creery Island. This nesting attempt was apparently unsuccessful. Seventy-one cygnets were recorded on the estuary in October 1996 and 82 in December 1996. Most were in Austin Bay. The cygnets most probably originated from nests on wetlands not far from Peel-Harvey.

Several broods of Australian Shelduck and Pacific Black Duck ducklings were found on widely separated parts of the estuary and the lower Harvey River in October 1996. Two Grey Teal ducklings and five unidentified ducklings were also encountered on the lower Harvey River in the same month.

Flightless pelican chicks were found in a nest area on Boundary Island in October 1996. Most of 100 adult Australian Pelicans were sitting on eggs at this location in December 1996 and 120 large chicks were present at this location in February 1997.

A single Black-winged Stilt nest with eggs was found in the samphire marsh of Soldiers Cove in October 1996.

In October 1996 there were indications of nesting by several pairs of Pied Oystercatcher on Channel, Boundary and Boodalan Islands. A Silver Gull nest with eggs was found on Boodalan Island in the same month.

A sign and temporary fencing near the mouth of the natural entrance channel to Peel Inlet in February 1997 indicated nesting by Fairy Tern, however nesting was not confirmed.

7. DISCUSSION

7.1 Waterbirds on Peel-Harvey following Construction of Dawesville Channel

It is apparent from the 1996-97 data that 2-3 years following construction of the Dawesville Channel Peel-Harvey Estuary remained one of the most important waterbird habitats in Western Australia. The December 1996 count of 50,776 birds exceeds that recorded for any other estuary in the south-west of the State. Lake Muir, near Manjimup, is the only wetland in the south-west at which a higher number of waterbirds (51,613 birds in March 1989) has been recorded (Halse et al 1990; ANCA 1996).

The number of waterbird species (60) recorded on Peel-Harvey Estuary during the surveys of 1996-97 is significantly less than a number previously reported (86) for all pre-1996 Peel-Harvey surveys combined (ANCA 1996). That the first-mentioned number is lower is to be expected as waterbirds are highly mobile species and species lists for individual wetlands typically grow as more surveys are conducted. Also, as mentioned in section 5.3, the survey methods of 1996-97 were not well suited to finding secretive species such as crakes and rails. Further consideration of species presence/absence data is proposed for later reports, when the results of the 1998-99 and 1976-77 surveys will be presented and compared. Suffice to say here that the 60 species recorded in 1996-97 represent a substantial diversity of waterbird types.

Waterbirds were unevenly distributed within Peel-Harvey Estuary during the 1996-97 surveys, with the greatest numbers of birds occurring in south-eastern Peel Inlet (Austin and Robert Bays), the southern

end of Harvey Estuary and north-central Peel Inlet. The first and last areas are largely within formal conservation reserves. The southern end of Harvey Estuary has a conservation reserve adjoining its eastern shore but is otherwise largely unprotected.

7.2 Impacts of Dawesville Channel on Waterbirds

The second aim of the project that is the subject of this report is to identify significant impacts of construction of the Dawesville Channel on waterbird species, numbers and distributions on Peel-Harvey Estuary. Before a proper assessment can be made, it is necessary to report the results of the 1998-99 surveys and "baseline" surveys that were undertaken in 1976-77. This work is proposed.

7.3 Ramsar Convention Status of Peel-Harvey Estuary

In 1990, Peel-Harvey Estuary was listed, jointly with Lakes McLarty, Mealup and the Yalgorup Lakes, as a Wetland of International Importance under the Ramsar Convention. At that time, the estuary met the following three Ramsar Criteria (note that a site need meet only one Ramsar Criterion to be eligible for listing).

1. It is a particularly good example of a specific type of wetland, characteristic of its region.
3a. It regularly supports 20,000 waterfowl.
3c. Where data on populations are available, it regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl.

Since listing in 1990, the Ramsar Criteria have been further developed and re-numbered by Ramsar Conferences of Contracting Parties. The current equivalents of the above Criteria are as follows.

1. It contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
5. It regularly supports 20,000 or more waterbirds.
6. It regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Of interest in the context of this report is whether or not Peel-Harvey Estuary continues to meet Ramsar Criteria 5 and 6 following opening of the Dawesville Channel in April 1994. However, before addressing these questions it is necessary to consider how the word "regularly" should be interpreted.

Rose & Scott (1997) suggested use of five-year averages of annual maxima in waterbird numbers for determining whether the relevant levels (20,000 birds or 1% of population) occur "regularly". The Ramsar Convention Bureau (2000) has supported this approach and also suggested an alternative based on numbers counted in at least two thirds of seasons for which data are available. Importantly, the Bureau has also recognised that situations exist (e.g. drought refuges or difficulty in obtaining data) where data collected over shorter time periods may be acceptable for determining a wetland's importance for waterbirds.

In relation to nomination of Western Australian wetlands for listing under the Ramsar Convention, Jaensch & Watkins (1999) have recommended the following approach.

> "In regard to criterion 3 (a), the existence of reliable counts of 20,000 waterbirds, or highest counts (during one year) of individual species which sum to 20,000 waterbirds, in at least several of the past 25 years and with no clear evidence of recent decline in numbers, was considered an adequate basis for criterion 3 (a) to be met. Where few surveys had been conducted at the site but there was evidence of recurrence in at least several of the past 25 years of the wetland conditions that had on at least one occasion supported 20,000 waterbirds, the criterion was considered met (especially if the highest numbers were well in excess of 20,000 waterbirds, e.g. 100,000)".
>
> "In testing against [criterion 3c], it was decided that there should be no clear evidence of recent decline in numbers to below the 1% level".

The present authors support the approach recommended by Jaensch & Watkins (1999) and have applied

this to Peel-Harvey as follows.

Ramsar Criterion 5

It is clear from the results of the 1996-97 waterbird surveys reported above that Peel-Harvey Estuary supported more than 20,000 waterbirds in 1996-97. At least 60,562 waterbirds made use of Peel-Harvey Estuary at some time during 1996-97. 50,776 waterbirds were present in December 1996 and 37,071 in February 1997. On this basis it is concluded that, in 1996-97, Peel-Harvey continued to meet Ramsar Criterion 5 (formerly 3a) for inclusion in the Ramsar List of Wetlands of International Importance.

Ramsar Criterion 6

"One percent of population" levels have been published for 29 of the 60 waterbird species recorded on Peel-Harvey Estuary during 1996-97 (Watkins and AWSG 1993, Rose and Scott 1997). These 29 species are listed in Appendix 12, together with their respective maximum 1996-97 counts and 1% levels.

Five species, Red-necked Stint, Banded Stilt, Red-necked Avocet, Caspian Tern and Fairy Tern, had maximum 1996-97 Peel-Harvey counts that were greater than their respective 1% levels (Table 3). On this basis it is concluded that, in 1996-97, Peel-Harvey continued to meet Ramsar Criterion 6 (formerly 3c) for inclusion in the Ramsar List of Wetlands of International Importance.

Table 3. Species with maximum 1996-97 Peel-Harvey counts exceeding 1% population levels.

Species	Maximum Peel-Harvey count in 1996-97	One Percent Level of relevant population	Distribution of relevant population (Rose & Scott 1997)
Red-necked Stint	14672	4700	E Siberia/SE&E Asia/Aust/NZ
Banded Stilt	6954	2100	Southern Australia/Tasmania
Red-necked Avocet	2443	1100	Australia
Caspian Tern	180	30	Australia/New Zealand
Fairy Tern	262	60	Western Australia

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APPENDICES

APPENDIX 1. Waterbird species and numbers counted in all survey sectors of Peel-Harvey Estuary during October 1996, December 1996 and February 1997.

