Feathering the Future of Burnett Mary Shorebirds

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Executive Summary

Fifty-two percent of migratory shorebird populations worldwide are in decline (Nebel et al., 2008) and 20% of species that regularly use the East Asian-Australasian Flyway have been officially classified as globally threatened with substantial population decline (Milton, 2003). The threats that these birds face are largely related to habitat loss, however, both migratory and resident shorebirds face numerous other threats. These threats include: global warming and sea level rise, water pollution, predation by introduced predators such as foxes and cats, and human disturbance. Both migratory and resident shorebirds are also threatened in Australia, where the major risks to shorebird populations are human disturbance, predation, habitat loss and degradation and lack of knowledge and awareness to shorebird conservation needs.

The objective of the study was to develop an adaptive experimental management approach using management techniques to address specific threat to shorebirds. Building on the activity undertaken by Queensland Wader Study Group, which mapped over 200 shorebird roost and nesting locations along the Burnett Mary region and identified/typified potential threats to these sites, a workshop with stakeholders, and interest groups was held to facilitate knowledge exchange and identify management priorities for addressing major threats to shorebirds in the Burnett Mary region. From October 2007 to April 2008, three pilot projects to address the threats to shorebirds in the Burnett Mary region were conducted.

Human disturbance

Human activity has the potential to negatively affect shorebirds (e.g. Burger, 1994; Thomas et al., 2003); therefore a management technique to protect nesting shorebirds in the Burnett Mary region using eight temporary beach closures (TBCs) along the Burnett coast was trialled to test the effectiveness of this shorebird conservation tool. Compliance to the TBCs was investigated along with the efficacy of TBC’s to protect shorebird eggs against trampling by beach users. Compliance was found to be high (96.2%) and no eggs were crushed inside the TBC, which suggests that the use of TBCs in the Burnett Mary region is an effective management technique for the conservation of shorebirds.

Predation

A major cause of breeding failure for many resident shorebirds is predation by introduced predators such as foxes (Dowling and Weston, 1999; Priest et al., 2002). Therefore, in an attempt to reduce predation by foxes on shorebird eggs and chicks, baiting with 1080 poison was trialled along a 5 km section of Burrum Coast National Park. The results were inconclusive due to the short duration of the study. However, research indicates that with a comprehensive baiting regime, this technique should be effective at reducing predation on shorebird eggs and chicks along the Burnett coast. However, the high cost and resources required in maintaining the effectiveness of this management technique and success at protecting shorebird populations may be outweighed by other less expensive management options.
Lack of knowledge and awareness

The general lack of community understanding or education of shorebird related conservation issues are significant threats to shorebird survival. Therefore, a survey was conducted to determine the level of knowledge and awareness people had of shorebirds, the threats they face and the most effective educational/management actions required to protect shorebirds. The results indicated that although 66% of people were aware of shorebirds, only 23% correctly identified 80% of birds as shorebirds. Dogs were recorded at every site despite the fact that dogs were prohibited at two sites. At each site dogs were observed off the leash even though leashes were required by law. The survey also showed that individuals/local residents and community groups were considered to be the two most important groups to undertake management activities to protect shorebirds. This strongly indicates that further education through education activities, signage and pamphlets are likely to benefit the conservation of shorebirds in the Burnett Mary region.

Finally, recommendations for future on-ground management of shorebirds include:

- The use of TBCs at sensitive shorebird sites
- That TBCs be made of stronger material, including the stakes
- That use of signage explaining the need for TBCs at access points to the beach were TBCs are in place
- That available resources be put towards developing signage, to be erected at shorebird beaches, about the need to protect shorebirds
- That information pamphlets about shorebirds be distributed in sensitive shorebird areas and that education activities are conducted on a regular basis.
General Introduction

Australia is home to approximately 18 species of resident shorebirds that breed and feed throughout the year and a temporary home to a further 36 species of migratory shorebirds that use our shores to rest and feed between September and April each year. Research has indicated that shorebird populations across one third of Australia are in serious decline and that in just a few decades (1980s-1996) the mean number of shorebirds has declined by 77% (Nebel et al., 2008). More than 80% of people (~17 million) live near the coast as we too place a high value on resources that the coast provides, such as land for housing, industry, agriculture and recreation (both on land and in the water) (Priest et al., 2002). This high usage of the coast results in a real potential for conflict and therefore a need to manage human/shorebird interactions to protect and conserve shorebirds.

Shorebirds that migrate to Australia from their breeding grounds in northern China, Alaska and Siberia require suitable feeding sites as well as protection from predators and disturbances to recuperate from long flights and to rebuild much depleted energy reserves. Shorebirds typically feed in intertidal habitats and shallow wetlands (water less than 10cm deep), surrounded by low sparse vegetation. When they are not feeding or transiting, shorebirds roost, generally at or above the high tide mark on open shores with a surrounding area of clear visibility so that they can be safe from predation. To conserve energy roost sites are generally conveniently located close to feeding areas. Given large variation in morphology, feeding method and dietary preferences between and sometimes within species as well as changes in tidal cycles a number of different roost and feeding sites in an area are often typically used by shorebirds (Priest et al., 2002; QPWS, 2005).

The broad region over which migration occurs is known as a ‘flyway’ and the specific flyway used by birds on their way to Australia is the East Asian-Australasian flyway. Approximately 8 million migratory shorebirds use this flyway and already 80% of wetlands in east and south-east Asia, which are vital to the birds, are classified as threatened, with over half under serious threat (Bamford et al., 2006; anon., 2003). Fifty-two percent of migratory shorebird populations worldwide with sufficient data are in decline (Nebel et al. 2008) and 20% of species (19 species) that regularly use the East Asian-Australasian Flyway have been officially classified as globally threatened with substantial population decline (Milton, 2003). The threats that these birds face are largely related to habitat loss, however, both migratory and resident shorebirds face a myriad of other threats. These threats include: global warming and sea level rise, water pollution, predation by introduced predators such as foxes and cats, and human disturbance.

Human activities can impact on shorebirds and with one-quarter of Australia’s population living within 3 kilometres of the coast there is increasing conflict between recreation and shorebirds in the coastal zone. The main activities within this zone that threaten shorebirds are 4WD vehicles being driven through sensitive shorebird habitat, dogs being allowed to roam free off the leash and beachcombing activities (Priest et al., 2002). Human disturbance may affect shorebirds in different ways depending on the time of day or time of year. At high tide, human disturbance can result in increased energy expenditure affecting the ability of the birds to build fat reserves to satisfy their annual cycle (e.g. moult, migration, breeding). Whereas at low tide, if feeding is disrupted, food intake can be reduced, again affecting the ability to build fat reserves. Furthermore, over summer when shorebirds are breeding, human disturbance can result in nest abandonment, increased
predation of unattended eggs or chicks, thermal stress to chicks or increased vigilance among parents resulting in reduced time spent foraging and/or in allocation of less food to chicks and the direct crushing of eggs or young chicks (QPWS, 2005). For example, Dowling and Weston (1999) found that mortality of hooded plover (Thinornis rubricollis) nests (about 60%) and chicks (about 70%) on a heavily used beach in Victoria was high with trampling by people the major cause. Various management techniques have been developed to reduce the impact of human disturbance on breeding shorebirds. These often include use of signage indicating that the area is a sensitive shorebird breeding area and providing information on appropriate behaviour (i.e. walking on or near the water line, having dogs under strict control and on leashes and not to remain in the area for any length of time). Other techniques include fencing of areas to restrict access or the use of wardens to provide information and to act as a deterrent to unsuitable behaviour. Medeiros et al., (2007) found that the use of protective measure (such as warning signs and wardening) significantly reduce the impact of human disturbance of the nesting success of little terns in Portugal with birds being up to 34 times more likely to succeed in areas with protective measures. However, compliance with these protective measures still remains an issue and a better understanding of the factors that influence compliance levels is required to develop management techniques that will afford the greatest level of protection for threatened shorebirds (Dodge et al., in prep).

A major cause of breeding failure for many resident shorebirds is predation by introduced predators such as dogs, cats and foxes or natural predators at artificially high population levels (Dowling & Weston, 1999; Priest et al., 2002). A reduction in the level of predation can be achieved either through predator control (i.e. baiting or shooting) or by providing protection from predators. At Phillip Island in Victoria, wire cages around the nests of hooded plovers have been used to protect eggs and small chicks from predation and also trampling (Priest et al., 2002). Another management technique that has also been used at Phillip Island is the provision of chick shelters placed on nesting beaches allowing chicks to shelter from and avoid predators. The use of chick shelters has additional benefits in that may afford greater protection from thermal stress and also allow a greater amount of time for feeding as when placed between the dune and the water line they significantly reduce the distance to cover.

The general lack of community understanding or education of shorebird related conservation issues are significant threats to shorebird survival. By far the greatest threat, even today, remains the ignorance of the importance of wetlands and the roles they play in shorebird conservation (QPWS, 2005). Antos and Weston (2006) examined the awareness of residents living near community-based shorebird conservation programs and found that about half of the people sampled (54%) were unaware of the project. Even when information on shorebird conservation needs are provided on signage restricting access near nesting areas the uptake of this information and levels of compliance is varied, with some sectors of the community such as males and older age groups showing significantly lower levels of compliance (Dodge et al., in prep.).

Shorebirds in the Burnett Mary Region

Of the 19 sites of international and national importance for shorebirds identified in Queensland, one occurs in the Burnett Mary NRM region, the Great Sandy Strait. This site has nine species of international importance and one species of national importance (Appendix 2). The region provides
habitat for over 3,500 resident and over 40,000 migratory shorebirds during the summer months (Watkins, 1993; Priest et al., 2002; QPWS, 2005). It is the top-ranked region in Australia for the eastern curlew *Numenius madagascariensis* (listed as Rare under Queensland’s *Nature Conservation Act 1992*) which uses the area during both the southern and northern migrations (>6,000 birds, about 30% of the world population), and the whimbrel *Numenius phaeopus* which uses the area during northern migration (roughly 3,000 birds, about 10% of world population). The Great Sandy Strait is also particularly significant for the bar-tailed godwit *Limosa lapponnica* (roughly 13,000 birds, about 10% of the world population) and the grey-tailed tattler *Tringa breviceps* (7,500 birds, about 20% of the world population), which use the area during the northern migration and both southern and northern migrations respectively (Watkins, 1993).

