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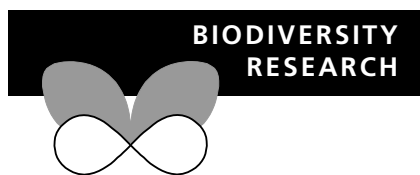
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Sandy beaches at the brink

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ABSTRACT

Sandy beaches line most of the world's oceans and are highly valued by society: more people use sandy beaches than any other type of shore. While the economic and social values of beaches are generally regarded as paramount, sandy shores also have special ecological features and contain a distinctive biodiversity that is generally not recognized. These unique ecosystems are facing escalating anthropogenic pressures, chiefly from rapacious coastal development, direct human uses — mainly associated with recreation — and rising sea levels. Beaches are increasingly becoming trapped in a 'coastal squeeze' between burgeoning human populations from the land and the effects of global climate change from the sea. Society's interventions (e.g. shoreline armouring, beach nourishment) to combat changes in beach environments, such as erosion and shoreline retreat, can result in severe ecological impacts and loss of biodiversity at local scales, but are predicted also to have cumulative large-scale consequences worldwide. Because of the scale of this problem, the continued existence of beaches as functional ecosystems is likely to depend on direct conservation efforts. Conservation, in turn, will have to increasingly draw on a consolidated body of ecological theory for these ecosystems. Although this body of theory has yet to be fully developed, we identify here a number of critical research directions that are required to progress coastal management and conservation of sandy beach ecosystems.

Keywords

Sandy beaches, human impacts, coastal conservation, biodiversity, global change.

INTRODUCTION

The world's open coastlines are dominated by sandy beaches (Bascom, 1980), which are highly valued by society (Whitmarsh *et al.*, 1999; Parsons & Powell, 2001). Because they are the prime sites for human recreation, beaches underpin many coastal economies around the world (Klein *et al.*, 2004); more people use sandy beaches than any other type of seashore. But beaches are not just piles of sand, they support a range of under-appreciated biodiversity. A single beach can harbour several hundred species of invertebrates when the smaller forms (i.e. the interstitial micro- and meiofauna) are included in diversity surveys (Armonies & Reise, 2000). Beaches also provide unique ecological services, such as filtration of large volumes of seawater, not covered by any other ecosystem (McLachlan & Brown, 2006). They recycle nutrients (McLachlan *et al.*, 1985; McLachlan, 1989; Kotwicki *et al.*, 2005) support coastal fisheries (McLachlan *et al.*, 1996) and provide critical habitats (nesting and foraging sites) for endangered species such as turtles and birds (Burger, 1991; Rumbold *et al.*, 2001).

The intrinsic ecological values and functions of beaches are often perceived as secondary to their economic value. A possible reason is that the study of beach ecology is only now emerging as a

theory-driven discipline. Several broad principles in beach ecology have recently been articulated (Defeo & Gómez, 2005; Defeo & McLachlan, 2005; McLachlan & Dorvlo, 2005; Scapini, 2006); these clearly emphasize the unique features of beaches. Importantly, drivers and ecological governing principles on sandy beaches differ markedly from those for other coastal ecosystems such as rocky shores and tidal wetlands. For example, sandy beach animals display a range of unique adaptations to these highly dynamic, three-dimensional environments, including mobility and burrowing abilities, rhythmicity in their behaviour, advanced sensory mechanisms and orientation, and plasticity (Brown & McLachlan, 1990; Brown, 1996; Scapini *et al.*, 1997). Similarly, the composition, diversity, and abundance of faunal communities on beaches are generally thought to be more strongly controlled by physical factors (e.g. wave climates, sediment properties) than by the biological interactions that act so strongly as an organizing force in other intertidal ecosystems (McLachlan *et al.*, 1993; McLachlan & Dorvlo, 2005).