		PEEL								HARVEY				Grand
Species	**Month**	**1**	**2**	**3**	**4**	**5** [3]	**6**	**7**	**Total**	**8**	**9** [3]	**10**	**Total**	**Total**
Musk Duck	Oct	0	0				1		**1**			0	**0**	**1**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	1	0	**1**	1	0	2	**3**	**4**
Black Swan [4]	Oct	0	9	0	5	0	1036	0	**1050**	0	0	2	**2**	**1052**
	Dec	0	0	4	9	0	573		**586**	0	5	0	**5**	**591**
	Feb	0	5	1	93	0	387	14	**500**	0	27	25	**52**	**552**
Australian Shelduck	Oct	0	124				3545		**3669**			59	**59**	**3728**
	Dec	0	194	4	36	28	3733		**3995**			532	**532**	**4527**
	Feb	0	237	26	14	2	402	0	**681**	2	16	85	**103**	**784**
Australian Wood Duck	Oct	0	0				0		**0**			3	**3**	**3**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Pacific Black Duck	Oct	0	110			*1*	558		**669**		*5*	75	**80**	**749**
	Dec	3	51	0	52	0	423		**529**			131	**131**	**660**
	Feb	51	14	0	44	7	179	0	**295**	0	117	207	**324**	**619**
Australasian Shoveler	Oct	0	0				501		**501**			0	**0**	**501**
	Dec	0	0	0	0	2	10		**12**			0	**0**	**12**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Grey Teal	Oct	0	14				306		**320**		*2*	26	**28**	**348**
	Dec	0	270	52	44	5	9471		**9842**			648	**648**	**10490**
	Feb	0	458	60	128	2	9585	6	**10239**	0	132	2241	**2373**	**12612**
Chestnut Teal	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	1	**1**	**1**
Pink-eared Duck	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	1	0	**1**	0	0	0	**0**	**1**

APPENDIX 1. Continued.

		PEEL								HARVEY				Grand
Species	**Month**	**1**	**2**	**3**	**4**	**5** [3]	**6**	**7**	**Total**	**8**	**9** [3]	**10**	**Total**	**Total**
Hardhead	Oct	0	0				9		**9**			0	**0**	9
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Hoary-headed Grebe	Oct	0	0				220		**220**			0	**0**	**220**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Great Crested Grebe	Oct	0	0				3		**3**			0	**0**	**3**
	Dec	0	0	0	0	0	2		**2**			0	**0**	**2**
	Feb	0	0	0	0	0	2	0	**2**	0	0	0	**0**	**2**
Darter	Oct	9	11			*1*	7		**28**			4	**4**	**32**
	Dec	5	12	1	6	1	16		**41**			3	**3**	**44**
	Feb	7	18	4	11	3	13	0	**56**	3	10	26	**39**	**95**
Little Pied Cormorant	Oct	34	20				338		**392**		*2*	24	**26**	**418**
	Dec	27	130	0	163	10	168		**498**			22	**22**	**520**
	Feb	39	266	1	263	106	537	232	**1444**	57	155	9	**221**	**1665**
Pied Cormorant	Oct	94	362				183		**639**			0	**0**	**639**
	Dec	58	675	0	3	0	89		**825**			8	**8**	**833**
	Feb	32	1008	0	2	0	47	0	**1089**	0	3	4	**7**	**1096**
Little Black Cormorant	Oct	10	11				149		**170**			321	**321**	**491**
	Dec	20	31	0	2	1281	13		**1347**			21	**21**	**1368**
	Feb	14	70	0	2	0	905	8	**999**	0	6	47	**53**	**1052**
Great Cormorant	Oct	0	9			*1*	10		**20**			4	**4**	**24**
	Dec	0	0	7	0	6	20		**33**			6	**6**	**39**
	Feb	1	5	1	0	13	9	0	**29**	1	0	2	**3**	**32**
Australian Pelican	Oct	2	94	108	84	19	84	6	**397**	12	4	38	**54**	**451**
	Dec	11	270	5	38	22	156	9	**511**	10	32	88	**130**	**641**
	Feb	10	267	15	84	8	172	25	**581**	7	10	30	**47**	**628**
White-faced Heron	Oct	0	14			*1*	10		**25**			4	**4**	**29**
	Dec	2	30	0	10	7	17		**66**			5	**5**	71
	Feb	3	43	2	12	4	48	2	**114**	5	6	9	**20**	**134**

APPENDIX 1. Continued.

		PEEL								HARVEY				Grand
Species	**Month**	**1**	**2**	**3**	**4**	**5** [3]	**6**	**7**	**Total**	**8**	**9** [3]	**10**	**Total**	**Total**
Little Egret	Oct	0	11				18		**29**			2	**2**	**31**
	Dec	0	19	0	8	5	16		**48**			8	**8**	**56**
	Feb	1	28	0	7	2	38	0	**76**	1	5	7	**13**	**89**
Great Egret	Oct	0	5				19		**24**			9	**9**	**33**
	Dec	1	5	2	6	2	27		**43**			10	**10**	**53**
	Feb	1	11	2	12	1	27	6	**60**	3	14	37	**54**	**114**
Nankeen Night Heron	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	1	0	0	0	0	0		**1**			0	**0**	**1**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Australian White Ibis	Oct	0	6				1		**7**		*12*	2	**14**	**21**
	Dec	1	15	0	0	0	0		**16**			3	**3**	**19**
	Feb	0	36	0	4	0	0	0	**40**	3	3	2	**8**	**48**
Yellow-billed Spoonbill	Oct	0	1				2		**3**			1	**1**	**4**
	Dec	0	5	0	0	1	0		**6**			0	**0**	**6**
	Feb	0	7	0	0	0	1	0	**8**	0	0	3	**3**	**11**
Osprey [6]	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	1	0	0	0		**1**			0	**0**	**1**
	Feb	0	0	0	0	0	0	0	**0**	0	1	0	**1**	**1**
Whistling Kite	Oct	0	1				0		**1**			4	**4**	**5**
	Dec	0	0	1	0	0	0		**1**			0	**0**	**1**
	Feb	0	0	0	1	0	1	0	**2**	0	0	3	**3**	**5**
White-bellied Sea-Eagle	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			1	**1**	**1**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Swamp Harrier	Oct	0	2				0		**2**			0	**0**	**2**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	1	0	**1**	0	0	3	**3**	**4**
Purple Swamphen	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	4	**4**	**4**

APPENDIX 1. Continued.

		PEEL								HARVEY				Grand
Species	**Month**	**1**	**2**	**3**	**4**	**5** [3]	**6**	**7**	**Total**	**8**	**9** [3]	**10**	**Total**	**Total**
Black-tailed Godwit	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	24	0	0	0	0		**24**			4	**4**	**28**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Bar-tailed Godwit	Oct	0	42				2		**44**			6	**6**	**50**
	Dec	1	93	149	4	59	1		**307**			0	**0**	**307**
	Feb	0	11	57	0	2	0	0	**70**	0	0	0	**0**	**70**
Whimbrel	Oct	0	11				0		**11**			0	**0**	**11**
	Dec	0	10	0	0	0	0		**10**			0	**0**	**10**
	Feb	0	10	0	0	0	0	0	**10**	0	0	0	**0**	**10**
Eastern Curlew	Oct	0	12				0		**12**			0	**0**	**12**
	Dec	0	18	0	0	1	0		**19**			0	**0**	**19**
	Feb	0	5	4	0	0	3	0	**12**	0	0	0	**0**	**12**
Common Greenshank	Oct	1	45				12		**58**		*33*	74	**107**	**165**
	Dec	1	91	3	19	13	25		**152**			162	**162**	**314**
	Feb	0	38	3	21	6	48	3	**119**	0	1	13	**14**	**133**
Terek Sandpiper	Oct	0	2				0		**2**			0	**0**	**2**
	Dec	0	2	0	0	1	1		**4**			0	**0**	**4**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Common Sandpiper	Oct	5	7				2		**14**			0	**0**	**14**
	Dec	4	9	0	0	0	4		**17**			0	**0**	**17**
	Feb	2	5	0	0	0	0	0	**7**	2	0	0	**2**	**9**
Grey-tailed Tattler	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	4	0	1	3	0		**8**			0	**0**	**8**
	Feb	0	1	0	3	0	0	0	**4**	0	0	0	**0**	**4**
Ruddy Turnstone	Oct	0	0				2		**2**			0	**0**	**2**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Great Knot	Oct	0	22				2		**24**			0	**0**	**24**
	Dec	1	25	0	0	0	0		**26**			0	**0**	**26**
	Feb	0	0	4	0	15	0	0	**19**	0	0	0	**0**	**19**

APPENDIX 1. Continued.