There are no specific shorebird management actions in the region, however, there are restrictions on dogs at many of the beaches and community groups such as Coastcare undertake activities to help protect and restore coastal and marine environments, thereby protecting shorebird habitats. Recently there has also been an extensive survey of the region to map and count shorebirds by the Queensland Wader Study Group (QWSG). The report from this survey details the number of shorebirds observed on Fraser Island, Lady Elliot Island, and Lady Musgrave Island and along the Burnett coast. The study was conducted between December 2005 and March 2007 and details shorebird high tide roosts, resident shorebird populations on the islands, a method in which to inform an assessment of the threats to the viability of shorebird roosts and indicate priority roosts that require management intervention, and finally a proposed monitoring plan for the Burnett Coast (Milton & Harding, 2007).

**Objectives**

This program builds on the work undertaken by QWSG as mentioned above. The aim of the project is to promote shorebird conservation through on-ground action using management measures to control recreational access and education and awareness initiatives at mapped shorebird roosting and nesting locations.

Therefore, the initial step was to conduct a workshop with representatives from QWSG, Queensland Parks and Wildlife, regional councils, BMRG and other community groups/public to discuss major shorebird threats in the region and to prioritise appropriate management actions at selected shorebird sites. From this workshop we were able to develop three pilot protects (management measures) to protect internationally significant populations of shorebirds within the Burnett Mary NRM region (see appendix 1 for details).
Human Disturbance

Introduction

It is well known that human activity has the potential to negatively affect shorebirds (e.g. Burger, 1994; Thomas et al., 2003). Humans and shorebirds utilise the same environment, i.e. beaches and shallow water, which can result in conflict. With an ever increasing population and the continual encroachment on coastal land, the habitat in which shorebirds breed, feed and rest is rapidly disappearing. Our activities not only affect shorebird habitat, they can also affect the water in which they feed (pollution), and their ability to rest and breed in relative safety (e.g. protected from beach erosion, human disturbance and predation). For example, Thomas et al., (2003) found that 100% of sanderlings either ran or took flight in response to humans 30 m away. The number of people, type of activity, free running dogs and proximity of people were found to significantly reduce the time that sanderlings spend consuming prey. Thus seemingly benign human activity (i.e. walking on the beach) can negatively affect shorebirds (Paton et al., 2000).

Human disturbance may affect shorebirds in different ways depending on the time of day or time of year. At high tide, human disturbance has the potential to increase energy expenditure as birds take flight to avoid the disturbance (displacement). Not only does this act require energy in itself, the birds may also have to resettle in an area of lesser quality (in terms of food and safety, i.e. predator avoidance). At low tide, feeding can be disrupted, resulting in reduced food intake. In both scenarios, human disturbance can affect the ability of the birds to build fat reserves which are necessary to satisfy their annual cycle (e.g. moult, migration, breeding). Furthermore, over summer when shorebirds are breeding, human disturbance can result in nest abandonment, increased predation of unattended eggs or chicks, thermal stress to chicks or increased vigilance among parents resulting in reduced time spent foraging and/or in allocation of parental care, such as the provision of food (QPWS, 2005). Direct death of eggs and chicks can also occur as a result of human disturbance through trampling. Dowling and Weston (1999) found that mortality of hooded plover (Thinornis rubricollis) nests (about 60%) and chicks (about 70%) was high on heavily trafficked beaches in Victoria with trampling by people being the major cause of mortality. In another example, Dodge et al., (in prep.) found that of the eggs lost in an artificial shorebird egg experiment, 46% were crushed by humans.

Various management techniques have been developed to reduce the impact of human disturbance on shorebirds. For example, signage on beaches has been used to indicate that the area is a sensitive shorebird breeding area. The signs inform people about how to behave in the area, i.e. walking on or near the water line, having dogs under strict control (on leashes) and not to remain in the area for any length of time. These signs can be effective with research indicating that protective measures (such as warning signs and wardens) significantly reduce the impact of human disturbance on the nesting success of little terns in Portugal with birds being up to 34 times more likely to succeed in areas with protective measures (Medeiros et al., 2007). However, compliance with these protective measures still remains an issue and a better understanding of the factors that influence compliance levels is required to develop management techniques that will afford the greatest level of protection for threatened shorebirds (Dodge et al., in prep.).
The objective of this study was two-fold:

1) to investigate flight response of breeding roseate terns (*Sterna dougallii*) to pedestrian activity.

2) to determine whether Temporary Beach Closures (TBCs) are an effective management technique for the conservation of shorebirds in the Burnett Mary Region. More specifically, to investigate the level of compliance of beach users to TBCs and their efficiency to protect shorebird eggs (artificial egg crushing experiment).
Methods

Flight response of terns to human activity

The original aim was to compare the behaviour of roseate terns in response to human activity on Lady Elliot Island with terns on Lady Musgrave Island, however due to inclement weather, observations were only conducted on Lady Elliot Island (23°55’15S, 152°41’55E), Australia. The response of breeding roseate terns (*sphenonotum dougallii*) to human activity was recorded at two sites, one which received high levels of human activity and one with low levels of human activity (Fig. 1). At each site there were approximately 30 adult birds nesting birds. Attempts were made to conduct daily counts of the number of eggs and chicks at each site, however, this activity resulted in high levels of disturbance e.g. birds taking flight, and was therefore abandoned. The distance between the colonies was approximately 200 m; therefore, they had the same aspect, topography and weather conditions. Observations of the birds were made between 0800 and 1800 on the 20th to the 23rd of November 2007. Any human activity within 20 m of the birds was recorded, including the time, number and age of people, their activity (e.g. linear, static, water or beach), their location on the beach and their distance to the terns.

![Figure 1 Total number of people recorded during the study at the high disturbance colony and at the low disturbance colony ± 1 SE.](image)

Temporary Beach Closure experiment

The study was conducted on eight beaches along the central coast of Queensland, Australia (Fig. 2). Sites 1-4 were in the Bundaberg region and included Moore Park, Mon Repos, Elliott Heads and Theoldolite Creek (Fig. 2). Sites 5-8 were in the Hervey Bay region and included Burrum Heads, O'Regans Creek, Gable Rocks and Urangan Beach. Although the length of each site varied due to surrounding topography e.g. rocky outcrops and proximity to rivers, each site was close to a known shorebird roosting/breeding site (Milton & Harding, 2007), was near human development and therefore received daily human activity and had distances of at least 150 m between access points. Tidal movements were similar for all sites. Sites 1-4 were studied between the 25th of October and
the 29\textsuperscript{th} of November 2007, while sites 5-8 were studied between 23\textsuperscript{rd} of January and the 23\textsuperscript{rd} of February 2008.

**Compliance**

The study area at each site was 150 m in length and the width of the beach (i.e. from the waters edge to the start of the vegetation/dunes). The TBC signs (1 m by 1 m) (Fig. 3) were erected on the morning of observation day 2 (OB2) (see below). Three signs were erected in the centre of the study area. The area closed was 50 m in length, with a varying width depending on the position of the high tide (Fig. 4 & 5). Observations were made from an observation hide (beach shelter), which was positioned 25 m to one side of the TBC.

Each site was visited four times, with the initial visit acting as a control (OB1), that is, where human behaviour was observed in the absence of a TBC. Compliance was recorded on observation days 2-4. Observation day 2 (OB2) occurred 1 or 2 weeks following OB1 on the same day of the week that OB1 occurred e.g. OB1 on Monday, and OB2 on the following Monday. Observation day 3 (OB3) was 1 week after OB2 and the final observation day (OB4) was two weeks following OB3.

On all observation days, any person (plus pet(s)) entering the study area between 0700 and 1800 was observed, with their behaviour and location on the beach recorded as follows:

- **Demographics**
  - age in years
    - <15
    - 15-30
    - 30-45
    - 45-60
    - >60
  - Gender
    - male
    - female

- **Location on beach**
  - below low tide
  - between tidal ranges
  - above high tide
  - dunes/vegetation

- **Activity**
  - beach activity, e.g. ball games
  - water activity, e.g. swimming
  - linear activity, e.g. walking
  - static activity, e.g. sun baking

- **Dogs**
  - presence of dog(s) i.e. number
- controlled, e.g. on/off the leash
- Read signage, e.g. yes/no

- Compliance
  - full compliance, e.g. person walked to the waters edge to pass the TBC area (as per instructions on the sign)
  - partial compliance, e.g. person avoided the TBC but walked above low tide
  - non-compliance — person or pet entered the TBC

In addition to human disturbance, weather conditions were also recorded using Speedtech Instrument Weathermate®.

Note: partial compliance was recorded because of the large range in tidal movements on these beaches (water’s edge (low tide) could be 50 m from the high tide mark). Also in an attempt to increase our understanding of peoples attitudes to TBCs.
Figure 2: Location of field sites along the Burnett Coast (Central Queensland) where the temporary beach closure trials were conducted. Yellow flags represent the first four field sites which were studied between October and November 2007, while blue flags represent field sites 5-8, which were studied during January and February 2008.
Figure 3  Temporary Beach Closure sign.

Figure 4  Schematic of the study area showing the position of the three signs delineating the temporary beach closure, key beach features and the position of the eggs used in the egg crushing experiment.
Figure 5 Site 4 (Elliott Heads) showing the temporary beach closure in relation to the vegetation/dunes and the location of the observation hide.

**Artificial egg crushing experiment**

Sixteen artificial nests (scraps) were made above the high tide area by creating a shallow hollow in the sand lined with some beach debris or vegetation e.g. grass, stones for camouflage, mimicking real nests. Half were placed inside the TBC and the other half outside of the TBC and to one side only (Fig. 4). Each nest contained 1 blown chicken egg, which was partially filled with expanda foam (to provide weight) and painted with brown and grey paint to resemble a beach stone-curlew egg (Fig. 6). Nests were created prior to 0700 on observation day 2-3. At the end of each day (approximately 1800) the eggs were collected and recorded as crushed or not.

