BI/ES - 050

Report on

# SOCIAL (HUMAN USE) MONITORING PROGRAMME FOR THE SWAN ESTUARY MARINE PARK

M.J. Bamford, A.R. Bamford and W. Bancroft

## DRAFT

Prepared for: WA Department of Conservation and Land Management,
Swan Coastal District,
47 Henry Street,
Fremantle, WA, 6160

Prepared by: M.J. & A.R. Bamford,
CONSULTING ECOLOGISTS.
23 Plover Way,
Kingsley, WA, 6026

24/06/'03

# EXECUTIVE SUMMARY

*Introduction and Methods*

The Swan Estuary Marine Park (SEMP) is Class A Marine Reserve No 4 and consists of three separate reserves on the estuary of the Swan River: Alfred Cove, Milyu and Pelican Point. The Marine Park and the estuary in general are recognised as being of great importance for waterbirds, but because of the location in the middle of a large city, there are concerns that the value of the park is being compromised. Past habitat loss has affected waterbirds, but the major recent concern has been through disturbance of waterbirds resulting from human usage of the Marine Park, and a documented decline in waterbird numbers at Pelican Point has been attributed largely to disturbance. Disturbance of waterbirds is becoming increasingly recognised as a conservation problem world-wide.

In the light of concerns about human usage of all three reserves within the Marine Park potentially having adverse impacts upon waterbirds, the Department of Conservation and Land Management sought funding for a study to investigate both human and waterbird usage of the Marine Park. This study aimed to:

- Document patterns of waterbird usage of the marine park;
- Document levels of human activity (including dogs) in the marine park;
- Record disturbance impacts of humans and dogs upon waterbirds;
- Provide recommendations for the management of impacts so that the waterbird conservation values and the recreational values of the Marine Park can be sustained.

This study was carried out from November 2002 to April 2003 and the sampling programme had two main components: six, all-day surveys with observations being made simultaneously at all three reserves from sunrise to sunset, and a programme of targeted surveys to focus on observations of disturbance events. Additional data was sought from community groups active at Alfred Cove and Pelican Point.

For the purposes of the all-day surveys, each reserve was divided into zones and was sampled at regular intervals. On each circuit, waterbirds, people and dogs were counted and their habitat and activity recorded. A total of 194 man-hours was spent conducting 190 circuits, and there were 106,621 waterbird records and 939 person/dog records made. During the all-day surveys, there were 427 disturbance events recorded, involving 9,803 waterbirds. The results of the all-day surveys provided six snap-shots of human and waterbird activity in the Marine Park, and of the sorts of interactions taking place that were affecting waterbirds. The targeted surveys enabled supplementary disturbance observations to be made. Disturbance observations, whether made during the all-day surveys or at other times, involved recording the species, number present, activity, habitat, source of the disturbance, the distance at which the birds altered their behaviour, the distance at which the birds moved away, the distance the birds travelled and the time the birds took to resume their activity.

*Results and Discussion*

The highest count of each waterbird species made in the 2002/2003 survey was compared with highest count from studies carried out in the 1980s and 1990s, and most species were present in numbers similar to or even greater than previously. In cases where the previous highest count was much greater than the highest count made in 2002/2003, the recent value was close to the mean of previous counts. This suggests that the abundance of most waterbird species has not altered in recent decades.

Human usage of the reserves within the Marine Park was not evenly spread across the reserves and included walking (541 records), jet-skiing (82 records), kite-surfing (80 records), dogs (74 records), fishing (64 records), and fewer than 25 records each of kayaking, bird-watching, boating, jogging and cycling.

At Alfred Cove, human activities were observed throughout the reserve but were concentrated in the west, with the main activities being walkers, small boats, kayaks, anglers and kite-surfers. There was a high degree of compliance with the dog fence installed in 2002 as levels of activity on the adjacent pathway were much higher than in the reserve. Pedestrians on the pathway, with and without dogs, exceeded levels of activity recorded on the playing fields at Troy Park, also adjacent to the reserve. Human activities in and around Alfred Cove tended to occur through the middle of the day in the reserve, but mainly in the mornings and afternoons on the pathway.

Milyu also has a pathway running alongside it, but this was used mainly by cyclists commuting to and from work, with only low numbers of pedestrians and dogs. Activity on the pathway was therefore concentrated in the mornings and evenings. Human activity within the reserve was very low, but activity levels were very high immediately to the north, and moderately high to the south. Activity to the north was associated with the PWC (jet-ski) freestyle area, and this area was the main location within the Marine Park where jet-skis were recorded. South of Milyu is a recreational beach associated with Como Jetty. Human activities within the reserve often involved people walking or jogging the entire length of the beach. Human activity in Milyu and on adjacent beaches occurred mainly through the middle of the day.

Pelican Point recorded low numbers of people within the reserve for much of the day, but activity peaked in the late afternoon, consisting mainly of kite-surfers and wind-surfers utilising the launching area and bay west of the reserve under favourable wind conditions. Pelican Point was the main site for kite-surfers and wind-surfers. Almost all wind-surfers and most kite-surfers operated in the open water, but there was some pedestrian activity within the reserve associated with these activities. There was also some usage of the reserve shoreline by kite-surfers for launching and landing. Other activities within Pelican Point included small boats associated with the adjacent Sea Scouts.

People walking along the beach caused the greatest number of disturbance events but was also the most common activity overall. Walkers were often associated with other activities, such as kite-surfers or jet-skis. Activities that caused a disproportionate

number of disturbance events relative to the frequency with which the activity was observed were kite-surfers (Alfred Cove only), boating, kayaking, jogging and fishing. In all cases, these activities were taking place in areas used by birds and the significance of the activity differed between the sites. For example, kite-surfing was frequently recorded at Pelican Point but caused few disturbance events, because the kite-surfers generally stayed in the open water and were only a problem for birds when individuals used the beach for launching or landing. In contrast, kite-surfers at Alfred Cove occasionally worked the shallow water over the mudflats, close to the sand-bars where birds roosted.

The distances at which waterbirds reacted to human activities varied between species and activities of both the birds and the people. In general, inactive birds were more sensitive to disturbance than active birds. Birds most tolerant of disturbance tended to be those that are regularly exposed to high levels of human activity and that are therefore habituated to some degree. Species most sensitive to disturbance were large waterbirds that take time and effort to take flight. Activities that caused the earliest response from birds were boats, kayaks and kite-surfers. Anglers also elicited a rapid response, whereas many birds were tolerant of approach by walkers. The actual distances ranged from mean values of 11m to mean values of 120m. However, a distance of only 50m would be sufficient to minimise disturbance of almost all waterbirds from most sorts of activities except small boats, kayakers and kite-surfers under some circumstances.

The combination of the sensitivity of birds to disturbance, the types of disturbance events that occur and where those events occur relative to where the birds are determines the vulnerability of birds to disturbance. For the Marine Park, a disturbance index was calculated for most species and it was found that for many of these, this index was lower than expected on the basis of the abundance of the birds. This indicated that they were successfully minimising their exposure to disturbance whilst remaining common in the Marine Park. Being able to forage and particularly roost in areas where disturbance levels are low is important for this to happen. The few species with high disturbance indices were not necessarily birds that are particularly sensitive to disturbance, but were birds that through their biology use habitats where they are likely to encounter people. These species forage on or close to shorelines, roost on shorelines and make less use of shallow water and sand-bars than other species. This brings them into contact with the single most abundant disturbance activity, which is people walking along the beach.

*Conclusions and Recommendations*

Observations on human activity and disturbance of waterbirds indicate that people walking on beaches are the main cause of disturbance, but that other activities can be disproportionately disturbing and have the potential to cause problems if they increase in frequency. The study also indicates that critical areas are those where birds are roosting, particularly at Pelican Point. Issues at each reserve and recommendations for future management are presented below.

Alfred Cove.

Levels of disturbance low and human activities concentrated near the western boundary of the reserve. Major problems are people walking or jogging along the beach, with or without dogs, and boats, kayaks and anglers in the vicinity of the sand-bars where waterbirds roost. Kite-surfers are a special problem because a very small number of individuals surf in the shallows between the sand-bars and the shoreline, whereas most other kite-surfers operate in deeper water close to the western boundary of the reserve. The dog fence constructed in 2002 appears to have revolutionised patterns of waterbird and human usage of the reserve and compliance with the fence is very high. Recommendations for Alfred Cove are:

- Pedestrian usage of the beach needs to be controlled through signage and modifications at one of the entry gates.
- The sand-bars are a special feature and roosting birds on these are very prone to disturbance. These are regularly accessed by anglers, small boats, kayaks and walkers, and occasionally by kite-surfers and wind-surfers. Signage aimed at encouraging people not to approach these sand-bars, especially when birds are present, is needed to control the level of activity.
- Community ownership of the reserve needs to be encouraged by acknowledging the cooperation of dog-owners, through informative signage and through a programme of public bird-watching events.

Milyu.

Levels of human usage are low and major disturbance events were limited to the occasional jogger or walker traversing the length of the reserve along the beach. The most important site for waterbirds is actually outside the reserve; the wader roosting beach in Zone 3. This is very close to a major recreational area associated with the PWC (jet-ski) freestyle area near the Narrows Bridge. Recommendations for management at Milyu proposed by Bamford (2002) are currently under consideration by the City of South Perth, Department of Planning and Infrastructure and Department of Conservation and Land Management. These recommendations include:

- Improved signage fencing at the southern boundary of the reserve to make people aware that the reserve exists and to encourage them to leave the beach at that point.
- Signage, plantings, a low barrier and an observation area at the wader roosting beach to make people aware of the significance of the beach and to enable them to see and understand the birds.
- Possible public bird-watching programme to introduce South Perth residents in particular to the value of the wader roosting beach.
- Possible development of a roost site for Red-necked Stints within Milyu Reserve.

Pelican Point.

High levels of human usage in the afternoon that coincide with the peak in waterbird activity, combined with the small area of the reserve, mean that disturbance of waterbirds is a major issue. The most important parts of the reserve for birds are the sand-bar, itself partly outside the reserve, the west-facing beach, which faces the bay used by kite-surfers and wind-surfers, and the lagoon. Disturbance is largely due to pedestrians on the beach

and to people on the beach in association with kite-surfers, but small boats and kayaks that come from the east, including Sea Scouts, are also a problem. Recommendations for Pelican Point are:

- Clear, simple signage to explain to people where important areas for birds are and where people should and shouldn't go. The signs should request that people not walk along the beach in areas important for birds. These should be on the beach at either end of the existing fence and on the beaches facing out into the river.
- A sign and map at the carpark indicating clearly the boundaries of the reserve and the important areas for birds. The sign should request that kite-surfers stay 50m clear of the west facing beach of the reserve.
- Assistance should be sought from stakeholders in the area, kite-surfing clubs, Sea Scouts and the Royal Perth Yacht Club and Mounts Bay Sailing Club to help publicise the importance of the beach and involve them in the management of the area.
- The existing fence should be modified to prevent casual entry into the reserve, such as by dogs, but to encourage controlled entry. For example, a self-closing gate could lead to a path and/or boardwalk that would guide people away from the beach to a vantage point on the reserve from where they can see the pond and roosting birds on the beach. Such controlled entry would only work with greatly improved, informative signage so that regular users of the area understood the right way and the wrong way to enter the reserve.
- The possibility of enhancing the value of the lagoon for roosting by Red-necked Stints should be examined. This is only used when the water level is low, so the creation of a sandy shoreline along one side of the lagoon that remained at high water levels would give the birds a dependable roost site.

<u>In General.</u>

There is a poor understanding within the community of what the birds are, why they are important and what disturbing the birds involves. This can be corrected through positive signage and ongoing publicity. Ultimately, successful management of the reserves will depend upon the human users of the river valuing the birds, understanding their needs and wanting to help protect them.

**Acknowledgements**

Many hours were spent in the field by our dedicated survey team:
Wes Bancroft, Michael Craig, Robert Davis, Brenden Metcalf, Kevin Fairbairn, Maureen Francesconi, Jennifer Wilcox, Mike Bamford, Mandy Bamford.

In addition to the survey team, a number of other people contributed their time, expertise and observations to this study. We are grateful to the following people for their help, ideas and information:
Max Bailey, Charles Meriam and members of Birds Australia, Ian Lane (Pelican Point Windsports), Lindsay Lloyd and the Friends of the Attadale Foreshore, Kylie Ryan and other officers from the Department of Conservation and Land Management, Ian Young (WinDesigns Australia), Joshua Bamford, Nathan Ducker, Shannon Matthews and Natalie Warburton.

## CONTENTS



Tables and Figures

## INTRODUCTION

The Swan Estuary Marine Park (SEMP) is Class A Marine Reserve No 4 and consists of three separate reserves on the estuary of the Swan River: Alfred Cove, Milyu and Pelican Point. These marine reserves encompass estuarine shallows and the shoreline to either the low water mark (Pelican Point) or the high water mark (Milyu and Alfred Cove), but in all cases there are adjacent nature reserves that effectively extend protection onto the adjacent foreshore.

The Marine Park is part of the Swan-Canning Estuary that is listed in A Directory of Important Wetlands in Australia (ANCA 1993). The major reason for this listing is the importance of the estuary for waterbirds, and the three marine reserves are the key to waterbird usage of the area. Alfred Cove is listed by Van Delft (1997) and had more waterbird species than any other wetland in the Perth area, while in the 1970s Pelican Point was described as "the finest sanctuary [for waterbirds] to be found in any city in the world" (Serventy and Raymond 1974). In a survey conducted in the 1980s, Alfred Cove was ranked first for the number of species out of 197 wetland reserves in the South-West, and 10$^{th}$ out of 285 reserves for the highest number of individual waterbirds (11,443) in any one count (Jaensch *et al.* 1988). In the same study, Milyu ranked 22 for the number of species and 51 for the highest single count. Pelican Point was not surveyed.

The three reserves that make up the SEMP have remained important for waterbirds despite their location within a large and growing city, but some changes have been documented. Bailey and Creed (1989) and Creed and Bailey (1998) have reported declines in numbers of waterbirds recorded at Pelican Point in weekly surveys that have been carried out since the late 1970s, but similar declines in overall waterbird abundance have not been reported from Milyu or Alfred Cove. Some species have declined throughout the Marine Park, however. The Sharp-tailed Sandpiper was recorded in its thousands in the late 1950s and early 1960s (Serventy *et al.* 1962), but subsequent counts have rarely exceeded 100 birds (Australasian Wader Studies Group, unpub. data). This decline was probably due to the loss of salt marsh habitat due to foreshore development on Burswood Island and Mounts Bay. Numbers of some other sandpiper species have also declined, although not so dramatically, but it is possible that these changes are artefacts of infrequent sampling or due to global population changes in these migratory species, as appears to be the case with the Curlew Sandpiper (Wilson 2001). Such global changes can be due to natural events and to human activities elsewhere within the range of migratory species.

The loss of salt marshes in Mounts Bay and on Burswood Island in the early 1960s was the last period of major habitat loss for waterbirds on the Swan – Canning Estuary that may have affected waterbird abundance in the Marine Park. Impacts upon waterbirds at the local scale still occur, however, and a concern that has been identified is the conflict that can take place between waterbirds and human usage of the estuary in general and the Marine Park in particular. Disturbance of waterbirds is emerging as a major conservation issue worldwide (Davidson and Rothwell 1993), and the location of the Marine Park means that some disturbance is inevitable. Anecdotal reports, particularly from bird-

watchers and members of Birds Australia (the Royal Australasian Ornithologists Union), suggest that disturbance of waterbirds within the Marine Park has been a concern since at least the 1980s. Consistent with this, the majority of responses to a draft management plan for the Marine Park concerned disturbance of waterbirds by jet skis, boats, windsurfers and domestic pets (Department of Conservation and Land Management 1996).

In response to concerns about disturbance of waterbirds, mainly from recreational activities, the Department of Transport instigated an investigation into the impact of personal watercraft (jet skis) on waterbirds at Milyu (Bamford and Bamford 1999), and a management plan for waterbirds at Milyu in relation to the operation of personal watercraft was prepared in 2002 (Bamford 2002). The earlier study found waterbirds to be tolerant of personal watercraft as long as the vessels did not land on the beach where the birds were roosting, but recorded disturbance to birds by people watching the personal watercraft. The management plan proposed measures to minimise this disturbance and emphasised the importance of understanding local patterns of movement of waterbirds between the three reserves within the Marine Park, driven largely by tidal changes.

At Alfred Cove, disturbance of waterbirds by dogs was debated at the community level and resulted in a local community group (The Friends of the Attadale Foreshore) and the WA Department of Conservation and Land Management successfully applying for funding to erect a low fence to separate a dog exercise area from the Marine Park. This fence was erected in winter 2002. Meanwhile, despite the presence of a tall fence and locked gate since the late 1970s, birdwatchers reported that levels of human activity within Pelican Point were so high that waterbird numbers were the lowest on record (M. Bailey and C. Meriam, pes. comm.).

With growing concerns about human usage of all three reserves within the Marine Park potentially having adverse impacts upon waterbirds, the Department of Conservation and Land Management sought funding for a study to investigate both human and waterbird usage of the Marine Park. This study was carried out from November 2002 to April 2003 and aimed to:

- Document patterns of waterbird usage of the marine park;
- Document levels of human activity (including dogs) in the marine park;
- Record disturbance impacts of humans and dogs upon waterbirds;
- Provide recommendations for the management of impacts so that the waterbird conservation values and the recreational values of the Marine Park can be sustained.

This report documents the findings of the study.

## METHODS

### Site Descriptions

The general locations of the three reserves that make up the Swan Estuary Marine Park are show on Figure 1. For the purposes of the study, each reserve was divided into a number of zones. These zones were based largely upon features of the shoreline and points from which observations were made, and are indicated on Figures 2, 3 and 4. Note that at all three sites there were zones outside the reserve that were either important for waterbirds (eg Milyu) or for people, and that zones extended onto adjacent foreshore areas, outside the reserves, in some cases. Overlying the zones, a 250m grid, based upon AMG coordinates, was used so that disturbance events and concentrations of waterbirds could be more specifically located than through the use of zones. This grid is also indicated on Figures 2, 3 and 4.

Alfred Cove is the largest of the three reserves and contains extensive tidal mudflats (Figure 2). A series of sandbars marks the edge of these mudflats but shallow water extends across the mouth of the cove to the eastern shore. Previous studies have demonstrated that waterbirds concentrate on the mudflats, shallows and sandbars. The reserve actually occupies most of Lucky Bay, with Alfred Cove itself only a small area of sheltered, relatively deep water in the south of the reserve. Except around the actual cove, where there is a salt marsh backed by paperbark trees, fringing vegetation is narrow. The dog fence installed in 2002 follows the reserve boundary for most of its length, and a dual use pathway runs along this but bypasses Troy Park. There are sporting fields to the east of the reserve and at Troy Park, while from opposite Burke Drive to the western end of the reserve is a dog exercise area. Surveys concentrated on the mudflats and the sheltered cove as indicated by the distribution of survey zones in Figure 2.

Milyu lies alongside the Kwinana Freeway and contains moderately extensive mudflats that are only exposed during very low tides (Figure 3). Previous studies have found that waterbirds are attracted to the mudflats when water levels are low, that roosting occurs on the point in Zone 6, but that the major roosting beaches for waterbirds and especially waders lie to the north of the reserve (Zone 3, see Figure 3). Personal watercraft operate from the beach in Zone 1 and a personal watercraft free-style area lies adjacent to Zones 1, 2 and 3. There is some passive recreation around Como Jetty (the southern end of Zone 8), and a dual use pathway lies between the freeway and the foreshore. The only barrier between the pathway and the beach, and at either end of the actual reserve, is a low, post and single rail fence.

Pelican Point is the smallest of the three reserves and contains mudflats along the southern shore that are exposed only at very low tides (Figure 4). The main features of the reserve for waterbirds are a sandy spit that extends beyond the point and is exposed except at high tide, and a brackish pool that lies within the point in Nature Reserve 40891. Much of the sandy spit appears to be outside the reserve. Adjacent to this reserve there is development including yacht clubs and Sea Scout headquarters. Immediately

west of the reserve is a carpark and recreation area where commercial and amateur windsurfers and kitesurfers are based, sailing mainly within Zone 4. Nature Reserve 40891 is fenced with a 2m cyclone wire fence on its landward side, and this extends into the river. The only access is via a locked gate. Despite this, the fence is regularly breached, either through holes or by people wading or sailing around it.

## Survey Programme

This study was based around six, all-day surveys when observations were made simultaneously at Alfred Cove, Milyu and Pelican Point. Each survey began at sunrise and continued until after sunset when it was no longer possible to see birds and when human activity had more or less ceased, and the survey involved making repeated circuits of the reserve, recording waterbirds, people, dogs and disturbance events as outlined below. These all-day surveys took place on 25th November 2002 and 4th January, 27th January, 27th February, 17th March and 29th March 2003. The 4th January, 27th January and 29th March were on weekends or public holidays, with other days being during the working week. The 27th January was the public holiday after the Australia Day fireworks show held on the Swan River on the evening of 26th January. Details of each survey day are presented in Table 1. Each circuit provided a snapshot of waterbird and human levels of abundance and activity at each reserve, and numbers were generally pooled for each zone.

In addition to the main survey days, some supplementary observations were made to target periods when high levels of human activity were likely to lead to disturbance of waterbirds. These supplementary surveys took place mainly at Pelican Point as at the other reserves, levels of human activity were generally so low that disturbance events were rare.

During the all-day surveys, the approach varied slightly between the reserves as follows:

Alfred Cove. Counted at intervals of 1 to 1.5 hours, depending on how long it took to complete each circuit. During each circuit, waterbirds, people and dogs were counted in each zone and their activity and habitat usually recorded (see below for descriptions of activities and habitats). These counts in the zones included people and dogs on the adjacent pathway and lawn behind the dog fence. In addition, between each circuit a 15 minute count of people and dogs on the dual use pathway at the boundary between Zones 2 and 3 was made. Disturbance events were recorded opportunistically (see below). Details of circuits carried out on each survey day are given in Table 1. There were totals of 53 circuits and 75 hours spent carrying out observations at Alfred Cove during all-day surveys, and one targeted survey of about 2 hours when disturbance observations were made (19th December 2002). Additional observations made on human activities in the reserve were provided by the Friends of the Attadale Foreshore (L. Lloyd pers. comm.).

Milyu. Counted at intervals of 1-1.5 hours, depending on how long it took to complete each survey. During each circuit, waterbirds, people and dogs were counted in each zone and their activity and habitat usually recorded (see below for descriptions of activities and habitats). These counts did not include people and dogs on the adjacent pathway as most of the traffic on the pathway consisted of commuting cyclists moving so quickly that it was not possible to count them and observe waterbirds at the same time. In addition, between each circuit a 10 or 15 minute count of people and dogs on the dual use pathway in Zone 1 was made. Disturbance events were recorded opportunistically (see below). Details of circuits carried out on each survey day are given in Table 1. There were totals of 53 circuits and 77 hours spent carrying out observations at Milyu during all-day surveys. No successful targeted surveys were carried out.