		PEEL								HARVEY				Grand
Species	**Month**	**1**	**2**	**3**	**4**	**5** [3]	**6**	**7**	**Total**	**8**	**9** [3]	**10**	**Total**	**Total**
Red Knot	Oct	0	18				0		**18**			0	**0**	**18**
	Dec	0	30	0	0	0	0		**30**			0	**0**	**30**
	Feb	0	28	2	0	9	0	0	**39**	0	0	0	**0**	**39**
Red-necked Stint	Oct	0	87				803		**890**			0	**0**	**890**
	Dec	0	435	40	20	110	6058		**6663**			8009	**8009**	**14672**
	Feb	0	657	11	0	884	46	0	**1598**	0	0	3242	**3242**	**4840**
Sharp-tailed Sandpiper	Oct	0	293				126		**419**			0	**0**	**419**
	Dec	0	375	0	118	0	126		**619**			666	**666**	**1285**
	Feb	0	436	0	33	6	16	0	**491**	3	0	13	**16**	**507**
Curlew Sandpiper	Oct	0	19				64		**83**			0	**0**	**83**
	Dec	0	3	0	0	0	0		**3**			310	**310**	**313**
	Feb	0	0	0	0	0	0	0	**0**	0	0	78	**78**	**78**
Pied Oystercatcher	Oct	2	6				4		**12**			1	**1**	**13**
	Dec	0	9	0	5	10	3		**27**			0	**0**	**27**
	Feb	8	6	0	1	0	0	0	**15**	0	0	0	**0**	**15**
Black-winged Stilt	Oct	2	86				1685		**1773**			0	**0**	**1773**
	Dec	9	323	16	14	43	1676		**2081**			212	**212**	**2293**
	Feb	3	175	43	17	18	1372	0	**1628**	0	0	104	**104**	**1732**
Banded Stilt	Oct	0	0				124		**124**			0	**0**	**124**
	Dec	0	0	0	0	0	760		**760**			0	**0**	**760**
	Feb	0	6	0	0	0	6948	0	**6954**	0	0	0	**0**	**6954**
Red-necked Avocet	Oct	0	0				450		**450**			570	**570**	**1020**
	Dec	0	0	118	0	70	72		**260**			2183	**2183**	**2443**
	Feb	0	0	0	0	0	0	0	**0**	0	0	9	**9**	**9**
Pacific Golden Plover	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	54	**54**	**54**
Grey Plover	Oct	2	43				7		**52**			0	**0**	**52**
	Dec	1	69	13	5	16	0		**104**			12	**12**	**116**
	Feb	2	41	11	2	12	0	0	**68**	0	0	0	**0**	**68**

APPENDIX 1. Continued.

		PEEL								HARVEY				Grand
Species	**Month**	**1**	**2**	**3**	**4**	**5** [3]	**6**	**7**	**Total**	**8**	**9** [3]	**10**	**Total**	**Total**
Red-capped Plover	Oct	4	10				459		**473**			0	**0**	**473**
	Dec	0	127	15	5	37	566		**750**			126	**126**	**876**
	Feb	0	74	57	0	68	0	0	**199**	0	0	230	**230**	**429**
Lesser Sand Plover	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	1	0	0	0	0	0	**1**	0	0	0	**0**	**1**
Greater Sand Plover	Oct	0	6				5		**11**			0	**0**	**11**
	Dec	0	1	1	0	0	0		**2**			0	**0**	**2**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Hooded Plover	Oct	0	1				0		**1**			0	**0**	**1**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Silver Gull	Oct	266	916			*144*	731		**2057**		*10*	385	**395**	**2452**
	Dec	383	610	197	216	129	2367		**3902**			503	**503**	**4405**
	Feb	420	652	109	126	113	94	0	**1514**	0	173	196	**369**	**1883**
Caspian Tern	Oct	0	16				6		**22**			4	**4**	**26**
	Dec	1	34	19	11	3	5		**73**			11	**11**	**84**
	Feb	9	60	7	35	3	22	0	**136**	6	0	38	**44**	**180**
Crested Tern	Oct	5	12				3		**20**			0	**0**	**20**
	Dec	9	8	0	9	0	24		**50**			2	**2**	**52**
	Feb	5	30	3	25	0	31	1	**95**	1	5	11	**17**	**112**
Fairy Tern	Oct	0	9				110		**119**			0	**0**	**119**
	Dec	2	33	8	2	0	0		**45**			0	**0**	**45**
	Feb	51	119	28	6	10	33	0	**247**	0	0	15	**15**	**262**
Whiskered Tern	Oct	0	0				736		**736**			0	**0**	**736**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
White-fronted Chat	Oct	0	3				0		**3**			0	**0**	**3**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	22	0	0	11	0	0	**33**	0	0	0	**0**	**33**

APPENDIX 1. Continued.

		PEEL								HARVEY				Grand
Species	**Month**	**1**	**2**	**3**	**4**	**5** [3]	**6**	**7**	**Total**	**8**	**9** [3]	**10**	**Total**	**Total**
Little Grassbird	Oct	0	15						**15**			0	**0**	**15**
	Dec	0	7	0	1	0	0		**8**			2	**2**	**10**
	Feb	0	10	0	0	0	0	0	**10**	0	0	0	**0**	**10**
Sub Total	**Oct**	436	2485	*108*	*89*	*167*	12333	*6*	**15624**	*12*	*68*	1618	**1698**	**17322**
Sub Total	**Dec**	541	4047	656	807	1865	26422	*9*	**34347**	*10*	*37*	13688	**13735**	**48082**
Sub Total	**Feb**	659	4860	451	946	1305	20969	297	**29487**	95	684	6750	**7529**	**37016**
Unidentified ducks	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	2	0	0	0	2003		**2005**			16	**16**	**2021**
	Feb	1	0	0	0	0	0	0	**1**	0	0	0	**0**	**1**
Unidentified cormorants	Oct	0	22				15		**37**			0	**0**	**37**
	Dec	1	0	0	0	0	1		**2**			50	**50**	**52**
	Feb	1	0	0	0	0	3	0	**4**	0	0	0	**0**	**4**
Unidentified knots	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	57	53	0	0	0		**110**			0	**0**	**110**
	Feb	0	0	5	0	0	0	0	**5**	0	0	0	**0**	**5**
Unidentified waders (stint/sandpiper size)	Oct	0	24				32		**56**			0	**0**	**56**
	Dec	0	53	0	0	4	301		**358**			153	**153**	**511**
	Feb	0	27	0	0	0	0	0	**27**	0	0	0	**0**	**27**
Unidentified terns	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	1	0	0	0	4	0	**5**	0	10	3	**13**	**18**
Sub Total	**Oct**	0	46	*0*	*0*	*0*	47	*0*	**93**	*0*	*0*	0	**0**	**93**
Sub Total	**Dec**	1	112	53	0	4	2305	*0*	**2475**	*0*	*0*	219	**219**	**2694**
Sub Total	**Feb**	2	28	5	0	0	7	0	**42**	0	10	3	**13**	**55**
GRAND TOTAL	**Oct**	436	2531	*108*	*89*	*167*	12380	*6*	**15717**	*12*	*68*	1618	**1698**	**17415**
GRAND TOTAL	**Dec**	542	4159	709	807	1869	28727	*9*	**36822**	*10*	*37*	13907	**13954**	**50776**
GRAND TOTAL	**Feb**	661	4888	456	946	1305	20976	297	**29529**	95	694	6753	**7542**	**37071**

APPENDIX 1. Continued.

