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Evidence that human disturbance reduces Snowy Plover chick survival

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ABSTRACT. Disturbance from human recreation may impact vulnerable life stages of beach-nesting plovers (*Charadrius* spp.). Although human recreation may decrease hatching success of Snowy Plovers (*C. alexandrinus*), we are unaware of any studies indicating an impact on chick survival. We tested whether the rate of chick loss in a breeding population of Snowy Plovers was lower on weekdays than on weekends and holidays, when beach visitation increases in most coastal areas. We used data collected on chick survival and the timing of chick loss in 1999 and 2000 at Point Reyes National Seashore, California. Observed weekend and holiday chick loss was 72% greater than expected in 1999 and 69% greater than expected in 2000. This suggests that increased human recreation on Point Reyes beaches over weekends and holidays negatively affected Snowy Plover chick survival.

SINOPSIS. **Evidencia que el disturbio por parte de humanos reduce la sobrevivencia de pichones de *Charadrius alexandrinus***

El disturbio por parte de humanos puede impactar etapas vulnerables del ciclo de vida de playeros que anidan en playas (*Charadrius* spp.). Aunque la recreación humana puede disminuir el éxito de eclosionamiento del playero *Charadrius alexandrinus*, desconocíamos de estudios que indicaran el impacto en la supervivencia de los pichones. Pusimos a pruebas si la tasa de pérdida de pichones en una población de los playeros mencionados era menor durante los dias de la semana en comparación con el fin de semana y los dias feriados, cuando incrementa la frecuencia de visitas por humanos a áreas costaneras. Utilizamos datos tomados sobre la sobrevivencia de pichones y el tiempo en que ocurrió la pérdida durante un estudio llevado a cabo en 1999 y 2000 en Point Reyes, California. La pérdida de pichones fue un 72% y un 69% mayor, que lo esperado, para los años 1999 y 2000, respectivamente. Esto sugiere que el incremento en la recreación de humanos, durante los fines de semanas y dias feriados en Point Reyes, afecta negativamente la sobrevivencia de *C. alexandrinus*.

Key words: beaches, *Charadrius alexandrinus*, chick survival, human disturbance, shorebird, Snowy Plover

A decline in the size of the U.S. Pacific Coast population of the Snowy Plover (*Charadrius alexandrinus*) has been attributed to several factors including increased recreational use of their coastal habitat (Page et al. 1995). Human recreational activities could contribute to population changes by affecting hatching rate, fledging rate, and/or adult or juvenile survival rates. Human disturbance has been shown to affect hatching rates in various plover species (Buick and Paton 1989; Strauss 1990; Dowling and Weston 1999). Studies of Piping Plovers (*C. melodus*) and Hooded Plovers (*Thinornis rubricollis*) have linked lower chick survival to human disturbance (Flemming et al. 1988; Strauss 1990; Dowling and Weston 1999). While there is evidence that human recreational activities can decrease hatching rates of *C. alexandrinus* (Warriner et al. 1986; Schulz and Stock 1991), there have been no studies of their impact on chick survival.

Since 1996, most Snowy Plover nests at Point Reyes National Seashore, California (the Seashore) have been protected from predators and people using fencing (exclosures). However, chicks leave the exclosures within hours of hatching, and are then exposed to human disturbance and predators for about a month before they begin to fly. After noting that plovers often lost chicks over weekends or holidays from 1996 to 1998, we initiated this two-year study to determine if chicks were more likely to disappear on weekends and holidays—when more people visit beaches.

STUDY AREA AND METHODS

Our study occurred on Point Reyes and Limantour beaches in Point Reyes National Seashore, Marin County, California. Both beaches are federally designated wilderness areas where

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motorized vehicles are prohibited, but pedestrian use is allowed. In addition to leash laws in all areas of the Seashore, year-round or seasonal restrictions prohibit dogs on beaches where plovers nest; however, violations are common. Both beaches are less than a 2-h drive from the San Francisco Bay Area. The Seashore's main visitor center receives an estimated 2.4 million visitors annually; however, no data accurately sampling weekday versus weekend Seashore beach visitation were available until 2002. When polled with a written survey in 2000, all seven National Park Service rangers who regularly patrol the Seashore beaches responded that visitation during summer months was higher on weekends and holidays than on weekdays. They estimated that visitor numbers were from 3 to 50 (median = 4) times higher on weekends and holidays than on weekdays. In 2002, a traffic counter was set up on one of the access roads to the main nesting beach at the Seashore. Over 15 wks (corresponding to the chick-rearing period), 84.3 (±8.5 SE) cars/day entered the parking lot on weekdays, compared to 408.6 (±39.0 SE) cars/day on weekends and holidays; for those 15 wks, the weekend/holiday to weekday ratio of cars/day averaged 5.0:1 (±0.36 SE, minimum 3.2:1, maximum 9.3:1).

