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Birds at a Southern California beach: seasonality, habitat use and disturbance by human activity

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Abstract. Use of a Santa Barbara beach by people and birds varied in both time and space. There were 100 birds, 18 people and 2 dogs per kilometer. Bird density varied primarily with the season and tide while human activity varied most between weekend and weekday. Bird distributions along the beach were determined mainly by habitat type (particularly a lagoon and exposed rocky intertidal areas). For crows and western gulls, there was some evidence that access to urban refuse increased abundance. Interactions between birds and people often caused birds to move or fly away, particularly when people were within 20 m. During a short observation period, 10% of humans and 39% of dogs disturbed birds. More than 70% of birds flew when disturbed. Bird species varied in the frequency that they were disturbed, partially because a few bird species foraged on the upper beach where contact with people was less frequent. Most disturbances occurred low on the beach. Although disturbances caused birds to move away from humans, most displacement was short enough that variation in human activity did not alter large-scale patterns of beach use by the birds. Birds were less reactive to humans (but not dogs) when beach activity was low.

Key words: beach, birds, disturbance, dogs, recreation, shorebirds

Introduction

About half of the shorebird species in North America are in decline, primarily due to habitat destruction and degradation (Howe et al. 1989; Brown et al. 2000a). The world's growing coastal population continues to increase the encroachment of people into shorebird habitat (Burger and Gochfeld 1991). A good example is Southern California, where the climate and culture make beach recreation popular along the Pacific Flyway. The resulting disturbance from humans and pets degrades habitat for shorebirds because disturbance may reduce foraging efficiency and opportunities for rest (Burger 1986; Brown et al. 2000b). Chronic, cumulative disturbance could, therefore, reduce shorebird reproduction and survivorship. In particular, short flights are energetically costly for small birds (Nudds and Bryant 2000) and shorebirds unsuccessful in gaining necessary fat reserves have very low survival rates (Brown et al. 2000b).

To better understand how management actions might reduce disturbance, I investigated recreational activity and the responses of birds (primarily shorebirds) on a Southern California Beach. My research objectives were to determine: (1) factors associated with bird and human use of the study site and (2) how disturbance varied with bird species, human activity and the distance between the two. Based on similar studies done with other species (Burger 1986), I expected that the effect of an activity on birds would vary among activity types and that some bird species would be more sensitive to disturbance than others (Burger and Gochfeld 1998).

People can disturb birds if they approach too closely or too quickly. In addition, some dogs may actively chase birds for prolonged periods. The sensitivity of shorebirds to dogs is illustrated by the observation that snowy plovers react at twice the distance to dogs that they do to pedestrians (Fahy and Woodhouse 1995; Lafferty 2001). Perhaps this heightened reaction is because being chased conditions birds to be wary of dogs or because birds instinctively view dogs as predators (Gabrielsen and Smith 1995). Although they do not remove habitat or kill birds directly, disturbances cause birds to suspend feeding and/or expend energy in flight, movement or vigilance. Impacts to birds are most likely a result of cumulative effects on reproduction and survivorship. Birds that forage slowly or ineffectively may not build the requisite fat reserves that are especially important to stressed and depleted migrants who must rest and feed to successfully resume their migratory journey (Puttick 1979).

Studies on piping plovers indicate that reproductive success is lower in areas with high human disturbance because of reduced foraging efficiency and the depletion of fat reserves (Burger 1986, 1991, 1994). In areas where people are absent, piping plovers can spend 90% of their active time feeding compared with less than 50% in areas where people are common (Burger 1994). Disturbance can also cause birds to abandon habitat (Burger 1986). On the northeast coast of North America, gulls and terns are least likely to be permanently displaced, ducks usually move a short distance while herons, egrets and shorebirds are most likely to be displaced the furthest distance (Burger 1981). In Ventura County, for example, shorebird abundance is low on beaches with high human use, presumably because disturbance causes birds to seek more isolated locations (McCrary and Pierson 2000). Pet activity, in particular, reduces shorebird abundance (Burger 1981; Klein 1993) and those birds that remain must spend more energy on vigilance and escape at the expense of foraging and rest (Pfister et al. 1992; Burger 1993; Burger 1994).

For this study, I observed shorebirds and human activity on the beach. In particular, I noted whether activity disturbed birds. Shorebirds were disturbed very frequently. The effect of disturbance was influenced by the type of activity and varied among bird species. Effects of disturbance on shorebird feeding and distribution were difficult to determine.

