Integrating marine and terrestrial habitats in shorebird conservation planning

PHILIPPA C.F. SHEPHERD*#, LESLEY J. EVANS OGDEN+ & DAVID B. LANK

Centre for Wildlife Ecology, Department of Biological Sciences, Simon Fraser University, 8888 University Drive, Burnaby, British Columbia, Canada, V5A 1S6, e-mail: Pippa.Shepherd@pc.gc.ca

Shepherd, P.C.F., Evans Ogden, L.J. & Lank, D.B. 2003. Integrating marine and terrestrial habitats in shorebirdconservation planning. *Wader Study Group Bull.* 100: 40–42.

Our studies in the Fraser River Delta, British Columbia, Canada, show that shorebirds that normally feed in the intertidal zone by day make greater use of terrestrial habitats for foraging than had previously been supposed, especially at night. We highlight the importance of shorebird ecologists extending their studies to evaluate fully the use of non-marine habitats and the significance of night-feeding. We outline the techniques that can be used to monitor habitat use and foraging strategies on a 24-hour day basis. We also draw attention to the importance of passing the results of such studies to land-use planners so that they can include key terrestrial habitats in management plans for coastal wetland sites.

INTRODUCTION

Many shorebird species are at risk as a result of their reliance on coastal habitats that are also favoured for human settlement. More than half of the coastal wetlands in the contiguous United States have been lost or altered since the arrival of European settlers, and in the last century alone, an estimated 70% of California's coastal wetlands have been lost to development (National Wetlands Working Group 1988, Bildstein *et al.* 1991, NOAA 2001, Speth 1979). Representing just 17% of the land area of the US, coastal counties support over half the US human population, and population growth in these areas exceeds the national average (Culliton 1998). Not surprisingly, coastal habitat alteration is occurring at an alarming rate.

Declines in many North American shorebird species have been attributed to the loss of coastal wetland habitats, and their conservation has been identified as one of the main strategies for reversing declines and stabilizing populations (Donaldson *et al.* 2001, Brown *et al.* 2001). Because shorebirds have relatively low reproductive potential, their populations are particularly sensitive to factors affecting adult survivorship (Hitchcock & Gratto-Trevor 1997, Sandercock, this volume). Most adult mortality takes place during migration or on the wintering grounds where shorebirds often concentrate in large numbers at relatively few key coastal wetland sites (Myers *et al.* 1987, Evans 1991). This tendency to concentrate in space and time "breaks the normal link between the abundance of a species and its immunity to extinction" (p. 21, Myers *et al.* 1987).

Conservation and restoration plans for key coastal wetland sites may provide further benefits to shorebird populations by incorporating adjacent terrestrial habitats in addition to intertidal marine and wetland habitats. The availability of intertidal foraging habitats varies with the tidal cycle, and birds may be completely excluded from certain sites during high tides. Where suitable adjacent habitat exists, some shorebird species move from intertidal areas to feed in nearby fields as high tides, lower temperatures, and rainfall reduce the profitability of foraging at intertidal sites (Goss-Custard 1969, Kelly & Cogswell 1979, Page *et al.* 1979, Townshend 1981, Rottenborn 1996, Colwell & Dodd 1997, Butler 1999, Shepherd *et al.* 2001). Shorebirds may also use different foraging habitats by day and by night (Robert *et al.* 1989, Mouritsen 1994, Dodd & Colwell 1998, Sitters *et al.* 2001).

