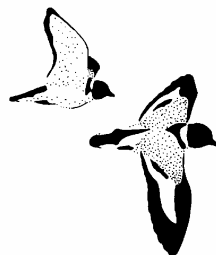


WATERBIRD MONITORING IN THE CONSERVATION ZONE OF
THE CREERY WETLANDS

December 1998 to April 2003

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EXECUTIVE SUMMARY

The Creery Wetlands are within the Peel-Yalgorup Ramsar Site, and are adjacent to the Mariners' Cove development. The region was nominated for listing under the Ramsar Convention because of its importance for waterbirds, being regularly used by in excess of 20,000 waterbirds in most years, and the Creery Wetlands are recognised as one of the most important sites for waterbirds within the system.

Because of the importance of the Creery Wetlands for waterbirds, one of the environmental conditions placed upon the Mariners' Cove development north of the Creery Wetlands was to monitor waterbirds to determine if the development has any adverse impacts on the birds. The monitoring project consists of conducting surveys before any development takes place, during major periods of earthwork and during the establishment of housing in the area. Monitoring began in December 1998 and this is the fourth report on the project, covering the period April 2002 to April 2003, but incorporating and comparing information collected for the earlier reports.

The approach to monitoring was to divide the Creery Wetlands into a series of zones, ranging from areas close to the development to areas well away from any potential disturbance. Although the zones vary in the sorts of habitats present and therefore are not true replicates, this layout of sampling should make it possible to detect different changes in abundance in zones close to and distant from the development. For the purposes of analysis, waterbirds were grouped into foraging guilds such as ducks and swans, herons and allies, cormorants, raptors (birds of prey), gulls and terns, plovers and sandpipers, stilts and the White-fronted Chat and Little Grassbird.

Thirteen surveys were carried out in the April 2002 to April 2003 survey period and 53 have been carried out since the study commenced in December 1998. Water levels varied greatly across the year and between years, with levels tending to be higher in winter than at other times of the year, with slightly more low tide surveys in 2001/2002 and 2002/2003 than earlier years. Although this difference was slight, mean weakly tide levels were consistently lower in spring/summer on 2001/2002 and 2002/2003 than earlier in the study.

Sixty waterbird species have been recorded since the study began, with 46 to 48 observed annually. The number of species has therefore been very consistent, but the annual minimum number of waterbirds to use the area has ranged from 5,079 (2001/2002) to 13,551 (2002/2003). The high numbers present in 2002/2003 was due to an influx of species such as the Black Swan, some ducks and the Banded Stilt from ephemeral inland wetlands, and to high counts of some migratory plovers and sandpipers. Herons and allies also increased in abundance, probably due to birds moving to coastal sites, but gulls and terns have declined. Counts of all waterbird guilds tended to be highest in spring and summer.

The high counts in 2002/2003 may have been influenced by external factors, such as breeding success of migratory shorebirds in northern Asia and the availability of inland wetlands, but low tide levels in 2002/2003 contributed to the suitability of the study area for many species. Persistent high tide levels, especially in summer 1999/2000 and 2000/2001, limited available habitat for wading species in those years. Extensive mudflats are exposed on the adjacent estuary when the tide falls below about 0.45m (Dept of Planning and Infrastructure height datum) and wading species

of waterbirds appear to rely on these mudflats. However, when tides vary, rather than being persistently high, samphire marshes of Creery Island (Zone 1) and close to the Mariners' Cove development (Zone 1) provide alternative shallows and damp mud during high tide. Waterbirds use different parts of the area depending on the water level on a daily or weekly basis, but numbers are suppressed for long periods if low tides do not occur to make the estuarine shallows and mudflats accessible.

Four species, the Curlew Sandpiper, Banded Stilt, Pacific Golden Plover and Grey Plover, were significantly less abundant in summer surveys from 1998 to 2002 compared with RAOU summer surveys from 1982 to 1988. In 2002/2003, however, counts of these species were generally high, apparently in response to low tide levels and the influx of birds from inland wetlands. As a result, no significant differences were found between mean summer counts in 2002/2003 compared with data collected in 1982-1988. This suggests that there has been no long-term impact upon the abundance of these species on the Creery Wetlands due to Mariners' Cove or to the construction of the Dawesville Channel, as has previously been suggested. However, the variability around some mean values was considerable and this may have masked some differences, particularly with the Curlew Sandpiper and Grey Plover.

To further examine possible impacts of the Mariners' Cove development upon waterbirds, the distribution and activity of waterbirds across the zones of the study area were examined, with particular attention on Zones 1 & 2 that are adjacent to the development, and Zones 3 & 4 that are similar in some respects as habitat, but are remote from possible disturbance. Data from summer 1998/1999 (pre-development), summer 1999/2000 (during construction), and the summers of 2000/2001, 2001/2002 and 2002/2003 (post-construction), were compared. For the purposes of analysis, the proportional distribution of each waterbird guild was examined across the zones in each of these periods. This was carried out with the expectation that any deleterious impacts of the development would result in lower proportions of waterbirds in the zones closest to the development during summer 1999/2000 and subsequently.

The proportional distribution of waterbird guilds across the zones was affected by the different water levels experienced in the four summers, but one group of waterbirds in particular, the ducks and swans, appeared to be affected during summer 1999/2000, with lower numbers expected in Zones 1 and 2 when compared with nearby zones. This suggested that they were avoiding the area due to disturbance from earthworks associated with the adjacent development. In following summers, however, the proportion of ducks in the zones closest to the development recovered, suggesting that deleterious impacts were short-lived.

Waterbirds in Zone 1 rely largely upon pools created when open areas are flooded by high water levels. The development has increased the frequency with which these pools are created, as the main canal links directly with Zone 1. This increased flooding may even have improved the value of Zone 1 for waterbirds. The combination of samphire and pools is important for waterbirds, and the balance is changing with the regeneration of samphire in some locations, and the death of samphire in others due to increased inundation. In Zone 4 (Creery Island), high water levels in 1999/2000 appeared to result in the death of large areas of samphire due to inundation. As a result, new pools within samphire were created and these were used by many waterbirds.

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INTRODUCTION

This is the fourth annual report on waterbird monitoring in the Conservation Zone of the Creery Wetlands and covers the period December 1998 to April 2003 (inclusive). Previous reports have been prepared on an approximately annual basis by Bamford Consulting Ecologists (2000, 2001 and 2002). Bamford Consulting Ecologists (2000) also provided background information on the significance for waterbirds of the Creery Wetlands and of the Peel-Yalgorup Ramsar site, of which the Creery Wetlands are now a part. The Peel-Yalgorup Ramsar Site supports over 20,000 waterbirds in most years, with the maximum count on the Peel-Harvey Estuary within the site being just over 110,000 in February 1977 (Jaensch and Lane 1993). The Creery Wetlands have been found to consistently support over 20% of all waterbirds within the Peel-Harvey Estuary (based upon unpublished data collected by the Department of Conservation and Land Management but reviewed by Kirke (1986); surveys carried out by Birds Australia (Jaensch *et al.* 1988 and unpub.); and surveys carried out by Ninox Wildlife Consulting (1990)).

Waterbird monitoring in the Conservation Zone of the Creery Wetlands is required under a Ministerial condition; this condition forms part of the approval of the development of the Mariners' Cove residential canal estate by Cedar Woods Properties Ltd. This condition has been applied because the juxtaposition of the development and the Wetlands has raised concerns about possible impacts upon the wetland environment and particularly the waterbirds that use the area.

The monitoring study was designed and is being conducted under the direction of the Mariners' Cove Waterbird and Research Monitoring Committee, comprising representatives from the Department of Conservation and Land Management, Birds Australia, Environment Australia and Cedar Woods Properties Ltd. The aim of the study, funded by Cedar Woods Properties Ltd, is to gather information on the impact of the development upon waterbirds of the Creery Wetlands. The study is therefore designed to monitor waterbird numbers regularly before, during and after development of the project. It is recognised that the study will also provide information on waterbird numbers that will be of more general use, such as allowing for comments to be made upon the impact of other changes that have occurred in the region, including the Dawesville Channel and general levels of human activity.

METHODS

As this is an ongoing monitoring project, the methodology established in the first year of sampling has largely been continued. Accordingly, the details of methods presented by Bamford Consulting Ecologists (2000) have been reproduced below, with some slight refinements that have been incorporated during the course of the study.

Waterbirds are very mobile animals and their levels of abundance at one site can be affected by a vast array of factors. Tidal variation and levels of human activity can affect waterbird abundance on an hourly or daily basis, while in the case of Palaearctic waders, the breeding success at sites on the Arctic tundra and the loss of sites in Asia used during migration are important. Therefore, surveys aimed at identifying the local impact of a development need to distinguish between this background variability in waterbird abundance and changes that might be due to the development. Achieving this goal requires regular, detailed surveys over as long a period as possible at sites where the development may have an effect, and at control sites where the abundance of waterbirds is not likely to be affected by the development. This was the approach taken to monitor the impacts of the Mariners' Cove development at the Creery Wetlands.

For the purpose of the surveys, the Creery Wetlands and adjacent estuary were divided into 9 zones based upon main landscape features and proximity to the Mariners' Cove development (see Figure 1). Zones 1 and 2 were areas of intermittently inundated samphire and other fringing vegetation close to the development; Zone 3 was the main Creery Lagoon, a large area of shallow, sheltered water; Zones 4 and 5 were Creery and Boundary Islands respectively, Creery Island in particular supporting large areas of mudflat and samphire, Zone 6 was the channel between the two islands; and Zones 7, 8 and 9 were the adjacent Peel Inlet. Zones 8 and 9 had large areas of tidal mudflat, whereas Zone 7 had little tidal mudflat but included one sand-bar.

With this layout of Zones, the local distribution of waterbirds across the Creery Wetlands can be examined with respect to abundance, patterns of usage and change over time. In particular, Zones 1 and 2 are close to the development and therefore most likely to be impacted, while Zones 7, 8 and 9 are a long way from the development and effectively act as controls. Ideally, control sites should have the same environmental features as sites where impacts may occur, but it is still possible to look at relative change within sites to see if the same trends occur in a range of sites. Zone 4 (Creery Island) has a large area of intermittently inundated samphire that is similar to the areas of samphire in Zones 1 and 2. Note that Zones 8 and 9 in particular are subject to high levels of disturbance from crabbers and anglers, especially in the summer months. Other zones are rarely visited by people.

Since development began, fencing and a canal have isolated all zones within the Creery Wetlands from the high levels of disturbance that previously occurred there, although an "airboat" was seen within Zone 3 (Creery Lagoon) on two occasions in the December 1998 to February 2000 period, and may well have been present subsequently. Earthworks associated with the development were closest to Zones 1 and 2 and occurred from October 1999. Earthworks and other activities have varied in intensity since that time, with canal construction completed by April 2000 and a gradual increase in boat traffic. During much of 2002 and into 2003, there were major earthworks within the development north of the main canal and therefore within 100m of Zone 1 (see Table 1).

Surveys were carried out approximately monthly and 13 surveys were conducted over the period from April 2002 to March 2003, with a total of 53 surveys carried out since

December 1998. Table 1 summarises the programme of field work. Surveys were carried out by Dr M. Bamford, Mrs M. Francesconi and Mr K. Fairbairn of Bamford Consulting Ecologists. Data entry and management were undertaken by Ms G. Tischler of Nimble Database Services and Mr Wes Bancroft of Bamford Consulting.

The majority of surveys were carried out in the morning to early afternoon and approximately the same route was followed on each occasion. This route is indicated on Figure 1. On each survey, all waterbirds were counted within each zone and, as far as possible, birds were not recorded a second time if they moved into another zone after being counted. Only waterbirds were counted, but this included White-fronted Chats and Little Grassbirds that are not always considered to be waterbirds although they are typically associated with wetland environments. Note was made of other birds and wildlife of interest, the water level and also of any disturbance events (see Table 1). Surveys generally avoided weekends and holidays because of high levels of public activity, potentially leading to disturbance of waterbirds, at such times.

Notes were also made on the water level during surveys. Persistent high tides, particularly in the summer of 1999/2000, appeared to be associated with low waterbird counts, and therefore tidal information for the mouth of the Peel Inlet was obtained from the Department of Planning and Infrastructure. The height datum used for these tide levels is 0.55 m below the Australian Height Datum. The tide information consisted of the level of the tide at the approximate time of each survey (Table 1) and mean weekly tides throughout the period of the study (Figure 2). During surveys, mudflats in Zones 7 and 9 were inundated when the tide exceeded about 0.45m and pools were present within Zones 1, 2 and 4, whereas these areas consisted of bare and often dry mud when the level was lower. During several of the surveys, mudflats were exposed or had been recently exposed, but pools persisted in Zones 1, 2 and 4 because of recent high water levels. Note that tide levels recorded by the Department of Planning and Infrastructure in the Peel Channel (near Mandurah City Centre) do not always correspond to tides observed during surveys, as there is a difference in tides because of distance and wind effects. For this reason, observations of actual water level conditions, the documented tide level and the mean weekly tide are all useful in understanding the water level conditions to which the birds are exposed. In some respects, the mean value (Figure 2) gives a good measure of the general conditions affecting the birds.