PRESSURES

Globally, burgeoning population growth in coastal areas is placing escalating pressures on sandy beaches at unprecedented scales

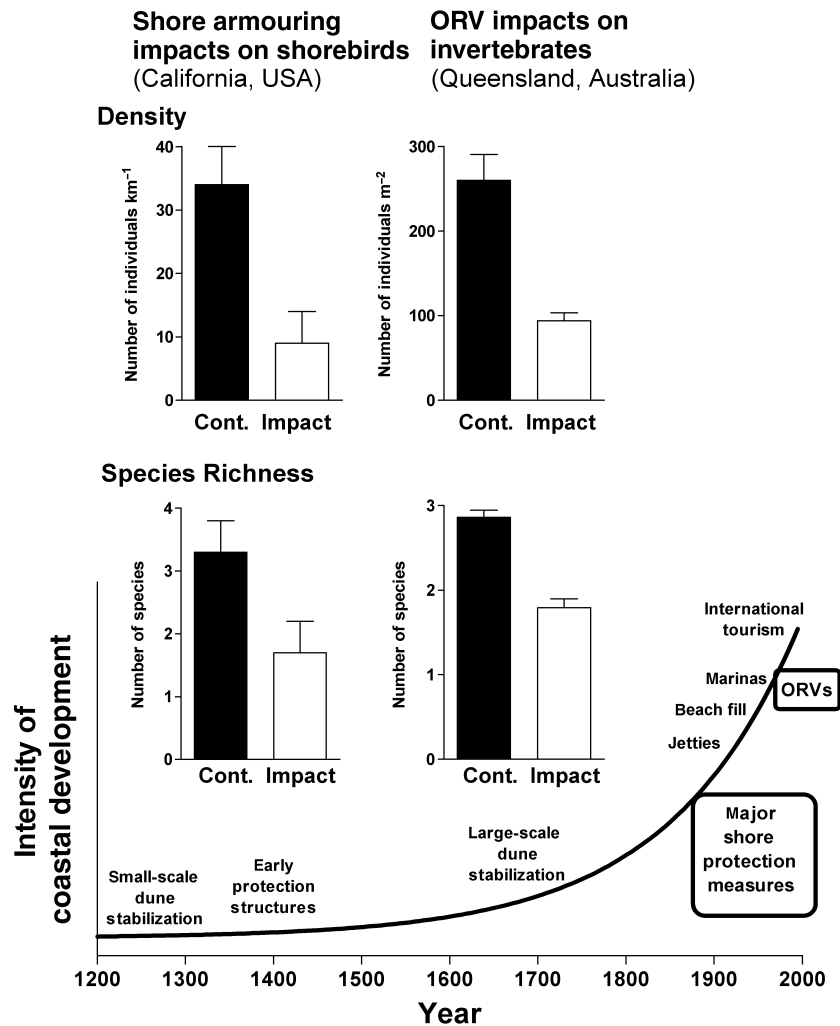


Figure 1 Ecological impacts of human activities on sandy beach biota illustrated by declines in abundance and species richness of birds on beaches with coastal defence structures, and benthic invertebrates on beaches subjected to heavy traffic by recreational off-road vehicles (ORVs). Bottom panel depicts a generalized trajectory of human modifications to soft coasts (modified from Nordstrom, 2000). Source data for shorebird impacts are from Jenny Dugan and David Hubbard (University California, USA) and from Thomas Schlacher (University Sunshine Coast, Australia) for beach invertebrates.

and amplitudes (Brown & McLachlan, 2002). Beaches are trapped in a 'coastal squeeze' between the impacts of urbanization on the terrestrial side and manifestations of climate change at sea. While unconstrained, beaches are resilient, changing shape and extent naturally in response to storms and variations in wave climate and currents. However, human modifications of the coastal zone severely limit this flexibility (Nordstrom, 2000).

Exacerbating this impact are human-induced alterations to coastal sediment supply and transport processes (Komar, 1998), as well as climate change-induced sea level rise and increased storminess (Slott *et al.*, 2006). Together, these stressors drive the global trend of beach erosion (Bird, 2000), with the result that coastlines are generally migrating inland. Because this brings beaches into conflict with human infrastructure, the mere threat of coastal erosion is enough to elicit a management response. Although ideally, this would entail natural retreat, removing man-made structures to accommodate the dynamism of the shore, this is generally not possible. In such cases, coastal authorities intervene more actively using either 'soft' engineering solutions (nourishment) or 'hard' armouring of the shoreline. The ecological consequences of engineering activities on beaches can be substantial at local scales (Fig. 1), and include the loss of biodiversity,

productivity, and critical habitats as well as modifications of the subtidal zone which is an important recruitment zone for many sandy beach animals (Peterson & Bishop, 2005; Dugan & Hubbard, 2006; Peterson *et al.*, 2006; Speybroeck *et al.*, 2006).

