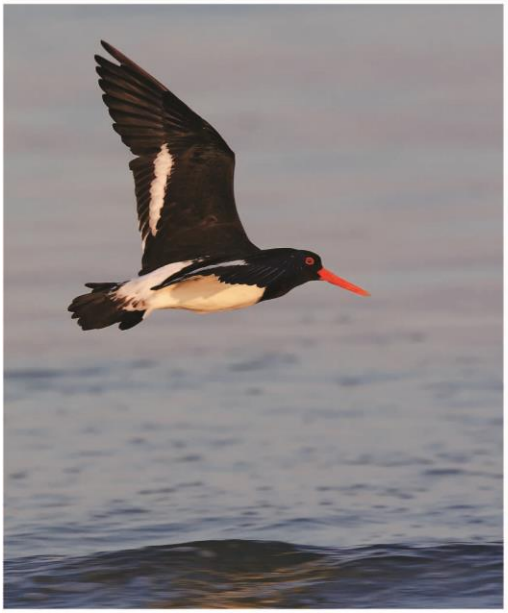
A practical guide for managing beach-nesting birds in Australia



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CONSERVATION THROUGH KNOWLEDGE

A practical guide for managing beach-nesting birds in Australia

Grainne S. Maguire

Birds Australia

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Birds Australia
Suite 2-05
60 Leicester Street
Carlton Vic 3053
E-mail: mail@birdsaustralia.com.au
Tel: (Australia): (03) 9347 0757 Fax: (03) 9347 9323
(Overseas): +61 3 9347 0757 Fax: +61 3 9347 9323

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Photos front cover: Red-capped Plover male and female (Chris Tzaros); Sooty Oystercatcher juvenile and adult (Glenn Ehmke); Hooded Plover flock (Glenn Ehmke); Pied Oystercatcher in flight (Glenn Ehmke); Beach Stone-curlew feeding (Ian Montgomery).

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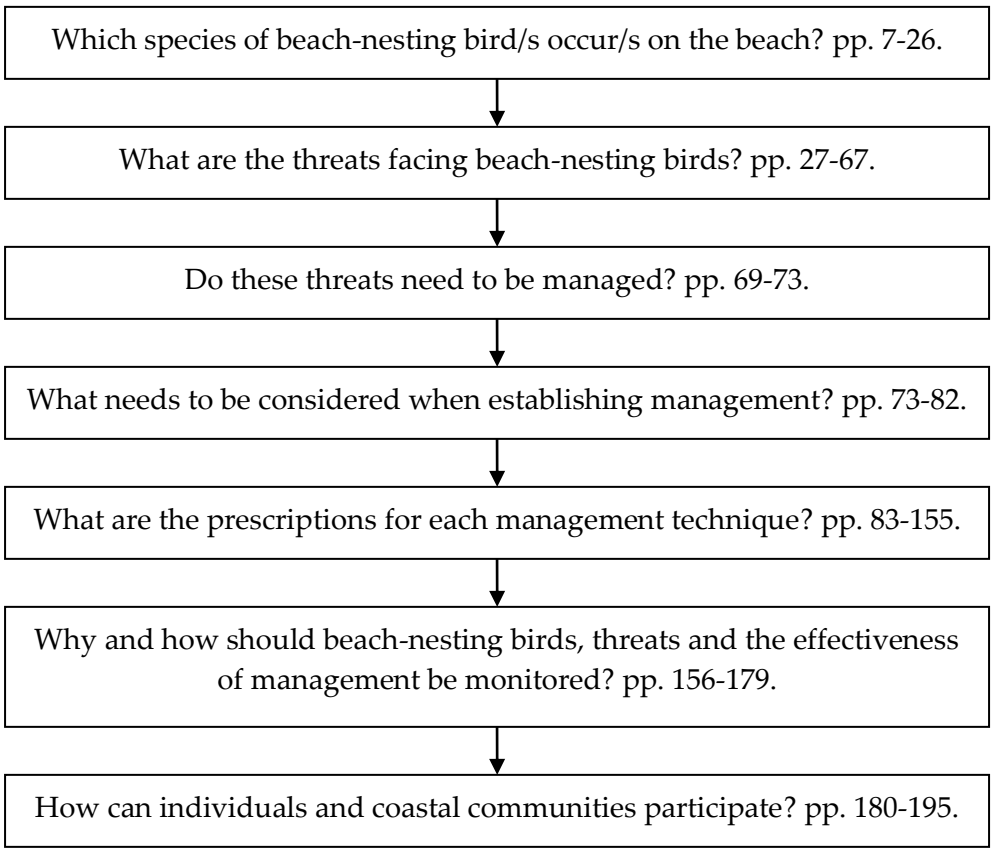
A practical guide for managing beach-nesting birds in Australia

This manual has been developed to assist land managers, government agencies, conservation organisations, committees of management, threatened species recovery teams, policy makers, communities, volunteers and individuals or groups with an interest in protecting beach-nesting birds.

The manual reviews the range of threats that are experienced by Australia's beach-nesting shorebirds and provides practical advice for reducing or eliminating these threats through on-ground management actions and raising public awareness, and for monitoring the success of these management actions. The manual also provides useful advice for initiating management or monitoring programs for beach-nesting birds. Many of the management actions outlined in this manual have been used extensively and successfully across Australia as well as overseas. Others are in their infancy and have been considered with appropriate caution. Due to the extremely sensitive breeding requirements of these birds, all of the management actions and monitoring guidelines outlined in this manual have been developed with the aim of minimising risks to beach-nesting birds.

Figure 1. How to use this manual



Introduction

The state of Australia's beach-nesting shorebirds

The mainland coast of Australia spans 36,000 kilometres, and over 80 % of Australians live within 50 km of the coast, with these numbers only set to rise (SoE 2006). Next to Australia's cities, the high amenity coastal regions of Australia (i.e. 'sea change' areas) have experienced the most sustained growth over the past 20 years. Coastal strip development through incremental extension of most of Australia's existing urban areas, threatens much of the temperate coast and tropical systems near existing centres of population. The 2006 State of the Environment report lists the following regions as under greatest threat from development: south-eastern Queensland and northern New South Wales (Hervey Bay to Byron Bay); Sydney mega-metropolitan region (Newcastle to Wollongong); the Port Phillip region (Queenscliff to Portsea) and north of Perth in the City of Wanneroo to south of Perth in the City of Mandurah. It is predicted that by 2050, the proportion of the Australian coast that will be urbanised will be 9.2 %, and in some regions, such as the coast between Nowra and Noosa, this proportion will be as high as 42 % (SoE 2006).

Added to developmental pressure and large resident populations, Australia's coasts are also heavily visited by international and domestic tourists. In 2004, domestic and international visitors spent about $20 billion on recreational activities involving coastal and ocean ecosystems (SoE 2006). Over $13 million was spent by Australians on their visits to the beach (largely transport costs), with over 88,000 overnight visits made. Worldwide, sandy beaches are used by more people than any other type of shore (Schlacher *et al.* 2007). Development and visitation lead to pressure for opening and dredging of estuary and lagoon channels, construction of marinas, beach groynes, coastal stabilisation projects, increased vehicle mobility and access to coastal areas, and ongoing demands for tourism and recreation facilities, which are severely degrading coastal habitats and ecosystem functions (SoE 2006). The animals dependent on these coastal environments are consequently some of the most threatened of any ecosystem.

Typically, beach-nesting birds are residents on the Australian coast year-round, and the beach provides habitat for their entire life cycle; foraging, roosting and breeding. Beach-

nesting birds lay their eggs on beaches above the high-tide mark, dunes or rocky shores, where sand, shell or rock provides an ideal substrate for their well camouflaged, stone coloured eggs. This camouflage serves to protect the eggs from native predators, and the colouration of their chicks also closely matches the coastal environment. Beach-nesting shorebirds nest closest to their food source so that when their eggs hatch, the tiny, precocial (i.e. relatively mature and mobile from the moment of hatching) chicks do not have to travel far to forage.

Birds that nest on beaches experience one of the harshest struggles of any bird to successfully produce young. Prior to human settlement, high tides, storms and native predators, such as gulls, ravens and birds of prey, had most impact on the breeding success of these birds, however, this was never severe enough to threaten the survival of beach-nesting species. Humans have greatly upset the natural balance between mortality and reproduction rates, by directly and indirectly impacting on the breeding success of beach-nesting birds, through: destruction and modification of habitat, introducing predators and contributing to increases in native predator populations, and recreational activities that lead to crushing of eggs and chicks, or disturbance of incubation, brooding or foraging activities which then leads to breeding failure. The features that adapt beach-nesting birds to their environment become detrimental to their breeding success where human recreation occurs: the location of nests, camouflage of the eggs and young, the long incubation and brood rearing phases, and the passive nature of nest and brood defence, make them highly susceptible to breeding failure.

Many beach-nesting bird species have experienced population declines, local extinctions and a contraction in range. They suffer from extremely low breeding success and are becoming increasingly threatened, due to mounting pressure from the human population and loss of habitat, and under further threat from rising sea levels associated with climate change. Despite the highly threatened nature of beach-nesting birds and their habitat, little emphasis has been placed on their conservation and management in the past. In Australia, there has been a bias in research and conservation efforts towards migratory shorebirds in comparison to resident species (Weston 2007), even though a greater number of resident species have threatened status (Milton *et al.* 2005). There are considerable gaps in our knowledge of the biology and habitat requirements of resident shorebirds (Marchant and Higgins 1993), of the threats (range and relative impacts), and the effectiveness of management actions aimed at tackling these threats.

The 'Promoting Coexistence between Recreationists and Beach-nesting Birds' project

In early 2006, Birds Australia (a non-government organisation committed to conservation of Australia's birds through information gathering and research) embarked on a project to improve and inform decision making for the conservation management of Australia's resident beach-nesting birds. The 'Promoting Coexistence between Recreationists and Beach-nesting Birds' project was funded by the Australian Government's Natural Heritage Trust and hosted by Port Phillip and Westernport Catchment Management Authority.

Total beach closures to protect these sensitive birds would deprive Australians of access to one of their most favoured environments and so would never be a feasible approach to their conservation. The project therefore focused on striking a balance between the protection of beach-nesting birds and the needs of beach recreationists (people that use the beach for recreational purposes, including walking, dog walking, swimming, surfing, fishing, etc.). This was primarily achieved through increasing awareness, understanding and involvement by communities in conservation of beach-nesters, particularly as many of the threats faced by these birds can quite easily be abated through public education, such as encouraging dog leashing on beaches during the breeding season.

The project used the Hooded Plover in Victoria as a case study for establishing management along the coast and investigating its effectiveness at improving breeding success. This project aimed to further develop and expand the management recommendations of Weston (2003) beyond areas managed by Parks Victoria, and was driven by many of the information gaps and research needs identified by Weston (2005). One hundred volunteers (including 17 groups) participated in monitoring 107 pairs of Hooded Plovers over two consecutive breeding seasons (2006-07 and 2007-08). These volunteers showed enormous commitment to the project, with each pair visited, on average, 23 times during a season, totalling 3,841 visits over the two years. This meant that for the majority of nests, we could pinpoint laying, hatching and failure dates (see Appendix 1 for a copy of the 2007-08 breeding season report). Volunteers also collected data on the threats present during each visit in the vicinity of the nest site. We were therefore able to relate breeding success directly to threats experienced by the pair, as well as management actions implemented.

Forty land managers participated in the project from 13 different agencies, including Parks Victoria, the Department of Sustainability and Environment (DSE), Committees of Management and local councils/shires. A range of management actions were investigated, including: *signage* (permanent interpretive signs, temporary signs flanking breeding sites, noticeboards); *fencing* the breeding site (permanent and temporary); placement of *chick shelters* on the breeding territory post-hatching; *wardening* of nest sites, and; fox control

measures (taste aversion training, baiting, trapping); as well as a range of educational actions including: distributing *brochures* to beach-users; mail-outs of *flyers and maps* to coastal residents; *school talks* at coastal primary schools; 'Dogs Breakfast' *public events*; community presentations and *workshops*, and; *media* releases.

This manual is based primarily on research findings and experiences with Hooded Plover management across the Victorian coast. It also draws heavily on research and experiences from managers across Australia and overseas involved with conservation of beach-nesting shorebirds, to review the range of threats experienced by beach-nesting shorebirds and the corresponding management techniques available for reducing/eliminating these threats, and to provide best practice advice for management implementation.

Beach-nesting bird nests. Photos: Grainne Maguire.

Chapter 1. Who are Australia's beach-nesting birds?

The following pages introduce Australia's resident beach-nesting shorebirds. Descriptions, photographs, distribution maps and information on habitat, breeding and threatened status are provided. Brief consideration is then given to other bird species that may nest on beaches in Australia, including the terns, to which some management actions covered in this manual are also applicable. Appendix 2 explores a selection of shorebirds from overseas which face similar threats to those in Australia.

Species descriptions

Pied Oystercatcher

Haematopus longirostris

Other Names: White-breasted Oystercatcher, Seapie, Red-bill, Wongbird, Eugerie-bird, (colloquially) Pied Oik.

Family: Haematopodidae

Length: 42-50 cm

Wingspan: 85-95 cm

Weight: 650-750 g

General description: Conspicuous, large, sturdy, black and white shorebird with long reddish bill, stout pink legs and feet. Tail reaches level with folded primaries. Sexes similar, but female slightly larger then male, with a slightly longer, more slender and pointed bill.

Similar species: None in Australia. Similar to South Island Pied Oystercatcher of New Zealand, *H. finschi*, which is thought to very rarely visit Australia.

Distribution: Continuously distributed around entire Australian coast, including offshore islands. Does not occur where sheer cliffs replace sandy beaches (e.g. east Nullarbor coast).

Habitat: Coastal, preferring intertidal mudflats and sandbanks, undisturbed sandy, shellgrit or pebble beaches, sand spits and sand bars, estuaries, coastal islands. Less

common along rocky reefs or shores, rock-stacks, and brackish or saline wetlands. Generally absent from coastlines of unbroken sea-cliffs.

Diet: Molluscs, worms, and crabs.

Social organisation: Breed as dispersed pairs, non-breeding birds flock, sometimes seen in family groups or as singles. In non-breeding season, flocks of up to 300 birds seen.

Breeding season: Broadly September- January in southern Australia, and from June, July or August in northern Australia.

Nest: Open beach above the high-tide mark on sand, shell-grit or shingle, sand-bars and margins of estuaries and lagoons, and dunes, at base or on slope, in open or among vegetation. Occasionally on mudflats or saltmarsh, and rock stacks, exposed coral ridges and offshore islands. Prefer undisturbed sites. High site fidelity (i.e. remain faithful to a site over time). Nest scrape is unlined or lined with shells, seaweed, dry seagrass, twigs, pieces of bark, leaves or grass.

Clutch size: 1-3 (average 2). **Egg description:** Stone grey, blotched and spotted blackish-brown or umber with inky grey underlining marks.

Breeding ecology: Both parents incubate, feed young and defend territory. Incubation 26-29 days. Young precocial but fed by parents until after fledging. Fledge at 7-8 weeks of age.

Breeding behaviours: Adults will remake scrape and return egg to it after being washed out by a high tide. When the incubating adult is disturbed, it generally remains silent, leaves nest and walks away, crouched, only flying from nest if pressed. It will lead to edge of territory and then fly back past nest or to other end of territory. Will false-brood (i.e. sit as though pretending to incubate eggs or brood chicks). During chick phase, parents will give alarm call, aerial circle, may chase or mob intruders, feign injury (broken-wing display) and give wing-rowing distraction display, or swoop. Other oystercatchers may join alarmed parents. Chicks will crouch, run and hide or may swim from danger. They generally remain hidden at high tide.

Threatened Status: Listed as of Least Concern on the IUCN Red List (2008). Listed as Vulnerable in NSW (Threatened Species Conservation Act) and Rare in SA (National Parks and Wildlife Act).

Sooty Oystercatcher

Haematopus fuliginosus

Other Names: Black Oystercatcher, Red-bill, Black Red-bill, (colloquially) Sooty Oik.

Family: Haematopodidae

Length: 40-52 cm

Wingspan: 100 cm

Weight: 750 g

General description: Large, stocky, all-black shorebird with long red bill, dull pink legs and feet, and long tail that extends past tips of folded primaries. Sexes distinguishable when together: female has longer more slender bill.

Sub-species: *Haematopus fuligniosus ophthalmicus* found in northern Australia (Gulf of Carpentaria and Cape York Peninsula) has larger, bare fleshy eye-ring and longer bill.

Similar species: Unmistakable, all black plumage distinguishes it from Pied Oystercatcher and all other Australian waders. Occasionally hybridizes with Pied Oystercatcher.

Distribution: Endemic to Australia, widespread in coastal east, south and west regions; mostly in the Bass Strait area. Distribution can be patchy along coast.

Habitat: Strictly marine coastal, usually within 50 m of the shore. Prefer rocky intertidal shorelines with little foliose algae (including rock stacks, wave-cut platforms, cliffs, reefs and outcrops), coral reefs or sandy beaches near intertidal mudflats. Sometimes on sheltered estuarine sand flats or banks, and sometimes seen on sandy beaches. In non-breeding season, may occupy sandy mudflats in sheltered bays.

Diet: Molluscs, crustaceans, polychaetes, ascidians, echinoderms and small fish.

Social organisation: Not well known. Breed as single, dispersed pairs; sub-adults and unpaired birds sometimes gregarious. Family or small groups of 6-8 seen, rarely solitary. May form larger winter flocks of 15-50 birds.

Breeding season: October to January; in southern Australia, eggs as early as July.

Nest: Commonly breed on offshore islands and rock stacks, often close to rocky coasts; on coral reefs and sometimes remote headlands or promontories or steep open beaches. Nest on sand, gravel or shingle or among coral rubble or rocks above high-tide mark; usually in open areas, but also amongst seaweed and vegetation such as pigface. Nest is unlined or lined with pebbles, shells, coral fragments, grass, twigs, seaweed, seagrass or samphire.

Clutch size: 1-3 eggs (average 1.8). **Egg description:** Stone coloured, blotched blackish-brown with markings of umber-brown and underlying spots and blotches of inky grey.

Breeding ecology: Both parents incubate, feed young and defend nest. Incubation unknown. Young independent 100-200 days after hatching.

Breeding behaviours: Incubating adults disturbed by an intruder will call, flick stones about, give distraction displays with wings held loosely from body and quivering, and may crouch or false brood. During chick phase, parents will feign lameness and roll and tumble on their backs. They will call, bob, walk rapidly to and fro over a 1-2 m area, or dive at the intruder. Young hide in crevices and under rock ledges, dive into rock pools and hide under ledges.

Threatened Status: Listed as of Least Concern on the IUCN Red List (2008). Listed as Vulnerable in NSW (Threatened Species Conservation Act) and Rare in SA (National Parks and Wildlife Act).

Beach Stone-Curlew

Esacus neglectus or giganteus

Other Names: Beach Thick-knee, Large-billed Stone Plover, Shore Plover, Beach Curlew.

Family: Burhinidae

Length: 54-56 cm

Wingspan: 89-109 cm

Weight: 1 kg

General description: Large thickset wader with distinctive shape; large head, up-tilted bill, short tail projecting a short distance from wing-tips, short legs with thick knees. Sexes alike.

Sub-species: None

Similar species: None; distinguished by large size, massive thick bill with yellow patches at base, and bold black and white pattern on head and wings that readily distinguish it from other waders. May be confused with Bush Stone-curlew, but is readily separated by size, stocky body and large bill. Similar in body size to Eastern Curlew *Numenius madasgacariensis*.

Distribution: North coast of Australia and associated islands, near Onslow in WA through to NSW, however now rarely seen along coastal regions in NSW.

Habitat: Exclusively coastal. Open undisturbed sheltered or surf beaches, offshore islands, beaches associated with estuaries, sandbanks, sand spits, coral atolls, reefs and rock platforms, tidal mud flats and sand flats, mangroves (< 1.5 m tall) and in coastal lagoons. Avoids long stretches of continuous mangroves or cliff.

Diet: Marine invertebrates, predominantly crabs.

Social organisation: Solitary or in pairs, generally not considered to flock but small gatherings can occur on moonlit nights. Breed as dispersed pairs, generally dispersed in lower densities than other shorebirds.

Breeding season: September – November (southern Australia), July – October/November (northern Australia)

Nest: Usually towards the landward side, above the high tide mark, on sandy beaches, or occasionally on sand banks or coral ridges, on islands or open coast. Nests have been observed in the open, among branches of fallen trees or under mangrove bushes. Nests can be in bare sand, encircled by dead leaves and twigs or lined with plant material.

Clutch size: 1 egg. **Egg description:** Creamy white, streaked and blotched olive-brown

Breeding ecology: Data limited. Incubation approximately 30 days, fledge at 7-12 weeks of age. Both adults defend nest and care for young.

Breeding behaviours: Incubating adult can be reluctant to leave nest and may become agitated. Pair known to charge intruder to within 20 m, sometimes in crouching position. If forced to leave young, they will fly in circle back to young when intruder retreats. Young

run and hide under vegetation and press body flat against sand. Apparently sensitive to disturbance.