Since surveys began in 1998, tidal conditions have been highly variable but were marked by a period of persistent high tides through 1999/2000 (Figure 2). Tidal conditions in 2001/2002 and 2002/2003 were distinguished by some exceptionally low levels, particularly in spring and summer 2002/2003. Low tides in spring and summer are important for waders (shorebirds) and mean levels were low to moderate from late winter 2001, with 17 mean weekly tides below 0.45m within the period in 2001/2002, and 18 mean weekly tides below 0.45m in 2002/2003. In contrast, there were only two such low mean values in 2000/2001 and none in 1999/2000. The number of surveys actually carried out when the tide was below 0.45m were similar each year (see Table 1), but the mean values indicate that persistent low levels occurred mainly in 2001/2002 and 2002/2003 (years 3 and 4 of the study).

For each record of a waterbird, the activity and habitat of the bird were scored. Activity categories recognised were: active (foraging, including birds that forage from the air, such as terns); inactive (roosting on a beach, perched on a branch or apparently sleeping on the water) and flying overhead (used for birds that do not forage when flying, so only used when birds obviously just flying through a zone to get somewhere else). Habitat categories were: open water; near-shore shallows; on the shoreline; on pools within samphire; amongst samphire; perched; and aerial (flying).

Because of the large number of waterbird species encountered, but often small numbers of most of those species, some analyses involved grouping taxonomically and ecologically related species. These groups or guilds were:

- Waterfowl (swans and ducks); mostly herbivores or omnivores feeding in sheltered, shallow water.
- Cormorants, Darter and Pelican; fish-eating species that feed in the estuary.
- Herons, egret and ibis; large wading birds that forage on fish and invertebrates usually in shallow water.
- Raptors (Marsh Harrier, Osprey and White-bellied Sea-Eagle); fish-eating birds of prey.
- Coots and rails; omnivores and insectivores with, especially skulking in dense vegetation on wetland margins.
- Oystercatcher, sandpipers and plovers; waders or shorebirds that feed on shorelines and in sheltered, shallow waters, especially in tidal areas.
- Banded and Black-winged Stilts; waders or shorebirds that typically feed in sheltered shallow waters that are not subject to strong tides.
- Terns and Gulls; fish-eating and scavenging seabirds of shoreline and shallows.
- White-fronted Chat and Little Grassbird; small bushbirds of samphire marsh.

In addition to the survey work conducted as part of this project, the results of earlier waterbird surveys of the Creery Wetlands were accessed for comparative purposes. The main sources of information were from a database maintained by Ninox Wildlife Consulting, and the waterbird database that resulted from surveys undertaken by the Royal Australasian Ornithologists Union (RAOU) from 1982 to 1988 and now maintained by Birds Australia Western Australia Inc. and Australian Ecological Services.

RESULTS AND DISCUSSION

Waterbird abundance and seasonal patterns

Sixty species of waterbirds have been recorded in the Creery Wetlands since the study began, with 46 to 48 species recorded annually. The minimum number of waterbirds that used the Creery Wetlands over the period April 2002 to March 2003 is the sum of the maximum count of each species as presented in Table 2. This sum was 13,551

waterbirds, which is nearly twice the previous highest count made in 1998-2000. Furthermore, the early high count of 8,672 was strongly influenced by a single high count of the Red-necked Stint (3500 on 22/11/'99).

The very high count made in 2002/2003 was due mainly to exceptional counts of ducks and swans (3,778 compared with the previous high count of 1,623) and of stilts and avocets (3,458 compared with the previous high count of 1,770). Numbers of sandpipers and plovers were also very high (5,185), particularly compared with 2000/2001 (2,568) and 2001/2002 (621). Individual species that were particularly abundant in 2002/2003 compared with previous years were the Black Swan, Grey Teal, Hoary-headed Grebe, Curlew Sandpiper, Red Knot, Sharp-tailed Sandpiper, Banded Stilt and Red-necked Avocet. Many of these species are known to utilise inland wetlands when these are available but to use coastal wetlands at other times, and their abundance in 2002/2003 is consistent with the drying of inland wetlands during 2001/2002. The drying of inland wetlands and increases in the abundance of Black Swans, Grey Teal, Hoary-headed Grebes in the South-West have been anecdotally reported by birdwatchers. Counts of the Black Swan and Hoary-headed Grebe greatly exceeded the maximum counts of these species recorded in the period 1982-1988 (Appendix 2), suggesting that such numbers are an unusual event.

Maximum counts of some species are clearly seasonal and link with regular migration, particularly among the sandpiper and plovers that breed in the northern hemisphere during our winter and are therefore most abundant from late spring to mid autumn. In contrast, Australian species that were moving to coastal wetlands peaked in abundance at differing times of the year, probably determined by when particular inland wetlands dried out. For example, in 2002/2003 the Red-necked Avocet was most abundant in July, the Banded Stilt in December, the Black Swan in May, the Grey Teal in October and the Hoary-headed Grebe in August (Table 2).

Figure 3 presents patterns of seasonal variation in the abundance of each waterbird group across the study area, with numbers divided into zones. Therefore, this gives a visual presentation of both seasonal and annual patterns overall, and of different patterns between the inner zones of the Creery Wetlands, and the outer zones of the adjacent estuary. Main features of these graphs are as follows:

- The abundance of ducks and swans was strongly seasonal in the inner zones of the Creery Wetlands, with consistent peaks in abundance generally in spring/summer, but with autumn peaks in 2001 and 2002. These autumn peaks may be related to very low water levels in wetlands in the South-West and to the movement of Black Swans in particular from inland sites. Seasonal patterns in abundance were less apparent on the adjacent estuary where peaks occurred in the autumn of some years. This was most obvious in 2002 and 2003 when there were high counts of Black Swans in Zone 8.
- The abundance of cormorants and the Australian Pelican was variable with poorly defined seasonal patterns and similar numbers on both the inner zones of the Creery Wetlands and the adjacent estuary throughout the period of study.

- Numbers tended to be lowest in winter and highest in spring/summer in most years.
- Herons, egrets and ibis were more abundant in the inner zones of the Creery Wetlands than on the adjacent estuary with seasonal patterns poorly developed. On the adjacent estuary, numbers were low up to late 2000 but were high subsequently, a pattern probably related to the movement of birds from inland sites. A similar trend did not occur in the inner zones of the Creery Wetlands where no long term trends in abundance were apparent. This may have been due to low tide levels coinciding with the influx of birds from inland sites, with the result that the inner zones were less suitable for herons and their allies at a time when these birds were at their greatest abundance in the general region.
 - The abundance of plovers and sandpipers displayed the expected seasonal pattern for these mainly migratory species that arrive in early spring and depart in mid autumn, but there were differences between the inner zones of the Creery Wetlands and the adjacent estuary. Seasonal patterns were very clear on the inner zones and the spring/summer peak was most marked in 2000/2001, when water levels were high and therefore extensive shallow water was present, particularly in Zones 1 and 4. In contrast, numbers of plovers and sandpipers were only high on the adjacent estuary in years when low water levels were experienced, particularly over summer 2002/2003. Although counts on the adjacent estuary were occasionally very high, such high counts occurred infrequently. Note that the spring/summer peak in 2001/2002 was lower than in other years even though low water levels should have made the zones on the adjacent estuary particularly suitable for plovers and sandpipers. These low numbers appeared to be a regional phenomenon, as low counts of plovers and sandpipers were reported throughout the South-West in that year (Birds Australia WA Observations Committee 2002). Such low counts may be associated with poor breeding success in northern Asia.
 - The abundance of stilts and avocets was strongly seasonal in the inner zones of the Creery Wetlands, with high counts over spring and summer, but stilts and avocets were rarely present on the adjacent estuary. The single high count in Zone 8 (in the adjacent estuary) in December 2002 was of Banded Stilts that were foraging during a very low tide on a still morning, and the birds moved to Zone 3 (Creery Lagoon) later that day. Counts were highest in 2002 and 2002/2003, especially in Zone 3 (Creery Lagoon) that provides sheltered shallows under most water level and weather conditions. The high counts late in the study period were driven by an influx of Banded Stilts that was probably associated with the drying out of inland wetlands.
 - Gulls and terns were the only waterbird guild that was more consistently abundant on the adjacent estuary than on the inner zones of the Creery Wetlands. Seasonal trends were unclear but abundance fell from early 2001 on the inner zones and from April 2002 on the adjacent estuary. These declines do not coincide well with patterns in tide levels or the drying of inland wetlands. The Silver Gull was the most abundant species in this guild and its local population may have been affected by management actions made elsewhere in the Mandurah region.

Numbers of waterbirds on the inner zones of the Creery Wetlands and the adjacent estuary displayed some consistent seasonal patterns, but also a lot of irregular and annual variation. This variation can be attributed to local factors, such as tidal patterns, but also to changes in the availability of wetlands in other areas and even to breeding success in northern Asia for migratory species. Usage of the inner zones of the Creery Wetlands was generally more consistent than usage of zones in the adjacent estuary, with tide levels greatly affecting usage of the inner zones and the adjacent estuary. This was because during high tide levels, extensive shallows are created on Creery Island (Zone 3) and in Zone 1 near Mariners' Cove. These same high levels result in deep water subject to wave action on the adjacent estuary. When tide levels are low, many of the shallows of the inner zones are dry, but the adjacent estuary then provides extensive shallows. Zone 3 (Creery Lagoon) always provides sheltered water and at least some shallows. None of the patterns observed suggests any impact from the Mariners' Cove development.

Long-term changes in waterbird abundance

Because the Creery Wetlands and other parts of the Peel/Harvey system had been regularly surveyed for waterbirds before the commencement of the current project, comparisons were previously made between data collected at the Creery Wetlands by the RAOU over the period 1982 to 1988, and data collected from December 1998 to March 2002 (Bamford Consulting Ecologists 2002). This was done to investigate evidence for long-term changes in abundance, such as declines in the abundance of some species suggested by Singor (1997) and Lane *et al.* (1997). Data collected from 1982 to 1988 are summarised in Appendix 2.

For most species, levels of abundance were broadly similar in the 1980s compared with the recent surveys, or can be explained by seasonal conditions, while a number of species have been recorded in higher numbers in the current study than previously. This may be due to more extensive coverage and to the occurrence of especially favourable conditions. In the previous report (Bamford Consulting Ecologists 2002), it was concluded that five species appeared to be less abundant in the recent surveys than during the 1980s. These species were the Curlew Sandpiper, Sharp-tailed Sandpiper, Grey Plover, Pacific Golden Plover and Banded Stilt, and these differences were found to be significant for the Curlew Sandpiper, Grey Plover, Pacific Golden Plover and Banded Stilt.

With the exception of the Grey Plover, all these species were more abundant, at least in terms of maximum counts, in 2002/2003 than in previous years. Therefore, comparisons with the 1982-1988 data were made with the 2002/2003 data only. Mean levels of abundance on the Creery Wetlands were calculated for the period 1982-1988 from the RAOU data for 17 summer surveys (November to March inclusive, see Appendix 2), and were compared with corresponding mean values from the 5 summer surveys carried out

in 2002/2003. Mean values from summer surveys of 1998-2002 are included for comparison.

Species	1982-1988 (N = 17)		1998-2002 (N = 22)		2002/2003 (N = 5)	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Curlew Sandpiper	204.9	490.16	*4.1	11.54	49.0	88.06
Sharp-tailed Sandpiper	279.6	610.62	176.5	206.78	458.8	451.89
Grey Plover	95.3	149.23	*9.4	9.25	7.2	9.25
Pacific Golden Plover	15.1	25.50	*1.1	2.95	13.6	17.84
Banded Stilt	2488.3	3148.09	*203.8	401.12	1786.4	1331.34

NB: Asterisks indicate mean values that are significantly less (5%) than those from 1982-1988.

In all cases, variation around the mean values was extreme and, as noted previously (Bamford Consulting Ecologists 2000), these large levels of variation have a considerable impact on statistical analyses. Despite this, comparisons of mean values from 2002/2003 with those of 1982-1988 using Student's T - Test were carried out with the following results:

Curlew Sandpiper; $T = 0.696 < t_{20, 0.05} = 1.725$, not significant;
 Sharp-tailed Sandpiper; $T = 1.189 < t_{20, 0.05} = 1.725$, not significant;
 Grey Plover; $T = 1.297 < t_{20, 0.05} = 1.725$, not significant;
 Pacific Golden Plover; $T = 0.122 < t_{20, 0.05} = 1.725$, not significant;
 Banded Stilt; $T = 0.479 < t_{20, 0.05} = 1.725$, not significant.

In contrast to these analyses carried out in previous years, no significant differences were found. There were no significant differences in the mean summer counts of these 5 species between 1982-1988 and 2002/2003. Previous significant differences found for the Curlew Sandpiper, Grey Plover, Pacific Golden Plover and Banded Stilt were therefore most likely due to natural variation resulting from persistent high water levels, the availability of alternative wetlands and in some cases possibly breeding success in northern Asia. It should be noted, however, that very high levels of variation around the mean values may have masked real differences in abundance, particularly with the Curlew Sandpiper and Grey Plover.

Waterbird distribution across survey zones and possible impacts of development

As is evident from Figure 3, the abundance of waterbirds was not uniform across the survey zones and some species and guilds were more abundant in some zones than others. These patterns of distribution are further examined in Table 3 for data collected in 2002/2003.

Ducks and swans were concentrated in Zone 3 (Creery Lagoon) and Zones 7 and 8 (the adjacent estuary, see Figure 1), as has been observed in previous years. The same pattern has been consistent with stilts and avocets. Herons and allies tend to be more widespread, with highest counts in Zones 3 and 8 but moderate numbers of Zones 1, 2, 4,

7 and 9. In contrast, cormorants and the Australian Pelican, and gulls and terns, are consistently most abundant in zones on the adjacent estuary. Plovers and sandpipers were most abundant in the outer zones but also utilised Zones 1, 3 and 4. The White-fronted Chat and Little Grassbird were largely confined to Zones 1 to 4 where suitable samphire vegetation was present.