SHOREBIRD FORAGING STRATEGIES IN THE FRASER RIVER DELTA

We investigated habitat preferences, foraging activity budgets and diet composition of Dunlin *Calidris alpina pacifica* in the Fraser River Delta, British Columbia, the northernmost site in North America to support a large non-breeding population (numbering 30–60 thousand individuals) (Warnock & Gill 1996, Shepherd 2001a). The Fraser Delta is the largest wetland on Canada's Pacific coast and supports the country's highest densities of waterbirds, raptors and shorebirds in winter (Butler & Campbell 1987). It is also a key stopover site for migratory species flying between breeding habitats in Canada, Alaska and Russia and non-breeding habitats in southern USA and Central and South America. Over two million shorebirds use the Delta annually, including internationally important populations of Dunlin and Western Sand-

* Corresponding author
# Present address: Ecosystem Services, Western Canada Service Centre, Parks Canada, 300–300 W. Georgia Street, Vancouver, British Columbia, Canada, V6B 6B4
+ Present address: Centre for Applied Conservation Research, 3rd Floor, Forest Sciences Centre, 2424 Main Mall, University of British Columbia, Vancouver, British Columbia, Canada, V6T 1Z4

pipers *Calidris mauri* (Butler & Vermeer 1994). The land surrounding the Delta supports a variety of agricultural uses and suburban housing, and is an area of increasingly dense human settlement.

We used radio telemetry and direct observation to investigate Dunlin habitat preferences and activity budgets in both marine and terrestrial habitats, and stable isotope analyses to determine the relative contribution of marine and terrestrial food to the Dunlin diet (Shepherd 2001b, Evans Ogden 2002). Shorebirds wintering in temperate estuaries are generally active both day and night (Mouritsen 1994, Warnock & Takekawa 1996). In order to avoid obtaining biased or incomplete results, we therefore collected data throughout the 24-hour day and twice-daily tidal cycles. We found that individual Dunlin spent similar proportions of time foraging day and night, and that use of available habitats differed between day and night (Shepherd 2001b). Our research showed that more than 70% of radio-marked individuals used terrestrial habitats adjacent to the intertidal zone, that Dunlin located in terrestrial habitats used them primarily for foraging (on average more than 60% of the time spent there), and that terrestrial food items made up an average of about 30% of the Dunlin diet (determined by staple isotope analysis) (Shepherd 2001b, Evans Ogden 2002). Interestingly, we found that use of terrestrial foraging habitats was primarily nocturnal. We hypothesized that this was because predation risk and human-related disturbance in the terrestrial habitats were lower at night than during the day, since both humans and the Dunlins' primary predators (falcons) are mostly only active by day. Wilson's Plovers *Charadrius wilsonia cinnamominus* wintering in Venezuela switched to foraging primarily at night apparently due to an increase in the risk of predation during the months that their diurnal predators (Peregrines *Falco peregrinus*) were present (Thibault & McNeil 1994).

Because alternative terrestrial foraging habitats were primarily used at night, their value to Dunlin had previously been underestimated and the conservation requirements of shorebirds had not been incorporated into local land-use planning processes. Avian management plans for terrestrial habitats in the Fraser Delta region had focused on the needs of raptors, passerines, and waterfowl; birds whose requirements can differ from those of shorebirds. For example, raptor management zones consist of areas covered with tall grasses and other vegetation with man-made perches, places that shorebirds tend to avoid. Hedgerows are promoted as habitat for passerines, but the resulting fragmentation of fields and addition of perching and hiding sites for raptors may be detrimental to shorebirds. Until recently, freshwater wetlands in the region were managed exclusively for waterfowl and kept at water levels that largely excluded foraging shorebirds.

Shorebird species that use alternative foraging habitats, particularly in terrestrial areas with human activity, provide an interesting challenge to managers by requiring an approach to conservation and land-use planning that integrates marine intertidal and adjacent terrestrial habitats, and implies the need for a management regime more complex than just habitat protection. Farmland can be managed and worked in ways that are compatible or incompatible with shorebird usage, and successful conservation plans will hinge on farmer support, cooperation, and willingness to engage in stewardship activities.