Pelican Point. Counted at intervals of 1 hour. During each survey, waterbirds and people were counted in each zone and their activity and habitat usually recorded (see below for descriptions of activities and habitats). In contrast with Alfred Cove and Milyu, the total counts took only 20-30 minutes, so time between counts was spent observing waterbird and human activity to the south of the reserve, where most windsurfers and kitesurfers operated. Disturbance events were recorded opportunistically (see below). Details of circuits carried out on each survey day are given in Table 1. There were totals of 84 circuits and 42 hours of observations carried out at Pelican Point during all-day surveys, with an additional 20 hours of targeted surveys carried out on 4th, 24th and 29th November, 12th December and 14th March. In addition, observations on human activities made by birdwatchers who visit Pelican Point on a weekly basis were provided (M. Bailey and C. Meriam pers. comm.).

**Activity and Habitat Recording**

For most waterbird and all human observations, activity and habitat were recorded and categories used are described below.

Activity - waterbirds

Waterbirds were described as being Active or Inactive. Active waterbirds were foraging for food or moving around. Inactive waterbirds were perched, such as on a post, standing on the shore or in shallow water, or sitting on the water but not obviously foraging. 'Inactive' included birds that were preening.

Activity - people

Activities of people were recorded in detail, with activities including: walking, jogging, cycling, windsurfing, kitesurfing, jetskiing, fishing and boating. Minor activities (those very rarely recorded) included people on rollerblades, scooters and wheelchairs. Walkers and cyclists were often recorded with dogs. People (and dogs where applicable) were recorded in their group sizes but numbers were generally pooled for each zone for the analysis of levels of activity.

Habitats

Habitat categories were used for waterbirds and people where applicable. Habitat categories were:

Open Water – water in which birds (or people) could not stand.

Shallow Water – water in which the birds (or people) were clearly standing.

Water's Edge – used for birds feeding right on the edge of the water, but including birds feeding on damp mud exposed by low tide.

Shore – used for birds on the shore but back from the water's edge, and for people walking along the beach.

Samphire – salt marsh habitat, especially in Zones 5 and 6 of Alfred Cove.

Pool – pools within salt marsh habitat, including the pool within Zone 2 of Pelican Point.

Perch – any post or rock on which birds could perch.

Path- at Alfred Cove and Milyu, the dual use pathway adjacent to the reserve.

Grass – lawn areas adjacent to the reserve, including Troy Park at Alfred Cove.

## Observations on Disturbance

Disturbance of waterbirds involves any event that alters the birds' behaviour. Disturbance events were recorded opportunistically during all-day surveys at each reserve, with supplementary observations made at Pelican Point and Alfred Cove. Key features recorded during each event were as follows:

- Time;
- Location (zone and quadrat);
- Waterbird species and number of individuals;
- Activity of waterbirds;
- Habitat of waterbirds;
- Source of disturbance (activity of person or people, presence of dog or dogs, habitat);
- Distance at which behaviour of birds altered (when feeding or roosting birds became alert);
- Distance at which birds took evasive action and nature of that action (walked or swam away, took flight);
- Distance birds travelled; and
- Time when birds resumed previous activity.

Note that not all these parameters could be recorded on every occasion.

## Summary of Sampling Regime

Six all-day surveys were carried out at each reserve, during which total counts (circuits) took place at approximately hourly intervals to provide regular snapshots of waterbird and human activities. Targeted surveys took place on other days at Pelican Point and once at Alfred Cove to provide additional disturbance data.

Alfred Cove - On each of the six all-day surveys, regular counts (circuits) of waterbirds, people and dogs in each zone and on the foreshore adjacent to the zone, with habitat and activity recorded. Between these total counts, 15 minute counts of human usage of the dual use pathway. Disturbance events recorded opportunistically during and between circuits.

Milyu - On each of the six all-day surveys, regular counts (circuits) of waterbirds, people and dogs in each zone, with habitat and activity recorded. Between these total counts, 10 minute counts of human usage of the dual use pathway. Disturbance events recorded opportunistically during and between circuits.

Pelican Point - On each of the six all-day surveys, regular counts (circuits) of waterbirds, people and dogs in each zone, with habitat and activity recorded. Disturbance events recorded opportunistically during and between circuits. Targeted surveys carried out on other days to observe disturbance events and human impacts upon waterbirds.

## Study Limitations

Surveys of waterbirds and people were readily undertaken, requiring only a moderate to high level of skill in waterbird identification and a rigorous approach to recording observations. Recording disturbance events was more difficult. At Alfred Cove and Milyu, the size of the reserves meant that events could occur when the observer was not present, so some records were incomplete. At Pelican Point, the numbers of waterbirds present was generally very low so despite high levels of human activity on many occasions, there were often no birds present to be disturbed. This implies, but does not prove, that ongoing disturbance by people has resulted in low waterbird usage of Pelican Point.

## Study Personnel

Field surveys were carried out by operating shifts so that surveys were continuous but individual surveyors were able to take a break or at least move to another reserve. Surveyors were: Dr M. Bamford (all reserves), Dr M. Craig (Alfred Cove and Milyu), Mr R. Davis (Pelican Point and Milyu), Mr B. Metcalf (Milyu), Mr W. Bancroft (Milyu), Ms J. Wilcox (Pelican Point), Mrs M. Bamford (Pelican Point and Alfred Cove), Mr J. Bamford (Pelican Point and Alfred Cove), Mrs M. Francesconi (Alfred Cove) and M K. Fairbairn (Alfred Cove). Database management was carried out by Mr W. Bancroft and report preparation by Dr M. Bamford, Mrs M. Bamford and Mr W. Bancroft.

### Presentation of Results and Discussion

Results and observations are presented and discussed in the following sections:

Counts of waterbirds and people

- Maximum counts of waterbirds (all species pooled), people and dogs at each reserve. These values allow for broad comparisons to be made between the reserves and for comparisons to be made with past maximum counts of waterbirds.
- Counts of waterbirds (all species pooled), people and dogs in each circuit in each reserve, compared with the water level during each all-day survey. These values examine the diurnal patterns of abundance of waterbirds and people, and the influence of the tide. Differences between weekdays and weekends can also be considered.

The distribution of waterbirds and people

- The distribution of waterbirds and people across the survey zones at each reserve.
- The distribution of activities of people using each reserve.

Disturbance of waterbirds by people

- The number of disturbance events recorded in each reserve, presented for each circuit of each all-day survey, and a summary of the number of disturbance events caused by different human activities related to the number of such activities.
- Impacts of disturbance, presenting information on the distances at which human activities disturbed different waterbird species.

The presentation and discussion of these results is followed by a general discussion, conclusions and recommendations.

## RESULTS AND DISCUSSION

### Maximum Counts of Waterbirds

The highest count of each waterbird species made in any circuit is presented for Alfred Cove, Milyu and Pelican Point in Table 2. Alfred Cove supported the largest numbers of species and individual waterbirds, with almost all species recorded in higher numbers at Alfred Cove than at the other two reserves. The greatest exception to this was the Little Pied Cormorant where the highest count was made at Pelican Point. A few of the more abundant species had roughly similar counts at two or even all three reserves, reflecting the daily movements of birds between the sites related to tidal movements reported by Bamford 1999). These included the Red-necked Stint, Black-winged Stilt, Grey Plover, Red-capped Plover and Fairy Tern. On some occasions during surveys, movements of birds between the reserves were observed.

In many cases, the maximum counts at Alfred Cove were similar to or exceeded those recorded during previous studies of the Marine Park. In particular, numbers of swans and ducks were high and there was a massive count of 4000 Little Black Cormorants compared with the previous maximum of only 1000. In contrast, the Eurasian Coot was absent while sandpipers with previous maxima of hundreds or even thousands were recorded in only low numbers.

Such differences may have little meaning when comparing maximum counts obtained in a single year with maximum values taken from counts collected over many years. For example, Coots are unusual on the Swan Estuary so the previous high count was probably a rare event. High numbers of ducks and swans, however, have been reported widely in the South-West in 2002/2003, probably due to the movement of birds away from ephemeral inland wetlands. The maximum count of the Red-necked Stint (1236), while much lower than the previous maximum of 10,000, is actually similar to the mean of 14 summer counts (1198) reported from 1980 to 1997 (Australasian Wader Studies Group unpubl. count data). Apparently low counts of the Red Knot (40 compared with a maximum of 200 but a mean of 6.3) and Curlew Sandpiper (201 compared with a maximum of 1276 but a mean of 168.3) are also similar to mean values from the 1980s and 1990s, with high counts rarely reported. Exceptions may be the Bar-tailed Godwit (1 compared with previous maximum of 250 and a mean of 11.5) and Great Knot (20 compared with 340 and a mean of 57.5).

Overall, the impression gained from the maximum counts recorded in this study is that waterbird numbers are broadly similar to those recorded in the 1980s and 1990s. This suggests that the clearly documented decline in waterbird numbers at Pelican Point (Creed and Bailey 1998) is a local rather than a regional effect, and that the Marine Park as a whole is maintaining its value for waterbirds.

## General Counts of People and Dogs in the Reserves

Measures of the abundance of people and dogs are presented in Tables 3a and 3b, and Table 6, to allow for comparisons to be made between the three reserves. These measures are the maximum count in any circuit and the percentage of circuits in which a particular activity was recorded. Records are from the river and shoreline only (excluding data from pathways and lawns), are divided by activity, and differentiate between records within each reserve and in zones outside the reserve but also on the shore or in the river for Alfred Cove and Milyu. There are clearly very great differences in the ways that people used the three reserves and adjacent areas.

Anglers were present in all reserves and were mainly saltwater fly fishers working the deep water on the edge of sandbanks, particularly at Alfred Cove. They were recorded in their greatest numbers at Alfred Cove within the reserve (Table 3a). They were present in the reserve on over 20% of circuits at Alfred Cove but were infrequently recorded elsewhere (Table 3b).

Boats were occasionally seen in large numbers (up to 7) in Pelican Point (Table 3a); these were small yachts from the adjacent Sea Scouts. The percentage of circuits in which boats were recorded, however, was uniformly low across the reserves (Table 3b).

The maximum number of dogs seen within or outside the reserves but on the river was low (Table 3a), whereas dogs were present for much of the day and in large numbers (an average of 15/hour) on the adjacent pathway at Alfred Cove. Despite the low number of dogs within the reserves, there was considerable variation in the percentage of circuits on which dogs were recorded, ranging from 1.2% of circuits in Pelican Point to 37.7% in zones outside Milyu (Table 3b). These were mainly in Zone 8, near Como Jetty (Figure 13). The percentage of circuits on which dogs were recorded was higher outside than inside the reserve at Alfred Cove and especially at Milyu. At Alfred Cove, the Friends of the Attadale Foreshore reported dogs within the reserve on 3 of 18 visits (16.7% of visits), which falls between the percentage of circuits with dogs in the dog beach area (Zone 7, 18.9% of circuits) and within the reserve (11.3% of visits).

Jetskis, kitesurfers and windsurfers were present in large numbers and in a high proportion of circuits in some areas, but were very unevenly distributed. Jetskis were seen mainly in Zones 1 and 9 outside Milyu Reserve and were present on a third of circuits. They were very uncommon at Alfred Cove and Pelican Point. In contrast, kitesurfers were seen mainly at Pelican Point and were present on nearly 17% of circuits. The maximum count of 18 kitesurfers during one circuit at Pelican Point was exceeded by a count of 23 made during a targeted survey, although both these high counts probably included kitesurfers moving between Zones 4 and 5, and therefore outside the reserve for part of the time. A mean of 7 kites/visit was determined by C. Meriam (unpubl. data) from 11 surveys carried out on Tuesday afternoons in January, February and March 2003. The number of kites on these surveys ranged from none to 13. The number of circuits in which kitesurfers were recorded was lower than might be anticipated on the basis of these afternoon records, but it was noted during all-day surveys that kitesurfers usually only came to Pelican Point in the afternoon when favourable winds were blowing. Kitesurfers were uncommon at Alfred Cove with counts of up to 3 within the reserve reported by the Friends of Attadale Foreshore, and they were present on 2 of 18 visits (11.1%) carried out by that group, which is a higher rate than recorded during circuits of the present study. At Alfred Cove, however, kitesurfers seen within the reserve were in the main areas used by waterbirds, especially Zone 3, whereas at Pelican Point, Kitesurfers were usually in Zone 4 and often outside the reserve in Zone 5.

Windsurfers were seen mainly at Pelican Point and were present on a quarter of circuits. They were always in Zones 4 and 5. They occurred in the reserve at Alfred Cove when windsurfers operating on the eastern side of Lucky Bay either deliberately or accidentally came across to the reserve under an easterly wind. These incidents included windsurfers who landed on the sandbars that were important roosting sites for waterbirds.

Pedestrians were present at all reserves and included people having picnics on the beach, people watching jetskis, kitesurfers or windsurfers, and kitesurfers who were either setting up or were blown ashore on the beach at Pelican Point. Only one prawning party

was recorded throughout the study, in Zone 7 (outside the reserve) at Alfred Cove. Pedestrians were in their lowest numbers and lowest percentage of circuits in the reserve at Milyu and at Pelican Point, although the low percentage of circuits at Pelican Point is deceptive as activity was noted to often be concentrated in the late afternoon.

The high maximum count of pedestrians at Milyu outside the reserve was due almost entirely to people in Zone 1 (the beach from which jet-skis operate), while the high maximum count in the reserve at Alfred Cove was due to a single large family having a picnic on the beach in Zone 1, with the next highest count being only 8. The percentage of circuits in which pedestrians were recorded appeared to be similar in Alfred Cove inside and outside the reserve, but most records within the reserve were actually in Zone 1 and pedestrians were rarely seen in other zones (see Table 5). People were present at Milyu outside the reserve on over half of the circuits.

Overall, levels of usage of the reserves by people were high at Pelican Point and low at Milyu, although with high levels of activity in Zone 1 to the north of Milyu Reserve. Levels of usage were moderate at Alfred Cove with activity concentrated in the west of the reserve.

**Diurnal patterns in Waterbird Abundance and Human Usage of the Marine Park**

Figures 5 to 10 present the circuit counts of waterbirds, people and dogs made on each survey day for Alfred Cove, Milyu and Pelican Point, and the levels of pathway activity between each circuit for Alfred Cove and Milyu. These illustrate diurnal patterns of variation in abundance and are also related to the water level on each day (Figure 11).

On 25th November (Figures 5 and 11), waterbird numbers were high in the early morning and late afternoon at Alfred Cove, peaked slightly in the middle of the day at Milyu but were high only in the late morning at Pelican Point. Alfred Cove supported more waterbirds throughout the day than either of the other reserves. The water level was very low for most of the day, and notes made during surveys suggested that Red-necked Stints in particular left Alfred Cove as the mudflats began to dry out, flying to the other reserves where the mudflats are only briefly exposed at such low water levels. Levels of human and dog activity were bimodal at Alfred Cove, with numbers highest in the mornings and late afternoon, were low throughout the day at Milyu (although there were no pathway records on this survey) and increased slightly in the late afternoon at Pelican Point. Although a small rise in human activity compared with the levels seen throughout the day at Alfred Cove, this rise consisted mainly of kitesurfers. The 25th November was a weekday and levels of human activity were clearly highest before and after work.

The 4th January (Figures 6 and 11) was a weekend with a gradually rising tide through much of the day, and the Alfred Cove mudflats were never fully exposed. Waterbird numbers initially rose at all three sites until mid-morning, suggesting that they had been outside the Marine Park overnight and early in the morning. Bamford (1999) has suggested that sandpipers, including the Red-necked Stint, may roost around the lakes on

Rottnest Island at night and commute between these lakes and the SEMP when tidal regimes provide suitable foraging habitat on the estuary. Following this morning peak, numbers declined at Alfred Cove as the tide rose and water depth increased over the mudflats, the water eventually flooding the sandbars where many birds roosted. At Milyu and Pelican Point, waterbird numbers were highest late in the day, but numbers at Pelican Point in particular were variable. Waterbird numbers at Pelican Point may have been affected by high levels of human activity through the middle of the day and into the afternoon, and the sharp fall in waterbird numbers around 17:00 hours was due to birds being disturbed by kitesurfers walking on the beach. Waterbirds, and especially waders such as the Red-necked Stint, are known to gather at Pelican Point in the late afternoon and will roost around the shoreline of the pond if this is available. In 2002/2003, the water level in this pond was generally too high for birds to roost there.

Levels of human activity at Alfred Cove were less clearly bimodal on 4th January than 25th November, presumably because the 4th January was on a weekend. There was a sharp fall in the hourly rate of activity on the pathway in the early afternoon, correlating with high temperatures, but the circuit count, which included people having picnics, seated in the shade and engaged in water-based activities, displayed no clear patterns across the day. At Milyu and Pelican Point, human activity levels were high from late morning to late afternoon, due to a broad period over which people were engaged in water-based activities. The peak was earlier at Milyu than at Pelican Point, probably because the afternoon sea-breeze creates conditions unfavourable for jet-skies, the main activity at Milyu, but favourable for kite-surfing and wind-surfing, the main activities at Pelican Point.

The 27th of January (Figures 7 and 11) was also a holiday, being the day after the Australia Day fireworks. Despite the high levels of disturbance that must have occurred at all three reserves overnight, numbers of waterbirds were high from early in the morning at Alfred Cove, with numbers gradually declining throughout the day. This corresponded with low tide at around sunrise when the mudflats were exposed. The rise in waterbird numbers at Milyu in the early afternoon was particularly dramatic and was due mainly to Red-necked Stints departing from Alfred Cove when the water over the mudflats became too deep for them to forage. As on the 4th January, waterbirds attempted to gather at Pelican Point in the late afternoon, but there were problems with disturbance and flocks were seen to arrive and depart regularly.

Human activity levels at Alfred Cove on 27th January, based only on circuit counts, displayed an early afternoon trough. At Milyu, pathway activity (mainly cyclists) was highest in the morning and afternoon, whereas activity within the reserve was highest across the middle of the day, when jet-skies were most active. Human activity levels at Pelican Point were initially low and then moderate but peaked sharply in the late afternoon, just when waterbirds were gathering at the reserve.

The 27th February (Figures 8 and 11) was a weekday with a very low tide through most of the day. Numbers of waterbirds at Alfred Cove and Milyu were mirror images, gradually rising at the former and declining at the latter until a sharp drop in numbers at Alfred

Cove reflected by a sharp peak at Milyu in the afternoon. These changes corresponded to the rising tide. Waterbird numbers at Pelican Point displayed the usual evening peak, but were also high through most of the morning. The high numbers present in the morning at Pelican Point were dominated by Little Black Cormorants and Silver Gulls roosting on the sandbar.

Levels of human activity at Alfred Cove and Milyu were strongly bimodal, presumably because most people were at work through much of the day, with little activity associated with water-based activities. This bimodality was particularly pronounced with the pathway activity at Milyu, where most recorded consisted of commuting cyclists. At Pelican Point, however, the pattern of human activity was similar to that seen on 27th January, with an increase in the late afternoon when kitesurfers and windsurfers came to the area after work and conditions were presumably favourable for them. The decline in waterbird numbers in the late morning and early afternoon occurred when human activity levels were moderate, but the decline occurred when almost all Little Black Cormorants were disturbed from the sandbar by a single pedestrian.

The 17th and 29th March (Figures 9, 10 and 11) were a weekday and weekend respectively but patterns of abundance of waterbirds and people varied in some respects from those seen during earlier surveys. Waterbird numbers showed some extreme fluctuations at Alfred Cove (29th March) and Pelican Point (both days), and these fluctuations were due largely to the movement of roosting cormorants. At Alfred Cove, the sharp peak in numbers in the middle of the day was due to Little Black Cormorants that had initially been feeding and then roosted on a sandbar, before flying out of the reserve. Their departure was associated with the arrival of a small boat that came to within 100m of the sandbar. Roosting cormorants also contributed to the gradual increase in waterbird numbers at Milyu on 17th March. The 29th March was unusual because there was no low tide, while there was only a brief low tide on 17th March. The low waterbird numbers (except for cormorants) was due to the virtual absence of small waders that were unable to forage because of the lack of shallow water or mudflats.

Levels of human activity on both the 17th and 29th March were influenced by weather conditions because the sea breeze was weak on both occasions. At Alfred Cove, human activity was approximately bimodal on both days. At Milyu, pathway activity was not recorded in the morning of 17th March, but peaked in the afternoon as cyclists headed home from work, while on 29th March numbers were more or less consistent throughout the day as expected for a weekend. The peak early in the morning was due to a cycling club of over 100 members passing through the survey area. There was virtually no jet-ski activity even on the weekend survey. The distribution of human activity was also unusual at Pelican Point, with low levels on both days. This is consistent with unfavourable wind conditions for kitesurfers and windsurfers. There was no evening influx of waterbirds at Pelican Point on either of these days, probably because this influx consists largely of Red-necked Stints and their numbers were low on both days.

Despite a lot of variation, some common patterns in the diurnal distribution of waterbirds and human activities did emerge. On days when the tide was low but increased,

waterbird numbers peaked at Alfred Cove early in the morning and declined as the birds (especially Red-necked Stints) moved away. The decline in numbers at Alfred Cove corresponded with an increase at Milyu and to some extent Pelican Point. Numbers tended to peak at Pelican Point later in the day, but fluctuated widely because this often coincided with high levels of human usage, with disturbance recorded on a number of occasions.

Patterns of human usage were generally predictable, with greater bimodality of pathway activities (pedestrians, dogs and cyclists) on weekdays than on weekends, and higher levels of water-based activities on weekends. Water based activities at Milyu centred around jet-skiing, which actually takes place north of the reserve with activity levels falling in the afternoon when the sea-breeze increases in strength. At Pelican Point, water-based activities consisted mainly of windsurfing and kitesurfing that take place in the afternoon when the sea-breeze is strongest, and therefore can occur on both weekdays and weekends. In the absence of a sea-breeze, levels of human activity were low at Pelican Point.

The different diurnal patterns in human activities at the three reserves are apparent by pooling all records from the six all-day surveys (Figure 12). At Alfred Cove, overall activity peaked in the mid-afternoon, while activity peaked in the later morning at Milyu. Pelican Point had the lowest levels of activity of all the reserves in the morning, with no records of people or dogs at all in three of the first four hours of the day across the six all-day surveys, but had high numbers of records from mid to later afternoon.

**The Distribution of Waterbirds and People within each Reserve**

The overall distribution of waterbirds, people and dogs across the zones in each reserve is illustrated in Figure 13. This includes records from the pathway at Alfred Cove. The distribution of records of people and dogs at Alfred Cove, excluding pathway and lawn observations and pooled for each zone, is presented on Table 5. Records excluding those from the pathway and lawns are for people and dogs on the shore or in the river, and therefore where they are likely to impact upon birds.