		PEEL								HARVEY				Grand
	Month	1	2	3	4	5 [3]	6	7	Total	8	9 [3]	10	Total	Total
TOTAL N°. OF SPECIES	Oct	13	40	*1*	*2*	*6*	40	*1*	**49**	*1*	*7*	22	**22**	**50**
TOTAL N°. OF SPECIES	Dec	20	36	20	25	25	29	*1*	**45**	*1*	*1*	27	**28**	**46**
TOTAL N°. OF SPECIES	Feb	18	36	22	24	23	29	9	**42**	14	17	32	**34**	**48**

NOTES

1. In this Appendix, a blank in a sector cell indicates that the sector was not surveyed for birds of that species in that month.
2. In this Appendix, a zero in a sector cell indicates that the sector was surveyed in that month, but no birds of that species were found.
3. In October 1996, sectors 5 and 9 were partially (very small parts) surveyed for all species (fully surveyed for swans and pelicans).
4. Swan numbers in sectors 1-6 in December 1996 are from counts made over several days (swans and pelicans, but not other species, were normally surveyed on a single day of each survey month – see section 5.2 for details). Sector 7 was not surveyed for swans in December 1996.
5. Some numbers in this Appendix appear in italics/small font. This is intended to show at a glance that, while some birds were counted, the relevant sector was not surveyed for all birds of that species (or, if a subtotal or total, for all birds of all species) in that month.
6. During the "general air survey" on 14 October 1996, a single Osprey was recorded in sector 8. Data from the October 1996 general air survey have not been included in Appendices 1-3 as they were generally inferior (substantially) to data gathered during ground surveys. The single Osprey record of October 1996 therefore does not appear in Appendix 1. Results of the October 1996 general air survey are presented in Appendix 9.

APPENDIX 2. Waterbird species and numbers counted in common survey sectors of Peel-Harvey Estuary during October 1996, December 1996 and February 1997.

	October 1996					December 1996					February 1997				
Species	**Sector 1**	**Sector 2**	**Sector 6**	**Sector 10**	**Total**	**Sector 1**	**Sector 2**	**Sector 6**	**Sector 10**	**Total**	**Sector 1**	**Sector 2**	**Sector 6**	**Sector 10**	**Total**
Musk Duck			1		**1**					**0**			1	2	**3**
Black Swan [2]		9	1036	2	**1047**			573		**573**		5	387	25	**417**
Australian Shelduck		124	3545	59	**3728**		194	3733	532	**4459**		237	402	85	**724**
Australian Wood Duck				3	**3**					**0**					**0**
Pacific Black Duck		110	558	75	**743**	3	51	423	131	**608**	51	14	179	207	**451**
Australasian Shoveler			501		**501**			10		**10**					**0**
Grey Teal		14	306	26	**346**		270	9471	648	**10389**		458	9585	2241	**12284**
Chestnut Teal					**0**					**0**				1	**1**
Pink-eared Duck					**0**					**0**			1		**1**
Hardhead			9		**9**					**0**					**0**
Hoary-headed Grebe			220		**220**					**0**					**0**
Great Crested Grebe			3		**3**			2		**2**			2		**2**
Darter	9	11	7	4	**31**	5	12	16	3	**36**	7	18	13	26	**64**
Little Pied Cormorant	34	20	338	24	**416**	27	130	168	22	**347**	39	266	537	9	**851**
Pied Cormorant	94	362	183		**639**	58	675	89	8	**830**	32	1008	47	4	**1091**
Little Black Cormorant	10	11	149	321	**491**	20	31	13	21	**85**	14	70	905	47	**1036**
Great Cormorant		9	10	4	**23**			20	6	**26**	1	5	9	2	**17**
Australian Pelican	2	94	84	38	**218**	11	270	156	88	**525**	10	267	172	30	**479**
White-faced Heron		14	10	4	**28**	2	30	17	5	**54**	3	43	48	9	**103**
Little Egret		11	18	2	**31**		19	16	8	**43**	1	28	38	7	**74**
Great Egret		5	19	9	**33**	1	5	27	10	**43**	1	11	27	37	**76**
Nankeen Night Heron					**0**	1				**1**					**0**
Australian White Ibis		6	1	2	**9**	1	15		3	**19**		36		2	**38**
Yellow-billed Spoonbill		1	2	1	**4**		5			**5**		7	1	3	**11**
Osprey					**0**					**0**					**0**
Whistling Kite		1		4	**5**					**0**			1	3	**4**
White-bellied Sea Eagle					**0**				1	**1**					**0**

APPENDIX 2. Continued.

Species	October 1996					December 1996					February 1997				
	Sector 1	Sector 2	Sector 6	Sector 10	Total	Sector 1	Sector 2	Sector 6	Sector 10	Total	Sector 1	Sector 2	Sector 6	Sector 10	Total
Swamp Harrier		2			**2**					**0**			1	3	**4**
Purple Swamphen					**0**					**0**				4	**4**
Black-tailed Godwit					**0**		24		4	**28**					**0**
Bar-tailed Godwit		42	2	6	**50**	1	93	1		**95**		11			**11**
Whimbrel		11			**11**		10			**10**		10			**10**
Eastern Curlew		12			**12**		18			**18**		5	3		**8**
Common Greenshank	1	45	12	74	**132**	1	91	25	162	**279**		38	48	13	**99**
Terek Sandpiper		2			**2**		2	1		**3**					**0**
Common Sandpiper	5	7	2		**14**	4	9	4		**17**	2	5			**7**
Grey-tailed Tattler					**0**		4			**4**		1			**1**
Ruddy Turnstone			2		**2**					**0**					**0**
Great Knot		22	2		**24**	1	25			**26**					**0**
Red Knot		18			**18**		30			**30**		28			**28**
Red-necked Stint		87	803		**890**		435	6058	8009	**14502**		657	46	3242	**3945**
Sharp-tailed Sandpiper		293	126		**419**		375	126	666	**1167**		436	16	13	**465**
Curlew Sandpiper		19	64		**83**		3		310	**313**				78	**78**
Pied Oystercatcher	2	6	4	1	**13**		9	3		**12**	8	6			**14**
Black-winged Stilt	2	86	1685		**1773**	9	323	1676	212	**2220**	3	175	1372	104	**1654**
Banded Stilt			124		**124**			760		**760**		6	6948		**6954**
Red-necked Avocet			450	570	**1020**			72	2183	**2255**				9	**9**
Pacific Golden Plover					**0**					**0**				54	**54**
Grey Plover	2	43	7		**52**	1	69		12	**82**	2	41			**43**
Red-capped Plover	4	10	459		**473**		127	566	126	**819**		74		230	**304**
Lesser Sand Plover					**0**					**0**		1			**1**
Greater Sand Plover		6	5		**11**		1			**1**					**0**
Hooded Plover		1			**1**					**0**					**0**
Silver Gull	266	916	731	385	**2298**	383	610	2367	503	**3863**	420	652	94	196	**1362**
Caspian Tern		16	6	4	**26**	1	34	5	11	**51**	9	60	22	38	**129**
Crested Tern	5	12	3		**20**	9	8	24	2	**43**	5	30	31	11	77

APPENDIX 2. Continued.