Threatened Status: Listed as Near Threatened on the IUCN Red List (2008). Considered Vulnerable (Woodall and Woodall 1989) due to habitat destruction, low rate of reproduction, increasing predator numbers (including cats, dogs and feral pigs) and disturbance by people (Marchant and Higgins 1993; Garnett and Crowley 2000). Garnett and Crowley (2000) lists the species as of Least Concern due to much of the habitat around the Top End and on offshore islands remaining undisturbed and relatively pristine. Population size is estimated at between 1000 (Marchant and Higgins 1993) and 5000 (Garnett and Crowley 2000) individuals. Listed as an Endangered in NSW (Threatened Species Conservation Act) and Vulnerable in QLD (Nature Conservation Act).

Hooded Plover

Thinornis rubricollis

Other Names: Hooded Dotterel or Dottrel, (colloquially) Hoodie.

Family: Charadriinae

Length: 19-23 cm

Wingspan: 36-44 cm

Weight: 90-100 g

General description: Medium-sized, stocky and pale plover with a black 'hood', a broad white 'collar' across the back of neck that is bordered at the base by a thin strip of black, a blackish stripe that extends across the base of the neck and shoulders to the sides of the breast, pale brownish-grey upperparts (except for some blackish around the tip of the upper-tail) and white underparts. Red bill tipped black, red rings around the eyes, brown irises and dull orange-pink legs and feet. Sexes alike.

Sub-species: Not formally recognised as distinct subspecies, but Western Australian birds differ in plumage, morphology, ecology and habitat to those in Eastern Australia.

Similar species: Adult plumage is distinctive and unique among Australian waders, however, inexperienced observers, or those with poor or brief views (especially of birds in flight), could mistake Ruddy Turnstones *Arenaria interpres* for adult Hooded Plovers (eastern). Juvenile plumage (eastern) is also quite distinctive, however, juveniles could be confused with Sanderlings *Calidris alba*, Double-banded Plovers *Charadrius bicinctus* or Ringed Plovers *C. hiaticula* (although the Ringed Plover, which breeds in the northern hemisphere, is a rare and accidental visitor to Australia). Unattended nestlings of the Hooded Plover (eastern) can be mistaken for chicks of the Red-capped Plover *C. ruficapillus*.

Distribution: Endemic to southern Australia, from Jervis Bay NSW to western Eyre Peninsula SA, Kangaroo Island, Tasmania and Bass Strait Islands, and in south-west WA, east to the western end of the Great Australian Bight and north to approximately 30° S.

Habitat: Coasts and coastal and inland salt lakes. In their eastern range, prefer sandy, high-energy ocean beaches, especially those that are broad and flat with beach-cast seaweed and backed by sparsely vegetated sand dunes rather than cliff. In South Australia, can occur on low-energy sheltered beaches with large amounts of seaweed. Also found on estuaries, tidal bays, rock platforms and rocky reefs near sandy beaches, and small beaches in lines of cliffs. Regularly use saline and freshwater lakes and lagoons near the coast. In their western range, use coastal beaches less and are more common round margins and shallows of near coastal or inland open salt lakes; are thought to move inland when coastal lakes dry out and Autumn rains fill inland lakes.

Diet: Polychaetes, molluscs, crustaceans, insects, turions and seeds. Feed in run-stop-peck manner typical of *Charadrius* plovers.

Social Organisation: Breed as dispersed pairs (territories range from 0.3 - 2 km in length), unpaired birds and first year birds occur in small groups or singly. In the non-breeding season, flocks of 30-100 have been observed. In Western Australia, flocks of 500 + occur on inland salt lakes.

Breeding season: In eastern range, August - March, and sometimes replacement clutches laid in April; in Western Australia, breeding has been recorded in all months of the year.

Nest: In the eastern part of the range, on ocean beaches above the high-tide mark, in sand dunes up to 600 m from the sea, in dune blow-outs (unvegetated, sandy depressions in the dune 'blown out' by strong winds) and amongst Aboriginal middens, on sand spits and margins of estuaries, low sand islands, and occasionally amongst rocks or on rocky outcrops. In Western Australia, also on the shores of coastal and inland lakes. Nest in open or by/between driftwood, seaweed or sparse vegetation. Nest unlined or lined with pebbles, shells, stone, twigs or seaweed.

Clutch size: 1-3 eggs (average 2.2), rare occurrences of 4-egg clutches. **Egg description:** Pale white or yellowish-grey blotched and spotted blackish-brown with underlying markings of inky grey.

Breeding ecology: Egg laying interval of 24-48 hours; incubation 26-31 days; chicks fledge after 33-36 days.

Breeding behaviours: Both parents incubate, brood and defend young. Incubating bird will walk or run from nest when approached, either waiting by water's edge or walking ahead of intruder, then run or fly back to near nest. Disturbed, incubating bird will also false brood, bob and false feed. Birds may perform broken-wing display or rodent-run (mimics the movement of a mouse or rat) distraction displays during the egg phase (more likely closer to hatching), but more commonly when there are chicks. Parents call to chicks to warn of approaching danger, and defend either through leading, distraction displays, or by running and diving at avian predators. Chicks will crouch and flatten, or run and hide in or near seaweed, vegetation, driftwood, cuttlefish, flotsam and jetsam (objects washed ashore), under rock ledges or in wheel ruts or depressions made by footprints or horse/stock hooves when disturbed.

Threatened Status: Listed as Near Threatened according to the IUCN Red List (2008). The species was previously listed as Threatened under the *Threatened Species Act* but was removed around 2000. Listed as Endangered in NSW (Threatened Species Conservation Act), Vulnerable in Victoria (Flora and Fauna Guarantee Act) and Vulnerable in SA (National Parks and Wildlife Act).

Population size: Eastern population estimated at 3000 individuals. The estimated population sizes for each state are: 46 to 58 birds in New South Wales (NSW National Parks and Wildlife Service 2000-2008), 400 to 600 birds in Victoria (Murlis 1989; Weston 1995; Birds Australia Hooded Plover count data), 1,700 birds in Tasmania (Holdsworth and Park 1993; Newman and Patterson 1984) and 320 to 540 birds in South Australia (Bransbury 1983; Natt and Weston 1995). Population declines have been recorded in Victoria (Baird and Dann 2003; Weston 1993) and Tasmania (Woehler and Park 1997). The western population is estimated at between 4000-6000 individuals (Garnett and Crowley 2000; Birdlife International 2008).

Red-capped Plover

Charadrius ruficapillus

Other Names: Red-capped Dotterel or Dottrel, Red-necked Plover, Sand-Lark

Family: Charadriinae

Length: 14-16 cm

Wingspan: 27-34 cm

Weight: 35-40 g

General description: Small, compact, grey-brown and white plover, with rufous crown and hindneck. Sexes differ, females have duller plumage than males, with the loral stripe light rufous to grey-brown (never black as in male), rufous of head and neck, paler, with centre of crown and sometimes nape, pale grey-brown.

Similar species: Small size, fine bill, pale upperparts and white on sides of tail distinguish it from all other resident and migrant plovers. Larger than Red-necked Stint *Calidris ruficollis*, smaller and slimmer than Double-banded Plover *Charadrius bicinctus* with shorter rear end, shorter, finer bill and proportionately longer legs. Juveniles and first immatures may be confused with non-breeding and juvenile Double-banded Plovers.

Distribution: In Australia, widespread, mostly in southern half with scattered records in all districts, especially near coast. Also occur in Indonesia and have been sighted in New Zealand (Olsen and Trainor 2005).

Habitat: Littoral, estuarine and terrestrial wetlands, especially in arid areas. Prefer saline and brackish waters, but tolerate varying salinities, including freshwater and hypersaline. Highest numbers occur inland around salt lakes, permanent or ephemeral, with open bare mudflats and sparse vegetation on the upper shore. In coastal areas, they prefer saline wetlands behind the coast including saltmarsh and saltpans. Also occur in bays, inlets,

estuaries, river deltas and lagoons, and less often on wide flat sandy ocean beaches, mainly those backed by dunes or banks of sand, shingle or shell grit.

Diet: Annelids, molluscs, small crustaceans and some vegetation.

Social organisation: Poorly known. Solitary or in pairs, also in family groups or flocks (particularly in northern Australia) during breeding season. In non-breeding season, flocks of 200+ and up to 1000-2000 have been observed. May breed as dispersed pairs or in loose colonies.

Breeding season: Seasonal in southern Australia, July-January and occasionally into February and March. In northern Australia, breeding recorded in all months, but mostly March-May and August-November.

Nest: On ground in sand, shell grit, mud or stony areas, on beaches, dunes, estuaries, sand spits, sandflats along river foreshores, saline wetlands and lakes, on islands in samphire, brackish or freshwater lagoons, swamps and dam banks. Nest is unlined or lined with shells, stones, grass, saltbush, seaweed, waterweed, twigs, feathers and even sheep dung.

Clutch size: 1-3 eggs, almost invariably 2 eggs, rarely 4 eggs. **Egg description:** Pale sandy stone to pale brown tinged green, blotched, spotted and mottled dark brown and black, with fewer underlying markings of ashy grey.

Breeding ecology: Incubation 30-31 days, fledging period unknown.

Breeding behaviours: Female does almost all incubation, but male may incubate during or just after laying. Parents both defend nest and young, through leading, broken-wing or rodent-run displays, crouch-running and calling. Chicks will crouch or squat/hide beside seaweed or clumps of mud, or under vegetation, and remain motionless even if touched.

Threatened Status: Listed as of Least Concern on the IUCN Red List (2008).

Other beach-nesters

There are several other bird species that may nest on beaches, including the Bush Stone-curlew (*Burhinus grallarius*), which more commonly occupy open forest and woodlands but are a rare occupant of beaches and islands, and have been recorded as nesting on beaches above the high-tide mark on bare sand; and the Masked Lapwing (*Vanellus miles*), which has one of the broadest habitat ranges of any shorebird and is highly adapted to human modified landscapes, may occasionally nest on beaches but more commonly nests in the open on pasture, croplands, cultivated land, urban parks and gardens, and edges of wetlands.

Terns are another group of predominantly beach-nesting bird species. They are seabirds that feed mostly by surface plunging, occasionally shallow plunging, and by dipping. They can also feed by hawking for insects over land and water, and by gleaning food while walking on ground or in shallow water. They tend to be highly gregarious birds when

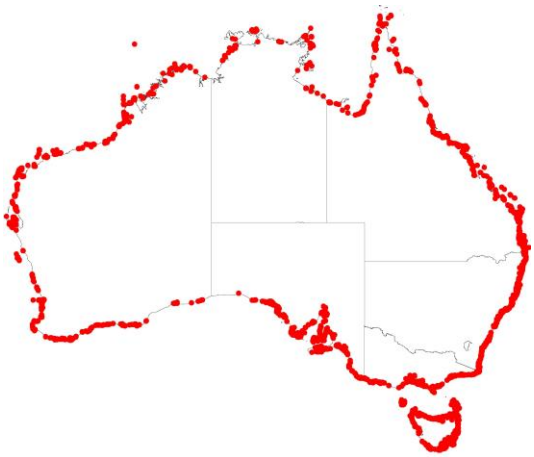
feeding, roosting and breeding, and normally breed in single-species or mixed-species colonies. A very small proportion of a few species may breed as isolated pairs (e.g. Caspian terns). The chicks are semi-precocial (not as developed) or precocial, but unlike resident shorebirds, are fed by the parents and this continues even after fledging. While the majority of terns breed in Australia, they have large ranges and most also breed internationally. All of the terns that nest on beaches in Australia are listed as of Least Concern according to the IUCN Red List (2008).

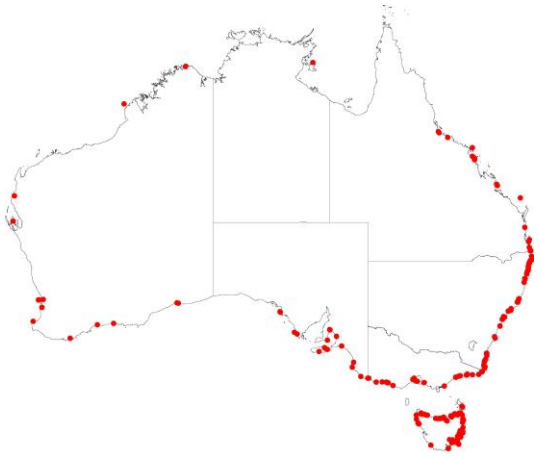
Terns are commonly beach-nesting birds, but because of the differences outlined above, are set apart from resident shorebirds that nest on beaches. While some management is similar for the two groups and ameliorating the overall impacts of human recreation on beaches would benefit both, the approach to management is very different for the two groups. Managing a colony is very different to managing widely dispersed breeding pairs, and the latter is a far greater challenge to managers because large numbers of breeding birds cannot be protected by single actions. This has resulted in differential investment in management of the two groups over time, as management of dispersed pairs is perceived as too costly relative to the proportion of the population protected.

Terns that breed on the Australian coast

- Caspian Tern (*Sterna caspia*): breed on low islands, cays, spits, banks, ridges and beaches of sand or shell, as well as among vegetation such as grasses, pigface, beaded glasswort or sea rocket. Breed often as solitary pairs, but also in colonies (3 to 200+ pairs). Often nest in association with other species of terns and gulls, particularly when nesting as solitary pairs.
- Lesser Crested Tern (*Sterna bengalensis*): breed in open areas on islands, low lying sandbanks, coral cays and rocky islands, and sometimes on isolated mainland beaches. Breed Colonially (2 to 2000+ pairs) and sometimes with other species of tern.
- Crested Tern (*Sterna bergii*): breed on islands, cays and banks of sand, shells, coral or rock. Rarely on reefs or in dunes. Nest in dense colonies (3 to 15,000 pairs), in mixed species colonies, and rarely as isolated pairs.
- Roseate Tern (*Sterna dougallii*): breed on offshore islands, mainly of sand, coral or rocks. Usually breed in colonies (20 to 5000 pairs), or in mixed species colonies, and only occasionally as solitary pairs.
- White-fronted Tern (*Sterna striata*): breed mostly in New Zealand, but also in Tasmania on exposed rocky islets, stacks or exposed reefs. Colonial breeders (10 to 2000+ pairs).
- Black-naped Tern (*Sterna sumatrana*): breed in tropical Indian and Pacific oceans; in Australia, in Northern Territory or Queensland. Nest in open, on sand or shingle beaches of coral cays or continental islands. Colonial (6 to 250 pairs), only one record of a solitary nest.

- Little Tern (*Sterna albifrons*): breed on sand-spits, banks, ridges or islets in sheltered coastal environments, such as lakes, estuaries and inlets, also on sandy ocean beaches and occasionally in sand dunes. Usually breed colonially (up to 50 pairs), occasionally with Fairy Terns and other tern species, or as solitary pairs. In NSW, colonies are usually small.
- Fairy Tern (*Sterna nereis*): nest above the high-tide mark on sheltered beaches, spits, bars, banks and ridges, usually of sand but also of shell grit or coral, either on the mainland or on inshore islands. In Australia, usually breed in colonies (2 to 400 pairs), but also nest solitarily. Often nest in association with other species, especially Little Terns.
- Sooty Tern (*Sterna fuscata*): breed on coral cays, atolls, sandbanks, rock stacks or offshore islets, in bare sand or coral grit, on beaches above the high-tide mark. Nest in large, conspicuous colonies (up to 246,000 pairs) or with other seabirds.
- Gull-billed Tern (*Sterna nilotica*): commonly breed on inland lakes and swamps or mud or sand islands, banks, flats or spits, rarely at coastal wetlands. Colonial (5 to 300+ pairs) and may nest in or near colonies of other species.



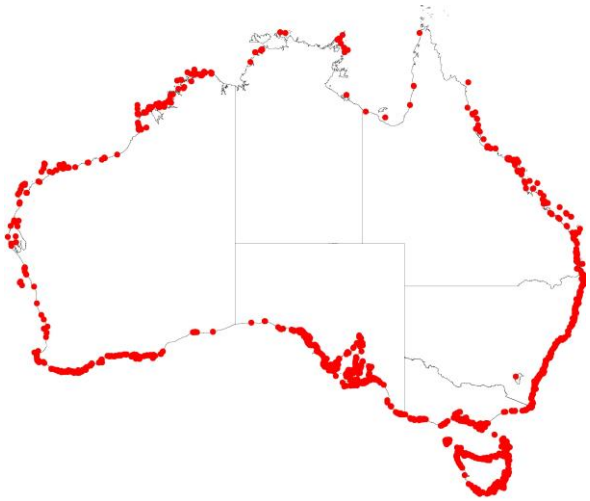


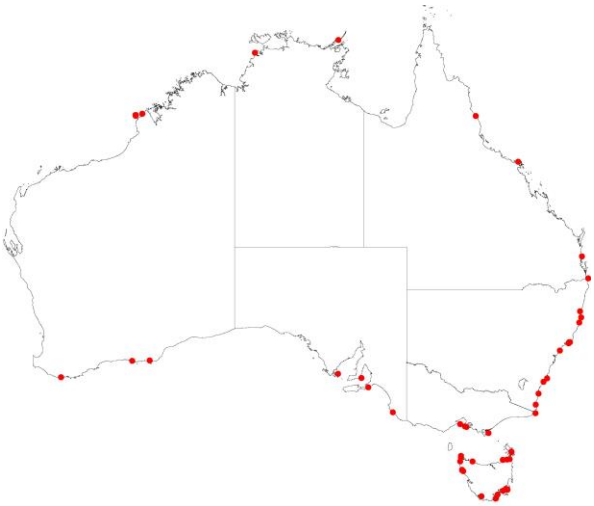
Pied Oystercatcher adult standing and incubating (Dean Ingwersen); Nest on rock (Grainne Maguire); Map of Australian distribution and known breeding locations (Birds Australia New Atlas Project 1998-2008); Nest on beach and eggs close-up (Grainne Maguire).





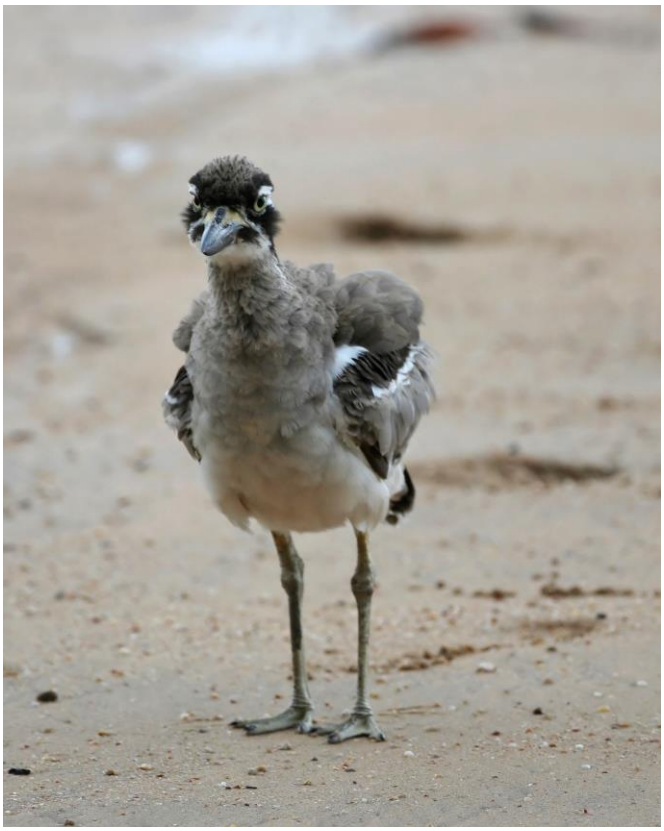

Pied Oystercatcher adult incubating (Dean Ingwersen); Adult walking (Chris Tzaros); Pied Oystercatcher chick walking and crouching (Glenn Ehmke); Pied Oystercatcher juvenile (left) with adult (Chris Tzaros); Juvenile (Chris Tzaros).

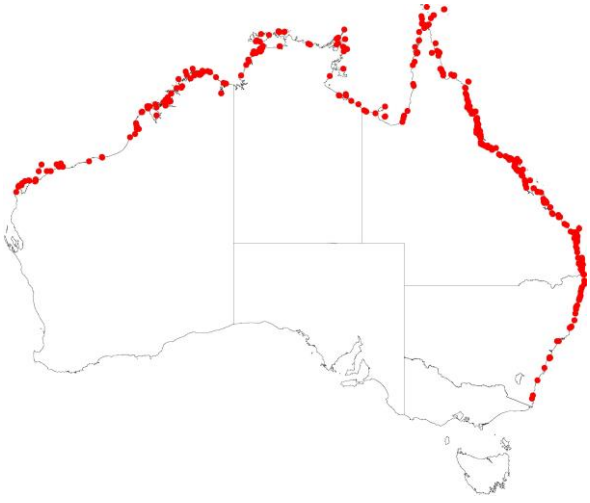


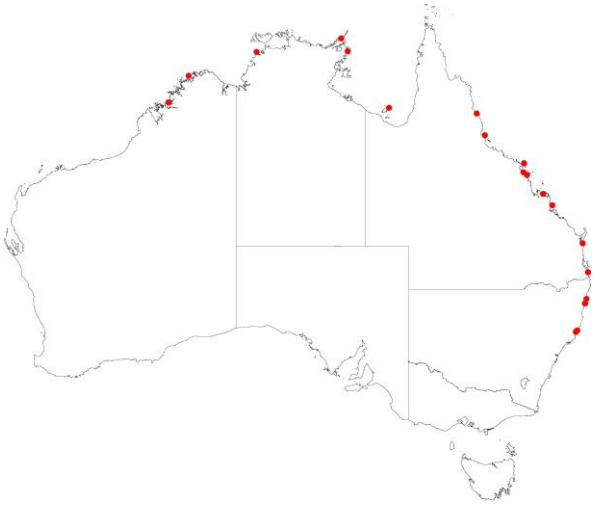


Sooty Oystercatcher adult (Glenn Ehmke); Adults on rock platform (Glenn Ehmke); Map of Australian distribution and known breeding locations (Birds Australia New Atlas Project 1998-2008); Sooty Oystercatcher nest on estuary; Nest under rock ledge (Glenn Ehmke).