Figure 6 Artificial nest with a painted egg to resemble a beach stone-curlew nest.
Data analysis

All data were tested for normality and homogeneity of variance using exploratory analysis and residual plots (Quinn and Keough 2002). Square root transformations were used where necessary to improve variables to meet the assumptions of the parametric statistical tests. Analysis of variance (ANOVA) was used to test the significance of the various recorded factors on the level of compliance to TBC. Tukey HSD post hoc tests were used to investigate which groups significantly differ from others in respect to the mean. Statistical significance was considered at the 0.05 level.
Results

Flight response of terns to human activity

There was no significant difference in the number of birds that responded, by taking flight, to people at the two study sites (F=0.127, df=1, p>0.05). Similarly there was no significant difference in the flight initiation distance (FID) between sites (F=1.805, df=1, p>0.05), however, there was a significant increase in the minimum time spent in flight when disturbed by a person(s) at the low disturbed site when compared to the high disturbed site (F=11.667, df=1, p<0.05) (Fig. 7). There was no significant difference in the maximum time spent in flight between sites (F=2.715, df=1, p>0.05).

Figure 7 Minimum flight time (min) of roseate terns from the high disturbance colony and from the low disturbance colony with ± 1 SE.

FID could not be correlated with the activity of the person(s) or with location on the beach as 97% of people undertook linear activity e.g. walking, and the distance between the colony and the water’s edge was variable due to tides. There was no apparent relationship between the number of birds in the air (flight response to human activity) and the number of people in the study area (Fig. 8a & b). Nor was there an obvious relationship between the mean number of people in the study area and the mean FID (Fig. 8c & d). There was also no correlation between the number of birds and FID at either site (high disturbance colony - R²=0.019 and low disturbance colony - R²=0.002 ) (Fig. 8e & f).
Figure 8a and b: The number of roseate terns in the air (flight response to human activity) and the number of people in the high disturbance colony and the low disturbance colony respectively between 0800 and 1800.

Figure 8c & d: Mean flight initiation distance of roseate terns and the number of people in both the high and low disturbance colonies respectively.

Figure 8e & f: Linear correlation showing a weak relationship between the number of roseate terns and the flight initiation distance at the high disturbance colony $R^2=0.019$ and low disturbance colony - $R^2=0.002$. 
Temporary Beach Closure experiment

Level of visitation at all sites was generally low, but varied considerably between sites (Table 2), with the greatest total number of people recorded at site 3 n=476 and the least total amount of people recorded at site 4 n=59. The number of people also varied within each site throughout the study period, with differences of up 120 people between observation days (site 3) and as little as 20 people between observation days (site 5) (Table 2).

Table 1 Description of visitor numbers per site. Site 1, 3-8 were visited four times and site 2 was visited 3 times.

<table>
<thead>
<tr>
<th>Site</th>
<th>Total # of people recorded</th>
<th>Minimum # of people recorded in 1 day</th>
<th>Maximum # of people recorded in 1 day</th>
<th>Mean # of people recorded (all days)</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Moore Park Beach</td>
<td>215</td>
<td>33</td>
<td>83</td>
<td>53.75</td>
<td>21.09</td>
</tr>
<tr>
<td>2 – Mon Repos</td>
<td>160</td>
<td>38</td>
<td>65</td>
<td>53.33</td>
<td>13.87</td>
</tr>
<tr>
<td>3 – Elliott Heads</td>
<td>476</td>
<td>47</td>
<td>167</td>
<td>119.00</td>
<td>51.70</td>
</tr>
<tr>
<td>4 – Theoldolite Creek</td>
<td>59</td>
<td>4</td>
<td>34</td>
<td>14.75</td>
<td>13.70</td>
</tr>
<tr>
<td>5 – Burrum Heads</td>
<td>161</td>
<td>30</td>
<td>50</td>
<td>40.25</td>
<td>8.26</td>
</tr>
<tr>
<td>6 – O’Regans Creek</td>
<td>308</td>
<td>68</td>
<td>95</td>
<td>77.00</td>
<td>12.25</td>
</tr>
<tr>
<td>7 – Urangan Beach</td>
<td>217</td>
<td>42</td>
<td>76</td>
<td>54.25</td>
<td>14.98</td>
</tr>
<tr>
<td>8 – Gables Rocks</td>
<td>169</td>
<td>33</td>
<td>56</td>
<td>42.25</td>
<td>10.05</td>
</tr>
</tbody>
</table>

The difference in gender of beach users was minimal, with males being slightly more commonly represented than females (Table 2). The age of beach users varied considerably between sites, with the five age classes represented at seven of the eight sites (Fig. 9). However, there was no clear pattern in age groups across the study (Fig. 9). In terms of the type of activity undertaken on the beach, linear activities, such as walking, were most commonly recorded, followed by water activity. The majority of activity was undertaken at low tide, although the area in which activity was undertaken differed considerably with site (Fig. 10). For example, 74% of activity was at low tide at site 7, while at site 4 activities were undertaken at three locations fairly evenly (Fig. 10). Activity in the dunes was limited, with people entering the dunes at six of the eight sites and then infrequently, with 12% at site 4, 6% at site 1, 2% at site 6, 1% of activities occurring in the dunes at sites 5-8 and 0% at site 2 (Fig. 11).
Table 2 The number of people recorded in the study area at each site, showing the % of males compared to females

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of people</th>
<th>% of males</th>
<th>% of females</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Moore Park Beach</td>
<td>215</td>
<td>58</td>
<td>52</td>
</tr>
<tr>
<td>2 – Mon Repos</td>
<td>160</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>3 – Elliott Heads</td>
<td>476</td>
<td>53</td>
<td>47</td>
</tr>
<tr>
<td>4 – Theoldolite Creek</td>
<td>59</td>
<td>53</td>
<td>47</td>
</tr>
<tr>
<td>5 – Burrum Heads</td>
<td>161</td>
<td>47</td>
<td>53</td>
</tr>
<tr>
<td>6 – O’Regans Creek</td>
<td>308</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>7 – Urangan Beach</td>
<td>169</td>
<td>57</td>
<td>43</td>
</tr>
<tr>
<td>8 – Gables Rocks</td>
<td>217</td>
<td>58</td>
<td>42</td>
</tr>
</tbody>
</table>

Dogs were recorded at every site despite that fact that dogs were prohibited at site 2 and 8 (where 2 and 14 dogs were recorded respectively). The percentage of times dogs were recorded at dog friendly beaches (sites 1, 3-7) differed with site, with the highest occurrence at site 7 (33%) and the lowest occurrence at site 3 (14%) (Table 3). Although it was a council requirement that dogs be on a leash at each study site, dogs were recorded off the leash between 42 and 92% of the time (Table 3). Sites 4 and 7 recorded the greatest evidence of dogs off the leash with 92% and 85% of dogs recorded off the leash respectively (Table 3).
Figure 9 The age distribution of beach users at each of the sites along the Burnett coast.
Figure 10 The percentage of time spent by beach users at each sites conducting linear activities, e.g. walking, water activities, beach activities, e.g. cricket and static activities, e.g. sun-baking.
Figure 11 The percentage of time spent by beach users at each site in the low tide area, between tidal ranges, in the high tide area and in the dunes/vegetation area.
Table 3 The percentage of beach users with dog(s) in the study area at each site, showing the percentage of dogs leashed and unleashed. Dogs were prohibited at Sites 2 and 8.

<table>
<thead>
<tr>
<th>Site</th>
<th>% of beach users without dogs</th>
<th>% of beach users with 1 dog</th>
<th>% of beach users with &gt;1 dog</th>
<th>% of dogs on leash</th>
<th>% of dogs off leash</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Moore Park Beach</td>
<td>72</td>
<td>22</td>
<td>6</td>
<td>58</td>
<td>42</td>
</tr>
<tr>
<td>2 – Mon Repos</td>
<td>99</td>
<td>0</td>
<td>1</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>3 – Elliott Heads</td>
<td>86</td>
<td>11</td>
<td>3</td>
<td>57</td>
<td>43</td>
</tr>
<tr>
<td>4 – Theoldolite Creek</td>
<td>80</td>
<td>10</td>
<td>10</td>
<td>8</td>
<td>92</td>
</tr>
<tr>
<td>5 – Burrum Heads</td>
<td>78</td>
<td>12</td>
<td>10</td>
<td>15</td>
<td>85</td>
</tr>
<tr>
<td>6 – O’Regans Creek</td>
<td>85</td>
<td>8</td>
<td>7</td>
<td>42</td>
<td>58</td>
</tr>
<tr>
<td>7 – Urangan Beach</td>
<td>67</td>
<td>30</td>
<td>3</td>
<td>18</td>
<td>82</td>
</tr>
<tr>
<td>8 – Gables Rocks</td>
<td>92</td>
<td>6</td>
<td>2</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

Compliance

Compliance with the TBC was high, with 96.2% (n=1204) of all people staying outside of the TBC area. However, 24.6% of people were only partially compliant in that they stayed outside of the TBC area but did not walk down by the water’s edge as instructed to do on the sign.

Of the nine factors recorded that could affect compliance with the TBC, five were found to be significant. Compliance was found to differ with site ($F=5.918$, df=7, $p<0.05$), location ($F=168.909$, df=3, $p<0.05$), activity ($F=14.126$, df=3, $p<0.05$) dog(s) ($F=3.9323$, df=2, $p<0.05$), and read ($F=5.787$, df=1, $p>0.05$).

Differences in levels of compliance differed with site, in particular, significantly more people were partially compliant as opposed to fully compliant at site 2 when compared to sites 5 and 8 (Fig. 12). Similarly, there was a greater proportion of people fully compliant at sites 5-8 when compared to site 3 at which a greater proportion of people were partially compliant (Fig. 12). Non-compliance occurred at all sites with the exception of site 4. The highest level of non-compliance was recorded site 7 (Fig. 12). In is interesting to note that overall, more people were fully compliant at sites 5-8 (Hervey bay region) when compared to sites 1-4 (Bundaberg region) but, there were more people non-compliant at sites 5-8 then at 1-4.

The location on the beach in which people undertook activities significantly influenced levels of compliance irrespective of the tidal cycle, with people at low tide being fully compliant 93% of the time compared to between tidal ranges – 26%, high tide – 47% and dunes – 46% (Fig. 13). Level of compliance also differed significantly when people were at the high tide mark compared to when they were between tidal ranges with a greater proportion of people being partially compliant when in the high tide area (Fig. 13).
Full compliance occurred significantly more often when people undertook water activities as opposed to all other activities (Fig. 14). In this case non-compliance was zero. The highest level of non-compliance occurred when people undertook static activity e.g. sun baking (Fig. 14). But if people were accompanied by two or more dogs, then they were less likely to be fully compliant (Fig. 15). Interestingly, the proportion of people who were fully compliant increased in those cases where the signage was not read (on that observation day) (Fig. 16).