Materials and methods

The study site (Figure 1) was a 2.85-km stretch of coastline that surrounds Coal Oil Point between Ellwood Beach and the community of Isla Vista (Santa Barbara Coun-

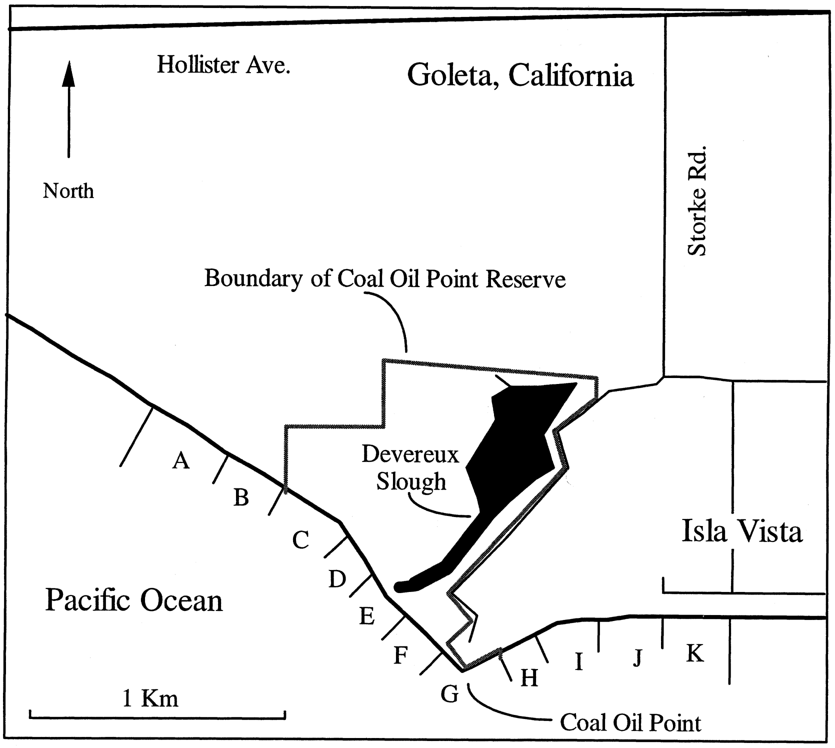

Figure 1. Map of the transect and study area.

ty, California). This area has a rich high-intertidal invertebrate assemblage, presumably due to the large amount of drift algae deposited on the beach from offshore kelp forests (Dugan et al. 2000), and attracts a diverse and abundant shorebird community. The Southern Pacific Coast Regional Shorebird Plan considers Coal Oil Point an important area for shorebirds (Page and Schuford 2000).

With an assistant, I conducted weekly shoreline surveys from January 1999 to January 2000 along the beach between 10 A.M. and 2 P.M. The survey transect was established to cover a recent (1999) US Fish and Wildlife Service designation of western snowy plover critical habitat. I divided the study area into 11 sectors based on landmarks, property boundaries and existing transects. We noted the weather and tide conditions at the start of the survey and collected beach profile data at each sector. For each sector, we counted the number of feeding and non-feeding birds (all species), as well as other animals and humans using the beach. We only counted birds if they interacted with the habitat. Usually, this meant that the bird was on the beach. We did not count birds that flew over-head with the exception of raptors which we counted if they were in clear view of the beach (due to their potential to disturb). We moved rapidly enough so that the chance of double counting was low. Nonetheless, it was possible to record people or birds in more than one transect or to miss them entirely.

We also recorded disturbances that clearly caused birds to fly or move. We actively avoided disturbing birds and when birds reacted to us we did not record the event as a disturbance. Disturbance agents were classified according to type, behavior, distance from bird(s) and location on the beach. Disturbed birds were classified according to species, behavior prior to disturbance, number of birds and response. Survey dates alternated between weekends and weekdays.

Depending on the comparison made, I analyzed data using Pearson's or Spearman correlation coefficients, Fisher's exact test, Kruskal–Wallis, Multivariate repeated measures analysis of covariance (ANCOVA) and χ^2 2×2 contingency tables when the data met the assumptions of the test employed. Counts were standardized for sector length prior to analysis. All data were correlational so associations do not necessarily imply causal relationships among variables.

Results

13 881 birds representing 57 species were counted during 48 surveys. Figure 2 lists the species and shows the frequency and abundance of the most common species. Half of the birds observed were feeding. The western snowy plover, a federally threatened bird, was the most abundant species and represented 25% of the birds seen.

