Local and regional differences in habitat utilization by Dunlins *Calidris alpina* as revealed by radio-telemetry: conservation implications

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In northern California (USA), radio-tagged Dunlins demonstrated differences in habitat utilization on both local and regional levels. Causes for these differences may include temporal variability in availability of feeding and roosting habitat owing to changing tide levels or differing degrees of physical isolation of lagoons where Dunlins winter. Other factors, such as disturbance, predation and individual preference, may also contribute to the differences observed but are not discussed in this paper. The conservation of suitable wintering habitat for Dunlins and other shorebirds requires site-specific information on movement patterns of populations of birds. The use of radio-telemetry is one way to begin to gather these types of data.

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En el norte de California, EUA, las observaciones de alondras de mar a las que se habian colocado indicadores radioactivos indicaron diferencias en la utilizacion del habitat, tanto a nivel local como regional. Esas deferencias podrian obedecer a varias causas, tales como la variabilidad temporal en la disponibilidad de los habitats en que se alimentan y anidan debido a variaciones en los niveles de las mareas, o los diferentes grados de aislamiento fisico de las laguna en que inviernan las alondras de mar. Otros factores que pueden contribuir tambien a las deferencias observadas, tales como las perturbaciones, la depredacion y las preferencias individuales no se examinan en este articulo. La conservacion de los habitats apropiados para la invernacion de las alondras de mare y ontras aves de ribera requiere informacion acerca de los patrones de desplazamiento de las poblacionesd de aves en sitios especificos. El empleo de la radiotelemetria es un primer paso para comenzar a obtener esos tipos de datos.

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Dans le nord de la Californie, l'étude de Bécasseaux variables munis de radio-émetteurs a révéle des différences d'utilisation des habitats tant à l'échelle locale qu'à l'échelle régionale. Ces différences pourraient s'expliquer par la variabilité temporelle des habitats d'alimentation et de repos disponsibles selon les mouvements de la marée ou le degré variable d'isolement des lagunes où ils hivernent. D'autres facteurs, dont il n'est pas question ici — perturbations, prédation et préférences individuelles — peuvent aussi expliquer les différences observées. Pour assurer la conservation des habitats d'hivernage des Bécasseaux variables et d'autres espèces d'oiseaux de rivage, il faut disposer d'information sur les caractéristiques des déplacements des populations d'oiseaux pour des sites particuliers. L'utilisation de la radio-télémétrie semble un moyen d'y parvenir.

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Introduction

Within California, approximately 90% of wetlands have been destroyed, including 70% of coastal wetlands (Page *et al.* 1990). The effect of this habitat destruction on the distribution and abundance of shorebird populations is poorly understood (Goss-Custard 1979; Senner & Howe 1984; Smit, Lambeck & Wolff 1987; Howe, Geissler & Harrington 1989). Radio-telemetry has the potential to further our understanding of shorebird distribution patterns significantly (*e.g.* Wood 1986).

In this paper, I present preliminary data on movement patterns of radio-tagged Dunlins *Calidris alpina* at two study sites in northern California (Figure 1).

Study sites

The Bodega Harbor study site is a 320-ha lagoon on the north-central coast of California (for description, see Ruiz *et al.* 1989). The Bolinas Lagoon study site is a 570-ha lagoon approximately 50 km south-east of Bodega Harbor (for description, see Page, Stenzel & Wolfe 1979).