The climate of the Point Reyes area is Mediterranean, with spring and summer days characteristically cool, dry, and either calm and foggy or windy and clear. The National Oceanic and Atmospheric Administration collects hourly temperatures and wind speed at 10-min intervals at buoy #46013 in the Point Reyes area. For the dates on which chicks were extant on the Seashore, the daily mean temperatures in 1999 averaged 11.39°C (±0.16 SE, $N = 91$ days) on weekdays and 11.26°C (±0.25 SE, $N = 39$ days) on weekends and holidays, and in 2000 averaged 11.83°C (±0.08 SE, $N = 86$ days) on weekdays and 11.62°C (±0.09 SE, $N = 37$ days) on weekends and holidays. On those same days, mean daily wind speed in 1999 averaged 6.79 m/s (±0.42 SE) on weekdays and 7.63 m/s (±0.64 SE) on weekends and holidays, and in 2000 averaged 7.26 m/s (±0.44 SE) on weekdays and 7.88 m/s (±0.56 SE) on weekends and holidays. Similarly, weekday daily maximum wind speeds and temperatures were not different from weekends and holidays in either year.

Point Reyes Beach is a sandy, 18.0-km long, west-facing, dune- and cliff-backed beach. Non-native European beach grass (*Ammophila arenaria*) forms densely vegetated, steep foredunes along much of its length. Upper beach width varies from 20–250 m depending on the time of year and location. Snowy Plovers once nested on the entire length of Point Reyes Beach, but since at least 1995 they have occurred only along the northernmost 8.7 km, where there are three access points with parking 0.0 km, 2.7 km, and 0.9 km from the beach. Limantour Beach is a 4.0-km long, south-facing, dune-covered sand spit with large overwash areas toward the tip at the western end, and a solid foredune of *A. arenaria* to the east; access is at the east end. Because of tidal inundation, beach erosion, and encroachment by *A. arenaria*, the extent of nesting area for Snowy Plovers was limited on Limantour Beach during the study.

Upper beach areas where we found pairs of plovers or scrapes (shallow depressions dug in the sand by males courting females) were roped off from the public and informative signs were posted. While roped areas, ranging from 20 m wide × 50 m long to 200 m wide × 250 m long depending on beach width, were installed to protect nest habitat from foot traffic, they sometimes were also utilized by plovers with broods. As a protection against predators, we also enclosed each nest within a 3.3 m × 3.3 m square fence made of 5.1 cm × 10.2 cm welded 14-gauge wire, and covered the top with twine strings spaced every 15 cm. We checked nests from a distance of 50 m to 100 m every 1–4 d and every 1–3 d near the projected hatching date. When we did not observe chicks within an exclosure or a parent carrying eggshells from a nest, we estimated hatching dates from egg-laying dates. We included all chicks that hatched in our analysis.

Although we did not mark plovers, we were easily able to keep track of individual broods because the number of broods was small and observations were frequent. Additionally, breeders included color-banded birds from other study sites, many adults had distinctive plumage, and broods could often be identified by chick size. To determine when chicks were lost, we checked broods before and after every weekend and holiday. We also sighted broods opportunistically during weekday and weekend

Table 1. Percent of observed and expected Snowy Plover chick loss during weekends/holidays and weekdays at Point Reyes National Seashore, California. Expected rates are based on the daily total number of chicks present on all weekdays and weekend/holiday days. Half of Fridays are counted as weekend/holiday days.

	Percent of chick loss				
	Weekends/holidays		Weekdays		Number of chicks lost
Year	Observed	Expected	Observed	Expected	
1999	66.7	38.7	33.3	61.3	18
2000	63.0	37.2	37.0	62.8	27

periods. To find chicks, we walked below the high tide line and stopped every 50 m–100 m to scan ahead and also scanned all known brood-rearing areas thoroughly. When plovers were located, we observed parental behavior from a stationary position 100 m to 200 m away for up to 45 min for clues on chick location and number of chicks. In all cases, we were able to locate and identify the adult(s) tending each brood, and on several occasions we observed courtship and nest initiation behavior upon loss of the last chick(s) of a brood. Chicks were monitored until they were 28 d old, or until they were determined lost. A loss event was defined as one or more chicks disappearing from a brood between consecutive checks. The time of loss was estimated to the nearest hour, as the midpoint between the two brood checks bracketing a loss event. We had no cases in which chicks that were determined to be lost were later found alive, although on three of the 214 brood checks made over the two years we had to abort a check due to disturbance from nearby beach visitors. For those cases we returned on a following day to observe the brood; no chicks were lost on these checks.