Annual pooled counts of maximum numbers of each species present in each zone (Table 3) go some way to looking for trends in usage that could be related to impacts of the Mariners' Cove development. For example, pooled counts in Zone 1, closest to the development, would be expected to decline if the development adversely affected the birds. In fact, trends in the distribution of birds across the zones over the three survey periods seem to be more related to water level conditions than anything else. For example, in 2000/2001, when water levels were persistently high, waterbird numbers were high in Zones 1 and 2 but low in Zones 6, 7 and 8 of the adjacent estuary. It appeared that birds were displaced from the estuary and used inner zones when water levels were high. Conversely, waterbird numbers were high on the adjacent estuary in 2002/2003, when water levels were low.

To further examine the possibility of impacts of the Mariners' Cove development upon waterbird abundance on the nearest parts of the Creery Wetlands, the proportional distribution of waterbirds was examined. This considered the distribution of waterbird records across all zones in summer (December, January and February) 1998/1999 (pre-development), 1999/2000 (during earthworks), and 2000/2001, 2001/2002 and 2002/2003 (post disturbance). Only summer data were used as this was the only period for which pre-development records were available. Summer is also the time when human activity is most likely to lead to disturbance of waterbirds and when over 75% of waterbird observations were made. This information is presented in Table 4, with raw data in Appendix 3.

The proportional distribution of waterbirds across the zones has varied considerably between the summer periods of each year, but much of this variation can be attributed to high or low water level conditions as discussed above. For example, cormorants and pelicans, and ducks and swans, were well represented in Zones 4 & 5 when water levels were high in 1999/2000 and 2000/2001, with lower proportions of these guilds in Zones 4 & 5 in 1998/1999, 2001/2002 and 2002/2003 when water levels were low.

The proportional distribution of waterbirds in Zones 1 & 2 is of great importance, as this is the area closest to the Mariners' Cove development. Furthermore, the habitats in Zones 1 & 2 are broadly comparable to those in Zones 4 & 5, with the latter area being remote from disturbance. This comparison does not work for all waterbird guilds, however. In the case of cormorants and the Australian Pelican, Zones 1 & 2 are rarely used but Zones 4 & 5 are used extensively when water levels are high. This usage consists mainly of Pelicans roosting on mudflats of Zone 4 and cormorants roosting on trees of Zone 5.

Ducks and the Black Swan made some usage of Zones 1 & 2 and it was previously suggested (Bamford Consulting Ecologists 2000) that the low proportion present in summer 1999/2000 was due to disturbance from construction activity. In contrast, the proportion of birds on Zones 4 & 5 was high in that year. This possible impact of disturbance appeared to be limited to 1999/2000, however, as the proportion of ducks and swans on Zones 1 & 2 was high in 2000/2001 and has followed a similar trend to that seen in Zones 4 & 5 subsequently.

Hérons and allies have consistently concentrated in Zones 3 & 6 (mainly Zone 3, Creery Lagoon, see Figure 1) with greater use of Zones 7 and 9 during the low water levels of 2002/2003. The proportion of herons and allies in Zones 1 & 2 and Zones 4 & 5 have been similar within each year and have displayed similar variations, suggesting no impact from Mariners' Cove.

Plovers and sandpipers have been remarkably consistent in their proportional presence in Zones 1 & 2, especially considering the range in total records from 601 (2001/2002) to 3189 (1998/1999), and the variation in water levels. The slight fall in proportional representation in 2002/2003 was much less than that seen in Zones 4 & 5, and probably relates to the very low water levels experienced during summer 2002/2003. As noted in a previous report (Bamford Consulting Ecologists 2002), use of Zone 4 (Creery Island) in particular appears to have been related to the death of large areas of samphire associated with persistently high water levels in 1999/2000. These deaths have created open pools where Sharp-tailed Sandpipers in particular forage. Similar deaths have not been observed in Zones 1 & 2, where some regeneration of samphire has occurred, mainly in areas previously disturbed by off-road vehicles. This regeneration could eventually result in the contraction of pools within samphire, particularly in Zone 1. This may reduce foraging areas for plovers and sandpipers, but at present the shoreline of the main canal is used extensively by the birds and this may compensate for the loss of open areas due to regeneration of samphire.

Stilts make little use of either Zones 1 & 2 or Zones 4 & 5, favouring the very extensive shallows of Zone 3 (Creery Lagoon) and to some extent Zones 7 and 8 (adjacent estuary). Gulls and terns similarly make little use of Zones 1 & 2 and 4 & 5. The White-fronted Chat and Little Grassbird are concentrated in zones where samphire is present, but the results with this guild are probably anomalous because they are hard to detect and only recorded in low numbers. There were too few records of raptors (birds of prey) to analyse.

Waterbird patterns of activity

In previous reports, patterns of waterbird activity and habitat usage were analysed for all observations in each zone. These observations were made in 2002/2003 but an analysis has not been carried out, as the patterns of activity and usage appear to be well defined. Key features of these patterns are as follows:

Cormorants and the Australian Pelican roost in Zones 1 and 4 and around the margins of the adjacent estuary, but forage in the open water of the adjacent estuary and in Zone 3. Mudflats in Zone 4 are particularly important for roosting pelicans, while trees on Creery and Boundary Islands are important for roosting by cormorants.

- Ducks and swans roost and forage in Zones 1 and 4 but primarily forage in Zone 3 (Creery Lagoon) and the zones of the adjacent estuary.
- Most observations of herons and allies were of foraging birds, but it has been noted that a greater proportion of herons and allies observed in Zone 1 were foraging when compared with the proportion in Zone 4. As Zones 1 and 4 are in some ways comparable, this difference is of interest and may be due to the pools in Zone 1 being linked to the estuary and therefore containing fish. In contrast the pools in Zone 4 are isolated from the estuary.
- Most records of sandpipers and plovers, and of stilts, were of foraging birds. The main exception was in Zone 3 (Creery Lagoon) where both Banded Stilts and Red-necked Avocets roost in the sheltered shallows. In contrast, records of gulls and terns consisted mainly of foraging birds in the inner zones but of foraging and roosting birds on the adjacent estuary.

With respect to the Mariners' Cove development, the most significant aspect of these observations is the way they define waterbird usage of Zone 1, adjacent to the development. This is a foraging area for most waterbirds, where they focus on the pools and the flooded samphire on the margins of these pools, although some ducks also roost within Zone 1.

CONCLUSIONS

As noted in previous reports on this project, the Creery Wetlands remain a significant site for waterbirds despite developments in the general region, including the nearby Mariners' Cove project and alteration of tidal regimes caused by the Dawesville Channel. The study has found that the Creery Wetlands are especially important for waterbirds as the inner zones of the wetlands are used consistently by a greater range of species than the adjacent estuary, with the abundance of many species varying in these two areas depending upon the water level. The Creery Wetlands, especially Zones 1 (salt marsh close to Mariners' Cove) and 4 (Creery Island), are flooded at high water levels and are then used by many waterbirds, while the adjacent estuary provides mudflats and shallows that are used by waterbirds when water levels are low. Zone 3 (Creery Lagoon) is one of the most consistently used sectors within the system because it is sheltered and always provides some shallows for foraging by waterbirds.

The abundance of most waterbirds is comparable with data collected in the 1980s, and low numbers of some species in the first few years of this project appear to have been due to persistent high tides that made the extensive shallows of the adjacent estuarine unsuitable for foraging. In 2001/2002 and particularly in 2002/2003, low tides were experienced in spring/summer, and differences in waterbird numbers between these two years (low numbers in 2001/2002 compared with very high numbers in 2002/2003) can

be explained by regional factors. In 2001/2002, numbers of migratory waterbirds were reported to be low throughout the South-West, either because of poor breeding success in northern Asia or because birds were using alternative, inland sites. These same inland sites may have drawn local waterbird species away from coastal areas. In 2002/2003, however, there was an influx of local waterbird species, particularly ducks and swans and the Banded Stilt, suggesting that inland sites were drying out and waterbirds were therefore moving towards coastal locations.

The abundance of waterbirds in the study area appears to be largely determined by factors operating outside the area, because even local waterbird species are highly mobile. This background variation makes determining impacts from the Mariners' Cove development difficult to detect. The only impact that appears to have occurred was a decline in the abundance of ducks and swans in Zone 1, the area of samphire and pools closest to Mariners' Cove, during the construction phase of summer 1999/2000. This was a short-term effect.

The nature of Zone 1 has been altered by the development through canal construction that now allows the zone to flood regularly, whereas it previously only flooded during very high tides or after rain. Pools in Zone 1 are also now flushed by the tide, so are likely to contain different assemblages of invertebrates and fish than was the case before canal construction. Levels of human activity have also been greatly reduced as the canal and fencing installed around the reserve prevent uncontrolled access. These changes may have led to increased waterbird usage of Zone 1, although this cannot be demonstrated, as too few data are available from the period prior to any development.

Waterbird usage in Zone 1 is concentrated in pools and samphire on the edges of these pools, particularly where the samphire has become sparse or died due to increased periods of inundation. Some of the open areas that form pools when the water level is high are natural or have at least been present for many decades (pers obs), but in some parts of Zone 1 the open areas were maintained by off-road vehicles. These are now being colonised by samphire. It appears likely that the areas of open ground/pools and samphire will eventually settle to a balance determined by the water level, but it is important that open areas are retained for waterbird usage. A similar situation exists in Zone 4 (Creery Island), where some large open pools have developed over the past 5 years, apparently due to the death of samphire as a result of inundation. This may be due to the persistent high water levels of 1999/2000, possibly exacerbated by the influence of the Dawesville Channel since 1994, which has raised tidal amplitudes.

TABLE ONE. Programme of field surveys at the Creery Wetlands, December 1998 to April 2003. Tide levels (datum 0.55 mAHD) were recorded at approximately the start time of each survey in the entrance channel to the Peel Inlet (provided by the Department of Planning and Infrastructure). The water level indicates the extent of mudflats and shallows across the Creery Wetlands at the time of each survey and do not always correspond with the tide level:

Low – pools in Zones 1, 2 and 4 small or dry, mudflats exposed in zones 8 and 9, sandbar exposed in Zone 7;

Moderate – pools in Zones 1, 2 and 4 extensive but still with areas of bare mud, limited mudflats but extensive shallows in Zones 8 and 9;

High – Zones 1, 2 and 4 extensively flooded with little or no bare mud; few shallows in Zones 8 and 9.

Year 1: December 1998 to February 2000.

Date	Start time	Water level and other Notes	Tide
06-Dec-98	09:00	Low	0.47
28-Dec-98	14:00	Very Low	0.27
22-Jan-99	14:30	Low	0.53
21-Feb-99	10:15	Low. Airboat drove through Creery Lagoon. Many crabbing parties in Zones 8 and 9.	0.53
25-Mar-99	09:00	Moderate	0.80
01-May-99	08:00	High	0.99
30-May-99	09:00	High	0.88
29-Jul-99	09:00	High	NA
28-Aug-99	09:00	High	0.91
25-Sep-99	10:00	Moderate	0.68
21-Oct-99	08:00	Moderate	0.61
07-Nov-99	09:00	Low. Earthworks beside Zone 1.	0.44
22-Nov-99	09:00	Low. Earthworks beside Zone 1.	0.44
10-Dec-99	09:00	Low. Earthworks beside Zone 1.	0.45
28-Dec-99	08:30	Moderate. Earthworks beside Zone 1. Airboat in Zone 3, crabbing parties in Zones 8 and 9.	0.80
21-Jan-00	09:00	Low. Earthworks beside Zone 1.	0.47
24-Feb-00	08:30	Low to moderate. Earthworks beside Zone 1.	0.69

Year 2: March 2000 to March 2001.

Date	Start time	Water level and other Notes	Tide
23-Mar-00	10:15	Moderate. Canal construction taking place.	0.63
16-Apr-00	09:40	Moderate. Canal construction taking place.	0.64
01-June-00	09:30	Very high. Main canal completed.	1.06
27-July-00	09:30	Moderate	0.75
27-Aug-00	11:15	High	0.89
27-Sept-00	13:00	Moderate	0.72
29-Oct-00	09:30	Low	0.55

Table 1 (cont.)

Date	Start time	Water level and other Notes	Tide
30-Nov-00	09:30	Very Low	0.39
28-Dec-00	09:30	Low to moderate	0.63
25-Jan-01	09:30	Low	0.44
25-Feb-01	09:30	Low	0.51
22-Mar-01	09:30	Very low	0.35

Year 3: April 2001 to March 2002.

Date	Start time	Water level and other notes	Tide
25-Apr-01	13:00	High	0.87
20-May-01	am	Very High	0.98
29-Jly-01	am	Moderate	0.83
26-Aug-01	am	Low	0.46
15-Sep-01	09:00	Low	0.66
27-Oct-01	13:00	Very Low	0.38
15-Nov-01	09:00	Moderate	0.65
07-Dec-01	13:00	Low	0.40
19-Jan-02	08:00	Moderate	0.51
09-Feb-02	10:00	Low	0.39
21-Mar-02	09:00	Low	0.43

Year 4: April 2002 to April 2003.