Bird abundances and density (Figure 2, Table 1) varied among seasons according to migration patterns, but did not vary significantly from weekend to weekday. Bird density also decreased marginally with tidal height and varied significantly, but inconsistently with temperature (Table 1). The density of birds varied significantly among sectors along the transect (Figure 3, Table 1). The birds were attracted to areas with exposed, rocky substrate (areas G–K, see Figures 1 and 3, had exposed rocks on some days; at these sites, the relative abundance of birds was positively associated with the percent of the beach profile that was exposed rock, $r = 0.61$, $n = 231$, $P < 0.01$). The proportion of rock substrate in these sectors was higher in the winter (due to sand removal by winter storms) and at low tide. Snowy plovers were not seen in the five sectors closest to the town of Isla Vista. Proximity to Isla Vista associated positively with crow ($r = 0.82$, $n = 10$, $P < 0.05$) and western gull abundance ($r = 0.71$, $n = 10$, $P < 0.05$). There were no indications that human activity reduced bird abundance at the scale of a sector. For example, the relative abundance of birds in a particular sector (i.e., the extent to which bird density deviated from the mean density at that sector) was not negatively associated with the amount of human activity in a sector (average $r = 0.09$, $n = 10$, $P > 0.05$).

During the average observation period there were 51 people along the transect (18 per kilometer). The average (and standard deviation) counts over the 48 dates were 31.8 (29.8) people walking or jogging,18.9 (25.0) sitting, 4.8 (4.4) dogs and 0.2 (0.9) horses. Other potential disturbance agents included 7.6 (8.7) crows and 0.2 (0.5) raptors. People were evenly distributed throughout the transect except for a high

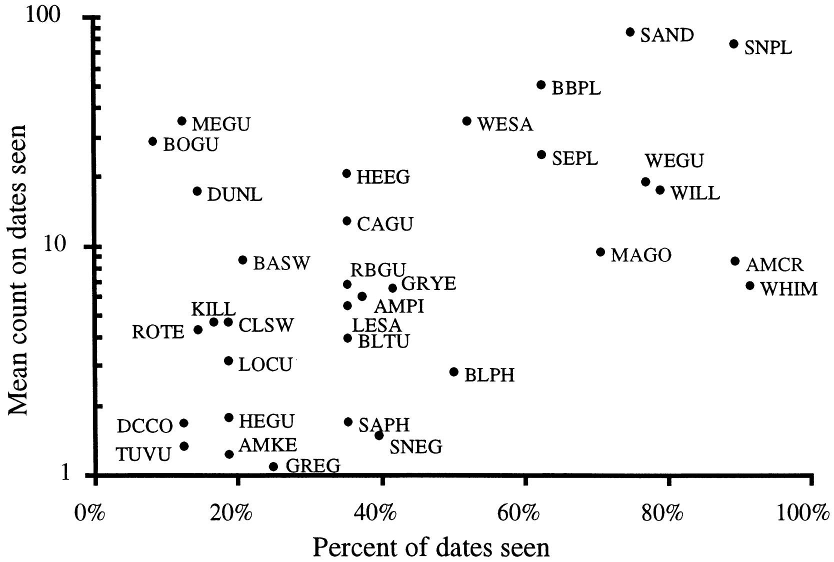

Figure 2. Frequency and abundance of common bird species. Species abbreviations (from the English) as per Klimkiewicz and Robbins (1978) listed below by feeding guild. Common shorebirds were: whimbrel (WHIM), western snowy plover (SNPL), willet (WILL), sanderling (SAND), marbled godwit (MAGO), semipalmated plover (SEPL), black-bellied plover (BBPL), western sandpiper (WESA), greater yellowlegs (GRYE), American pipit (AMPI), least sandpiper (LESA), black turnstone (BLTU), long-billed curlew (LOCU), killdeer (KILL), and dunlin (DUNL). Shorebirds seen but not plotted were: surfbird, spotted sandpiper, ruddy turnstone, long-billed dowitcher, American avocet and wandering tattler. Common gulls and terns were: western gull (WEGU), Heerman's gull (HEEG), California gull (CAGU), ring-billed gull (RBGU), royal tern (ROTE), mew gull (MEGU), and Bonaparte's gull (BOGU). Gulls and terns seen but not plotted were: least tern, Forster's tern and Caspian tern. Common 'Misc piscivores' were: snowy egret (SNEG), great egret (GREG), double-crested cormorant (DCCO). Misc. piscivores seen but not plotted were: brown pelican, green heron, common merganser and great blue heron. Common land birds were: American crow (AMCR), American pipit (AMPI), Say's phoebe (SAPH), barn swallow (BASW), cliff swallow (CLSW), American kestrel (AMKE), turkey vulture (TUVU). Land birds seen but not plotted were: white-tailed kite, merlin, western kingbird, loggerhead shrike, European starling, white-crowned sparrow, Cooper's hawk, red-shouldered hawk, and violet green swallow. Waterfowl seen but not plotted were: Canada goose and brant.