At Alfred Cove, waterbirds were concentrated in Zone 3, where birds can roost on sandbars and forage across the tidal mudflats. There were also large numbers of records in Zones 2 and 4. The number of records in Zone 2 is interesting, as anecdotal accounts from birdwatchers suggest this zone was previously little-used by waterbirds. The apparent change in usage of Zone 2 may be related to the introduction of the dog fence and the reported (anecdotally) decline in dog numbers in the reserve within this zone. Unfortunately, however, no data were systematically collected to document this change. Many of the waterbirds in Zone 2 were visiting a freshwater soak only about 30m from the dual use pathway.

At Milyu, waterbirds were concentrated in Zone 3, where Red-necked Stints in particular roost, and Zone 7, where a wide range of birds foraged on the mudflats (see Figure 3). At

Pelican Point, waterbird numbers were high only in Zone 1 (the pond) and Zone 3 (the south-facing beach, see Figure 4). Numbers would have been much higher in Zone 1 if the water level in the pond had been low, as under such conditions the pond is important for roosting by Red-necked Stints (M. Bamford pers. obs.).

Numbers of people and dogs were concentrated in Zones 1, 2 and 7 at Alfred Cove, with most records being on the pathway. The lower number in Zone 7 compared with Zones 1 and 2 is because many people arrive and depart from the path at the western end of the reserve. People at Zone 3 were mainly on the lawns of Troy Park. Excluding pathway and lawn data (Table 5), gives a different picture of the distribution of dogs and people, with almost all dog records in Zones 1 and 7, and people also concentrated in these zones. Most of the people in Zone 1 were only just into the reserve. The fairly high count in Zone 3 (21 records of people across the six survey days) was due largely to pedestrians walking across the mudflat (8 records), but there were also anglers, kayakers, wind-surfers and one kite-surfer. The low numbers of people and dogs in Zones 2 and 4 are encouraging.

At Milyu, most people were in Zone 1 and were watching jet-skis in Zone 9 (Figure 13). There were also small numbers of people in Zone 8, where almost all dog records occurred (30 out of a total of 35). The marked difference between numbers of people and dogs in Zone 8 (south of the reserve) compared with numbers in Zone 7 (the southernmost zone within the reserve) reflects a high level of compliance with the reserve boundary.

At Pelican Point, most people were recorded in Zones 3 and 4 (Figure 13). Across the six all-day surveys, there was only one dog recorded in Zone 3, one in Zone 4 and two in Zone 5. However, fresh dog footprints were seen on the beach in Zone 3 on every visit, suggesting that dogs enter the reserve more regularly than the number of records suggests. One possibility is that unaccompanied dogs enter the reserve at night.

**Human Usage of the Dual-Use Pathway at Alfred Cove and Milyu**

The dual-use pathway at Alfred Cove runs parallel to the shoreline from west of the reserve to opposite Haig Road, from where it runs alongside Burke Drive. In Zones 1 and 2, the pathway therefore runs alongside the dog fence between the reserve and the dog exercise area, while in Zone 7 it runs alongside the dog exercise beach. The distribution of people along the path by zone and with time of day were examined above, but the following section examines the distribution of the various activities in the sample of people recorded in regular 15 minute counts conducted at the junction of Zones 2 and 3, near Haig Road. This analysis looks at group size in relation to activity and group size and activity in relation to the number of dogs accompanying the people (Table 4).

A total of 541 people were recorded in 48 surveys, each lasting 15 minutes, so the overall rate was 45.1 people/hour. In the same period, 169 dogs were recorded at an overall rate of 14.1 dogs/hour. It is worth noting that this level of usage of the pathway greatly

exceeds the level of usage of the playing fields at Troy Park, adjacent to Point Waylen. Across the six all-day surveys, a total of 100 people were recorded using this park, including those attending a football match, whereas if the hourly usage rate of the pathway is used, about 500 people and 150 dogs may pass along the path each day. Some of these people and dogs may use the path twice a day, and many are probably daily users, but if 50% of the people use the path daily, this suggests that over 1000 people used it across a period of 6 days. The actual number may be higher than this.

Walking and cycling were the two best-represented activities, with small numbers of joggers and very small numbers of other activities. One or more dogs accompanied over half the people walking by themselves, but only about a third of groups of people of two or more were accompanied by a dog or dogs. About 10% of cyclists were accompanied by a dog.

The dual use pathway at Milyu also runs parallel to the reserve, but usage of this pathway by people was very different from usage of the pathway at Alfred Cove. In 36 counts and a period of 385 minutes, 549 people and 1 dog were recorded on the Milyu pathway. This is an overall rate of 85.5 people/hour but only 0.2 dogs/hr. Of the 549 people, 517 (94.2%) were cyclists. It was not possible to record group size, as cyclists frequently moved past in a continuous stream. Usage of the pathway at Milyu was mainly by commuting cyclists whereas usage of the pathway at Alfred Cove was mainly for recreational cycling and walking.

## Disturbance of Waterbirds – the significance of different activities

The distribution of activities that could lead to disturbance of waterbirds has been examined above. Activities that could lead to disturbance were recorded at all reserves (Tables 3 a & b), but the actual occurrence of disturbance incidents did not relate to levels of human activity, since disturbance can only occur when both people and birds are in approximately the same place. For example, of the 337 disturbance events recorded across the six all-day surveys and across all sites, nearly half (190) were recorded at Alfred Cove. However, the total count of people and dogs in the reserves and adjacent foreshore across all three sites in the all-day surveys was 1085, of which only 19% (206) were recorded at Alfred Cove. This suggests that relatively low levels of human activity at Alfred Cove are causing a disproportionate level of disturbance, but clearly there are more birds at Alfred Cove to be disturbed. Also important are the sorts of activities taking place and where they occur within or near to the reserve. Table 6 examines the number of people recorded within each activity category and compares this with the number of disturbance events caused by each activity. This provides a measure of the actual level of disturbance caused by each activity at each reserve.

All activity types caused some disturbance, but some caused very high numbers of disturbance events relative to the frequency of the activity. At Alfred Cove, boats, kayaks, anglers, kite-surfers and joggers caused high levels of disturbance even though most of these activities were rarely recorded. Joggers were not even recorded in the

reserve or on the adjacent foreshore, but the movement of joggers on the pathway led to 7 disturbance events. Perhaps of greatest interest is that although only 5 kite-surfers were recorded in Alfred Cove, 27 disturbance events were due to this activity. Kite-surfers included one person observed surfing in Zone 3 who repeatedly disturbed birds, accounting for about a third of events linked to kite-surfing, and this same person has been observed to use the reserve regularly (L. Lloyd pers. com.). In contrast, 35 records of dogs caused only 8 disturbance events and 15 wind-surfer records led to only one disturbance event. In both cases, dogs and wind-surfers were generally in areas not frequented by birds, such as Zones 1 and 7, although the absence of birds could be due to the levels of activity. Despite the high levels of impact of some activities, the most important activity in terms of number of disturbance events was people walking along the beach and across the mudflats.

At Milyu (Table 6), much lower levels of disturbance relative to levels of activity were recorded, because most activities were concentrated outside the reserve and away from areas where birds were common, although again these may be linked. Perhaps most significant was that a single jogger caused 21 disturbance events. This person jogged along the entire length of the beach from Como Jetty to Zone 1. Despite this, the most important activity was walking which led to 128 of the 179 disturbance events recorded at Milyu. Most of these events were due to people walking the length of the reserve.

Numbers of people were high but numbers of disturbance events were low at Pelican Point (Table 6), but this is probably because the people were concentrated in or close to the reserve, and human activity occurs largely in the late afternoon when birds also try to gather at the site. It seem likely that the documented decline in the abundance of waterbirds at Pelican Point (Creed and Bailey 1998) is due to this interaction. Despite the low levels of disturbance, activities that led to the highest disturbance rates were the same as those documented at the other sites, such as boats, fishing and kayaking. Birdwatchers, not counted during a circuit, also led to disturbance. Kite-surfers and wind-surfers were not major factors in causing disturbance especially considering their absolute abundance, but many of the pedestrians who did cause disturbance were related to these activities.

**Disturbance of Waterbirds – critical distances and disturbance indices**

Recorded distances at which each species responded to disturbance are presented in Table 7, with values for each disturbance type presented in Appendices 1 and 2. All records are presented for active and inactive birds. In many cases, sample sizes were small and the variation around the mean (standard error) was large, but some common trends emerge.

In general, species became alert and moved away from disturbance at a greater distance when inactive than when active. In some cases, this difference was considerable. For example, inactive (roosting on a beach) Red-necked Stints became alert at 43.5m and began to move away at 36.4m, whereas active (foraging on shoreline) Red-necked Stints did not become alert or alter their behaviour until approached to within an average of

23.9m, but moved away almost immediately (at 23.8m). This difference between active and inactive birds probably occurs because inactive birds may be slightly vulnerable, as they have to get up and prepare to take evasive action, whereas active birds are already moving and can readily take flight.

Exceptions to this pattern were mostly associated with small sample sizes, but in the case of the Black Swan it did appear that active birds reacted before inactive birds. However, it was also found with Black Swans that, on average, they moved away before they became alert. This anomaly is probably because Black Swans were seen in a variety of locations, and some of the birds may have a reduced response because of familiarity with people. Black Swans roosting on the sand-bars at Alfred Cove appeared more tolerant of disturbance than swans roosting on a beach, and swans foraging on a mudflat appeared more sensitive to disturbance than swans on open water. These patterns make sense in terms of the swans' ability to take evasive action, but sample sizes become too small for realistic analysis when examined at this level of detail.

The Black-winged Stilt also appeared to move away before it became alert, despite the largest sample sizes of any species. Further analysis need to be carried out on these records to see if site or disturbance type affected the result.

Some species were more sensitive overall to disturbance than others. Of species with reasonable sample sizes, the Pacific Black Duck, Pied Oystercatcher, Red-capped Plover and Silver Gull were tolerant of disturbance. Disturbance distances for these species ranged from a mean of 11.0m (Red-capped Plover when inactive), to a mean of 44.4m (inactive Pacific Black Duck). All are species familiar with people so a considerable degree of habituation can be expected. Species with large sample sizes that were most sensitive to disturbance were the Black Swan (mean up to 85.0m) and the Australian Pelican (77.7m). The response distances were broadly similar to those found by Paton *et al.* (2000) in controlled disturbance trials carried out on waterbirds in South Australia. In some cases, however, the distances recorded in the present study were less, probably because the birds in the SEMP are habituated to some level of disturbance.

Distances at which birds became alert and moved away from different types of disturbance are presented in Appendices 1 and 2, with species for which there were reasonable samples sizes for at least some disturbance types presented on Table 8. For all species where adequate sample sizes are available, boats, kayaks and kite-surfers disturb birds at greater distances than people or dogs. Similarly, anglers were more disturbing than people walking or jogging, possibly because the action of casting alerts the birds, or possibly because anglers tended to be standing well out into the water and this was perceived as unusual by the birds. Birds appear to learn and accept people where they are seen regularly, but become alert when people behave differently. This was very apparent on the pathway at Milyu, where people could walk close to roosting Red-necked Stints, but the birds would become alert if the person stopped, and would become rapidly alarmed if the person stepped off the path.

The differing sensitivity to disturbance of waterbird species dos not necessarily mean that sensitive species are more often disturbed than tolerant species. An important factor is where the birds normally occur, as some species rarely occur in positions where they are likely to be disturbed. Table 9 provides a summary that looks at what could be described as the disturbance index of each species; this is the relationship between the proportion of the total count of waterbirds represented by each species, and the proportion of the total count of birds involved in disturbance events represented by each species. An index of 1.0 indicates a species that was recorded being disturbed at the rate expected on the basis of its abundance, with an index of less than this being for species that are disturbed less often than expected. An index of >1.0 is found for species that are particularly prone to disturbance. This is a function of their sensitivity to disturbance, their sensitivity to particular types of disturbance and their pattern of habitat usage on the estuary bringing them into conflict with people.

The disturbance index values (Table 9) display a remarkable degree of consistency, with the values for many species being <1.0. This is probably because most birds are already acting in such a way as to minimise being disturbed. Their behaviour reduces the chances of being disturbed by people. For example, birds roosting on sandbars rather than the shoreline are reducing their chance of being disturbed.

Some species that were disturbed at very low rates, such as the Musk Duck and the three grebe species, occur in the open water and are very unlikely to encounter people, while the disturbance rate of some rarely encountered species has probably been underestimated because they were difficult to observe. For example the Bar-tailed Godwit, Red Knot and Great Knot were only ever seen on the mudflats at Alfred Cove and their response to disturbance was hidden if it occurred in the middle of a flock of cormorants and pelicans. On one occasion, a group of waders that may have included these species was flushed by a pedestrian from the beach in Zone 3 at Pelican Point, but the birds were unidentified.

A number of species had a disturbance index very close to 1.0. These included the Black Swan, Little Black Cormorant, Australian Pelican, Great Egret, Common Sandpiper and Pied Oystercatcher. The Little Black Cormorant was in marked contrast with other cormorants, which were disturbed less often than expected. The Little Black Cormorant occurred infrequently but in very large numbers, and this may have affected the results.

The only species with a disturbance index of >1.0 were the Grey Teal (1.38), White-faced Heron (1.60), Red-necked Stint (1.71), Red-necked Avocet (2.37) and Fairy Tern (2.14). In all cases, these high disturbance indices can be explained by the habitat usage of the birds bringing them into conflict with people. In some cases these were also species with large response distances.

The Grey Teal, White-faced Heron and Red-necked Avocet were mainly observed foraging on the mudflats in Zones 2 and 3 of Alfred Cove, and they tended to be close to the shoreline. This placed them near high levels of human activity along the pathway

adjacent to Zone 2. These were also species that tended to be moderately sensitive to disturbance with large response distances (Table 7).

The Fairy Tern was most frequently recorded roosting or foraging around the sand-bars at Alfred Cove (mainly in Zone 3) where human activities occurred infrequently. However, Fairy Terns were one of those species that repeatedly tried to roost at Pelican Point, usually in the afternoon when high tides pushed birds off the Alfred Cove sand-bars. This placed them into direct conflict with people and the Fairy Terns at Pelican Point were repeatedly disturbed. The short response distance of Fairy Terns from a quite large sample size (mean of 25.7m for 15 events, see Table 7) was calculated from data at Pelican Point, where the birds would allow a close approach and would return repeatedly.

The Red-necked Stint was tolerant of disturbance and foraged widely over the mudflats in Zones 2, 3 and 4 of Alfred Cove, where human activity levels were generally low. When roosting, however, it settled on beaches in Zone 2 at Alfred Cove, Zone 3 at Milyu and Zone 3 at Pelican Point. This selection of roosting sites increased the chances of being disturbed, while it is slightly more sensitive to disturbance when roosting than when foraging (Table 7).

All the species with high disturbance indices make use of beaches or habitats near beaches, and this also places them in the habitat where the most common form of human activity occurred, which was walking. Therefore, a combination of factors, both related to the birds and to people, led to the high disturbance indices.

## CONCLUSIONS

The Swan Estuary Marine Park, consisting of Alfred Cove, Milyu and Pelican Point Reserves, is recognised as being of great importance for waterbirds, but its position within a lage city means that impacts of human activity upon waterbirds are inevitable. Past impacts have been caused by loss of habitat, but major concerns in recent times have been levels of human usage leading to disturbance of waterbirds. This has led to active campaigns to manage human usage, such as the installation of a low fence at Alfred Cove to restrict access by dogs. Concern about the impact of human activity within and adjacent to the Marine Park on waterbirds also led to the current study.

The study has demonstrated that waterbird numbers are still high in the Marine Park as a whole, but independent work by Creed and Bailey (1998) has documented a clear decline in the abundance of many species at Pelican Point. There may have been slight overall declines in the abundance of some shorebird or wader species, but some of the counts made in the study (2002/2003) exceeded previously recorded maxima from the 1980s and 1990s.

Alfred Cove supports the largest numbers of waterbirds, with many of these foraging on the extensive mudflats that are exposed at low tide. Birds roost on a series of sand-bars that mark the outer edge of these mudflats. Milyu also has some mudflats used by birds

when foraging, but birds also roost on its shoreline. A small beach to the north of Milyu is the major high-tide roost for Red-necked Stints, the most abundant wader or shorebird in the Marine Park. Pelican Point supports the smallest numbers of birds, and in 2002/2003 the water level in the lagoon or pond located within the point was high, with the result that evening and overnight roosting around this lagoon by Red-necked Stints did not occur. When the water level in this lagoon is low over summer, the majority of Red-necked Stints present in the Marine Park roost on the lagoon's shore overnight. Despite the low numbers of birds at Pelican Point, and the reported decline in numbers, occasional high counts were recorded. It was apparent that several species still rely on the reserve for roosting, both on the sand-bar and on the west-facing beach, and that birds congregate on these sites particularly in the afternoon. This coincided with a high or at least rising tide.

Human usage of the reserves within the Marine Park was complex. At Alfred Cove, there were very high levels of activity of pedestrians, with and without dogs, on the adjacent dual use pathway, and these levels of activity exceeded those recorded on the playing fields at Troy Park, also adjacent to the reserve. Many more people were engaging in passive recreation on the pathway than were involved in organised sports on the playing field. Human activity within Alfred Cove Reserve and the adjacent river was concentrated at the western end of the reserve and it was clear that the dog fence was being very effective in reducing numbers of people and dogs in the reserve. Despite this, some human activities were observed throughout the reserve, the most apparent being small boats, kayaks, anglers and kite-surfers. Human activities in and around Alfred Cove tended to be concentrated in the mornings and afternoons, with this pattern being less marked on weekends than during the week.

Milyu also has a pathway running alongside it, but this was used mainly by cyclists commuting to and from work, with only low numbers of pedestrians and dogs. Human activity within the reserve was very low, but activity levels were very high immediately to the north, and moderately high to the south. On the river to the north of Milyu is a PWC (jet-ski) freestyle area, and this area was the main location within the Marine Park where PWC were recorded. People were recorded in large numbers on the adjacent beach. South of Milyu is a recreational beach and area used for dog walking, associated with Como Jetty. Human activities within the reserve often involved people walking or jogging the entire length of the beach. Human activity in and around Milyu was concentrated in the mornings and evening along the pathway, but through the middle of the day on the beaches and in the river.

Pelican Point recorded low numbers of people within the reserve for much of the day, but activity peaked in the late afternoon, consisting mainly of kite-surfers and wind-surfers utilising the launching area and bay west of the reserve under favourable wind conditions. Almost all wind-surfers and most kite-surfers operated in the open water, but there was some pedestrian activity within the reserve associated with these activities. There was also some usage of the reserve shoreline by kite-surfers for launching and landing.

The general patterns of waterbird and human usage at the three reserves suggest that problems with disturbance of waterbirds will differ between them. Problems are likely to be least at Milyu, because human usage of the reserve and the important beaches outside the reserve is low, moderate at Alfred Cove because, despite the fence, there is regular use of the reserve, and greatest at Pelican Point where human and waterbird usage in the afternoon coincide in a small area. Relative to levels of human activity, however, disturbance incidents were greatest at Alfred Cove, probably because this was the site where the largest numbers of waterbirds were present. At Pelican Point, the small area of habitat available for waterbirds usually meant that birds were soon displaced by humans and therefore disturbance was recorded only briefly, whereas at Alfred Cove there was sufficient habitat for the birds to move but remain within the area. Disturbance at Pelican Point was less frequent but more critical.

Human activities varied in their significance for waterbirds. People walking along the beach was the most common activity overall and caused the greatest number of disturbance events. These people were often associated with other activities, however, such as watching kite-surfers or jet-skis. Activities that caused a disproportionate number of disturbance events relative to the frequency with which the activity was observed were kite-surfers (Alfred Cove only), boating, kayaking, jogging and fishing. In all cases, these activities were taking place in areas used by birds. For example, jogging was a problem because joggers ran the entire length of the beach at Milyu, disturbing birds all the way, while kite-surfers at Alfred Cove occasionally worked the shallow water over the mudflats, close to the sand-bars where birds roosted. In contrast, kite-surfers at Pelican Point stayed in deep water and were only a problem for birds when some kite-surfers used the reserve beach for launching and landing. Boats and kayaks also tended to approach foraging and roosting birds. Bamford *et al.* (1990) also found that small boats disturb waterbirds. Activities that caused a disproportionately high level of disturbance events were also those that birds reacted to most strongly.

The distances at which waterbirds reacted to human activities varied between species and activities of both the birds and the people. In general, inactive birds were more sensitive to disturbance than active birds. Therefore, management of disturbance is especially critical at roosting areas, such as the sand-bars at Pelican Point, the roosting beach at Milyu and roosting location at Pelican Point. Birds that were most tolerant of disturbance tended to be those that are regularly exposed to high levels of human activity and that are therefore habituated to some degree. Species most sensitive to disturbance tended to be large waterbirds that take time and effort to take flight. Such birds cannot afford to allow a potential threat to get too close. Activities that caused the earliest response from birds were boats, kayaks and kite-surfers. Anglers also elicited a rapid response, whereas many birds were tolerant of approach by walkers. The actual distances ranged from mean values of 11m to mean values of 120m. However, a distance of only 50m would be sufficient to minimise disturbance of almost all waterbirds from most sorts of activities except small boats, kayakers and kite-surfers under some circumstances.

The combination of the sensitivity of birds to disturbance, the types of disturbance events that occur and where those events occur relative to where the birds are determines the

vulnerability of birds to disturbance. For the Swan Estuary Marine Park, a disturbance index was calculated for most species and it was found that for many of these, this index was lower than expected on the basis of the abundance of the birds. This indicated that they were successfully minimising their exposure to disturbance whilst remaining common in the Marine Park. Being able to forage and particularly roost in areas where disturbance levels are low is important for this to happen. The few species with high disturbance indices were not necessarily birds that are particularly sensitive to disturbance, but were birds that through their biology use habitats where they are likely to encounter people. These species forage on or close to shorelines, roost on shorelines and make less use of shallow water and sand-bars than other species. This brings them into contact with the single most abundant disturbance activity, which is people walking along the beach.

## RECOMMENDATIONS

Waterbirds are still abundant on the Swan Estuary Marine Park, even in Pelican Point where a decline in waterbird usage has been documented. Waterbirds are utilising the Marine Park despite sometimes high levels of human usage and disturbance, but the impacts of disturbance are something that can be managed. Lafferty (2001), for example, found that decreasing human usage of 5% of a beach led to an increase in the abundance of a range of waterbird species, with the protected areas acting as refuges for birds that might range into other areas for part of the day.

Within the Marine Park, there are some management issues that are common to each of the reserves, but there are also approaches specific to each reserve that will assist in controlling disturbance. The current situation in each of the reserves, and recommendations for future management, are presented below.

Alfred Cove.