![Figure 12 The percentage of people fully compliant, partially compliant and non-compliant to the temporary beach closures at each site.](image1)

![Figure 12 The percentage of time spent in each of the zones on the beach.](image2)
Figure 13 The percentage of time spent undertaking linear activity, water activity, beach activity and static activity on the beach.

Figure 14 The percentage of people with a dog(s) on the beach and their level of compliance.
Figure 15 The percentage of people who read and did not read the signage and their level of compliance.
Egg crushing

The egg crushing experiments strongly indicated that TBCs are effective at protecting eggs with 0% eggs crushed (n=368), however, only 10 eggs (2.7%) were crushed outside of the TBC area. One egg was crushed at site 4 and at site 3 and both times this was a result of a dog and both occurred during the last observation day i.e. 4 weeks after the TBC was set up. The remaining eggs (8) were crushed at site 6 on observation day 3 by a young boy who deliberately crushed the eggs using a yabby pump (Fig. 17). Although no eggs were crushed at site 1, dog prints were seen around 3 eggs inside the TBC and 9 eggs outside of the TBC. This occurred one week after the TBC was set up (OB2).

Figure 16 Crushed egg at site 6 on observation day 3. Eggs were crushed by a young boy using a yabby pump.
**Discussion**

**Flight response of terns to human activity**

The flight initiation distance of roseate terns in the low disturbance colony was similar to that of the terns in the high disturbance colony. Gill *et al.*, (2001) described that the priorities that animals assign to different activities can affect the behavioural response they show to disturbance and that therefore animals in poor body condition or in poor feeding habitat, for example, will show a lesser response to disturbance than those in good body condition and in a high quality feeding areas. Thus, animals who have no option but to continue feeding for as long as possible will endure more disturbance than those that have the resources to stop feeding and find a safer environment in which to feed (Beale & Monaghan, 2004). Following this reasoning, the results suggest that the birds were equally sensitive to humans, in similar body condition and in similar quality nesting habitat.

However, birds in the high disturbance colony spent significantly less time in flight than those in the low disturbance colony. This would then suggest that either the birds in the low disturbance colony had slightly better habitat for nesting, or that the birds were in slightly better body condition. This would require further research with a greater length of observation time and investigation into body condition and site quality. However, given that the terns nest each year on the island (albeit the exact nesting location changes), and the birds chose one of the busiest places in terms of human activity in 2007, it is likely that the level of disturbance caused by human activity was not considered to be of sufficient strength to stop birds from nesting.

An important factor when investigating the response of wildlife to human disturbance, particularly when the aim of the research is the development of management guidelines, is the long term effect of disturbance. Repeated disturbance can alter the behaviour of wildlife in five ways: (i) attraction, which is the strengthening of an animal’s response as a result of positive reinforcement, and is often manifested as physical movement towards the stimuli (Knight & Cole, 1991); (ii) avoidance, which is an aversion to negative consequences associated with a stimulus (Knight & Cole, 1991; Allaby, 1999); (iii) sensitisation, which is an increased responsiveness to the stimulus over time (Richardson *et al.*, 1995; Allaby, 1999); (iv) habituation, which is the gradual waning of a response as a result of repeated stimulation, where the stimulus lacks significant consequences for the animal (Hinde, 1970); and (v) tolerance, which occurs when an animal remains in the vicinity of the stimulus because there is no option to leave (Richardson *et al.*, 1995). Knowing which response is elicited by a particular stimulus allows management strategies to be developed that are appropriate and effective at minimising disturbance over the long-term.

**Compliance**

Compliance to temporary beach closures was high (96.2%) which suggests that TBCs are an effective management technique for protecting shorebirds. This figure is similar to that found by Dodge *et al* (in prep.) who recorded compliance to TBCs in Victoria at 94%. Despite the 3.8% non-compliance, no eggs were crushed in the TBCs compared to 2.7% outside of the TBC, providing further support to the effectiveness of TBCs. We therefore infer that TBCs would be effective at increasing hatching success by reducing egg crushing by humans (& dogs).

Non-compliance to TBCs, although low, is important to understand from a management perspective, so that management actions can be developed to further reduce non-compliance, especially if the
nests being protected are from a critically endangered species. The reasons for non-compliance may be difficult to measure as direct communication is essential to understand the motivation of the non-compliant person. Research indicates that human attitudes are consistent with behaviour (e.g. Aslin & Bennett, 2000; Palmberg & Kuru, 2000). In order to improve compliance it is necessary to understand who is non-compliant and their motivation for non-compliance.

**Factors affecting compliance**

Unlike Dodge *et al.*, (in prep.) who found that age and gender influenced level of compliance, our study found that these two factors had no affect on compliance to the TBCs. However, we did find that compliance varied with site, location on the beach, activity undertaken, presence and number of dog(s) and whether the sign was read. It is important to remember that compliance was measured on three levels; 1) fully compliant was a person who walked to the waters edge to pass the TBC area, 2) partially compliant was a person who avoided the TBC are but walked above the low tide, and 3) non-compliant was a person (or pet) who entered the TBC area.

It is difficult to separate out and discuss each of the factors found to influence level of compliance. The reasons for this will become clear in the discussion below.

Attributing reasons for the differences in compliance with site is not straight forward as the motivation for where people were on the beach, and therefore whether they are partially or fully compliant (by default) is unknown. Unless the sign was read, a person would not know that it is best to walk by the water’s edge. The difference between full compliance and partial compliance could be a matter of ‘concern for the environment and shorebirds’. It may be the case that individuals who have an interest in the protection of shorebirds are more likely to walk by the water’s edge than people who have no concern for shorebirds. Locals who wish to encourage nesting shorebirds may be more inclined to be fully compliant than non-locals who have no vested interest in the beach and its inhabitants.

Although the tidal range was similar at all beaches, the timing of the tides and therefore the area of each zone exposed could have influenced where people undertook different activities (e.g. low tide vs high tide) and therefore whether they were fully compliant or partially compliant. For example, if the area between tide marks is large then it may be more appealing to walk in that area rather than at the water’s edge where it is necessary to avoid the waves. Rather than being fully compliant, the person then becomes only partially compliant even though they may be 30 m from the TBC sign. Further research is required to investigate these differences.

It is not surprising that those undertaking water activities were fully compliant most of the time and never non-compliant. It is also not surprising that beach activities resulted in both partial and full compliance as these activities tend to involve moving around the beach and therefore crossing into different zones. Of interest is static activity, as this behaviour can be conducted in any zone, so failure to be at least partially compliant is either due to not seeing the signs (unintentional non-compliance) or a lack of interest, which may be reflected as intentional non-compliance. Both cases were observed during the study. Once again it is clear that awareness and understanding of the disturbance that people can cause nesting shorebirds, and therefore concern for shorebirds, is vital to reduce levels of non-compliance.
The level of compliance may also be related to the attributes of the site, for example, the higher proportion of partially compliant visitors at site 2 (Mon Repos) could be related to the fact that the beach is a turtle rookery. Even though people avoided the high tide area, which was often 1-2 m from the dunes/vegetation, they may still have wanted to walk closer to the dunes in case they could spot signs of turtle nests. These examples illustrate the need to understand the motivation behind peoples’ actions to be able to understand why people are partially compliant or non-compliant as opposed to fully compliant to TBCs.

What is clear, however, is that compliance was related to dogs. In most instances where a dog(s) was present the activity undertaken by their owner was linear activity, e.g. walking. Usually this activity occurred at the water’s edge (full compliance) or in the zone between tides (partial compliance). However, as previously mentioned, the actual motivation as to why people walked (with their dog) between tidal ranges rather than at the water’s edge is unknown. Non-compliance in these situations occurred because the dog(s) was off the leash and ran into the TBC area. At all sites dogs were prohibited to run free, which means that this behaviour could be interpreted as an intentional breach of dog regulations and non-compliance with TBCs.

The finding that the proportion of people who were fully compliant increased when signage was not read is counter-intuitive. However, the most plausible reason for this is that a large proportion of people who were fully compliant had already read the sign.

**Egg crushing**

The consequence for non-compliance with TBCs is a potential increase in nesting failure due to eggs crushing or disturbance to chicks. This study focused on egg crushing and found that despite low levels of non-compliance, TBCs were effective at protecting eggs. The main cause of egg crushing in this study was a young boy who deliberately crushed the eggs. Research has indicated that environmental education and outdoor activities at school foster an empathic relationship to the environment (Palmberg & Kuru, 2000). Therefore, education is likely to greatly benefit management techniques such as TBCs which aim to protect nesting shorebirds.

**Improving compliance**

It is clear from the above discussion that the motivation behind peoples’ actions is the key to understanding the various changes in level of compliance that occurred with changes in site, location on the beach, activity and dogs. Raising awareness and knowledge of shorebirds and the threats they face should increase the probability of appropriate human behaviour and therefore increase protection of nesting shorebirds (Soloman 1998, Kasapoglu & Ecevit 2002). For the cases in which non-compliance is deliberate, management strategies could include greater enforcement of regulations through on-the-spot fines for entering TBCs and allowing dogs to run free. Research has indicated that TBCs with fences are more effective at increasing compliance than TBCs without fences, and introducing warden’s increases compliance even further (Dodge et al., in prep). These extra resources may be an option at sites where non-compliance is high or where nesting shorebirds are particularly sensitive.
Predation

Introduction

A major cause of breeding failure for many resident shorebirds is predation by introduced predators such as dogs, cats and foxes or natural predators at artificially high population levels (Dowling & Weston, 1999; Priest et al., 2002). Shorebirds are typically ground nesting birds that breed in a broad variety of habitats. Those that breed on the coast tend to create shallow simple nests called scrapes. Although they can be lined with a few stones or shells, it often appears that the egg(s) are simply lying on the sand. Although most shorebirds defend their scrape with distraction displays and aggression (Geering et al., 2007), and eggs are well camouflaged, eggs and chicks are easily crushed by people and predated on (Isaksson et al., 2007; Schulz & Bamford, 1987).

Although the effect of predation is the same in that individuals are removed from the population, the red fox (Vulpes vulpes), a common introduced predator in Australia, is considered a major threat to breeding shorebirds (Geering et al., 2007). When food is plentiful, foxes hunt regularly and cache food (Macdonald, 1977). This means that during the shorebird breeding period when eggs and chicks are readily available, one fox can cause the death of a large number of shorebirds. An autopsy of a single fox in Western Australia contained the remains of about 38 red-capped plover chicks (Geering et al., 2007). Foxes have been found to cause nest failure in 36.4% of cases (n=22) in hooded plover nests (Weston & Marrow, in prep.). Unlike threats such as global warming and sea level rise, predation can be reduced at local and regional scale by careful management.