We estimated the relative exposure of chicks on weekends/holidays versus weekdays. To account for the differing number of mid-week and weekend/holiday days and the varying number of chicks on different days, we estimated chick exposure (CE). CE was calculated by summing separately the daily total number of chicks on the beach over weekends/holidays and over weekdays for the entire breeding season. Because we generally searched for chicks before the weekend on Friday mornings, we included half of all Friday CE in the weekend/holiday sum and half in the weekday sum. Under the null hypothesis, that chick loss on weekends and holidays does not differ from chick loss on weekdays, we calculated expected losses on weekdays and weekends/holidays based on relative CE (Table 1). All chi-square tests used were continuity-corrected, with a rejection probability of $\alpha = 0.05$.

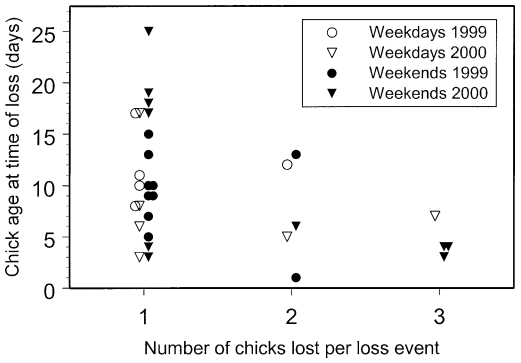

Fig. 1. Snowy Plover chick age at the time of loss, and the number of chicks lost, for 15 loss events in 1999 and 17 loss events in 2000 at Point Reyes National Seashore, California.

RESULTS

On Point Reyes and Limantour beaches, 20 adults nested in 1999 (nine females and 11 males) and 31–37 in 2000 (17–18 females and 14–19 males). Eighty-three chicks hatched (42 in 1999 and 41 in 2000) from 30 of the total 49 clutches during the two seasons; of these, 38 fledged. The hatch dates were random with respect to day of the week; 19 clutches hatched between Monday and Thursday and 11 hatched between Friday and Sunday ($\chi^2_1 = 0.47$, $P = 0.50$). Most chicks that were lost disappeared within 14 d of hatching (88.9% in 1999 and 81.5% in 2000; Fig. 1). We found no difference in chick age at the time of loss between 12 weekday and 20 weekend/holiday events (comparing ages less and greater than 8.5 days, $\chi^2_1 = 0.13$, $P = 0.71$; Fig. 1).

The majority of loss events involved only one chick per brood, 72% of 32 loss events equaling 23 of the 45 chicks lost (Fig. 1). No entire broods disappeared in single-loss events in 1999; but in 2000, four broods, all seven days or younger in age, disappeared in single-loss events. This, in part, was responsible for the threefold increase in the percent of chicks lost within the first seven days of hatching between 1999 (22.2%) and 2000 (77.8%). Estimated chick age at the time of loss spanned 3 to 25 (median = 9.6) d when only one chick was lost between checks, and from 1 to 13 d (median = 6.0) when two chicks were lost (Fig. 1).

In 1999, there were 319 weekend/holiday CE days versus 505 on weekdays and in 2000, 216 weekend/holiday CE days versus 364 on weekdays. Observed weekend/holiday chick loss was 72% greater than expected in 1999 and 69% greater in 2000 ($\chi^2_1 = 11.7$ for combined years, $P < 0.001$, Table 1).

The chick loss rate (i.e., the number of chicks lost per CE) in 2000 was over twice that in 1999. On weekends and holidays 0.038 chicks were lost/CE in 1999 and 0.079 in 2000. On weekdays 0.012 chicks were lost/CE in 1999 and 0.027 in 2000. Thus, in both years the number of chicks lost, relative to CE, was about three times greater on weekends and holidays than on weekdays.

DISCUSSION

Greater than expected rates of chick loss on weekends/holidays suggest that human use of beaches influenced Snowy Plover chick survival. Other plovers also are similarly affected by human disturbance. In Australia, chick-fledging rates of Hooded Plovers were significantly higher at sites where public access was restricted and dogs prohibited, compared to nearby beaches with no limits on human recreational activities or dog restrictions (Dowling and Weston 1999). Comparisons between sites with high and low levels of human recreation showed that high-level sites have lower Piping Plover chick survival rates (Flemming et al. 1988; Strauss 1990; Goldin and Regosin 1998).