Table 1. Multivariate repeated measures analysis of bird density. Sectors, not dates, were used as repeated measures since the same tide, temperature, season and weekend designation affected all sectors within a given date.

Source	Wilk's λ	*F*	df	*P*
Sector	0.38	4.41	10, 27	0.0010
Season	0.11	2.89	30, 79	0.0001
Weekend	0.59	1.86	10, 27	0.0975
Season ∗ weekend	0.14	2.59	30, 79	0.0004
Temperature	0.37	4.65	10, 27	0.0007
Tide	0.55	2.20	10, 27	0.0505

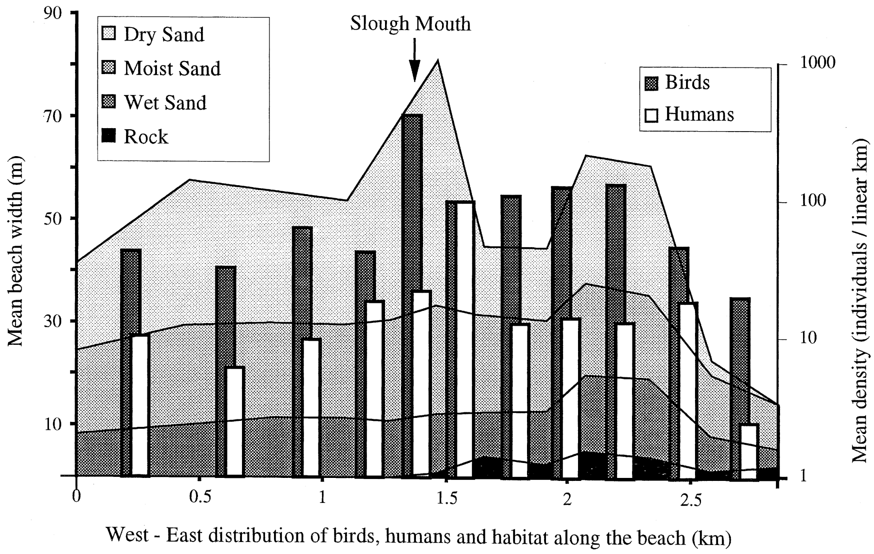

Figure 3. Beach width, substrate type and density of birds and humans along the transect.

density at a sunbathing area in the middle of the transect (F) and a low density at the most eastern sector (K, east of the Camino Majorca Stairs) which was often narrow or covered by water (Figure 3). Not surprisingly, human activity (Figure 4, Table 2) was substantially higher on weekends.

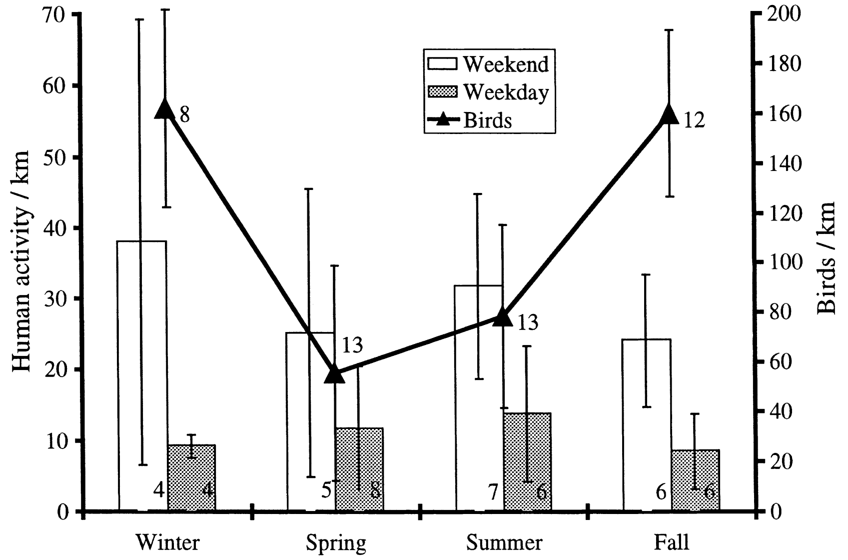

Figure 4. Seasonal variation in beach use by humans and birds (includes all bird species). Sample size included in bar or next to point. Weekend effect for birds removed for simplicity. Error bars indicate 95% confidence intervals. Averages were based on a weekly 2.85 km beach transect. See Tables 1 and 2.

Table 2. Multivariate repeated measures analysis of human density. See Table 1.

