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Short communication

Do fences protect birds from human disturbance?

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Abstract

Outdoor recreation and ecotourism are becoming increasingly popular, but such human activities are not entirely benign to birds. One way to manage wildlife habitats is to restrict public access with a fence or some similar barrier, under the assumption that this provides wildlife with a refuge from human activities. We tested this assumption by measuring the responses of 10 species of birds at a site containing a fence with a relatively large number of visitors on only one side. We compared these responses to those at a less-visited, control site. Responses were measured by quantifying flight initiation distance (FID), the distance birds would allow a human to approach before fleeing. Overall, we found birds on the protected side of the fence responded similarly to birds at the low visitation control site, and significantly differently from birds at the high visitation site. Our results suggest that by reducing the number of humans and providing areas of refuge within highly visited habitats, protective barriers allow birds to behave as they would in an undisturbed environment.

Keywords: Conservation behavior; Human impacts; Fencing; Buffer distances

1. Introduction

Ecotourism and recreation, including bird-watching, hiking, jogging, and other outdoor activities are increasingly common, and as a result, human contact with birds and other wildlife is becoming more frequent. Unfortunately, these activities are not benign (Boersma and Parrish, 1998; Schram, 1998; Wearing and Neil, 1999), because human presence can adversely affect avian abundance and reproductive success. For example, pink-footed geese (*Anser brachyrhnchus*) avoided potential feeding patches in proportion to the amount of human activity present (Gill et al., 1996). Similarly, New Zealand dotterel chicks (*Charadrius obscurus aquilonius*) decreased their amount of foraging time in the presence of people (Lord et al., 1997). European oystercatchers (*Haematopus ostralegus*) decreased the amount of parental care given to chicks when disturbed by humans (Verhulst et al., 2001). Even more subtle physiological effects were seen in adelie penguins (*Pygoscelis adeliae*), which exhibited much-increased heart rates in response to human presence and approach (Culik et al., 1990). The increased heart rates indicated the penguins experienced stress, and this stress may negatively impact reproduction.

In many wildlife habitats, common management practice is to restrict public access to certain parts (Tuite et al., 1984). Restriction commonly involves posting signs (Erwin, 1989; Nordstrom et al., 2000), but in some cases fencing protects birds from human activity (Burger et al., 1995). In highly visited sites, physical barriers such as fences may be the most effective way to control access.

Several studies have shown that birds avoid humans when possible (Burger et al., 1995; Burger and Gochfeld, 1998) and prefer undisturbed habitats over disturbed ones (Hockin et al., 1992). However, it is not known if birds behave the same on the undisturbed side of a protective barrier compared with an undisturbed location. If birds do not act as they would in an undisturbed environment, the barrier has not eliminated human impacts.

Flight initiation distance (FID), also termed flush distance, is the distance at which an animal moves away from an approaching human and has been used as a

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standardized way to quantify the perception of predation risk (Blumstein et al., in press). Several studies have found that FID decreases as a result of repeated exposure to humans (Burger and Gochfeld, 1983; Smit and Visser, 1993; Lord et al., 2001; Miller et al., 2001).

In order to quantify the difference between protected versus unprotected sides of a barrier, we examined the responses of waterbirds at two southern Californian wetlands to direct human approach. One of the wetlands contained a fence that separated a relatively ‘‘high visit’’area from a ‘‘low visit’’ area. The other wetland was a low visit site without a fence and acted as a control. While we had only one fenced wetland, we extended our inference by studying 10 species of birds. We hypothesized that birds would not respond differently at the control site and at the protected side of the more visited wetland. However, birds on the high visit side of the fence were expected to habituate to human disturbance and respond with a shorter FID than at the other two sites. A difference in response on either side of the fence would indicate the birds acted according to the differing levels of human activity, and that this barrier may effectively create an undisturbed environment.