Species	October 1996					December 1996					February 1997				
	Sector 1	Sector 2	Sector 6	Sector 10	Total	Sector 1	Sector 2	Sector 6	Sector 10	Total	Sector 1	Sector 2	Sector 6	Sector 10	Total
Fairy Tern		9	110		**119**	2	33			**35**	51	119	33	15	**218**
Whiskered Tern			736		**736**					**0**					**0**
White-fronted Chat		3			**3**					**0**		22			**22**
Little Grassbird		15			**15**		7		2	**9**		10			**10**
Sub Total	436	2485	12333	1618	**16872**	541	4047	26422	13688	**44698**	659	4860	20969	6750	**33238**
Unidentified ducks					**0**		2	2003	16	**2021**	1				**1**
Unidentified cormorants		22	15		**37**	1		1	50	**52**	1		3		**4**
Unidentified knots					**0**		57			**57**					**0**
Unidentified waders		24	32		**56**		53	301	153	**507**		27			**27**
Unidentified terns					**0**					**0**		1	4	3	**8**
Sub Total	0	46	47	0	**93**	1	112	2305	219	**2637**	2	28	7	3	**40**
GRAND TOTAL	436	2531	12380	1618	**16975**	542	4159	28727	13907	**47335**	661	4888	20976	6753	**33278**
TOTAL N°. OF SPECIES	13	40	40	22	**50**	20	36	29	27	**44**	18	36	29	32	**46**

NOTES

1. In this Appendix, a blank in a sector cell indicates that the sector was surveyed for waterbirds in that month, but no birds of that species were found.
2. Swan numbers in sectors 1-6 in December 1996 are from counts made over several days (swans and pelicans, but not other species, were normally surveyed on a single day of each survey month – see section 5.2 for details).

APPENDIX 3. Waterbird species and numbers counted in common survey sectors of Peel-Harvey Estuary during December 1996 and February 1997.

	December 1996								February 1997							
Species	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 10	Total	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 10	Total
Musk Duck								**0**						1	2	**3**
Black Swan [2]			4	9		573		**586**		5	1	93		387	25	**511**
Australian Shelduck		194	4	36	28	3733	532	**4527**		237	26	14	2	402	85	**766**
Australian Wood Duck								**0**								**0**
Pacific Black Duck	3	51		52		423	131	**660**	51	14		44	7	179	207	**502**
Australasian Shoveler					2	10		**12**								**0**
Grey Teal		270	52	44	5	9471	648	**10490**		458	60	128	2	9585	2241	**12474**
Chestnut Teal								**0**							1	**1**
Pink-eared Duck								**0**						1		**1**
Hardhead								**0**								**0**
Hoary-headed Grebe								**0**								**0**
Great Crested Grebe						2		**2**						2		**2**
Darter	5	12	1	6	1	16	3	**44**	7	18	4	11	3	13	26	**82**
Little Pied Cormorant	27	130		163	10	168	22	**520**	39	266	1	263	106	537	9	**1221**
Pied Cormorant	58	675		3		89	8	**833**	32	1008		2		47	4	**1093**
Little Black Cormorant	20	31		2	1281	13	21	**1368**	14	70		2		905	47	**1038**
Great Cormorant			7		6	20	6	**39**	1	5	1		13	9	2	**31**
Australian Pelican	11	270	5	38	22	156	88	**590**	10	267	15	84	8	172	30	**586**
White-faced Heron	2	30		10	7	17	5	**71**	3	43	2	12	4	48	9	**121**
Little Egret		19		8	5	16	8	**56**	1	28		7	2	38	7	**83**
Great Egret	1	5	2	6	2	27	10	**53**	1	11	2	12	1	27	37	**91**
Nankeen Night Heron	1							**1**								**0**
Australian White Ibis	1	15					3	**19**		36		4			2	**42**
Yellow-billed Spoonbill		5			1			**6**		7				1	3	**11**
Osprey			1					**1**								**0**
Whistling Kite			1					**1**				1		1	3	**5**
White-bellied Sea Eagle							1	**1**								**0**

APPENDIX 3. Continued.

Species	December 1996								February 1997							
	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 10	Total	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 10	Total
Swamp Harrier								**0**						1	3	**4**
Purple Swamphen								**0**							4	**4**
Black-tailed Godwit		24					4	**28**								**0**
Bar-tailed Godwit	1	93	149	4	59	1		**307**		11	57		2			**70**
Whimbrel		10						**10**		10						**10**
Eastern Curlew		18			1			**19**		5	4			3		**12**
Common Greenshank	1	91	3	19	13	25	162	**314**		38	3	21	6	48	13	**129**
Terek Sandpiper		2			1	1		**4**								**0**
Common Sandpiper	4	9				4		**17**	2	5						**7**
Grey-tailed Tattler		4		1	3			**8**		1		3				**4**
Ruddy Turnstone								**0**								**0**
Great Knot	1	25						**26**			4		15			**19**
Red Knot		30						**30**		28	2		9			**39**
Red-necked Stint		435	40	20	110	6058	8009	**14672**		657	11		884	46	3242	**4840**
Sharp-tailed Sandpiper		375		118		126	666	**1285**		436		33	6	16	13	**504**
Curlew Sandpiper		3					310	**313**							78	**78**
Pied Oystercatcher		9		5	10	3		**27**	8	6		1				**15**
Black-winged Stilt	9	323	16	14	43	1676	212	**2293**	3	175	43	17	18	1372	104	**1732**
Banded Stilt						760		**760**		6				6948		**6954**
Red-necked Avocet			118		70	72	2183	**2443**							9	**9**
Pacific Golden Plover								**0**							54	**54**
Grey Plover	1	69	13	5	16		12	**116**	2	41	11	2	12			**68**
Red-capped Plover		127	15	5	37	566	126	**876**		74	57		68		230	**429**
Lesser Sand Plover								**0**		1						**1**
Greater Sand Plover		1	1					**2**								**0**
Hooded Plover								**0**								**0**
Silver Gull	383	610	197	216	129	2367	503	**4405**	420	652	109	126	113	94	196	**1710**
Caspian Tern	1	34	19	11	3	5	11	**84**	9	60	7	35	3	22	38	**174**
Crested Tern	9	8		9		24	2	**52**	5	30	3	25		31	11	**105**
Fairy Tern	2	33	8	2				**45**	51	119	28	6	10	33	15	**262**

APPENDIX 3. Continued.

	December 1996								February 1997							
Species	**Sector 1**	**Sector 2**	**Sector 3**	**Sector 4**	**Sector 5**	**Sector 6**	**Sector 10**	**Total**	**Sector 1**	**Sector 2**	**Sector 3**	**Sector 4**	**Sector 5**	**Sector 6**	**Sector 10**	**Total**
Whiskered Tern								**0**								**0**
White-fronted Chat								**0**		22			11			**33**
Little Grassbird		7		1			2	**10**		10						**10**
Sub Total	541	4047	656	807	1865	26422	13688	**48026**	659	4860	451	946	1305	20969	6750	**35940**
Unidentified ducks		2				2003	16	**2021**	1							**1**
Unidentified cormorants	1					1	50	**52**	1					3		**4**
Unidentified knots		57	53					**110**								**0**
Unidentified waders		53			4	301	153	**511**		27						**27**
Unidentified terns								**0**		1				4	3	**8**
Sub Total	1	112	53	0	4	2305	219	**2694**	2	28	0	0	0	7	3	**40**
GRAND TOTAL	542	4159	709	807	1869	28727	13907	**50720**	661	4888	451	946	1305	20976	6753	**35980**
TOTAL N° OF SPECIES	20	36	20	25	25	29	27	**46**	18	36	22	24	23	29	32	**47**

NOTES

1. In this Appendix, a blank in a sector cell indicates that the sector was surveyed for waterbirds in that month, but no birds of that species were found.
2. Swan numbers in sectors 1-6 in December 1996 are from counts made over several days (swans and pelicans, but not other species, were normally surveyed on a single day of each survey month – see section 5.2 for details).

APPENDIX 4. Species and numbers of DUCKS (including unidentified ducks) counted in all survey sectors of Peel-Harvey Estuary during 1996-97.