Date	Start time	Water level and other notes	Tide
18-Apr-02	09:30	High	0.57
30-May-02	08:00	Moderate	0.40
22-Jne-02	09:00	Moderate	0.64
19-Jly-02	09:00	Very High	0.83
25-Aug-02	08:30	Moderate	0.69
06-Sep-02	09:30	Moderate. Earthworks opposite Zone 1.	0.54
11-Oct-02	08:00	Low to Moderate. Helicopter flying low over area. Earthworks opposite Zone 1.	0.41
24-Nov-02	09:00	Very Low. Earthworks opposite Zone 1.	0.35
18-Dec-02	09:00	Very Low. Earthworks opposite Zone 1.	NA
01-Feb-03	11:00	Low to Moderate. Earthworks opposite Zone 1.	0.35
21-Feb-03	10:00	Moderate. Earthworks opposite Zone 1.	0.53
06-Mar-03	08:30	Moderate. Earthworks opposite Zone 1.	0.51
10-Apr-03	10:30	Moderate. Earthworks opposite Zone 1.	0.63

TABLE TWO. Maximum total count of each waterbird species on the Creery Wetlands in the periods December 1998 to February 2000, March 2000 to March 2001, April 2001 to March 2002 and April 2002 to April 2003. The survey month when each maximum count was obtained is indicated. See Appendix One for monthly counts from April 2002 to April 2003. Monthly counts from other years appear in previous reports.

Species	1998-2000		2000-2001		2001-2002		2002-2003	
	Max.	Mth	Max.	Mth	Max.	Mth	Max	Mth
Australasian Shoveler	-		2	Sep	-		-	
Australian Shelduck	523	Dec	366	Nov	252	Oct	170	Mar
Black Swan	169	May	250	Oct	1155	May	2205	May
Grey Teal	487	Dec	20	Aug	90	Mar	1002	Oct
Pacific Black Duck	442	Dec	158	Sep	135	May	101	Oct
Wood Duck	2	Oct	2	Sep	2	Aug	-	
Hoary-headed Grebe	-		-		-		300	Aug
Australasian Grebe	-		-		1	May	2	May
Darter	10	Feb	19	Nov	16	Sep	20	May
Great Cormorant	4	Sept	22	Aug	10	Apr	5	Jly
Little Black Cormorant	101	Nov	355	Oct	80	Feb	102	Sep
Little Pied Cormorant	220	May	257	Nov	378	Apr	275	Feb
Pied Cormorant	100	Feb	108	Sep	100	Apr	36	Jne
Australian Pelican	105	Dec	60	Mar	55	Apr	187	Mar
Great Egret	17	Feb	17	Mar	18	Aug	32	Mar
Little Egret	36	Jly	26	Mar	39	Mar	60	Mar
Nankeen night-Heron	1	Oct	-		-		-	
White-faced Heron	106	Nov	47	Nov	43	Oct	39	Oct
Australian White Ibis	40	Feb	34	Apr	31	Aug	34	Dec
Yellow-billed Spoonbill	20	May	26	Feb	40	Mar	64	Apr
Marsh Harrier	1	NA	2	Mar	1	May	1	Apr
Osprey	-		2	Mar	1	May	2	Jne
White-bellied Sea-Eagle	1	Nov	-		1	Feb	2	Apr
Buff-banded Rail	-		-		2	Jly	-	
Australian Spotted Crake	-		-		-		2	Dec
Baillon's Crake	-		-		-		3	Sep
Purple Swamphen	-		-		1	Oct	-	
Pied Oystercatcher	10	Dec	10	Aug	3	Oct	3	Nov
Bar tailed Godwit	143	Feb	70	Nov	70	Jan	20	Dec
Black-tailed Godwit	15	Dec	1	Mar	-		-	
Common Sandpiper	1	Dec	3	Sep	1	Sep	-	
Grey-tailed Tattler	14	Jan	-		3	Dec	1	
Ruddy Turnstone	-		-		4	Dec	-	
Curlew Sandpiper	3	Dec	50	Feb	1	Feb	205	Dec
Whimbrel	30	Dec	21	Nov	19	Feb	28	Nov
Eastern Curlew	28	Dec	51	Jan	8	Oct	1	Feb
Great Knot	201	Dec	50	Jan	-		12	Nov
Red Knot	95	Sep	55	Mar	74	Feb	770	Dec

Table 2 (cont.)

Species	1998-2000		2000-2001		2001-2002		2002-2003	
	Max.	Mth	Max.	Mth	Max.	Mth	Max	Mth
Greenshank	91	Dec	112	Sep	35	Feb	62	Nov
Long-toed Stint	-		2	Mar	-			
Marsh Sandpiper	-		2	Jan	5	Nov		
Red-necked Stint	3500	Nov	1160	Nov	170	Mar	2750	Nov
Sharp-tailed Sandpiper	800	Dec	566	Jan	161	Feb	1118	Nov
Banded Stilt	407	Feb	500	Nov	1520	Mar	3100	Dec
Black-winged Stilt	409	Dec	166	Jan	250	Feb	258	Mar
Red-necked Avocet	-		-		-		100	Jly
Pacific Golden Plover	-		9	Jan	9	Jan	43	Feb
Greater Sand Plover	1	Nov	3	Sep	1	Feb	4	Dec
Grey Plover	13	Feb	43	Mar	4	Aug, Mar	33	Nov
Red-capped Plover	176	Jan	370	Nov	52	Feb	130	Nov
Red-kneed Dotterel	-		-		4	Aug		
Caspian Tern	4	Sep	29	Jun	8	May	7	Feb
Crested Tern	10	Mar	20	Aug	5	Mar	8	Apr
Fairy Tern	52	Sep	100	Oct	110	Jly	30	Feb
Gull-billed Tern	1	May	1	Jly	-			
Whiskered Tern	200	Dec	-		-		100	Aug
Silver Gull	233	Jan	499	Dec	92	Feb	65	Dec
Sacred Kingfisher	1	May	-		1	Oct	1	Jne
White-fronted Chat	19	Nov	27	Dec	17	May	14	Apr
Little Grassbird	14	Mar	20	Aug	12	Sep	44	Jly
Minimum number of:								
Cormorants, Pelican	540		821		639		625	
Ducks and swans	1623		798		1634		3778	
Hérons, egrets, ibis	225		150		171		229	
Plovers and sandpipers	4935		2568		621		5185	
Stilts	816		666		1770		3458	
Gulls and terns	500		649		215		210	
Chat, grassbird	33		47		29		58	
All waterbirds	8672		5699		5079		13551	

TABLE THREE. Maximum number of each species and waterbird guild recorded in each survey zone over the period April 2002 to April 2003.

Species	Zone								
	1	2	3	4	5	6	7	8	9
Australian Shelduck	11	8	150	80			10	40	
Black Swan	3		330	5	2		500	2000	20
Grey Teal		60	1000	10			3	30	
Pacific Black Duck	12	20	100	15		2	33	32	4
Hoary-head Grebe		1	7	1		10	300	100	
Australasian Grebe		2							
Darter	16	1	2	1	2	4	4		1
Great Cormorant	4	2			1	3			
Little Black Cormorant	2	4	4		4	6	100	2	
Little Pied Cormorant	2	36	26	1	100	61	127	80	40
Pied Cormorant	1	36			4	8			3
Australian Pelican			20	4	40	40	50	150	80
Great Egret	2	2	4	3		1	10	29	4
Little Egret	16	4	31	20	2	2	8	26	2
White-faced Heron	3	4	18	2	12		11	17	8
Australian White Ibis	4	3	4	2	3	1	20		20
Yellow-billed Spoonbill	5	11	35	20			10	23	8
Marsh Harrier	1		1	1					
Osprey					2				
White-bellied Sea-Eagle				2	1		1		
Australian Spotted Crake		2							
Baillon's Crake				3					
Pied Oystercatcher				2	1			2	2
Bar Tailed Godwit			1				16	3	8
Curlew Sandpiper				10			5		200
Eastern Curlew	1								1
Great Knot							12		
Greenshank	7	5	20	10	13	6	18	20	40
Grey Tailed Tattler					1				
Red Knot				128			350		400
Red-necked Stint	80		55	250			450	40	2500
Sharp-tailed Sandpiper	50		205	60			110	220	1000
Whimbrel			1				15		12
Banded Stilt	61	2	3000	200			200	2100	
Black-winged Stilt	33	24	150	120	20		34	200	5
Red-necked Avocet				100					
Greater Sand Plover	1						4		1
Grey Plover			1				11		22
Pacific Golden Plover	18						23		20
Red-capped Plover	130		4	16			1	4	6

Table 3 (cont.)

Species	Zone								
	1	2	3	4	5	6	7	8	9
Caspian Tern	1	2	3	1	2	2	3	1	6
Crested Tern						2	2	8	1
Fairy Tern			2			2	2		30
Silver Gull		1	10	50	4	1	34	25	10
Whiskered Tern				1		100			
Sacred Kingfisher				1					
White-fronted Chat	6	6	4	8	2				
Little Grassbird	20	14	3	11					
Waterbird guilds:									
Cormorants and Pelicans	25	79	52	6	151	122	281	232	124
Ducks	26	89	1587	111	2	12	846	2202	24
Hérons, Egrets, Ibis	30	24	92	47	17	4	59	95	42
birds of prey				2	3		1		
Coots and Rails		2		3					
Plovers and Sandpipers	287	7	287	476	15	6	1015	289	4212
Stilts and Avocets	94	26	3150	420	20		234	2300	5
Gulls and Terns	1	3	15	52	6	107	41	34	47
Grassbirds and Chats	26	20	7	19	2				
Totals: 2002/2003	490	250	5191	1140	220	251	2478	5152	4454
Totals: 2001/2002	404	119	2269	349	260	206	1033	1317	519
Totals: 2000/2001	960	526	1660	1320	460	49	629	386	1788
Totals: 1998/2000	597	114	3248	1507	281	255	4353	1610	1441

TABLE FOUR. The distribution of main waterbird groups across the Creery Wetlands in summer 1998/1999 (before development), summer 1999/2000 (during development), and the summers of 2000/2001, 2001/2002 and 2002/2003 (after development). Each value is the percentage of the total count of each waterbird group in each zone. Actual numbers counted are presented in Appendix 3.

Waterbird guild	Year	Zones						Total
		1 & 2	3 & 6	4 & 5	7	8	9	
Cormorants & Pelican	1998/99	-	42.3	17.0	17.7	8.0	15.1	702
	1999/00	-	3.0	56.8	40.1	-	-	464
	2000/01	1.7	7.4	76.4	5.6	1.3	7.6	537
	2001/02	0.7	16.5	9.7	23.1	18.7	31.4	455
	2002/03	2.6	19.2	19.3	26.2	19.7	13.0	610
Ducks & swans	1998/99	8.3	50.9	4.8	4.4	20.5	11.2	2734
	1999/00	1.5	52.1	45.7	0.7	0.1	-	1905
	2000/01	17.2	33.9	47.3	-	1.5	-	389
	2001/02	8.9	36.4	13.8	2.9	33.5	4.5	514
	2002/03	2.4	33.8	1.5	25.4	36.6	0.2	2586
Herons & allies	1998/99	17.2	64.2	3.3	4.6	9.3	1.3	151
	1999/00	16.1	54.8	14.6	14.3	0.3	-	336
	2000/01	22.0	24.6	33.5	1.3	11.0	7.6	236
	2001/02	3.2	62.5	3.7	14.8	7.4	8.3	216
	2002/03	6.2	31.5	8.4	32.6	1.1	20.2	178
Plovers & Sandpipers	1998/99	12.4	38.0	6.9	2.4	18.9	21.5	3189
	1999/00	13.4	4.3	64.4	17.2	0.6	-	1080
	2000/01	11.8	8.0	32.0	2.2	1.6	10.7	2972
	2001/02	11.0	25.0	30.9	8.0	12.6	12.5	601
	2002/03	5.6	10.0	0.7	30.2	9.0	44.5	3001
Stilts	1998/99	3.1	94.6	0.6	0.1	1.6	-	1395
	1999/00	-	29.3	4.9	51.2	14.6	-	41
	2000/01	5.4	71.9	1.0	20.6	0.2	1.0	598
	2001/02	-	93.8	0.1	0.1	4.9	0.1	2041
	2002/03	0.4	57.8	0.6	3.2	37.9	0.1	6192
Gulls & terns	1998/99	7.8	15.6	-	1.1	74.9	0.6	526
	1999/00	-	19.3	1.1	53.4	26.3	-	654
	2000/01	0.5	47.0	7.9	0.5	35.4	8.9	738
	2001/02	1.0	7.7	1.0	1.4	86.5	2.4	208
	2002/03	-	6.5	2.4	24.1	28.2	38.8	170
Chat, Grassbird	1998/99	96.6	3.4	-	-	-	-	29
	1999/00	-	-	-	-	-	-	0
	2000/01	50.0	1.6	29.7	18.8	-	-	64
	2001/02	28.0	34.4	37.5	-	-	-	32
	2002/03	85.7	-	14.3	-	-	-	21

Table 4 (cont.)