Because natural shoreline retreat is today constrained along most developed coastlines by human infrastructures, we can predict future compression and loss of critical coastal ecosystems and habitats including not only dunes (Feagin *et al.*, 2005), but also functional beaches themselves. In addition to erosion and engineering, human activities are also impacting beaches directly (Table 1, Fig. 1). For example, increasing demands on beaches for recreation are highly detrimental in cases of heavy and inappropriate uses such as off-road vehicles driven on beaches (Fig. 1; Williams *et al.*, 2004; Schlacher & Thompson, in press).

RESEARCH NEEDS

The world's sandy beaches are iconic assets to society, but escalating threats to these systems pose formidable conservation challenges. Treating beaches as if they were simply piles of sand devoid of life places at risk the immense ecological values of sandy beaches (McLachlan & Brown, 2006). Although these ecological values of

Table 1 Key anthropogenic pressures on sandy beaches.

Key pressure	Reference(s)
Climate change and sea level rise	Feagin <i>et al.</i> (2005); Cowell <i>et al.</i> (2006); Harley <i>et al.</i> (2006)
Coastal infrastructure and development	Nordstrom (2000); Scapini (2002)
Shoreline armouring and erosion	Beentjes <i>et al.</i> (2006); Dugan & Hubbard (2006)
Beach nourishment	Peterson <i>et al.</i> (2000, 2006); Speybroeck <i>et al.</i> (2006)
Resource exploitation	
Fisheries	Defeo & de Alava (1995); McLachlan <i>et al.</i> (1996); Schoeman <i>et al.</i> (2000)
Mining/sand extraction	McLachlan (1996); Simmons (2005)
Pollution	
Chemical (oil spills)	de la Huz <i>et al.</i> (2005); Junoy <i>et al.</i> (2005)
Litter	Derraik (2002)
Freshwater discharge (quality and quantity)	Lercari & Defeo (1999); Lercari <i>et al.</i> (2002)
Grooming and cleaning	Llewellyn & Shackley (1996); Dugan <i>et al.</i> (2003)
Recreation and tourism	de Ruyck <i>et al.</i> (1997); Davenport & Davenport (2006)
Human trampling	Rickard <i>et al.</i> (1994); Fanini <i>et al.</i> (2005); Gheskiere <i>et al.</i> (2005)
Off-road vehicles (ORVs)	Godfrey & Godfrey (1980); Williams <i>et al.</i> (2004); Schlacher & Thompson (in press)
Beach and dune camping	Hockings & Twyford (1997)
Wildlife disturbance	Burger (1991); Parris <i>et al.</i> (2002); Thomas <i>et al.</i> (2003)
Light pollution	Salmon (2003); Bird <i>et al.</i> (2004)

Human perturbations affect sandy beaches both directly (e.g. habitat destruction, overfishing, off-road vehicles) and indirectly (e.g. human-induced climate change resulting in sea level rise and beach erosion). Impacts can also be interactive or additive, and act as either press or pulse disturbances over a wide range of spatial and temporal scales.

beaches are publicly less recognized than their social and economic equivalents, their loss could have large ramifications in the form of irreversible damage to crucial ecosystem functions (e.g. water filtration, nutrient recycling), loss of biodiversity, and destruction of critical habitats for endangered species.

To conserve the irreplaceable biodiversity and ecosystem features of sandy beaches, coastal management will have to progressively incorporate ecological aspects of beaches, which in turn requires sound ecological science. Although the fundamental principles of beach ecology are starting to become integrated into a coherent framework (Defeo & McLachlan, 2005), management responses require better predictive capabilities about the ecological ramifications of human activities and perturbations (Table 1, Fig. 1), than are currently available for many situations.

The limits of our scientific understanding of how sandy beaches respond ecologically to the plethora of human threats are fast emerging as crucial impediments for the conservation of these threatened ecosystems. A number of broad, non-exclusive research directions are therefore considered critical to address these gaps:

- 1 The identification, quantification, and economic valuation of vital ecosystem services provided by beaches.
- 2 The responses of beach ecosystems to the intensification of erosion and disturbance regimes and to human interventions that seek to counteract shoreline change and beach erosion.
- 3 The ecological consequences, including impacts on ecosystem services, of human activities, such as recreation, extractive use, and pollution, that directly impact beaches.
- 4 The functional relationships between drivers of the physical environment (e.g. wave regimes, sediment properties), organism transport, and the structure and function of beach ecosystems.