Levels of disturbance are generally low and concentrated near the western boundary of the reserve, but occasional human activities occur throughout the reserve, including in those areas most important for waterbirds. Major problems are people walking or jogging along the beach, with or without dogs, and boats, kayaks and anglers in the vicinity of the sand-bars where waterbirds roost. Kite-surfers are a special problem because a very small number of individuals surf in the shallows between the sand-bars and the shoreline, whereas most other kite-surfers operate close to the western boundary of the reserve. The dog fence constructed in 2002 appears to have revolutionised patterns of waterbird and human usage of the reserve, but these patterns were not documented beforehand. Compliance with the fence is very high. Recommendations for Alfred Cove are:

- Pedestrian usage of the beach needs to be controlled. Signage on the beach near the access gates could ask that people not walk the length of the beach. One of the gates (closest to Haig Road) in the dog fence is close to an area where birds roost and forage, and should be either closed, or post-and-rail fencing installed on the beach at this point to allow restricted access.

- The sand-bars are a special feature and roosting birds on these are very prone to disturbance. These are regularly accessed by anglers, small boats, kayaks and walkers, and occasionally by kite-surfers and wind-surfers. The current level of disturbance at these sand-bars seems to be tolerated by the birds, but signage aimed at encouraging people not to approach these sand-bars, especially when birds are present, is needed to control the level of activity.
- Community ownership of the reserve needs to be encouraged by acknowledging the cooperation of dog-owners, through informative signage and through a programme of public bird-watching events.

Milyu.

Levels of human usage are low and major disturbance events were limited to the occasional jogger or walker traversing the length of the reserve along the beach. The most important site for waterbirds is actually outside the reserve; the wader roosting beach in Zone 3. This is very close to a major recreational area associated with the PWC (jet-ski) freestyle area near the Narrows Bridge. Recommendations for management at Milyu have been proposed by Bamford (2002) and are currently under consideration by the City of South Perth, Department of Planning and Infrastructure and Department of Conservation and Land Management. These recommendations include:

- Improved signage and a post-and-rail fence or similar at the southern boundary of the reserve to make people aware that the reserve exists and to encourage them to leave the beach at that point.
- Signage, plantings, a low barrier and an observation area at the wader roosting beach to make people aware of the significance of the beach and to enable them to see and understand the birds.
- Possible public bird-watching programme to introduce South Perth residents in particular to the value of the wader roosting beach.
- Possible development of a roost site for Red-necked Stints within Milyu Reserve.

Pelican Point.

High levels of usage for at least part of the day, combined with the small area of the reserve, means that disturbance of waterbirds is a major issue. High levels of activity occur on the river within and outside the reserve, but are so close to the shore within the reserve that problems are inevitable. Human and bird activity in the reserve also both peak in the late afternoon and the most important parts of the reserve for birds are the sand-bar, itself partly outside the reserve, the west-facing beach, which faces the bay used by kite-surfers and wind-surfers, and the lagoon. Disturbance is largely due to pedestrians on the beach and to people on the beach in association with kite-surfers, but small boats and kayaks that come from the east, including Sea Scouts, are also a problem. Although long-established as a reserve, there seems little awareness among people in the area of what the reserve is for, why there is a fence, what the birds are that people shouldn't disturb and what disturbance actually means. Recommendations for Pelican Point are:

- Clear, simple signage to explain to people where important areas for birds are and where people should and shouldn't go. The signs should request that people not

walk along the beach in areas important for birds. These should be on the beach at either end of the existing fence and on the beaches facing out into the river.

- A sign and map at the carpark indicating clearly the boundaries of the reserve and the important areas for birds. The sign should request that kite-surfers stay 50m clear of the west facing beach of the reserve.
- Assistance should be sought from stakeholders in the area, kite-surfing clubs, Sea Scouts and the Royal Perth Yacht Club and Mounts Bay Sailing Club to help publicise the importance of the beach and involve them in the management of the area.
- The existing fence should be modified to prevent casual entry into the reserve, such as by dogs, but to encourage controlled entry. For example, a self-closing gate could lead to a path and/or boardwalk that would guide people away from the beach to a vantage point on the reserve from where they can see the pond and roosting birds on the beach. Such controlled entry would only work with greatly improved, informative signage so that regular users of the area understood the right way and the wrong way to enter the reserve.
- The possibility of enhancing the value of the lagoon for roosting by Red-necked Stints should be examined. This is only used when the water level is low, so the creation of a sandy shoreline along one side of the lagoon that remained at high water levels would give the birds a dependable roost site.

In General.

There is a poor understanding within the community of what the birds are, why they are important and what disturbing the birds involves. This can be corrected through positive signage and ongoing publicity. Ultimately, successful management of the reserves will depend upon the human users of the river valuing the birds, understanding their needs and wanting to help protect them.

TABLE ONE. Dates of all-day surveys, indicating the start and finish times of each circuit at each reserve.

| Site Name | Circuit | Date | | | | | |
|---|---|---|---|---|---|---|---|
| | | 25/11/2002 | 4/01/2003 | 27/01/2003 | 27/02/2003 | 17/03/2003 | 29/03/2003 |
| Alfred Cove | 1 | 06:00 - 06:45 | 05:45 - 06:40 | 06:15 - 07:20 | 06:30 - 07:25 | 06:15 - 07:10 | 06:28 - 07:25 |
| | 2 | 07:10 - 08:00 | 07:15 - 08:00 | 07:55 - 09:00 | 08:15 - 09:25 | 07:34 - 08:28 | 07:46 - 08:31 |
| | 3 | 08:50 - 10:15 | 08:40 - 09:55 | 10:00 - 11:20 | 09:50 - 10:25 | 08:48 - 09:41 | 08:52 - 09:40 |
| | 4 | 11:10 - 12:10 | 11:08 - 12:05 | 12:25 - 13:40 | 11:25 - 12:30 | 10:25 - 11:20 | 10:01 - 10:34 |
| | 5 | 12:55 - 13:45 | 12:35 - 13:37 | 15:10 - 16:30 | 12:55 - 14:05 | 11:35 - 12:30 | 10:56 - 11:23 |
| | 6 | 14:50 - 15:45 | 14:06 - 15:04 | 16:45 - 17:50 | 14:37 - 15:50 | 12:55 - 13:40 | 11:47 - 12:45 |
| | 7 | 16:35 - 17:30 | 15:33 - 16:30 | 18:20 - 19:00 | 16:20 - 17:20 | 14:05 - 14:55 | 13:30 - 14:10 |
| | 8 | 18:05 - 18:50 | 17:15 - 17:55 | | 17:45 - 18:40 | 15:11 - 15:47 | 14:55 - 15:30 |
| | 9 | | 18:27 - 18:55 | | | 16:08 - 16:47 | 16:10 - 16:40 |
| | 10 | | | | | 17:08 - 17:44 | 17:15 - 18:00 |
| | 11 | | | | | 18:04 - 18:37 | |
| Milyu | 1 | 06:05 - 08:13 | 05:30 - 06:43 | 05:20 - 06:20 | 05:45 - 06:52 | 05:50 - 05:50 | 06:00 - 06:00 |
| | 2 | 08:50 - 09:52 | 07:19 - 08:27 | 06:58 - 07:55 | 07:29 - 08:21 | 07:13 - 07:50 | 07:30 - 07:30 |
| | 3 | 10:20 - 10:20 | 08:59 - 10:01 | 09:05 - 10:10 | 09:02 - 10:00 | 08:35 - 08:35 | 08:45 - 08:45 |
| | 4 | 12:00 - 12:00 | 10:40 - 11:44 | 10:50 - 11:47 | 10:33 - 11:38 | 10:15 - 11:22 | 09:45 - 09:45 |
| | 5 | 13:46 - 15:04 | 12:40 - 13:52 | 12:31 - 13:57 | 12:28 - 13:36 | 11:57 - 12:32 | 11:00 - 11:00 |
| | 6 | 15:38 - 16:01 | 14:44 - 15:32 | 14:40 - 16:04 | 14:35 - 15:34 | 13:12 - 13:31 | 13:38 - 14:30 |
| | 7 | 16:48 - 17:44 | 16:07 - 17:05 | 16:39 - 17:27 | 16:18 - 17:28 | 14:23 - 14:50 | 14:38 - 15:03 |
| | 8 | 18:17 - 19:11 | 17:41 - 18:19 | 18:15 - 19:00 | 17:55 - 18:35 | 15:40 - 16:20 | 15:20 - 16:01 |
| | 9 | | | | 18:58 - 18:58 | 17:05 - 17:35 | 16:17 - 17:01 |
| | 10 | | | | | | 17:15 - 17:55 |
| | 11 | | | | | | 18:33 - 18:45 |

Table 1 (cont.)

| Site Name | Circuit | Date | | | | | |
|---|---|---|---|---|---|---|---|
| | | 25/11/2002 | 4/01/2003 | 27/01/2003 | 27/02/2003 | 17/03/2003 | 29/03/2003 |
| Pelican Point | 1 | 05:30 - 06:00 | 05:30 - 06:00 | 05:30 - 06:00 | 05:50 - 06:15 | 06:00 - 06:30 | 06:30 - 07:00 |
| | 2 | 06:30 - 07:00 | 06:30 - 07:00 | 06:30 - 07:00 | 06:50 - 07:15 | 07:00 - 07:30 | 07:30 - 08:00 |
| | 3 | 07:30 - 08:00 | 07:30 - 08:00 | 07:30 - 08:00 | 07:50 - 08:15 | 08:00 - 08:30 | 08:30 - 09:00 |
| | 4 | 08:30 - 09:00 | 08:30 - 09:00 | 08:30 - 09:00 | 08:50 - 09:15 | 09:00 - 09:30 | 09:30 - 10:00 |
| | 5 | 09:30 - 10:00 | 09:30 - 10:00 | 09:30 - 10:00 | 09:50 - 10:15 | 10:00 - 10:30 | 10:30 - 11:00 |
| | 6 | 10:30 - 11:00 | 10:30 - 11:00 | 10:30 - 11:00 | 10:50 - 11:15 | 11:00 - 11:30 | 11:30 - 11:45 |
| | 7 | 11:30 - 12:00 | 11:30 - 12:00 | 11:30 - 12:00 | 11:50 - 12:15 | 12:00 - 12:30 | 12:30 - 13:00 |
| | 8 | 12:30 - 13:00 | 12:30 - 13:00 | 12:30 - 13:00 | 12:50 - 13:15 | 13:00 - 13:30 | 13:30 - 14:00 |
| | 9 | 13:30 - 14:00 | 14:30 - 15:00 | 13:30 - 14:00 | 13:50 - 14:15 | 14:00 - 14:30 | 14:30 - 15:00 |
| | 10 | 14:30 - 15:00 | 15:30 - 16:00 | 14:30 - 15:00 | 14:50 - 15:15 | 15:00 - 16:30 | 15:30 - 16:00 |
| | 11 | 15:30 - 16:00 | 16:30 - 17:00 | 15:30 - 16:00 | 15:50 - 16:15 | 17:00 - 17:30 | 16:30 - 17:00 |
| | 12 | 16:30 - 17:00 | 17:30 - 18:00 | 16:30 - 17:00 | 16:50 - 17:15 | 18:00 - 18:40 | 17:30 - 18:00 |
| | 13 | 17:30 - 17:30 | 18:30 - 19:00 | 17:30 - 18:00 | 17:50 - 18:15 | | 18:00 - 18:20 |
| | 14 | 18:30 - 19:00 | 19:30 - 20:00 | 18:30 - 19:00 | 18:50 - 19:10 | | |
| | 15 | | | 19:30 - 19:50 | 19:10 - 19:25 | | |
| | 16 | | | 19:55 - 20:10 | | | |

TABLE TWO. Maximum count of each waterbird species at each reserve (AC = Alfred Cove, Mil = Milyu, PP = Pelican Point) from any circuit in the current study, compared with maximum previous counts from the SEMP. Asterisks indicate species observed but not counted. Common and scientific names after Christidis and Boles (1994), with alternative names in parenthesis.

| Species | | AC | Mil | PP | Max. count |
|---|---|---|---|---|---|
| **Anatidae** (ducks, geese and swans) | | | | | |
| Blue-billed Duck | *Oxyura australis* | - | - | - | 1[2] |
| Musk Duck | *Biziura lobata* | 153 | 1 | - | 78[3] |
| Freckled Duck | *Stictonetta naevosa* | - | - | * | - |
| Black Swan | *Cygnus atratus* | 152 | 31 | 12 | 25[3] |
| Australian Shelduck | *Tadorna tadornoides* | 25 | 4 | 3 | 14[2] |
| Australian Wood (Maned) Duck | *Chenonetta jubata* | - | - | - | 2[2] |
| Pacific Black Duck | *Anas superciliosus* | 86 | 30 | 26 | 99[2] |
| Australasian Shoveler | *Anas rhynchotis* | - | - | - | 2[2] |
| Grey Teal | *Anas gibberifrons* | 355 | 21 | 2 | 240[2] |
| Chestnut Teal | *Anas castanea* | 1 | - | - | 1[2] |
| Pink-eared Duck | *Malacorhynchus membranaceus* | - | - | - | * |
| Hardhead (White-eyed Duck) | *Aythya australis* | - | - | - | 4[2] |
| **Podicepididae** (grebes) | | | | | |
| Australasian Grebe | *Tachybaptus novaehollandiae* | 10 | 1 | - | 4[2] |
| Hoary-headed Grebe | *Poliocephalus poliocephalus* | 50 | 2 | - | 92[2] |
| Great Crested Grebe | *Podiceps cristatus* | 3 | - | - | 9[3] |
| **Anhingidae** (darters) | | | | | |
| Darter | *Anhinga melanogaster* | 4 | 3 | 1 | 9[3] |
| **Phalacrocoracidae** (cormorants) | | | | | |
| Little Pied Cormorant | *Phalacrocorax melanoleucos* | 50 | 54 | 607 | 144[2] |
| Pied Cormorant | *Phalacrocorax varius* | 10 | 2 | - | 80[2] |
| Little Black Cormorant | *Phalacrocorax sulcirostris* | 4000 | 120 | 603 | 1000[1] |
| Great Cormorant | *Phalacrocorax carbo* | 19 | 13 | 1 | 210[1] |
| **Pelecanoididae** (pelicans) | | | | | |
| Australian Pelican | *Pelecanus conspicillatus* | 114 | 12 | 3 | 87[3] |
| **Ardeidae** (herons and egrets) | | | | | |
| White-faced Heron | *Ardea (Egretta) novaehollandiae* | 4 | 2 | 2 | 4[2] |
| Little Egret | *Ardea (Egretta) garzetta* | 1 | 1 | - | 1[3] |
| Eastern Reef Egret | *Egretta sacra* | - | 1 | - | - |
| White-necked Heron | *Ardea pacifica* | - | - | - | * |
| Great Egret | *Ardea (Egretta) alba* | 1 | 1 | 1 | 14[2] |
| Cattle Egret | *Ardea (Ardeola) ibis* | - | - | - | 2[2] |
| Nankeen Night Heron | *Nycticorax caledonicus* | - | 1 | - | 2[2] |
| **Plataleidae** (ibis and spoonbills) | | | | | |
| Glossy Ibis | *Plegadis falcinellus* | - | - | - | * |
| Australian White Ibis | *Threskiornis molucca* | 186 | 33 | - | 199[3] |

Table 2 (cont.)

| Species | | AC | Mil | PP | Max. count |
|---|---|---|---|---|---|
| Straw-necked Ibis | *Threskiornis spinicollis* | - | - | - | 2[2] |
| Yellow-billed Spoonbill | *Platalea flavipes* | - | - | - | 2[3] |
| **Accipitridae** (kites, hawks and eagles) | | | | | |
| Osprey | *Pandion haliaetus* | 4 | 2 | 1 | 2[2] |
| White-bellied Sea Eagle | *Haliaeetus leucogaster* | - | - | - | 1[4] |
| Swamp Harrier | *Circus approximans* | - | - | - | 1[2] |
| **Rallidae** (crakes and rails) | | | | | |
| Buff-banded Rail | *Rallus philippensis* | 3 | - | 1 | 13[1] |
| Baillon's Crake | *Porzana pusilla* | - | - | - | * |
| Australian Spotted Crake | *Porzana fluminea* | - | - | - | 2[2] |
| Spotless Crake | *Porzana tabuensis* | - | - | - | 5[2] |
| Purple Swamphen | *Porphyrio porphyrio* | 1 | - | - | 1[2] |
| Black-tailed Native-hen | *Gallinula ventralis* | - | - | - | * |
| Eurasian Coot | *Fulica atra* | - | - | - | 2500[1] |
| **Scolopacidae** (sandpipers) | | | | | |
| Black-tailed Godwit | *Limosa limosa* | - | - | - | 2[2] |
| Bar-tailed Godwit | *Limosa lapponica* | 1 | - | 1 | 250[1] |
| Whimbrel | *Numenius phaeopus* | - | - | - | 1[5] |
| Eastern Curlew | *Numenius madagascariensis* | * | - | - | 2[2] |
| Marsh Sandpiper | *Tringa stagnatalis* | - | - | - | 3[2] |
| Common Greenshank | *Tringa nebularia* | 17 | 1 | 5 | 47[3] |
| Wood Sandpiper | *Tringa glareola* | - | - | - | 4[2] |
| Terek Sandpiper | *Tringa (Xenus) terek* | 1 | - | - | 4[6] |
| Common Sandpiper | *Tringa hypoleucos* | 1 | 2 | 1 | 6[2] |
| Grey-tailed Tattler | *Tringa brevipes* | - | 1 | - | 3[6] |
| Ruddy Turnstone | *Arenaria interpres* | - | - | - | 1[2] |
| Great Knot | *Calidris tenuirostris* | 20 | - | 6 | 340[1] |
| Red Knot | *Calidris canutus* | 40 | - | 33 | 200[1] |
| Sanderling | *Calidris alba* | - | - | - | 1[2] |
| Red-necked Stint | *Calidris ruficollis* | 1236 | 740 | 400 | 10000[1] |
| Long-toed Stint | *Calidris subminuta* | - | - | - | 1[2] |
| Pectoral Sandpiper | *Calidris melanotos* | - | - | - | 2[1] |
| Sharp-tailed Sandpiper | *Calidris acuminata* | 150 | 4 | 10 | 150[6] |
| Curlew Sandpiper | *Calidris ferruginea* | 201 | 8 | 33 | 1276[6] |
| Broad-billed Sandpiper | *Limicola falcinellus* | - | - | - | 1[2] |
| Ruff | *Philomachus pugnax* | - | - | - | 1[1] |
| Red-necked Phalarope | *Phalaropus lobatus* | - | - | - | 1[1] |
| unidentified sandpiper | | 225 | 2 | - | |
| **Haematopodidae** (oystercatchers) | | | | | |
| Sooty Oystercatcher | *Haematopus fuliginosus* | - | - | - | 1[6] |
| Pied Oystercatcher | *Haematopus longirostris* | 96 | 15 | 3 | 120[3] |

Table 2 (cont.)

| Species | | AC | Mil | PP | Max. count |
|---|---|---|---|---|---|
| **Recurvirostridae** (stilts and avocets) | | | | | |
| Black-winged Stilt | *Himantopus himantopus* | 137 | 48 | 150 | 387[6] |
| Banded Stilt | *Cladorhynchus leucocephalus* | 1 | - | - | 4[6] |
| Red-necked Avocet | *Recurvirostra novaehollandiae* | 37 | 47 | - | 187[2] |
| **Charadriidae** (lapwings and plovers) | | | | | |
| Pacific Golden Plover | *Pluvialis fulva* | - | - | * | 2[2] |
| Grey Plover | *Pluvialis squatarola* | 39 | 6 | 27 | 101[1] |
| Red-capped Plover | *Charadrius ruficapillus* | 65 | 114 | 40 | 1500[1] |
| Lesser Sand Plover | *Charadrius mongolus* | - | - | - | * |
| Greater Sand Plover | *Charadrius leschenaultii* | - | - | - | 1[2] |
| Black-fronted Dotterel | *Elseyornis (Charadrius) melanops* | - | - | - | 1[2] |
| Hooded Plover | *Thinornis (Charadrius) rubricollis* | - | - | - | 1[1] |
| Red-kneed Dotterel | *Erythrogonys cinctus* | - | - | - | 30[2] |
| Banded Lapwing | *Vanellus tricolor* | - | - | - | 2[2] |
| **Laridae** (gulls and terns) | | | | | |
| Silver Gull | *Larus novaehollandiae* | 584 | 559 | 275 | 2000[1] |
| Caspian Tern | *Hydroprogne caspia* | 28 | 5 | 4 | 23[3] |
| Crested Tern | *Sterna bergii* | 60 | 8 | 2 | 50[3] |
| Common Tern | *Sterna hirundo* | - | - | - | 1[3] |
| Fairy Tern | *Sterna nereis* | 52 | 30 | 29 | 102[1] |
| Whiskered Tern | *Chlidonias hybrida* | - | - | - | 2[3] |
| Number of species: | | 41 | 36 | 29 | 82 |
| Pooled maximum counts: | | 8223 | 1927 | 2282 | |

Sources of information for SEMP maximum counts:

1. ANCA (1993).
2. Jaensch *et al.* (1988).
3. Bamford (1999).
4. J. Henry, pers. comm.
5. M.J. Bamford, pers. obs.
6. Australasian Wader Studies Group (unpub. data).