A reduction in the level of predation can be achieved by providing protection from predators. Exclusion of predators though fencing or caging of nests has been partially successful at increasing productivity and hatching success (e.g. piping plovers in the USA Murphy et al., 2003, various species in the USA Ikuta & Blumstein, 2003). At Phillip Island in Victoria, wire cages around the nests of hooded plovers have been used to protect eggs and small chicks from predation and also trampling (Priest et al., 2002). Isaksson et al., (2007) found that eggs contained in protected nests (cages) had a significantly higher daily survival rate than unprotected eggs in two species of shorebirds. However, cages and fencing do not necessarily protect against foxes, especially in the case of free roaming chicks. Therefore, predator control through baiting or shooting is a potential management technique that addresses both egg and chick survival. The aim of this study was to determine whether baiting is an effective management technique to reduce predation of foxes on shorebird eggs and chicks on beaches in central Queensland.
Methods

The study was conducted in late November through to mid December 2007 at Burrum Coast National Park, Queensland, Australia (25°07’45S, 152°35’18E). Forty artificial nests, spaced 100 m apart, were created above high tide close to the vegetation. Nests were scrapes in the sand with either a chicken egg (approximate size of a beach-stone curlew egg) or a dead one-day old chicken. Nests 1-20 contained an egg and nests 21-40 contained a chick. At each scrape a small stake was placed for identification purposes (Fig. 18). The sand around the nest was swept clear of any footprints to create a ‘sand pad’. Any footprints found on the sand pad during nest checks could then be attributed to a potential predator.

Figure 18 Example of a scrape containing an egg next to an identification stake.

The experiment lasted for 20 days, and consisted of two sampling periods, before and after baiting. The ‘before’ treatment occurred on day 1-5 and consisted of the egg/chick being placed in the scrape in the late afternoon and then checked the following morning to determine the fate of the egg/chick. Eggs and chicks were removed each morning and replaced the same afternoon with fresh specimens to avoid the eggs/chicks rotting and releasing unnatural olfaction cues. The ‘after’ treatment occurred on days 15-19 and was a replicate of the before treatment. Thirteen Foxoff® baits (active ingredient 1080 - sodium monofluoroacetate) were distributed every 400 m at bait stations (Fig. 19) along a bush track behind the high-tide and nest area (10-30 m) on days 8, 10 and 12. Baiting stations where checked on days 10, 12 and 15. All baits were replaced on days 10 and 12 and notes made if baits taken. Notes and photographs were made of any footprints at the bait station to determine the potential predator.
Figure 19 One of the bait stations along the bush track showing the sand pad.

One caveat of the study is that chicken eggs and deceased chickens were used as prey. Although the eggs may not have been sufficiently different to beach stone-curlew eggs, deceased chickens would certainly represent different environmental cues than live chicks. Although chicks were replaced each day and were only exposed for a maximum of 16 hr (late afternoon through to the morning) they may have provided different sensory cues to predators than live shorebird chicks. Furthermore, both the eggs and the chicks were easy targets for predators as there were no protective parents to guard the eggs/chicks. Resident shorebirds defend young with distraction displays and aggression (Geering et al., 2007).

Data analysis
All data were tested for normality and homogeneity of variance using exploratory analysis and residual plots (Quinn & Keough, 2002). Descriptive statistics and paired t-test were used to compare bait uptake and prey removal. Statistical significance was considered at the 0.05 level.
Results

Fifty-one eggs/chicks (25.6%) were taken prior to baiting, of which 49 (96.1%) were chicks, compared to 104 eggs/chicks (52%) post baiting, of which 82 (78.8%) were chicks. The total number of prey taken before baiting was significantly different to the number of prey taken after baiting, with significantly more prey taken after baiting (t=-6.906, df=198, p<0.001). However, of the prey taken prior to baiting 19 chicks (37.4% of all prey) were taken by crabs as evident from chicks in crab burrows (Fig. 20), while 7 chicks (6.7% of all prey) were taken by crab post baiting (Table 3). More importantly however, was that there were 6 chicks and 1 egg taken prior to baiting and 18 chicks and 19 eggs taken by foxes post baiting (Table 3). The fate of remaining 79 eggs/chicks was unknown. This was primarily due to overnight rain that washed away predator footprints from the sand pads. There were 48 instances of fox prints (12%) and of these, prey was removed 91.7% of time (as represented by prints) (Fig. 21). Foxes took both eggs and chicks in similar numbers (chicks representing 54.5% of prey taken).

Table 4 Fate of eggs and chicks on each observation day (B=before baiting & A = after baiting).

<table>
<thead>
<tr>
<th>Observation day</th>
<th># of eggs removed</th>
<th>Predator</th>
<th># of chicks removed</th>
<th>Predator</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>0</td>
<td>NA</td>
<td>8</td>
<td>Unknown</td>
</tr>
<tr>
<td>B2</td>
<td>1</td>
<td>fox</td>
<td>8</td>
<td>2 x crab</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 x unknown</td>
</tr>
<tr>
<td>B3</td>
<td>0</td>
<td>NA</td>
<td>7</td>
<td>2 x crab</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 x unknown</td>
</tr>
<tr>
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Figure 17 Chick partially buried in ghost crab burrow.

Figure 18 The number of nests in which eggs or chicks were removed on each treatment day showing the number of nests at which fox prints were recorded. The grey bars represent the number of nests at which eggs/chicks were present together with fox prints.
Bait uptake differed between days, with day 1 having the highest uptake (Fig. 22). Fox prints were observed in most instances where baits taken (Fig. 22).

Figure 19 The number of baits taken during baiting showing the percentage of baiting stations (13 in total) at which fox prints were recorded.
**Discussion**

Fox control can be effective at reducing predation (see below); however, the results of this study are inconclusive in term of the effectiveness of baiting for foxes for the protection of shorebirds. Although a large proportion of bait was taken, the fate of all of the baits was not known. This coupled with the fact that egg/chick uptake was higher post baiting casts doubt on the efficacy of baiting conducted in this study on reducing predation on shorebird eggs and chicks. However, research on fox control in Australia is extensive and has shown that baiting, using 1080, is considered to be the most cost-effective technique for fox control over large areas (Saunders et al., 1999).

There are multiple factors that could have influenced the increase in egg/chick uptake post baiting in this study, for example, length of baiting and the nature of the fox. Research has indicated that a significant proportion of Foxoff® baits taken by foxes are not immediately eaten, but removed and reburied (Saunders et al., 1999). Therefore, it is possible that baiting in this study did not result in the removal (death) of foxes (in sufficient numbers) to reduce predation. Even if a large proportion of foxes were killed, foxes from surrounding areas could have dispersed into the area negating the efforts of predator removal.

Foxes are highly intelligent animal’s cable of learning from their experiences (Saunders et al., 1999). The high proportion of eggs and chicks taken on the last day suggest that the foxes had learned of the food. There is some experimental evidence that foxes can form learned aversions to baits (Gentle et al. 2004; Baker et al. 2007). Therefore, it is important to incorporate the intelligence of the fox into a baiting program so that foxes do not have the opportunity to learn of the baits, thereby reducing the effectiveness of fox control.

Successful fox control using 1080 baits requires multiple baiting periods per year, and ideally multiple years of baiting. Although the frequency with which to bait depends on the purpose for reducing fox numbers, it is recommended that baits are laid at least twice a year to target the breeding season (winter) and dispersal period (autumn) of the fox (Saunders et al., 1999). Additional baiting can then be undertaken during the breeding and dispersal period of the species under protection. For example, Queensland Parks and Wildlife bait three times per year (for two weeks at a time) at Mon Repos Conservation Park to reduce fox predation on turtles. Baiting occurs during fox breeding (July), fox dispersal and turtle nesting (November) and turtle hatching (late summer) (Shane Jackson, Environmental Protection Agency, pers. comm.). Fox control at Mon Repos has reduced predation on turtle eggs and hatchlings from 90% to 5% (Shane Jackson, Environmental Protection Agency, pers. comm.). For shorebirds, both nesting and migratory, additional baiting could be conducted during the nesting period and prior to the arrival of migratory shorebirds.

**Recommendations for reducing fox predation for the conservation of shorebirds in the Burnett Mary Region.**

Although the study does not provide convincing evidence for or against baiting for foxes as an effective management technique to reduce predation on shorebird eggs and chicks on beaches in central Queensland, research has indicated that 1080 baiting for foxes can be a successful management technique in reducing predation. For example, Saunders et al., (1995) report a 30-fold increase in the abundance of Rothschild’s rock wallaby (Petrogale rothschildi) following the removal of foxes from Dolphin Island by 1080 baiting. It is also considered to be the most cost-effective
technique for fox control over large areas (Saunders et al., 1995). It is therefore reasonable to assume that a comprehensive baiting regime conducted over multiple years in sensitive shorebird breeding habitats will be effective at reducing predation by foxes and increase shorebird nesting success and abundance.

In conjunction with a baiting program nest enclosures and chick shelters could be trialled as a method to increase hatching and fledging success. Research on the effectiveness of nest and chick enclosures (particularly from avian predators) has demonstrated increases in hatching success (see Mabee & Estelle, 2000, Burness & Morris, 1992) and fledging success (e.g. Mueller, 1982; Lafferty, 2001). One particular study on hooded plover chicks in Victoria found that fledging rate of chicks with access to artificial shelters was 75% higher than those with only natural shelter (Duivenvoorden, 2007). However, factors such as predator attraction (to enclosures) and whether the species will use the shelter needs to be investigated before the benefit of the technique in reducing predation on shorebirds on central Queensland beaches can be determined.
Lack of Knowledge and Awareness

Introduction

The general lack of community understanding or education of shorebird related conservation issues are significant threats to shorebird survival. By far the greatest threat, even today, remains the ignorance of the importance of wetlands and the roles they play in shorebird conservation (QPWS, 2005). The focus of research has been on more tangible threats such as predation and human disturbance and not on enhancing knowledge and awareness of shorebirds, even though it is commonly regarded as important. It is widely accepted that education can increase the probability of appropriate human behaviour and therefore increase protection of wildlife (Soloman 1998, Kasapoglu & Ecevit, 2002). There are however, studies on the effectiveness of signage and wardening, both sources of information, on reducing human impacts on breeding shorebirds (e.g. Burger, 1984; Mederiros et al., 2007; Dodge et al., in prep.). These studies indicate that signage, and wardening can result in greater protection of shorebirds from human activity, with the combination of signage, fencing and wardens being the most effective at obtaining high levels of compliance amongst beach users (Dodge et al., in prep.).