5 The implications of habitat loss and fragmentation as well as weakened linkages across critical ecotones and habitats for the conservation of sandy beach biodiversity, including endangered vertebrates such as turtles.

6 The effects of cumulative impacts from multiple stressors and disturbances operating at increasingly larger spatial scales and greater frequencies on the structure, function, and recovery dynamics of sandy beach ecosystems.

The scope of this list emphasizes the urgency of expanding research efforts on these threatened ecosystems. Interdisciplinary and innovative approaches as well as increased public outreach will be required to address the conservation crisis facing the world's sandy beaches.

REFERENCES

- Armonies, W. & Reise, K. (2000) Faunal diversity across a sandy shore. *Marine Ecology Progress Series*, **196**, 49–57.
- Bascom, W. (1980) *Waves and beaches: the dynamics of the ocean surface*. Anchor Press, Garden City, New York.
- Beentjes, M.P., Carbines, G.D. & Willsman, A.P. (2006) Effects of beach erosion on abundance and distribution of toheroa (*Paphies ventricosa*) at Bluecliffs Beach, Southland, New Zealand, New Zealand. *Journal of Marine and Freshwater Research*, **40**, 439–453.
- Bird, E.C.F. (2000) *Coastal geomorphology: an introduction*. John Wiley, Chichester, UK.
- Bird, B.L., Branch, L.C. & Miller, D.L. (2004) Effects of coastal lighting on foraging behavior of beach mice. *Conservation Biology*, **18**, 1435–1439.