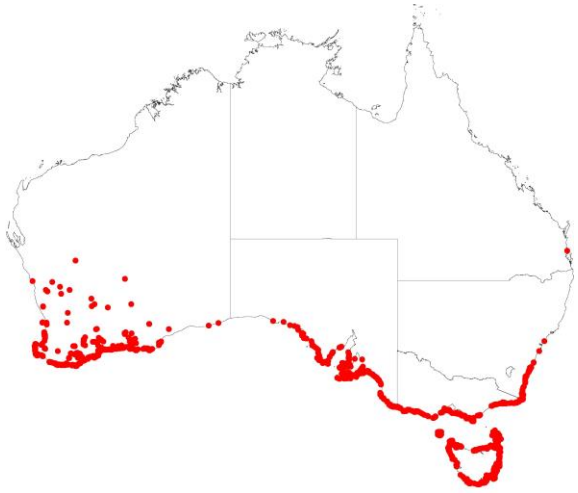
Sooty Oystercatcher adults resting on beach; Juvenile and adult giving alarm call. Photos: Glenn Ehmke.

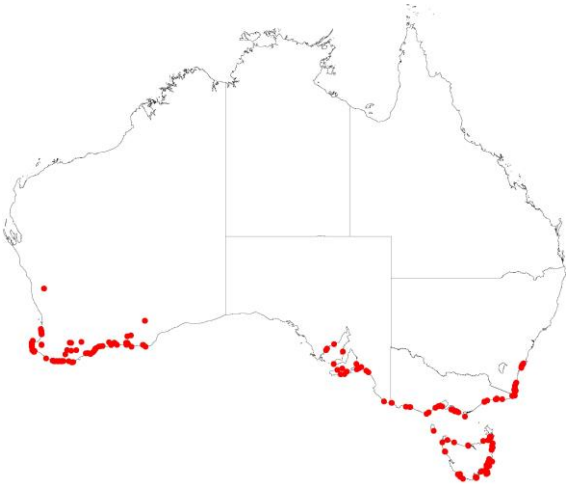


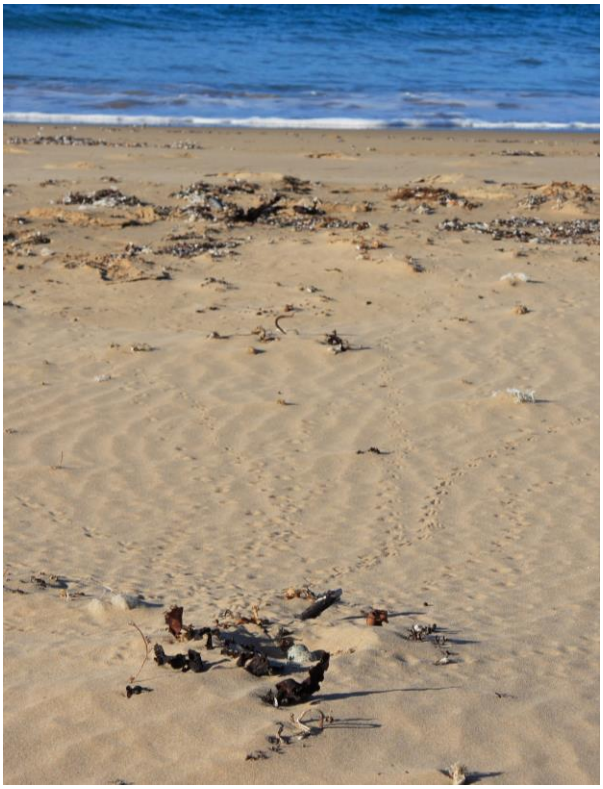




Beach Stone-curlew adult front-on (Ian Montgomery); Pair (Ian Montgomery); Adult (Dean Ingwersen); Map of Australian distribution and known breeding locations (Birds Australia New Atlas Project 1998-2008).



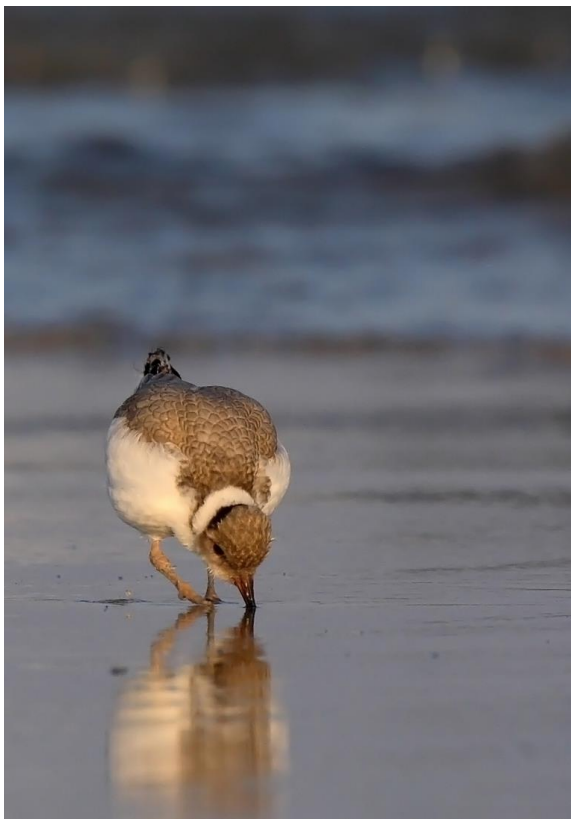




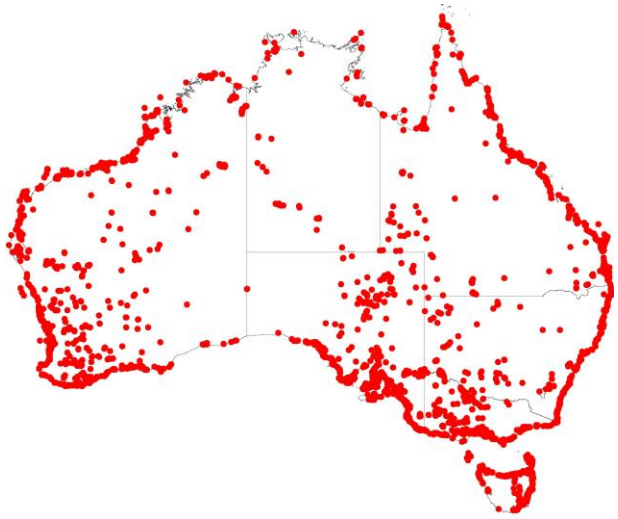
Adult Hooded Plover and Juvenile (Glenn Ehmke); Adult (Chris Tzaros); Map of Australian distribution and known breeding locations (Birds Australia New Atlas Project 1998-2008); Nest above the high-tide mark (Glenn Ehmke); Change over of incubation duty at nest (Glenn Ehmke); Egg close-up (Grainne Maguire).

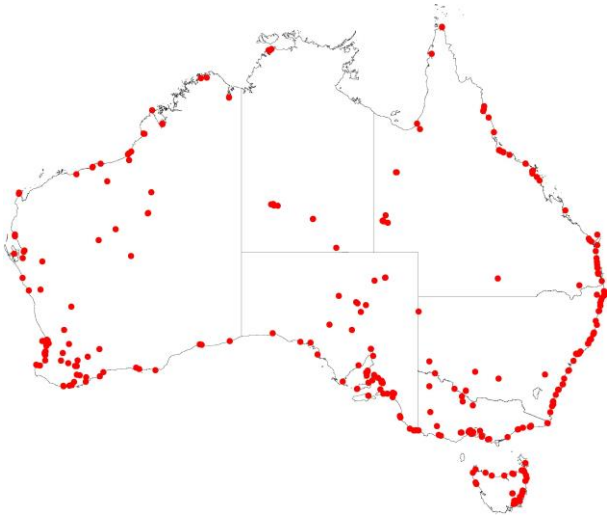






Hooded Plover 2-day old chick sitting in depression (Glenn Ehmke); 4-day old chicks feeding below high-tide mark (Glenn Ehmke); Chicks with metal leg bands (Mike Weston); Day of hatching (Mike Weston); Four-week old chick foraging (Glenn Ehmke); Fledged chick close-up (Mike Weston); Recently fledged chick (Glenn Ehmke).





Red-capped Plover adult male (Chris Tzaros); juvenile (Chris Tzaros); Map of Australian distribution and known breeding locations (Birds Australia New Atlas Project 1998-2008); Adult female (Dean Ingwersen); Adult male with invertebrate in beak (Chris Tzaros).







Red-capped Plover nests (Grainne Maguire); Adult male foraging (Glenn Ehmke); Chick (Mike Weston); Juvenile (Glenn Ehmke); Chick (Mike Weston); Family of Red-capped Plovers (left: juvenile, back: male; right: female; Photo: Glenn Ehmke).




Bush Stone-curlew (Dean Ingwersen); Masked Lapwing side on (Ashley Herrod); Masked Lapwing front on (Chris Tzaros); Masked Lapwing chick (Chris Tzaros).




Crested Terns courting and mating x 3 (Glenn Ehmke); Little Tern at nest (David Gallan).

Chapter 2. What are the threats to Australia's beach-nesting birds?

Beach-nesting birds are highly sensitive to changes to their habitat, introduced predators, and the wide range of human recreational activities that occur on their breeding beaches. The presence and intensity of these threats or threatening processes can vary both temporally (e.g. weekends vs. weekdays, holiday vs. non-holiday periods, season, time of day) and spatially (e.g. geographic location), and their impacts can be influenced by the morphology of the beach and climatic conditions. Threats operate by impacting breeding success of beach-nesting birds, either directly or indirectly:

Direct impacts

- Trampling and/or crushing eggs and chicks
- Eggs washed away by tides
- Eggs buried
- Eggs roll out of nests
- Drowning of chicks
- Predation of eggs, chicks and juveniles
- Predation of breeding adults
- Death of breeding adults and juveniles through collisions with vehicles or horses
- Death of chicks or breeding adults through entanglement

Indirect impacts

- Loss of habitat: reduces the species' distributional range, which influences genetic exchange between populations and the adaptational responses of populations to natural disasters, and results in the loss of breeding territories, which can lead to increased territorial disputes that disrupt breeding.
- Modification of habitat: can force birds to nest in suboptimal habitats, e.g. modification of the dune may result in birds nesting on beaches where nests are more vulnerable to

the tide, and where human recreation is more heavily concentrated (Weston and Elgar 2007).

- Disturbance of incubating adults: the most common form of nest defence for beach-nesting shorebirds is to temporarily abandon the nest when approached by a potential predator, such as a person or dog. The incubating bird will remain away from the nest until the potential predator has left the vicinity, so that the nest's location will be protected by its camouflage. If the adult remains away for too long or if disturbances are too frequent, the eggs can be exposed to harsh temperatures that lead to the death of the embryo inside (Welty 1982; Schulz and Bamford 1987; Bergstrom 1991; Schulz 1992a), or can be exposed to other approaching predators (Flemming *et al.* 1988; Hanisch 1998), as the bird becomes preoccupied with 'leading' or 'distracting' (see p. 168) the initial approaching predator (for a full review of impacts see Weston and Elgar 2007). Thermal stress to eggs also appears to result in higher rates of egg abandonment (Weston 2000).
- Disturbance of broods: beach-nesting shorebirds will warn their chicks when a potential predator approaches and the chicks will go into hiding. The chicks will remain hidden until the disturbance ends, and if this lasts for a long period or occurs too frequently, the chicks can die from exposure to harsh temperatures (dehydration, hypothermia) (Burger 1981; Watson 1988; Yalden and Yalden 1989, 1990; Bergstrom 1991), can be more susceptible to other approaching predators, as parents may be preoccupied with 'leading' or 'distracting' the initial approaching predator (Flemming *et al.* 1988; Ahlund and Götmark 1989; Keller 1991; Mikola *et al.* 1994), or can die from starvation due to reduced foraging time or being forced to forage in suboptimal habitat (Flemming *et al.* 1988; Burger 1991; Patterson *et al.* 1991; Loegering and Fraser 1995; Lord *et al.* 1997; Goldin and Regosin 1998). For a full review of impacts to Hooded Plover chicks see Weston and Elgar (2005). Flemming *et al.* (1988) found that Piping Plover (*Charadrius melodus*) chicks (in North America) fed less and were brooded less when humans were within 160 metres and that chick peck rate during feeding was lower when humans were present. They speculated that because chicks shifted from feeding and energy conservation activities to vigilance and cryptic predator avoidance behaviours, their energy reserves would be depleted, making them more susceptible to predators and inclement weather. Cairns (1977) found that Piping Plover chicks typically tripled their weight during the first two weeks after hatching and chicks that failed to achieve at least 60 % of this weight gain by day 12 were unlikely to survive. Furthermore, Loegering (1992) found that chick weight and bill length measured at four or five days of age were significantly higher for chicks that ultimately fledged than for those did not survive. This suggests that disturbance of foraging chicks and the resultant impact on weight gain, can significantly impact survival.

Summary of threats to beach-nesting birds and their impacts

Source of threat	**Impact (d= direct, i=indirect)**
Natural threats	
High tides	Washing out eggs (d); drowning chicks (d)
Storms and extreme weather	Washing out or burying eggs (d); egg/chick exposure (i)
Avian predators:	
Birds of Prey	Predation of chicks or adults (d)
Ravens/Magpies	Predation of eggs or chicks (d)
Gulls	Predation of eggs or chicks (d)
Other birds	Predation of eggs (d)
Reptilian predators	Predation of eggs or chicks (d)
Human-related threats	
Coastal development	Loss or modification of habitat (i); increases in predator numbers or predator use of habitat (i); increases in recreational pressure (i)
Recreationists:	
Static	Crushing of eggs or chicks (d); disturbance (i)
Mobile (non-motorised)	Crushing of eggs or chicks (d); disturbance (i); modification of habitat (i)
With dogs	Crushing of eggs or chicks (d); disturbance (i)
On horses	Crushing of eggs or chicks (d); collisions with and death of adults and juveniles (d); disturbance (i); modification of habitat (i)
In vehicles (land)	Crushing of eggs or chicks (d); collisions with and death of adults and juveniles (d); disturbance (i); modification of habitat (i)
In vehicles (water)	Disturbance (i)
In vehicles (air)	Disturbance (i)
Kites and Fireworks	Disturbance (i)
Stock (cattle, sheep, goats, camels)	Crushing of eggs or chicks (d); modification of habitat (i)
Litter	Entanglement and death of chicks or breeding adults (d); increases in predator numbers or predator use of habitat (i)
Introduced predators:	
Foxes	Predation of eggs, chicks or adults (d)
Cats	Predation of eggs, chicks or adults (d)
Rats	Predation of eggs and newly-hatched chicks (d)
Weeds:	
Sea Spurge	Loss or modification of habitat (i)
Sea wheat grass	Loss or modification of habitat (i)
Marram Grass	Loss or modification of habitat (i)
Sea rocket	Potential modification of habitat (i)
Dune stabilisation	Loss or modification of habitat (i)
Beach cleaning and kelp harvesting	Crushing of eggs or chicks (d); collisions with and death of adults (d); disturbance (i); loss or modification of habitat (i)
Driftwood removal	Crushing of eggs or chicks (d); disturbance (i); loss or modification of habitat (i)
Oil spills	Oiling and death of chicks and adults (d)

Detailed Threat descriptions

High Tides

Flooding of nests by high tides appears to be an important contributor to the loss of clutches (McGarvie and Templeton 1974; Murlis 1989; Stewart 1989; Ressom 2001). Over two successive breeding seasons from 2006 to 2008, 39 % of 121 identified Hooded Plover nest failures across the Victorian coast were attributed to high tides (Maguire unpubl. data). Dowling and Weston (1999) and Weston (2000), on the otherhand, found that only 2 % of 295 Hooded Plover nests were flooded in Victoria, and about 7 % of 79 nests were flooded in Tasmania (Hanisch 1998, Weston 2003). The relative importance of tidal inundation of nests can be difficult to calculate. It can either be overestimated, as it is one of the easiest causes of failure to identify, or underestimated, because many nests are lost to tides before they are detected. Flooding of nests may become more frequent as sea levels rise, and may be becoming more prevalent as dune habitats become less suitable for nesting, due to human modifications such as Marram Grass infestations and brush matting.

Chicks can be washed out to sea by freak waves and drown, especially when feeding at the water's edge or out on a rock platform. A drowned Hooded Plover chick was found at the high-tide mark on a beach in Anglesea, Victoria; the chicks at this territory were frequently observed foraging at the edge of rock platforms and were often left unattended as parents busily distracted passing humans and dogs (Maguire pers. obsv.). Hooded Plover broods on the beach have also been seen to be hit by large waves, and chicks washed seaward before they were able to escape (M. Weston pers. comm.). Oystercatcher chicks may be less vulnerable to drowning, as they are known to swim up to 150 m across lagoons and lakes (NSW National Parks and Wildlife Service 2007, 2008).

Management options

- *Nest relocation* (pp. 109-110): invasive, potentially enhances predator detection, may reduce learning behaviour. Should be considered only in cases where the pair have no room to adapt to high tides.
- *Walls and trenches* (p. 110): shows potential, but caution needs to be exercised to ensure adults and chicks can move safely to and from nest.
- *Encouraging dune nesting* (p. 119): preferable management option, encourages nesting in dunes where threats from human recreation are also reduced.

Storms and extreme weather conditions

Storm events can result in tidal surges, which increase the likelihood of nests becoming inundated. Storms also bring wild weather that can intensify the impacts of thermal stress

on eggs and chicks. Coupled with disturbance, the eggs can be quickly buried in strong winds; Hooded Plover nests have been almost three quarters buried by sand within 10 minutes of the parent being absent due to disturbance (Maguire pers. obsv.) and once eggs are completely buried, the parents abandon the nest (Maguire unpubl. data). On days of extreme heat (over 30º C) and extreme cold (less than 15º C), the eggs and chicks can quickly perish in the absence of incubating and brooding.

Management options

- *Nest relocation* (pp. 109-110): in the event that a storm is expected to increase the height of the highest tide beyond the level of the nest, it may be necessary to move the nest up to 2 m. Great caution needs to be taken to ensure incubation resumes at the relocated nest.
- *Temperature-relative temporary site closures* (p. 108): promising, but difficult to implement and dependent on a limited number of access points.
- *Chick shelters* (pp. 104-107): desirable management option for chicks providing shelter from extreme temperatures.
- *Shelter over the nest*: is not recommended as this will decrease the view incubating birds have of approaching predators/people and increase the conspicuousness of the nest, leading to nest abandonment or an increased likelihood of predation.

Hooded Plover nest inundated by tide; High-tide mark to base of dune; Hooded Plover eggs partially buried during strong winds. Photos: Grainne Maguire.

Avian Predators

Beach-nesting birds have evolved with a range of native avian predators. They defend their eggs and chicks through a number of adaptations (Page *et al.* 1983): (1) cryptic coloration of adults, eggs, and young, which acts as camouflage against detection by predators; (2) retreat from the nest at a predator's approach; (3) extreme mobility and

elusiveness of precocial young; (4) low nesting density; (5) active defence through running at or swooping aggressively at persistent predatory birds, or; (6) performing distraction displays, such as the broken-wing display or rodent run, to lure them away from hidden eggs/chicks. Weston and Elgar (2005) found that 96 % of encounters that elicited Hooded Plover aggression were with other birds, particularly gulls (62 %) and intruding conspecifics (22 %), as well as passerines (8 %), corvids (2 %) and raptors (2 %).

Development of the coast and human recreational pressure has resulted in major increases in some avian predator populations (e.g. gulls) and in their increased use of beaches for foraging (e.g. ravens, gulls). Consequently, the impacts of native predators are likely to be far higher than the natural levels beach-nesting birds have evolved with.

Signing and fencing of nesting areas on the beach and dunes may provide perches for avian predators (Hallett *et al.* 1995; Weston 2003; NSW National Parks and Wildlife Service 2007). Although signs and fences are important conservation tools in many areas, land managers need to be aware that modifications to them may be necessary to deter predators in some circumstances.