Source	Wilk's λ	F	df	P
Sector	0.84	0.51	10, 27	0.8675
Season	0.47	0.78	30, 79	0.7796
Weekend	0.46	3.13	10, 27	0.0088
Season ∗ weekend	0.47	0.79	30, 79	0.7676
Temperature	0.82	0.59	10, 27	0.8014
Tide	0.88	0.94	10, 27	0.9427

During the 2–10 min we observed them, 10% the people disturbed an average of 10 birds each (of which about 7 flew). Joggers, which were less abundant than walkers, had the same probability of disturbing birds but disturbed twice as many birds per disturbing person (Table 3). Walkers, on the other hand, were more often in groups so that there was, on average, no difference between the number of birds disturbed by a walking event or a jogging event. People not moving along the beach were much less likely to disturb birds and, when they did, they disturbed far fewer birds. Most disturbances occurred when a disturber was within 20 m of a bird (Figure 5).

On average, there were 11 dogs to every 100 people, for an average density of 2 dogs per km. Due to the increased amount of human activity on the weekends, dog abundance was more than twice as high on weekends (8) as on weekdays (3) (t-test, $P < 0.005$). Thirty-nine percent of dogs observed disturbed 22 birds each, 75% of which flew (Table 4). Leashing reduced both the probability that a dog disturbed birds (2×2 $\chi^2 = 5.1$, Fisher's exact test, (1 tailed) $P = 0.018$) and the number of birds per disturbance (Table 4). However, only 7% of pets were leashed. About 9% of dogs chased birds during the brief observation period. Not surprisingly, dogs that chased

Table 3. Disturbance to shorebirds by people. Disturbance was defined as causing a bird to move or fly. Activity corresponds to the total counts described as means in the Results. '% that disturb' was based on a 2–10 min observation period and was thus an underestimate of what a person disturbed during their entire time on the beach. Disturbers were divided into walkers, joggers and bike riders. A disturbance event could be caused by more than one disturber, e.g., two joggers, so data were divided accordingly. 'Birds/disturbance' was the number of birds disturbed per event. 'Birds/disturber' was the number of birds disturbed per human that was involved in a disturbance. Standard deviations were not calculated for the latter because of the difficulty in assigning disturbed birds to individuals in a group of disturbers. Aircraft were present, but were not recorded. They did not cause disturbances in this study.

	Walk	Jog	Still/Play	Bike	Total
Activity (n)	1524		907	–	2431
Disturbed (%)	16		0.4	–	10
No of events, No of disturbers	128, 201	109, 127	4, 7	8, 11	259, 346
No of disturbed birds	2272	3160	16	104	5552
Birds/disturbance (SD)	17.8 (27.3)	29.0 (63.8)	4 (5.3)	13 (4.8)	22 (46.7)
Birds disturbed/disturber	11.3	24.9	2.2	9.4	16
Disturbed birds that flew (%)	62	84	81	88	74

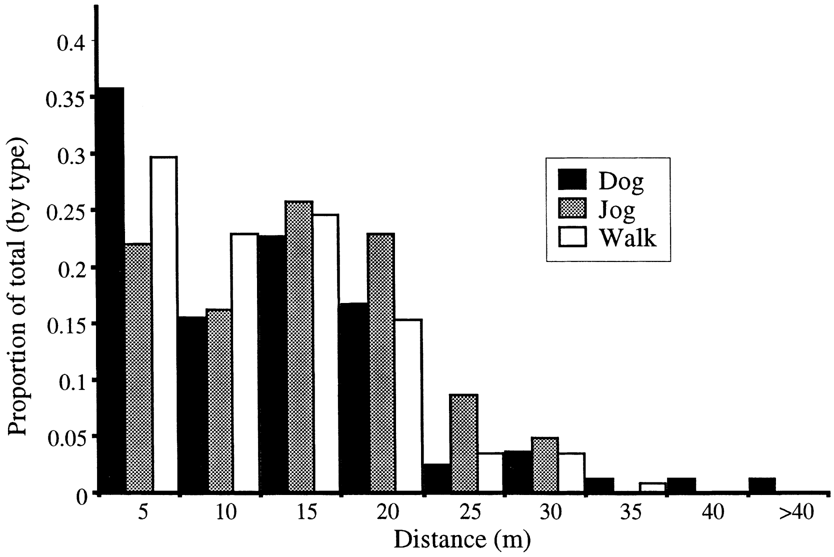

Figure 5. Relative frequency distribution of distances between birds that were disturbed and the disturbing agent. Each disturbance type sums to one. See Tables 3 and 4 for the relative abundance of the disturbance agents.

birds were significantly more likely to disturb birds than were unleashed dogs that did not chase birds ($2 \times 2\ \chi^2 = 41$, $P < 0.0001$). Although dogs that chased birds disturbed a greater number of birds per event than unleashed dogs that did not chase, this difference was not statistically significant.