Waterbird guild	Year	Zones						Total
		1 & 2	3 & 6	4 & 5	7	8	9	
All waterbirds	1998/99	8.7	50.4	5.5	3.8	18.9	12.6	8726
	1999/00	5.1	30.7	42.2	17.9	4.2	-	4480
	2000/01	12.1	27.5	37.6	5.2	7.7	9.9	4534
	2001/02	3.3	61.2	8.0	5.4	15.5	6.7	4067
	2002/03	2.3	38.7	1.9	15.9	29.3	12.0	12758

FIGURE ONE. Survey zones for waterbird monitoring at the Creery Wetlands. Hatching indicates the area of construction activity during 1999/2000, while the fine dotted line indicates the survey route usually taken, starting in Zone 8. This line divides where the members of the survey team separated to cover different areas. The Zones are: 1 & 2: Samphire marsh with shallow pools influenced by the tide. Mariners' Cove development (hatched area) lies just to the north of Zone 1.

3. Creery Lagoon. A large, shallow and substantially enclosed body of water that is influenced by the tide. This zone includes the shorelines of adjacent zones.

4 & 5. Creery and Channel Islands. The shorelines are in adjacent zones, but there are areas of samphire marsh and pools on the islands. Creery Island in particular has large areas of samphire marsh and mudflat.

6. Channel between Creery and Channel Islands.

7, 8 and 9. Open water and shoreline of the Peel Inlet adjacent to Creery Island (7), the Coodanup Foreshore (8) and estuarine shallows south-west of Channel Island (9). These are important foraging areas that are unlikely to be affected by development adjacent to the Creery Wetlands and therefore have the potential to act as control sites. Zone 7 includes a sand-bar opposite Zone 6.

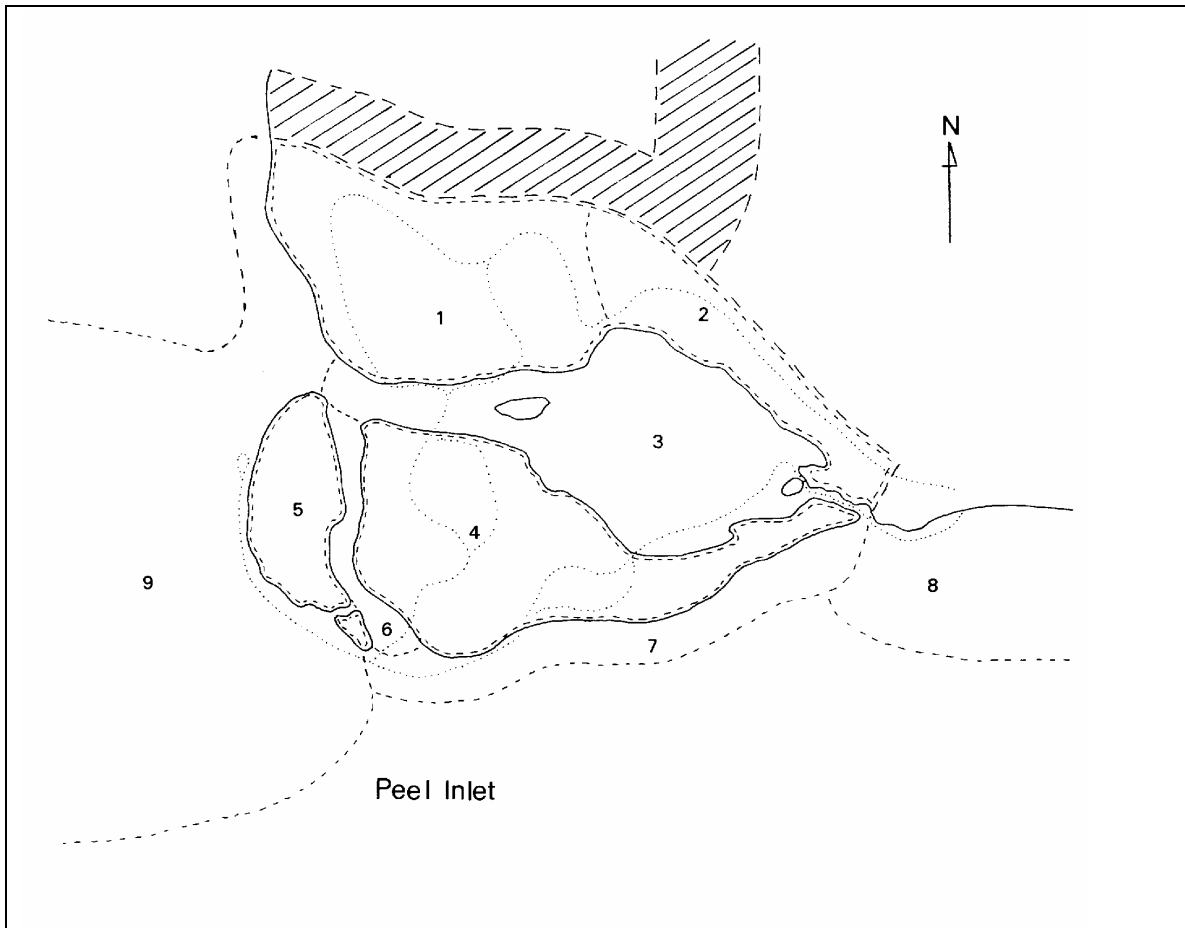


FIGURE TWO. Mean weekly tide, December 1998 to March 2003, in the entrance channel to the Peel Inlet (Department of Planning and Infrastructure data).

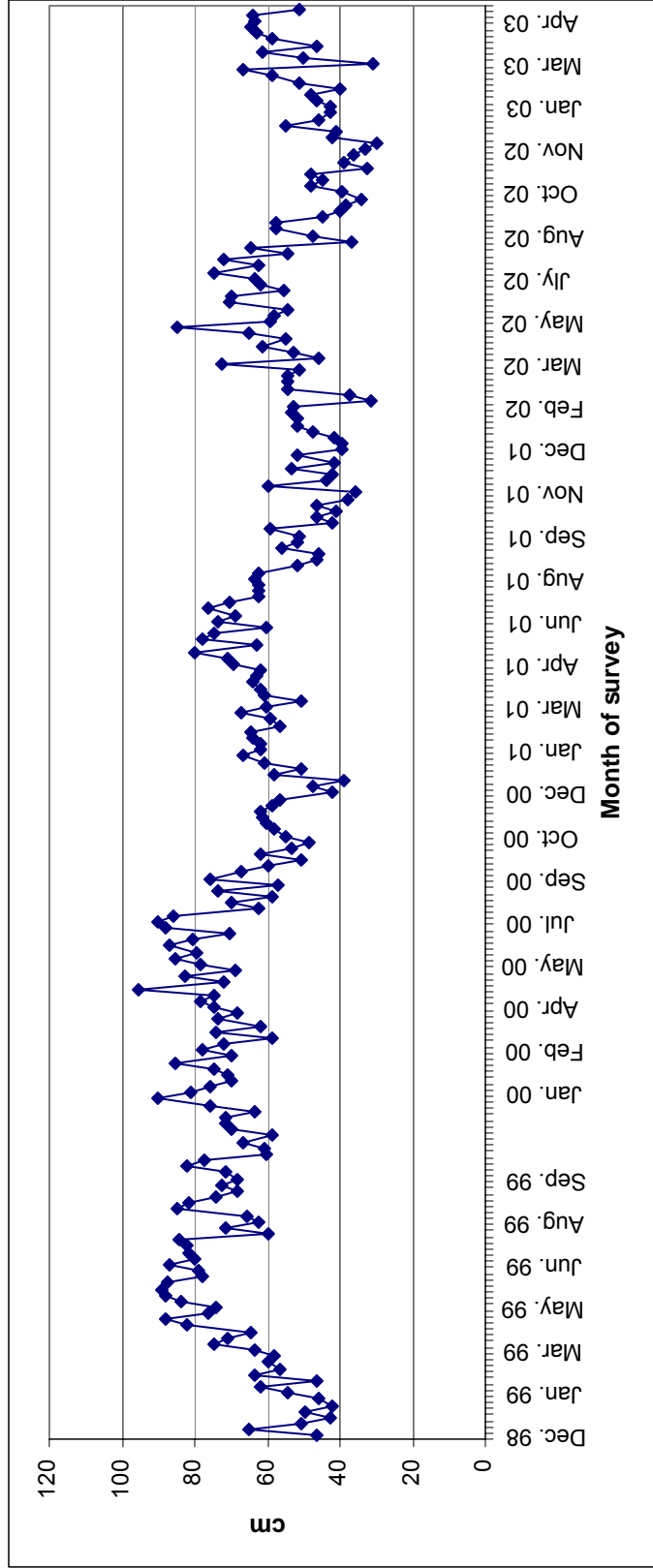


FIGURE THREE. Variation in the number of waterbirds of each guild in the inner zones of the Creery Wetlands (Zones 1 to 6) and in the adjacent estuary (Zones 7 to 9), December 1998 to April 2003.

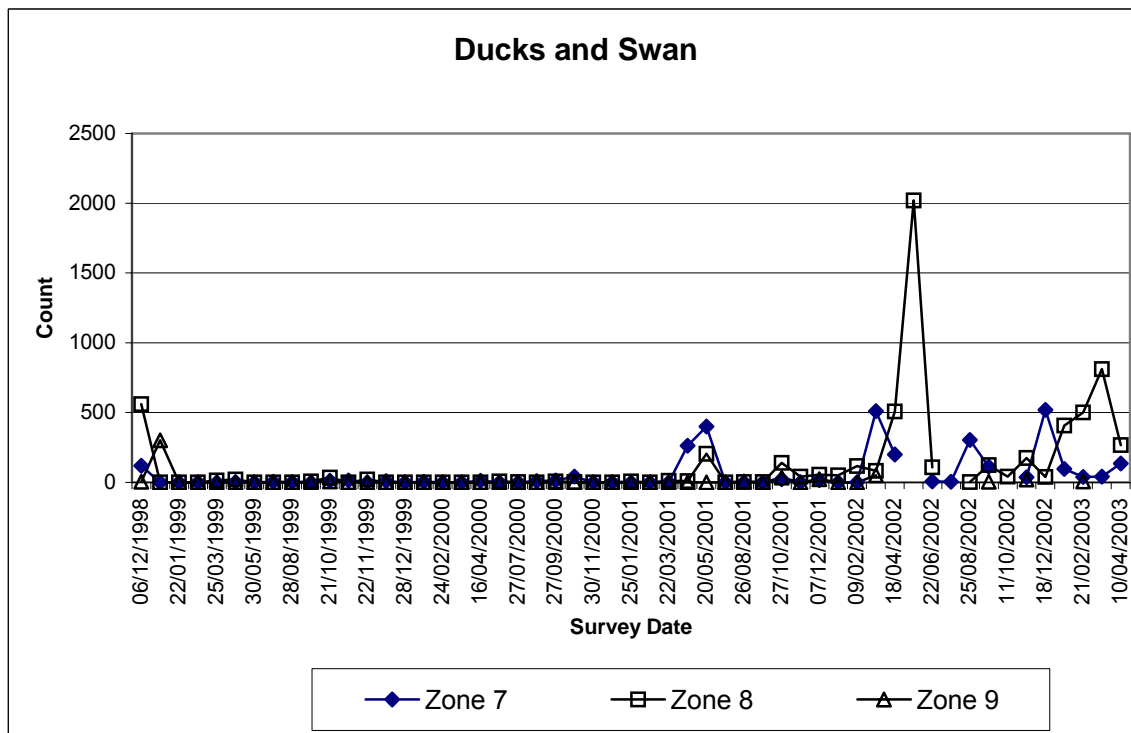
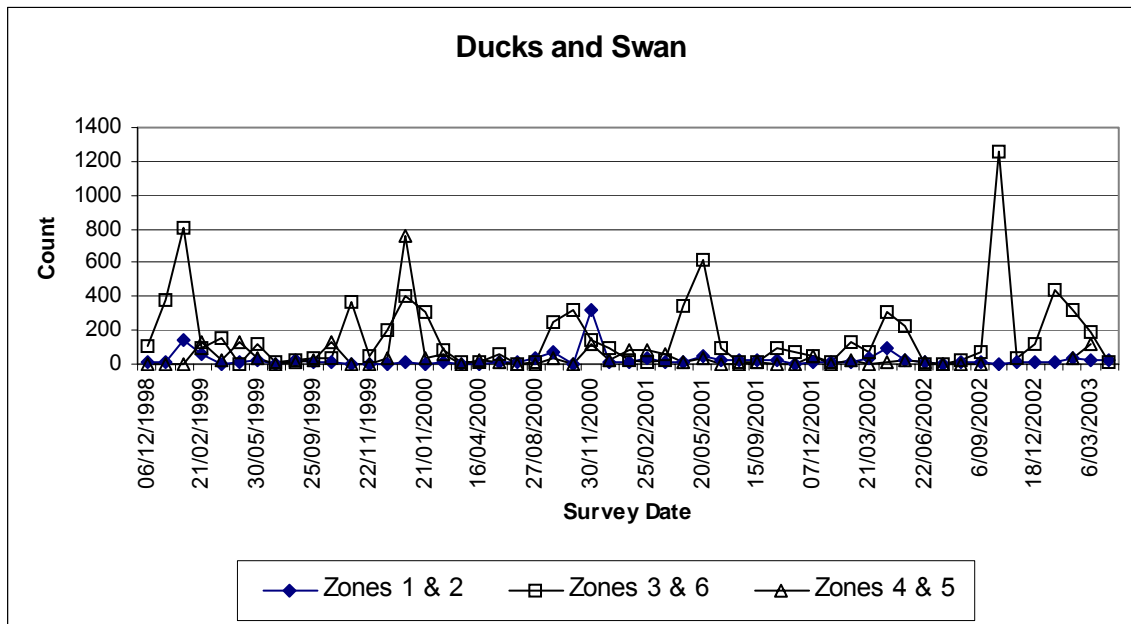


Figure 3 (cont.)

