

Towards ecologically meaningful and socially acceptable buffers: Response distances of shorebirds in Victoria, Australia, to human disturbance

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ARTICLE INFO

Article history:

Received 6 January 2011

Received in revised form 6 July 2011

Accepted 8 August 2011

Available online 8 September 2011

Keywords:

Flight initiation distance (FID)

Shorebirds

Buffers

Human dimensions

Disturbance

ABSTRACT

Buffers are often used to separate threatening stimuli, such as humans, from wildlife but with few exceptions buffer widths are based on little empirical information. We measured the distance at which a response (i.e., flight initiation distance [FID]) occurred among 28 of Australia's 36 regularly occurring shorebird species when presented with an approaching human ($n = 760$ approaches in Victoria, south eastern Australia). Species differed in their FID, with species with higher body masses having longer FIDs ($F_{1,26} = 36.830$, $p < 0.001$; $R^2 = 0.586$). Mean FIDs for species were 18.6–126.1 m ($n = 370$ approaches by a walker). Depending on the species, FID was significantly influenced by the starting distance of the human approach, flock size, previous exposure to humans and stimulus type (walker, jogger, walker with dog). The FIDs reported suggest that current buffer designations will reduce disturbance to many but not all shorebird species tested. We also surveyed 295 residents and users of shorebird habitat, who reported an overall positive attitude to shorebird conservation, and generally regarded buffers as an appropriate way of managing disturbance to shorebirds (except for walkers, the commonest recreational activity). By overlaying the buffer widths nominated by respondents as appropriate for shorebirds with the FIDs exhibited by shorebirds, we present the efficacy of buffers from both social and ecological perspectives.

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1. Introduction

In south-eastern Australia, shorebird habitats are often popular for human activities, especially recreation (Antos, Ehmke, Tzaros, & Weston, 2007). Human recreation is most frequent and extensive during times of the year when migratory shorebirds are most abundant, and when most resident shorebirds breed (October–April; Geering, Agnew, & Harding, 2007). Thus, there is substantial temporal and spatial overlap between people and shorebirds, and projected increases in human populations and diversification of recreational activities mean that such overlap will increase (Priest, Straw, & Weston, 2002). Disturbance (the behavioural and/or physiological response of an animal to anthropogenic stimuli such as people, dogs, vehicles, etc.) is viewed as a key threat to shorebirds (Burger, 1981; Burger & Gochfeld, 1991; Pfister, Harrington, & Lavine, 1992; Priest, Straw, & Weston, 2002; Vos, Ryder, & Grand, 1985). Disturbance can cause permanent or temporary

displacement from preferred habitat, exposure of eggs or chicks (flightless young) to diminished parental defence or exposure to thermal extremes, disruption of behavioural displays, decreased energy intake through disrupted foraging or increased competition and increased energy expenditure associated with responses (Blumstein, 2003; Cayford, 1993; Gill, 2007; Goss-Custard and Verboven, 1993; Kirby, Clee, & Seager, 1993; Pienkowski, 1992; Weimerskirch et al., 2002; Weston & Elgar, 2005, 2007). The distance at which wildlife respond behaviourally (e.g., walk, run, flee) to disturbance is commonly referred to as the flight initiation distance (FID; Blumstein, 2003; Blumstein, Anthony, Harcourt, & Ross, 2003; Rodgers & Smith, 1997; Tarlow & Blumstein, 2007).

Conservation managers need to manage disturbance and this can be achieved using a variety of techniques (e.g., banning particular activities; limiting visitor access at certain times of the year, limiting the number of access points). One of the most widely accepted approaches, 'buffers' or 'set-backs', rely on the finding that wildlife responses diminish with increasing distance between stimuli and wildlife (Lafferty, 2001b; Pfister et al., 1992; Whitfield, Ruddock, & Bullman, 2008). However, such management is currently hampered by a lack of basic information, such as the distance at which birds respond to stimuli (i.e., FID) and whether type of stimulus, stage of the life cycle or other factors influence responses (Burger, Gochfeld, Jenkins, & Lesser, 2010; Whitfield et al., 2008).

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Table 1

A selection of prominent factors which influence FID among birds.

Factor	Source
Site and/or habitat quality	Blumstein (2003) and Blumstein et al. (2003)
Nature (type) of the stimulus	Battern (1977), Burger (1981), Goss-Custard and Verboven (1993), Kirby et al. (1993), Koolhaas et al. (1993), Rodgers and Smith (1997), Lafferty (2001a, 2001b) and Weston and Elgar (2005, 2007)
Starting distance of stimulus (distance at which a human starts their approach to the focal bird/s)	Blumstein (2003)
Group size of approaching humans	Burger and Gochfeld (1991), Goss-Custard and Verboven (1993) and Geist, Liao, Libby, and Blumstein (2005)
Previous exposure of the birds to humans	Cooke (1980), Burger and Gochfeld (1983), Pienkowski (1992), Cayford (1993) and Lord et al. (2001)
Time of day or tide cycle	Burger and Gochfeld (1991) and Goss-Custard and Verboven (1993)
Stage of life cycle (i.e., breeding or non-breeding, and stage of breeding)	Burger (1981), Burger et al. (1989, 2010), Rodgers and Smith (1997) and Lafferty (2001b)
Parental investment	Burger et al. (1989) and Brunton (1990)
Flock size	Yasue (2005), Burger and Gochfeld (1991) and Fernández-Juricic et al. (2002)
Climatic conditions	Burger and Gochfeld (1983) and Fernández-Juricic et al. (2002)
Time of year/season	Goss-Custard and Verboven (1993), Holmes et al. (2005) and Burger et al. (2010)
Angle of approach	Burger and Gochfeld (1981) and Burger et al. (2010)
Sex, species, body size or dominance	Goss-Custard and Verboven (1993), Weimerskirch et al. (2002), Gill (2007) and Tarlow and Blumstein (2007)

A variety of factors may influence FID among birds (Table 1), and an understanding of these may underpin more appropriate buffer-width designations (Blumstein et al., 2003; Burger & Gochfeld, 1981; Holmes, Knight, Stegall, & Craig, 1993; Koolhaas, Dekinga, & Piersma, 1993).