There was substantial variation among bird species in the proportion of individuals that were disturbed (Figure 6). Neither size of bird, guild (e.g., gull, shorebird, piscivore), frequency of occurrence or density had an effect on the proportion of individuals of a particular species that was disturbed (Multiple regression with all $P > 0.05$). A smaller proportion of land birds (10%) was disturbed than other birds (59%) ($n_1 = 33$ of the most common species, Mann–Whitney $U = 143$, $P = 0.022$). Although a higher proportion of aquatic bird species that frequented the water's edge

Table 4. Disturbance to shorebirds by dogs. See Table 3 for explanation. All chasing dogs were unleashed but were not included in the unleashed totals.

	Leashed	Unleashed	Chasing	Total
Activity (total *n*, see Table 3)	18	221	25	264
Disturbed (%)	11	34	100	39
No. of events, No. of disturbers	2, 2	61, 75	25, 25	88, 102
No. of disturbed birds	11	1329	727	2229
Birds/disturbance (SD)	5.5 (6.3)	22.5 (40.9)	29.1 (38.8)	24.2 (39.2)
Birds/disturber	5.5	18.3	29.1	21.9
Disturbed birds that flew (%)	100	76	81	72

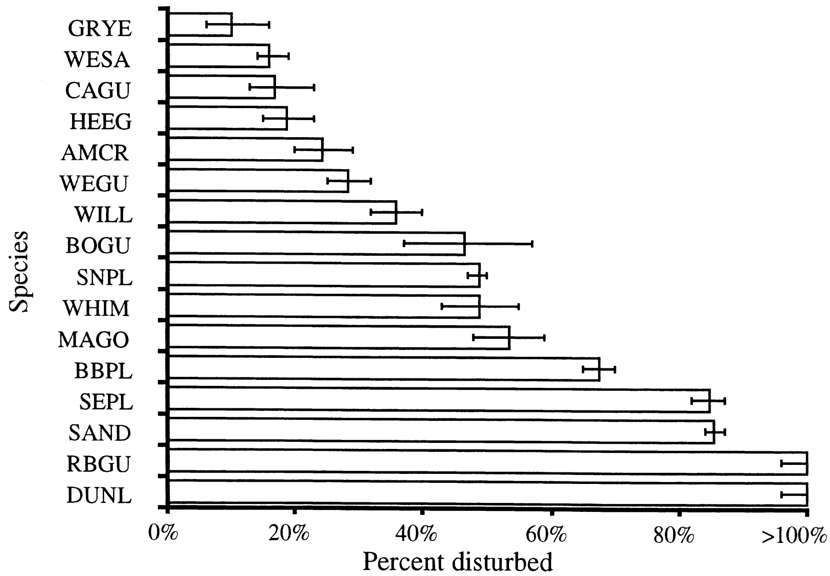

Figure 6. Variation in disturbance among the most common aquatic birds. Data were pooled over all survey dates. Bars are 95% confidence intervals around the percentage for the pooled data. Abbreviations as per Figure 1.

were disturbed (78%) than aquatic birds that were more typically found on the dry sand (19%), this was not significantly different, perhaps due to low sample size ($n_2 = 26$ of the most common aquatic species, Mann–Whitney $U = 29.5$, $P = 0.08$). There was a non-random distribution of the locations (dry sand, moist sand, saturated sand or rock, $\chi^2 = 6032$, df = 3, $P < 0.0001$) of disturbances (number of disturbed birds) indicating that disturbances were concentrated in moist and saturated sand (Figure 7). The same pattern was evident for disturbance events and disturbers. These results were likely due to the easily observable pattern that more humans and birds (except snowy plovers) were on the lower beach (though these data were not specifically taken for humans unless a disturbance occurred).

The proportion of birds disturbed increased with the amount of activity in each beach sector (Spearman $\rho = 0.41$, $n = 366$, $P < 0.01$). The average distance that birds reacted to humans increased with the proportion of birds that were disturbed on a particular day ($r = 0.49$, $n = 37$, $P < 0.01$), suggesting disturbance sensitized birds. In contrast, the distance that birds reacted to dogs was independent of the amount of disturbance on a particular date ($r = -0.03$, $n = 37$, $P > 0.05$). The proportion of all birds feeding did not decline significantly with increased disturbance rates ($r = -0.18$, $n = 45$, $P > 0.05$) or with increased beach activity ($r = -0.14$, $n = 45$, $P > 0.05$), although for some common bird species (black-bellied plover, $r = -0.47$, $n = 27$ and willet, $r = -0.42$, $n = 21$) the association between disturbance and feeding was stronger.