In order to provide comprehensive advice to land managers and stewards, we needed to determine which habitats were preferred by Dunlin and to quantify their relative importance. Dunlin showed a significant and consistent overall preference for foraging in marine intertidal habitats over terrestrial habitats. However, the majority of the wintering population also foraged terrestrially (Shepherd 2001b, Evans Ogden 2002). Within the terrestrial zone, Dunlin preferred soil-based agricultural habitats with short vegetation (including pastures, bare fields with below-ground crop remains, fields with above- and below-ground crop remains, and winter cover crops) over other terrestrial habitats (including suburban areas, greenhouse areas, tall grasses, wooded areas, turf, and nursery crops) (Shepherd 2001b). Of the soil-based agricultural habitats, pasture, which is heavily and naturally fertilized with cattle manure in the Fraser Delta, was the most preferred.

At the Fraser River Delta, the northern end of the Dunlin's core winter range, access to nearby terrestrial habitats may be required by many individuals in order to meet daily energy requirements (Davidson & Evans 1986, Shepherd 2001b, Evans Ogden 2002). However, without behavioural data collected at night, or stable isotope data showing relative proportions of marine and terrestrial foods in the diet over the winter period, we would not have understood the importance of maintaining soil-based agricultural habitats adjacent to intertidal habitats. Other studies support the contention that alternative high tide foraging habitats, in particular soil-based agricultural fields, can be important for wintering shorebird populations (Velasquez and Hockey 1991, Colwell & Dodd 1995, Warnock & Takekawa 1996, Rottenborn 1996, Weber & Haig 1996, Butler 1999, Dann 1999, Masero & Perez-Hurtado 2001, Smart & Gill 2003). Predicted mortality rates of Eurasian Oystercatchers *Haematopus ostralegus* wintering in Britain in an environment similar to that of the Fraser Delta increased significantly when upshore and field foraging areas were removed from a population model (Stillman *et al.* 2000).

The use of soil-based agricultural habitats as alternative foraging sites is not limited to shorebirds. Lovvorn & Baldwin (1996) found that intertidal habitats with adjacent farmland supported 75–94% of individuals of four waterfowl species wintering in the Puget Sound region (just south of the Fraser Delta), and found that few locations with no adjacent farmland supported significant waterfowl populations. The presence of grazing waterfowl can also facilitate subsequent agricultural habitat use by shorebird species, such as Dunlin, that prefer short vegetation. In the Fraser Delta, winter field vegetation can grow quite tall, thereby restricting access to soil invertebrates and obscuring the view of approaching predators. Waterfowl convert the fields by grazing into more shorebird-favourable habitat, and shorebirds in the region have been observed to make greater use of agricultural habitats after the wintering waterfowl have grazed back the vegetation (Taitt 1997, Evans Ogden 2002).

CONCLUSIONS

We contend that shorebird ecologists working at non-breeding coastal wetland sites, particularly at times or in places where energetic costs are high such as periods of pre-migratory fattening or places where temperatures are low, should take into account the birds' requirements throughout the full 24-hour day and whole tidal cycles. Such data can be collected by observation (with the assistance of modern night

vision equipment), by radar, by radio telemetry, or by stable isotope analysis to provide a more complete picture of shorebird requirements. It is also essential that researchers investigate the use of alternative high tide foraging habitats, particularly soil-based agricultural lands, and the relative importance of these habitats to the birds. Where research findings indicate significant value of such habitats, we encourage shorebird ecologists to provide their findings to land use planners, and advocate for the inclusion of these habitats into conservation plans for key coastal wetland sites.

ACKNOWLEDGEMENTS

We are grateful to Jenny Gill for comments on an earlier draft of our manuscript.

REFERENCES

Bildstein, K.L., Bancroft, G.T., Dugan, P.J., Gordon, D.H., Erwin, K.M., Nol, E., Payne, L.X. & Senner, S.E. 1991. Approaches to the conservation of wetlands in the western hemisphere. *Wilson Bull.* 103: 218–254.

Brown, S., Hickey, C., Harrington, B. & Gill, R. 2001. *United States Shorebird Conservation Plan, 2nd edition.* Manomet Center for Conservation Science, Manomet, MA, USA.