Internationally, FID data are available for a selection of birds, however, FIDs do not appear to be readily transferable across species (Gill, 2007; Holmes, Giese, & Kriwoken, 2005; Yasue, 2005). FIDs are available for some seabirds (Erwin, 1989; Rodgers & Smith, 1995, 1997), waterbirds (Battern, 1977; Burger et al., 2010; Erwin, 1989; Rodgers & Smith, 1995, 1997; Vos et al., 1985), raptors (Holmes et al., 1993), and several comparative studies include other non-passerines and passerines (Blumstein, 2006; Moller, 2008). Current FID data available to managers are inadequate for setting meaningful buffers for Australian shorebirds. Thus, there remains a need to better establish FIDs among shorebirds in Australia. One aim of this study was to document FIDs of shorebirds to produce more meaningful separation distances between humans and shorebirds in south-eastern Australia.

In addition to better understanding FIDs of shorebirds and the possible implications for setting meaningful separation distances between humans and shorebirds, it is important to compare this information with the social acceptability of new or different buffers. An understanding of the human dimensions of wildlife management efforts, such as the establishment of buffers, is critical if such efforts require broad community support and acceptance to be effective. It is widely accepted that wildlife management programs, which exclude human social considerations, risk low compliance or even failure (e.g., Holsman, Petchenik, & Cooney, 2010). Thus, this study also includes human opinions of various buffer options.

This study aimed to:

1. Determine whether FID varies in relation to a set of prominent potential influences, namely: between shorebird species of different sizes (masses), and in relation to different types of human stimuli (a walker, a jogger, and a walker accompanied by a dog on a leash), previous exposure of birds to humans (restricted versus unrestricted site access), different group sizes of birds, the distance at which a human begins an approach and over different stages of the life cycle (using the masked lapwing, *Vanellus miles* as a model species).
2. Compare FID with visitor opinions on appropriate buffer distances for various recreational activities (e.g., walking, jogging, walking with a dog) and social support for hypothetical management scenarios.

To the best of our knowledge, this is the first study to examine the effectiveness of different buffer distances from both ecological and social perspectives.

2. Methods

FID data collection occurred between October 2008 and March 2009, between 0800 and 2130 h (AESTD). The study was conducted in the southern half of Victoria, south-eastern Australia. Within the study area, data were collected from areas of suitable shorebird habitat (see Geering et al., 2007) including the margins of lakes, lagoons (natural or artificial) and coastal areas including beaches. The study area included a variety of land tenures and uses; from popular summer recreation areas to private farmland and commercial land with highly restricted human access. As FID might be influenced by prior experience with humans (Burger & Gochfeld, 1983; Cayford, 1993; Cooke, 1980; Fernández-Juricic, Jimenez, & Lucas, 2002; Pienkowski, 1992), each sampling location was categorised as 'restricted' or 'unrestricted' human access. Restricted access refers to a requirement of any form of permission for entry and, unrestricted access refers to land that is easily accessible, without access restrictions. Within restricted and unrestricted land tenures, a 30 min midday point count [$n = 22$] around a randomly selected shorebird recorded the number of humans that passed within a 300 m radius of the selected bird. The occurrence of humans tended to be lower in restricted areas ($\chi^2 = 3.315$, $df = 1$, $p < 0.069$), and we assume that these categories represent a useful surrogate for human presence and hence the degree of 'exposure to humans'. Additionally, distance between these focal birds and the nearest human access point was measured using a Bushnell® Elite 1500 Range Finder and did not differ between restricted and unrestricted areas ($T_{19} = 1.137$, $p < 0.270$; $n = 21$ focal birds where measurements were made).

We delivered experimental stimuli to shorebirds, a commonly used approach which allows a range of potentially confounding factors to be controlled (see below). A 'stimulus' was defined as the presentation of a potential threat to shorebirds; three 'stimulus types' were used: a walker (1 m s^{-1}), a jogger (3 m s^{-1}) and a walker with a leashed dog. An 'experimental approach' refers to a standardised approach to shorebirds, during which a variety of data were recorded (see below). A 'response' refers to a change in behaviour of the focal shorebirds upon presentation of a stimulus, and a 'flight response' refers to fleeing on foot or in flight.

Approaches were made to non-breeding shorebirds and a sample of breeding masked lapwings. Birds were randomly selected for experimentation and a variety of habitats were visited to maximise the variety of species sampled and the number of replicates for each. All shorebird species were subjected to a walking approach. Jogging and walking with a dog approaches were made to a subset

of commonly encountered species. The stimulus type was randomly assigned to focal shorebirds using a random number table. Locations were recorded for each data collection point using GPS. Once an individual (or flock) was sampled, no other conspecifics were sampled within 50 m of that location, and we generally avoided resampling birds. While some movement of birds between sampling points is possible, the application of this rule, across the study area and study species, enabled us to reasonably assume that data are independent.

All approaches were made by HKG, who wore standard clothes (white long-sleeved top and grey pants) and only approached single-species groups of birds which were not being influenced by other stimuli such as predators. No rapid body movements occurred, and the observer (and leashed dog, a male mixed breed kelpie) remained silent during approaches. 'Starting distances' (the distance between the observer and the focal birds) was maximised to ensure no 'startling' occurred (Blumstein, 2003) and was measured before each approach. FID was measured as the distance between the shorebird at its original location (i.e., pre-response) and the location of the observer when the response occurred; approaches ended when a flight response occurred. All distances were recorded using a Bushnell® Elite 1500 Range Finder.

FID may be influenced by body mass (Fernández-Juricic et al., 2002) and we wished to examine this. Our experiments involved unsexed birds (none of the species encountered could be reliably sexed by observation alone), so we sourced body masses of unsexed birds captured in Australia from Baker, Dettmann, Scotney, Hardy, and Drynan (1997) for subsequent analysis.