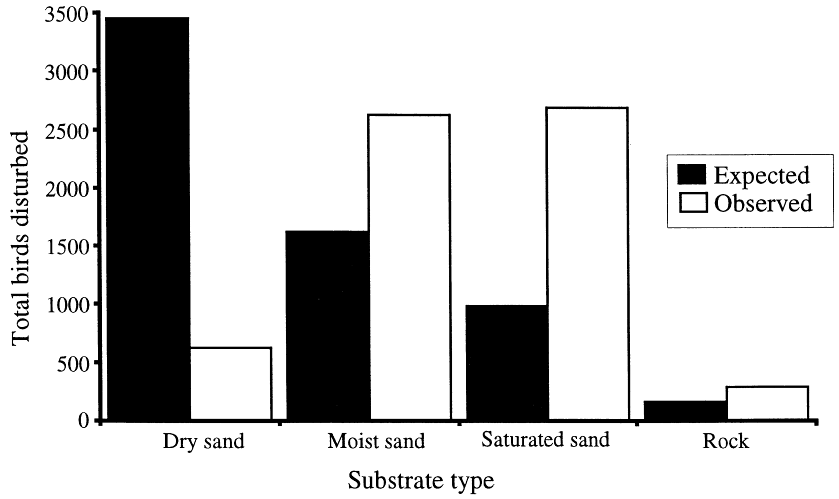

Figure 7. Location of disturbances among substrate type (observed) relative to available substrate type (expected). Expected values for each substrate type are the total number of disturbed birds times the proportion of a particular substrate type recorded for the beach (averaged over all dates). People and birds were generally lower on the beach (moist and saturated), with the exception of a sunbathing area, where most of the people were on the dry sand. The departure from expected, therefore, is most likely because people and birds did not use the habitat evenly (because we did not record habitat use, I could not evaluate this quantitatively).

When averaged over the course of the year, there was no association between the spatial distribution of birds and the spatial distribution of people along the transect ($r = 0.12$, $n = 11$, $P > 0.05$). Although disturbed birds always moved away from the activity that disturbed them (see also Smit and Visser 1993), an analysis of the distribution of birds among sectors and dates did not reveal that birds increasingly occupied less populated sectors as overall beach activity increased ($r = 0.0$, $n = 45$, $P > 0.05$), a trend that was consistent for all common species. This was true for an independent study of snowy plovers which found that plovers did not find more isolated locations to roost as human activity increased from the early morning to the afternoon (Lafferty 2001).

Discussion

Large-scale seasonal variation and habitat features such as a lagoon and rocky intertidal area determined the distribution of birds at Coal Oil Point. Work/school schedules influenced patterns of human activity within the study area. Although people disturbed birds, their presence did not significantly alter the large-scale distribution of birds. Disturbances were frequent and varied according to the type of human activity. Birds were particularly sensitive to dogs. Most disturbances occurred on the wet sand, the area where many birds fed and humans walked and jogged.

Distribution

At Coal Oil Point, a lagoon mouth (Devereux Slough) in the center of the transect (sector E) attracted birds around its margin (and snowy plovers that roosted on the dry sand of the delta) and a rocky point provided rich foraging habitat at low tide for many species, especially in the winter where rocks were exposed. Crows and western gulls may have been more common near the college student community of Isla Vista because these species will feed on garbage (Ward and Low 1997). The change in sector use with season by birds was most likely due to the fact that rock was more exposed at the eastern sectors in the winter and due to the lower abundance of snowy plovers (the species with the highest site fidelity to the lagoon mouth) in the summer months.

The weekday–weekend effect was the main factor determining human density. Unfortunately, due to the several day spaces between counts, I could not determine whether bird densities along the transect actually declined in response to weekend activity. In comparison to birds, spatial variation in how people used the site was relatively low except for high numbers of people sunbathing at a sector called Sands Beach, particularly on weekends (the spatial distribution of people in the water was strongly influenced by two surfing areas – we did not count surfers if they were in the water). Although one might expect summer beach crowds, winter months had as much activity, presumably due to good winter surfing conditions, overcast summer weather and the fact that many students were away during summer break.