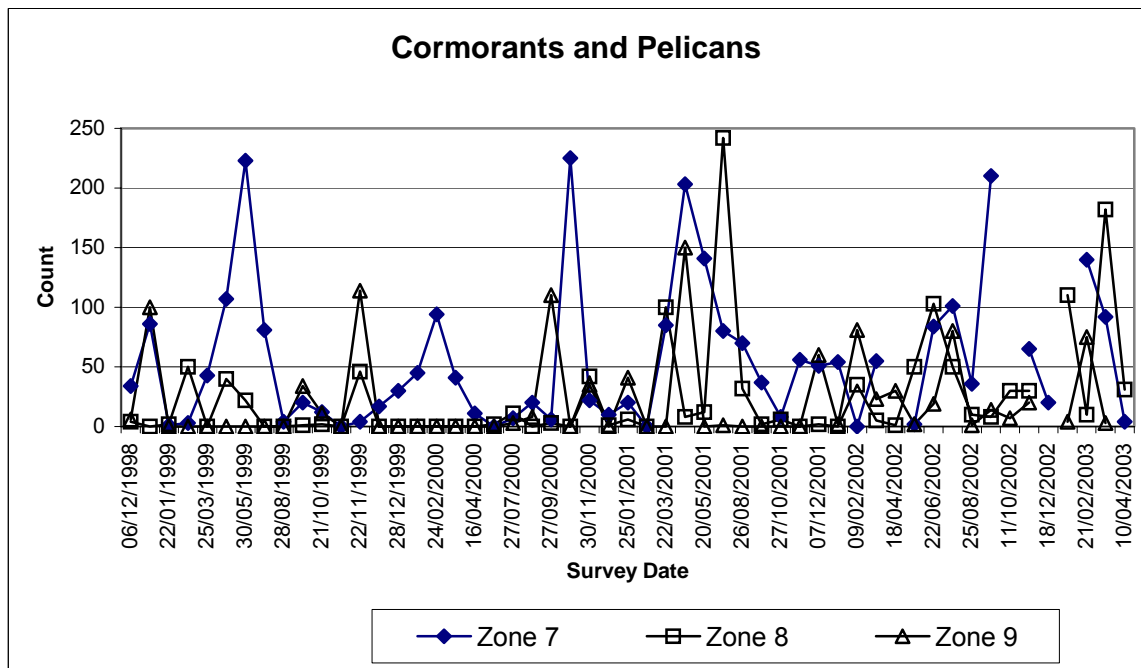
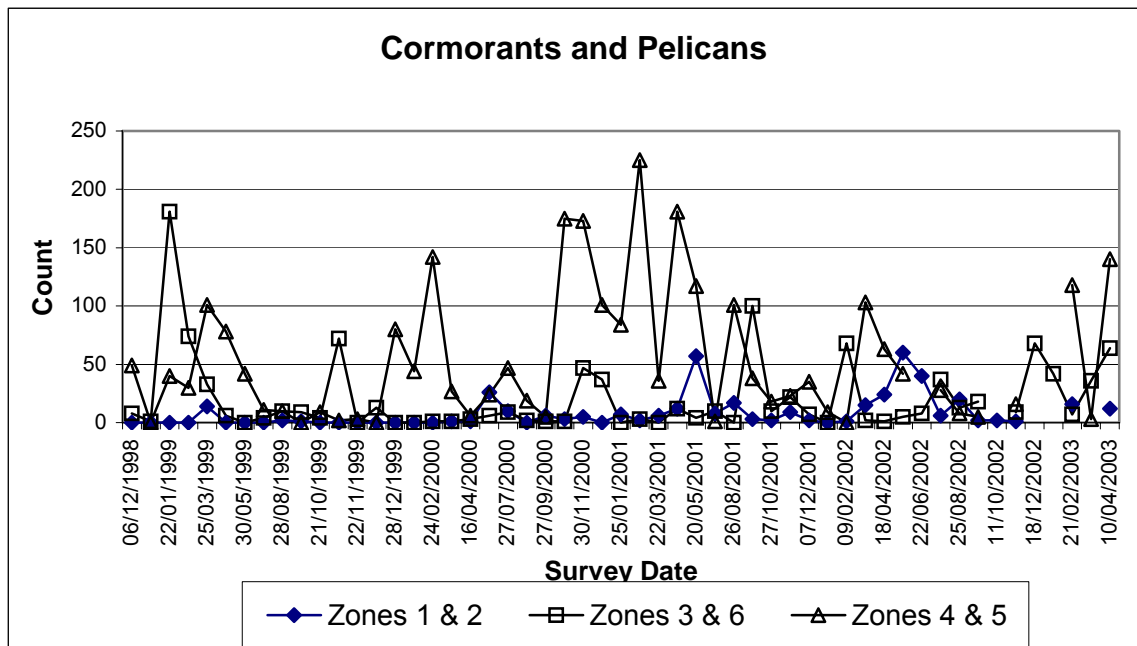


Figure 3 (cont.)

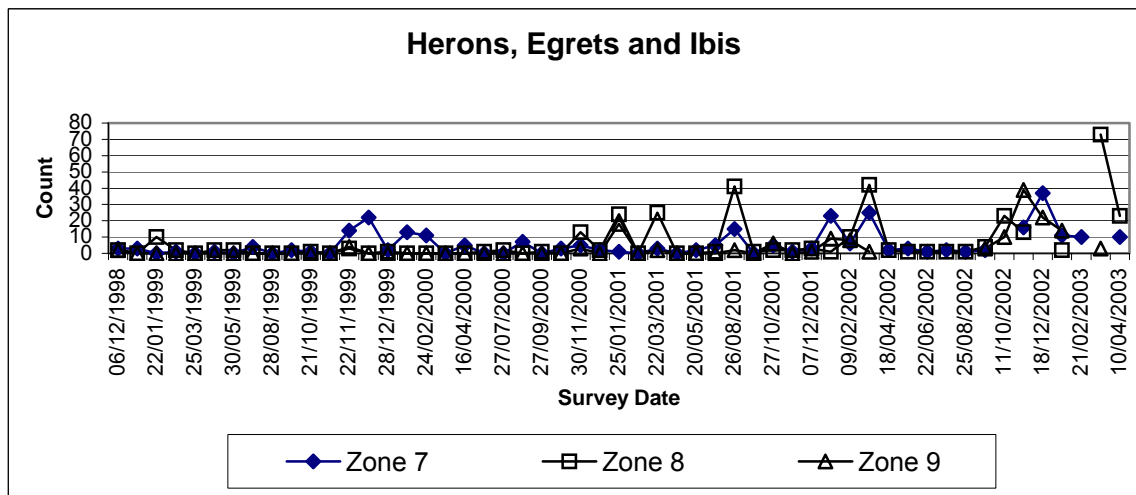
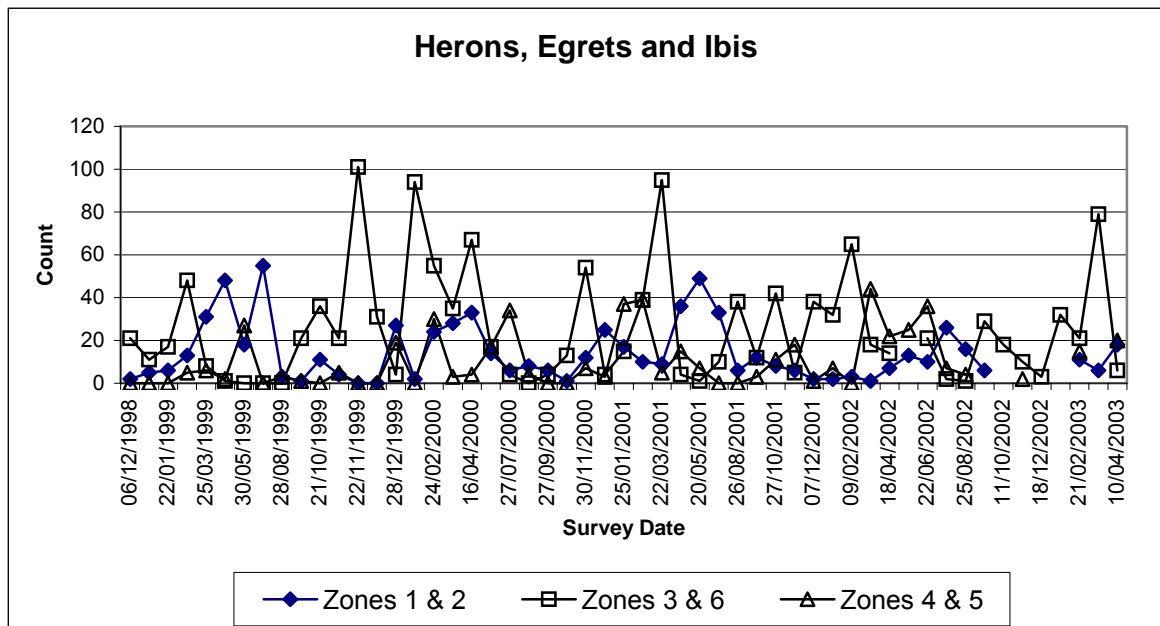


Figure 3 (cont.)

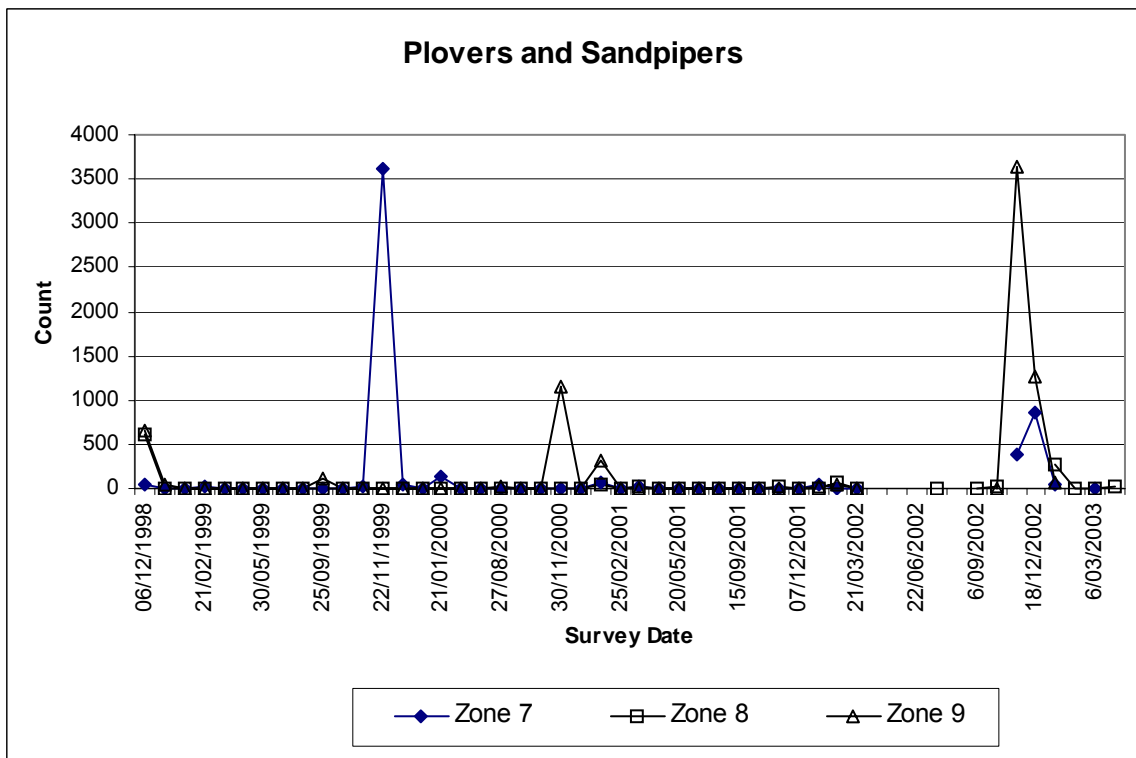
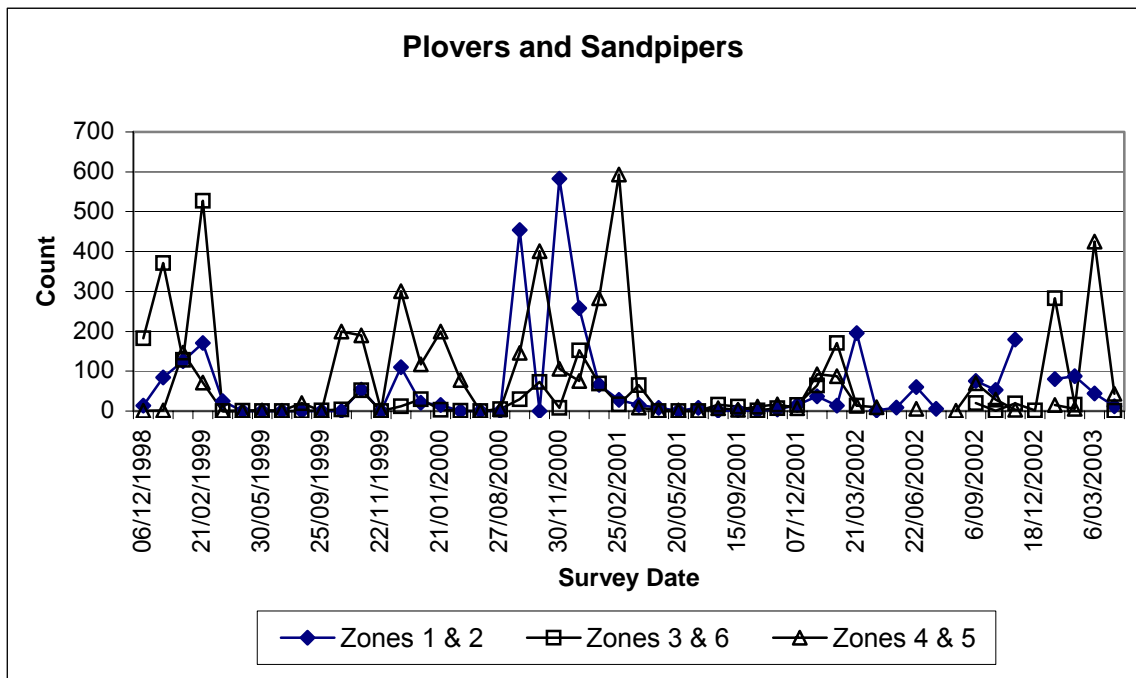


Figure 3 (cont.)