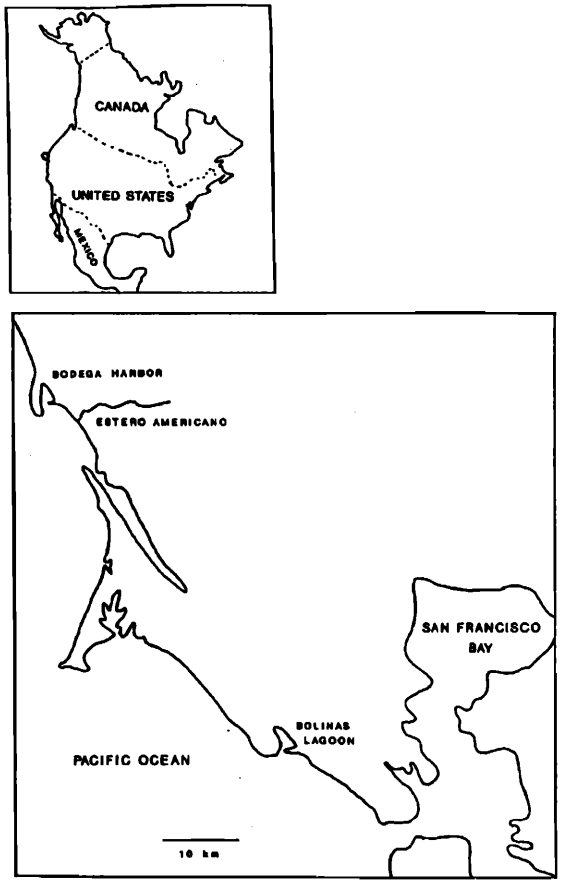

Figure 1. Study area, identified by circle on small map.

Methods

Bodega Bay

In December 1989, a preliminary radio-telemetry study was conducted at Bodega Bay. Four ~1.3-g radio-transmitters (Holohil Systems Ltd., 3387 Stonecrest Rd, Woodlawn, Ontario K0A 3M0, Canada) were glued to the upper backs of Dunlins with cyanoacrylate (Superglue®). Additionally, each bird was banded with a unique combination of colour bands and a numbered aluminium US Fish and Wildlife Service (USFWS) band and measured. These Dunlins were radio-tagged in mid-December and followed sporadically until the second week of January. Estuaries within a 50-km radius were checked for marked birds on an irregular basis.

Bolinas Lagoon

In January 1991, 10 Dunlins were outfitted with radio-transmitters and released at Bolinas Lagoon. Radio-transmitters were glued to the lower backs of the Dunlins just above the uropygial gland (see Hill and Talent 1990), using a waterproof epoxy (#332 Epoxy Adhesive, Titan Corp., 5629 208th St. SW, Lynnwood, WA 98036, USA) manufactured specifically for attaching radio-transmitters on birds. To reduce their visibility, each transmitter was coloured brown, and the trailing antenna was coloured a flat black. Additionally, each bird received a unique combination of colour bands and a USFWS band and was measured.

I attempted to locate all active radio-tagged birds approximately two times per day ($\bar{x}$ = 2.3 ± 1.1 times/day, range = 0–5, n = 29 days). Resighting efforts were concentrated within 3 km of Bolinas Lagoon.

Each radio-tagged Dunlin was recorded as roosting, foraging/moving or unknown. The signals from radio-tagged Dunlins that were moving/feeding were found to be erratic. These behaviours were confirmed with birds that were visually located. Birds were considered to be roosting if the radio signal remained steady between radio fixes or if the birds were visually located.

Data from the first two days after a tagged bird was released were not used except in calculating the total number of days the radio ran. Observations of the same individual within two hours of each other were not used in the analyses in order to ensure independence of observations. Frequency data were tested using Pearson's Chi Square test (STATA, Santa Monica, CA).

Tides between -0.6 and 0.0 m were classified as low tides; tides between +0.1 and +0.9 m as medium tides; and tides greater than 0.9 m as high tides.

Results

Bodega Bay

Of the four birds radio-tagged in Bodega Bay, two were killed by avian predators within seven days of being released. One bird was never detected again.

The fourth bird was followed for 14 days. On 21 December at 21:30, it was located roosting in a small *Salicornia* marsh in Bodega Harbor, and the next morning at 09:30 it was resighted midway up Estero Americano about 5 km from Bodega Harbor (Figure 1). This bird was relocated in Bodega Bay on 31 December, but not on three subsequent search days.