2. Methods

2.1. Study sites

This study was conducted at the Bolsa Chica Wetlands (33°41′ N, 118°02′ W) and the Seal Beach National Wildlife Refuge (33°44′ N, 118°04′ W), both of which are wetland habitats near Huntington Beach in Orange County, California. The sites were selected based on their relative amounts of human activity. The Bolsa Chica reserve is divided into two sections and was considered as two separate sites for this study. The southern part of the reserve (Bolsa Chica) contains a loop trail and is open to the general public. The northern part (Bolsa Oil), separated from the southern part by a chain-link fence, is restricted to the public and has been used for oil-drilling for more than 50 years (Dillingham Environmental Company, 1971). The only visitors to Bolsa Oil are a few oil workers who primarily drive trucks through the area, and occasional biologists from the US Fish and Wildlife Service. The Seal Beach National Wildlife Refuge, 5–10 km to the northwest, is located within a naval weapons station and consequently has greatly restricted public access. As at Bolsa Oil, most of the movement through the Seal Beach reserve is done in trucks rather than on foot.

2.2. Data collection

Data were collected on weekdays from July through December 2001 between 07:00 and 18:00. Each site was systematically visited on varying days of the week and at varying times of the day. Two assistants helped with data collection. At the Bolsa Chica site, we collected data while walking around the loop trail. At Bolsa Oil and Seal Beach, data were collected in the designated sections to which we were allowed access. At these sites, the same sections were covered each time. For a 10-min period during each visit, we recorded the total number and activities of people passing within a 100 m radius of where we were collecting flush distance data as a quantitative measure of the human activity at each site.

Flight initiation distance was recorded for birds that were accessible by foot, including individuals in shallow water. This distance was measured in paces. Before data collection began, observers trained themselves to have a consistent stride length and to walk at a consistent pace for over at least 30 m. Distances were recorded using the following technique. Once a bird was identified, the observer walked directly toward it at a constant pace of 0.5 m/s, noting the number of steps at which the bird first looked at the observer, when it became agitated, when it stopped foraging, and when it moved away. The observer then walked up to the initial location of the bird and recorded the total number of steps travelled. The other recorded step numbers were subtracted from this total number to obtain the number of steps from the bird at which each reaction occurred. These step counts were subsequently converted into meters using measurements of each observer’s stride length. Additional information recorded at the time of each flush was the date of the observation, the bird’s initial behavior, the number of conspecifics within 10 m, number of heterospecifics within 10 m, the height in tree (if applicable), the distance to cover (in m), the distance to trees (in m), and the distance to water (in m). These factors were recorded because of their potential influence on perceived predation risk (Burger and Gochfeld, 1991; Gutzwiller et al., 1998). Once FID information was collected for a single bird, the observer moved to another location so as not to bias subsequent approaches to other birds.

2.3. Data analysis

Because variances were not always uniform, we used a Kruskal–Wallis non-parametric ANOVA to test for overall differences in relative human visitation rates among the three sites, followed by Mann–Whitney post-hoc comparisons with a Bonferoni corrected P-critical value of 0.017 (0.05/3 comparisons = 0.017).

To determine which species could be analyzed in our study, a species by location cross-tabulation was performed. Those species with greater than three observations at a given site were selected for subsequent analysis. To understand the influence of the fence separating the two Bolsa sites, we compared the FID for each species found in sufficient numbers at all three sites. We viewed Seal Beach as a control site. For each of the species found at these three sites, non-parametric ANOVA tests were performed to determine whether FID varied with location. These were followed by post-hoc comparisons between pairs of sites. To remove the effects of potentially obscuring or confounding variables that may explain variation in FID, additional ANOVA tests were performed on the categorical variables, and correlation coefficients were calculated for all continuous variables. Significant associations were explored with ANCOVA models that also included location. We employed a backward-stepping algorithm where the least significant variables were removed until the models' adjusted R^2 was maximized. Residuals from these ANCOVA models were examined for normality; most appeared normal.

Some species were found only at Bolsa Chica and Bolsa Oil. To these five species we added the five other species found at all three sites and made a direct comparison of FID at the two Bolsa sites. If birds responded to the fence separating these two sites, we predicted that there would be a significant difference in FID between the sites. We used Mann–Whitney *U* tests to compare FID for these species and then fitted a similar series of ANCOVA models as described above to control for potentially obscuring or confounding variation.