TABLE THREE-A. Maximum count of people (and dogs) in each activity category in each reserve. Records are from the river and shoreline only (ie no pathway records), and are divided into zones within the reserve and outside the reserve for Alfred Cove and Milyu (see Figures 3 and 4). Counts from Pelican Point are all considered to be from within the reserve, as it was difficult to determine when kitesurfers and windsurfers in particular were in Zone 4 or Zone 5 (See Figure 4).

| Activity category | Alfred Cove | | Milyu | | Pelican Point |
|---|---|---|---|---|---|
| | Reserve | Outside | Reserve | Outside | Reserve |
| Angler | 8 | 2 | 1 | 2 | 1 |
| Boat | 1 | 1 | 1 | 3 | - |
| Cyclist | - | 2 | - | - | - |
| Dog | 3 | 4 | 1 | 4 | 2 |
| Jetski | - | 1 | - | 13 | 1 |
| Jogger | - | - | | 1 | - |
| Kayaker | 5 | 3 | 2 | 2 | 1 |
| Kitesurfer | 2 | 5 | - | - | 18 |
| Pedestrian | 32 | 10 | 3 | 61 | 8 |
| Windsurfer | 6 | - | - | - | 15 |
| SUM | 57 | 28 | 8 | 86 | 46 |

TABLE THREE-B. The percentage of all circuits in which each category of human activity was recorded at each reserve. The total number of circuits in each reserve is given in parenthesis. Records are from the river and shoreline only, and are divided into zones within the reserve and outside the reserve for Alfred Cove and Milyu (see Figures 3 and 4), but for the reserve only at Pelican Point.

| Activity category | Alfred Cove (53) | | Milyu (53) | | Pelican Point (84) |
|---|---|---|---|---|---|
| | Reserve | Outside | Reserve | Outside | Reserve |
| Angler | 20.8 | 7.5 | 3.8 | 3.8 | 7.1 |
| Boat | 3.8 | 1.9 | 1.9 | 1.9 | 3.6 |
| Cyclist | 1.9 | - | - | - | - |
| Dog | 11.3 | 18.9 | 1.9 | 37.7 | 1.2 |
| Jetski | - | 1.9 | - | 32.1 | 1.2 |
| Jogger | - | 1.9 | - | 1.9 | - |
| Kayaker | 5.7 | 1.9 | 1.9 | 5.7 | 2.4 |
| Kitesurfer | 3.8 | 1.9 | - | - | 16.7 |
| Pedestrian | 18.9 | 17.0 | 11.3 | 58.5 | 9.5 |
| Windsurfer | 11.3 | - | - | - | 25.0 |

TABLE FOUR. Human usage of the dual use pathway at Alfred Cove: group size, composition and activity of people with and without dogs. Values indicated are the numbers of groups of that size. For example, there were 3 groups of 3 people with no dogs, 2 groups of 3 people with 1 dog and 1 group of 3 people with 2 dogs. The total is the total number of groups of each size, while the grand total indicates the total number of groups within each category and, in parenthesis, the total number of people within those groups.

| Group size and activity | Number of dogs | | | | Total | Grand total |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | | |
| 1 pedestrian | 69 | 58 | 7 | | 134 | 240 |
| 2 pedestrians | 61 | 24 | 9 | 3 | 97 | (364) |
| 3 pedestrians | 3 | 2 | 1 | | 6 | |
| 4 pedestrians | 1 | | 1 | | 2 | |
| 10 pedestrians | | | | 1 | 1 | |
| 1 jogger | 19 | | | | 19 | 21 |
| 2 joggers | 2 | | | | 2 | (23) |
| 1 cyclist | 62 | 6 | | | 68 | 100 |
| 2 cyclists | 27 | | | | 27 | (150) |
| 3 cyclists | 1 | | | | 1 | |
| 4 cyclists | 2 | | | | 2 | |
| 5 cyclists | 1 | | | | 1 | |
| 12 cyclists | 1 | | | | 1 | |
| 1 scooter | 1 | | | | 1 | 4 |
| 1 wheelchair | 1 | | | | 1 | (4) |
| 1 rollerblader | 1 | 1 | | | 2 | |

NB. Of the 69 pedestrians walking alone, 3 were pushing a pram.
Of the 58 pedestrians walking alone but with a dog, one was pushing a pram.

TABLE FIVE. The total number of records of dogs and people in each zone at Alfred Cove across the six all-day surveys, excluding records from the pathway and lawn areas. These records are therefore of people on the shoreline or in the river inside the reserve (Zones 1, 2, 3, 4, 5) or outside the reserve (Zone 7). There were no records of people or dogs from Zone 6.

| Zone | Total number of records: | |
|---|---|---|
| | People | Dogs |
| 7 | 47 | 17 |
| 1 | 80 | 14 |
| 2 | 13 | 2 |
| 3 | 21 | - |
| 4 | 8 | 1 |
| 5 | 3 | - |

TABLE SIX. The total count of people in each activity across the six all-day surveys at each reserve, compared with the number of disturbance events due to each activity. Note that a single example of an activity could lead to multiple disturbance events. Where disturbance events are listed for an activity that did not occur at a site, this is because the activity either took place on a pathway or occurred outside one of the standard circuits.

Alfred Cove

| Activity | Total people | Total disturbance events | Disturbance ratio |
|---|---|---|---|
| Walking | 100 | 73 | 0.73 |
| Fishing | 36 | 43 | 1.19 |
| Kite-surfing | 5 | 27 | 5.40 |
| Kayaking | 10 | 19 | 1.90 |
| Boating | 3 | 10 | 3.33 |
| Dogs | 35 | 8 | 0.23 |
| Jogging | - | 7 | - |
| Cycling | 2 | 2 | 1.00 |
| Wind-surfing | 15 | 1 | 0.67 |
| | 206 | 190 | |

Milyu

| Activity | Total people | Total disturbance events | Disturbance ratio |
|---|---|---|---|
| Walking | 397 | 128 | 0.32 |
| Jogging | 1 | 21 | 21.00 |
| Bird-watching | 16 | 8 | 0.50 |
| Fishing | 5 | 6 | 1.20 |
| Jet-skiing | 82 | 6 | 0.07 |
| Dogs | 35 | 4 | 0.11 |
| Kayaking | 7 | 2 | 0.29 |
| Kite-surfing | - | 2 | - |
| Swimming | - | 1 | - |
| Cycling | - | 1 | - |
| | 397 | 179 | |

Pelican Point

| Activity | Total people | Total disturbance events | Disturbance ratio |
|---|---|---|---|
| Walking | | 13 | 0.30 |
| Kite-surfing | | 12 | 0.16 |
| Fishing | | 12 | 0.52 |
| Boating | | 8 | 0.62 |
| Kayaking | | 6 | 1.20 |
| Bird-watching | | 5 | - |
| Dog | | 2 | 0.50 |
| | | 58 | |

TABLE SEVEN. Mean distances at which waterbirds became alert and at which they moved away in response to disturbance events (± 1 standard error, sample size in parenthesis). Mean values for each disturbance type are given in Appendices 1 and 2.

| Species | Activity | Mean distance (m) at which: | |
|---|---|---|---|
| | | Alert | Move away |
| Australian Shelduck | Active | | |
| | Inactive | 150 (1) | 30 (1) |
| Black Swan | Active | 85 ± 11.2 (12) | 71.3 ± 9.3 (12) |
| | Inactive | 67.5 ± 11.1 (10) | 58.3 ± 10.1 (9) |
| Grey Teal | Active | 31.4 ± 3.5 (14) | 34.7 ± 5.1 (16) |
| | Inactive | 49.1 ± 11.2 (16) | 50.7 ± 12.8 (14) |
| Pacific Black Duck | Active | 16.7 ± 3.3 (3) | 45 ± 17.5 (6) |
| | Inactive | 44.4 ± 7.6 (8) | 40.5 ± 6.7 (10) |
| Great Cormorant | Active | 10 (1) | 10 (1) |
| | Inactive | 66.3 ± 28.8 (4) | 23.3 ± 8.8 (3) |
| Little Black Cormorant | Active | | |
| | Inactive | 200 (1) | 200 (1) |
| Little Pied Cormorant | Active | 10 (1) | 10 (1) |
| | Inactive | 44.2 ± 8.9 (13) | 31.8 ± 5.3 (19) |
| Australian Pelican | Active | | |
| | Inactive | 77.7 ± 10.7 (11) | 51.7 ± 13.5 (6) |
| Great Egret | Active | 20 (1) | |
| | Inactive | 35 ± 15 (2) | 32.5 ± 12.5 (2) |
| White-faced Heron | Active | 61.8 ± 46.1 (4) | 77.3 ± 61.4 (3) |
| | Inactive | 30 ± 0 (2) | |
| Australian White Ibis | Active | 54.8 ± 8.7 (12) | 41.9 ± 7.7 (14) |
| | Inactive | 46.7 ± 16.7 (3) | 10 (1) |
| Osprey | Active | | |
| | Inactive | 100 (1) | 100 (1) |
| Common Greenshank | Active | 20 ± 5.8 (3) | 16.7 ± 6.7 (3) |
| | Inactive | 65 ± 45 (2) | 60 ± 40 (2) |
| Common Sandpiper | Active | 60 (1) | 80 ± 20 (2) |
| | Inactive | | |
| Curlew Sandpiper | Active | 18 ± 0 (2) | |
| | Inactive | 15 (1) | 8 (1) |
| Grey-tailed Tattler | Active | | 100 (1) |
| | Inactive | | |
| Red-necked Stint | Active | 23.9 ± 3.6 (14) | 23.8 ± 3.2 (26) |
| | Inactive | 43.5 ± 13.9 (13) | 36.4 ± 11 (17) |
| Sharp-tailed Sandpiper | Active | 30 (1) | 30 (1) |
| | Inactive | | |

Table 7 (cont.)

| Species | Activity | Mean distance (m) at which: | |
|---|---|---|---|
| | | Alert | Move away |
| Pied Oystercatcher | Active | 18.8 ± 3.8 (4) | 25 ± 6.9 (5) |
| | Inactive | 35.6 ± 6.8 (8) | 31.3 ± 8.6 (6) |
| Black-winged Stilt | Active | 29.5 ± 4.9 (33) | 38.3 ± 11.3 (44) |
| | Inactive | 47.5 ± 11.7 (6) | 41.4 ± 10.6 (7) |
| Red-necked Avocet | Active | 29 ± 11.4 (3) | 24.7 ± 10.7 (3) |
| | Inactive | | |
| Grey Plover | Active | 62.5 ± 18.2 (6) | 48.4 ± 12.8 (10) |
| | Inactive | 55 ± 24.7 (3) | 26.1 ± 11.7 (8) |
| Pacific Golden Plover | Active | | 27.5 ± 2.5 (2) |
| | Inactive | | |
| Red-capped Plover | Active | 13.7 ± 3.2 (6) | 9.5 ± 0.9 (11) |
| | Inactive | 11 ± 4.9 (3) | 20 ± 5 (3) |
| Caspian Tern | Active | | |
| | Inactive | 85 ± 25 (2) | 70 ± 15.3 (3) |
| Crested Tern | Active | | |
| | Inactive | | 30 (1) |
| Fairy Tern | Active | 50 (1) | 50 (1) |
| | Inactive | 35 ± 25 (2) | 25.7 ± 6.4 (15) |
| Silver Gull | Active | 16.3 ± 2.4 (4) | 29 ± 12.4 (3) |
| | Inactive | 28.8 ± 6 (16) | 19 ± 4.1 (27) |

TABLE EIGHT. Mean distances at which selected waterbird species responded to the main disturbance types. A and I indicate active and inactive birds. Mean values based on samples of 4 or more events are presented in italics. Other records, sample sizes and standard error for each mean in Appendices 1 and 2.

Distances at which birds became alert

| Species | Boat | Kayak | Kite-surfing | Fishing | Jogging | Walking | Dog |
|---|---|---|---|---|---|---|---|
| Black Swan (A) | *102.5* | 125 | - | 40.0 | - | 60.0 | - |
| Black Swan (I) | | 100 | *87.5* | | 30.0 | *48.8* | |
| Grey Teal (A) | 40.0 | 40.0 | 60.0 | | 36.7 | *22.1* | - |
| Grey Teal (I) | - | 40.0 | *102.5* | 40.0 | *28.8* | 30.0 | 25.0 |
| Australian Pelican (I) | - | 110.0 | *94.0* | 55.0 | - | 36.7 | - |
| Aust. White Ibis (A) | - | - | - | *85.0* | - | *39.6* | 40 |
| Red-necked Stint (A) | - | 30.0 | - | - | 15.0 | *20.6* | *37.5* |
| Red-necked Stint (I) | - | - | 93.3 | 50.0 | 20.0 | *30.0* | - |
| Pied Oystercatcher (I) | - | - | 55.0 | 22.5 | - | *32.5* | - |
| Black-winged Stilt (A) | - | - | 65.0 | *46.4* | *27.5* | *21.8* | 20.0 |
| Black-winged Stint (I) | - | 40.0 | 63.3 | 30.0 | - | - | 25.0 |
| Silver Gull (A) | - | - | - | - | - | *16.3* | - |
| Silver Gull (I) | - | *52.5* | 45.0 | - | - | *15.0* | - |

NB. Black-winged Stilt (A) 10.0m in response to bird-watcher

Distances at which birds became moved away

| Species | Boat | Kayak | Kite-surfing | Fishing | Jogging | Walking | Dog |
|---|---|---|---|---|---|---|---|
| Black Swan (A) | 73.3 | 91.7 | - | 40.0 | - | 60.0 | |
| Black Swan (I) | 100.0 | 70.0 | 75.0 | - | - | *43.8* | - |
| Grey Teal (A) | 40.0 | 40.0 | - | - | *52.4* | *23.8* | - |
| Grey Teal (I) | - | 40.0 | *100.0* | 40.0 | *27.5* | 30.0 | 25.0 |
| Aust. White Ibis (A) | - | 50.0 | - | 80.0 | - | *24.1* | - |
| Red-necked Stint (A) | - | 30.0 | - | - | 15.0 | *22.4* | 37.5 |
| Red-necked Stint (I) | - | - | *75.0* | 50.0 | 10.0 | *21.8* | - |
| Black-winged Stilt (A) | - | - | 37.5 | *41.9* | 93.6 | *24.7* | 10.0 |
| Black-winged Stint (I) | - | 40.0 | 60.0 | 30.0 | - | 15.0 | 25.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Grey Plover (A) | - | - | - | 120.0 | 33.3 | *34.5* | - |
| Grey Plover (I) | - | - | 100.0 | 50.0 | 15.0 | *8.8* | - |
| Silver Gull (I) | - | 15.5 | 50.0 | - | 10.0 | *15.5* | - |

NB: Black-winged Stilt (A) *18.0*m in response to birdwatcher
Silver Gull (I) 15.0m in response to birdwatcher

TABLE NINE. The relationship between the proportion of each species in the total number of waterbirds recorded and the proportion of each species among the birds recorded being disturbed during the six all-day surveys.

| Species | % of total count | % of disturbed waterbirds | Disturbance index |
|---|---|---|---|
| Australian Shelduck | 0.15 | 0.02 | 0.13 |
| Black Swan | 3.68 | 3.49 | 0.95 |
| Chestnut Teal | 0.01 | | |
| Grey Teal | 7.95 | 10.98 | 1.38 |
| Musk Duck | 2.98 | | |
| Pacific Black Duck | 1.28 | 1.08 | 0.84 |
| Australasian Grebe | 0.01 | | |
| Great Crested Grebe | 0.01 | | |
| Hoary-headed Grebe | 0.16 | | |
| Darter | 0.04 | | |
| Great Cormorant | 0.65 | 0.34 | 0.52 |
| Little Black Cormorant | 8.83 | 8.16 | 0.92 |
| Little Pied Cormorant | 2.96 | 1.02 | 0.34 |
| Pied Cormorant | 0.08 | | |
| Australian Pelican | 2.11 | 2.18 | 1.03 |
| Great Egret | 0.03 | 0.03 | 1.00 |
| White-faced Heron | 0.05 | 0.08 | 1.60 |
| Australian White Ibis | 1.77 | 1.14 | 0.64 |
| Osprey | 0.05 | 0.01 | 0.20 |
| Buff-banded Rail | 0.02 | | |
| Bar-tailed Godwit | 0.01 | | |
| Common Greenshank | 0.25 | 0.09 | 0.36 |
| Common Sandpiper | 0.02 | 0.02 | 1.00 |
| Curlew Sandpiper | 1.51 | 0.73 | 0.48 |
| Great Knot | 0.17 | | |
| Red Knot | 0.15 | | |
| Red-necked Stint | 31.11 | 53.28 | 1.71 |
| Sharp-tailed Sandpiper | 0.71 | 0.05 | 0.07 |
| Pied Oystercatcher | 2.44 | 2.44 | 1.00 |
| Black-winged Stilt | 5.42 | 3.41 | 0.63 |
| Red-necked Avocet | 0.30 | 0.71 | 2.37 |
| Grey Plover | 1.12 | 0.54 | 0.48 |
| Red-capped Plover | 2.56 | 1.39 | 0.54 |
| Caspian Tern | 0.39 | 0.26 | 0.67 |
| Crested Tern | 0.46 | 0.16 | 0.35 |
| Fairy Tern | 0.72 | 1.54 | 2.14 |
| Silver Gull | 19.55 | 6.79 | 0.35 |
| Sample size: | 106,621 | 9,803 | |

FIGURE ONE. The Swan Estuary Marine Park, indicating the locations of Alfred Cove, Milyu and Pelican Point Reserves. The inset map shows the area of the Swan River Estuary that has been enlarged. The scale bar is 1km.

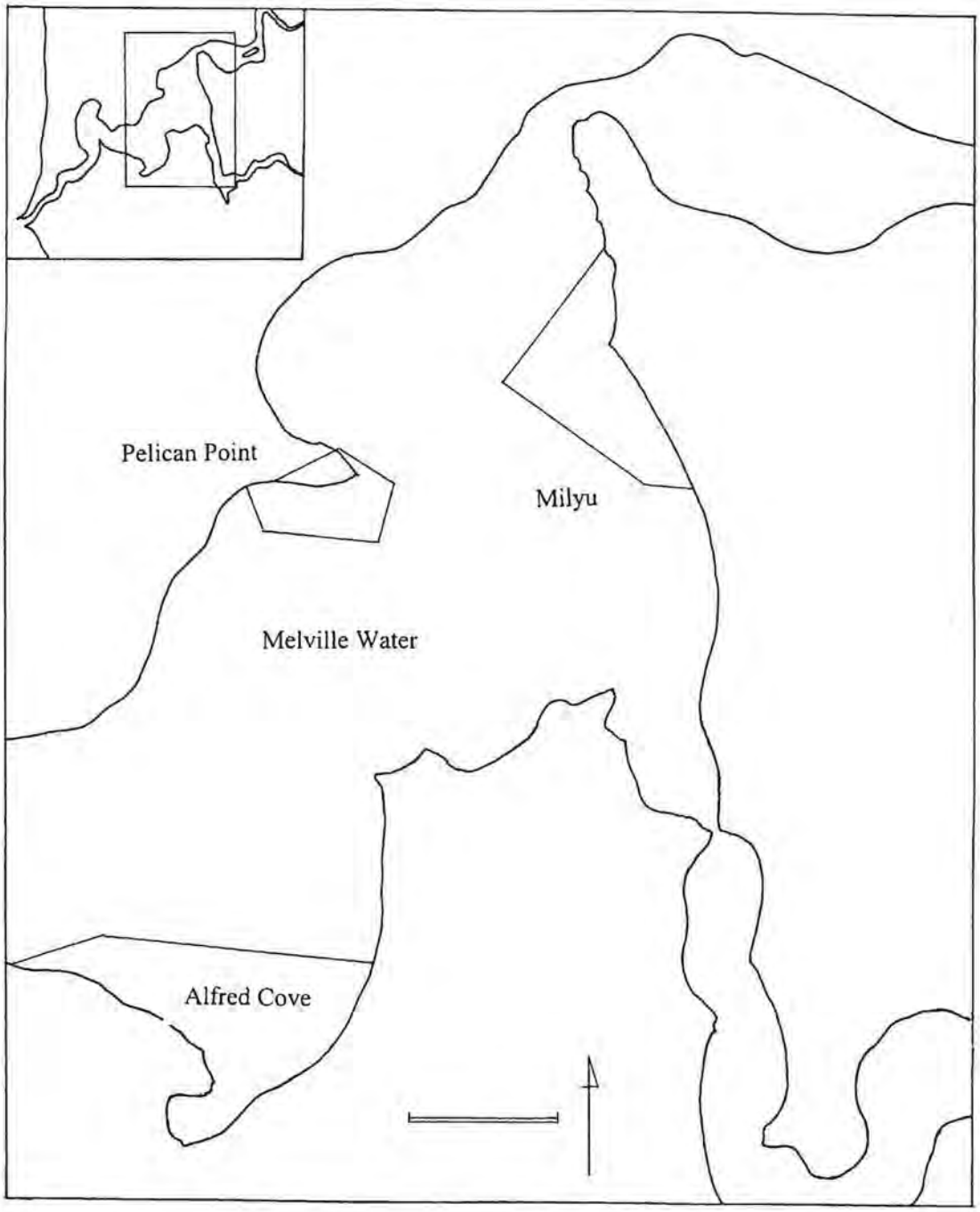


FIGURE TWO. Alfred Cove Reserve, indicating the locations of Survey Zones 1 to 7. The Zones extend approximately to the edge of the tidal mudflats, indicated by the dotted line. Survey Zone 9 is the PWC area. The boundaries of the reserve are indicated by a broken line, while the dot-dash line indicates the location of the dual use pathway. Hatching indicates roosting areas, including sandbars in Zones 2, 3 and 4. The scale bar is 250m.

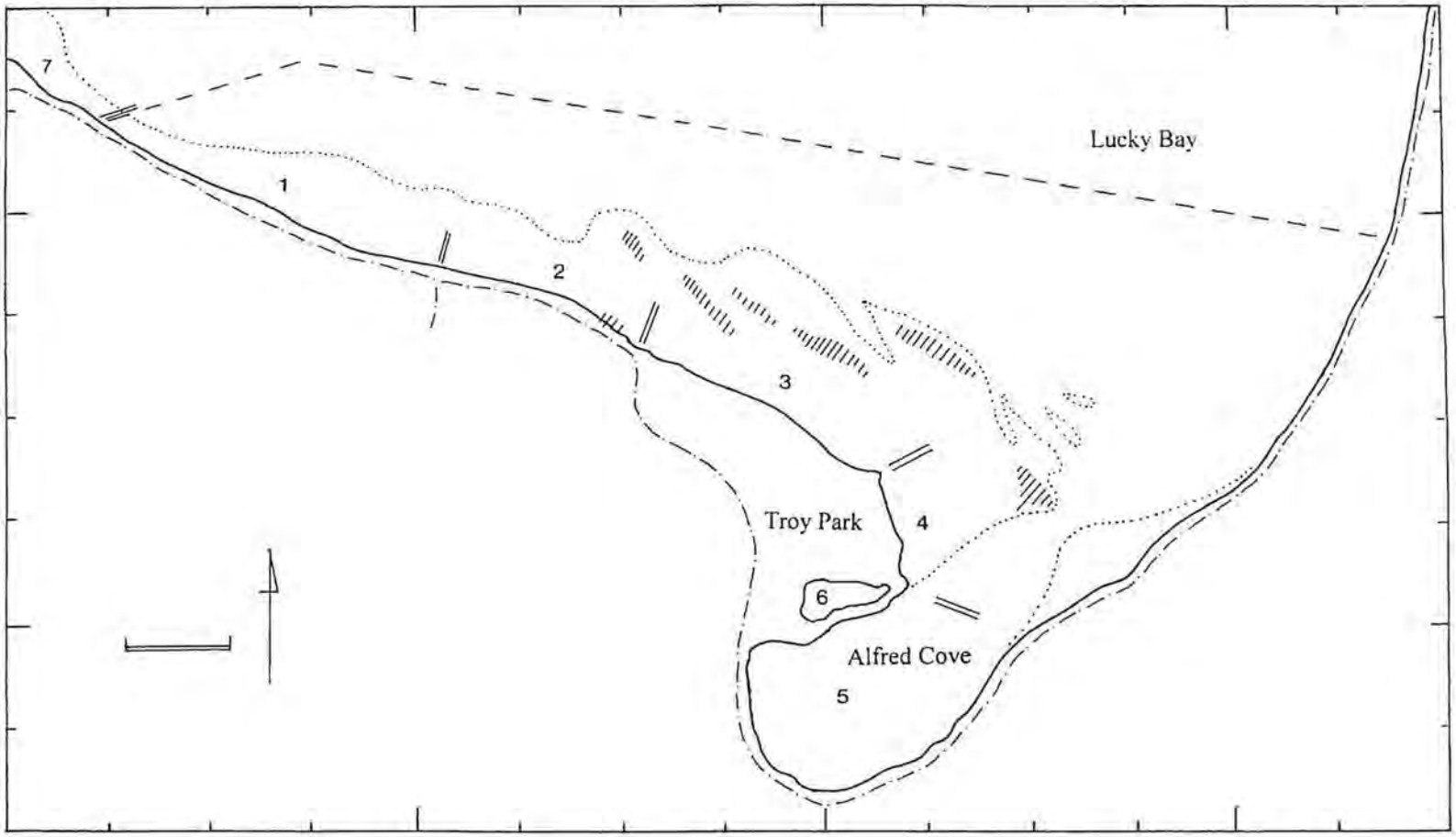


FIGURE THREE. Milyu Reserve, indicating the locations of Survey Zones 1 to 9. Only Zones 5, 6 and 7 are within the reserve. Zones 1 to 4 extend to the edge of the PWC Area, while Zones 5 to 8 extend approximately 200m offshore. Zone 9 is the PWC area. The boundaries of Milyu Reserve and the PWC area are indicated by broken lines, while the dot-dash line indicates the location of the dual use pathway. The fine dotted line in Zones 6, 7 and 8 is the extent of mudflats exposed at low tide and used by foraging birds. Hatching in Zones 3 and 6 indicates roosting areas. The scale bar is 250m.