- Brown, A.C. (1996) Behavioural plasticity as a key factor in the survival and evolution of the macrofauna on exposed sandy beaches. *Revista Chilena de Historia Natural*, **69**, 469–474.
- Brown, A.C. & McLachlan, A. (1990) *Ecology of sandy shores*. Elsevier, Amsterdam.
- Brown, A.C. & McLachlan, A. (2002) Sandy shore ecosystems and the threats facing them: some predictions for the year 2025. *Environmental Conservation*, **29**, 62–77.
- Burger, J. (1991) Foraging behavior and the effect of human disturbance on the piping plover (*Charadrius melodus*). *Journal of Coastal Research*, **7**, 39–52.
- Cowell, P.J., Thom, B.G., Jones, R.A., Everts, C.H. & Simanovic, D. (2006) Management of uncertainty in predicting climate-change impacts on beaches. *Journal of Coastal Research*, **22**, 232–245.
- Davenport, J. & Davenport, J.L. (2006) The impact of tourism and personal leisure transport on coastal environments: a review. *Estuarine Coastal and Shelf Science*, **67**, 280–292.
- Defeo, O. & de Alava, A. (1995) Effects of human activities on long-term trends in sandy beach populations: the wedge clam *Donax hanleyanus* in Uruguay. *Marine Ecology Progress Series*, **123**, 73–82.
- Defeo, O. & Gómez, J. (2005) Morphodynamics and habitat safety in sandy beaches: life-history adaptations in a supralittoral amphipod. *Marine Ecology Progress Series*, **293**, 143–153.
- Defeo, O. & McLachlan, A. (2005) Patterns, processes and regulatory mechanisms in sandy beach macrofauna: a multi-scale analysis. *Marine Ecology Progress Series*, **295**, 1–20.
- Derriak, J.G.B. (2002) The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin*, **44**, 842–852.
- Dugan, J.E. & Hubbard, D.M. (2006) Ecological responses to coastal armouring on exposed sandy beaches. *Shore and Beach*, **74**, 10–16.
- Dugan, J.E., Hubbard, D.M., McCrary, M.D. & Pierson, M.O. (2003) The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California. *Estuarine Coastal and Shelf Science*, **58**, 25–40.
- Fanini, L., Cantarino, C.M. & Scapini, F. (2005) Relationships between the dynamics of two *Talitrus saltator* populations and the impacts of activities linked to tourism. *Oceanologia*, **47**, 93–112.
- Feagin, R.A., Sherman, D.J. & Grant, W.E. (2005) Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats. *Frontiers in Ecology and the Environment*, **3**, 359–364.
- Gheskiere, T., Vincx, M., Weslawski, J.M., Scapini, F. & Degraer, S. (2005) Meiofauna as descriptor of tourism-induced changes at sandy beaches. *Marine Environmental Research*, **60**, 245–265.
- Godfrey, P.J. & Godfrey, M. (1980) Ecological effects of off-road vehicles on Cape Cod. *Oceanus*, **23**, 56–67.
- Harley, C.D.G., Hughes, A.R., Hultgren, K.M., Miner, B.G., Sorte, C.J.B., Thornber, C.S., Rodriguez, L.F., Tomanek, L. & Williams, S.L. (2006) The impacts of climate change in coastal marine systems. *Ecology Letters*, **9**, 500–500.
- Hockings, M. & Twyford, K. (1997) Assessment and management of beach camping within Fraser Island World Heritage Area, South East Queensland. *Australian Journal of Environmental Management*, **4**, 25–39.
- de la Huz, R., Lastra, M., Junoy, J., Castellanos, C. & Vieitez, J.M. (2005) Biological impacts of oil pollution and cleaning in the intertidal zone of exposed sandy beaches: preliminary study of the ‘Prestige’ oil spill. *Estuarine Coastal and Shelf Science*, **65**, 19–29.
- Junoy, J., Castellanos, C., Vieitez, J.M., de la Huz, M.R. & Lastra, M. (2005) The macroinfauna of the Galician sandy beaches (NW Spain) affected by the Prestige oil-spill. *Marine Pollution Bulletin*, **50**, 526–536.
- Klein, Y.L., Osleeb, J.P. & Viola, M.R. (2004) Tourism-generated earnings in the coastal zone: a regional analysis. *Journal of Coastal Research*, **20**, 1080–1088.
- Komar, P.D. (1998) *Beach processes and sedimentation*. Prentice Hall, New Jersey.
- Kotwicki, L., Weslawski, J.M., Szaltynis, A., Stasiak, A. & Kupiec, A. (2005) Fine organic particles in a sandy beach system (Puck Bay, Baltic Sea). *Oceanologia*, **47**, 165–180.
- Lercari, D. & Defeo, O. (1999) Effects of freshwater discharge in sandy beach populations: The mole crab *Emerita brasiliensis* in Uruguay. *Estuarine Coastal and Shelf Science*, **49**, 457–468.
- Lercari, D., Defeo, O. & Celentano, E. (2002) Consequences of a freshwater canal discharge on the benthic community and its habitat on an exposed sandy beach. *Marine Pollution Bulletin*, **44**, 1397–1404.
- Llewellyn, P.J. & Shackley, S.E. (1996) The effects of mechanical beach cleaning on invertebrate populations. *British Wildlife*, **7**, 147–155.
- McLachlan, A. (1989) Water filtration by dissipative beaches. *Limnology and Oceanography*, **34**, 774–780.
- McLachlan, A. (1996) Physical factors in benthic ecology: effects of changing sand particle size on beach fauna. *Marine Ecology Progress Series*, **131**, 205–217.
- McLachlan, A. & Brown, A.C. (2006) *The ecology of sandy shores*. Academic Press, Burlington, Massachusetts.
- McLachlan, A. & Dorvlo, A. (2005) Global patterns in sandy beach macrobenthic communities. *Journal of Coastal Research*, **21**, 674–687.
- McLachlan, A., Dugan, J.E., Defeo, O., Ansell, A.D., Hubbard, D.M., Jaramillo, E. & Penchaszadeh, P.E. (1996) Beach clam fisheries. *Oceanography and Marine Biology an Annual Review*, **34**, 163–232.
- McLachlan, A., Eliot, I.G. & Clarke, D.J. (1985) Water filtration through reflective microtidal beaches and shallow sublittoral sands and its implications for an inshore ecosystem in Western Australia. *Estuarine Coastal and Shelf Science*, **21**, 91–104.
- McLachlan, A., Jaramillo, E., Donn, T.E. Jr & Wessels, F. (1993) Sandy beach macrofauna communities and their control by the physical environment: a geographical comparison. *Journal of Coastal Research*, **15**, 27–38.
- Nordstrom, K.F. (2000) *Beaches and dunes on developed coasts*. Cambridge University Press, Cambridge, UK.