Masked lapwings were selected as a model to examine FID among breeding shorebirds because they are a common and widespread resident species (Chambers, Gibbs, Weston, & Ehmke, 2008). Birds were determined to be either 'non-breeding' or 'breeding' after a period of unobtrusive observation. Breeding lapwings were further classified into two stages of breeding, namely 'incubation' (the presence of eggs) and 'brood-rearing' (the presence of one to four chicks). The parent who was observed incubating the eggs or attending the brood was the focal bird, and was subject to the approach. Hatching dates of chicks were estimated using published growth rates ($F_{1,12} = 302.37$, $p < 0.001$, $R^2 = 0.962$; $\text{Age} = 2.139 \times \text{Culmen length [mm]} - 23.495$; from data in Dann, 1981).

2.1. Measuring the human dimension

We surveyed visitor and resident opinions on appropriate buffer distances for various recreational activities (e.g., walking, jogging, walking with a dog) and social support for hypothetical management scenarios at a large, central, major bay (Western Port Bay, Victoria) which is listed under the Ramsar convention. This site was chosen for its importance for shorebirds, and for which buffers are a potential management option.

Four sites were selected on the basis of high importance for shorebirds, and because they hosted substantial levels of human use. These were: Hastings (38°18'S 145°11'E), Observation Point (38°27'S 145°16'E), Stockyard Point (38°19'S 145°31'E) and Warneet (38°13'S 145°18'E). As part of a larger study to examine the human dimensions of shorebird conservation in Western Port Bay, Australia, postal questionnaires were distributed to residential homes in these four coastal localities and face-to-face interviews were conducted with foreshore users between 26th March and 5th April 2010. A total of 205 postal questionnaires (19% response rate; 14–28% across sites) were completed and 90 interviews were conducted (70% response rate). Data from the four sites were pooled for analysis.

The questionnaire asked respondents the question 'If an activity was to be excluded from an area to protect important bird

populations what width of buffer zone, from which people are excluded, do you think would be required?' Response options of 'no buffer', '25 m', '50 m' and '100+ m' were provided for seven recreational activities (jogging, dog walking, walking, boating, fishing, jet skiing and bait collecting) ($n = 202$ respondents). Questionnaire and interview participants were also asked to indicate their support for 19 hypothetical management actions (e.g., designated times or areas for dog walking) ($n = 286$ –292 across items in the question).

2.2. Statistical analysis

Standard statistical procedures followed Quinn and Keough (2002) and were conducted on Genstat (Version 7.1), SPSS (Version 17.0) and R (Version 2.13). Unless otherwise stated we used the General Linear Modelling (GLM) approach with FID as the dependent variable (log-transformed) and starting distance as a covariate in each model. Additional fixed factors (exposure to humans and stimulus type), covariates (flock size) and interaction terms were included subject to the amount of data available (a sample size of at least five for fixed factors and interaction terms). A model of best fit was determined based on the highest adjusted R^2 values (Quinn & Keough, 2002). The regression of mean FID on mean body mass featured a wide range of sample sizes so was weighted by sample size (see, for example, Moller, 2008). Untransformed data are presented to improve readability and do not imply data are normally distributed. Unless otherwise stated, means are presented \pm one standard error.

3. Results

Seven hundred and sixty approaches were conducted to 5025 birds of 28 species. The walking approach was used in 58% of all approaches ($n = 442$); non-walker approaches ($n = 318$) were conducted on 2522 birds across ten species. Non-walker approaches involved jogging (49%; $n = 155$), and a walker with a leashed dog (51%; $n = 163$). Masked lapwings accounted for 22% ($n = 169$) of all approaches; 68% of approaches to masked lapwings were to non-breeding birds ($n = 115$; all stimulus types). Three approaches to breeding birds were not walker only approaches and thus are excluded from subsequent analysis. Walking approaches to incubating parents accounted for 2% ($n = 4$) of all approaches to breeding masked lapwings, a low sample size because of an unusually early and brief nesting season; 15% ($n = 25$) of approaches to breeding masked lapwings involved brood-rearing birds and the remaining 13% of approaches involved flying young ($n = 22$).

Mean FID across the 28 species was 43.5 ± 1.8 m (6.0–218.0 m; $n = 370$ walker approaches to non-breeding birds; Table 2). FID varied among species (One way ANOVA, $F_{27,342} = 17.00$, $p < 0.001$). Migrants had shorter FIDs compared with residents ($F_{1,370} = 11.161$, $p < 0.001$, walker approaches to non-breeding adults only; residents, 46.9 ± 2.6 m, migrants, 40.6 ± 2.6 m). This model featured group size as a covariate because migrants tend to occur in flocks more than many resident species ($F_{1,370} = 7.688$, $p < 0.006$; overall $R^2 = 0.048$). FID was significantly and positively influenced by species body mass (linear regression weighted for sample size, $F_{1,26} = 36.830$, $p < 0.001$; $R^2 = 0.586$; $\text{FID} = 0.081 \times \text{mass (g)} + 27.730$; Fig. 1).

3.1. Factors influencing FID in response to walker approaches

Results of GLMs for walker approaches are presented in Table 2. Starting distance (walker, 42.4 ± 1.6 m, 4–218 m, $n = 442$; all approaches, 97.4 ± 2.2 m, 10–410 m, $n = 760$) caused a significantly greater FID for seven of sixteen species in which it was included in the model (9 of 16 if $\alpha < 0.10$). Exposure to humans was included in nine models and was associated with a significantly greater FID

Table 2

Mean, maximum and minimum (untransformed) FID by species exposed to a walking approach, with the GLM of best fit (highest adjusted R^2) for each species. Species are presented in taxonomic order (Christidis & Boles, 2008). Blanks indicate a variable not included in the model, and entries in the columns 7–9 indicate p values; the adjusted R^2 is provided for the model listed. The directions of significant continuous variables are indicated in brackets, and those of categorical variables are presented in Fig. 2. Reference (see Fig. 1) refers to the rank of each species with respect to eye height (1 = the species with the lowest eye height).