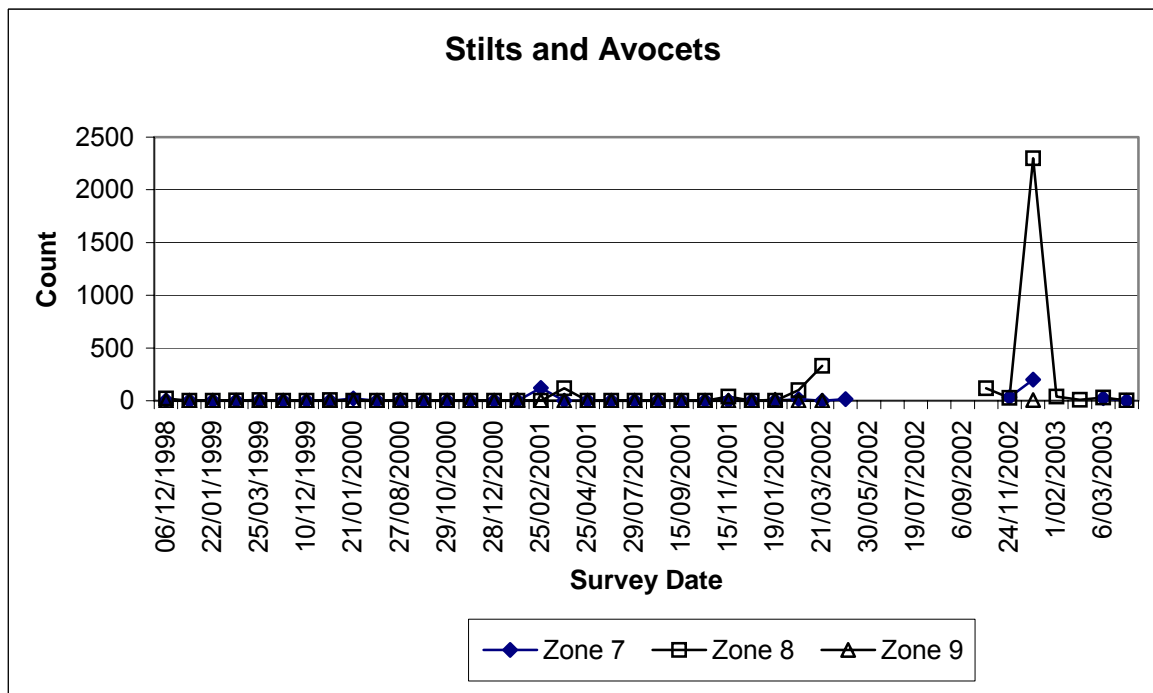
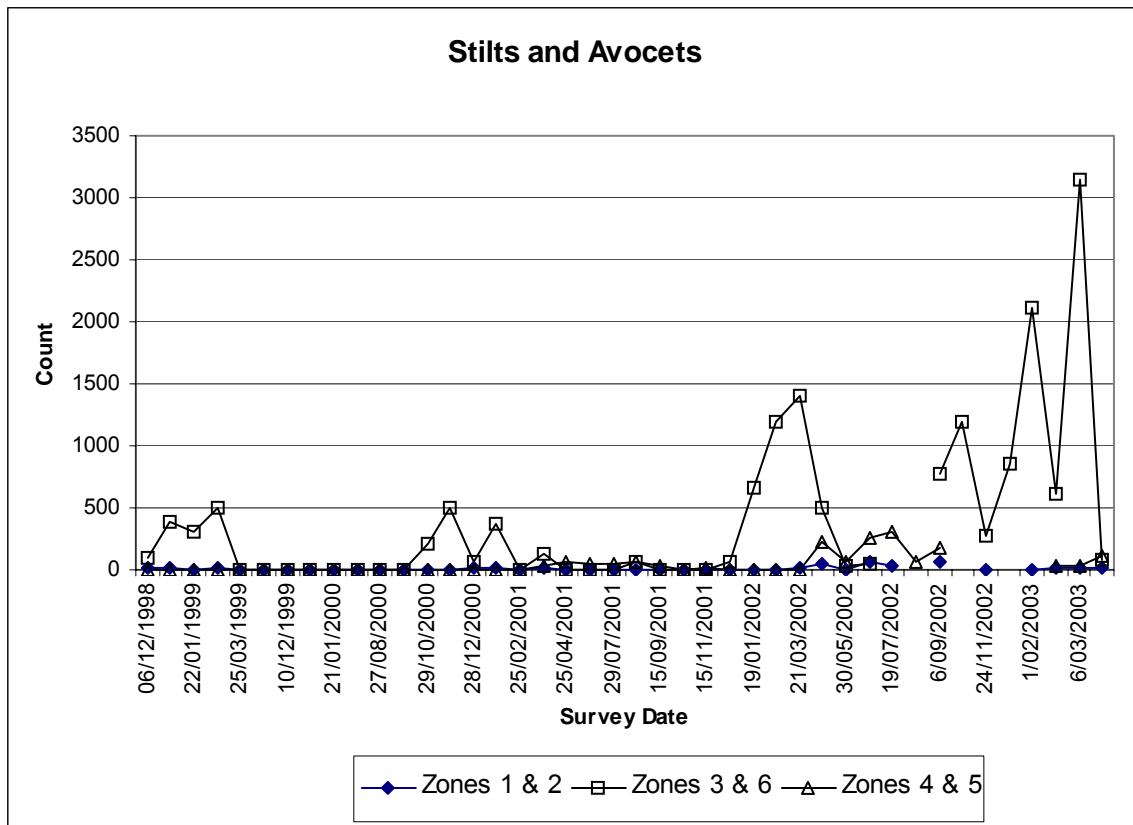
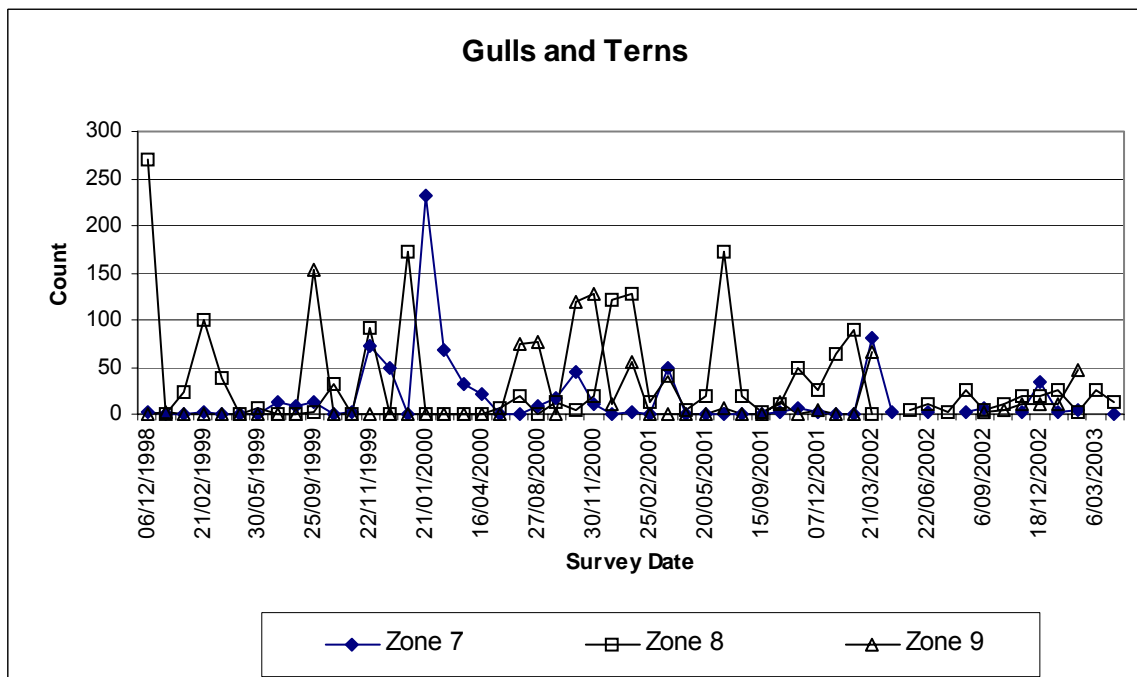
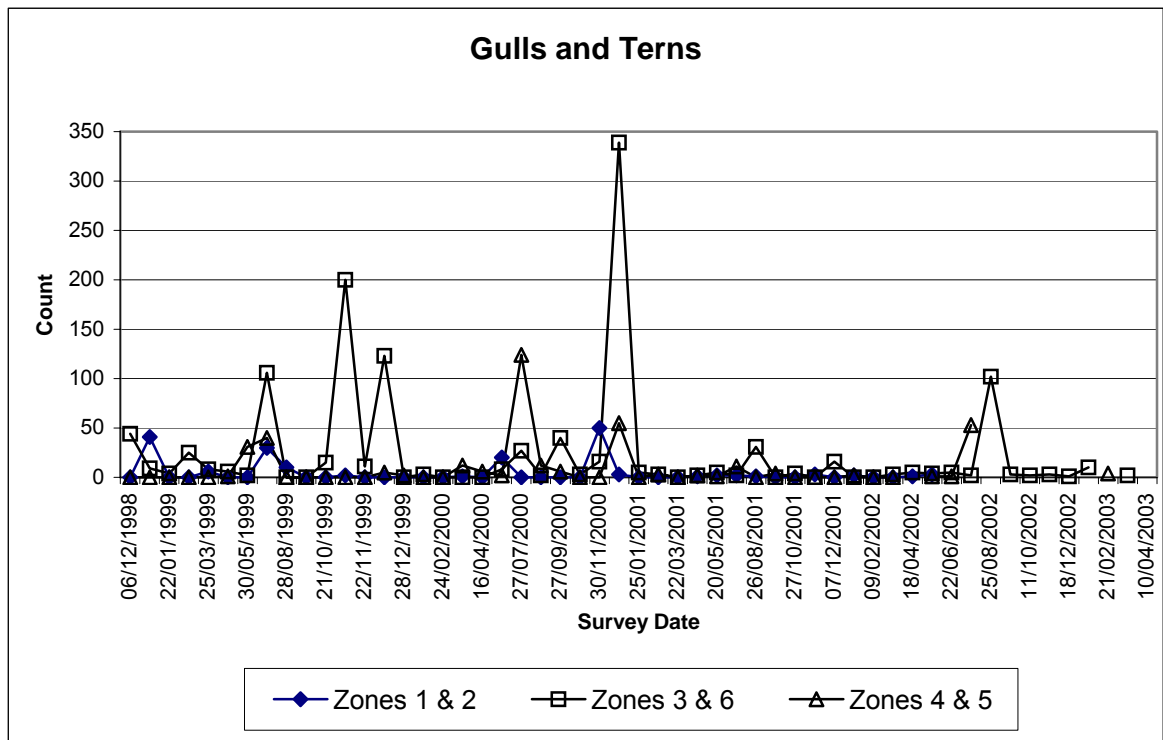


Figure 3 (cont.)



REFERENCES

- Bamford Consulting Ecologists (2000). Waterbird Monitoring in the Conservation Zone of the Creery Wetlands, December 1998 to February 2000. Unpub. report to Bowman Bishaw Gorham, Perth.
- Bamford Consulting Ecologists (2001). Waterbird Monitoring in the Conservation Zone of the Creery Wetlands, March 2000 to March 2001. Unpub. report to Bowman Bishaw Gorham, Perth.
- Bamford Consulting Ecologists (2002). Waterbird Monitoring in the Conservation Zone of the Creery Wetlands, April 2001 to March 2002. Unpub. report to Bowman Bishaw Gorham, Perth.
- Jaensch, R.P., Vervest, R.M. and Hewish, M.J. (1988). Waterbirds in Nature Reserves of South-Western Australia, 1981-1985: Reserve Accounts. Royal Australasian Ornithologists Union Report No. 30.
- Jaensch, R. and Lane, J. (1993). Western Australia. Chapter 10 in A Directory of Important Wetlands in Australia. Australian Nature Conservation Agency.
- Kirke, A. (1986). A Study of the Conservation Value of Three Foreshore Areas of the Peel Inlet – Harvey Estuary. Technical Report to the Peel-Harvey Conservation and Development Committee.
- Lane, J.A.K., Pearson, G.B. and Clarke, A.G. (1997). Waterbird Use of Peel-Harvey Estuary following opening of the Dawesville Channel in Aril 1994. Progress Report. Department of Conservation and Land Management, Perth.
- Ninox Wildlife Consulting (1990). The Significance of Mosquito Breeding Areas to the Waterbirds of Peel Inlet, Western Australia. Waterways Commission Report No. 20.
- Ninox Wildlife Consulting (1999). Waterbird Monitoring within the Port Mandurah Stage 2 Project Area. Progress Report 1998-1999. Unpub. report to Bowman Bishaw Gorham.
- Observations Committee (2002). Observations. WA Bird Notes 101: 2-5
- Singor, M. (1997). Waders of the Creery Wetland and Adjacent Mudflat, Western Australia. The Stilt 30: 39-48.