- Parris, L.B., Lamont, M.M. & Carthy, R.R. (2002) Increased incidence of red imported fire ant (Hymenoptera: Formicidae) presence in loggerhead sea turtle (Testudines: Cheloniidae) nests and observations of hatchling mortality. *Florida Entomologist*, **85**, 514–517.
- Parsons, G.R. & Powell, M. (2001) Measuring the cost of beach retreat. *Coastal Management*, **29**, 91–103.
- Peterson, C.H. & Bishop, M.J. (2005) Assessing the environmental impacts of beach nourishment. *Bioscience*, **55**, 887–896.
- Peterson, C.H., Bishop, M.J., Johnson, G.A., D'Anna, L.M. & Manning, L.M. (2006) Exploiting beach filling as an unaffordable experiment: benthic intertidal impacts propagating upwards to shorebirds. *Journal of Experimental Marine Biology and Ecology*, **338**, 205–221.
- Peterson, C.H., Hickerson, D.H.M. & Johnson, G.G. (2000) Short-term consequences of nourishment and bulldozing on the dominant large invertebrates of a sandy beach. *Journal of Coastal Research*, **16**, 368–378.
- Rickard, C.A., McLachlan, A. & Kerley, G.I.H. (1994) The effects of vehicular and pedestrian traffic on dune vegetation in South Africa. *Ocean and Coastal Management*, **23**, 225–247.
- Rumbold, D.G., Davis, P.W. & Perretta, C. (2001) Estimating the effect of beach nourishment on *Caretta caretta* (loggerhead sea turtle) nesting. *Restoration Ecology*, **9**, 304–310.
- de Ruyck, A., Soares, A.G. & McLachlan, A. (1997) Social carrying capacity as a management tool for sandy beaches. *Journal of Coastal Research*, **13**, 822–830.
- Salmon, M. (2003) Artificial night lighting and sea turtles. *Biologist*, **50**, 163–168.
- Scapini, F. (2006) Keynote papers on sandhopper orientation and navigation. *Marine and Freshwater Behaviour and Physiology*, **39**, 73–85.
- Scapini, F., ed. (2002) *Baseline research for the integrated sustainable management of Mediterranean sensitive coastal ecosystems*. A manual for coastal managers, scientists and all those studying coastal processes and management in the Mediterranean. Istituto Agronomico per l'Oltremare, Società Editrice Fiorentina, Firenze, Italy.
- Scapini, F., Audoglio, M., Chelazzi, L., Colombini, I. & Fallaci, M. (1997) Astronomical, landscape and climatic factors influencing oriented movements of *Talitrus saltator* in nature. *Marine Biology*, **128**, 63–72.
- Schlacher, T.A. & Thompson, L.M.C. (in press) Physical impacts caused by off-road vehicles (ORVs) to sandy beaches: spatial quantification of car tracks on an Australian barrier island. *Journal of Coastal Research*, in press.
- Schoeman, D.S., McLachlan, A. & Dugan, J.E. (2000) Lessons from a disturbance experiment in the intertidal zone of an exposed sandy beach. *Estuarine Coastal and Shelf Science*, **50**, 869–884.
- Simmons, R.E. (2005) Declining coastal avifauna at a diamond-mining site in Namibia: comparisons and causes. *Ostrich*, **76**, 97–103.
- Slott, J.M., Murray, A.B., Ashton, A.D. & Crowley, T.J. (2006) Coastline responses to changing storm patterns. *Geophysical Research Letters*, **33**, L18404.
- Speybroeck, J., Bonte, D., Courtens, W., Gheschiere, T., Grootaert, P., Maelfait, J.P., Mathys, M., Provoost, S., Sabbe, K., Stienen, E.W.M., Van Lancker, V., Vincx, M. & Degraer, S. (2006) Beach nourishment: an ecologically sound coastal defence alternative? A review. *Aquatic Conservation — Marine and Freshwater Ecosystems*, **16**, 419–435.
- Thomas, K., Kvitek, R.G. & Bretz, C. (2003) Effects of human activity on the foraging behavior of sanderlings *Calidris alba*. *Biological Conservation*, **109**, 67–71.
- Whitmarsh, D., Northen, J. & Jaffry, S. (1999) Recreational benefits of coastal protection: a case study. *Marine Policy*, **23**, 453–463.
- Williams, J.A., Ward, V.L. & Underhill, L.G. (2004) Waders respond quickly and positively to the banning of off-road vehicles from beaches in South Africa. *Wader Study Group Bulletin*, **104**, 79–81.