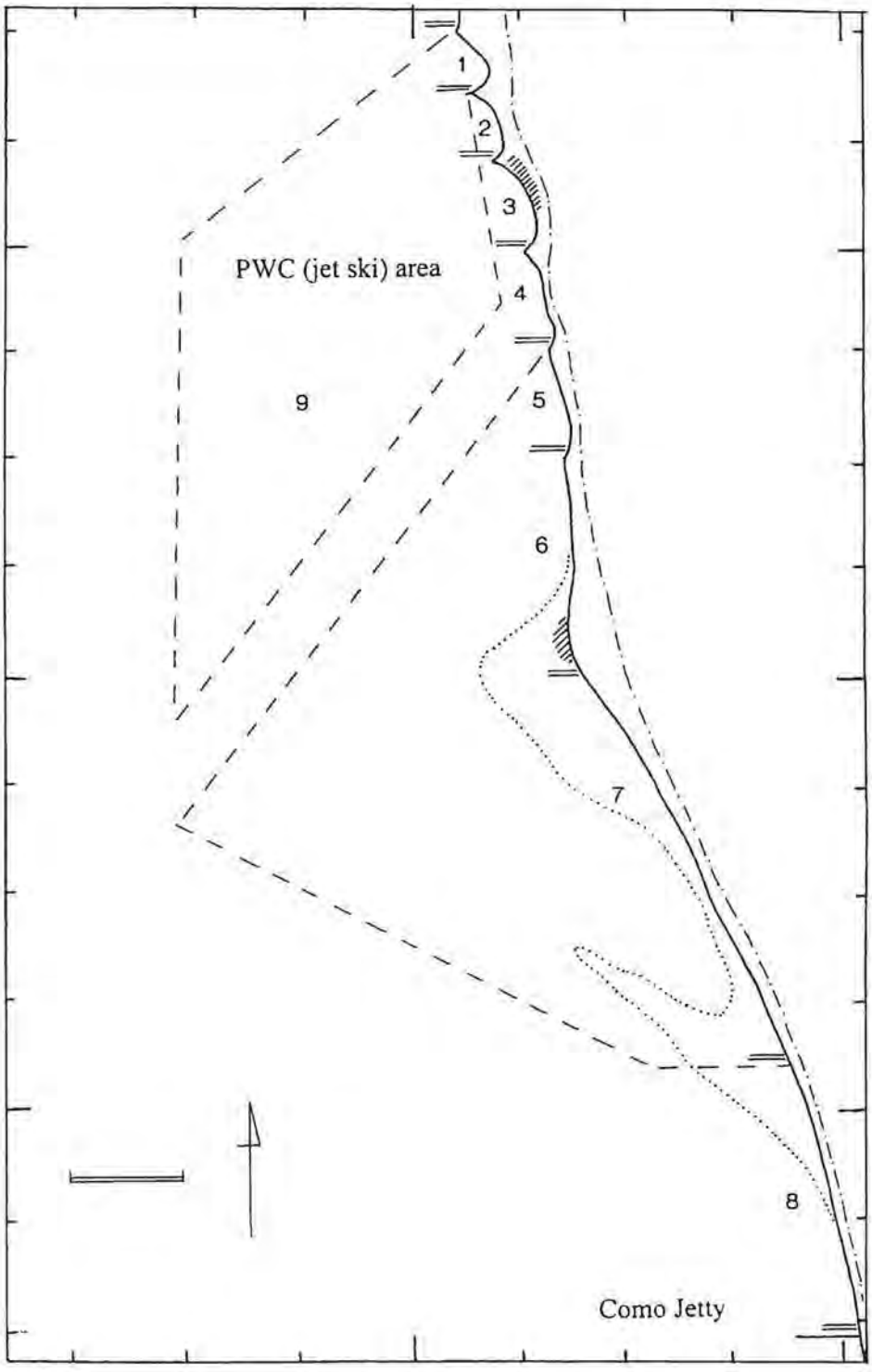


FIGURE FOUR. Pelican Point Reserve, indicating the locations of Survey Zones 1 to 6. Zone 1 is the pool within the land area of the reserve, while Zones 5 and 6 are outside the reserve. The reserve boundary is indicated by a broken line. The fine dotted line is the extent of mudflats exposed at low tide and used by foraging birds. Hatching in Zones 1, 2 and 3 indicates roosting areas. The scale bar is 250m.

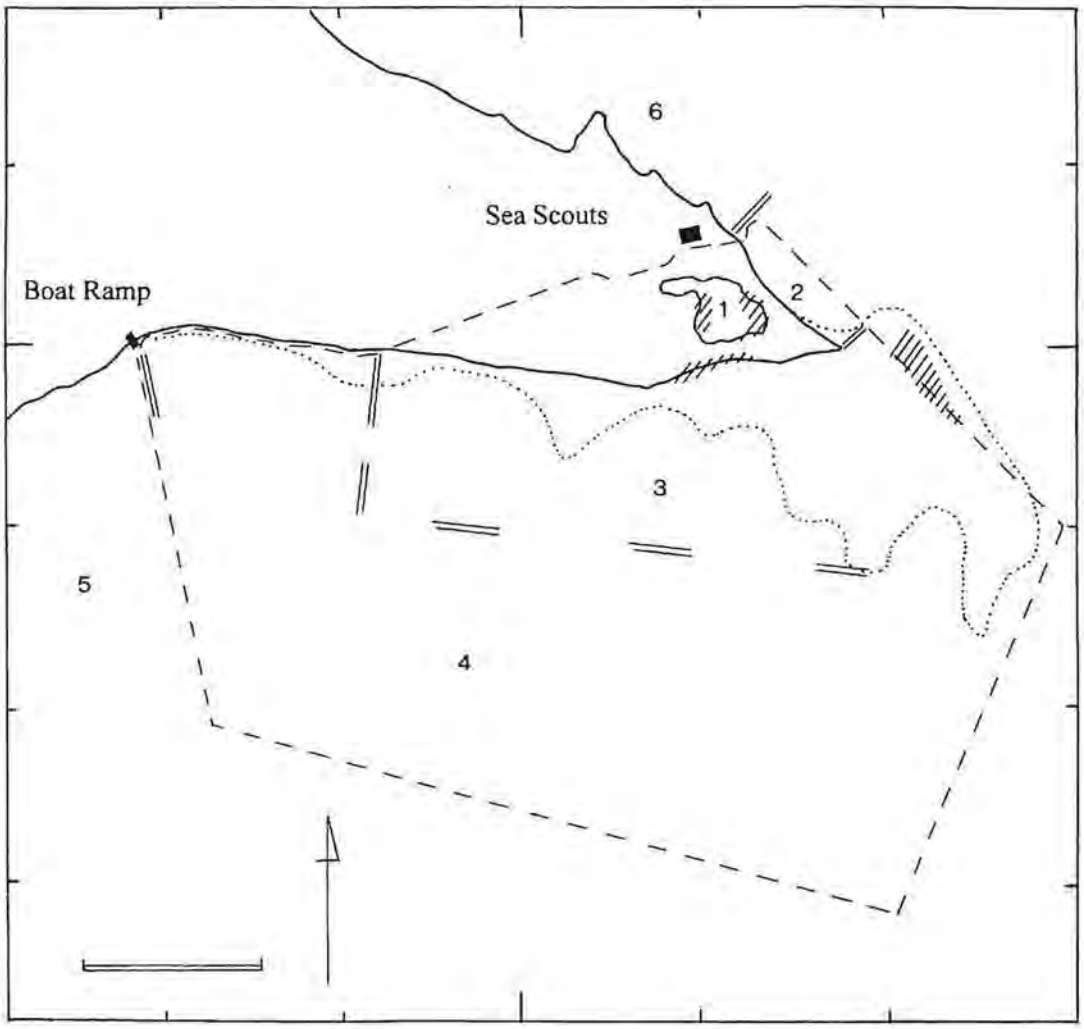
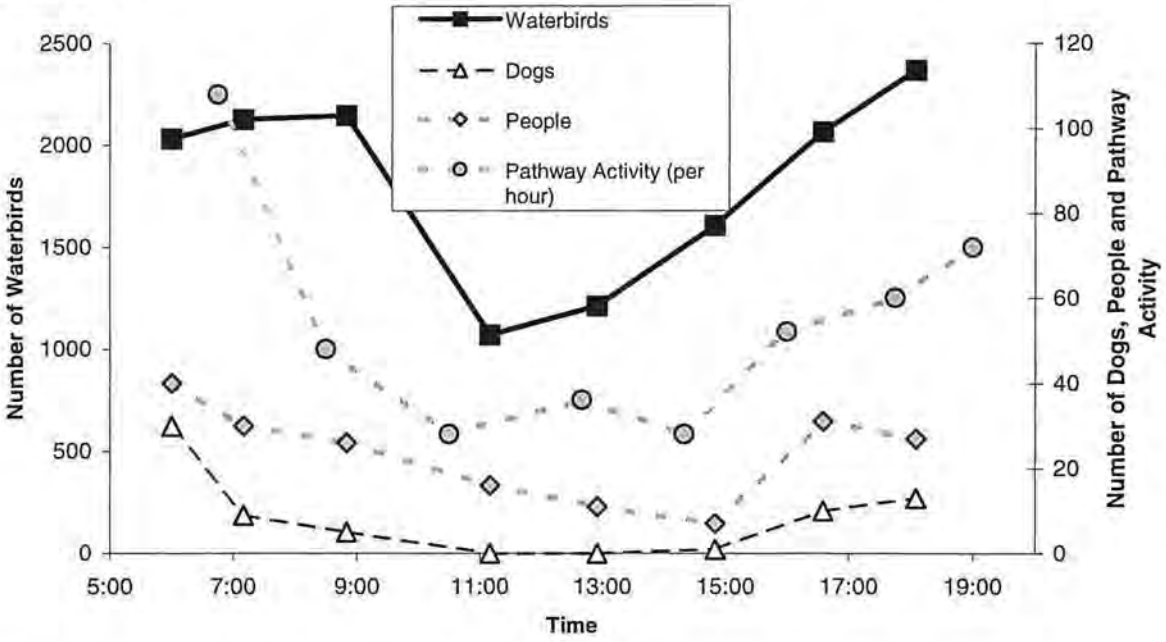
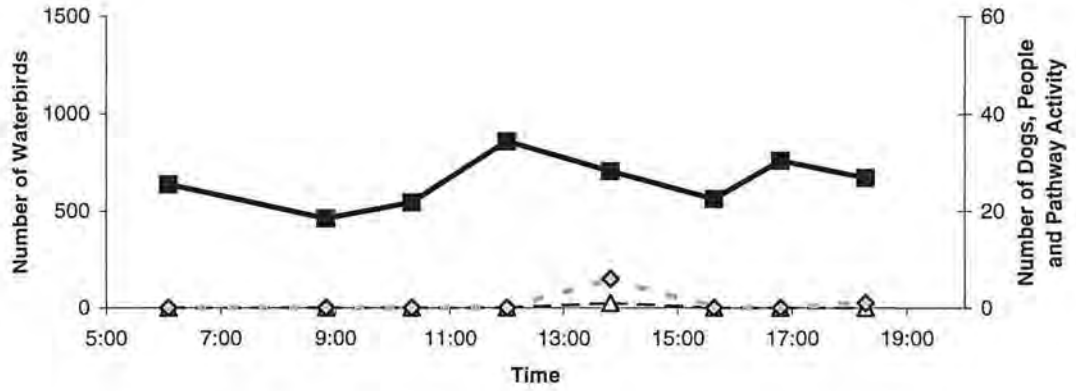


FIGURE FIVE. Diurnal variation in numbers of waterbirds, people and dogs at Alfred Cove, Milyu and Pelican Point on 25th November 2002. Pathway activity is the hourly rate of people (pedestrians, cyclists, etc) and dogs pooled determined from counts made at one location (Alfred Cove only).

Alfred Cove




Milyu




Pelican Point

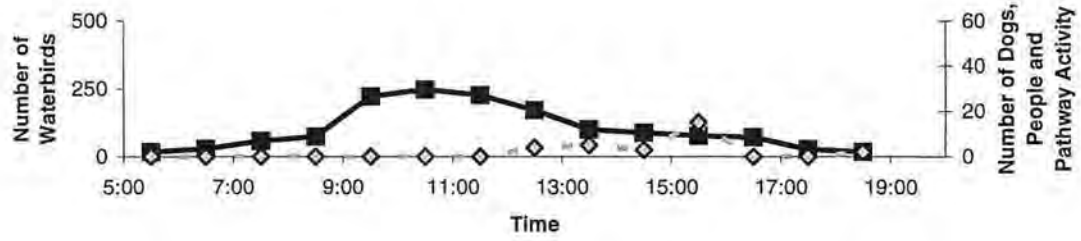
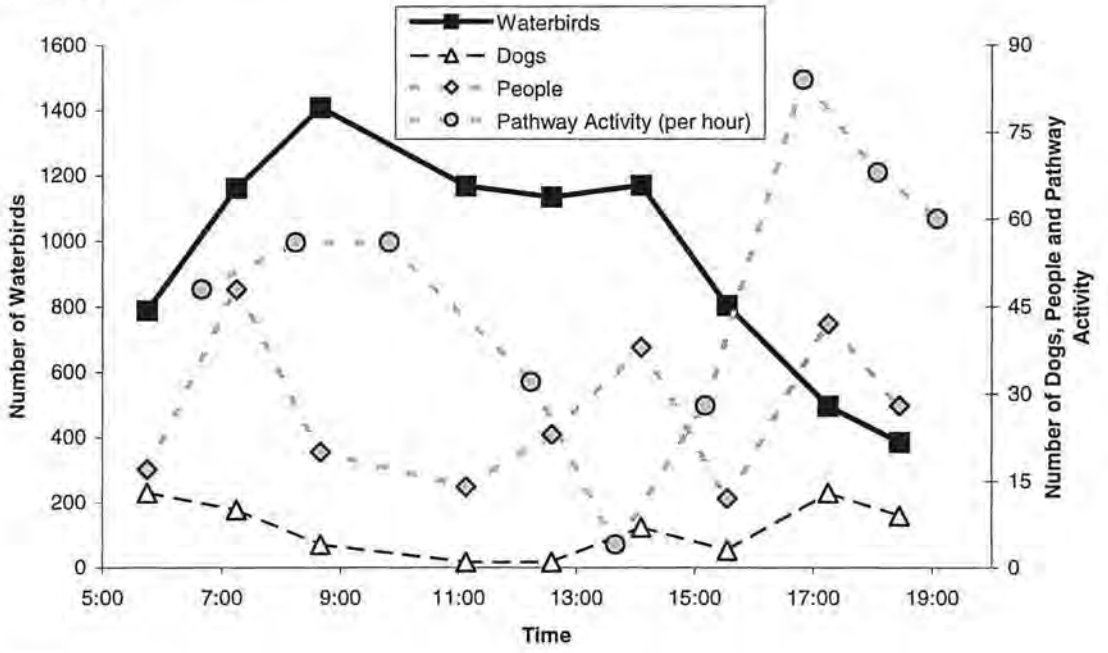
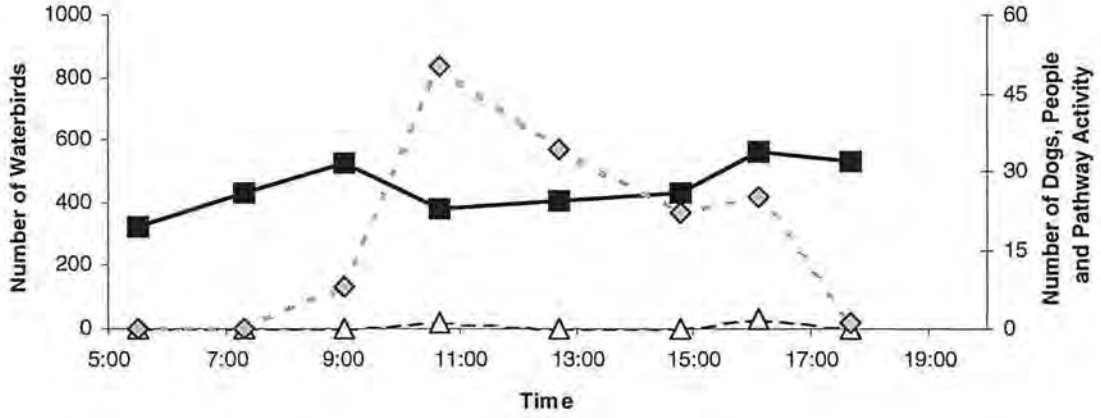


FIGURE SIX. Diurnal variation in numbers of waterbirds, people and dogs at Alfred Cove, Milyu and Pelican Point on 4th January 2003. Pathway activity is the hourly rate of people (pedestrians, cyclists, etc) and dogs pooled determined from counts made at one location (Alfred Cove and Milyu only).

Alfred Cove




Milyu




Pelican Point

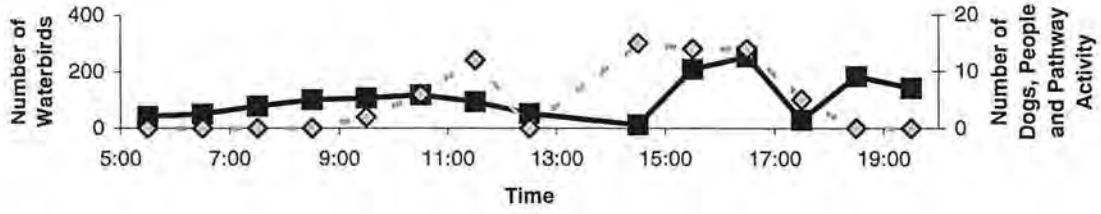
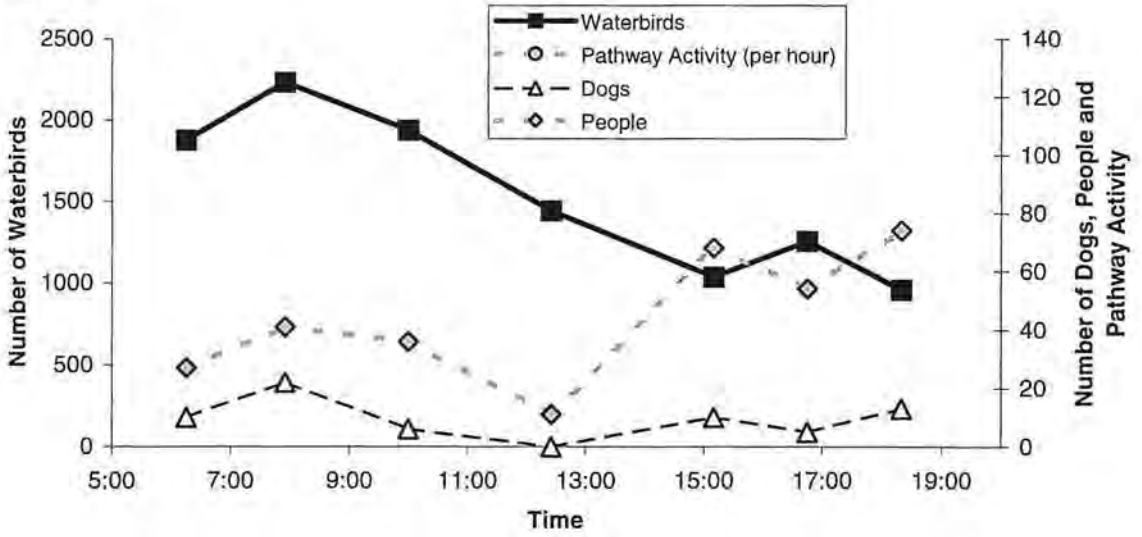
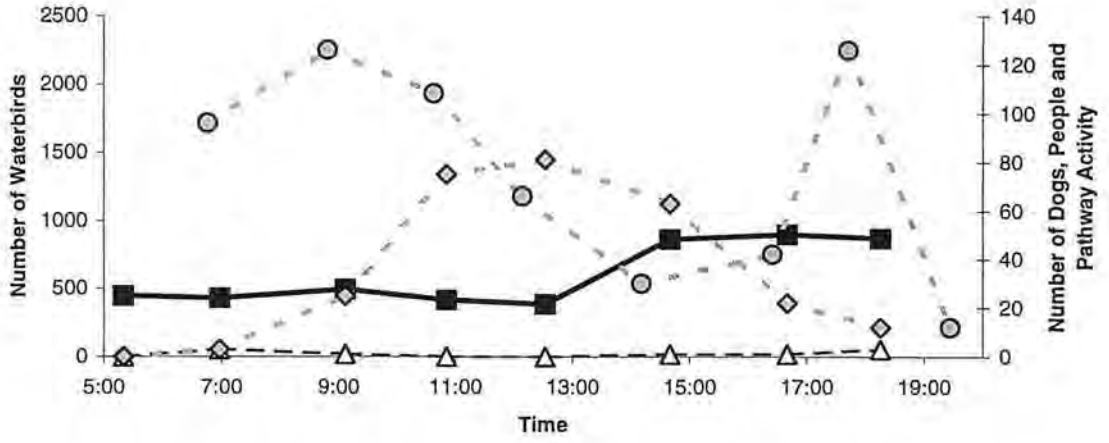


FIGURE SEVEN. Diurnal variation in numbers of waterbirds, people and dogs at Alfred Cove, Milyu and Pelican Point on 27th January 2003. Pathway activity is the hourly rate of people (pedestrians, cyclists, etc) and dogs pooled determined from counts made at one location (Alfred Cove and Milyu only).