Appendix 1. Total count of each species in each survey, April 2002 to April 2003.

Species	18/04/02	30/05/02	22/06/02	19/07/02	25/08/02	6/09/02	11/10/02	24/11/02	18/12/02	1/02/03	21/02/03	6/03/03	10/04/03
Australian Shelduck	8	38	10	7	12	16	164	76	123	13	44	170	
Black Swan	1013	2205	9			77		42	500	827	859	970	338
Grey Teal	70	14	4			4	1002		33	120	14	20	39
Pacific Black Duck	32	43	6	6	29	30	101	48	30		12	10	38
Australasian Grebe		2	1	2			1						
Hoary-head Grebe	8		101		300	202	36	100		1	10	9	30
Darter	1	20	4	2	12	3		4	1	4	5	1	
Great Cormorant	2	1		5						3	3		
Little Black Cormorant	3	4	4	23	11	102		60		5	13	9	2
Little Pied Cormorant	101	69	86	147	24	90	16	8	75	118	275	119	145
Pied Cormorant	2		36	9			3		3	4	4		
Australian Pelican	10	67	124	116	41	62	20	69	9	22	66	187	104
Great Egret	5	6	5	9	6	7	8	7	3	8	16	32	2
Little Egret	6	4	27	22	2	10	2	3	10	19	12	60	2
White-faced Heron	7	9	4	1	5	13	39	28	12	1	13	24	
Australian White Ibis		2	4	2	8	4	2	30	34	13	6	9	9
Yellow-billed Spoonbill	29	21	29	4	2	10		12	3	18	10	36	64
Marsh Harrier	1	1		1				1	1	1	1		1
Osprey						2							
White-bellied Sea-Eagle	2			1	1								
Australian Spotted Crane									2				
Baillon's Crane						3							
Pied Oystercatcher				2	1	2		3	2	2			

Species	18/04/02	30/05/02	22/06/02	19/07/02	25/08/02	6/09/02	11/10/02	24/11/02	18/12/02	1/02/03	21/02/03	6/03/03	10/04/03
Bar-tailed Godwit							1	18	20	8		3	
Curlew Sandpiper								30	205			10	
Eastern Curlew										1			1
Great Knot								12					
Greenshank	12	3	15	3		31	44	62	31	26	10	14	4
Grey Tailed Tattler							1						
Red Knot								33	770	20		128	
Red-necked Stint						54	2	2750	450	185	31	257	65
Sharp-tailed Sandpiper						60	15	1118	655	430	71	20	
Whimbrel								28	3	7			
Banded Stilt	767	40	183	84	20	811	1320	204	3100	2000	628	3000	145
Black-winged Stilt	31	62	187	148	50	182		142	252	151	61	258	68
Red-necked Avocet				100		12							
Greater Sand Plover									4	1			1
Grey Plover								33	2	1			1
Pacific Golden Plover								4	3	43		18	
Red-capped Plover		4	50	1		20	50	130		20		33	9
Caspian Tern	2	5	5	5		3		1			7	2	1
Crested Tern	4		2			4				6		6	8
Fairy Tern						1	2	14		2	30		
Silver Gull	2	7	10	52	28	10	14	20	65	40	20	20	4
Whiskered Tern			1		100								
Sacred Kingfisher			1			1					1		1
White-fronted Chat	14	8		12		10		6			4	7	4
Little Grassbird	6	10	3	44	13	19		9		4	13	8	4

Appendix Two. Mean counts of each species recorded in RAOU surveys of the Creery Wetlands carried out in 17 summer surveys (November to March) over the period February 1982 to March 1988. Also indicated is the maximum count obtained during any survey within the period February 1982 to March 1988.

Species	Max	Mean	St. Dev.
Anatidae (ducks and swans)			
Black Swan <i>Cygnus atratus</i>	120	18.2	37.2
Australian Shelduck <i>Tadorna tadornoides</i>	500	162.5	142.5
Pacific Black Duck <i>Anas superciliosus</i>	200	14.1	24.9
Grey Teal <i>Anas gibberifrons</i>	951	183.7	317.0
Australasian Shoveler <i>Anas rhynchotis</i>	10	NA	NA
Australian Wood Duck <i>Chenonetta jubata</i>	0	0	
Podicepsidae (grebes)			
Hoary-headed Grebe <i>Poliocephalus poliocephalus</i>	0	0	
Australasian Grebe <i>Tachybaptus novaehollandiae</i>	2	NA	NA
Anhingidae (darters)			
Darter <i>Anhinga melanogaster</i>	8	1.5	2.4
Phalacrocoracidae (cormorants)			
Great Cormorant <i>Phalacrocorax carbo</i>	12	0.4	1.5
Pied Cormorant <i>Phalacrocorax varius</i>	258	10.2	21.3
Little Black Cormorant <i>Phalacrocorax sulcirostris</i>	100	5.8	14.3
Little Pied Cormorant <i>Phalacrocorax melanoleucos</i>	405	30.5	41.1
Pelecanoididae (pelicans)			
Australian Pelican <i>Pelecanus conspicillatus</i>	100	19.8	27.6
Ardeidae (herons and egrets)			
White-faced Heron <i>Egretta novaehollandiae</i>	52	10.6	14.5
Little Egret <i>Egretta garzetta</i>	21	4.9	5.9
Great Egret <i>Egretta alba</i>	30	3.5	4.4
Nankeen Night Heron <i>Nycticorax caledonicus</i>	0	0	
Plataleidae (ibis and spoonbills)			
Glossy Ibis <i>Plegadis falcinellus</i>	1	0.1	0.2
Australian White Ibis <i>Threskiornis molucca</i>	17	2.8	4.4
Straw-necked Ibis <i>Threskiornis spinicollis</i>	9	0.5	2.2
Royal Spoonbill <i>Platalea regia</i>	1	NA	NA
Yellow-billed Spoonbill <i>Platalea flavipes</i>	52	0.1	0.3
Accipitridae (kites, hawks and eagles)			
Osprey <i>Pandion haliaetus</i>	2	0.4	0.6
White-bellied Sea Eagle <i>Haliaeetus leucogaster</i>	1	NA	NA
Swamp Harrier <i>Circus approximans</i>	1	0.1	0.2
Rallidae (crakes and rails)			
Australian Spotted Crake <i>Porzana fluminea</i>	1	NA	NA

Appendix 2 (cont.)

Species		Max	Mean	St. Dev.
Scolopacidae (sandpipers)				
Black-tailed Godwit	<i>Limosa limosa</i>	1	0.1	0.3
Bar-tailed Godwit	<i>Limosa lapponica</i>	500	135.2	156.9
Whimbrel	<i>Numenius phaeopus</i>	7	1.6	2.1
Eastern Curlew	<i>Numenius madagascariensis</i>	11	4.0	3.4
Common Redshank	<i>Tringa totanus</i>	1	NA	NA
Marsh Sandpiper	<i>Tringa stagnatalis</i>	284	0.1	0.2
Common Greenshank	<i>Tringa nebularia</i>	200	37.8	44.0
Terek Sandpiper	<i>Tringa terek</i>	7	0.5	1.7
Common Sandpiper	<i>Tringa hypoleucos</i>	2	0.4	0.6
Grey-tailed Tattler	<i>Tringa brevipes</i>	5	0.4	1.2
Ruddy Turnstone	<i>Arenaria interpres</i>	0	0	
Great Knot	<i>Calidris tenuirostris</i>	850	127.7	4.4
Red Knot	<i>Calidris canutus</i>	100	NA	
Sanderling	<i>Calidris alba</i>	10	0.6	2.4
Red-necked Stint	<i>Calidris ruficollis</i>	3246	479.2	1009.9
Long-toed Stint	<i>Calidris subminuta</i>	0	0	
Pectoral Sandpiper	<i>Calidris melanotos</i>	2	0.2	0.5
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	2381	279.6	610.6
Curlew Sandpiper	<i>Calidris ferruginea</i>	2000	204.9	490.2
Broad-billed Sandpiper	<i>Limicola falcinellus</i>	1	0.1	0.2
Ruff	<i>Philomachus pugnax</i>	1	0.1	0.2
Haematopodidae (oystercatchers)				
Pied Oystercatcher	<i>Haematopus longirostris</i>	60	6.3	14.4
Recurvirostridae (stilts and avocets)				
Black-winged Stilt	<i>Himantopus himantopus</i>	340	91.5	105.9
Banded Stilt	<i>Cladorhynchus leucocephalus</i>	9000	2488.3	3148.1
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>	101	9.2	24.6
Charadriidae (lapwings and plovers)				
Pacific Golden Plover	<i>Pluvialis fulva</i>	85	15.1	25.5
Grey Plover	<i>Pluvialis squatarola</i>	600	95.3	149.2
Red-capped Plover	<i>Charadrius ruficapillus</i>	223	29.9	55.4
Lesser Sand Plover	<i>Charadrius mongolus</i>	4	0.2	1.0
Greater Sand Plover	<i>Charadrius leschenaultii</i>	15	3.0	4.8
Black-fronted Dotterel	<i>Elsayornis melanops</i>	1	NA	
Laridae (gulls and terns)				
Silver Gull	<i>Larus novaehollandiae</i>	1000	168.8	267.7
Gull-billed Tern	<i>Gelochelidon nilotica</i>	6	1.2	2.0
Caspian Tern	<i>Hydroprogne caspia</i>	7	1.5	2.0
Crested Tern	<i>Sterna bergii</i>	22	1.7	3.2
Fairy Tern	<i>Sterna nereis</i>	15	1.6	2.7
Whiskered Tern	<i>Chlidonias hybrida</i>	200	NA	
White-winged Black Tern	<i>Chlidonias leucoptera</i>	1	NA	
Meliphagidae (honeyeaters and chats)				
White-fronted Chat	<i>Epthianura albifrons</i>	NA	NA	

Appendix Three. The distribution of the main waterbird guilds across the Creery Wetlands in summer 1998/1999 (before development), summer 1999/2000 (during development), and the summers of 2000/2001, 2001/2002 and 2002/2003 (after development). Each value is the number of individuals within each waterbird guild combined from all surveys in each summer period (December to February). Table 4 presents these values as the percentage of the total count of each waterbird group that is present in each zone.

Waterbird guild	Year	1 & 2	3 & 6	4 & 5	7	8	9	Total
Cormorants & Pelican	1998/99	-	297	119	124	56	106	702
	1999/00	-	14	264	186	-	-	464
	2000/01	9	40	410	30	7	41	537
	2001/02	3	75	44	105	85	143	455
	2002/03	16	117	118	160	120	79	610
Ducks & swans	1998/99	227	1392	130	120	560	305	2734
	1999/00	28	992	871	13	1	-	1905
	2000/01	67	132	184	-	6	-	389
	2001/02	46	187	71	15	172	23	514
	2002/03	61	875	40	657	947	6	2586
Hérons & allies	1998/99	26	97	5	7	14	2	151
	1999/00	54	184	49	48	1	-	336
	2000/01	52	58	79	3	26	18	236
	2001/02	7	135	8	32	16	18	216
	2002/03	11	56	15	58	2	36	178
Plovers & Sandpipers	1998/99	394	1210	221	76	602	686	3189
	1999/00	146	46	696	186	6	-	1080
	2000/01	352	238	951	65	49	317	2972
	2001/02	66	150	186	48	76	75	601
	2002/03	167	301	21	907	271	1334	3001
Stilts	1998/99	43	1319	8	2	23	-	1395
	1999/00	-	12	2	21	6	-	41
	2000/01	32	430	6	123	1	6	598
	2001/02	-	1915	1	15	100	10	2041
	2002/03	22	3577	40	200	2348	5	6192
Gulls & terns	1998/99	41	82	-	6	394	3	526
	1999/00	-	126	7	349	172	-	654
	2000/01	3	347	58	3	261	66	738
	2001/02	2	16	2	3	180	5	208
	2002/03	-	11	4	41	48	66	170

Appendix 3 (cont.)

Waterbird guild	Year	1 & 2	3 & 6	4 & 5	7	8	9	Total
Chat, Grassbird	1998/99	28	1	-	-	-	-	29
	1999/00	-	-	-	-	-	-	0
	2000/01	32	1	19	12	-	-	64
	2001/02	9	11	12	-	-	-	32
	2002/03	18	-	3	-	-	-	21
All waterbirds	1998/99	759	4398	483	335	1649	1102	8726
	1999/00	228	1374	1889	803	186	-	4480
	2000/01	547	1246	1707	236	350	448	4534
	2001/02	133	2489	324	218	629	274	4099
	2002/03	297	4937	241	2023	3736	1526	12758