		PEEL								HARVEY				Grand
Species	**Month**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**8**	**9**	**10**	**Total**	**Total**
Musk Duck	Oct	0	0				1		**1**			0	**0**	**1**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	1	0	**1**	1	0	2	**3**	**4**
Australian Shelduck	Oct	0	124				3545		**3669**			59	**59**	**3728**
	Dec	0	194	4	36	28	3733		**3995**			532	**532**	**4527**
	Feb	0	237	26	14	2	402	0	**681**	2	16	85	**103**	**784**
Australian Wood Duck	Oct	0	0				0		**0**			3	**3**	**3**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Pacific Black Duck	Oct	0	110			1	558		**669**		5	75	**80**	**749**
	Dec	3	51	0	52	0	423		**529**			131	**131**	**660**
	Feb	51	14	0	44	7	179	0	**295**	0	117	207	**324**	**619**
Australasian Shoveler	Oct	0	0				501		**501**			0	**0**	**501**
	Dec	0	0	0	0	2	10		**12**			0	**0**	**12**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Grey Teal	Oct	0	14				306		**320**		2	26	**28**	**348**
	Dec	0	270	52	44	5	9471		**9842**			648	**648**	**10490**
	Feb	0	458	60	128	2	9585	6	**10239**	0	132	2241	**2373**	**12612**
Chestnut Teal	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	1	**1**	**1**
Pink-eared Duck	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	1	0	**1**	0	0	0	**0**	**1**
Hardhead	Oct	0	0				9		**9**			0	**0**	**9**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**

APPENDIX 4. Cont.

Species	Month	PEEL 1	2	3	4	5	6	7	Total	HARVEY 8	9	10	Total	Grand Total
Unidentified ducks	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	2	0	0	0	2003		**2005**			16	**16**	**2021**
	Feb	1	0	0	0	0	0	0	**1**	0	0	0	**0**	**1**
TOTAL N° OF DUCKS	**Oct**	0	248			*1*	4920		**5169**		7	163	**170**	**5339**
	Dec	3	517	56	132	35	15640		**16383**			1327	**1327**	**17710**
	Feb	52	709	86	186	11	10168	6	**11218**	3	265	2536	**2804**	**14022**
N°. OF IDENTIFIED SPECIES	**Oct**	0	3			*1*	5		**6**		*2*	4	**4**	**7**
	Dec	1	3	2	3	3	4		**4**			3	**3**	**4**
	Feb	1	3	2	3	3	5	1	**5**	2	3	5	**5**	**6**

NOTES

1. In this Appendix, a blank in a sector cell indicates that the sector was not surveyed for birds of that species in that month.
2. In this Appendix, a zero in a sector cell indicates that the sector was surveyed in that month, but no birds of that species were found.
3. Some numbers in this Appendix appear in italics and small font. This indicates that, while some birds were counted; the relevant sector was not surveyed for all birds of that species (or, if a subtotal or total, for all individuals of all duck species) in that month.

APPENDIX 5. Species and numbers of CORMORANTS (including unidentified cormorants) counted in all survey sectors of Peel-Harvey during 1996-97.

		PEEL								HARVEY				Grand Total
Species	**Month**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**8**	**9**	**10**	**Total**	
Little Pied Cormorant	Oct	34	20				338		**392**		*2*	24	**26**	**418**
	Dec	27	130	0	163	10	168		**498**			22	**22**	**520**
	Feb	39	266	1	263	106	537	232	**1444**	57	155	9	**221**	**1665**
Pied Cormorant	Oct	94	362				183		**639**			0	**0**	**639**
	Dec	58	675	0	3	0	89		**825**			8	**8**	**833**
	Feb	32	1008	0	2	0	47	0	**1089**	0	3	4	**7**	**1096**
Little Black Cormorant	Oct	10	11				149		**170**			321	**321**	**491**
	Dec	20	31	0	2	1281	13		**1347**			21	**21**	**1368**
	Feb	14	70	0	2	0	905	8	**999**	0	6	47	**53**	**1052**
Great Cormorant	Oct	0	9			*1*	10		**20**			4	**4**	**24**
	Dec	0	0	7	0	6	20		**33**			6	**6**	**39**
	Feb	1	5	1	0	13	9	0	**29**	1	0	2	**3**	**32**
Unidentified cormorants	Oct	0	22				15		**37**			0	**0**	**37**
	Dec	1	0	0	0	0	1		**2**			50	**50**	**52**
	Feb	1	0	0	0	0	3	0	**4**	0	0	0	**0**	**4**
TOTAL N° OF CORMORANTS	**Oct**	138	424			*1*	695		**1258**		*2*	349	**351**	**1609**
	Dec	106	836	7	168	1297	291		**2705**			107	**107**	**2812**
	Feb	87	1349	2	267	119	1501	240	**3565**	58	164	62	**284**	**3849**
N° OF IDENTIFIED SPECIES	**Oct**	3	4			*1*	4		**4**		*1*	3	**3**	**4**
	Dec	3	3	1	3	3	4		**4**			4	**4**	**4**
	Feb	4	4	2	3	2	4	2	**4**	2	3	4	**4**	**4**

NOTES

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2. In this Appendix, a zero in a sector cell indicates that the sector was surveyed in that month, but no birds of that species were found.
3. Some numbers in this Appendix appear in italics and small font. This indicates that, while some birds were counted, the relevant sector was not surveyed for all birds of that species (or, if a subtotal or total, for all individuals of all cormorant species) in that month.

APPENDIX 6. Species and numbers of KNOTS (including unidentified knots) counted in all survey sectors of Peel-Harvey Estuary during 1996-97.

		PEEL								HARVEY				Grand Total
Species	**Month**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**8**	**9**	**10**	**Total**	
Great Knot	Oct	0	22				2		**24**			0	**0**	**24**
	Dec	1	25	0	0	0	0		**26**			0	**0**	**26**
	Feb	0	0	4	0	15	0	0	**19**	0	0	0	**0**	**19**
Red Knot	Oct	0	18				0		**18**			0	**0**	**18**
	Dec	0	30	0	0	0	0		**30**			0	**0**	**30**
	Feb	0	28	2	0	9	0	0	**39**	0	0	0	**0**	**39**
Unidentified knots	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	57	53	0	0	0		**110**			0	**0**	**110**
	Feb	0	0	5	0	0	0	0	**5**	0	0	0	**0**	**5**
TOTAL N° OF KNOTS	**Oct**	0	40				2		**42**			0	**0**	**42**
	Dec	1	112	53	0	0	0		**166**			0	**0**	**166**
	Feb	0	28	11	0	24	0	0	**63**	0	0	0	**0**	**63**
N° OF IDENTIFIED SPECIES	**Oct**	0	2				1		**2**			0	**0**	**2**
	Dec	1	2	0	0	0	0		**2**			0	**0**	**2**
	Feb	0	1	2	0	2	0	0	**2**	0	0	0	**0**	**2**

NOTES

1. In this Appendix, a blank in a sector cell indicates that the sector was not surveyed for birds of that species in that month.
2. In this Appendix, a zero in a sector cell indicates that the sector was surveyed in that month, but no birds of that species were found.

APPENDIX 7. Species and numbers of STINT & SANDPIPER SIZED WADERS (including unidentified species) counted in all survey sectors of Peel-Harvey Estuary during 1996-97.