Birds of prey

Birds of prey have been reported as predators of beach-nesting birds worldwide. Kruse *et al.* (2001) reported American Kestrels (*Falco sparverius*) and Great Horned Owls (*Bubo virginianus*) as responsible for 93 % of Piping Plover chick mortality in South Dakota. American Kestrels and Peregrine Falcons (*Falco peregrinus*) are predators of Western Snowy Plover (*Charadrius alexandrinus nivosus*) chicks and adults, but have not been implicated in egg losses (U.S. Fish and Wildlife Service 2007). In one wildlife area, Snowy Plover fledging success increased from 9 % to 64 % after a kestrel unexpectedly disappeared, but dropped from 61 % to 23 % after a harrier began foraging there (Page *et al.* 1998). In 1997, a Merlin (*Falco columbarius*) was suspected of taking 13 banded Western Snowy Plovers within a period of just a few days (U.S. Fish and Wildlife Service 2007). Nankeen Kestrels (*Falco cenchroides*) have been observed predating Hooded Plover chicks (Weston 1998; Duivenvoorden 2007) and Peregrine Falcons (Schulz 1992b), and Black-shouldered Kites (*Elanus axillaris*), Swamp Harriers (*Circus approximans*) and Whistling Kites (*Haliastur sphenurus*) have been implicated in the disappearance of Hooded Plover and Pied Oystercatcher chicks in NSW (NSW National Parks and Wildlife Service 2007, 2008). Observations have also been made of Nankeen Kestrels predating Pied Oystercatcher chicks, and a White-bellied Sea-eagle (*Haliaeetus leucogaster*) predating an injured Pied Oystercatcher adult (NSW National Parks and Wildlife Service 2007). In New Zealand, a Harrier (*Circus approximans*) swooped at an incubating New Zealand Dotterel (*Charadrius obscures*), but the Dotterel escaped and the Harrier instead ate the eggs (Wills *et al.* 2003).

Duivenvoorden (2007) found that Hooded Plover chicks reacted strongly to the presence of birds of prey, almost as strongly as for humans, dogs and horses, and were more likely to run further distances towards the dune to hide than when responding to encounters with other birds. Weston and Elgar (2005) found that birds of prey caused Hooded Plovers to cease brooding in 33 % of encounters.

Management options

- *Chick shelters* (pp. 104-107): provide refuge for chicks from predators.
- *Predator exclusion* (pp. 127-131): is not recommended for sites where birds of prey are regularly observed, as they can use cages as a cue for detecting prey and have been observed predating adults and chicks exiting cages.

Ravens and Magpies

Raven (Forest Ravens *Corvus tasmanicus*, Australian Ravens *C. coronoides*, Little Ravens *C. mellori*) populations are thought to have increased since European settlement (Blakers *et al*. 1984; Schulz and Bamford 1987; Schulz 1992a). Increases in food resources, such as coastal tips and urban rubbish bins, may sustain artificially high populations, and ravens are attracted to the dunes when coastal shrubs are fruiting (Weston and Morrow 2000).

Ravens have been identified as major predators of beach-nesting bird eggs and, to some extent, chicks. In NSW, Victoria and Tasmania, ravens have been identified as predators of Hooded Plover and Oystercatcher eggs, accounting for up to 11 % of nest failures (Hanisch 1998; Weston 2000; Weston and Morrow 2000; Berry 2001; Keating and Jarman 2003; NSW National Parks and Wildlife Service 2006, 2007, 2008; Maguire unpubl. data). In western Victoria, ravens predated 21 % of experimentally deployed nests on beaches containing quail eggs (Stojanovic 2008). Liebezeit and George (2002) provide a thorough review of corvid predation on the eggs and chicks of threatened species, including Snowy Plovers and California Least Terns, in the USA. In the USA, nest predation by corvids (Common Ravens and American Crows) accounted for 12 %, 35 % and 50 % of Western Snowy Plover nest failures in three different regions (Hickey *et al.* 1995; Powell *et al.* 1996, Powell *et al.* 1997; Lauten *et al.* 2006). While ravens are not thought to prey on chicks to the same extent as eggs, when nest cages have been used to protect eggs, rates of chick predation by ravens have been high (U.S. Fish and Wildlife Service 2007; NSW National Parks and Wildlife Service 2008). Ravens are also known to have hunted and killed flying Hooded Plovers (Weston 2000, 2003).

Magpies have not been observed predating beach-nesting bird eggs, but adult Hooded Plovers display aggression and perform distraction displays to magpies, suggesting they are a potential egg predator (Weston 2000). An incubating Hooded Plover repeatedly performed the broken wing display to a magpie approaching its nest, even allowing the

magpie to peck at it before the magpie eventually gave up its search after over five minutes of distraction displays (Maguire pers. obsv.).

Duivenvoorden (2007) found that Hooded Plover chicks were frequently disturbed by approaching ravens and were more responsive to ravens than to gulls. The reaction of chicks was commonly to crouch on the spot. In one observation, a flock of 20 ravens flying vocally overhead, caused chicks to run and hide within an artificial teepee shelter and they did not emerge until the ravens had left the area. Weston and Elgar (2005) found that 77 % of Hooded Plover encounters with ravens resulted in interruptions to brooding (for up to a maximum of 19 minutes), and interruptions to chick foraging in 43 % of encounters. Lafferty (2001) found that Western Snowy Plovers are disturbed more intensely by encounters with corvids than all other threatening stimuli.

Management options

- *Chick shelters* (pp. 104-107): provide refuge for chicks from predators.
- *Predator control* (pp. 125-126): non-lethal methods, such as feeding stations, are preferred over lethal methods, such as poisoning and shooting; however some problem individuals may need to be lethally controlled.
- *Predator training* (pp. 126-127): ravens and magpies are intelligent birds and may respond well to 'conditioned taste aversion' training.
- *Predator exclusion* (pp. 127-131): nest cages are used widely by some managers, but this management option should be treated with extreme caution as there can be risks to the breeding birds and their chicks. Furthermore, this management does not offer a solution to predator impacts on chicks.

Gulls

Gull populations have undoubtedly increased since European settlement (Blakers *et al.* 1984). This is particularly true of the Silver Gull *Larus novaehollandiae*. Other native gulls common to the Australian coast are the Pacific Gull *L. pacificus* and the Kelp Gull *L. dominicanus*.

Silver gulls have been identified as predators of Hooded Plover, Little Tern and Pied Oystercatcher eggs. On the Bega River mouth in NSW, Silver Gulls destroyed 30 Little Tern nests by smashing eggs and consuming the contents (NSW National Parks and Wildlife Service 2006). On the Victorian coast, close to 8 % of Hooded Plover nest failures were attributed to gull predation (Maguire unpubl. data). Silver Gulls predated 19 % of experimentally deployed nests of quail eggs along beaches in Western Victoria (Stojanovic 2008). Silver Gulls have also been observed attacking and predating a two-day old Hooded Plover chick (Burke *et al.* 2004). Silver Gulls have been seen consuming Pied Oystercatcher

eggs in Tasmania (P. Park *in litt.* cited in Weston 2003). Interestingly, a Pied Oystercatcher has been observed nesting within a Silver gull nesting colony, less than half a metre from a Silver Gull nest, at Corner Inlet, Victoria (Maguire pers. obsv.). In the USA, gulls pose a special threat to breeding Western Snowy Plovers because they not only depredate nests and chicks, but also usurp and trample nesting habitat and crush eggs (Page *et al.* 1983; Persons and Applegate 1997; U.S. Fish and Wildlife Service 2007). In New Zealand, black-backed gulls account for 13.4 % of nest failures of New Zealand Dotterels on Matakana Island, and video footage revealed in one instance, that the incubating adult was unable to drive off a group of five gulls approaching the eggs (Wills *et al.* 2003). Furthermore, black-backed gulls account for a high number of New Zealand Dotterel chick mortalities (Wills *et al.* 2003).

Generally, beach-nesting birds are effective at defending their eggs and chicks against gulls (Weston 2000). However, gulls were able to approach nests more closely when the attending adults were disturbed away from the nest by humans, which may suggest gull predation is more likely in highly disturbed areas (Weston 2000).

Management options

- *Chick shelters* (pp. 104-107): provide refuge for chicks from predators.
- *Predator control* (pp. 125-126): non-lethal methods, such as feeding stations, are preferred over lethal methods, such as poisoning and shooting; however some problem individuals may need to be lethally controlled.
- *Predator training* (pp. 126-127): it is unknown as to whether gulls can be trained to avoid predating eggs using 'conditioned taste aversion'.
- *Predator exclusion* (pp. 127-131): nest cages are used widely by some managers, but this management option should be treated with extreme caution as there can be risks to the breeding birds and their chicks. Furthermore, this management does not offer a solution to predator impacts on chicks.

Other birds

A number of other bird species may contribute to nest failure of beach-nesting birds. Pied Oystercatchers have been observed predating Hooded Plover eggs (Weston 2003). Masked Lapwings have been observed destroying four New Zealand Dotterel clutches, pecking one to two small holes in each egg (Wills *et al.* 2003). Australian White Ibis (*Threskiornis molucca*) and Straw-necked Ibis (*T. spinicollis*) are known to forage on beaches and have been suggested as a potential predator of beach-nesting bird eggs (B. Baird *in litt.* cited in Weston 2003). However, in a comprehensive review of the diet of both ibis species, neither was recorded eating young birds or eggs, but they will sometimes eat small mammals (Marchant and Higgins 1990). Ibis could potentially crush the eggs of smaller beach-

nesting bird species, as they forage over extensive areas of the upper beach and dunes (Weston 2003; Maguire pers. obsv.).

Burger (1987) suggests that by nesting near more aggressive nest defenders, such as terns, beach-nesting shorebirds may experience greater nesting success. However, this is questionable as birds may spend a lot of time defending their nests from the terns themselves (Flemming 1987). Little Terns have been observed harassing nesting Hooded Plovers, which resulted in high levels of disturbance (NSW National Parks and Wildlife Service 2006). An Artic Tern has been observed killing a Piping Plover in a territorial dispute (Flemming 1991).

Conspecifics (members of the same species) are also potentially disturbing to beach-nesting birds. Intruding Hooded Plovers have been observed dive-bombing and striking Hooded Plover chicks, resulting in lengthy aggressive encounters between the parents and intruders (Teoh and Weston 2002; G. Ehmke pers. comm.). On the Mornington Peninsula in Victoria, the frequent and lengthy territorial disputes between Hooded Plovers and a small flock of non-breeding Hooded Plovers were thought to have contributed to the loss of a brood of four, due to the brood being left unattended for long periods (Maguire pers. obsv.). Furthermore, frequent disputes between Hooded Plovers and their conspecifics have been implicated in the failure of nests with eggs that became buried in heavy winds while the parents were absent (Maguire unpubl. data). The loss and modification of habitat may enhance territorial disputes between beach-nesting birds, as they may be forced to nest closer to one another or be left without a breeding territory.

Management options

- *Chick shelters* (pp. 104-107): provides refuge for chicks from predators.
- *Predator exclusion* (pp. 127-131): nest cages are used widely by some managers, but this management option should be treated with extreme caution as there can be risks to the breeding birds and their chicks. Furthermore, this management does not offer a solution to predator impacts on chicks.

Reptilian Predators

Goannas have been identified as predators of Hooded Plover and Pied Oystercatcher eggs (Lashmar 1984; Bransbury 1991; Schulz 1995; NSW National Parks and Wildlife Service 2006, 2007, 2008). Snakes are also suspected of taking Hooded Plover eggs (Weston 2003). There is no evidence to suggest that natural rates of reptilian predation have increased; for example on Kangaroo Island, goanna numbers have remained stable over time (Dennis and Masters 2006).

Management options

- *Predator control*: if the impacts of reptilian predators are considered significant, it may become necessary to use non-lethal methods of control, such as relocation of problem individuals.
- *Predator exclusion* (p. 127-131): nest cages may be ineffective at protecting eggs from reptiles as they can enter or reach inside due to the recommended mesh size for shorebird cages.

Avian predators: Australian Magpie, Peregrine Falcon, White-bellied Sea Eagle, Nankeen Kestrel x 2, Forest Raven. Photos: Grainne Maguire (magpie), Glenn Ehmke, Dean Ingwersen (raven).

Avian predators: Hooded Plover attacking Silver gull, Silver gull flocks, Pacific Gulls, Kelp Gulls on rock.
Photos: Glenn Ehmke, Grainne Maguire (black and white silver gulls).

Hooded Plover chick being attacked by intruding Hooded Plover; parents defending and attacking intruder.
Photos: Glenn Ehmke.

Coastal Development

Coastal developments can destroy or degrade beach-nesting bird habitat, leading to abandonment of areas by beach-nesting birds or increased exposure to threats. Development leads to the necessity for greater coastal infrastructure (e.g. access points) and associated dune stabilisation, which further reduce habitat availability and suitability (Weston and Morrow 2000; U.S. Fish and Wildlife Service 1996). Habitat loss and degradation caused by urban development through construction of seawalls, breakwaters, jetties, piers, homes, hotels, parking lots, access roads, trails, bike paths, day-use parks, marinas, ferry terminals and recreational facilities has led to significant declines in Western Snowy Plover numbers (U.S. Fish and Wildlife Service 2007). Jetties and groins for example may cause significant habitat degradation by robbing sand from the down drift shoreline (U.S. Fish and Wildlife Service 2007).

In the USA, Piping Plovers appear to select areas for nesting that are less accessible or receive few visitors (Hoopes 1993; Elias-Gerken 1994; U.S. Fish and Wildlife Service 1996) and will shift their habitat use in response to the presence of people (Burger 1991, 1994). After preventing human access, areas have been recolonised by Piping Plovers for breeding (U.S. Fish and Wildlife Service 1996). Oystercatchers and Beach Stone-curlew generally avoid developed and highly disturbed areas. This is consistent with the predictions of Blumstein *et al.* (2005) that larger species will have greater alert distances to people and predators, increasing spatial and temporal limitations on suitable habitat with increasing human visitation. On the other hand, Hooded Plovers can occur on heavily disturbed beaches. Across Victoria, Hooded Plovers occur on average within 950 m of a beach access point (Birds Australia Hooded Plover count 2006). This is largely due to development of most available ocean coast in Victoria. While species such as Hooded Plovers may persist in heavily developed or recreated areas, it is in these areas where breeding success is lowest and these sites can be considered population sinks. On the South African coast, the African Oystercatcher (*Haematopus moquini*) experiences significantly lower feeding rates in developed parts of the coast, compromising its ability to raise even a single chick successfully in the face of disturbance (Leseberg *et al.* 2000).

The construction process itself can cause intense disturbance to birds that are wintering or breeding in an area. Burton *et al.* (2002) found that construction of a barrage, bridge and housing development in a coastal area in the United Kingdom led to reduced densities of five species, including the Eurasian Oystercatcher *Haematopus ostralegus*, and to reduced feeding activity. It was suggested that the disturbance to feeding led to birds leaving the site to seek less disturbed feeding areas.

Management options

- *Coastal planning considerations* (pp. 153-154): direct and indirect impacts to beach-nesting birds should be considered during the planning of any coastal development.
- *Site closures* (pp. 107-108): in the face of increasing coastal development, it may become necessary to set aside some beaches as conservation areas, either permanently or seasonally preventing access.
- *Regulations and enforcement* (pp. 142-153): recreation on breeding beaches should be appropriately regulated, particularly with regard to dogs, horses and vehicles.
- *Policy changes*: where regulations are deemed inadequate at protecting beach-nesting birds from human impacts, it may become necessary to make these regulations stricter.
- *Educational programs/materials* (pp. 133-140): where developments adjacent to breeding beaches occur, an education program needs to be implemented to raise awareness about the threats to beach-nesting birds.

Recreationists

People visit the beach for a variety of recreational purposes and these can be split into different categories according to the way in which these activities impact beach-nesting birds:

Static activities

This refers to recreational activities that are concentrated in one location, for example, sunbaking, picnicking, sandcastle building, fishing and pipi collecting (Weston in prep.). Weston (in prep.) recorded the presence of static activity during 74.4 % of 82 days of observations of Hooded Plover breeding territories. Static activities predominantly occurred on the upper beach. This suggests that these activities carry a greater risk of crushing nests located above the high-tide mark.

Static activities are also likely to negatively impact breeding success through disturbance if the activity occurs too close to the nest or chicks (Burger 1986; McGarical *et al.* 1991). An experiment by Weston (in prep.) showed that disturbance was more extreme for static compared to mobile people: incubating Hooded Plovers stayed off the nest for longer and were less likely to return to the nest when disturbed by a static person. Fahy and Woodhouse (1995) further reveal that the disturbance types that kept incubating Western Snowy Plovers off their nests for the longest period of time were stationary visitors and surf fishermen, probably because of the duration of these stationary disturbances that occurred close to nests. Schultz and Stock (1993) found that resting and sunbathing people were apparently more disruptive to Kentish Plovers (*Charadrius alexandrinus*) than walking people because the latter generally followed the high-tide line.

Static activities are likely to be long in duration (e.g. longer than an hour) and thus even a single event has the potential to cause nest failure, particularly on days of extreme weather. For example, if a person was to sunbake close enough to a nest to keep the incubating adult from returning, and to remain there for one or two hours on a day with temperatures exceeding 30º C, then the eggs would most likely bake on the hot sand and the embryo inside would die. If a group of picnickers was to disturb chicks into hiding and set up their picnic on the beach nearby, then the chicks may stay hidden for the entire duration of the picnic – if the day is too hot, they could dehydrate and if it is too cold, lack of parental brooding could lead to hypothermia. If there are multiple static recreationists on the beach at once, then chicks have little opportunity to come out and feed on the beach and by the water's edge, which could lead to starvation.

Dune boarding or racing/sliding down the dunes are also static activities, but these fall into a higher category of threat. Dune boarders have a high probability of crushing nests and chicks as they cover a greater area of the upper beach and dunes, and they disturb incubating birds and foraging chicks if they are too close to the breeding site. Dune boarding also heavily impacts the environment by severely eroding the dune face and destroying native vegetation. This not only discourages beach-nesting birds from selecting these impacted sites for nesting, but also encourages land managers to lay brush over these dune faces, making them unsuitable for nesting for the long term.

Management options

- *Signs* (*permanent, temporary notices, flanking the nesting site*; pp. 86-89): it is extremely important to stipulate that recreationists should not sit in front of or too close to nesting sites. Sometimes it may be necessary to erect a warning sign below the high-tide mark that highlights this area as a feeding zone or disturbance buffer.
- *Fences* (*temporary rope or mesh fencing*; pp. 97-104): effective at symbolically delineating the buffer zone.
- *Site closures* (pp. 107-108): it may become necessary to prevent access to a site during the breeding season or on days of extreme temperature, to reduce impacts of disturbance.
- *Site wardens* (pp. 141-142): are particularly effective during busy periods, such as on weekends or public holidays; wardens help reinforce messages on signage and increase the effectiveness of protective fences. Wardens can be especially useful for protecting mobile chicks.
- *Educational programs/materials* (pp. 133-140): raising public awareness about the threats to beach-nesting birds is fundamental to bringing about long-term social change in recreational behaviour.

Static and mobile beach activities. Photos: Grainne Maguire, Glenn Ehmke, Matt Hoskins, Jen Sutfin.

Mobile (non-motorised) activities

This refers to recreational activities where people move through an area, for example, walkers and joggers. Mobile humans predominantly use the wet, hard sand as it is easier to walk/jog on, and thus the majority of mobile humans are less likely to impact beach-nesting birds. However, for people that travel above the high-tide mark or through the dunes (often used for athletic or football training, boot camps, etc.), the chances of crushing eggs or chicks are high. In Mornington Peninsula National Park, Victoria, 30 % of Hooded Plover nests were crushed by humans prior to implementation of management actions, and this occurred in both beach (51 %) and dune (21 %) habitats (Dowling and Weston 1999). Hooded Plovers often nested near to informal dune tracks, presumably due to the openness of the area, and thus were vulnerable to crushing (Dowling and Weston 1999). Furthermore, Dodge *et al.* (in prep.) showed that most artificial beach-located nests were crushed by mobile humans (64 %), but also indicated that mobile humans exhibited the highest rate of compliance with protective signage and fencing, thus showing high potential for this threat to be reduced.

Mobile humans are likely to disturb incubating birds or foraging chicks, but for short periods in comparison to static activities. Nevertheless, disturbance can be severe enough to cause breeding failure if mobile humans pass nests frequently, as impacts are cumulative. Fahy and Woodhouse (1995) found that incubating Western Snowy Plovers were most frequently flushed by joggers and walkers than any other type of recreationist. Weston and Elgar (2007) found that walkers accounted for almost 50 % of encounters (n=1821) that incubating Hooded Plovers experienced and caused the incubating bird to temporarily abandon the nest 21.5 % of the time. The frequency of disturbance by walkers was lower than expected and it was suggested that walkers without dogs may be less threatening than other stimuli because they are slow moving, do not persecute the birds and occur frequently (Weston and Elgar 2007). Regardless, the frequency of their occurrence still accounted for the highest percentage of time birds spend off the nest relative to natural breaks from incubation or to encounters with potential avian predators (Weston and Elgar 2007). The maximum duration of time a bird was disturbed from the nest by walkers was 24.5 minutes, not including cases where multiple disturbances occurred in succession, where birds were unable to return to the nest for longer periods. Furthermore, joggers and walkers accounted for 59 % of disturbances to Hooded Plovers with broods (in 1510 encounters with potential threats) and caused chicks to hide for the longest duration until they resumed normal activity (Weston and Elgar 2005). Human encounters were more likely to cause chick foraging to cease than encounters with potential avian predators (Weston and Elgar 2005).