Table 1
The number of flight initiation distance observations of each species at each location

Species	Bolsa Chica	Bolsa Oil	Seal Beach
Black-bellied plover	6	36	
Black-necked stilt	37	33	4
Great blue heron	13	12	22
Great egret	17	17	21
Greater yellowlegs	4	6	
Least sandpiper	35	3	
Ring-billed gull	6	8	
Snowy egret	31	7	13
Western sandpiper	11	10	
Willet	36	21	16

3. Results

There was a significant difference in the number of people among the three study sites (Fig. 1, $P<0.001$). Visitation was significantly higher at Bolsa Chica compared to the other two sites, with a significant difference between Bolsa Chica and Bolsa Oil ($P<0.001$) and Bolsa Chica and Seal Beach ($P<0.001$), but no significant difference between Bolsa Oil and Seal Beach ($P=0.890$). Species found at all three locations and species found at only Bolsa Chica and Bolsa Oil are listed in Table 1.

Comparisons of species found at all three sites revealed that overall, species' FID was significantly shorter at Bolsa Chica than Bolsa Oil (Table 2, Fig. 2). FID also was significantly shorter at Bolsa Chica than Seal Beach. However, except for snowy egrets, there was not a significant difference in FID between Bolsa Oil and Seal Beach (Table 2).

The final ANCOVA model for the three sites that incorporated covariates indicated that location was still

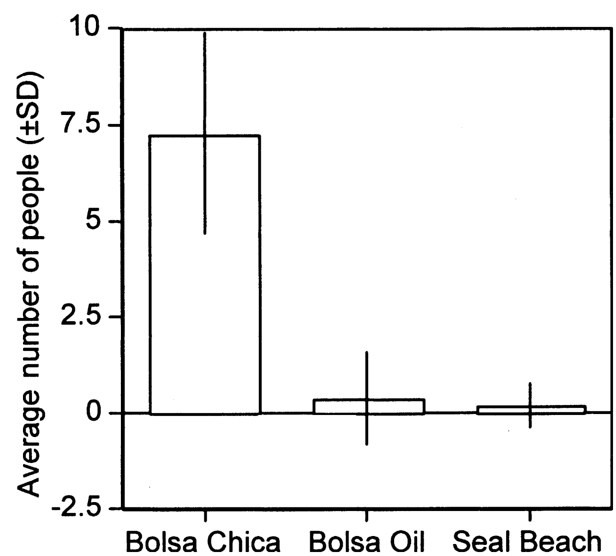

Fig. 1. Average (±SD) number of people at each location counted during a 10 min census on ⩾13 days.

Table 2
Summary of pair-wise comparisons of flight initiation distances between sites

Species	ANOVA with location only[a]			Final ANCOVA including location[b,c]		
	BC versus BO	BC versus SB	BO versus SB	BC versus BO	BC versus SB	Bo versus SB
Black-necked stilt	X			X	X	
Great blue heron	X	X		X	X	
Great egret	X	X		X	X	
Snowy egret	X	X	X	X	X	X
Willet	X	X		X	X	

[a] All *P*-values <0.001.
[b] All *P*-values <0.009.
[c] Starting distance significant for all species ($P<0.016$), number of conspecifics significant for great egret ($P<0.003$).