It is difficult to determine how human use of beaches adversely affects chick survival because it is rare to witness chick loss or to find direct evidence of mortality. Plover chicks of various species have been stepped on, killed by dogs and cats, and run over by vehicles (Strauss 1990; Yalden and Yalden 1990; Keedwell 2001; PRBO, unpubl. data), but we did not observe any of these events during our study.

Humans also may adversely affect plover chicks in other ways. When adults and chicks react to humans by shifting behavior from foraging and brooding to crouching or vigilance (Flemming et al. 1988; Strauss 1990; Hoopes 1993; Goldin 1993), chicks may be subjected to reduced parental brooding, limited foraging time, and increased exposure to predators or inclement weather (Flemming et al. 1988; Strauss 1990; Yalden and Yalden 1990). Although we observed plover broods changing their behavior from resting, brooding, or foraging to running, calling, and standing alert in response to human disturbance, we did not systematically study disturbance and, thus, cannot make any statistical inferences about Snowy Plover responses.

Human activity may also cause brood movement (Flemming et al. 1988; Strauss 1990), resulting in the separation of one or more chicks from the rest of the brood. Broods may be forced into less suitable habitat, thereby negatively affecting chick growth rates and survival (Yalden and Yalden 1990; Loegering and Fraser 1995). Movement into adjacent territories can result in attacks on the young by other adult plovers, resulting in chick death and abandonment (Warriner et al. 1986; Yalden and Yalden 1990). Snowy Plover broods moved up to 2.5 km in the study area, but we were unable to determine whether disturbance or other factors caused the broods to move.

Although the direct causes of chick loss in this study eluded us, greater rates of chick loss on weekends and holidays than weekdays suggest human activities were a factor. More information is needed on how human recreation contributes to chick mortality in plovers so that appropriate management actions can be developed to reduce human-induced chick loss.

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LITERATURE CITED

BUICK, A. M., AND D. C. PATON. 1989. Impact of off-road vehicles on the nesting success of Hooded Plovers *Charadrius rubricollis* in the Coorong region of South Australia. Emu 89: 159–172.

DOWLING, B., AND M. A. WESTON. 1999. Managing a breeding population of the Hooded Plover *Thinornis rubricollis* in a high-use recreational environment. Bird Conservation International 9: 253–270.

FLEMMING, S. P., R. D. CHIASSON, P. C. SMITH, P. J. AUSTIN-SMITH, AND R. P. BANCROFT. 1988. Piping Plover status in Nova Scotia related to its reproductive and behavioral response to human disturbance. Journal of Field Ornithology 59: 321–330.

GOLDIN, M. R. 1993. Effects of human disturbance and off-road vehicles on Piping Plover reproductive success and behavior at Breezy Point, Gateway National Recreation Area, New York. M.S. thesis. University of Massachusetts, Amherst, MA.

———, AND J. V. REGOSIN. 1998. Chick behavior, habitat use, and reproductive success of Piping Plovers at Goosewing Beach, Rhode Island. Journal of Field Ornithology 69: 228–234.

HOOPES, E. M. 1993. Relationships between human recreation and Piping Plover foraging ecology and chick survival. M.S. thesis. University of Massachusetts, Amherst, MA.

KEEDWELL, R. 2001. Evaluation of radio transmitters for measuring chick mortality in the Banded Dotterel. Waterbirds 24: 217–223.

LOEGERING, J. P., AND J. D. FRASER. 1995. Factors affecting Piping Plover chick survival in different brood-rearing habitats. Journal of Wildlife Management 59: 646–655.

PAGE, G. W., J. S. WARRINER, J. C. WARRINER, AND P. W. C. PATON. 1995. Snowy Plover (*Charadrius alexandrinus*). In: The birds of North America (A. Poole, and F. Gill, eds.), no. 154. Academy of Natural Sciences, PA, and American Ornithologists' Union, Washington D.C.

SCHULZ, R., AND M. STOCK. 1991. Kentish Plovers and tourists: competitors on sandy coasts. Wader Study Group Bulletin 68: 83–91.

STRAUSS, E. 1990. Reproductive success, life history patterns, and behavioral variation in a population of Piping Plovers subjected to human disturbance. Ph.D. dissertation. Tufts University, Boston, MA.

WARRINER, J. S., J. C. WARRINER, G. W. PAGE, AND L. E. STENZEL. 1986. Mating system and reproductive success of a small population of polygamous Snowy Plovers. Wilson Bulletin 98: 15–37.

YALDEN, P. E., AND D. W. YALDEN. 1990. Recreational disturbance of breeding Golden Plovers *Pluvialis apricarius*. Biological Conservation 51: 243–262.