The lack of an association between the spatial distribution of birds and the spatial distribution of people along the transect suggests that habitat features may be more important in determining the distribution of birds than human activity, at least at the spatial scale at which I divided the transects into sectors. When disturbed birds moved, they did not often move out of the sector where they were disturbed, making the effect of disturbance on displacement difficult to detect on the scale of a sector. This is consistent with McCrary and Pierson (2000) who did not see an effect of human activity on shorebird abundance when they limited their analysis to a particular beach; only when they compared human and bird use among beaches did they see a negative association. Burger (1986) also saw an effect of disturbance on bird distribution when comparing sites at large spatial scales.

Disturbance

Fitness impacts to birds from single acts of disturbance are difficult to assess (Burger 1986), except for nesting birds, which may suffer dramatically from a single event. Along this stretch of beach it was clear that each bird was disturbed, on average, dozens of times per day. Such disturbances may come at the expense of feeding and rest for species that are making energetically demanding migrations (Nudds and Bryant 2000). The lack of an association between feeding (for most birds) and human activity contrasts with the results of Burger and Gochfeld (1991) who found that human activity altered foraging rates of sanderlings, underscoring that species specific differences (as seen in this study) may be important in this regard (Burger and Gochfeld 1998). That birds reacted to humans at a greater distance on days where the risk of getting disturbed was high suggests that birds can be hypersensitized to humans. It is also interesting that birds changed their sensitivity to humans but not to dogs, perhaps because being chased always gives birds a valid concern about the presence of dogs. These data differ from Fitzpatrick and Bouchez' (1998) observation that shorebirds can become habituated to disturbance. This might be because habituation may require predictable patterns of human activity which birds can learn pose no threat to them (Burger 1989; Burger and Gochfeld 1991). At Coal Oil Point, human activity is neither predictable nor inconsequential for birds. Other factors shown to increase sensitivity of birds, but not investigated here, include time of day (Burger and Gochfeld 1991), watercraft (Burger 1998), noise levels (Burger and Gochfeld 1998) and location to location variation (Burger 1986; McCrary and Pierson 2000).

Dogs disturbed birds disproportionate to their numbers due to the tendency for some dogs to chase birds and the possibility that some birds, such as snowy plovers, are more sensitive to dogs than humans (Lafferty 2001). The observation of 11 dogs to every 100 people was slightly less than the 15 dogs per 100 people observed at 13 Ventura County beaches (40 miles south of the study), where three beaches had over 30 dogs per 100 people (McCrary and Pierson 2000). Although the countywide leash law was posted at the main beach entrance, this law was not enforced, explaining the near absence of compliance by dog owners.

The differential susceptibility among bird species to disturbance was partially explained by habitat use. Most disturbances occurred at the lower beach where many birds were foraging or resting and many people were walking or jogging. Birds that tended to roost (snowy plovers) or forage (whimbrel) in the upper beach were less frequently disturbed. This is best explained by the likelihood of a disturbance greatly increasing as the distance between the disturber and the bird decreases. Fitzpatrick and Bouchez (1998); Burger (1981) also note that different species responded differentially to disturbances. Fitzpatrick and Bouchez (1998) suggest that this relates to differences among species in cryptic plumage. Although it is not clear that plumage explains most of the variation seen in my study, such a pattern is consistent with the observation that snowy plovers rely on cryptic coloration and remaining motionless to avoid predators and were much more hesitant to fly (25%) from a disturbance relative to other species (75%).

Conservation

Given the high rates of disturbance and the resulting implications for shorebird conservation, what actions could reduce impacts? The main finding from this study is that the rate of disturbance at a particular location was primarily a function of: (1) the type, location and frequency of human activity and (2) the distribution, abundance and species composition of the bird community. Managing any of these factors could, therefore, reduce disturbance rates. One goal might be to minimize overlap between birds and humans by concentrating human activity away from preferred shorebird habitat (such as lagoon and rocky intertidal areas). Possible management actions to accomplish this might include the strategic distribution of parking lots and beach-access points. Where birds and humans do overlap, reducing the frequency of high-impact activity, such as unleashed pets, could also substantially reduce disturbance. Changing human behavior is likely to be a challenge, requiring sustained efforts of education, notification and enforcement.

Although little is presently done specifically to protect shorebirds, the guiding land-use document for coastal California, The California Coastal Act, acknowledges the need to 'regulate the time, place and manner of public access' to protect the 'fragility of the natural resources in the area' (California Public Resources Code Section 30214(a3)). This goal is consistent with the Southern Pacific Coast Regional Shorebird Plan that proposes limiting human disturbance to shorebirds and, in particular, restricting dogs from beaches with important shorebird habitat and leashing dogs on all other beaches (Page and Shuford 2000). As conflicts between wildlife and human recreation become more acute, coastal policy, planning and implementation may benefit from studies such as this.

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