Species	Reference	N	Mean \pm SE	Min.	Max.	Starting distance	Exposure to humans	Flock size	Adjusted R^2
Pied oystercatcher <i>Haematopus longirostris</i>	23	21	41.52 \pm 3.53	23	85	0.571	0.264	0.252	0.004
Sooty oystercatcher <i>H. fuliginosus</i>	25	14	64.28 \pm 11.51	16	134	0.335		0.945	0.040
Black-winged stilt <i>Himantopus himantopus</i>	26	20	38.00 \pm 3.73	14	79	0.015 (+)	0.046	0.379	0.357
Red-necked avocet <i>Recurvirostra novaehollandiae</i>	27	5	73.00 \pm 17.52	27	113				
Pacific golden plover <i>Pluvialis dominica</i>	17	3	49.33 \pm 5.81	40	60				
Grey plover <i>P. squatarola</i>	24	1	44.00						
Red-capped plover <i>Charadrius ruficapillus</i>	3	20	32.75 \pm 3.45	12	80	0.002 (+)	0.070	0.581	0.436
C. bicinctus	6	7	32.14 \pm 2.84	24	46	0.633			0.141
Black-fronted dotterel <i>Elseya melanops</i>	2	17	23.88 \pm 1.98	10	42	0.024 (+)	0.003		0.481
Hooded plover <i>Thinornis rubricollis</i>	13	8	41.12 \pm 6.06	17	70	0.810			0.155
Erythronyx cinctus	4	10	21.20 \pm 1.95	13	31	0.670			0.098
Vanellus tricolor	15	1	74.00						
V. miles <i>Vanellus miles</i>	22	55	62.62 \pm 5.81	14	218	<0.001 (+)	<0.001	0.177	0.517
Latham's snipe <i>Gallinago harwickii</i>	11	30	18.63 \pm 1.76	9	45	0.094			0.064
Black-tailed godwit <i>Limosa limosa</i>	20	4	31.25 \pm 1.65	27	35				
Bar-tailed godwit <i>L. lapponica</i>	18	4	59.50 \pm 5.25	45	69				
Whimbrel <i>Numenius phaeopus</i>	21	1	90						
Eastern curlew <i>N. madagascariensis</i>	28	22	126.13 \pm 6.23	81	196	0.026 (+)			0.185
Common sandpiper <i>Tringa hypoleucos</i>	9	1	43.00						
Grey-tailed tattler <i>T. brevipes</i>	14	1	23.00						
Common greenshank <i>T. nebularia</i>	19	17	55.41 \pm 6.75	25	145	0.028 (+)	0.022		0.400
Marsh sandpiper <i>T. stagnatilis</i>	16	20	44.10 \pm 5.19	20	99	0.043 (+)	0.945	0.866	0.090
Ruddy turnstone <i>Arenaria interpres</i>	8	6	29.66 \pm 5.84	17	54				
Sanderling <i>Caldris alba</i>	5	5	32.00 \pm 3.53	22	39				
Red-necked stint ^a <i>C. ruficollis</i>	1	23	18.73 \pm 1.81	9	41	0.634		<0.001 (+)	0.406
Pectoral sandpiper <i>C. melanotos</i>	10	2	23.00 \pm 7.00	16	30				
Sharp-tailed sandpiper <i>C. acuminata</i>	7	31	20.29 \pm 1.35	6	44	0.094	0.812	0.599	0.012
Curlew sandpiper <i>C. ferruginea</i>	12	21	25.19 \pm 1.39	14	35	0.535	0.073	0.991	0.186

^a An outlier (a flock of 500 birds) was excluded from analysis.

for birds in restricted areas over unrestricted areas in four models (and approached significance for curlew sandpiper and red-capped plover [i.e., $p < 0.10$]) (Fig. 2). Flock size (all approaches: 6.6 ± 0.8 birds; 1–500 birds; $n = 760$) was included in nine models and significantly and positively influenced the FID of red-necked stint (the

species in which the largest flocks sizes were recorded, i.e., 120 birds [one outlier of 500 birds was excluded from analyses]).

3.2. Type of approach and FID

Further analyses were conducted using type of approach (i.e., walker, jogger, walker with dog) as a fixed factor (Table 3). The type

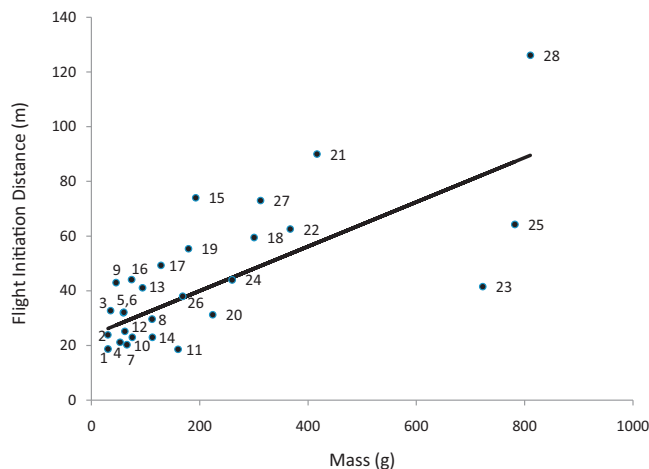


Fig. 1. The relationship between FID (m) in response to a walker approach and body mass (g). Reference numbers refer to species listed in Table 2, and the line is the line of best fit as determined by linear regression weighted for sample size.