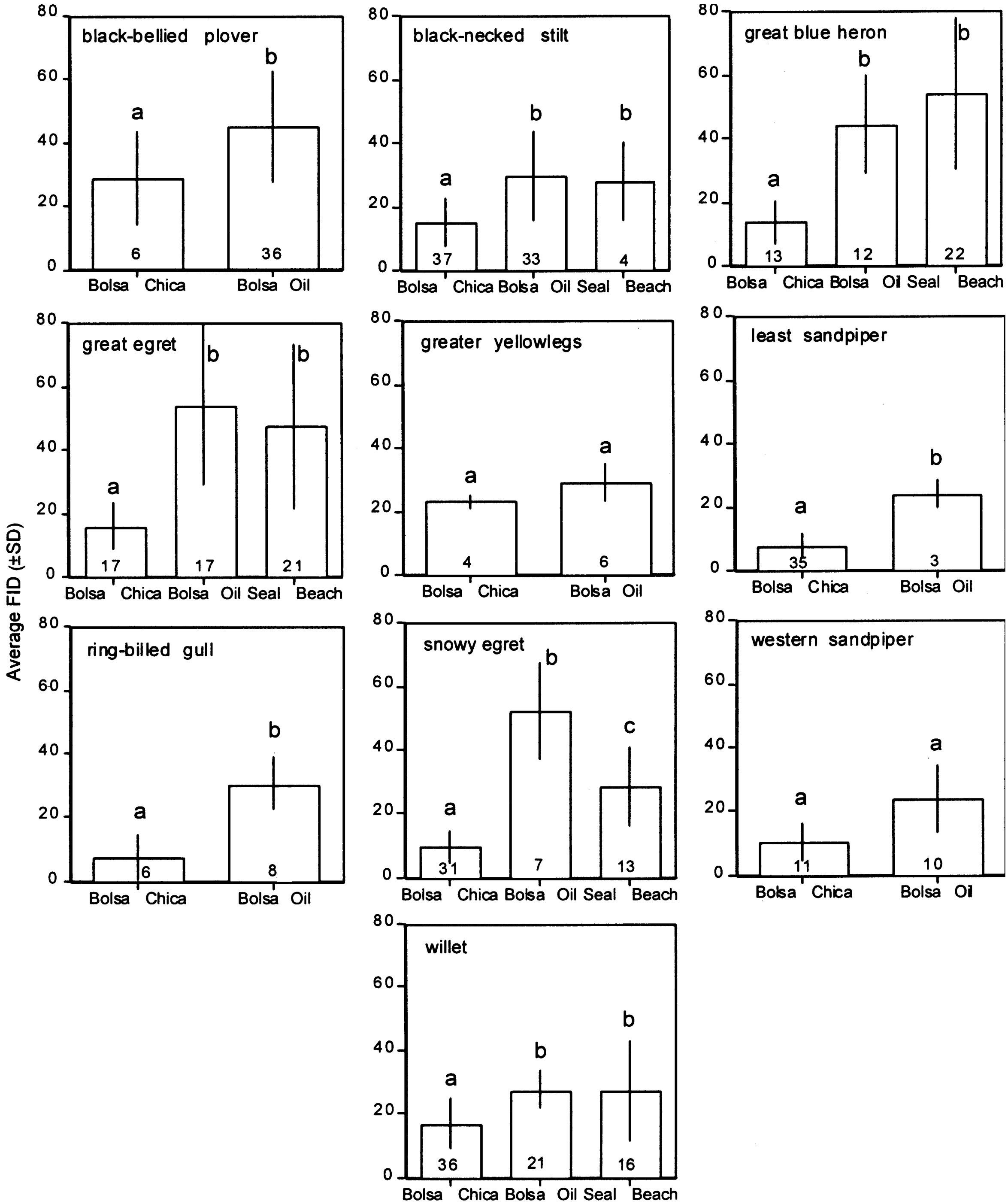

Fig. 2. Average (±SD) flight initiation distance for each species at each location. Different letters indicate significantly different main effects.

significant for all species (Table 2). Additionally, starting distance explained significant variation for all species, and the number of conspecifics explained significant variation for great egrets. FID was significantly shorter at Bolsa Chica than Bolsa Oil. FID was also significantly shorter at Bolsa Chica compared with Seal Beach. Only snowy egrets had FID values that were significantly larger at Bolsa Oil than Seal Beach.

When only two sites were examined, all species had significantly shorter FIDs at Bolsa Chica versus Bolsa Oil (Table 3). The final ANCOVA model for the two site comparisons demonstrated that location was significant for 7 out of the 10 species (Table 3). Other potentially confounding variables differed among species. Starting distance explained significant variation for half of the species, group size explained significant variation for

Table 3
Summary of *P*-values comparing flight initiation distances at Bolsa Oil and Bolsa Chica

Species	M–W Location[a]	ANCOVA Location[b]	D-start	Date	Gp. Size	D-cover	D-water	Adjusted R^2
Black-bellied plover	0.04	0.886	0.002		0.249	0.687	0.199	0.352
Black-necked stilt	<0.001	<0.001	<0.001					0.411
Great blue heron	<0.001	<0.001						0.638
Great egret	<0.001	<0.001	<0.001	0.275	0.002			0.906
Greater yellowlegs	0.047	0.577	0.265			0.001		0.859
Least sandpiper	0.015	<0.001						0.571
Ring-billed gull	<0.001	0.001	0.099					0.746
Snowy egret	<0.001	<0.001	0.001					0.870
Western sandpiper	0.002	0.111	0.224		0.022	0.017		0.796
Willet	<0.001	<0.001						0.336

[a] Mann–Whitney *U* tests.
[b] ANCOVA models (see text for details).

great egrets and western sandpipers, and the distance to cover explained significant variation for greater yellowlegs and western sandpipers.