There are many factors influencing knowledge uptake and awareness of environmental issues such as shorebird conservation, including age, gender and education. Dodge et al., (in prep.) showed that males and older age groups were more likely to be non-compliant to temporary beach closures (protection of nesting shorebirds) than females and younger age groups. Although it was not clear whether this was do to the physical barrier that signage, fencing and wardens represented, or whether this was due to an understanding, through education, of the need for shorebird protection. The actual source of information is also important, that is, which source is most effective at educating people so that people alter their behaviour and take responsibility of their action around shorebirds. Antos and Weston (2006) found that although biased towards people with an interest in birds, awareness of community based shorebird conservation projects in their geographical area was largely due to membership with conservation organisations (34%) followed by friends and relatives (20%) and newspapers (14%). Knowledge of this kind is essential in developing effective education campaigns for the conservation of shorebirds.

The aim of this research was to undertake a survey of beach users in central Queensland to determine the level of knowledge and awareness people have of shorebirds, the threats they face and the most effective educational/management actions required to protect shorebirds. This information is then used to make management recommendations, through education and awareness, for the conservation of shorebird populations in central Queensland.
Methods

Information survey
A 36 question survey designed to assess beach users knowledge of shorebirds and the threats they face was conducted during summer 2008 (Appendix 3). Ten beaches in the Bundaberg and Hervey Bay areas were targeted. In total 163 people completed the survey from all age groups, although age groups 1 (0-15) and 3 (30-45) were under represented (Fig. 23).

![Pie chart showing age distribution of survey respondents.]

Figure 20 The percentage of beach users in each of the age classes.

Education initiatives
Two education initiatives were also undertaken in April 2008 to increase awareness of shorebirds.

Dog walker’s breakfasts
Together with the council and BMRG, two dog walker’s breakfasts were held on the first weekend in April. The aim of the breakfasts was to provide dog owners with information about shorebirds, the affect dogs can have on shorebirds and how to avoid causing disturbance. Educational material, including study holders, dog leashes and pamphlets, was given to dog owners to encourage the protection of shorebirds (Fig. 24).

Artwork competition
Primary Schools in the Bundaberg and Hervey bay area were invited to take part in a competition to design artwork for postcards to promote shorebird conservation. Six schools were sent ‘Shorebird education kits’ developed by the Queensland Wader Study Group to educate students about shorebirds. Two school submitted artwork of which the top three were developed into postcards to be distributed to the public. Students were also given stickers to promote shorebird conservation (Fig. 24).
Figure 21 Education activities aimed at promoting shorebird conservation: the dog walker’s breakfasts at Elliott Heads and at Hervey Bay, and Bundaberg Central State School showing the winning student and with one of the postcards.
Results

General information on public surveyed
As mentioned above, the age of beach users varied. There was approximately equal number of males to females (57% and 43% respectively). Education level varied from students at secondary school to professionals. Beach users were both national and international coming from a total of 17 countries. Fourteen percent of people belonged to an environmental group such as Birds Australia and 17% were a member of a volunteer group such as Coastcare. Most people visited the beach weekly (69%) (Fig. 25a) and a large percentage of people spent over 1 hour (56%) on the beach per visit (Fig. 25b).

![Figure 22a](image1.png) The frequency with which people visited the beach, and figure 25b the length of time people spent at the beach per visit.

Sixty-six percent of people surveyed believed they knew what a shorebird was, however, when tested using photographs of shorebirds and non-shorebirds, only 23% correctly identified 80% of birds as shorebirds (Fig. 26a). A further 19% correctly identified 60-80% of birds. Seventy-two percent incorrectly labelled at least one non-shorebird as a shorebird (Fig. 26b).

![Figure 23a](image2.png) The percentage of people who correctly identified photographs of shorebirds, and figure 28b the percentage of people who correctly identified non-shorebirds from photographs.
Beach users obtained information from a variety of sources, of which the top three were newsprint (16%), signage at a beach (15%) and tv/radio story (15%) (Fig. 27).

Figure 24 The sources of information where people obtained information about shorebirds.

Over half the people spent the majority of their time on the beach at low tide (57%) undertaking linear activities such as dog walking and running (53%) (Fig. 28a&b).

Figure 28a Beach users’ allocation of time spent in the four areas on a beach, and figure 28b the activities undertaken on the beach.
Awareness specific to shorebirds and threats they face

When asked to rank 10 environmental issues in terms of their importance, the conservation of internationally significant shorebird populations was ranked number 1 in 23% of cases. All 10 issues were ranked 1st by at least some people (Fig. 29). Beach users believed that human disturbance followed by lack of education/awareness were the greatest threats to shorebirds (22% and 17% respectively Fig. 30). Behaviours such as walking, swimming and sun-baking were believed to cause little to no disturbance to shorebirds (81%, 86%, 89% respectively), while walking a dog off leash and 4WDriving were believed to cause high to extreme levels of disturbance (65% and 77% respectively). Ninety percent of people did believe, however, that shorebirds and people could co-exist and 69% of people believed they could do something to protect and conserve shorebirds. Forty-one percent of people considered themselves moderately concerned about shorebirds and the need to protect them and only 5% considered themselves to be ‘not at all concerned’. On the other hand, they believed that only 28% of people in general were moderately concerned and that 15% were not at all concerned (Fig. 31a & b).

Figure 29 Ten environmental issues and the percentage of people who ranked them as the primary conservation concern.
Figure 25 The ranking of threats to shorebirds in order of severity by respondents.

a) b)

Figure 26a The level of concerned expressed about shorebirds and the need to protect them by individual respondents, and figure 33b the level of concern respondents believed the general public had for shorebirds conservation.

In terms of management of shorebird populations and sites, 84% of beach users were not aware of any management actions in place in their region to protect shorebirds. When asked who should undertake management actions to protect shorebirds 23% believed individuals/local residents should, followed by community groups with 14% (Fig. 32). When asked how individuals could protect shorebirds, responses varied considerably but included:

- Be aware and observe,
- Clean up rubbish
- Education
- Protect habitat and do not disturb
The response from beach users to various management actions to protect shorebirds indicated that >70% of people believed that it was of high to extreme importance to:

- Prohibit 4WDs on beaches at or near high tide
- Ensure that 4WD users obtain a permit in order to drive on beaches
- Ensure the inclusion of information on shorebirds and responsible driving practices with the issuing of 4WD beach permits
- Erect signage at beaches to educate beach users about appropriate behaviour and the need to protect shorebirds
- Monitor shorebird populations
- Encourage school children to become more aware of shorebirds and involved in local activities to promote shorebird conservation.

When faced with a ban on specific activities on the beach, >70% of people indicated that they would be very disappointed if walking, swimming and sunbaking were no longer allowed on the beach. While 72% of people indicated that they would be happy to have 4WD activity banned on the beach. Interestingly, only 21% of people would be very disappointed to see dog walking off the leash banned.

Opinions about a temporary beach closure (above the high tide mark) on the beach at which people completed the survey differed with the period of closure. Twenty percent of people strongly disagreeing to a closure of 1 week, this increased to 31% for 1 month, 45% for 4-6 months and 71% for a permanent closure. Similarly, the number of respondents that agreed to the closure decreased with an increase in the period of closure, with 27% agreeing with a 1 week closures, 14% for 1 month, 10% for 4-6 months, and 1% agreed with a permanent closure.

When asked to rank resources as to their effectiveness in promoting awareness of shorebirds, 25% of people ranked libraries as the number one source, followed by TV/radio (12%) and signage at the beach as (11%) (Fig. 33). However, signage at the beach ranked highest (20%) when asked as to the
likelihood of reading information about shorebirds. People were least likely to attend a presentation at the local community centre and listen to a story on the radio (9%) (Fig. 36).

Figure 283 The ranking of resources in terms of efficacy in promoting awareness of shorebird by respondents

Figure 29 The ranking of information resources in terms of readability by respondents.
Discussion

In general, most beach users surveyed were aware of shorebirds and although identification skills were limited, the conservation of shorebirds ranked highest in a list of 10 important environmental issues. This is possibly an artefact of the survey, rather than a true representation of the importance of shorebird conservation in general. Ninety percent of respondents believed that people and shorebirds could co-exist and most of these people (69%) believed that they could take action to help protect shorebirds. Over half of the respondents gave suggestions as to what they could do. Sixty-three percent of respondents stated that they were moderately to deeply concerned about shorebirds, however the majority of respondents (34%) believed that people in general showed only a little concern for shorebirds. So although those surveyed indicated that shorebird conservation was important, overall, respondents believed that the general public were less concerned about shorebirds.

Overall, the results of the study are positive; awareness of shorebirds was relatively good. Most respondents scored beach activities such as 4WDriving and walking a dog off the leash as causing high to extreme disturbance to shorebirds. It is interesting that 32% of people classified horse riding and ball games as high to extreme in terms of disturbance. Although both of these activities involve large amounts of movement and therefore have the potential to disturb birds, they are quite different and pose different threats to shorebirds, particularly, as beach games tend to occur all over the beach (all locations) and generally occur for long periods of time (as opposed to horse riding that tends to occur below the low tide and is a passing threat). Sun-baking was considered to be relatively benign by most respondents; however, this activity has the potential to cause high levels of prolonged disturbance. For example a person lying above the high tide area may be sufficiently close to a nest (well camouflaged and therefore not spotted) that an adult bird cannot protect the eggs. Extended periods of nest desertion by adults during the hottest part of the day may result in overheating of the egg and embryo death. So this seemingly benign activity actually has the potential to cause more disturbance than a 4WD passing at the water’s edge. This example highlights the importance of disseminating information about shorebirds and ways in which human activity can cause disturbance.