Bolinas Lagoon

The fates of ten Dunlins radio-tagged at Bolinas Lagoon were as follows. One bird was predated after two days; one bird was not seen after the first day; and two birds' radios fell off within the first six days. Data on behaviour and habitat use were collected on the remaining six Dunlins. The mean time that these radios emitted signals was 18.8 ± 4.1 days (range = 12–24 days).

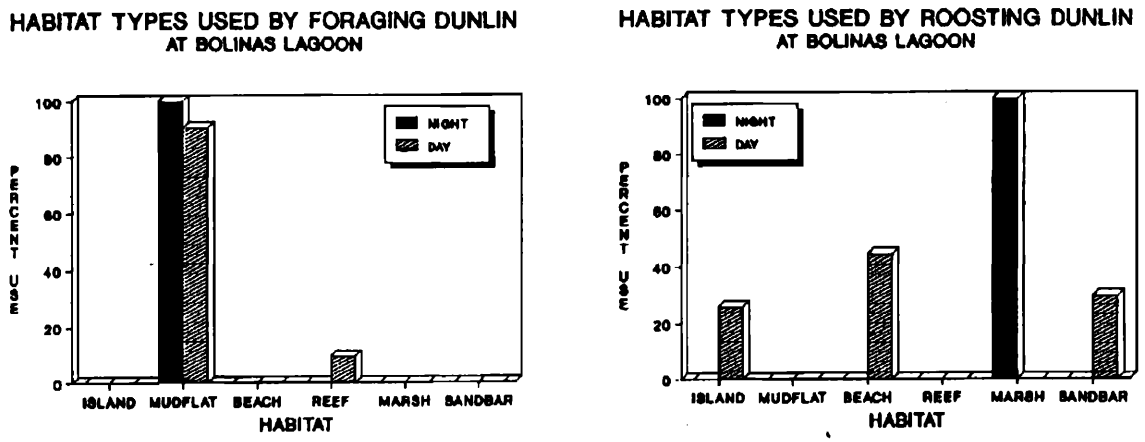

Figure 2. Habitat types used by radio-tagged Dunlins at Bolinas Lagoon according to behaviour (foraging and roosting) and time of day.

The radio-tagged Dunlins used different habitats within the area for different activities (χ^2 = 168.0, d.f. = 5, $p < 0.001$; see Figure 2). All locations for foraging radio-tagged Dunlins were at mudflats within Bolinas Lagoon (n = 107) and on an outer-coast reef 1 km north of the mouth of the lagoon (n = 7). Locations of roosting birds were at an island beach within the Bolinas Lagoon (n = 7), the outer-coast beach (n = 12), a sand-bar within the lagoon (n = 8) and a marsh also within the lagoon (n = 18).

Habitats used by foraging and roosting Dunlins in the Bolinas Lagoon area during the day differed significantly from habitats used during the night (χ^2 = 50.9, d.f. = 5, $p < 0.001$). Dunlins were located foraging on the mudflats during both the day (n = 67) and the night (n = 40) (Figure 2). They foraged on the outer-coast reef during the day (n = 7) but were never located there at night. Night-roosting Dunlins were located only in the marsh within Bolinas Lagoon (n = 18) (Figure 2). During the day, they roosted on the other sites (island beach, n = 7; coast beach, n = 12; sand-bar, n = 8).

Use of the different habitat types by roosting and foraging Dunlins varied significantly with the tide height (χ^2 = 93.6, d.f. = 10, $p < 0.001$) (Figure 3). The island, outer beach, marsh and sand-bar habitats were never used on low tides, whereas the outer-coast reef was used mainly on low tides. Mudflats were the habitat most frequently used by the radio-tagged Dunlins on all tides.

Daily monitoring of radio-tagged Dunlins within the Bolinas area showed few movements away from the lagoon. All birds except one were located every day while their radios were active. One bird was not found on 3 of the 20 days its radio was active.