Butler, R.W. 1999. Winter abundance and distribution of shorebirds and songbirds on farmlands on the Fraser River delta, British Columbia, 1989–1991. *Can. Field-Nat.* 113: 390–395.

Butler, R.W. & Campbell, R.W. 1987. *The birds of the Fraser River delta: populations, ecology and international significance.* Canadian Wildlife Service Occasional Paper #65.

Butler, R.W. & Vermeer, K. 1994. *The abundance and distribution of estuarine birds in the Strait of Georgia, British Columbia.* Canadian Wildlife Service Technical Report 83.

Colwell, M.A. & Dodd, S.L. 1995. Waterbird communities and habitat relationships in coastal pastures of northern California. *Cons. Biol.* 9: 827–834.

Colwell, M.A. & Dodd, S.L. 1997. Environmental and habitat correlates of pasture use by nonbreeding shorebirds. *Condor* 99: 337–344.

Culliton, T.J. 1998 (on-line). *Population: distribution, density and growth.* State of the Coast website, National Oceanic and Atmospheric Association (NOAA). Silver Spring, MD (http://state-of-coast.noaa.gov/).

Dann, P. 1999. Feeding periods and supratidal feeding of red-necked stints and curlew sandpipers in Western Port, Victoria. *Emu* 99: 218–222.

Davidson, N.C. & Evans, P.R. 1986. The role and potential of man-made and man-modified wetlands in the enhancement of the survival of overwintering shorebirds. *Colonial Waterbirds* 9: 176–188.

Dodd, S.L., & Colwell, M.A. 1998. Environmental correlates of diurnal and nocturnal foraging patterns of nonbreeding shorebirds. *Wilson Bull.* 110: 182–189.

Donaldson, G.M., Hyslop, C., Morrison, R.I.G., Dickson, H.L. & Davidson, I. 2001. *Canadian Shorebird Conservation Plan.* Canadian Wildlife Service, Ottawa, Canada.

Evans, P.R. 1991. *Seasonal and annual patterns of mortality in migratory shorebirds: some conservation implications.* In: Perrins, C.H., Lebreton, J.-D, & Herons, G.J.M. (eds.) Bird population studies, pp. 346–359. Oxford University Press, Oxford, England.

Evans Ogden, L.J. 2002. *Non-breeding shorebirds in a coastal agricultural landscape: winter habitat use and dietary sources.* Ph.D. thesis, Simon Fraser University, British Columbia, Canada.

Goss-Custard, J.D. 1969. The winter feeding ecology of the Redshank. *Ibis* 111: 338–356.

Hitchcock, C.L. & Gratto-Trevor, C. 1997. Diagnosing a shorebird local population decline with a stage-structured population model. *Ecology* 78: 522–534.

Kelly, P.R. & Cogswell, H.L. 1979. Movements and habitat use by wintering populations of Willets and Marbled Godwits. *Stud. Avian Biol.* 2: 69–82.

Lovvorn, J.R. & Baldwin, K.R. 1996. Intertidal and farmland habitats of ducks in the Puget Sound region: a landscape perspecitve. *Biol. Cons.* 77: 97–114.

Masero, J.A.& Perez-Hurtado, A. 2001. Importance of the supratidal habitats for maintaining overwintering shorebird populations: how redshanks use tidal mudflats and adjacent saltworks in southern Europe. *Condor* 103: 21–30.

Mouritsen, K.N. 1994. Day and night feeding in dunlins *Calidris alpina*: choice of habitat, foraging technique and prey. *J. Avian Biol.* 25: 55–62.

Myers, J.P., Morrison, R.I.G., Antas, P.Z., Harrington, B.A., Lovejoy, T.E., Sallaberry, M., Senner, S.E. & Tarak, A. 1987. Conservation strategy for migratory species. *Am. Sci.* 75: 19–26.

National Wetlands Working Group 1988. *Wetlands of Canada.* Environment Canada and Polyscience Publishers Report, Montreal, Canada.