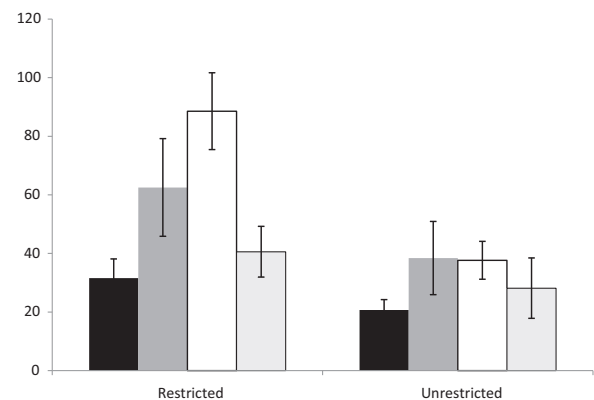


Fig. 2. Untransformed mean FID (m) (\pm 95% Confidence Intervals [CIs]) across restricted and unrestricted locations (a surrogate for levels of exposure to humans) for black-fronted dotterel (black bars), common greenshank (dark grey bars), masked lapwing (open bars) and black-winged stilt (light grey bars).

Table 3
GLM models of FID (m) for species exposed to three different stimulus types, with the model of best fit (highest adjusted R^2) presented for each species. Blanks indicate a variable not included in the model, and entries in columns 3–7 indicate p values. The direction of significant continuous variables is indicated in brackets, and those of significant categorical variables are presented in Fig. 3. Species are presented in taxonomic order (Christidis & Boles, 2008).

Species	N	Stimulus type	Starting distance	Exposure to humans	Flock size	Stimulus type × exposure to humans	Adjusted R^2
Pied oystercatcher	60	0.001	0.038 (+)	0.888	0.466	0.146	0.227
Black-winged stilt	47	0.713	0.018 (+)	<0.001 ^a		0.885	0.265
Red-capped plover	68	0.416	0.040 (+)	0.622	0.224	0.329	0.046
Masked lapwing	114	0.015	<0.001 (+)	<0.001 ^a	0.345	0.146	0.444
Latham's snipe	52	0.017	0.002 (+)				0.250
Red-necked stint ^b	60	0.204	0.838		0.089		0.038
Sharp-tailed sandpiper	69	0.080	0.019 (+)	0.246	0.989	0.250	0.109
Curlew sandpiper	35	0.072	0.658		0.765		0.042

^a FID in restricted areas is higher than in unrestricted areas.

^b An outlier (a flock of 500 birds) was excluded from analysis.

of stimulus presented (walker, jogger, walker with a leashed dog) varied between species but significantly influenced FID of the pied oystercatcher, Latham's snipe and masked lapwing (Fig. 3); curlew and sharp-tailed sandpipers approached significance (i.e., $p < 0.10$). Starting distance had a significant positive influence on FID for six of eight species modelled. Exposure to humans was included in five models and caused a significantly greater FID for masked lapwings and black-winged stilt in restricted areas over unrestricted areas. Flock size was included in six models but was not significant for any species (though approached significance for red-necked stint, i.e., $p < 0.10$) (Table 3).

3.3. Breeding and FID

We found 25 masked lapwing broods (53 chicks). The ages of 40 chicks were used in analysis (the remaining 13 chicks evaded capture). There was no association between FID and the mean age of chicks within a brood (linear regression, $F_{1,1.105} = 0.142$, $p < 0.710$, $R^2 = 0.006$). FID of adult masked lapwing was not significantly influenced by breeding status ($F_{1,1.105} = 0.049$, $p < 0.320$) but was influenced by exposure to humans ($F_{1,1.105} = 0.891$, $p < 0.001$; the interaction was not significant $F_{1,1.105} = 0.027$, $p < 0.458$; Fig. 4). Starting distance featured as a significant and positive covariate ($F_{1,105} = 4.788$, $p < 0.001$).

3.4. The human dimension

Respondents (questionnaire and interviews, $n = 295$) provided basic demographic information. Most questionnaire respondents were residents (60%, $n = 183$), while the remainder were holiday home users. Most respondents were female (57% of 202 questionnaire respondents) and 50–69 years of age (58%, $n = 203$). This slight bias was expected given that the areas sampled are

popular retirement destinations (Australian Bureau of Statistics, 2008). The questionnaire apparently avoided the reported under representation of females in human dimensions of wildlife surveys (Dougherty, Fulton, & Anderson, 2003; Jacobson, Brown, & Scheufele, 2007). Respondents were most commonly retired (44%), while others worked full time (32%) or part time (16%) or conducted home duties (6.2%) ($n = 193$). Most respondents had attended adult higher education institutions (78%, $n = 198$).

Respondents expressed an overall positive attitude towards bird conservation; 86% (254) agreed that 'land and water that provides critical habitat for birds should be protected' ($n = 294$). Respondents were largely supportive of most of 19 hypothetical management techniques (such as, restrictions, regulations, pest control and improved amenities); $69 \pm 3\%$ supported 18 active management techniques (excluding the low support for the 'no management' option) (Table 4). An exception appeared for 'seasonal or permanent limitations on access for walkers, to avoid disturbance of wildlife' where only 39% (112) were supportive ($n = 288$). Apart from this, there were no management techniques where over half of the respondents were not supportive of any given initiative.

Most respondents to the postal questionnaire ($n = 202$) reported that some level of buffer (i.e., ≥ 25 m) is required to manage activities that have the potential to disturb shorebirds: 64% (130) for walking, 88% (173) for walking with dog, 73% (147) for jogging, 89% (178) for boating, 84% (168) for fishing, 88% (172) for bait collecting and 99% (195) for jet skiing. With the exception of walking, more respondents reported that larger buffers are required for adequate shorebird management (Figs. 5 and 6).

4. Discussion

This study provides FID data which could be used to set ecologically meaningful buffers for 28 of Australia's 36 regularly occurring shorebirds (Priest et al., 2002). Most shorebirds use wetlands,

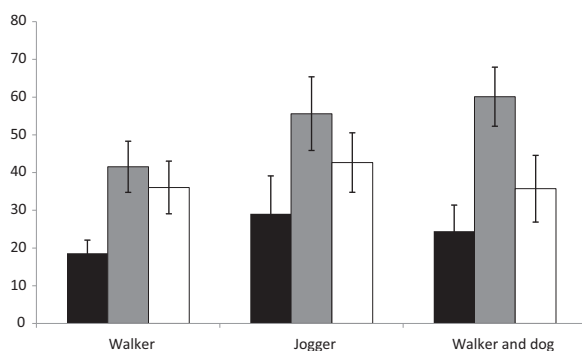


Fig. 3. The influence of stimulus type on FID (m). Stimulus type significantly influenced the FID of Latham's snipe (black bars), pied oystercatcher (dark grey bars) and masked lapwing (open bars). Untransformed mean FIDs ($\pm 95\%$ CIs) are shown.