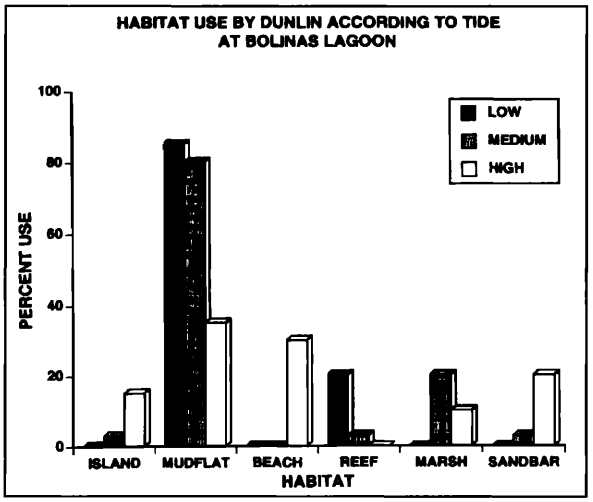

Figure 3. Habitat types used by radio-tagged Dunlins at Bolinas Lagoon according to tide height: low tide = -0.6 to 0 m; medium tide = +0.1 to +0.9 m; high tide = +1.0 to +1.8 m.

Discussion

Differences in habitat utilization by Dunlins on a temporal scale of 1–24 hours were clearly demonstrated by radio-tagged Dunlins on Bolinas Lagoon. Not surprisingly, the tide cycle affected where Dunlins were likely to be found, but the differences in where Dunlins were found during the day versus during the night were more unexpected. Habitat types within the Bolinas Lagoon area were also differentially used by radio-tagged Dunlins. Mudflats were the most frequently used feeding substrate by these Dunlins, yet a coastal reef was also utilized by foraging birds during the daylight hours. These types of data are needed for the successful conservation of shorebird habitat. Knowledge of local spatial and temporal patterns of distribution allows one to rank the importance of different habitats to shorebirds. By knowing when and where shorebirds are likely to occur within an

estuary, action can be taken to minimize disturbance to shorebird populations and to conserve the required habitats.

My study of habitat use and movement patterns of two nearby yet different groups of Dunlins suggests that habitat use on a regional level can be quite varied. At Bodega Harbor, one Dunlin used a series of lagoons within a 12-km radius during its daily/weekly activities. This bird was frequently not found in Bodega Harbor, and it was located once feeding in an estuary approximately 6 km away after having been located 12 hours earlier roosting in Bodega Harbor. Similarly, Dunlins colour-banded in Bodega Harbor have been frequently resighted in the estuaries surrounding the Bodega area (P. Connors, per. commun.). The proximity of suitable estuaries and lagoons to Bodega Harbor may make it energetically advantageous for Dunlins to capitalize on tidal differences between estuaries and lagoons by extending their foraging time (Ruiz *et al.* 1989; P. Connors and J.L. Maron, unpubl. data). For instance, by leaving Bodega Harbor on a rising tide and flying to Estero Americano (Figure 1), a Dunlin could extend its feeding time by at least three hours owing to the time lag in tides between the two areas (P. Connors and J.L. Maron, unpubl. data).

Radio-telemetry work and resightings of colour-marked Dunlins at Bolinas Lagoon indicated that Bolinas Dunlins were quite site-faithful[1]. The geographical isolation of Bolinas Lagoon may make it energetically detrimental for Dunlins to use other lagoons during daily activities.

Despite my small sample sizes, my analysis of Dunlins' movement patterns allows one to appreciate the complexity of the habitat requirements of wintering shorebird populations (see also Page, Stenzel & Wolfe 1979). Bolinas Dunlins used a single estuary almost exclusively during their daily activities, but at Bodega at least one Dunlin utilized a series of lagoons and estuaries during its daily activities.

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1 Radio-telemetry work in Bolinas Lagoon in 1992 revealed a different pattern from that in 1991. Following the first significant rainfall of the season (there were no rainstorms in 1991 while the radios were active), some of the radio-tagged birds flew between San Francisco Bay and Bolinas Lagoon, a distance of 12–14 km, sometimes on a daily basis. There was also heavy raptor predation in 1992.