NOAA (National Oceanic and Atmospheric Administration) 2001. *What's happening with coastal wetlands?* Wetland habitat protection division website (www.nmfs.noaa.gov/habitat/habitatprotection/wetlands4.htm).

Page, G.W., Stenzel, L.E. & Wolfe, C.M. 1979. *Aspects of occurrence of shorebirds on a central California estuary.* In: Pitelka, F.A. (ed.) Shorebirds in marine environments, pp. 15–32. Stud. Avian Biol. No. 2. Cooper Ornithol. Soc., Allen Press, USA.

Robert, M., McNeil, R. & Leduc, A. 1989. Conditions and significance of night feeding in shorebirds and other water birds in a tropical lagoon. *Auk* 106: 94–101.

Rottenborn, S.C. 1996. The use of coastal agricultural fields in Virginia as foraging habitat by shorebirds. *Wilson Bull.* 108: 783–796.

Shepherd, P.C.F. 2001a. *Status and conservation of dunlin (Calidris alpina) in Canada.* Bird Trends 8. Canadian Wildlife Service Publication, Ottawa, Canada.

Shepherd, P.C.F. 2001b. *Space use, habitat preferences, and time-activity budgets of non-breeding dunlin (Calidris alpina pacifica) in the Fraser River Delta, B.C.* Ph.D. thesis, Simon Fraser University, British Columbia, Canada.

Shepherd, P.C.F., Lank, D.B., Smith, B.D., Warnock, N., Kaiser, G.W. & Williams, T.D. 2001. Sex ratios of dunlin wintering at two latitudes on the Pacific coast. *Condor* 103: 352–360.

Sitters, H.P., Gonzalez, P.M., Piersma, T., Baker, A.J. & Price, D.J. 2001. Day and night feeding habitat of Red Knots in Patagonia: profitability versus safety? *J. Field Ornith.* 72: 86–95.

Smart, J. & Gill, J.A. 2003. Non-intertidal habitat use by shorebirds: a reflection of inadequate intertidal resources? *Biol. Cons.*, in press.

Speth, J. 1979. Conservation and management of coastal wetlands in California. *Stud. Avian Biol.* 2: 151–155.

Stillman, R.A., Goss-Custard, J.D., West, A.D., Le V. Dit Durrell, S.E.A., Caldow, R.W.G., McGrorty, S. & Clarke, R.T. 2000. Predicting mortality in novel environments: tests and sensitivity of a behaviour-based model. *J. Appl. Ecol.* 37: 564–588.

Taitt, M.J. 1997. *Wildlife Monitoring of Farmland Cover Crops in 1995/6.* Report prepared for the Delta Farmland and Wildlife Trust, Delta, B.C.

Thibault, M. & McNeil, R. 1994. Day/night variation in habitat use by Wilson's plovers in northeastern Venezuela. *Wilson Bull.* 106: 299–310.

Townshend, J.D. 1981. *The importance of field feeding to the survival of wintering male and female Curlews Numenius arquata on the Tees estuary.* In: Jones, N.V & Wolff, W.J. (eds). Feeding and survival strategies of estuarine organisms, pp. 261–273. Plenum Press, New York, USA.

Velasquez, C.R. & Hockey, P.A.R. 1991. The importance of supratidal foraging habitats for waders at a south temperate estuary. *Ardea* 80: 243–253.

Warnock, N.D. & Gill, R.E. 1996. *Dunlin (Calidris alpina).* In: Poole, A. & Gill, F. (eds.) The birds of North America, Number 203. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC, USA.

Warnock, S.E. & Takekawa, J.Y. 1996. Wintering site fidelity and movement patterns of Western Sandpipers *Calidris mauri* in the San Fransisco Bay estuary. *Ibis* 138: 160–167.

Weber, L.M. & Haig, S.M. 1996. Shorebird use of South Carolina managed and natural coastal wetlands. *J. Wildl. Manag.* 60: 73–82.