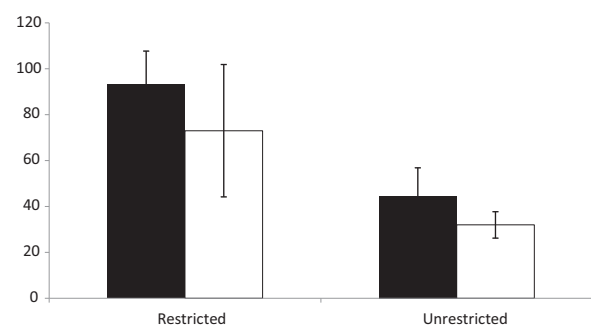


Fig. 4. FID (m) in response to walker approaches of non-breeding (black bars) and breeding (open bars) masked lapwings in areas of different exposure to humans. Untransformed mean FIDs ($\pm 95\%$ CIs) are shown.

Table 4

Respondents' levels of support for 19 hypothetical management techniques which could be used to manage shorebirds.

Hypothetical management technique	N	Very supportive (%)	Undecided (%)	Not supportive at all (%)
Observation platforms and bird hides	291	82.1	7.6	10.3
Board walks/formed paths	291	82.1	8.6	9.3
Bins	288	72.9	15.8	11.8
Fox control (e.g., baiting)	291	78.4	7.9	13.7
Cat curfews for nearby houses	291	90.7	4.1	5.2
Mosquito control	291	72.9	11.3	15.8
Artificial bird habitat (e.g., artificial islands)	291	66.3	8.2	25.4
Designated times or areas for dog walking	289	61.6	21.8	16.6
Seasonal or permanent limitations on access for fishers, to avoid disturbance to wildlife	292	53.1	19.9	27.1
Dog tidy bins provided	289	78.5	14.5	6.9
Seasonal or permanent limitations on access for walkers, to avoid disturbance of wildlife	288	38.9	36.1	25.0
Leashing regulations for dogs	285	80.7	8.8	10.5
Tighter regulations for bait collection	289	63.0	9.3	27.7
Seasonal or permanent limitations on access for boats, to avoid disturbance of wildlife	292	54.8	20.5	24.7
Greater role of community-based friends groups	290	58.3	10.0	31.7
Improved infrastructure (e.g., walkways, fences)	291	76.6	11.3	12.0
Groynes and other defences against rising sea levels	286	54.9	14.3	30.8
Regular ranger/warden patrols	292	73.3	9.9	16.8
No management at all	290	5.2	85.9	9.0

and wetland buffers are often set arbitrarily and fulfil multiple purposes, e.g., amenity, to manage hydrology and conserve biodiversity (Weston, Antos, & Glover, 2009). Few jurisdictional guidelines are in place for wetland buffers, but a commonly used buffer width in south-eastern Australia is 50 m (DSE, 2005); in response to a lone walker, 54% of the species we examined had FIDs in excess of 50 m on at least one occasion, and mean FIDs of over 50 m were recorded for eight species. Thus, even with complete compliance among humans, existing buffer widths are unlikely to eliminate disturbance to shorebirds; the degree to which it is reduced remains unknown. Moreover, some buffers are used as recreational corridors which effectively decreases separation distances between people and birds (Weston et al., 2009).

Variation in FID was evident across species and has been widely reported (Blumstein et al., 2003; Burger, 1981; Burger & Gochfeld, 1981; Cooke, 1980; Holmes et al., 1993; Kirby et al., 1993; Rodgers & Smith, 1997) and has often been regarded as a function of body mass although it is not clear why body mass would influence FID (Burger & Gochfeld, 1981; Cooke, 1980; Fernández-Juricic et al., 2002; Frid & Dill, 2002; Holmes et al., 1993). Flight for heavier birds might be comparatively more energetically costly, therefore fleeing earlier may enable birds to use less costly escape options, such as walking or running (Fernández-Juricic et al., 2002). Alternatively, smaller birds are less conspicuous than larger birds and may continue foraging in the presence of an approaching threat (Holmes et al., 1993). Larger shorebirds may have been preyed upon more substantially by humans, either historically or in parts of the world where the practice still occurs (Geering et al., 2007), and thus birds may have evolved or learned to be particularly wary of humans. Another possible explanation for interspecific variation in FID may lie with the visual detection abilities of each species; larger eye size is associated with higher body mass and longer FIDs, and eye size corrected for body size is also associated positively with longer FIDs (Møller & Erritzøe, 2010).

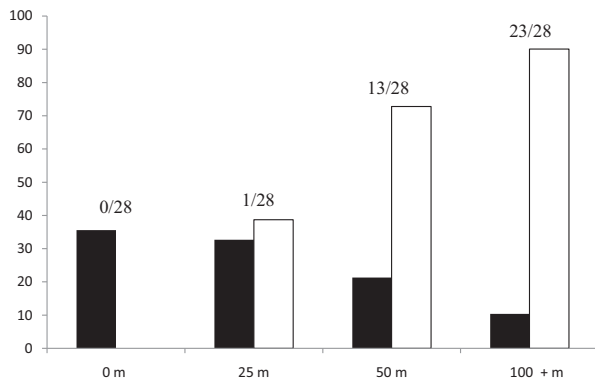
No other variable measured influenced FID more frequently than starting distance (see also Blumstein, 2003). Where significant, as the starting distance of a walker increased, so did FID. One possible explanation is that the perceived value of a resource (i.e., the feeding/roosting location) decreases in value as a threat nears. An approaching threat needs to be monitored thus reducing time spent foraging or roosting, and effectively decreasing the value of the location to the bird (Blumstein, 2003; Burger & Gochfeld,

1991; Yasue, 2005). A short FID may force an individual to fly rather than walk, requiring greater energy requirements during the escape (Blumstein, 2003; Fernández-Juricic et al., 2002). Therefore, a greater FID potentially conserves more energy than does a shorter FID (Blumstein, 2003; Frid & Dill, 2002). The influence of starting distance on FID also has implications for site management, because visual obstructions (occurring naturally or potentially artificial ones used as a management tool) may effectively decrease the starting distance of any human approaches, and thus the FID of shorebirds at the site.