Alfred Cove




Milyu




Pelican Point

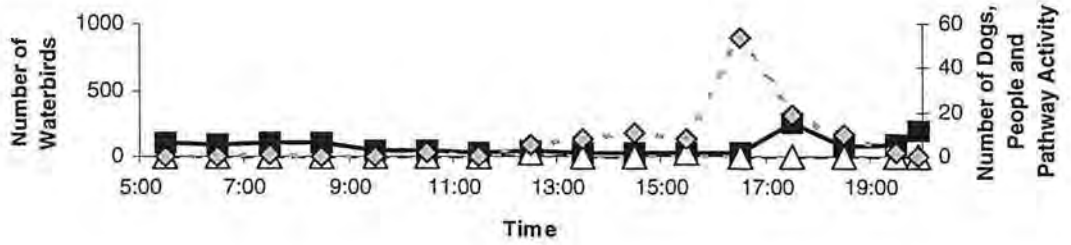
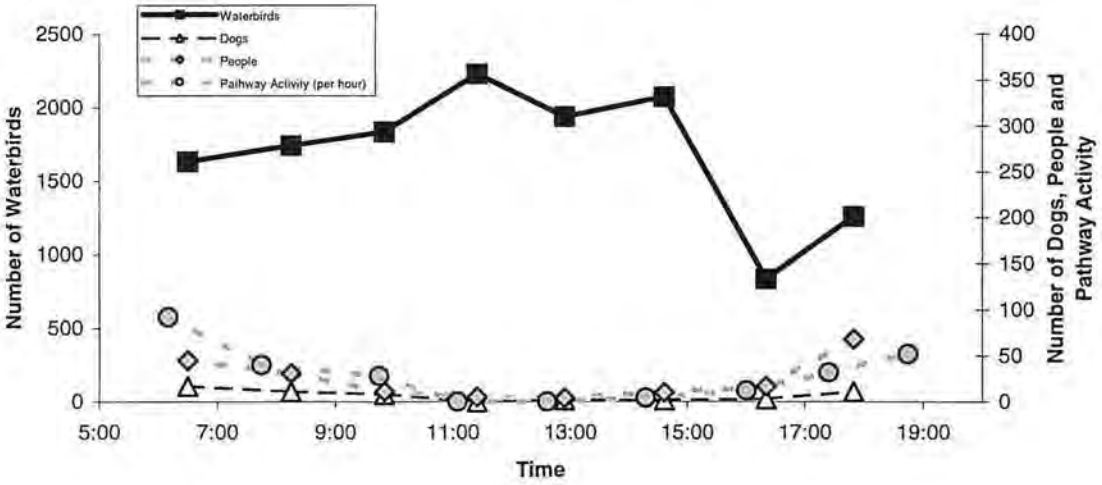
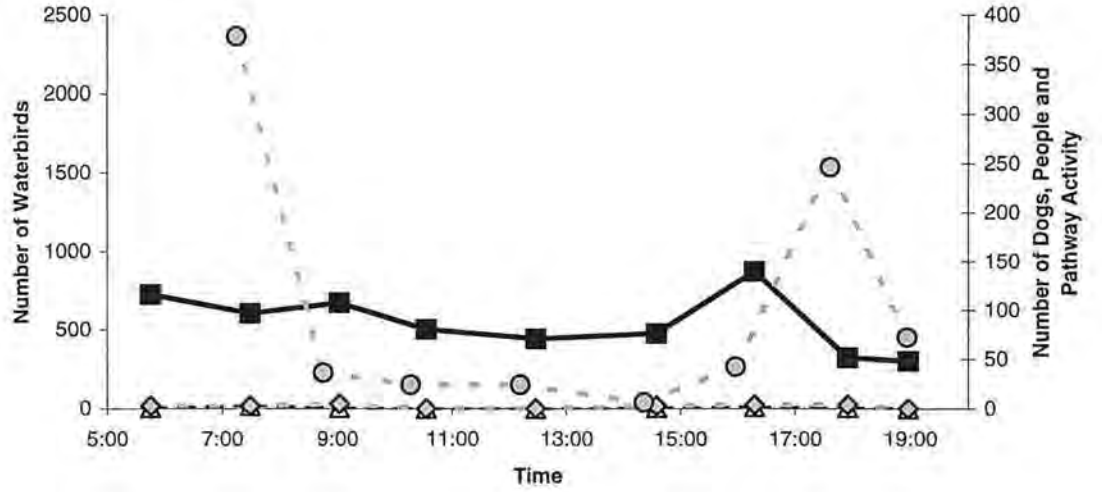


FIGURE EIGHT. Diurnal variation in numbers of waterbirds, people and dogs at Alfred Cove, Milyu and Pelican Point on 27th February 2003. Pathway activity is the hourly rate of people (pedestrians, cyclists, etc) and dogs pooled determined from counts made at one location (Alfred Cove and Milyu only).

Alfred Cove




Milyu




Pelican Point

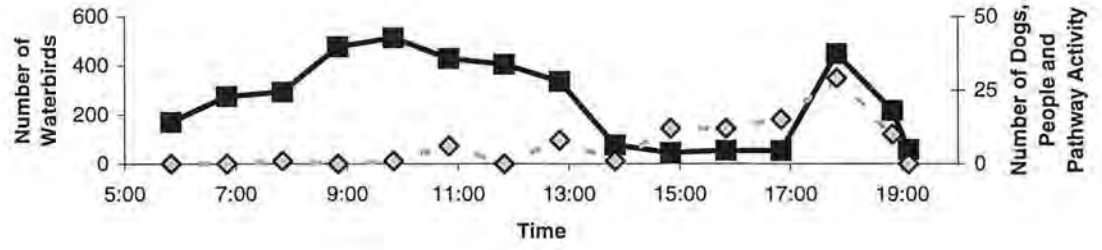
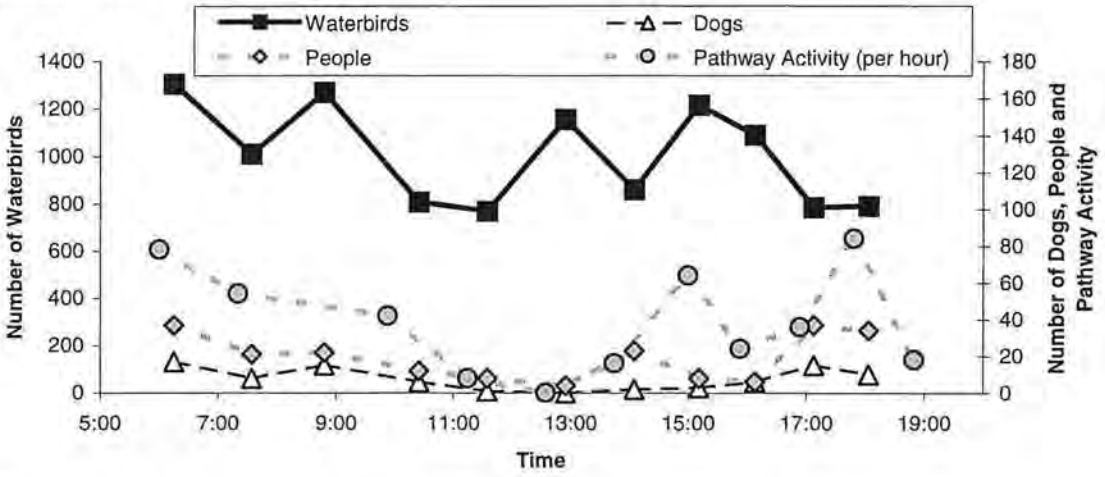
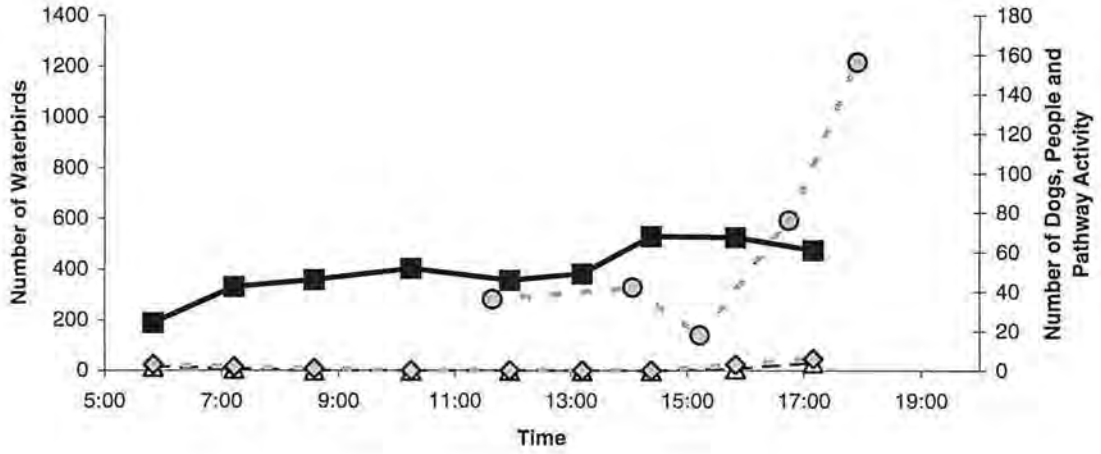


FIGURE NINE. Diurnal variation in numbers of waterbirds, people and dogs at Alfred Cove, Milyu and Pelican Point on 17th March 2003. Pathway activity is the hourly rate of people (pedestrians, cyclists, etc) and dogs pooled determined from counts made at one location (Alfred Cove and Milyu only).

Alfred Cove




Milyu




Pelican Point

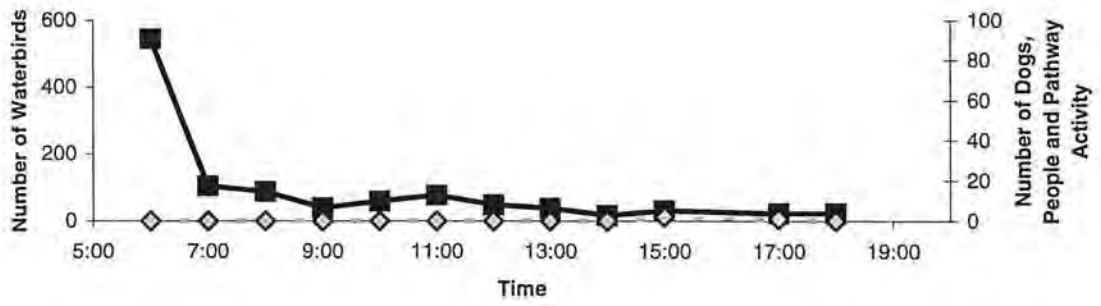
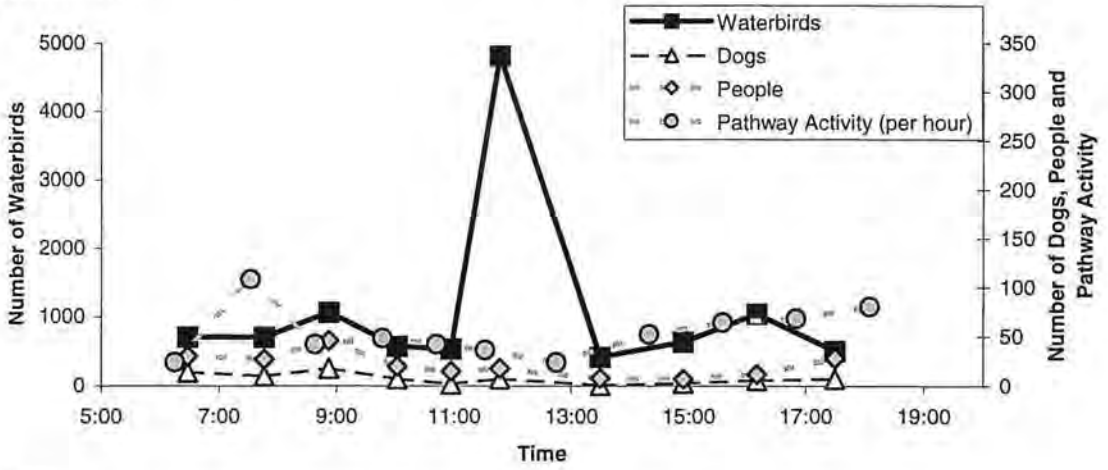
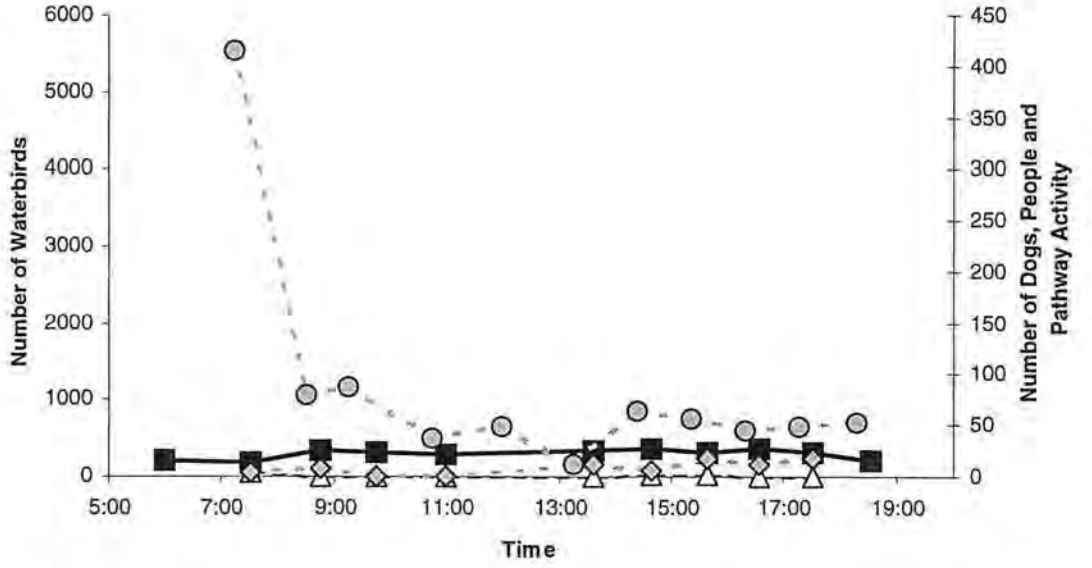


FIGURE TEN. Diurnal variation in numbers of waterbirds, people and dogs at Alfred Cove, Milyu and Pelican Point on 29th March 2003. Pathway activity is the hourly rate of people (pedestrians, cyclists, etc) and dogs pooled determined from counts made at one location (Alfred Cove and Milyu only).

Alfred Cove




Milyu




Pelican Point

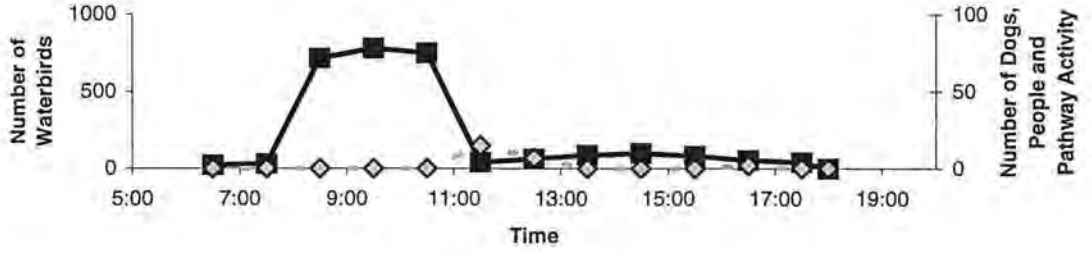
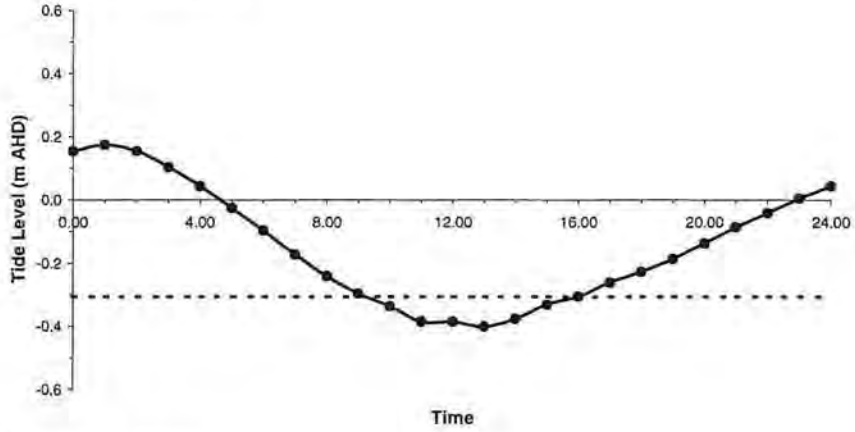
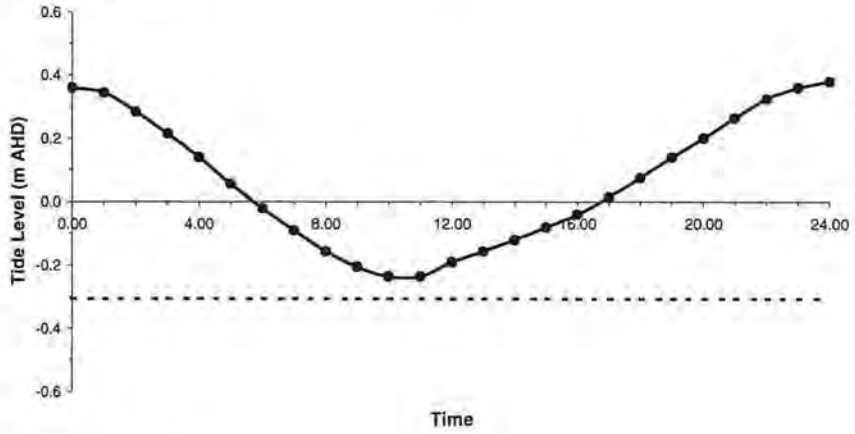


FIGURE ELEVEN. Tide level at hourly intervals on each all-day survey. The broken line indicates the level at which the mudflats at Alfred Cove are exposed. Data from Barrack Street Jetty and provided by the Department of Planning and Infrastructure.

25th November 2002




4th January 2003




27th January 2003

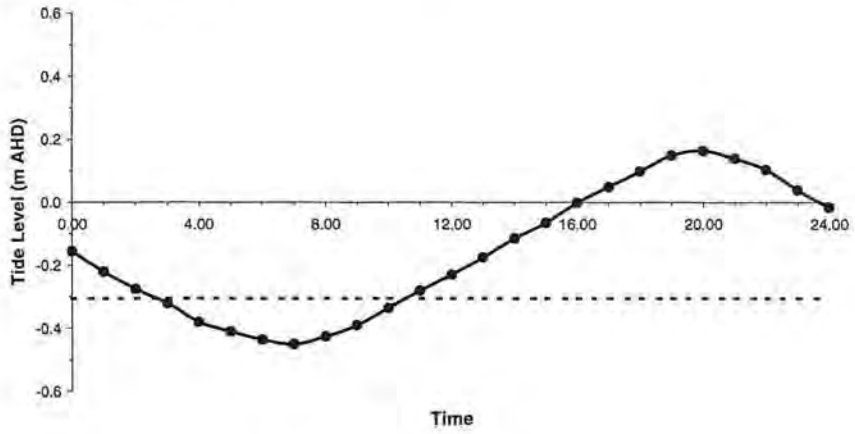
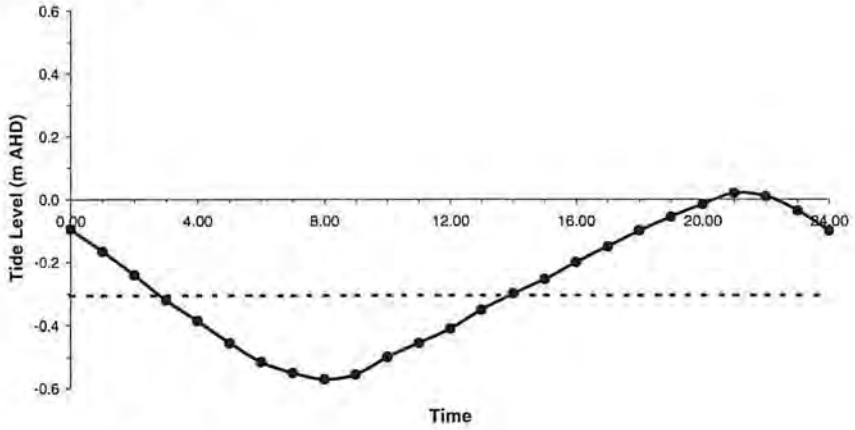
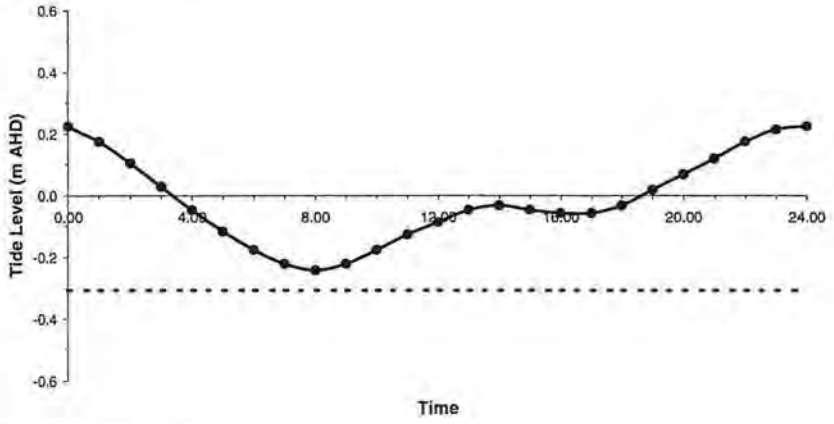


Figure 11 (cont.).