Management options

- *Signs* (*permanent, temporary notices, flanking the nesting site*; pp. 84-89): important for directing visitors to walk past nesting sites along the water's edge.
- *Fences* (*permanent access point or dune fencing, temporary rope or mesh fencing*; pp. 96-104): permanent fencing is effective for directing visitors to the beach along formalised paths to reduce erosion impacts and risks of egg/chick crushing, and temporary fences for symbolically delineating the nesting area that needs to be avoided.
- *Chick shelters* (pp. 104-107): offer refuge from approaching pedestrians.
- *Site closures* (pp. 107-108): it may become necessary to prevent access to a site during the breeding season or on days of extreme temperature, to reduce impacts of disturbance.
- *Sympathetic dune stabilisation* (p. 111): where access through the dunes is problematic, erosion control may need to be implemented but this needs to be sympathetic to the nesting requirements of beach-nesting birds.
- *Site wardens* (pp. 141-142): are particularly effective during busy periods, such as on weekends or public holidays; wardens help reinforce messages on signage and increase the effectiveness of protective fences. Wardens can be especially useful for protecting mobile chicks.
- *Educational programs/materials* (pp. 133-140): raising public awareness about the threats to beach-nesting birds is fundamental to bringing about long-term social change in recreational behaviour.

Recreationists with dogs

Humans accompanied by a dog, particularly an unleashed dog, have been recognised as posing a much greater threat to breeding birds and their eggs and chicks compared to humans without a dog (e.g. Page *et al.* 1977; Pike 1985; Burger 1986; Hoopes 1993; Fahy and Woodhouse 1995; Bryant 2002; Dowling and Weston 1999; Finney *et al.* 2004; Lafferty 2001; Lord *et al.* 2001; Weston 2003; Wills *et al.* 2003; Yalden and Yalden 1990).

In over 150 hours of observations on 15 nests, Page *et al.* (1977) found that Western Snowy Plovers flushed more frequently and remained off their nests longer when a person was accompanied by a dog than when alone. Within 50 m, people with dogs caused flushing 100 % of the time and at a distance of over 100 m, people with dogs caused flushing 52 % of the time (Page *et al*. 1977). Adult Piping Plovers and their chicks ceased feeding 52 % of the time when dogs were within 50 m compared to 31 % when humans were within the same proximity (Hoopes 1993). Hoopes (1993) also found that the response distance of Piping Plovers was greater for dogs (46 m) compared with humans (23 m), and that the reacting birds moved more than double the distances and remained away from the nest longer when disturbed by dogs compared to people. Yalden and Yalden (1990) found that

breeding plovers in the United Kingdom flushed from the nest at greater distances when a walker was accompanied by a dog. Lord *et al.* (2001) studied the impact of three treatment types (walking, running or leading a dog) on northern New Zealand Dotterels and found that people who were accompanied by a dog caused the greatest level of disturbance in terms of flush distance, length of time away from the nest and distraction display intensity.

At wintering sites, disruption of foraging and roosting may result in decreased accumulation of the energy reserves necessary for shorebirds to successfully breed or for migratory birds to complete the migration cycle (Burger 1986, Pfister *et al.* 1992). Wintering Western Snowy Plovers were flushed in 73 % of 74 instances when dogs with or without people approached to within 15 m (Golden Gate National Recreation Area unpubl. Data cited in U.S. Fish and Wildlife Service 2007).

The highest frequencies of Hooded Plover nest absences were in response to humans accompanied by unleashed dogs (Weston and Elgar 2007). Hooded Plovers appear to respond with higher rates of nest absences in response to encounters with unleashed dogs compared to leashed dogs. Incubating Hooded Plovers left the nest in 21 % of encounters with leashed dogs, similar to that for encounters with walkers, while 38.4 % of encounters with a walker accompanied by an unleashed dog caused the incubating bird to leave the nest for as long as 30 minutes (Weston and Elgar 2007). Furthermore, unleashed dogs (with walkers) caused the brooding of chicks to cease on 51.4 % of encounters, compared with 33.3 % for leashed dogs (Weston and Elgar 2005). This suggests that it is the behaviour of dogs rather than their mere presence that influences disturbance of breeding Hooded Plovers.

Domestic dogs have been known to partially or entirely destroy shorebird nests, including those protected with symbolic fencing (e.g. Western Snowy Plover nests, cited in U.S. Fish and Wildlife Service 2007; experimental beach-located nests, Dodge *et al.* in prep.; Hooded Plover nests, B. Baird pers. comm., Maguire unpubl. data). On the Victorian coast, 10 % of known Hooded Plover nest failures were attributed to dogs crushing or predating eggs (n=121; Maguire unpubl. data), and on Phillip Island, at least 24 % of nests over a four year period were lost to dogs (B. Baird unpubl. data). Dogs have been observed eating Hooded Plover eggs (Hanisch 1998) and mauling (Weston 1998c; Weston and Morrow 2000) and killing Hooded Plover chicks (B. Baird pers. comm.). Furthermore, domestic dogs are known to chase adult beach-nesting birds (Retallick and Bolitho 1993; Weston and Morrow 2000; Maguire pers. obsv.), which can lead to prolonged absences from the nest or brood. Unleashed dogs have been observed chasing Piping Plovers (McConnaughey *et al.* 1990), destroying their nests (Hoopes *et al.* 1992), and killing their chicks (Cairns and McLaren 1980; U.S. Fish and Wildlife Service 1996). Dogs have also been observed killing New Zealand Dotterel chicks (Wills *et al.* 2003).

Lambert and Ratcliff (1979) and Taylor *et al.* (2005) suggest that it is likely that dogs are seen by shorebirds as much more of a threat than humans, as dogs are more likely to catch and kill them or their chicks. It would not be adaptive for a bird to distinguish between dogs that will chase and those that won't, as a mistake in judgment is potentially life threatening. Birds might also perceive the pattern of movement of an unleashed dog on a beach as more threatening than the movement of a leashed dog, due to the their tendency to move up and down the beach perpendicular to the water's edge (Burger 1986), and the unpredictable nature and the speed of this movement (Maguire pers. obsv.). Animals often develop anti-predator responses to rapidly approaching objects or loud noises (such as a running or barking dog), even if that object is not a known predator (Frid and Dill 2002).

The threats that unleashed dogs pose to breeding birds can be reduced through responsible ownership. However, there appears to be a distinct reluctance for dog owners worldwide to leash their dogs, even on beaches that are clearly signed as off-limits to dogs or as on-leash areas (Natt and Weston 1995; Dowling and Weston 1999; Weston 2003; Dodge *et al.* in prep.; U.S. Fish and Wildlife Service 2007). Dodge *et al.* (in prep.) revealed that 20 % of dog owners were non-compliant with protective signage and fencing, and 99 % of this non-compliance was through not leashing their dog. In New Zealand, Bridson (2000) discovered that most people thought that dogs were a threat to breeding New Zealand Dotterels, including those that regularly walked their dogs at the beach. Between 68-78 % of respondents thought that dogs should be excluded from 'wildlife refuge' beaches, but largely because of the disruption this caused to their own recreational experience. More than 90 % of respondents believed in fining dog owners in breach of regulations, however, many thought that only owners of 'big dogs', uncontrolled dogs or those caught chasing birds should be prosecuted (Bridson 2000). In her interviews of dog owners from coastal Victoria, Henry (2006) discovered that the majority of respondents did not feel obliged to leash their dogs at the beach. This was potentially explained by: conflicting values about wildlife conservation, human recreation and dog access to beaches; the commonly held belief that people's own dog(s) are less of a threat to beach-nesting birds than dogs in general, and; a strong belief that unleashed exercise is beneficial for dog health. Several external barriers to compliance were identified, including the *social influence* of beaches generally being perceived by the broader dog-owner community as a good place for unleashed dogs, lack of *provision of information about the threats that dogs pose to beach-nesting birds*, lack of, or at least lack of awareness, of *designated off-leash areas* and lack of *enforcement*. Enforcement of dog regulations on beaches by the managing agencies is often lax or nonexistent (Weston 2003; U.S. Fish and Wildlife Service 2007).

Management options

- *Signs* (*permanent, temporary notices, flanking nest site*; pp. 84-89): important for directing visitors to leash their dogs and to walk past nesting sites along the water's edge.
- *Fences* (*permanent access point or dune fencing, temporary rope or mesh fencing*; pp. 96-104): permanent fencing is effective at directing visitors to the beach along formalised paths to reduce erosion impacts and risks of egg/chick crushing. Temporary rope fences are only effective if dog owners leash their dogs when passing. Mesh fencing is necessary in areas with low compliance with leashing, but these offer little protection for chicks that are a distance from the fenced area.
- *Chick shelters* (pp. 104-107): offer a hiding place for chicks from approaching dogs.
- *Regulations and enforcement* (pp. 142-153): as a minimum, dogs must be leashed on breeding beaches. High rates of non-compliance with leashing regulations create a need for enforcement.
- *Policy changes*: where regulations are deemed inadequate at protecting beach-nesting birds from dog impacts, it may become necessary to make these regulations stricter. Alternative off-leash areas should be provided.
- *Site wardens* (pp. 141-142): are particularly effective during busy periods, such as weekends or holidays; wardens encourage dog owners to leash their dogs and provide educational materials. Wardens can be especially useful for protecting mobile chicks.
- *Educational programs/materials* (pp. 133-140): raising public awareness about the threats of unleashed dogs to beach-nesting birds is fundamental to bringing about long-term social change in dog owner behaviour. Research has revealed that most dog owners do not understand how disturbance can lead to breeding failure.

Recreationists on horses

Horses ridden on beaches and dunes can have major impacts on the breeding success of beach-nesting birds. While most equestrian use of beaches occurs on the wet sand, during high tide periods, horse riders are forced to ride above the high-tide mark. Horses can crush nests if ridden above the high-tide mark or in the dunes; they can crush chicks, particularly if ridden swiftly along the beach, as chicks can not move as quickly out of their path, and; they could potentially collide with and injure or kill adults. Excessive disturbance by horse riders can also contribute to nest failure through exposure of eggs and chicks to thermal extremes, predators and energetic stress. Horses, being large, hoofed animals, also have an impact on the physical environment. If ridden in the dunes, they contribute to heavy erosion, and when ridden on the soft sand of the beach, leave craters that make chick navigation across the beach difficult.

Horses have crushed and disturbed Western Snowy Plover nests (Point Reyes Bird Observatory unpubl. data; Page 1988; Persons 1995; Craig *et al.* 1992; Woolington 1985),

and Snowy Plovers are consequently more likely to fly away from approaching horses (Page 1988; Lafferty 2001). Horses ridden along the base of the foredune have been observed to crush Hooded Plover nests in western Victoria (Maguire pers. obsv.).

Management options

- *Signs* (*permanent, temporary notices, flanking the nesting site*; pp. 84-89): important for directing horse riders to the water's edge.
- *Fences* (*permanent access point or dune fencing, temporary rope or mesh fencing*; pp. 96-104): permanent fencing is effective at directing horse riders to the beach along formalised paths to reduce erosion impacts and risks of egg/chick crushing. Temporary rope or mesh fences symbolically delineate the nesting site for approaching horse riders, but offer little protection for mobile chicks.
- *Chick shelters* (pp. 104-107): offer a hiding place for chicks from approaching horses.
- *Site closures* (pp. 107-108): on very narrow beaches, it is recommended that horse riding be prohibited during the breeding season. Elsewhere the impacts of horses should be reviewed and seasonal closures may need to be implemented.
- *Regulations and enforcement* (pp. 142-153): as a minimum, horse riders should be required to ride below the high-tide mark and at times of low tide. Riders should also slow their horses to walking pace past fenced or signed nesting areas. Regulations should be strictly enforced.
- *Policy changes*: where regulations are deemed inadequate at protecting beach-nesting birds from horse impacts, it may become necessary to make these regulations stricter.
- *Site wardens* (pp. 141-142): may be effective, particularly during the chick phase – however it may be easier to liaise with horse riders directly by approaching riding schools, trainers or local horse owners.
- *Educational programs/materials* (pp. 133-140): horse riders should be educated about the threats that horses can pose to beach-nesting birds.

Recreationists in motorised vehicles - land

Vehicle use of coastal environments has the potential to be devastating to the breeding success of beach-nesting birds, to the survival of adults and to the physical environment. Vehicles on beaches include: 4-wheel drives (4WDs), trail bikes, quad bikes, kite cars, horse drawn carts and sulkies, as well as management or research vehicles.

Harrison (2005) revealed that at south Ballina beach, NSW, 4 adult shorebird vehicle fatalities occurred in just four weekends of observation. Despite being an important breeding area for 15-18 pairs of Pied Oystercatchers (~21 % of the state's population), vehicle use is completely unrestricted at this beach. Over 34 % of vehicles were driven on the mid-beach, 9.5 % on the upper beach and 2 % on the foredune; all of which severely

compromise egg and chick survival. Furthermore, many vehicles parked on the beach above the high-tide mark or the foredune.

In the Coorong, South Australia, 81 % of experimentally deployed nests on beaches were crushed by 4WDs within the length of a typical month long incubation period (Buick and Paton 1989). In western Victoria, illegally driven vehicles (trail bikes) crushed 18 % of Hooded Plover nests (Weston and Morrow 2000). Dodge *et al.* (in prep.) revealed that Surf Life Saving Club patrol vehicles crushed 8 % of experimentally deployed beach-located nests on the central Victorian coast, indicating that management vehicles also have an impact.

Vehicles have crushed Piping Plover eggs and killed adults and chicks (Pike 1985; Melvin *et al.* 1994). Melvin *et al*. (1994) in their research on the Piping Plover in Massachusetts and New York reported that 18 Piping Plover chicks and adults were killed by off-road vehicles over a four year period. They also revealed that chicks were killed on beaches where little vehicle usage occurred and that less than five to ten vehicle passes per day were established to be a threat to chicks and brooding adults. Melvin *et al.* (1994) also specified that over half of the plover deaths occurred on days when 20 passes were made. Vehicles have also destroyed Western Snowy Plover eggs, chicks and adults, and contributed to abandonment of nests and considerable stress and harassment to adults with broods (Stern *et al.* 1990; Casler *et al.* 1993; Widrig 1980; Colwell *et al.* 2006; U.S. Fish and Wildlife Service 2007).

Western Snowy Plover adults and chicks have been observed using tire tracks and human footprints for resting, which increases their chances of being run over (Powell and Collier 1994). In Massachusetts, between 1989 and 1997, a total of 25 Piping Plover chicks and 2 adults were found dead in off-road vehicle tire ruts on the upper beach between the mean high tide line and the foredune (U.S. Fish and Wildlife Service 2007). Buick and Paton (1989) also report that Hooded Plover chicks shelter in wheel ruts and this probably accounts for the high rate of chick crushing by vehicles on the Coorong (30 % of chick mortalities). It is likely that deep or numerous wheel ruts on beaches are likely to impede chick movement between the foraging zone and dune. Hosier *et al.* (1981) and Lamont *et al*. (2002) found that tire tracks could significantly impede the ability of sea-turtle hatchlings to reach the surf.

Driving on beaches at night seems to be particularly hazardous to beach-nesting birds. In the USA, ranger patrol vehicles have crushed Western Snowy Plover chicks at night, and Air Force personnel have collided with and killed adults at night (U.S. Fish and Wildlife Service 2007). Nocturnal driving on beaches in poor weather has also resulted in collisions with and death of Hooded Plover adults (M. Weston pers. comm.).

Vehicles can also lead to recreationists (commonly anglers) accessing remote areas of beach that would otherwise have remained undisturbed (U.S. Fish and Wildlife Service 2007; Williams *et al.* 2004). Hoopes *et al.* (1992) found that off-road vehicles caused Piping Plovers to flush or move an average distance of 40 metres. Fahy and Woodhouse (1995) found that vehicles caused the most significant alert and flight behaviours by Western Snowy Plovers, even when driven along the water's edge in compliance with regulations. This disturbance has the potential to impact habitation of beaches by beach-nesting birds. Stephens (2004) found that Hooded Plovers occurred in higher densities on beaches in south-east South Australia and on Kangaroo Island where vehicle use is low, and Dennis and Masters (2006) reported the greatest declines in the number of Hooded Plover breeding pairs on Kangaroo Island's beaches where vehicles have unregulated access. In South Africa, breeding shorebirds, such as the threatened African Oystercatcher, increased in numbers and productivity after the removal of vehicles from beaches (Williams *et al.* 2004).

In addition to disturbance of shorebirds, vehicles impact on other fauna that nest on beaches. Mann (1977) showed that sand compaction from driving above a nest can decrease nesting success and kill turtle hatchlings, and Nester and Frazer (2007) revealed that vehicles frequently disturbed incubating turtles, resulting in lower incubation temperatures, which has the capacity to skew the population sex ratio through reducing the proportion of female hatchlings.

In addition to directly impacting breeding success of beach-nesters, vehicles can significantly impact invertebrate fauna as well as the physical environment. A study by Schlacher and Thompson (2007) revealed that the majority (65 %) of burrowing invertebrate species of the intertidal zone are directly exposed to traffic. Furthermore, a study by Schlacher *et al.* (2008) in Queensland revealed that driving on beaches reduced both the diversity and abundance of the invertebrate (macrobenthic) fauna, thus reducing food availability for resident as well as migratory shorebirds. Off-road vehicles can be highly destructive to the environment (Palmer and Leatherman 1979; Godfrey and Godfrey 1980), by causing severe sediment disruption and erosion (Anders and Leatherman 1987; Priskin 2003b; Schlacher and Thompson *in press*) and destruction of dune vegetation (Luckenbach and Bury 1983; Rickard *et al.* 1994). Driving on beaches early in the breeding season degrades the quality of substrate and can deter Piping Plovers from nesting or cause them to desert nests (Hoopes *et al.* 1992; Hoopes 1994).

Management options

- *Bollards and gates* (p. 111): it may be necessary to use bollards to prevent vehicle access to beaches, but these will be ineffective for preventing trail bike access. Locked gates at access roads can be used to limit the number of vehicles allowed per day.

- *Signs* (*permanent, temporary notices, flanking the nesting site*; pp. 84-89): important for directing vehicles to the water's edge.
- *Fences* (*permanent access point or dune fencing, temporary rope or mesh fencing*; pp. 96-104): permanent fencing is effective at limiting vehicle access to specific vehicle entry and exit points to reduce erosion impacts and risks of egg/chick crushing. Temporary rope or mesh fences symbolically delineate the nesting site for approaching vehicles and signify areas where parking is prohibited, but offer little protection for mobile chicks.
- *Chick shelters* (pp. 104-107): offer a hiding place for chicks from approaching vehicles, but would offer little protection if run over by vehicles.
- *Site closures* (pp. 107-108): on very narrow beaches, it is recommended that vehicles be prohibited during the breeding season. Elsewhere the impacts of vehicles should be reviewed and seasonal closures may need to be implemented.
- *Regulations and enforcement* (pp. 142-153): as a minimum, vehicles should be required to drive below the high-tide mark and at times of low tide. Speed limits should be set, particularly past fenced or signed nesting areas, and there should be limits to the number of vehicles permitted on any beach at a given time. Regulations should be strictly enforced.
- *Policy changes*: vehicles have devastating impacts on the beach environment, its flora and fauna, and thus vehicle access to the Australian coast should be reduced below current levels. Where regulations are deemed inadequate at protecting beach-nesting birds from vehicle impacts, it may become necessary to make these regulations stricter.
- *Educational programs/materials* (pp. 133-140): visitors should be educated about the threats that vehicles can pose to beach-nesting birds.

Recreationists in vehicles - water

Recreational activities that occur in or over water (such as kayaking, wind surfing, jet skiing and boating) may not directly affect beach-nesting birds, but can be detrimental when recreationists use the beach to take a break from these activities or as access, exit or launching points. The noise of motorised boats and jet skis may disturb beach-nesting birds, e.g. Piping Plovers (U.S. Fish and Wildlife Service 2003).

Management options

- *Signs* (*temporary notices, flanking the nesting site*; pp. 85-89): notices should be posted at boat launching ramps or piers identifying beaches with active nesting pairs; signs that flank the nesting site are useful in areas where visitors commonly disembark from their boats to take a break.
- *Fences* (*temporary rope or mesh fencing*; pp. 97-104): temporary rope or mesh fences symbolically delineate the nesting site and are useful in areas where visitors commonly disembark from their boats to take a break.

- *Site closures* (pp. 107-108): some islands could be made into permanent or seasonal shorebird conservation areas where disembarking from boats is prohibited.
- *Chick shelters* (pp. 104-107): offer a refuge for chicks from disturbances.
- *Educational programs/materials* (pp. 133-140): materials outlining threats to beach-nesting birds should be distributed to boat owners.