Human disturbance as a threat to shorebirds ranked 1st most frequently (out of seven), which is promising as this ‘threat’ is something that individuals can attempt to improve on. This coupled with the fact that individual/local residents was the preferred group to undertake management actions to conserve shorebird, followed by community groups, suggests that with the right guidance and background knowledge, shorebird populations in the BRMG region can anticipate improved protection. However, in reality, asking people to change is difficult and evident from the number of people who let their dog(s) off the leash in areas where it is a requirement, by council, to walk dogs on a leash (pers obs). Thirty-seven percent of people would be disappointed if walking dogs off a leash was no longer allowed on their beach even though this behaviour was considered to cause high to extreme levels of disturbance to shorebirds by 65% of people. Careful management is required to manage these opposing needs and expectations in order to conserve shorebirds.

Information and Management

Information about shorebirds was obtained from a variety of sources of which, newsprint, signage at the beach and tv/radio stories were the most common. Antos and Weston (2006) also found newsprint (14%) to be an important source of awareness (3rd out of 11) for shorebird conservation
projects in Australia. However, when asked which resources were most effective in promoting the awareness of shorebirds the library was ranked the highest by 25% of participants followed by TV/radio and signage at the beach. In terms of learning more about shorebirds if given the opportunity only 9% of participants’ ranked radio as most important and 10% ranked newsprint as most important. The top ranking sources were signage at the beach and pamphlets in the mail. Thus, even though the source of information was not consistent in terms of current knowledge, where to find it and readability, signage at the beach appears to be the main resource in raising awareness of shorebirds and the need to protect them.

In terms of on-ground management of shorebirds in the Burnett Mary region, six (out of 23) possible management actions received high to extreme importance ratings from >70% of participants, these were (in order of ranking):

1) Prohibiting 4WDS on beaches at or near high tide

2) Encouraging school children to become more aware of shorebirds and involved in local activities to promote shorebird conservation

3) Placing signage at beaches to educate beach users about appropriate behaviour and the need to protect shorebirds

4) Requiring 4WD users to obtain a permit in order to drive on beaches

5) Monitoring of shorebird populations

6) Inclusion of information on shorebirds and responsible driving practices with the issuing of 4WD beach permits

Of further interest to this study, was the management technique of temporarily closing off a section of the beach to protect nesting shorebirds. Although the majority of people (33%) ranked this action as ‘of moderate importance’ only 30% agreed to a temporary beach closure (TBC) of 2-3 months which would cover most of the time required for incubation and fledging for most nesting shorebirds in Australia (Geering et al., 2007). This suggests that although people believe an action is important they are not necessarily willing to support and comply with the management action (i.e. TBC). To address this attitude, it is crucial to increase the general awareness and knowledge of shorebirds, the threats they face and the importance of undertaking actions to reduce human disturbance. Awareness raising can contribute to the effectiveness of conservation projects (Bouton & Fredrick, 2003; Shunula, 2002), with an increase in reproductive success of hooded plovers attributed to the management regime (which included various forms of media coverage and education activities) for example (Dowling & Weston, 1999). Research has also shown that there is a positive trend between the number of information sources and the level of awareness (Antos & Weston, 2006). Thus, to increase awareness of shorebirds in the BMRG region, signage should be erected at sensitive shorebird sites and pamphlets should be distributed in the mail. This will hopefully engage the community and engender stewardship in shorebird conservation.
Management Recommendations for Shorebird Conservation in the Burnett Mary Region

The protection of internationally significant shorebird populations in the Burnett Mary region, and in Australia in general, requires careful management. Shorebirds face multiple threats of which some can be addressed on local and regional scales. The three management techniques trialled as part of the ‘Feathering the Future of Burnett Mary Shorebirds’ project can be applied on regional and national scales.

Temporary Beach Closures

Although there was some resistance among beach users to TBCs, particularly with increased duration of closure, compliance to the TBCs was generally high (96.2%). This indicates that this management technique to protect nesting shorebirds, their eggs and chicks against human disturbance, can be successfully used at sensitive shorebird besting sites in the Burnett Mary Region.

We recommended that signage used for TBCs is made of stronger material than that used in this study. Corflute (5mm) was used, which sustained damage by strong winds and king tides towards the end of the study. We also recommend that metal stakes are used rather than plastic as plastic stakes can be bent and cut by sharp objects. Signage explaining the need for TBCs at access points to the beach near the TBC may also promote greater levels of compliance.

Baiting for fox control

The effectiveness of baiting for foxes for the protection of shorebird eggs and chicks is not clear from this study. Further research, with increased baiting effort would indicate whether this method is successful in the Burnett Mary region. However, given that research suggests that a comprehensive baiting regime can be effective at reducing predation on eggs and chicks (and accordingly increase hatching and fledging success); it stands to reason that this method would be effective in the Burnett Mary region.

Knowledge and Awareness

Through knowledge comes understanding. Understanding the importance of protecting significant shorebird populations in the Burnett Mary region or in any region within Australia, should foster a caring attitude towards shorebirds. This research has shown that although 66% of people believed they knew what a shorebird was, only 23% were able to correctly identify 80% of birds as shorebirds. This result highlights the need to raise awareness and knowledge of shorebirds, the threats they face and the action that can be undertaken by individuals to protect shorebirds in the Burnett Mary region.

This study has found that although information sources such as the library, t.v./radio and signage at the beach are considered most effective at promoting awareness, signage at the beach and a pamphlet in the mail were ranked with the highest likelihood of being read. Therefore, we suggest that available resources be put towards: 1) developing signage, to be erected at shorebird beaches, about the need to protect shorebirds, and 2) distribution of information pamphlets about shorebirds in the mail.
We also recommend that education activities such as the dog walker’s breakfast and the artwork competition be held regularly in the future to promote shorebird awareness. The feedback from these events was positive, which suggests that they are effective at raising awareness of shorebird conservation. Not only do the events stimulate action, and thus thought, but they also show that local government agencies and education institutions are actively involved in supporting shorebird conservation.
References


Appendix 1

Summary of outcomes – Workshop on Feathering the Future of Burnett Mary Shorebirds 7/9/2007

The aim of the workshop was to facilitate knowledge exchange and identify management priorities for addressing major threats to shorebirds in the Burnett Mary NRM region. In doing so, the specific aims of the day were:

1) Review of shorebird threats in the region and prioritisation of actions and locations; and
2) Identification of pilot projects

Review of shorebird threats in the region and prioritisation of actions and locations

1) Lack of awareness and knowledge of shorebirds and the threats that they face.
2) Disturbance to shorebirds, including:
   a. Camping, 4WD, motorbikes and quads. In particular, that these activities are unregulated and occurring above capacity.
   b. Dogs. Particularly while camping, in tourist sites and in urban areas.
   c. People.
   d. Recreational and tourist aircraft.
   e. Recreational boating and water spots.
   f. Bait collection, both recreational and commercial.
3) Habitat loss and/or decline in habitat quality
   a. Loss via urban encroachment
   b. Foreshore vegetation change/loss, including introduced plants
   c. Rubbish dumps
   d. Land tenure. In particular - lack of management.
   e. Coastal development – Marinas
4) Predators. Both introduced (foxes, dogs and cats) and natural (silver gull).
5) Water quality
6) Pollution and heavy metals
7) Sea level rise – global warming

Methods of addressing these threats were:

1) Lack of awareness and knowledge – To target beach users, both local and tourists. The following methods of educating/providing information were suggested:
   a. Signage
   b. Information nights and talks at local schools
   c. Pamphlets, brochures, fact sheets
   d. Posters, stickers
   e. Media – local papers, radio, TV.
   f. Information for fisherman, perhaps a stubby holder or fish ruler, especially at events/competitions
   g. Dog breakfast – information and dog leashes
2) Disturbance
   a. Temporary beach closures (TBC) using signage
   b. Compliance with TBC
c. Reduced access points using signage
d. Vehicle use protocols & restrictions
e. Dog restrictions
f. Nest cages and chick shelters

3) Habitat loss/decline in quality
   a. Experiments with artificial roost sites and nesting birds. For example, egg roll out experiments as a result of changes in dune morphology.
   b. Weed removal, revegetation, hedging
   c. Assess roosts and buffer areas against land tenures, specifically, proximity to threats

4) Predators
   a. Exclusion fencing to exclude dogs, cats and foxes.
      i. Resident birds – measure breeding success, e.g. hatching and fledging
      ii. Migratory birds – measure number of birds, behaviour
   b. Baiting programs – as above
   c. Information to fishermen and tourists to be mindful of feeding silver gulls etc
d. Fines for dogs/cats
e. Nest cages and chick shelters

5) Water quality – Although this is a threat to shorebirds, we did not discuss this as such as this is more of a longer-term issue and beyond the scope of the current project.

6) Pollution and heavy metals – as above

7) Sea level rise/global warming - as above

Potential sites

1) Lady Musgrave Island
2) Lady Elliot Island
3) Baffle creek
4) Moore park beach
5) Dr Mays Island – Elliot river
6) Gables rocks
7) Point Vernon
8) Coonarr Creek
9) Theoldolite creek
10) Great Sandy Strait

Identification of pilot projects and refinements of management techniques

1) Human disturbance
   a) Compliance of beach users to temporary beach closures (TBC),
   b) Effectiveness of TBCs at reducing egg crushing,
   c) Effects of human activity on hatching success and fledging success of terns on offshore island.

2) Predation
   a) Effectiveness of baiting to reduce fox predation on shorebird eggs and chicks

3) Awareness and knowledge
   a) Determine the level of awareness and knowledge of shorebirds and the threats they face in the Burnett Mary Region using a survey
   b) Conduct education activities, such as a dog walker’s breakfast and an artwork competition for schools
Appendix 2

Table 5 The international and national species of significance found in the Great Sandy Strait.

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<tr>
<td>Pacific golden plover*</td>
<td>820</td>
<td>3</td>
<td>National</td>
</tr>
</tbody>
</table>

* Source Driscoll 1990
*Source Lane 1987
~Source Royal Australasian Ornithologists Union Databases
Appendix 3

Central Queensland University

STUDY: Feathering the Future of Burnett Mary Shorebirds

1) How old are you?
   - □ 0-15
   - □ 16-30
   - □ 31-45
   - □ 46-60
   - □ 61+

2) What is your gender?
   - □ Female
   - □ Male

3) In which suburb/town do you live? __________________________

4) In which country were you born? __________________________

5) What is your highest level of education attained? __________________________

6) What is your occupation? __________________________

7) Are you a member of any volunteer groups?
   - □ Rotary/Apex/Lions Club
   - □ CWA
   - □ CFA/SES
   - □ Surf Lifesaving
   - □ Coast Care
   - □ Other? ________________

8) How many hours per month would you spend volunteering?
   - □ less than 1 hours
   - □ 1-3 hours
   - □ 4-8 hours
   - □ 8-16 hours
   - □ more than 16 hours
9) Are you a member of any environmental groups?
- Australian Conservation Foundation
- World Wide Fund for Nature (WWF)
- Field Naturalist Club
- Wildlife Preservation Society of Queensland
- Other?