		PEEL								HARVEY				Grand Total
Species	**Month**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**8**	**9**	**10**	**Total**	
Red-necked Stint	Oct	0	87				803		**890**			0	**0**	**890**
	Dec	0	435	40	20	110	6058		**6663**			8009	**8009**	**14672**
	Feb	0	657	11	0	884	46	0	**1598**	0	0	3242	**3242**	**4840**
Sharp-tailed Sandpiper	Oct	0	293				126		**419**			0	**0**	**419**
	Dec	0	375	0	118	0	126		**619**			666	**666**	**1285**
	Feb	0	436	0	33	6	16	0	**491**	3	0	13	**16**	**507**
Curlew Sandpiper	Oct	0	19				64		**83**			0	**0**	**83**
	Dec	0	3	0	0	0	0		**3**			310	**310**	**313**
	Feb	0	0	0	0	0	0	0	**0**	0	0	78	**78**	**78**
Red-capped Plover	Oct	4	10				459		**473**			0	**0**	**473**
	Dec	0	127	15	5	37	566		**750**			126	**126**	**876**
	Feb	0	74	57	0	68	0	0	**199**	0	0	230	**230**	**429**
Lesser Sand Plover	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	1	0	0	0	0	0	**1**	0	0	0	**0**	**1**
Greater Sand Plover	Oct	0	6				5		**11**			0	**0**	**11**
	Dec	0	1	1	0	0	0		**2**			0	**0**	**2**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Unidentified waders	Oct	0	24				32		**56**			0	**0**	**56**
(stint/sandpiper size)	Dec	0	53	0	0	4	301		**358**			153	**153**	**511**
	Feb	0	27	0	0	0	0	0	**27**	0	0	0	**0**	**27**
TOTAL N° OF STINT/SANDPIPER	**Oct**	4	439				1489		**1932**			0	**0**	**1932**
SIZED WADERS	**Dec**	0	994	56	143	151	7051		**8395**			9264	**9264**	**17659**
	Feb	0	1195	68	33	958	62	0	**2316**	3	0	3563	**3566**	**5882**

NOTES

1. In this Appendix, a blank in a sector cell indicates that the sector was not surveyed for birds of that species in that month.
2. In this Appendix, a zero in a sector cell indicates that the sector was surveyed in that month, but no birds of that species were found.

APPENDIX 8. Species and numbers of TERNS (including unidentified terns) counted in all survey sectors of Peel-Harvey Estuary during 1996-97.

		PEEL								HARVEY				Grand Total
Species	**Month**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**8**	**9**	**10**	**Total**	
Caspian Tern	Oct	0	16				6		**22**			4	**4**	**26**
	Dec	1	34	19	11	3	5		**73**			11	**11**	**84**
	Feb	9	60	7	35	3	22	0	**136**	6	0	38	**44**	**180**
Crested Tern	Oct	5	12				3		**20**			0	**0**	**20**
	Dec	9	8	0	9	0	24		**50**			2	**2**	**52**
	Feb	5	30	3	25	0	31	1	**95**	1	5	11	**17**	**112**
Fairy Tern	Oct	0	9				110		**119**			0	**0**	**119**
	Dec	2	33	8	2	0	0		**45**			0	**0**	**45**
	Feb	51	119	28	6	10	33	0	**247**	0	0	15	**15**	**262**
Whiskered Tern	Oct	0	0				736		**736**			0	**0**	**736**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	0	0	0	0	0	0	**0**	0	0	0	**0**	**0**
Unidentified terns	Oct	0	0				0		**0**			0	**0**	**0**
	Dec	0	0	0	0	0	0		**0**			0	**0**	**0**
	Feb	0	1	0	0	0	4	0	**5**	0	10	3	**13**	**18**
TOTAL N° OF TERNS	**Oct**	5	37				855		**897**			4	**4**	**901**
	Dec	12	75	27	22	3	29		**168**			13	**13**	**181**
	Feb	65	210	38	66	13	90	1	**483**	7	15	67	**89**	**572**
N° OF IDENTIFIED SPECIES	**Oct**	1	3				4		**4**			1	1	**4**
	Dec	3	3	2	3	1	2		**3**			2	2	**3**
	Feb	3	3	3	3	2	3	1	**3**	2	1	3	3	**3**

NOTES

1. In this Appendix, a blank in a sector cell indicates that the sector was not surveyed for birds of that species in that month.
2. In this Appendix, a zero in a sector cell indicates that the sector was surveyed in that month, but no birds of that species were found.

APPENDIX 9. Results of General Air Survey of October 1996.

On Monday 14 October 1996 a "general air survey" was conducted by JL from 1015 to 1118 hrs in order to replicate the general air survey conducted on Wednesday 13 October 1976 from 1020-1150 hrs. Results are presented below.

Sector 1: Cormorant (1), Australian Pelican (1, 2, 1, 1, 1), Silver Gull (4, more, 15, 2, 10).

Sector 2: Black Swan (2), Australian Shelduck (10, 5, 2), ducks (c50), Pied Cormorant (50), cormorant (100 black & white cormorants mainly Pied, 4, 50), Australian Pelican (1, 1, 2, 1, 4, 2, 4. On Boundary Island there were "15 young at water's edge, 10 young further back, 5 flying down from nest area"), egret (1), Yellow-billed Spoonbill (1), Silver Gull (200, 10, 3, 5, 50, 100, 50, 250, 150, 200, 50, 1).

Sector 3: Australian Pelican (50, 5, 3, 3), egret (1?, 1), Silver Gull (1, 200, 15).

Sector 4: Black Swan (5, 3), ducks (10, 20), cormorant (some, 4, 1, 300, 3), Australian Pelican (25, 20, 30), Australian White Ibis (2), Red-necked Stint-sized waders (50), migratory waders (300), Silver Gull (20, 20, 40, 100, 50, 50, 50, 100, 1, 1, 2, 1, 1, 10).

Sector 5: Australian Shelduck (30), cormorant (5, 15), Silver Gull (80).

Sector 6: Black Swan (100, 10, 2, 20, 20, 200, hundreds, 100, 500, hundreds, small numbers, 3, 2, 20, 30, 100, 300, 100, 50), Australian Shelduck (1), Pacific Black Duck (unspecified), ducks (unspecified, c500 including Australian Shelduck, a few hundred, some, more, 20, some), grebe (20 flying), cormorant (25, 4, 20 black & white, 100, 1), Australian Pelican (2, 1, 4, 1, 3, 1), egret (2, 20, 2, 2?), Australian White Ibis (2), small waders (20), waders (several hundred), Banded Stilt (c200), Silver Gull (3, 2, 6, 10, 30, 50), terns (50 small, 2, 80 very small), Grant Pearson with boat and telescope (1).

Sector 7: Grey Teal (5), cormorant (40, 3), Australian Pelican (4, 4, 3), Silver Gull (2, 15?).

Sector 8: Darter (1), cormorant (15, 3), Australian Pelican (2, 1, 1, 3), egret (1), Osprey (1 flying), waders (80), Silver Gull (10, 4, 6, 1, 1, 10, 20, scattered).

Sector 9: Ducks (5), Little Pied Cormorant (10), cormorant (5, 5, 3, 400? Feeding), Australian Pelican (1, 2, 1, 1, 1, 4, 1, 7, 12, 1), egret (1, 1, 1, 1), Australian White Ibis (6), Whistling Kite (1), Common Greenshank (10, 6, 30), small waders (30), Pied Oystercatcher (3), Silver Gull (10, unspecified, 60, 10, 5, 4), terns (1).

Sector 10: Black Swan (2, 2), Australian Shelduck (20, 10), ducks (2, 2), "flightless ducks steaming" (10; ground survey on 18/10/96 revealed that these were class II Australian Shelduck ducklings), Darter (1), cormorant (1, 2, 10), Australian Pelican (22, 4), egret (1, 1, 1, 1, 1, 1), Yellow-billed Spoonbill (1), egret or spoonbill (3), Whistling Kite (1, 1), Silver Gull (1, 10, 20, 20, 10, 5, 10, 10, 1, 20, 25, 10, 1), Caspian Tern (1), terns (4).

The above figures undoubtedly under-represent the number of species and birds present and should therefore be considered minimum figures only. Results of the ground surveys conducted during following days are considered far superior.

When conducted in 1976-77, the general air surveys were to gain a broad overview of bird numbers and distributions immediately prior to conducting ground surveys of areas where birds were usually most numerous. The October 1996 survey was considered unsatisfactory in comparison with the 1976-77 surveys. Two comments recorded at the time were "flew too high to see all ducks, grebe, coot" and ""not picking the terns well". The aircraft had to be flown at a higher altitude due to an increase, since 1976-77, in the number of houses fringing the estuary. For this reason, and because the areas to be surveyed on the ground had already been decided (they were to match the areas surveyed in 1976-77), general air surveys were not conducted in subsequent survey months of 1996-97.