Recreationists in vehicles - air

Low-flying aircraft (e.g. within 152 m of the ground) can cause disturbances to breeding and wintering Western Snowy Plovers and the noise of helicopters can be disturbing from greater altitudes (Howard *et al.* 1993; U.S. Fish and Wildlife Service 2007). Hatch (1997) found that all types of low-flying aircraft may potentially be perceived as predators by Western Snowy Plovers. Hooded Plovers have been observed flushing from the nest when low flying aircraft passed overhead, and an incubating bird stood over its nest and then flushed when a hang-glider flew overhead (Weston pers. comm.). In some areas, beach-nesting birds may become habituated to aircrafts flying overhead, such as some pairs of Western Snowy Plovers (U.S. Fish and Wildlife Service 2007) and Hooded Plovers that have been observed nesting by runways (B. Semmens pers. comm.).

Management options

- *Chick shelters* (pp. 104-107): offer a refuge for chicks from disturbances.
- *Policy changes*: the impacts of regular flights over breeding beaches should be reviewed and where helicopters or planes cause significant disturbance, restrictions should be set in place to minimise this disturbance, e.g. limits on the number of tourist helicopter flights per day.
- *Educational programs/materials* (pp. 133-140): liaising with flight operators to provide information about threats to beach-nesting birds could be useful for establishing compromises.

Kites and Fireworks

Beach-nesting birds may perceive kites as potential avian predators (Hoopes *et al.* 1992; Hatch 1997). Western Snowy Plovers react to kites by either increasing their vigilance or displacing up to 25 m (Hatch 1997). Hoopes *et al.* (1992) found that Piping Plovers are intolerant of kites and flushed at greater distances from this disturbance, displaced longer distances and for longer durations compared to any other human disturbance.

Fireworks can also disturb beach-nesting birds, to the extent that birds may abandon their eggs and chicks (Piping Plovers: Howard *et al.* 1993; Western Snowy Plovers: U.S. Fish and Wildlife Service 2007).

Management options

- *Chick shelters* (pp. 104-107): offer a refuge for chicks from disturbances.
- *Educational programs/materials* (pp. 133-140): visitors may need to be educated about the threats that kites or hang gliders can pose to beach-nesting birds. Land managers or local government agencies that give permission for events where fireworks are used should be informed of threats to beach-nesting birds and may need to impose permit restrictions for such events that allow for an appropriate buffer distance.

Stock

In some parts of the coast, cattle and sheep, even goats and camels, have unrestricted access to beaches. Much of Kangaroo Island's northern coastline is accessible to sheep, and feral goats are frequently recorded grazing on fore-dune vegetation and on beaches on the western coastline in Flinders Chase National Park (Dennis and Masters 2006). On King Island, cattle can access much of the coastline where they forage on kelp. Elsewhere in Australia where private farm properties border the coast, sheep and cattle may roam onto beaches when fencing isn't adequately maintained (Weston 2003). Hooded Plovers on Phillip Island in Victoria have abandoned their territories when trampled by sheep foraging on dune vegetation, in particular Sea Rocket, *Cakile maritima* (Baird and Dann 2003). On the NSW coast, electric fencing was installed around a Hooded Plover nesting site to protect it from roaming cattle that were suspected of crushing a previous nest (NSW National Parks and Wildlife Service 2006). On the Great Plains in the USA, Piping Plover nests are crushed by grazing cattle, and stock create deep depressions in the sand that chicks can fall into and be unable to escape from (Wershler and Wallis 1987; Hofman 1992; Alberta Piping Plover Recovery Team 2006). Piping Plover nesting success has been shown to be lower on territories with evidence of cattle activity (Prindiville Gaines and Ryan 1988; Hofman 1992). On New Zealand's offshore islands, sheep and cattle are responsible for crushing Chatham Island Oystercatcher nests and disturbing incubating adults (A fact sheet downloadable from www.doc.govt.nz/ provides a particularly amazing photo of sheep surrounding and nuzzling a Chatham Island Oystercatcher on its nest). Video footage of Banded Dotterel nests in New Zealand also revealed that adults would display vigorously to approaching sheep, but the sheep would ignore them and subsequently trample the nest (Sanders and Maloney 2002).

Management options

- *Fences* (*permanent dune fencing*, *temporary mesh fencing*; pp. 96-104): permanent fencing of farm properties to prevent access to the dune or beach is necessary for reducing erosion impacts and risks of egg/chick crushing by stock. Temporary mesh fences may be necessary at sites where stock continue to access the beach, but theses offer little protection for mobile chicks.
- *Chick shelters* (pp. 104-107): offer a refuge for chicks from crushing and disturbances.
- *Educational programs/materials* (pp. 133-140): it is important to liaise with farmers whose properties are adjacent to breeding beaches to inform them of the threats stock pose to beach-nesting birds.

Litter

A survey in 1996 found that 73 % of Australian beach litter was from land-sourced plastics, and a further 13 % was debris from fishing (SoE 2001). The disposal of plastic waste at sea is prohibited under the MARPOL Convention (International Convention for the Prevention of Pollution from Ships, Annex V) and enforced in Australia through legislation. In addition, there are national and fishery specific codes of conduct designed to minimise all discards and waste associated with fishing. Beach litter continues to be a problem in Australia despite community interest in 'Clean Up' days.

Fishing line and synthetic fibres used in fishing nets have the potential to become entangled in the legs of beach-nesting birds and can result in their death (e.g. Hooded Plover adults and chicks, B. Baird *in litt.* cited in Weston 2003; Weston unpubl. data; Maguire unpubl. data). Terns, gulls and pelicans commonly become hooked or entangled in fishing gear when foraging near active fishers, and birds that forage along estuaries, beaches and breakwalls are frequently entangled by unattended set lines or discarded tackle. At least 10 % of Australian pelicans along the NSW coast were found to be suffering from entanglement by fishing line (NSW Scientific Committee 2004). The NSW Scientific Committee (2004) listed the Hooded Plover, Little Tern and Pied and Sooty Oystercatchers as species likely to be affected by entanglement and/or ingestion of plastics and fishing gear.

Litter left behind by recreationists can attract and encourage increased foraging of avian (e.g. Silver Gulls and Ravens) and mammalian (e.g. foxes and cats) predators on beaches, which increases the likelihood of these predators encountering beach-nesting bird eggs and chicks.

Management options

- *Educational programs/materials* (pp. 133-140): it is important to raise awareness about the hazards discarded plastics and fishing line pose to seabirds and shorebirds, as well as other wildlife, and to encourage visitors to put their rubbish in bins or take it away with them, so that predator populations do not flourish.
- *Emergency response training* (p. 155): this includes training people in the capture and handling of beach-nesting birds so that in the event of birds becoming entangled there is the capacity to respond and rehabilitate affected birds.

Introduced Predators

In natural ecosystems, there is a co-evolution between predator and prey species, with prey species slowly evolving evasion/defense behaviour as predator species slowly evolve effective prey-capturing behaviour. However, when exotic predators are introduced into the ecosystem, they often thrive in these environments, reaching high population densities and because native prey have not evolved to cope with the strategies of these predators, their impacts can be severe.

Foxes

There is considerable variation in the impact of fox predation on breeding success of beach-nesting birds. It is thought that even though urban development can encourage fox densities three or more times greater than in rural Australia (Coman *et al.* 1991; Marks and Short 1996), it is in relatively pristine areas that foxes become the dominant local threat to beach-nesting birds, such as Hooded Plovers (Weston 2003).

In NSW, foxes are the most common predator of Hooded Plover, Oystercatcher and Little Tern eggs and chicks (NSW National Parks and Wildlife Service 2006, 2007, 2008). At the Bega River mouth in NSW, a single fox was responsible for killing 30 Little Tern chicks and 14 eggs in just two days (NSW National Parks and Wildlife Service 2006). In Western Australia, the stomach contents of a single fox contained up to 30 chicks of Red-capped Plovers (R. Johnstone pers. comm.). On the Victorian coast, rates of 17 % and 27 % of Hooded Plover nest failures were attributed to fox predation (Weston 2003; Maguire unpubl. data). In western Victoria, Weston and Morrow (2000) attributed 28.6 % of known Hooded Plover nest failures to fox predation, while Stojanovic (2008) found fox predation rates of experimentally deployed nests containing quail eggs to be as high as 37 % along beaches in western Victoria.

Fox control has the potential to reduce predation pressure on shorebird nests. In an area where foxes were controlled through baiting, Dowling and Weston (1999) found that 2 % of Hooded Plover nests were predated by foxes. In the USA, fox predation reduced the

hatching success of Western Snowy Plovers by 30 % from 1984 to 1990, but after implementing predator control and using exclosures around nests, hatching rates rose from 43 % to 68 % (Neuman *et al.* 2004).

Foxes do not always detect beach-located nests and have been recorded as passing within less than a metre of Hooded Plover nests without detection (Ressom 2001; M. Quinn pers. comm.; Maguire pers. obsv.). Management, such as nest cages or small fences around the nest, may enhance the detection of nests by foxes, as they have been observed circling exclosures and have been linked with the predation of Hooded Plover and Western Snowy Plover chicks and adults (NSW National Parks and Wildlife Service 2006, 2007, 2008; U.S. Fish and Wildlife Service 2007; A. Whitelaw pers. comm.).

Management options

- *Predator control* (pp. 120-124): there are a number of control methods for foxes including baiting, trapping, spotlight shooting and den destruction.
- *Predator training* (pp. 126-127): foxes show potential to be trained to avoid prey types using 'conditioned taste aversion'.
- *Predator exclusion* (pp. 127-131): nest cages are used widely by some managers, but this management option should be treated with extreme caution as there can be risks to the breeding birds and their chicks, and does not offer a solution to predator impacts on chicks. Exclusion fencing, including electric fences, may be effective but are costly and difficult to maintain. Scent deterrents show potential but require further research.

Cats

Cats are opportunistic predators and will eat a wide variety of foods including birds (Seebeck and Clunie 1997; Urquhart and Teoh 2001). Video monitoring of nests of three species of ground-nesting birds (Banded Dotterel *Charadrius bicinctus*, Black Stilt *Himantopus novaezelandiae* and Black-fronted Tern *Sterna albostriata*) in New Zealand revealed that cats were responsible for 43 % of predation of eggs and were the only mammal responsible for death of chicks and adults (Sanders and Maloney 2002). In New Zealand, cats are identified as major predators of New Zealand Dotterel, Shore Plovers (*Thinornis novaeseelandiae*) and Chatham Island Oystercatchers (*Haematopus chathamensis*) and have contributed to local extinctions and species declines (Dowding 1997; DOC 2001; Dowding and Murphy 2001; Harper 2002; Moore *et al.* 2001; Dowding and Davis 2007). On Matakana Island in New Zealand, cats accounted for 11 % of New Zealand Dotterel nest failures (Wills *et al.* 2003). In the USA, cats have also been identified as predators of Western Snowy Plover adults and eggs (Page 1988; U.S. Fish and Wildlife Service 2007). In Australia, Marchant and Higgins (1993) list cats as a threat to Beach Stone-Curlew and cats have predated Hooded Plover nests in Tasmania (Hanisch 1998) and been suspected

predators of Hooded Plover adults at some caged nest sites at Phillip Island Nature Park (B. Baird pers. comm.).

Management options

- *Predator control* (pp. 124-125): there are a number of control methods for cats including trapping and spotlight shooting. Poisoning has a high risk of impact on non-target animals.
- *Predator exclusion* (pp. 127-131): nest cages are used widely by some managers, but this management option should be treated with extreme caution as there can be risks to the breeding birds and their chicks, and does not offer a solution to predator impacts on chicks.
- *Policy changes*: local governments should enforce regulations for cats to be kept indoors at night and cats to be desexed. In coastal areas of high conservation value and where houses occur on the edge of the dune, there may need to be stricter regulations imposed, such as prohibiting cats or keeping them indoors day and night.
- *Educational programs/materials* (pp. 133-140): responsible cat ownership should be encouraged by providing information about the impacts of cats on wildlife.

Rats

Rats are common predators of ground-nesting birds, and in New Zealand have been another major predator of shorebirds, many of which are now highly threatened (Dowding and Murphy 2001). Norway Rats have been reported predating nests of New Zealand Dotterel (Wills *et al.* 2003) and were identified as the predator at 35 % of predated Pied Stilt (*Himantopus himantopus*) and Black Stilt nests in New Zealand (Pierce 1986). Rats have been suspected of predating Hooded Plover eggs in Victoria (M. Weston pers. comm.; B. Baird pers. comm.) and Tasmania (Berry 2001; Hanisch 1998). Rats could potentially predate newly-hatched chicks.

Management options

- *Predator control*: in areas where rats pose a threat to beach-nesting bird eggs, traps should be set near the nesting site.



Dogs off-leash (Grainne Maguire); Hooded Plover parents and chick running from dog straining against lead (Glenn Ehmke); Dog prints around abandoned Hooded Plover egg (Grainne Maguire).



Horse prints on mid-beach; Horse rider at water's edge; Horse prints on upper beach (Grainne Maguire).



Trail bike rider on estuary VIC (Chris Tzaros); Vehicle tracks on beach SA (Glenn Ehmke); Vehicle tracks on estuary VIC (Grainne Maguire).

Litter by Hooded Plover interpretive sign (Dean Ingwersen); Hooded Plover feet entangled with fishing net fibres (Mike Weston); Trail bike tracks through dune (Grainne Maguire); Fox with fresh kill in coastal saltmarsh (Chris Tzaros); Cat and fox prints on beach (Glenn Ehmke).

Weeds

Weeds can modify the dune and beach environment, limiting the availability and/or suitability of these habitats for nesting. Below, four of the main weeds present in Australian dune systems are discussed in relation to their threats to beach-nesting birds:

Sea Spurge

Description

- Sea Spurge (*Euphorbia paralias*) is a highly invasive weed that spreads through the dunes and down to the beach strand above the high-tide mark, as well as into coastal herbfields, grasslands and shrublands. It can also grow along rocky shorelines in low numbers, in sand-filled cracks between rocks.
- It originates from Europe and it first appeared in Albany, Western Australia in the 1920s and soon after at Port Victoria in South Australia, presumably introduced in shipping ballast water. It has since spread throughout southeastern Australia including Tasmania and the Bass Strait islands.
- Sea Spurge is a perennial shrub up to 70 cm high with multiple woody stems and a deep taproot. It has fleshy leaves that arise densely from the stems and these vary from oblong shaped at the base to almost circular at the flower heads. Tiny flowers are produced from October to May, cupped within green bracts. Larger plants may shed thousands of seeds each year. Each seed is about 5 mm in diameter, buoyant, salt-

tolerant and readily dispersed by wind or water. Seeds can survive for up to two years on ocean currents, spreading from one coastline to the next.

Impacts

- Sea Spurge greatly reduces available nesting habitat for resident shorebirds by forming dense mats of vegetation over bare sand patches and spits.
- These dense clusters aggressively invade and exclude native vegetation (Harris and Kirkpatrick 1996).
- Sea Spurge alters beach morphology and creates a very different foredune shape compared to that formed by native plants. It also creates dense infestations just above the high-tide mark, preventing natural sand movement inland.

Management options

- *Weed control* (pp. 112-114): manual removal of Sea Spurge is effective for small infestations, however, large infestations may require chemical removal. Mechanical removal is not recommended.

Sea Wheat-grass

Description

- Sea Wheat-grass (*Thinopyrum junceiforme*) is a perennial beach grass native to the Baltic and Atlantic coasts of Europe. It was deliberately introduced to Australia for dune stabilisation purposes.
- Sea Wheat-grass is a distinctive beach grass that does not form tussocks like most other beach grasses do. It is rhizomatous and forms a low sward on beaches. At favourable sites it can reach 50 cm in height, however, it may be reduced to 10-20 cm high when growing on foredunes. The leaves are bluish green, widely spreading and may be up to 30 cm in length and 5 mm broad. Flowers are carried on long spiky stems and are arranged alternately in one plane like a rye grass. Flowering occurs over December and January but the brittle seed heads do not persist for long on the plant. Sea Wheat-grass spreads by lateral extension of rhizomes that break the surface of the sand forming daughter plants and by seed dispersal. It may also regenerate from fragmented rhizomes.

Impacts

- Sea Wheat-grass traps and stabilises sands where native vegetation does not generally occur, thereby altering the natural beach landforms and preventing the movement of sand. It builds low wide foredunes in low wind situations or areas of prograding shoreline (i.e. shorelines being built forward or seaward by sand deposition and accumulation), and develops hummocky dune fields in high wind environments (Heyligers 1985).

- No native plants or plant communities are currently recognised as under threat because of Sea Wheat-grass. Spinifex appears to maintain its dominance on foredunes in the presence of sparse Sea Wheat-grass infestations (Rudman 2003).
- There are no documented impacts on the impacts of Sea Wheat-grass on beach-nesting birds, however, Sea Wheat-grass may reduce available nesting habitat for resident shorebirds by reducing the amount of vegetation-free sand available.

Management options

- *Weed control* (p. 114): options of manual or chemical removal.

Marram Grass

Description

- Marram Grass (*Ammophila arenaria*) is a highly invasive dune-stabilising grass, with high tolerance to burial, drought and erosion associated with storm surge and high waves. It was deliberately introduced from Europe for the purpose of stabilising dunes and controlling erosion because it is very effective at trapping sand and grows vigorously. It is typically only considered a weed in areas where it has established of its own accord or where conservation values are being degraded.
- Marram Grass is a perennial, rhizomatous grass of beach and sand dune systems that forms dense, tussock-like hummocks. It produces deep and extensive rhizomes both vertically and horizontally which give rise to daughter plants. Tussocks may be up to 120cm high with tightly rolled leaf blades about 60 cm long. The very large membranous ligule (i.e. inside of the leaf at the junction of the blade and sheath), up to 3 cm long, which often splits into two spikes, is a key diagnostic feature of Marram Grass. Flower heads may be up to 25 cm long and are 1 to 2.5 cm in diameter. It only produces small amounts of seeds, but spreads rapidly through lateral extensions of rhizomes, which give rise to new tussocks. Fragments of these rhizomes, when washed into the sea, can be spread to other beaches to start new infestations.

Impacts

- Dune morphology and dynamics are radically and permanently altered by the presence of Marram Grass. Marram tussocks trap wind blown sand, causing dune building around plants. This leads to the creation of large, steep faced dunes, a striking contrast to the lower angled foredunes associated with native vegetation (Barbour and Johnson 1977; Wiedemann 1984; Heyligers 1985). These steep faced dunes are more prone to wave attack and erosion. Accumulation of sand within Marram dune systems can also remove sand from beach, surf and inshore areas, affecting sand movement and availability along the coast, so that mobile, transgressive dunes are being permanently lost in areas dominated by Marram. Furthermore, stabilisation of dunes with Marram has reduced the amount of unvegetated area above the tideline and decreased the

width of the beach, as Marram can grow in areas of sand not otherwise occupied by native vegetation (Wiedemann 1987).

- Native sand binding grasses do not compete well against the rapid growth rates and sand accumulation capability of Marram Grass. Dunes stabilised with Marram have lower plant species richness and different species composition to natural dunes (Webb *et al.* 2000). In some areas, native plants have declined or been completely eliminated (Barbour *et al.* 1976, Wiedemann 1984; Boyd 1992; Pickart *et al.* 1990; Wiedemann 1993; Wiedemann and Pickart 1996). In Tasmania, two native beach grass communities and five other coastal dune plant communities have been replaced by Marram Grass (Kirkpatrick and Harris 1995). Native beach plants that may be reduced in extent as a result of Marram invasion include: *Spinifex sericeus, Austrofestuca littoralis, Carex pumila* and *Atriplex billardierei* (Kirkpatrick and Harris 1995).
- Slobodchikoff and Doyen (1977) found that Marram Grass markedly depressed the diversity and abundance of sand-burrowing arthropods at coastal dune sites in central California.
- Hooded Plovers no longer nest on some Tasmanian beaches because of the use of Marram Grass for erosion control (Park 1994).
- In the USA, the open features that characterise Western Snowy Plover breeding habitat have been lost due to dune stabilisation with Marram Grass (U.S. Fish and Wildlife Service 2007). The density of vegetation and steepening of the dunes also hampers brood movements, and creates habitat that harbours predators (Stern *et al.* 1991; U.S. Fish and Wildlife Service 2007).

Management options

- *Sympathetic dune stabilisation* (p. 111): alternative forms of dune stabilisation need to be used to replace the use of Marram Grass, including brush laying (in appropriate areas, taking into account nesting habitat requirements), planting of native grasses or permanently fencing dunes.
- *Weed control* (pp. 114-118): there are several options for removal of Marram Grass, including manual, mechanical and chemical removal. The best methods of removal are thought to be burning the site and following up with chemical or mechanical removal; or chemical removal alone.
- *Encouraging dune nesting* (p. 119): removal of Marram Grass should be prioritised for key sites where available habitat for beach-nesting birds is severely reduced and where rising sea levels associated with climate change are likely to result in habitat loss.
- *Policy changes*: planting non-native dune stabilising grasses such as Marram Grass should be banned in Australia.










Sea Spurge x 3; Marram Grass x 4; Sea Rocket surrounding Hooded Plover nest; Sea Rocket plants along base of foredune; Sea Rocket by Hooded Plover nest. Photos: Grainne Maguire.