27th February 2003




17th March 2003




29th March 2003

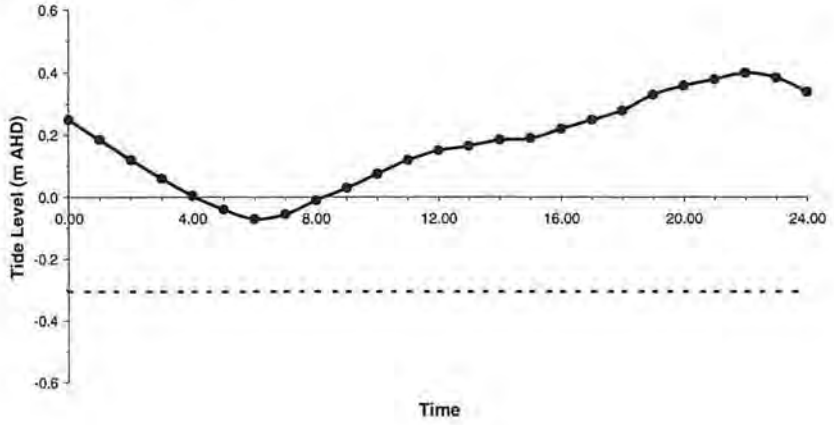
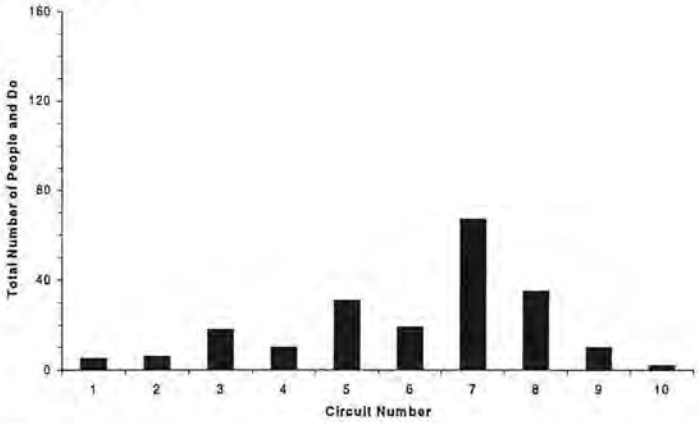
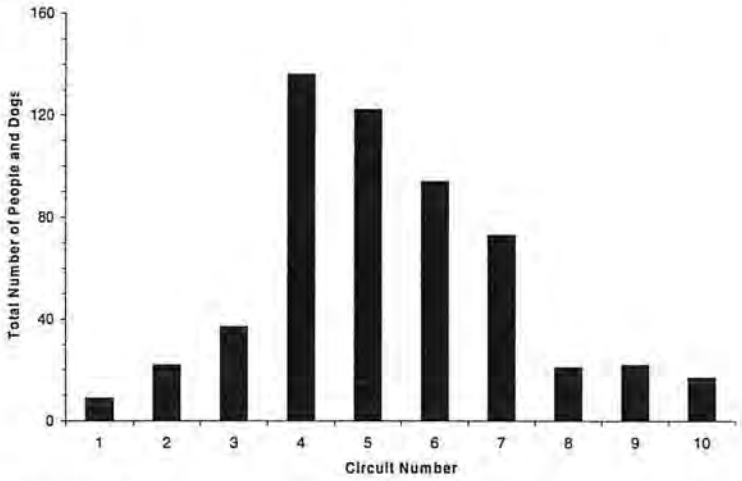


FIGURE TWELVE. The total number of people and dogs in each circuit number, all surveys pooled, for each site. The circuit number approximates time of day, with circuit 1 occurring just after sunrise and the last circuit taking place at around sunset.

Alfred Cove




Milyu




Pelican Point

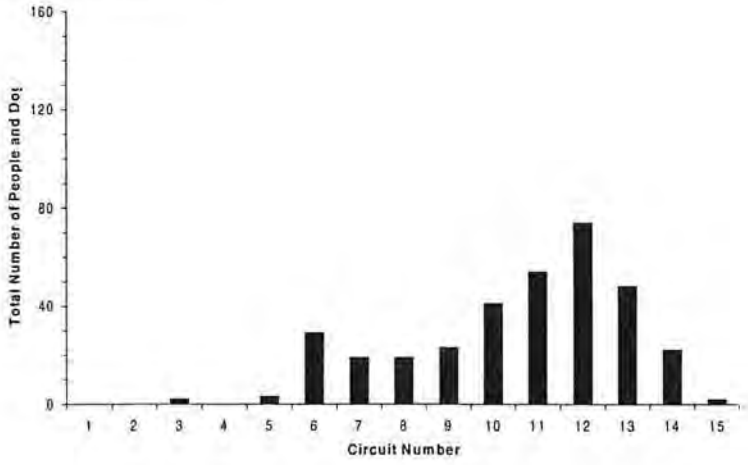
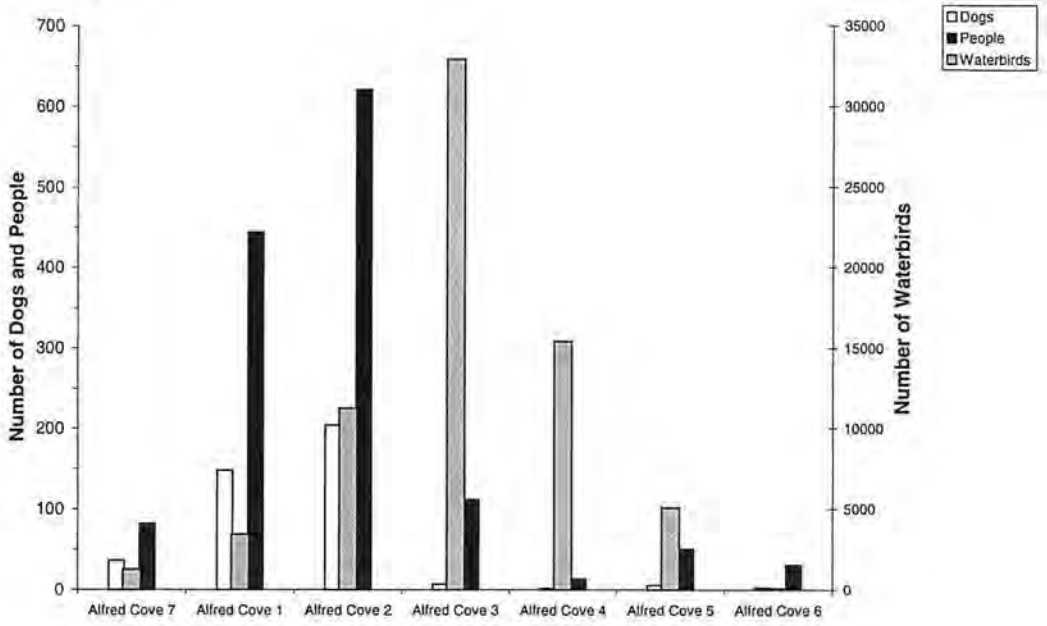


FIGURE THIRTEEN. The total numbers of dogs, people and waterbirds recorded in each survey zone at each site; all surveys pooled. These include records on the adjacent pathway at Alfred Cove and Milyu

Alfred Cove




Milyu

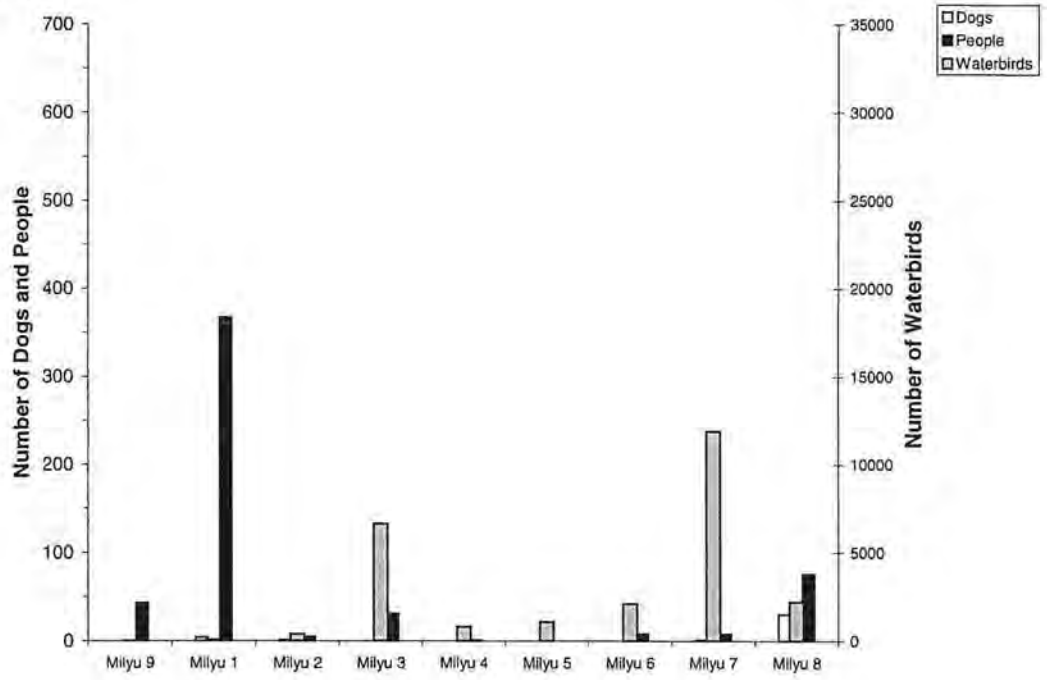
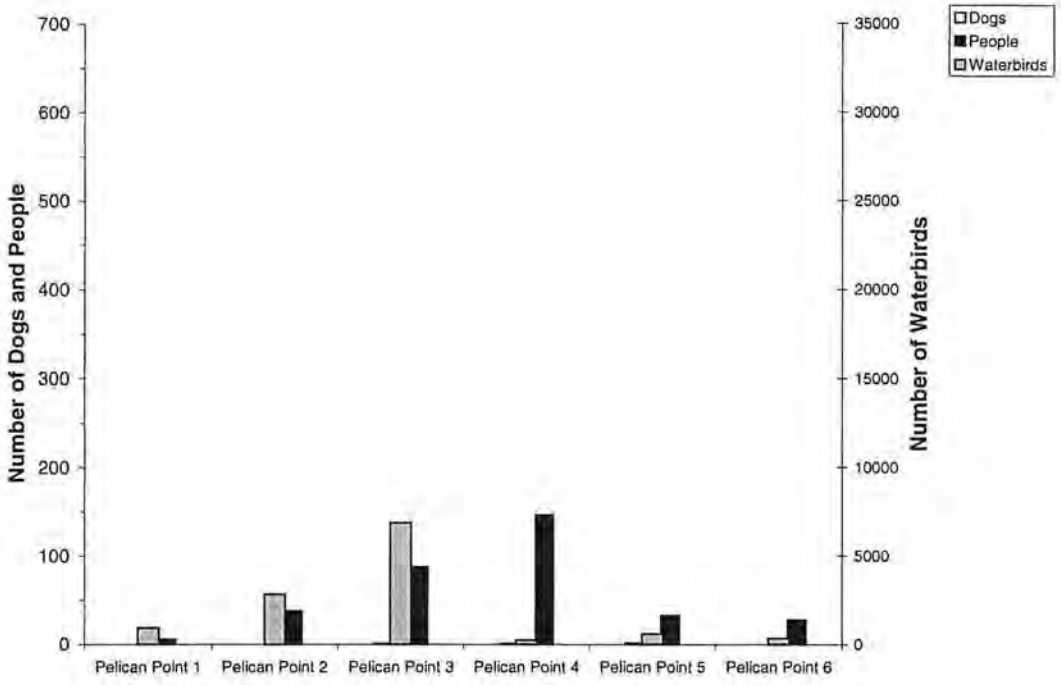


Figure 13 (cont.)

Pelican Point



## REFERENCES

ANCA (1993). A Directory of Important Wetlands in Australia. Australian Nature Conservation Agency, Canberra.

Bailey, M. and Creed, K. (1989). Observations of bird species at Pelican Point, Perth, Western Australia. West. Aust. Naturalist 17: 8.

Bamford, A.R., Davies, S.J.J.F. & Van Delft, R. (1990). The effects of model power boats on waterbirds at Herdsman Lake, Perth, Western Australia. The Emu 90: 260-265.

Bamford, M. (1999). Movements of Waders on the Swan Estuary. Western Australian Bird Notes 89: 10-11.

Bamford, M.J. and Bamford, A.R. (1999). Ecological Research Consultancy – Monitoring Programme to Determine Whether Use of Personal Watercraft is Affecting Wildlife. Unpub. report by Bamford Consulting Ecologists to Department of Transport, Fremantle.

Bamford, M.J. (2002). Management Plan for the Protection of Waders Adjacent to the Personal Watercraft Freestyle Area, South Perth. Unpub. report by Bamford Consulting Ecologists to the City of South Perth and the Department of Planning and Infrastructure.

Creed, K. and Bailey, M. (1998). Decline in Migratory Waders at Pelican Point, Swan River, Western Australia. Stilt 33: 10-14.

Davidson, N. and Rothwell, P. (eds). (1993). Disturbance to Waterfowl on Estuaries. Wader Study Group Bulletin 68, Special Issue.

Department of Conservation and Land Management (1996). Swan Estuary Marine Park and Adjacent Nature Reserves Draft Management Plan. Department of Conservation and Land Management for the National Parks and Nature Conservation Authority, Perth.

Ford, J.R. (1958). Seasonal variation in populations of Anatidae in the Bibra Lake district. Emu 58: 31-41.

Jaensch, R.P., Vervest, R. and Hewish, M.J. (1988). Waterbirds in Nature Reserves of South-Western Australia 1981-1985: Reserve Accounts. Royal Australasian Ornithologists Union Report No. 30. RAOU Melbourne.

Lafferty, K.D. (2001). Disturbance to wintering western snowy plovers. Biological Conservation 101: 315-325.

Paton, D.C., Ziembicki, M., Owen, P. and Heddle, C. (2000). Disturbance Distances for Waterbirds and the Management of Human Recreation with Special Reference to the Coorong Region of South Australia. Final Report for the Migratory Waterbird Component of the National Wetlands Programme.

Serventy, D.L., Farner, D.S. and Nichols, C.A. (1962). Trapping and Maintaining Shore Birds in Captivity. Bird Banding 33: 123-130.

Serventy, V. and Raymond, R. (eds.) (1974). Australia's Wildlife Heritage. 6: 2698. Paul Hamlyn Pty, Ltd, NSW.

Van Delft, R.J. (1997). Birding sites Around Perth. Second (revised) edition. Birds Australia – Western Australian Group, Perth.

Wilson, J. (2001). The January and February 2001 Victoria wader count. The Stilt 40: 55-64.

APPENDIX ONE. Mean distances at which waterbirds became alert in response to different disturbance events (± 1 standard error, sample size in parenthesis).

| Species | Activity | Bird-watching | Boating | Cycling | Dog | Fishing | Jetskiing | Jogging | Kayaking | Kite- |
|---|---|---|---|---|---|---|---|---|---|---|
| Australian Shelduck | Active | | | | | | | | | |
| | Inactive | | | | | | | | | |
| Black Swan | Active | | 102.5 ± 18.4 (4) | | | 40 ± 0 (2) | | | 125 ± 25 (2) | |
| | Inactive | | | | | | | 30 (1) | 100 (1) | 87.5 ( |
| Grey Teal | Active | | 40 (1) | 35 (1) | | | | 36.7 ± 6.7 (3) | 40 (1) | 60 |
| | Inactive | | | | 25 ± 0 (2) | 40 (1) | | 28.8 ± 6.6 (4) | 40 ± 0 (2) | 102.5 ( |
| Pacific Black Duck | Active | | | | | 20 (1) | | | | 10 |
| | Inactive | | | | 25 ± 0 (2) | 65 ± 5 (3) | | | | 45 ± |
| Great Cormorant | Active | | | | | | | | | 10 |
| | Inactive | | | | | 102.5 ± 47.5 (2) | | | | |
| Little Black Cormorant | Active | | | | | | | | | |
| | Inactive | | 200 (1) | | | | | | | |
| Little Pied Cormorant | Active | | | | | | | | | 10 |
| | Inactive | | | | | 100 ± 0 (2) | 5 (1) | | 20 (1) | 10 |
| Australian Pelican | Active | | | | | | | | | |
| | Inactive | | | | | 55 (1) | | | 110 ± 10 (2) | 94 ± |
| Great Egret | Active | | | | | | | | | |
| | Inactive | | | | 50 (1) | | | | 20 (1) | |

Appendix 1 (cont.)

| Species | Activity | Bird-watching | Boating | Cycling | Dog | Fishing | Jetskiing | Jogging | Kayaking | Kite- |
|---|---|---|---|---|---|---|---|---|---|---|
| White-faced Heron | Active | | | | | | | | | |
| | Inactive | | | | | | | | | |
| Australian White Ibis | Active | | | | 40 (1) | 85 ± 9.6 (4) | | | | |
| | Inactive | | | | | | | | | |
| Osprey | Active | | | | | | | | | |
| | Inactive | | | | | | | | | |
| Common Greenshank | Active | | | | | 10 (1) | | 30 (1) | | |
| | Inactive | | | | | 20 (1) | | | | 11 |
| Common Sandpiper | Active | | | | | | | | | |
| | Inactive | | | | | | | | | |
| Curlew Sandpiper | Active | | | | | | | | | |
| | Inactive | | | | | | | | | |
| Red-necked Stint | Active | | | | 37.5 ± 12.5 (2) | | | 15 (1) | 30 ± 0 (2) | |
| | Inactive | | | 15 (1) | | 50 (1) | 25 ± 15 (2) | 20 (1) | | 93.3 ( |
| Sharp-tailed Sandpiper | Active | | | | | | | 30 (1) | | |
| | Inactive | | | | | | | | | |
| Pied Oystercatcher | Active | | | | | 15 (1) | | | | |
| | Inactive | | | | | 22.5 ± 7.5 (2) | | | | 55 ± |
| Black-winged Stilt | Active | 10 ± 5 (3) | | | 20 (1) | 46.4 ± 19 (7) | | 27.5 ± 3.6 (6) | | 65 ± |
| | Inactive | | | | 25 (1) | 30 (1) | | | 40 (1) | 63.3 ( |

Appendix 1 (cont.)

| Species | Activity | Bird-watching | Boating | Cycling | Dog | Fishing | Jetskiing | Jogging | Kayaking | Kite- |
|---|---|---|---|---|---|---|---|---|---|---|
| Red-necked Avocet | Active | | | | | | | | | |
| | Inactive | | | | | | | | | |
| Grey Plover | Active | | | | | 120 ± 0 (2) | | 33.3 ± 3.3 (3) | | |
| | Inactive | | | | | 50 (1) | | 15 (1) | | 10 |
| Red-capped Plover | Active | | | 5 (1) | | 15 (1) | | | | |
| | Inactive | | | | | | 10 (1) | | | |
| Caspian Tern | Active | | | | | | | | | |
| | Inactive | | | | | | | | | 11 |
| Fairy Tern | Active | | 50 (1) | | | | | | | |
| | Inactive | | | | | 60 (1) | | | | |
| Silver Gull | Active | | | | | | | | | |
| | Inactive | | | | | | 25 (1) | | 52.5 ± 17 (4) | 45 ± |

APPENDIX TWO. Mean distances at which waterbirds moved away in response to different disturbance events (± 1 standard error, sample size in parenthesis).

| Species | Activity | Bird-watching | Boating | Cycling | Dog | Fishing | Jetskiing | Jogging | Kayaking |
|---|---|---|---|---|---|---|---|---|---|
| Australian Shelduck | Active | | | | | | | | |
| | Inactive | | | | | | | | |
| Black Swan | Active | | 73.3 ± 13.3 (3) | | | 40 ± 0 (2) | | | 91.7 ± 30 (3) |
| | Inactive | | 100 (1) | | | | | 30 (1) | 70 (1) |
| Grey Teal | Active | | 40 ± 0 (2) | 35 (1) | | | | 52.5 ± 16.5 (4) | 40 (1) |
| | Inactive | | | | 25 ± 0 (2) | 40 (1) | | 27.5 ± 7.5 (4) | 40 ± 0 (2) |
| Pacific Black Duck | Active | | | | | 20 (1) | | | |
| | Inactive | 10 (1) | | | 25 ± 0 (2) | 65 ± 5 (3) | | | |
| Great Cormorant | Active | | | | | | | | |
| | Inactive | | | | | | | 10 (1) | |
| Little Black Cormorant | Active | | | | | | | | |
| | Inactive | | 200 (1) | | | | | | |
| Little Pied Cormorant | Active | | | | | | | | |
| | Inactive | 20 ± 5.8 (3) | | | | 53.3 ± 21.9 (3) | | | 10 (1) |
| Australian Pelican | Active | | | | | | | | |
| | Inactive | | | | | | | 10 (1) | 50 (1) |
| Great Egret | Active | | | | | | | | |
| | Inactive | | | | 45 (1) | | | | 20 (1) |

Appendix 2 (cont.)

| Species | Activity | Bird-watching | Boating | Cycling | Dog | Fishing | Jetskiing | Jogging | Kayaking |
|---|---|---|---|---|---|---|---|---|---|
| White-faced Heron | Active | | | | | | | | |
| | Inactive | | | | | | | | |
| Australian White Ibis | Active | | | | | 80 ± 8.9 (4) | | | 50 (1) |
| | Inactive | 10 (1) | | | | | | | |
| Osprey | Active | | | | | | | | |
| | Inactive | | | | | | | | |
| Common Greenshank | Active | | | | | 10 (1) | | 30 (1) | |
| | Inactive | | | | | 20 (1) | | | |
| Common Sandpiper | Active | | | | | | | | |
| | Inactive | | | | | | | | |
| Curlew Sandpiper | Active | | | | | | | | |
| | Inactive | | | | | | | | |
| Grey-tailed Tattler | Active | | | | | | | 100 (1) | |
| | Inactive | | | | | | | | |
| Red-necked Stint | Active | | | | 37.5 ± 12.5 (2) | | | 15 (1) | 30 ± 0 (2) |
| | Inactive | | | | | 50 (1) | 40 (1) | 10 (1) | |
| Sharp-tailed Sandpiper | Active | | | | | | | 30 (1) | |
| | Inactive | | | | | | | | |
| Pied Oystercatcher | Active | | | | | 15 (1) | | | |
| | Inactive | | | | | 22.5 ± 7.5 (2) | | | |
| Black-winged Stilt | Active | 18 ± 3.4 (5) | | | 10 (1) | 41.9 ± 17.1 (8) | | 93.6 ± 67.8 (7) | |
| | Inactive | | | | 25 (1) | 30 (1) | | | 40 (1) |

Appendix 2 (cont.)

| Species | Activity | Bird-watching | Boating | Cycling | Dog | Fishing | Jetskiing | Jogging | Kaya |
|---|---|---|---|---|---|---|---|---|---|
| Red-necked Avocet | Active | | | | | | | | |
| | Inactive | | | | | | | | |
| Grey Plover | Active | 6 (1) | | | | 120 ± 0 (2) | | 33.3 ± 3.3 (3) | |
| | Inactive | | | | | 50 (1) | | 15 (1) | |
| Pacific Golden Plover | Active | | | | | | | | |
| | Inactive | | | | | | | | |
| Red-capped Plover | Active | | | 5 (1) | | 15 (1) | | | |
| | Inactive | | | | | | | | |
| Caspian Tern | Active | | | | | | | | |
| | Inactive | | | | | | | | |
| Crested Tern | Active | | | | | | | | |
| | Inactive | | | | | | | | |
| Fairy Tern | Active | | 50 (1) | | | | | | |
| | Inactive | | | | 5 (1) | 60 (1) | | | |
| Silver Gull | Active | | | | | | 7 (1) | | |
| | Inactive | 15 (1) | | | | | | 10 (1) | 15 ± 5 (2) |