Note that the single Osprey seen in sector 8 during the 14 October 1996 general air survey was the only bird of this species recorded during the entire (air and ground) October 1996 Peel-Harvey survey.

APPENDIX 10. Breeding waterbirds of Peel-Harvey Estuary in 1996-97.

The following evidence of waterbird breeding activity was recorded during the 1996-97 Peel-Harvey Estuary waterbird surveys. All observations were made by J. Lane.

Black Swan ***Cygnus atratus***

One empty nest mound (no shell fragments) in samphire marsh north of Creery Island (sector 2a) on 15 Oct 96. Seventy-one mostly large-downy cygnets in 17 broods in Austin Bay (sector 6) on 16 Oct 96.

Four cygnets in sector 4 on 11 Dec 96. Seventy cygnets in sector 6 on 12 Dec 96 (these were one "flightless cygnet" near Yunderup Canals; 65 "feathered cygnets" near Coolup Drain; four "large cygnets" in Robert Bay). Approximately eight "large feathered cygnets" near western shore of sector 10 on 14 Dec 96.

Australian Shelduck ***Tadorna tadornoides***

Three flightless class III ducklings in main channel (sector 2) north of Boundary Island on 15 Oct 96. Twelve large class III and thirteen class III ducklings on the eastern side of Peel Inlet (sector 6) on 17 Oct 96. Eleven class III ducklings near Egg Island (also known as Brunswick Island; in sector 10) on 18 Oct 96. Approximately 23 large class II ducklings near western shore of sector 10 on 18 Oct 96.

Pacific Black Duck ***Anas superciliosa***

Distraction display by one bird near rushes on western shore of Boundary Island (sector 2b) on 15 Oct 96. Two class I ducklings in Yunderup Canals entrance channel (sector 6) on 17 Oct 96. Seven class II ducklings in main Yunderup Canal (sector 6) on 17 Oct 96. Five large class III, ten class III, three large class II ducklings on lower Harvey River (sector 10) on 18 Oct 96.

Grey Teal ***Anas gracilis***

Two class I ducklings on lower Harvey River (sector 10) on 18 Oct 96.

Unidentified duck species

Approximately five class III ducklings on lower Harvey River (sector 10) on 18 Oct 96.

Australian Pelican ***Pelecanus conspicillatus***

A small number of chicks, including six with down only and six with "feathers starting", seen in a nest area on Boundary Island (sector 2b) on 15 Oct 96. There were also eleven flightless feathered chicks on the eastern shore of the island.

Nesting ("150-200 birds in nest area. Most of 100 are sitting on eggs") on Boundary Island on 11 Dec 96.

120 large chicks on Boundary Island on 19 Feb 97.

Additional observations will be presented in a later report on pelican nesting on Peel-Harvey.

Black-winged Stilt ***Himantopus himantopus***

One nest with eggs photographed on the samphire marsh of Soldiers Cove (sector 2a) on 15 Oct 96.

Pied Oystercatcher ***Haematopus longirostris***

The behaviour of one pair at north end of Channel Island (sector 2a) on 15 Oct 96 and one pair at southern end of Boundary Island (sector 2b) on 15 Oct 96 suggested nests or young nearby. One adult with one "large well-feathered chick" on Boodalan Island (sector 6) on 17 Oct 96.

Two adults with "one young fledged oystercatcher" at north end of Channel Island (Sector 2) on 11 Dec 96.

Silver Gull ***Larus novaehollandiae***

One nest with two warm eggs on Boodalan Island (sector 6) on 17 Oct 96.

Fairy Tern Sterna ***nereis***

Fenced off area and sign indicating breeding on eastern side of natural entrance channel (sector 1) on 18 Feb 97. Area not inspected.

APPENDIX 11. 1996-97 Peel-Harvey Estuary waterbird survey program.

TYPE/AREA OF SURVEY [3]	OCT 1996	DEC 1996	FEB 1997
General aerial	M 14, JL	-	-
Pelicans aerial	M 14, JL	M 9, JL	M 17, JL
Swans aerial (Harvey only)	M 14, JL	M 9, JL	M 17, JL
Swans by boat (Peel only)	M 14, GP	M 9 (data missing)	M 17 AC
Sector 1	Tu 15, JL	Su 15, JL	Tu 18, JL
Sector 2a	Tu 15, JL	Tu 10, JL	Tu 18, JL
Sector 3	-	Tu 10, JL	Tu 18, JL
Sector 2b	Tu 15, JL	W 11, JL	W 19, JL
Sector 4	-	W 11, JL	W 19, JL
Sector 9	-	-	W 19, AC
Inner Sector 6 (on foot)	W 16, JL	Th 12, JL	Th 20, JL
Sector 7	-	-	Th 20, AC
Sector 8	-	-	Th 20, AC
Outer Sector 6 (by boat)	Th 17, JL	F 13, JL	F 21, JL
Sector 5	-	F 13, JL	Su 23, JL
Sector 10	F 18, JL	Sa 14, JL	Sa 22, JL

NOTES

1. Cells in the above table contain the day and date on which each sector was surveyed and initials of the personnel who conducted each survey. AC=A.G. Clarke, GP=G.B. Pearson, JL=J.A.K. Lane.
2. Rows have been arranged in chronological order to show the standard sequence of survey.
3. See section 5.2 of this report for descriptions of the Types and Areas of survey.

APPENDIX 12. Maximum counts, 1% levels and relevant population distributions of the 29 species of waterbirds recorded on Peel-Harvey in 1996-97 for which 1% levels (Watkins & AWSG 1993, Rose & Scott 1997) have been published.

Species	Maximum Peel-Harvey count in 1996-97	One Percent Level of relevant population	Distribution of relevant population (Rose & Scott 1997)
Black Swan	1052	4000	Australia
Hoary-headed Grebe	220	5000	New Zealand/Australia
Great Crested Grebe	3	65	Australia
Black-tailed Godwit	28	1600	E&SE Asia/New Guinea/Aust
Bar-tailed Godwit	307	3300	Alaska/E&SE Asia/Aust/NZ
Whimbrel	11	400	SE Asia/New Guinea/Aust/NZ
Eastern Curlew	19	210	E&SE Asia/Australia/NZ
Common Greenshank	314	400	E&SE Asia & Australia
Terek Sandpiper	4	360	Not presented
Common Sandpiper	17	300	Not presented
Grey-tailed Tattler	8	480	Not presented
Ruddy Turnstone	2	280	Not presented
Great Knot	26	3200	E&SE Asia/Aust/New Guinea
Red Knot	39	2000	New Guinea/Australia/NZ
Red-necked Stint	**14672**	**4700**	E Siberia/SE&E Asia/Aust/NZ
Sharp-tailed Sandpiper	1285	1700	N America/E Sib/NG/Aust/NZ
Curlew Sandpiper	313	2500	E/SE Asia & Australia
Pied Oystercatcher	27	110	Australia/S New G/Tas/Aru Is
Black-winged stilt	2293	5320	Not presented
Banded Stilt	**6954**	**2100**	Southern Australia/Tasmania
Red-necked Avocet	**2443**	**1100**	Australia
Pacific Golden Plover	54	900	Not presented
Grey Plover	116	160	Not presented
Red-capped Plover	876	950	Australia
Lesser Sand Plover	1	270	Not presented
Greater Sand Plover	11	990	Not presented
Hooded Plover	1	50	Not presented
Caspian Tern	**180**	**30**	Australia/New Zealand
Fairy Tern	**262**	**60**	Western Australia

NOTES

1. The five species with maximum 1996-97 Peel-Harvey counts exceeding their respective 1% population levels are shown in **bold.**
2. "Relevant populations" are the populations to which the birds of Peel-Harvey Estuary belong. Some species of waterbirds, e.g. many species of migratory shorebirds, have two or more distinct populations with limited intermingling.