10) In general, how often do you visit the beach or coast?
- daily
- 4-6 times per week
- 1-3 times a week
- 2-3 times per month
- once per month
- once every 3 months
- 1-3 times per year
- infrequently

11) How long have you been visiting this beach?
- First time
- 1-3 months
- 4-12 months
- 1-2 years
- 3 years or more

12) How long is your average stay on this beach?
- less than 15 mins
- 15-30 mins
- 30-60 mins
- 1-3 hours
- more than 3 hours

13) What time of day do you usually visit the beach?
- Before 6am
- 6am – 9am
- 9am – 12pm
- 12pm – 3pm
- 3pm – 6pm
- after 6pm

14) What is the approximate distance in kilometers from your place of accommodation to this beach?
- less than 10km
- 10-30km
- 30-50km
- 50-100km
- more than 100km

15) What type of accommodation are you staying in?
- your own home
- holiday house
- hotel/caravan Park
- staying with relatives/friends
- none (i.e. day visit only)
16) Rank in order of frequency (1-8 where 1 is most frequent), the activities you undertake at this beach

<table>
<thead>
<tr>
<th>Walking/jogging/running</th>
<th>Kite Surfing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog walking</td>
<td>4WD</td>
</tr>
<tr>
<td>Sun-baking/sitting</td>
<td>Horse riding</td>
</tr>
<tr>
<td>Swimming/Surfing</td>
<td>Beach cricket/ball games</td>
</tr>
<tr>
<td>Fishing</td>
<td>Other? ________________</td>
</tr>
</tbody>
</table>

17) Where do you spend the majority of your time whilst on the beach?

<table>
<thead>
<tr>
<th>near waters edge</th>
<th>in the dunes (vegetation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>above the high tide mark</td>
<td>between the high and low tide marks</td>
</tr>
</tbody>
</table>

18) Do you know what a shorebird is?

| yes | no |

19) From what sources have you heard about shorebirds?

<table>
<thead>
<tr>
<th>newspaper/magazine article</th>
<th>TV/radio story</th>
</tr>
</thead>
<tbody>
<tr>
<td>signs at a beach where shorebirds occur</td>
<td>friends/relatives</td>
</tr>
<tr>
<td>participation in other conservation activities</td>
<td>your own children</td>
</tr>
<tr>
<td>local community groups</td>
<td>school/university/work</td>
</tr>
<tr>
<td>education material (e.g. stickers, pamphlets, fact sheets or posters)</td>
<td></td>
</tr>
<tr>
<td>Internet</td>
<td>Other? ___________________</td>
</tr>
</tbody>
</table>

58
20) Please tick which of the birds below are shorebirds

- spotted turtle dove
- sooty oyster catcher
- ruddy turnstone
- bar-tailed godwit
- greater sand plover
- eastern curlew
- green sandpiper
- grey-tailed tattler
- red-necked phalarope
- black swan
- pacific black duck
- pacific gull
- red-necked stint
- lesser sand plover
- beach stone curlew
- little stint
- dusky moorhen
- pacific golden plover
21) Please indicate which of the following shorebirds you think may be present at this beach

<table>
<thead>
<tr>
<th>bar-tailed godwit</th>
<th>eastern curlew</th>
<th>grey-tailed tattler</th>
</tr>
</thead>
<tbody>
<tr>
<td>great knot</td>
<td>lesser sand plover</td>
<td>beach stone-curlew</td>
</tr>
<tr>
<td>whimbrel</td>
<td>pacific golden plover</td>
<td>red-necked stint</td>
</tr>
<tr>
<td>red-capped plover</td>
<td>little ringed plover</td>
<td>hooded plover</td>
</tr>
</tbody>
</table>

22) Which of the following activities do you think shorebird undertake on this beach?

| Feeding | Resting/roosting | Breeding |

23) How important do you think shorebird conservation is? Please rank the following environmental issues in order of their importance, where 1 = most important

__  Conservation of internationally significant shorebird population
__  Impact of climate change on coral reefs
__  Loss of tropical rainforests
__  Worldwide declines in frog populations
__  Global warming/greenhouse gas emissions
__  Conserving koala populations in the wild
__  Conserving Tasmanian devil populations in the wild
__  Logging and timber harvesting
__  Increasing abundance of invasive animals
__  Increasing abundance of invasive plants
24) Of the activities listed below, please indicate the level of disturbance you think they cause to shorebirds, where 1 = none, 2 = low, 3 = moderate, 4 = high, 5 = extreme

- walking
- walking a dog on a leash
- walking a dog off the leash
- swimming
- sun baking
- surfing
- kite-surfing
- fishing
- horse riding
- 4WD
- ball games, e.g. cricket

25) Please rank in order of severity (where 1 is most severe) the potential threats faced by shorebirds

- Human disturbance
- Lack of awareness and knowledge
- Habitat loss/decline in quality
- Predation
- Water quality
- Pollution and heavy metals
- Sea level rise (global warming)
- Other?

26) Do you think that shorebirds and people can co-exist together on beaches

| yes | no |

27) Do you know if there are any actions being undertaken to protect shorebirds on this beach or in this region?

| yes, please specify | no |

If so, do you know who is undertaking these management actions

Please specify
28) Please rank in order of importance (where 1 is most important) who you believe should undertake management actions to protect and conserve shorebirds

- Individuals/local residents
- Community groups, e.g. Coast care
- Non-Government Organisations/Conservation groups e.g. World Wide Fund for Nature, Birds Australia
- Local government e.g. Shire Council
- State Government e.g. Environment Protection Authority, Queensland Parks and Wildlife Service
- Federal Government e.g. Department of Environment and Climate Change
- Industry e.g. Mining companies, Port of Brisbane
- Natural Resource Management Groups e.g. Burnett Mary Regional Group

29) Do you believe that you can do anything to protect and conserve shorebirds?

| yes | no |

If yes, what could you do? ________________________________

30) How would you feel if the following activities were no longer allowed on this beach? Please circle. Where 1 = very disappointed, 2 = slightly disappointed, 3 = in different, 4 = happy, 5 = not at all happy

- walking
- walking a dog on a leash
- walking a dog off the leash
- swimming
- sun baking
- surfing
- kite-surfing
- fishing
- horse riding
- 4WD
- ball games, e.g. cricket
31) Please indicate by circling the appropriate number below, whether you think the following actions are important or not important for helping to protect shorebirds, where 1 = no at all important, 2 = of low importance, 3 = of moderate importance, 4 = of high importance, 5 = extremely important.

- Removal of predators e.g. foxes
- Use of temporary beach closures to exclude people from areas used by shorebirds (preventing human disturbance)
- Prohibiting 4WDs on beaches at ALL times
- Prohibiting 4WDs on beaches at or near high tide
- Requiring 4WD users to obtain a permit in order to drive on beaches
- Inclusion of information on shorebirds and responsible driving practices with the issuing of 4WD beach permits
- Signage located at beaches to educate beach users about appropriate behaviour and the need to protect shorebirds
- Restricting the number of access points onto beaches to reduce human disturbance
- Use of nest cages/chick shelter to reduce predation of shorebird eggs and chicks
- Preventing people from fishing in areas where shorebirds are sensitive to human disturbance
- Tougher controls on coastal development to prevent loss of habitat
- Prohibiting dogs on beaches
- Ensuring that dogs are restrained by leashes whenever on the beach
- Monitoring of shorebird populations
- Restricting access of surfers/kite surfers to areas where shorebirds are sensitive to human disturbance
- Education campaign/promotion of the need to protect shorebirds
- Encouraging school children to become more aware of shorebirds and involved in local activities to promote shorebird conservation
- Research into shorebird conservation
- Support for community groups to undertake activities to help protect shorebirds
- Increased funding for State Government agencies to help protect shorebirds
- Greater international efforts to protect shorebirds throughout their range
Distribution of educational material (e.g. stickers, pamphlets, fact sheets or posters) to promote shorebird conservation  
Greater enforcement of compliance of people to shorebird conservation measures

32) Please indicate by circling the appropriate number, how you would feel about a temporary beach closure (an area above the high tide mark only) for the following periods of time. Where 1 = strongly disagree, 2 = disagree, 3 = don’t know, 4 = agree, 5 = strongly agree

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 week</td>
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<tr>
<td>A fortnight</td>
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<tr>
<td>1 month</td>
<td></td>
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<tr>
<td>2-3 months</td>
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<td>4-6 months</td>
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<tr>
<td>6-12 months</td>
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<tr>
<td>Permanently</td>
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</tbody>
</table>

33) Please rank the following resources in order of their importance, where 1 = most important, as to how effective you think they are in promoting awareness of the need to protect shorebirds

<table>
<thead>
<tr>
<th>Resource</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Library</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University staff</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Newspaper/magazine article</td>
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<tr>
<td>T.V./radio</td>
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<tr>
<td>Parks and Wildlife staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Signs at the local beach</td>
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<tr>
<td>Local conservation groups</td>
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</tr>
<tr>
<td>Environmental officers at the local council</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Education material e.g. posters, pamphlets, fact sheets</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

34) Please circle to which extent you care about shorebirds and need to protect them

<table>
<thead>
<tr>
<th>Degree of Concern</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) deeply concerned</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) moderately concerned</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) a little concerned</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) not at all concerned</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) don’t know</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

35) Please circle to which extent you believe people in general care about shorebirds and the need to protect them.

<table>
<thead>
<tr>
<th>Degree of Concern</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) deeply concerned</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) moderately concerned</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) a little concerned</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) not at all concerned</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) don’t know</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
36) Please rank the likelihood (where 1 is most likely) of you reading the following information resources about shorebirds if given the opportunity

__ a poster on the beach near an access point
__ a poster in the car park/play ground
__ pamphlet in the mail
__ a fact sheet in the mail
__ a fact sheet in the local supermarket
__ an article in the local newspaper
__ a story/news segment on the local radio
__ a talk given in the local community centre/library

THANK YOU FOR YOUR PARTICIPATION