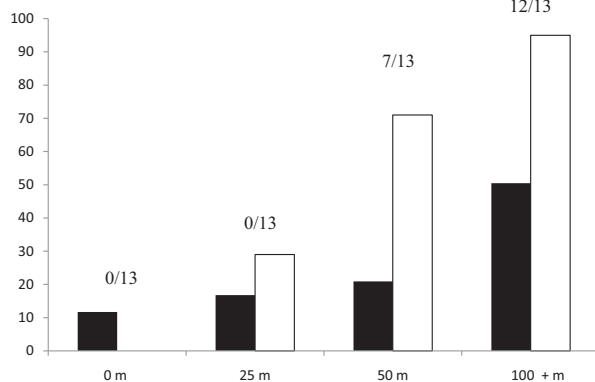
Larger group sizes are generally associated with longer FIDs; the distance at which a flock flees in response to an approaching threat occurs at the distance of the most alert member of the flock (Cooke, 1980; Fernández-Juricic et al., 2002; Hilton, Cresswell, & Ruxton, 1999). However, the reduction in individual vigilance associated with an increase in group size is a frequently reported relationship, and is generally thought to result from a decrease in predation risk to flock members, or an increase in competition among foraging flock members (Beauchamp, 2001; Randler, 2005; Roberts, 1996). We found flock size influenced only one species, red-necked stint, which occurs in large flocks in south eastern Australia (Geering et al., 2007), and for which we sampled the greatest range of flock sizes. Red-necked stint had greater FIDs when they were in larger groups. More data may reveal a greater effect of flock size for other species.

Exposure to humans influenced FID among species differently. Four species fled at a greater distance to an approaching walker in restricted areas suggesting that some species are able to habituate to the presence of humans and have decreased the distance at which they respond in unrestricted areas; this has been reported for other birds (Blakney, 2004; Burger & Gochfeld, 1981; Cooke, 1980; Fernández-Juricic et al., 2002; Goss-Custard & Verboven, 1993; Lord, Waas, Innes, & Whittingham, 2001). It has been suggested that habituation may constitute a mechanism through which the effect of disturbance of shorebirds by people can be reduced. However, our results suggest not every species will habituate, and for those that do habituate, the reduction in response varies in extent but responses remain substantial. The greatest reduction in FID across restricted and unrestricted areas found by this study was for masked lapwings, an aggressive species which colonises many urban areas (Chambers et al., 2008), in which the mean FID in unrestricted areas was half of that in restricted areas.

A. Walking



B. Jogging



C. Dog walking

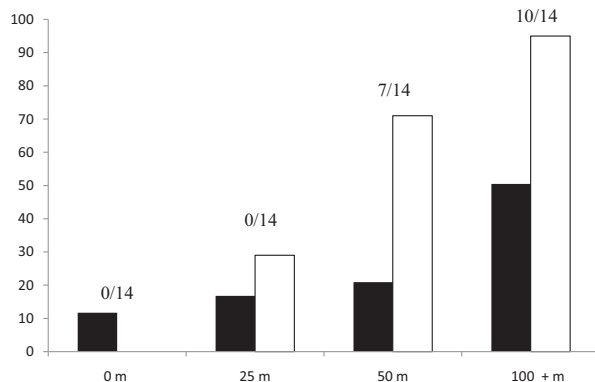


Fig. 5. Opinions of respondents ($n=202$) on the width of buffers required for various activities (solid bars) and the percentage of 'flights' (non-breeding adults) which would have been prevented by each buffer width for each stimuli (assuming the species mix encountered by this study is typical; open bars). Flight data for (A) walkers, from 372 experimental approaches to 28 species of shorebird, (B) joggers, from 153 experimental approaches to 14 species of shorebird and (C) dog walkers from 160 approaches of a walker and a leashed dog to 14 species. Numbers above bars indicate the number of species which would have flights eliminated by the given buffer width (based on maximum species FID recorded for each stimulus type).

An understanding of how FIDs vary in response to different human activities helps define which characteristics of human activity shorebirds find most threatening (Burger, 1981; Koolhaas et al., 1993; Lafferty, 2001b; Lord et al., 2001). In this study, the different stimulus types presented to shorebirds significantly influenced the FID of three species (five if $\alpha < 0.10$ is applied). The non-walker approaches caused consistently greater FIDs than the walking approach. The typical pattern revealed by this study suggests that a jogger and a walker with a dog are perceived as a greater threat than a walker, which is consistent with findings for other birds

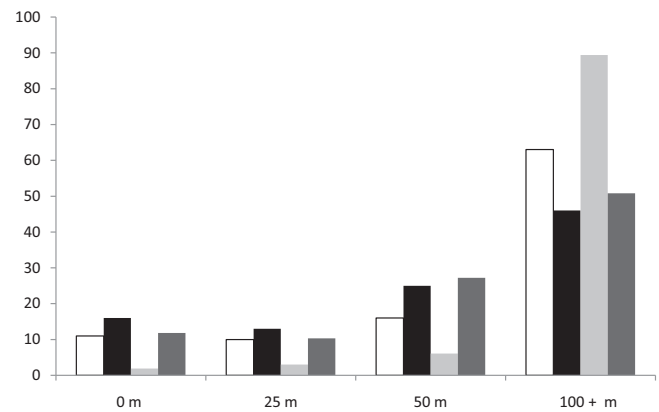


Fig. 6. Opinions of respondents ($n=202$) on the buffer width required to manage disturbance caused by a variety of recreational activities (see Fig. 5 for walking, jogging and walking with a dog). Open bars represent 'boating', solid bars represent 'fishing', light grey bars represent 'jet skis' and dark grey bars represent 'bait collecting'.