Sea Wheat Grass on foredune; Brush matting; Heavy dune use despite signage (David Reid); Hooded Plover on nest on unvegetated dune slope (Glenn Ehmke); Dune blowout and midden; Dune system with blowouts and native Spinifex Grass; Dune blowout and midden. Photos: Grainne Maguire unless specified.

Sea Rocket

Description

- Sea or Beach Rocket (*Cakile maritime*) is a sprawling, succulent annual herb growing to 40 cm. Leaves are succulent, brittle and bluntly toothed, flowers ranging in colour from white to purple. Fruit are green at first but become corky and buoyant. They have horns with a rocket appearance. Sea Rocket can grow in the dunes or fringe the upper beach.

Impacts

- Sea Rocket has not been identified as a problem for beach-nesting birds. Hooded Plovers are known to nest near Sea Rocket and it does not appear to limit nesting habitat availability (Maguire pers. obsv.), and on Phillip Island, Sea Rocket offers an important refuge for chicks (Baird and Dann 2003).
- Furthermore, endangered Orange-bellied Parrots (*Neophema chrysogaster*) are known to feed on the seeds of Sea Rocket in the south-east (Gibbons 1984).

Management options

- No management is recommended for sea rocket as it has not been identified as a threat to beach-nesting birds.

Dune stabilisation

One of the main sources of habitat modification that impacts beach-nesting birds results from measures to control erosion in dunes. The main methods of dune stabilisation used in Australia are brush matting (laying dense mats of dry, cut brush over bare patches of sand) or planting dune-stabilising grasses, such as Marram Grass (which was still being recommended into the 1990s, e.g. Kesby and Druett 1997) or Spinifex (Weston 2003).

Marram Grass, as mentioned in the above section, is an invasive weed that outcompetes native vegetation, prevents mobility of the dune and creates steep dune faces that are more susceptible to erosion at the base from high tides. Many beach-nesting shorebirds avoid nesting in highly vegetated areas because this severely impairs their view of approaching predators. Beach-nesters rely on bare sand to lay their eggs and Marram forms dense, uniform mats of vegetation, leaving virtually no bare sand available for nesting. Marram further impedes the movement of chicks in and out of the dunes, limiting refuge availability. This method of erosion control has the ability to make habitat permanently unsuitable for beach-nesting birds.

Brush matting also limits nesting habitat availability for beach-nesting birds, as commonly all bare patches of sand are covered with brush, particularly dune blowouts, which are the favoured nesting habitat of Hooded Plovers. Removal of brush matting once native plants have regenerated underneath helps return habitat to its original condition, and may mean that the negative impacts of brush matting on habitat availability can be reversed.

Management options

- *Sympathetic dune stabilisation* (p. 111): planting Marram Grass or laying brush over the entire dune can result in loss of nesting habitat for beach-nesting birds. Alternative forms of erosion control need to be implemented at sites where these birds nest: including brush laying (but only of the upper dune), planting of native grasses or permanently fencing dunes.
- *Encouraging dune nesting* (p. 119): in areas where dune nesting sites have been covered with brush or Marram, creation of bare patches of sand and unvegetated pathways for the birds to access the beach freely could encourage the birds to nest again in the dunes.
- *Coastal planning considerations* (pp. 153-154): Coastal Management Act consent should not be granted for erosion control projects that will compromise habitat availability for beach-nesting birds. Alternatives must be used at these sites.

- *Educational programs/materials* (pp. 133-140): land managers need to be educated about the importance of dune blowouts and areas of bare sand in dunes for beach-nesting birds, and provided with options for controlling erosion in these areas that do not compromise nesting habitat availability.

Beach cleaning and kelp harvesting

Beach cleaning or raking and kelp harvesting can have major impacts on the habitat of beach-nesting birds including: removing the natural wrackline (area of beach containing seaweed and other natural wave-cast organic debris) feeding habitat, reducing the availability of invertebrate prey (as they get removed with the kelp and driftwood), altering beach topography, removing cover (e.g. seaweed, driftwood, cuttlefish) that chicks use as refuge and preventing the establishment of native beach vegetation (Schulz 1992a; Parks Victoria 1998; Weston and Morrow 2000; Weston 2003; U.S. Fish and Wildlife Service 2007). Furthermore, beach cleaning can directly impact the breeding success of beach-nesters if carried out during the breeding season, by crushing nests and chicks or causing prolonged disturbance due to the presence and noise of the tractors (Weston 2003; U.S. Fish and Wildlife Service 2007).

Management options

- *Policy changes* (p. 119): beach cleaning and kelp harvesting needs to be prohibited from breeding beaches, at least during the breeding season.

Driftwood removal

Driftwood removed for firewood or for other purposes (e.g. decorating the garden, use in reptile cages or aviaries) can result in crushing of nests and young chicks that frequently crouch by driftwood to hide from predators and people. Nests have been crushed by people dragging driftwood along the beach for firewood (U.S. Fish and Wildlife Service 2007). Night-time collecting of wood increases the risk of stepping on nests and chicks, which are difficult to see even during daylight hours.

Furthermore, driftwood forms an important component of beach-nesting bird habitat, contributing to dune-building and adding organic matter to the sand as it decays (Washington Department of Fish and Wildlife 1995). Additionally, driftwood provides adults and chicks with shelter from wind and blowing sand and adults often build their nests beside driftwood (Marchant and Higgins 1993; U.S. Fish and Wildlife Service 2007; Maguire unpubl. data).

Management options

- *Regulations and enforcement* (p. 119): on beaches where driftwood removal is problematic, regulations may need to be introduced and enforced.
- *Educational programs/materials* (pp. 133-140): beach users should be educated about the importance of driftwood as habitat for beach-nesting birds and the risks collection poses to their eggs and chicks.

Oil spills

Oil spills have the potential to have major local impacts on beach-nesting shorebirds, causing mortality, reduced foraging and growth rates and displacement from preferred habitat (see references in Weston *et al.* 2008). Eggs may also become oiled if the tide or wind carries the oil into the nest or oiled adults may transfer oil to the egg when incubating (Weston *et al.* 2008). In previous oil spills, the care and rehabilitation of shorebirds, such as the Hooded Plover, has been neglected in favour of caring for higher numbers of common species such as the Little Penguin *Eudyptula minor* (Weston 2003). Oiled Hooded Plovers have been successfully trapped, cleaned and released in a Victorian oil spill (Weston *et al.* 2008).

Management options

- *Emergency response training* (p. 155): this includes training people in the capture and handling of beach-nesting birds so that in the event of an oil spill there is an increased capacity to respond and rehabilitate affected birds.

Summary of threats and corresponding management options (pages 83-155).

	Signs – permanent	Signs - notices	Signs – flanking	Bollards and gates	Fences - access	Fences - dunes	Fences – temp rope	Fences – temp mesh	Site / access closures	Chick shelters	*dune stabilisation	Weed control	Habitat - modify	Nest relocation	Predator control	Predator training	Predator exclusion	Coastal planning	Policy changes	Regulation enforcement	Wardening	Educational materials	Emergency response
High Tides													√	√									
Storms & bad weather										√			√	√									
Avian predators																							
Birds of Prey										√													
Ravens/Magpies										√					√	√	√						
Gulls										√					√	?	√						
Other birds										√							√						
Reptilian predators															√		?						
Coastal development									√									√	√	√		√	
Recreationists																							
Static	√	√	√				√	√	√												√	√	
Mobile	√	√	√		√	√	√	√	√	√	√										√	√	
With dogs	√	√	√		√	√	√	√	√	√									√	√	√	√	
On horses	√	√	√		√	√	√	√	√	√									√	√	√	√	
In vehicles (land)	√	√	√	√	√	√	√	√	√	?									√	√		√	
In vehicles (water)		√	√				√	√	√	√												√	
In vehicles (air)										√									√			√	
Kites and fireworks										√												√	
Stock						√		√		√												√	
Litter																						√	√
Introduced predators																							
Foxes															√	√	√						
Cats															√		√		√			√	
Rats															√								
Weeds																							
Sea Spurge												√											
Sea wheat grass												√											
Marram Grass											√	√	√						√				
Dune stabilisation											√		√					√				√	
Beach cleaning																			√				
Driftwood removal																				√		√	
Oil spills																							√



Chapter 3. Management of beach-nesting birds

This section provides information for managers or volunteers implementing on-ground works, developing educational/interpretive materials or formulating policy for beach-nesting birds. Any management needs to occur with appropriate permissions and with careful consideration of the costs and benefits to the birds and the local community. It must be emphasized that anyone who undertakes on-site management needs to have training or experience, and must adhere to the strict guidelines for minimising risks of egg and chick crushing or disturbance of these highly sensitive, breeding birds (see Chapter 4, p. 172).

Monitoring is an essential part of the management regime and is explored in Chapter 4.

Why is management needed?

For a long time now, it has been the general perception that managing a single pair or nest would be a resource-intensive activity of little benefit to a species as a whole. While this may be true for some species, widely dispersed pairs of beach-nesting birds require a single pair approach to management. The 'promoting coexistence' project has shown that management of a single pair or nest can significantly boost breeding success, and therefore fecundity rates for the population as a whole. Close to fifty percent of fledglings produced by approximately half of Victoria's population of Hooded Plovers came from highly threatened beach sites that were managed. If the population relied on the breeding success of pairs in isolated or inaccessible sites, then fecundity would only be half of what was achieved with management. When the current state of development of Australia's coast is considered, it becomes very clear that isolated and inaccessible areas are already rare and will become more so in the future. The reality is that we have created a situation whereby we are obliged to manage the impacts of our own actions in order to return some balance to the environment and its plant and animal inhabitants.

While managing for single species is necessary in this context, management should consider the ecosystem as a whole. It can be useful to view dispersed beach-nesting birds

as a flagship for beach ecosystem rehabilitation, ameliorating threatening processes and encompassing the needs of multiple species dependent on the same habitat. In the words of the Atlantic Coast Piping Plover recovery team (U.S. Fish and Wildlife Service 1996): "the direction conservation should take for Piping Plovers and the like, should be remedial efforts aimed at the restoration of the natural processes that maintain the natural ecosystem, as these are likely to have the greatest long-term benefits. Important components of ecologically sound beach management include perpetuation of natural dynamic coastal formation processes; management of human recreation to prevent or minimise adverse impacts on dune formation, vegetation, and the invertebrate and vertebrate fauna; and efforts to counter the effects of human-induced changes in the types, distribution, numbers and activity patterns of predators."

It is important to note, however, that while many management actions can encompass the needs of several species at once and can improve the overall coastal environment, dispersed beach-nesting birds still require some species-specific managements focused at the nest level to manage threats related to human recreation. In the USA, Snowy Plovers and California Least Terns (*Sternula antillarum browni*) sometimes nest in the same area, however, the recovery team make a point of stating that while some efforts can address the needs of both species, others need to be focused on one species, because of "the species' differences in nest spacing, brood-rearing, foraging behaviour, time of breeding, vulnerability to disturbance and monitoring techniques" (U.S. Fish and Wildlife Service 2007).

How should sites be selected for management?

For colonially nesting species (such as Little Terns *Sterna albifrons*), the criterion used for allocating resources and deciding where management will occur is commonly the number of breeding pairs nesting at a given location, that is, the size of the colony. Because of the dispersed nature of beach-nesting shorebirds, it becomes difficult to identify where management priorities should be focused. Do areas with only the highest densities of beach-nesting birds need protecting? How is such a density calculated, by park or land tenure boundaries? Should we focus on maintaining the species range, and thus on areas of decline? Or should we use a source/sink approach, and recognise some areas or pairs as highly productive and worthy of protection, and others as poorly productive and thus a drain on resources?

In Victoria, there has been a tendency to view areas with the greatest density of breeding Hooded Plovers as those that should be targeted for management, and the remaining range of the species as less important. This would limit management to two major sections of the coast: Discovery Bay to Warrnambool in the far west of the state, and the Mornington Peninsula, Phillip Island and Bass Coast, east of Melbourne. Such a

concentration of management would neglect large sections of coast that are important to linking populations, such as eastern Victoria with New South Wales, where the species range has already dramatically declined. Furthermore, areas of the coast west of Melbourne, where the species range has contracted (e.g. between Anglesea and Apollo Bay) leaving few remaining pairs, would get little recognition under this management regime. It is important to consider the population as a whole and to recognise that dispersal of the population across its breeding range serves as a hedge against catastrophes (for example oil spills, storm events or disease) which might depress regional survival and/or productivity. Maintaining robust, well-distributed subpopulations should reduce variance in survival and productivity of the population as a whole, facilitate interchange of genetic material between subpopulations and promote recolonisation of any sites that experience declines or local extinctions due to low productivity and/or temporary habitat changes (U.S. Fish and Wildlife Service 1996). In other words, it is unwise to put all our eggs in the one basket.

The 'Promoting coexistence' project selected sites for Hooded Plover monitoring and management across Victoria using the following approach:

1. The entire coast of Victoria was surveyed within a two-week window during the breeding season to locate Hooded Plover breeding territories.
2. For each Hooded Plover sighting, the threats present within a 100 m radius were recorded. This snap-shot approach is likely to underestimate the true range and intensity of threats experienced by pairs. To partly overcome this, assessments of prints were also made to detect evidence of previous mammalian (including people, dogs, foxes, horses, etc) visitors to the territory.
3. In addition to assessing threats, any form of existing management at the site was also noted (including attributes of the nearest beach access points, such as signage present).
4. The distribution of pairs was mapped and overlays of threats compiled, including: a simple threat index (total number of threat types present) as well as measures of the severity of threats: presence of vehicles (illegal in Victoria), number of unleashed dogs, total number of predators, intensity of horse use and evidence of dune use (e.g. dune boarding or used as an informal access).
5. For the purposes of improving the breeding success of the most threatened Hooded Plovers, sites with the highest presence of each of these threat criteria were selected (e.g. sites with five or more threats out of a possible ten; sites with off-lead dogs in a leash only or dog restricted area, etc…).[1]

[1] For the purpose of a scientific study, a stratified random selection of sites across the range of the above threat criteria would be assigned to monitoring, and a subset of these to management (e.g. for a total of forty sites: 20 would be chosen randomly from all low threat sites and 20 chosen randomly from all high threat sites; ten of each assigned to management/monitoring and ten of each assigned to monitoring only).

6. The most threatened sites were then short-listed according to their accessibility (sites greater than 1.5 km from an access point were considered logistically unfeasible to manage) and local feedback from managers and community members about their perceptions of the threat status of sites, and whether there was commitment to participate in management and/or monitoring.
7. A range of additional sites was chosen for monitoring only; these sites were often adjacent to managed sites and could therefore be visited at the same time, or were in less accessible areas that volunteers were keen to monitor.
8. A list of potential on-ground actions was compiled for each of the sites selected for management, taking into account the threats recorded in initial surveys and the management recorded as already in place. Sites were then visited to attain more detailed information about threats and feasibility of management.
9. Once the breeding season commenced, management was further adapted to suit individual situations.

The Mornington Peninsula contains between 15 and 18 % of Victoria's population of Hooded Plovers. Managers have limited resources to allocate between the two conservation parks (Point Nepean National Park and Mornington Peninsula National Park) where the 30 breeding pairs occur. Management decisions come down to a combination of the following criteria:

- Whether the source of threat/s is manageable: i.e. natural (tide, native predators) vs. human-related.
- The intensity of human visitation: for example, in Point Nepean National Park, human access is confined to a limited area and prohibited from the majority of nesting areas (due to safety precautions associated with unexploded ordinance in the area). Many sites within the Mornington Peninsula National Park however, experience some of the highest human visitation rates in the state. However, there are a few sites that maintain low visitation rates due to their greater distance from an access point.
- Whether sites have required management in the past to produce fledglings.
- Whether sites have benefited from past management (i.e. have experienced higher hatching or fledging success compared to when they went unmanaged).
- Sites where hatching success is consistently high.
- Volunteer assistance: volunteers increase the capacity to monitor pairs and therefore, nests are more likely to be discovered and their location relayed to managers.

In Alberta, critical habitat for Piping Plovers is identified according to: 1) its use by ≥2 pairs of birds (≥4 adults or ≥2 nests) in ≥2 breeding seasons over a 15-year window; or 2) any documented use (probable or confirmed breeding) in ≥4 seasons during the 15-year period (Alberta Piping Plover Recovery Team 2006). The consistency of site use over time is

therefore another important criterion to note, as this indicates the suitability of habitat and that these sites are core rather than suboptimal habitat.

The New Zealand Dotterel recovery plan (Dowding and Davis 2007) highlights the lack of resources available for the Department of Conservation (DOC) to manage all key breeding sites and thus, the need for community groups or other groups and agencies to manage or sponsor protective actions so that the number of sites can be increased. An appendix within the recovery plan (Dowding and Davis 2007) provides details of how sites are chosen for management.

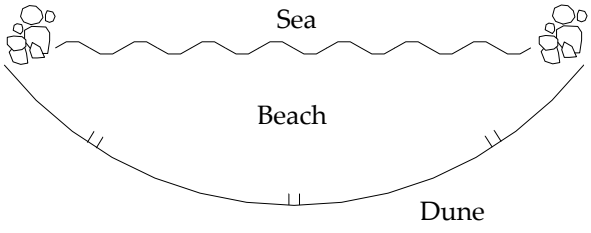
Site considerations

A manager should begin by considering the attributes of the breeding location and how these will affect management decisions.

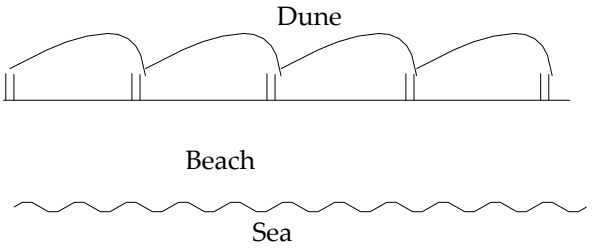
Beach morphology

- The location of the nest and layout of the beach will be important to the decision of whether to manage the nest and the type of management implemented. Figures 2-4 offer advice on the types of management needed for nests located on dunes, beaches and estuaries (see diagrams below for beach and estuary configurations).

Beach configurations

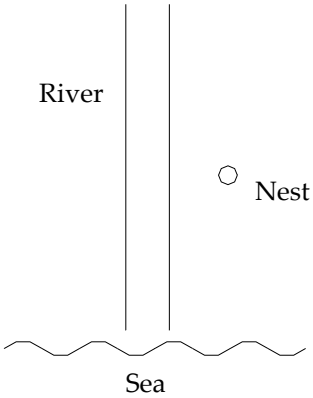


Cove beach with three access points

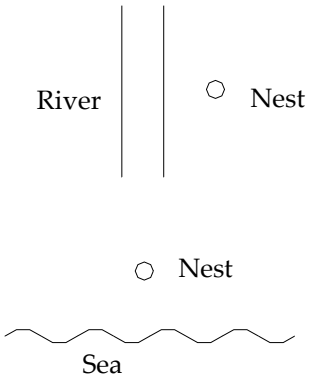


Continuous beach with multiple dune access points

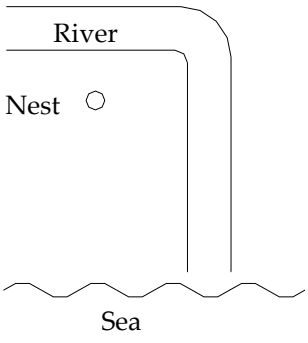
Estuary configurations



River open to sea, nest on one side



River closed to sea, nest at side or mouth



River open to sea, nest framed by river at rear and side

- The factors of most importance will be the accessibility of the site (largely related to the distance from access points), location of the beach relative to population centres (see Coastal Location below) and the types of recreation most likely in the area. For example, when a nest is located 1.5 km from an access point and is on a beach that people use for walking without dogs more commonly than other types of recreation, then management should not be required. However, if the nest is at the same distance from an access point but is opposite a popular surf break or good fishing location, then it will be likely that people will linger in the area and even walk onto the upper beach or dunes to rest their bags or equipment. In this case, management would be recommended.
- Information presented is for beaches accessible by foot, but for those accessible by boat only, the decision to manage will rest entirely on how frequently boats land at the site. If there is no obvious boat landing area, then it may be easier to post information on noticeboards at the nearest boat launching areas with warnings about locations with active nests.
- The height of the tide and width of the beach will also determine whether there will be room for fencing and how visible the signs will be from the water's edge, thus how large they should be (see signage and fencing sections, pp. 84-104).
- The narrower the beach, the more heavily concentrated the impacts of recreationists will be (Cairns and McLaren 1980).

Coastal location

The location of the beach itself will be important to management, not only from the perspective of how frequently the beach will be accessed/visited, but also in terms of the social characteristics of the people using the beach and the style of education that will be effective, the likelihood of vandalism and the opportunities available for effective education and communication.

Visitors vs. Locals

- If the breeding site is on a beach near a major population centre, then the visitor base will be diverse and it may be difficult to target education programs. Infrequent visitors to beaches can either be: 1) less likely to comply with signage as they are essentially on 'vacation from responsibility' and do not feel that the consequences will affect them; or 2) they can be more likely to read and comply with signage as the visit is a novel experience, enhanced by signs that draw their attention to the environmental values of the area they have chosen to visit. On beaches that have such a broad reaching visitor base, education will have to be ongoing and remain simplified. Wardens on beaches will be particularly effective at these beaches, providing personalized education to

visitors, reaching a large number of new visitors, and being able to answer individual questions.