4. Discussion

The aim of our study was to determine whether wetland birds responded differently to humans on the high visit side of a protective barrier compared to the low visit side. Significantly more people were observed at Bolsa Chica than at either Bolsa Oil or Seal Beach and, importantly, there was no significant difference in human visitation at Bolsa Oil and Seal Beach. We therefore expected that species would respond to humans similarly at the latter two sites. In contrast, birds at Bolsa Chica experienced a greater exposure to human activities, and we hypothesized that they might habituate and have significantly smaller FIDs.

While we only had one fenced area in our study, we did examine multiple species. Five species [black-necked stilts (*Himantopus mexicanus*), great blue herons (*Ardea herodias*), great egrets (*Ardea alba*), snowy egrets (*Egretta thula*), and willets (*Catoptrophorus semipalmatus*)] examined at the three study sites behaved as predicted with significantly greater FID values at Seal Beach and Bolsa Oil compared with Bolsa Chica. This was true when location was considered alone, as well as in the final ANCOVA model that accounted for other potentially confounding variables. For all of these species except snowy egrets, there was no significant difference in FID between Seal Beach and Bolsa Oil, indicating birds responded similarly to low disturbance.

When all 10 species were examined at just Bolsa Chica and Bolsa Oil, significant differences in FID were observed between the two sites when location was considered alone. Seven out of these 10 species showed significant differences in FID between the two sites in the final ANCOVA model as well.

Our results indicated that birds responded differently to human intrusion on either side of the fence and were generally less sensitive to human disturbance at the high visit site. This finding was consistent with previous studies that have found habituation to occur with repeated exposure to humans (Cooke, 1980; Burger and Gochfeld, 1983, 1991; Lord et al., 2001). On the Bolsa Oil side of the fence, birds exhibited greater FIDs similar to at an undisturbed habitat. We therefore infer that by reducing the number of visitors to an area, fences and other such barriers may be an effective management tool, even for relatively small wetlands such as those found in southern California.

While we know that a majority of the species responded differently on either side of the fence at the Bolsa Chica wetlands, we do not know whether the birds were responding to the fence itself, or simply responding to the distance that separated the people from them. In other words, the birds may have perceived that the fence was preventing humans from coming into direct contact with them. In this case, the birds would respond to disturbances similarly throughout the entire fenced-off area, including the area right against the fence. If the birds were simply responding to a set-back distance away from humans, there would be an area near the fence in which birds were still influenced by humans on the other side. Personal observations revealed that birds at Bolsa Chica were often loafing close to the fence on the "protected" side even when people were right next to the fence on the opposite side.

Future studies might explore these ideas by testing directly the effect of a fence on bird responses. For example, a study could focus on birds within 10–20 m of a fence and measure FID when birds and humans were on the low visit (inside) versus the high visit (outside) side of a fenced area. Birds would be expected to have a small FID when both they and humans were outside the fence, and a large FID when both they and humans were inside the fence. If the fence were perceived as protective, FID would be shorter when birds were on the inside and humans were on the outside, than when both were on the outside. Likewise, FID would be shorter when birds were on the outside and humans were on the inside than when both were on the inside.

This information on the birds' perception of humans has important implications for the amount of land that needs to be set aside as an undisturbed reserve. If there is indeed an area of influence around the fence, this area will need to be accounted for with adequate buffer zones when designing reserves.

For most of these species at the Bolsa wetland, we conclude that a fence can be a useful management tool for wetland habitats, as it restricts human access and thereby allows birds to behave as they might in an undisturbed habitat. However, further investigations are needed to determine whether birds perceive barriers as protective in themselves, or whether they simply respond to a set-back distance away from humans. This information will determine the best management strategy for wetland design and will allow managers to determine the amount of area needed for a reserve, as well as barrier placement to confer the most protection.

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