(Burger, 1981; Kirby et al., 1993; Lafferty, 2001b; Lord et al., 2001). The perception of a walker with a dog as a threat is unsurprising for Australian shorebirds. Direct mortality to eggs, chicks, and even adults is reported from wild and domestic dogs and foxes *Vulpes vulpes*, and dingoes *Canis lupus dingo* were probably a traditional predator of shorebirds (Dowling & Weston, 1999). Shorebirds and other birds respond to dogs at greater distances and with greater intensities compared with humans alone (Lafferty, 2001a, 2001b; Lord et al., 2001; Weston & Elgar, 2007); our dog was leashed and unleashed dogs may evoke even longer FIDs. Much shorebird habitat is used extensively by dog walkers (Williams, Weston, Henry, & Maguire, 2009) and it is likely that birds instinctively view dogs as a threat and respond at greater distances (Burger, 1981; Lafferty, 2001b). The jogging approach caused a greater FID than the walker approach (without the dog). The only difference between the standardised jogger and walker approaches used in this study was speed, suggesting higher approach speeds were more threatening (see also Burger, 1981; Fernández-Juricic, Zollner, LeBlanc, & Westphal, 2007; Frid & Dill, 2002; Goss-Custard & Verboven, 1993).

The masked lapwing was used as a model species to study the influence of breeding status on FID, though we acknowledge other species may respond differently, particularly those with passive rather than the active defence strategies of lapwings. Masked lapwings did not alter FID when breeding (though we sampled few nests), a finding which accords with studies of some birds (Lafferty, 2001b; Lord et al., 2001; Rodgers & Smith, 1997) while others alter FID in relation to breeding status (Blakney, 2004; Burger et al., 1989; Delaney, Grubb, Beier, Pater, & Reiser, 1999; Rodgers & Smith, 1997). Masked lapwing parents did not decrease FID as their investment increased (i.e., chicks aged), concordant with other studies (Burger & Gochfeld, 1983; Burger et al., 1989). Variation in parental defence (e.g., distraction displays) may reflect parental investment more directly than FID (Burger et al., 1989). Masked lapwings showed a significantly lower FID when breeding in unrestricted than restricted access areas, presumably from habituation towards humans or as a strategy to avoid frequent absences from eggs or chicks (Burger & Gochfeld, 1981).

A more comprehensive understanding of FIDs gives conservation managers the opportunity to reconsider management approaches to meet both recreation and conservation objectives. The management implications of this study are significant but, to be effective, must be considered within the context of the human dimensions of shorebird conservation. Management approaches such as buffers rely upon high compliance among recreationists, thus social support is critical to their success (Decker, Brown, &

Siemer, 2001; Miller, 2009). Our study found high levels of support for the protection of shorebirds, with respondents reporting a view that land and water which provides critical habitat for birds should enjoy protection. However, the links between values, attitudes and behaviours are complex and pro-environmental attitudes do not necessarily translate into pro-environmental behaviours (Manfredo & Dayer, 2004). General attitudes (e.g., pro-environmental attitudes) are only loosely related to specific behaviours (e.g., avoidance of important shorebird habitat on beaches) (McKnight & Sutton, 1994). Thus, “if we wish to increase predictive efficiency, we need to specify precisely *which* attitude leads to *what* behaviour” (McKnight & Sutton, 1994, p. 167). While this predictive relationship was beyond the scope of our study, we explored views on a range of specific behaviours and these give some insight into the possible effectiveness of various management regimes.

Our results show that beach users hold the view that some width of buffer is required to protect shorebirds from a range of recreational activities, however, this view was not consistent across different activities. This may be because people perceive some recreational activities (e.g., jet-skiing and boating) to disturb shorebirds at greater distances than others (e.g., walking) and this perception aligns with our FID findings (e.g., greater FIDs for joggers and dog walkers cf. walkers). We also found that respondents were less supportive of buffers for walkers, possibly out of self-interest given that walking was the commonest recreational activity among respondents. Therefore, further research is needed to examine support for recreation-specific buffers among key stakeholder groups (e.g., fishers, watercraft users) to examine how significant self-interest is for buffer support and whether such attitudes translate into actual behaviours.

While there appears to be considerable community support for buffers, this could be further enhanced through the use of participatory or social marketing processes (McKenzie-Mohr & Smith, 1999; Walker et al., 2002), which can include information on the FID of shorebirds in response to particular recreational activities. This information could be used to support or refine the beliefs already held by coastal users about shorebird disturbance and conservation. Conservation managers can use the ecological and social research from our study to prioritise which behaviours to target and to assess the impact, probability and penetration of desired shorebird conservation behaviours (McKenzie-Mohr & Smith, 1999). This will ensure that resources are directed where they will be most beneficial.

Acknowledgements

Thanks to Geoff Glover, Ben Gaylard, Jim and Anthea Whitelaw, Jane Hayes, Victoria Dixon, Jodie Winnell; Peter Dann (Phillip Island Nature Parks); Brian Martin, Danny Hudson and Bernie McCarrick (Parks Victoria); James O'Connor (Birds Australia); Noel Taylor (Cheetham Salt); Steve Ford (Alcoa); William Steele (Melbourne Water); and Rebecca Koss, Justin Lawson, Thomas Mitchell (Deakin University). This project was conducted in accordance with Deakin University Animal Ethics Committee Permit A48/2008, National Parks Permit 10004656, DSE Scientific Permit No. FF380165, Western Treatment Plant Study Permit SP 08/02 and Human Research Ethics Committee Permit STEC-01-2010-MILLER. This project was partly supported by Birds Australia and the Central Coastal Board, through funding from the Australian Government's Caring for our Country program, the Deakin University Faculty of Science and Technology Research Performance Fund, and the Deakin Centre for Integrative Ecology Research Assistant Fund.

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