- It is likely that the mix of visitors and locals using a beach will change over the course of the breeding season, often weekday, spring and late summer users are predominantly local, while visitor use peaks during summer and around holidays and weekends.
- If the breeding site is on a beach near a small coastal town, then it is possible to target the town's population with mail-outs and educational activities that encourage interest and pride in local beach-nesting birds. It is also useful to focus on local schools and involve the students directly in management activities, such as sign making or construction of chick shelters, as this will encourage adults within the population to show interest if conservation efforts are connected to their children. Local populations can be more reluctant to comply with signs as they view the beach as an extension of their own backyard and can be unhappy at being asked to change their behaviour by an 'outsider'. There can be confusion as to why they are being asked to change their behaviour now, when they have been behaving that way in the past and the birds have always been there and still are. Educational campaigns need to be focused and to build on information over time. Support from locals should be highlighted in the campaigns yet the management priorities should not be swayed by local opinion if these conflict with what is required to protect the breeding birds. Many small towns can be passionate and enthusiastic about protecting local species, and they should be rewarded in the media and used as positive examples to sway the more reluctant of communities.

Vandalism

- Was it vandalism or a vicious tide? The tide can smash apart signs, pull down fences and distribute materials further down the beach. Beach goers can rescue tide damaged materials and put them up in the dune. When a manager or volunteer arrives at the beach and sees the damage, they can sometimes jump to the conclusion of vandalism. Be certain to look for evidence of a high tide and if it has been a week since visiting, be cautious in concluding vandalism.
- If a particular beach has a problem with vandalism, or if breeding occurs around New Years Eve or 'schoolies' week, then it will be worthwhile using laminated signs and cheaper materials at these sites for that time period, and taking extra precautions with installation of signs, such as deeply anchoring sign posts. If vandalism is frequent and targeted at the breeding site, then the local authorities should be notified. To help the authorities apprehend the offender/s, take note of the day of the week or time of day when the vandalism occurs. It won't be wise to cease management at the site in the face of targeted vandalism, as this rewards the offender/s and leaves the breeding pair more

vulnerable to threats than before (as the public will now be cued into signs signaling breeding and their removal will indicate the end of nesting). A media release about the vandalism and a phone number for reporting sightings of offender/s may help resolve the situation.

Localised Threats

- On the Victorian coast, for example, threats to beach-nesting birds vary dramatically with geographic location. This relates to the types of recreation that are more common in the different areas and to the size of the visiting human population. In the south-west of Victoria, vehicles driven illegally on beaches, horse riding/training and the lack of dog leashing restrictions, result in some of the most heavily threatened Hooded Plover breeding sites in the state. While on some parts of the Bellarine Peninsula, despite being so close to major population centres such as Melbourne and Geelong, visitation can be infrequent and threats far less intense. On the Mornington Peninsula, the sheer number of visitors to the beach is of most threat to the birds, as well as the lack of compliance with dog regulations.
- It is essential for a manager to target communication devices to key audiences, that is, to understand the recreational purpose of visitors to the beach in question, and to weight these recreational groups according to frequency and intensity of threat when wording signage and formulating an educational program.

Figure 2. How to manage dune located nests – a decision tree

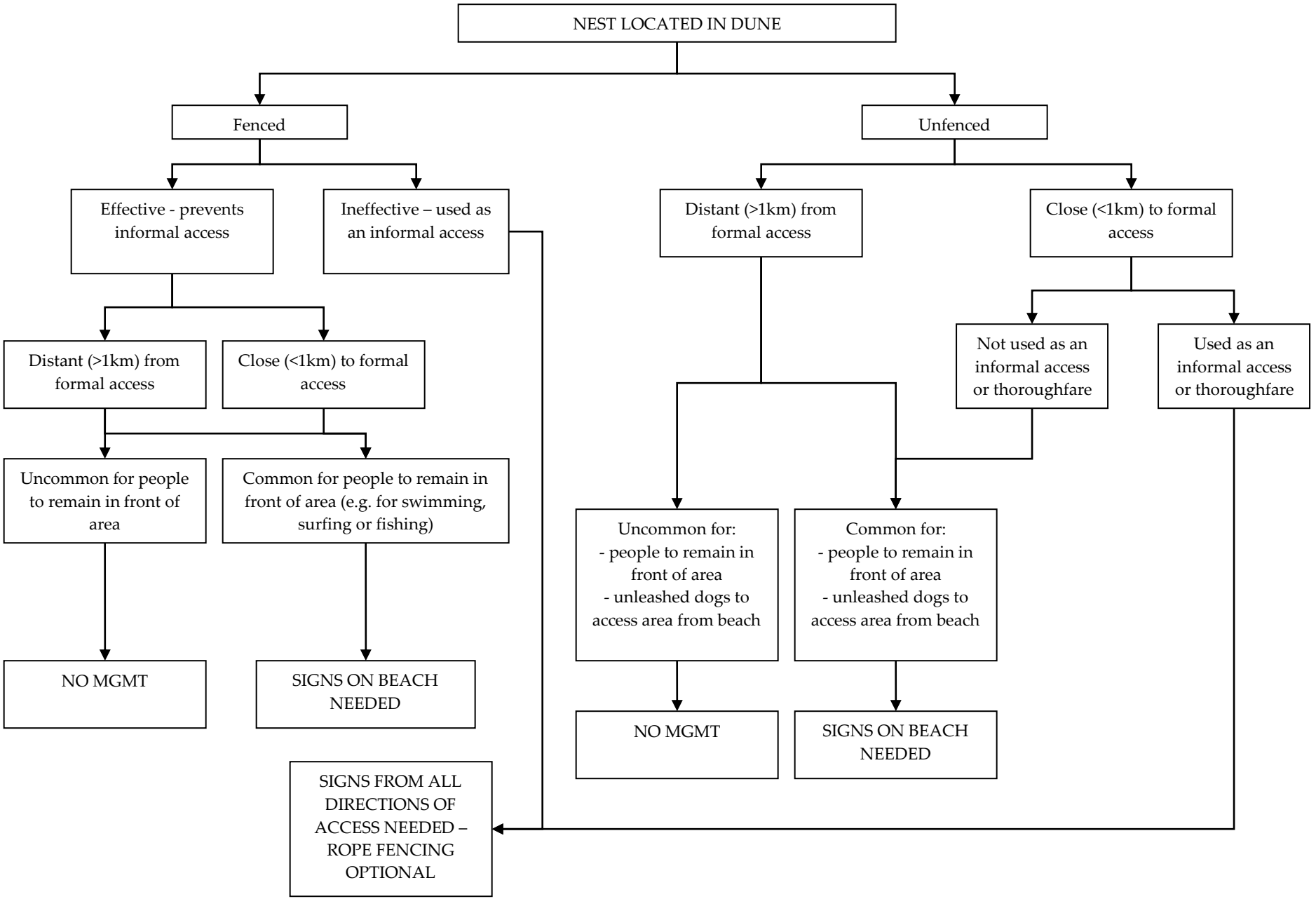


Figure 3. How to manage beach located nests – a decision tree

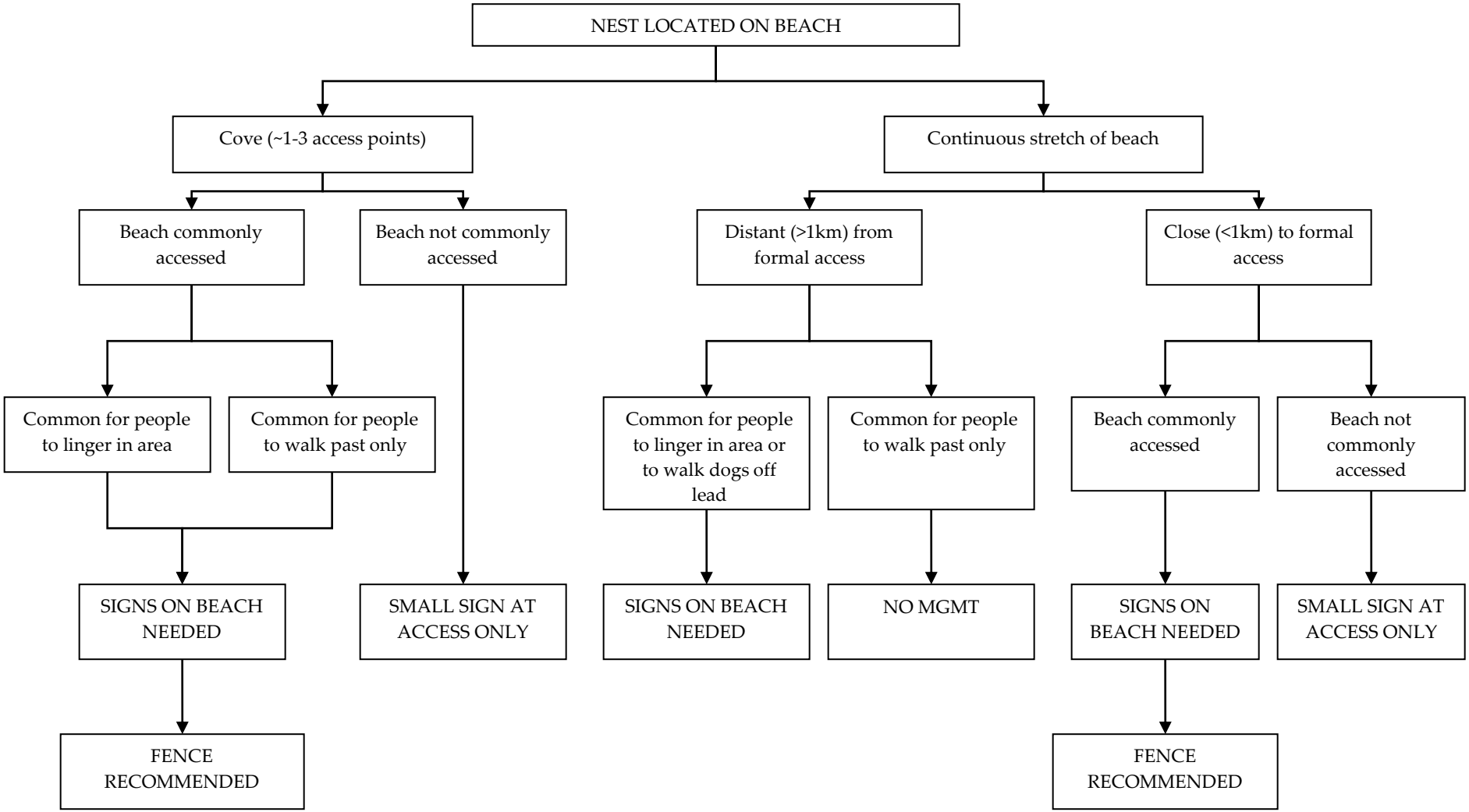
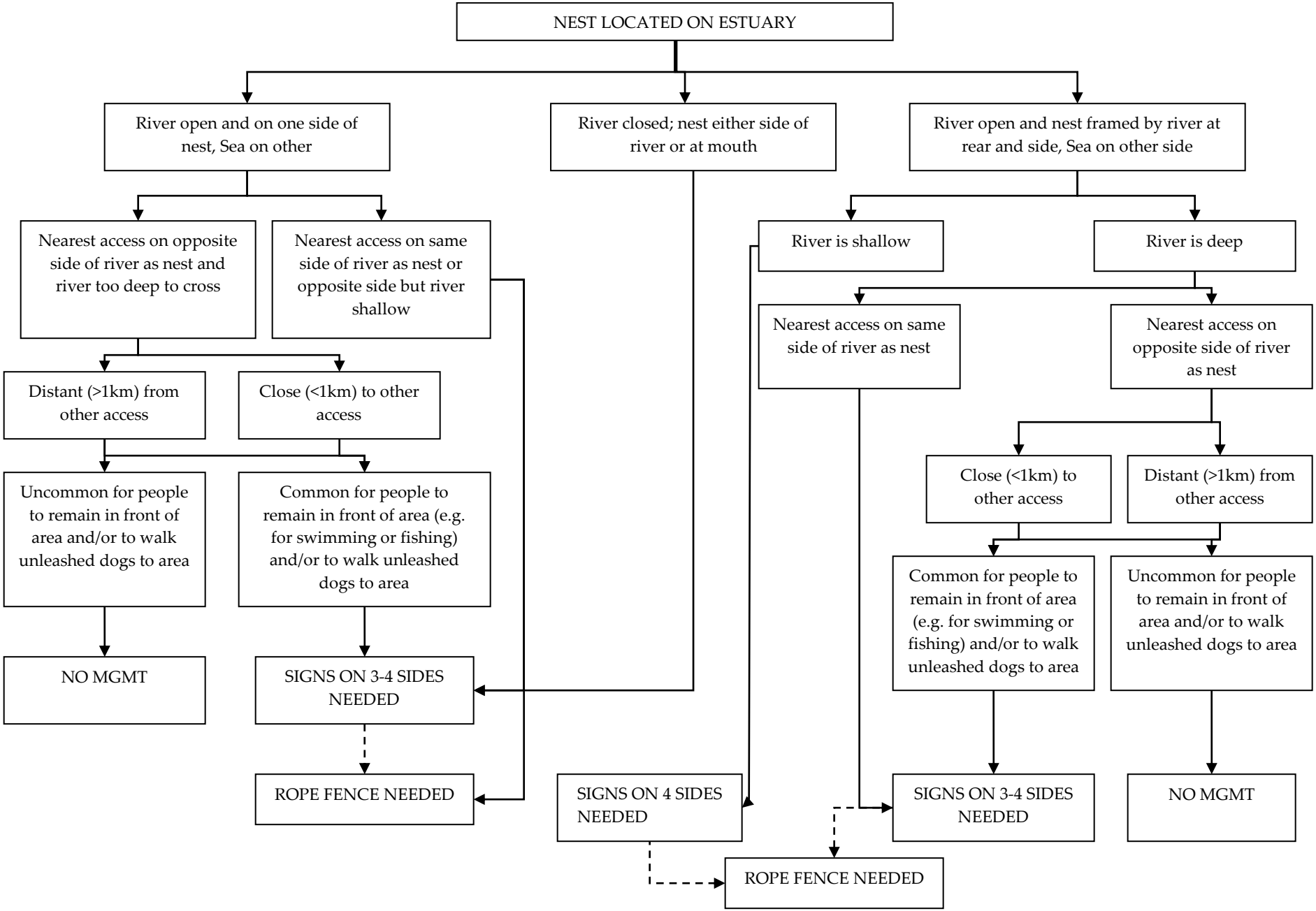


Figure 4. How to manage estuary located nests – a decision tree.



How invasive should management be?

Potential negative impacts of managing nests should always be considered and caution taken when modifying a widely-used management technique or trialing a new technique. There are several beach-nesting bird management techniques currently in use that can be considered invasive and risky; these include relocating or elevating nests to prevent tidal inundation (see pp. 109-110) and the use of small enclosed cages around the nest (see pp. 127-131). While tidal inundation is a natural cause of failure, in some areas, this risk has increased due to human modification of habitat, for example, infestations of Marram Grass force birds to nest on the beach as the dunes are no longer available. The desirable solution is to manage the source of the threat rather than the symptoms: in this example, to tackle the Marram Grass infestation rather than relocate individual nests. Nest cages may increase hatching success in some circumstances, but lead to abandonment or predation of adults in others. Furthermore, cages may actually increase the risks of predation post-hatching, and do nothing to reduce predation pressures facing chicks, thus do not resolve the impacts of predators overall. Predation control targeted at pairs under pressure is likely to be more effective. Management should aim to solve the overall problem rather than temporarily delay it. The effectiveness of techniques, regardless of how commonly used they are, should always be evaluated and adapted over time, and less invasive techniques should be opted for.

How important is timing?

Timing is everything when it comes to protecting the nesting sites of beach-nesting birds. For beaches that are heavily visited by people, it is essential that signs and fencing be erected around the nest site as soon as possible after the nest is discovered/reported: ideally on the same or next day, and certainly before the weekend if possible. It may be beneficial to fence an area that has been used for nesting in the past (either previous season, or within the same season) prior to egg-laying, as it is likely the birds will re-nest in the area or be encouraged to nest there due to reduced human pressure.

Special preparations need to be made for weekends, public events or holidays, as nesting sites are likely to be heavily impacted by the increased number of visitors at these times. It is important to visit the site prior to these occasions to look for any undiscovered nests and/or to ensure that signage and fencing are properly in place and well-maintained. Furthermore, it is useful to inform staff (such as surf-life savers, toll booth operators, weekend rangers), who are likely to be working in the area, of any active nests and to provide them with brochures to distribute to visitors.

Do managers need training?

Beach-nesting birds are extremely sensitive to disturbance and their eggs and chicks prone to crushing. For any area where beach-nesting birds breed, regardless of whether special effort will be made to protect breeding birds, managers need to be aware of the risks that their everyday management of the park or area may pose to the birds.

All management staff, including summer staff, should at a minimum be able to identify the birds and be informed of their status and threats (achieving this could be as simple as providing brochures to all staff). For parks with a large number of staff, it can be useful to send a memo or post an up-to-date list of active nest locations on a noticeboard.

Management staff often use quad bikes or 4WDs to patrol beaches (and even to access nesting sites to be managed), and if driven above the high-tide mark (which becomes unavoidable if visiting at times of high tide), they run the risk of crushing the eggs, chicks and even the adults. Page 152 provides advice for the use of management vehicles on beaches.

Weed or erosion control, tree planting, collecting rubbish and other activities that involve walking on the upper beach or dunes can also be risky activities if undertaken during the breeding season. Thus, managers firstly need to be aware that these birds are present and secondly, to plan such activities for the non-breeding season. Where this is not possible, participating staff and volunteers must receive appropriate training in identifying the birds, their nesting behaviours and potential nest locations, and in minimising risks.

If birds are known to breed by estuaries and an artificial opening is scheduled, it is vital that the site be visited beforehand to determine whether there are any active nests or chicks in the vicinity. There may be a need to relocate the nest or to monitor the chicks during the opening to ensure they remain out of the path of machinery and that they stay on the side of the river which offers the best habitat. The services of an experienced person will be required in this situation.



Artificial estuary opening; Keeping watch for Hooded Plover chicks; River opens to sea (Grainne Maguire).

When events such as fun runs or surf carnivals are planned for the breeding season, approvals and permit conditions need to highlight impacts to beach-nesting birds and instructions for event staff to alleviate these impacts. If birds are actively nesting at the proposed site, it may be necessary to insist on an alternative location. It would never be appropriate to approve events such as major horse riding events or dune buggy events during the breeding season.

It is extremely important that anyone who will be working with the birds, either monitoring or managing them, have the appropriate training. Even the task of putting up signs to flank a nesting site with eggs is of great risk if the person is unaware of the nest's exact location and of the measures that need to be taken if the eggs have already hatched.

Researchers have gone to great lengths to determine the most effective and least risky techniques for protecting nest sites (e.g. fencing nest sites). It is therefore essential that managers abide by the instructions or precautions highlighted for implementing these techniques to avoid any damage. Advice for any proposed changes to management techniques should be sought from the relevant experts, for example research organisations or departments who have published papers on that species or counterpart species. Nests have been known to fail when managers have made on-the-spot decisions without seeking proper advice.

The breeding season of beach-nesting birds is often lengthy, and it is likely that staff responsible for protecting nests and chicks will take some leave during this time. It is important that there be a stand-in for this staff member and that this person has, or receives, the appropriate training.

Management options in detail

The following section goes into detail about each management technique available for protecting beach-nesting birds, including:

Signage

Most beach users mean no harm to beach-nesting birds and generally only need to be informed of potential impacts. Signs are the most valuable tool a manager has for protecting beach-nesting birds. If no attempt is made to educate or warn beach users that they are about to enter a breeding area and are a potential danger to the birds, then breeding success will relate purely to chance and the impacts of human recreation in the short and long-term will not be alleviated.

Sign options

Permanent interpretive signs

- **Placement**: the start or end of beach access paths, at viewing platforms or lookouts.
- **Purpose**: to inform the public of the presence of beach-nesting birds and of their plight.
- **Content considerations**: coverage of the full range of beach-nesting birds found at the site, the time of year they nest and specifications for their protection.
- **Advantages**: permanent signs lend weight to temporary signage, give people prior warning to managements they may observe on the beach, and are effective at providing extra information that signs flanking breeding sites cannot provide. For sites where additional management will not occur, these signs are the only means of educating visitors and providing information on how to protect beach-nesting birds. Permanent signs permit greater investment in the sign itself, and so can be attractive and eye-catching. They generally require less maintenance and have a longer "shelf-life" compared with temporary signs.
- **Disadvantages**: more costly than temporary signs. They lose effectiveness over time, as regular visitors to the site become habituated to the signs. It can be useful to reposition the signs over time, to remind people that the issue is still relevant.

Size

- Interpretive signs about beach-nesting birds can be free standing, or this information can form part of an interpretive shelter or larger interpretive board about the park's wildlife.
- The size of a free-standing sign will in part depend on the specifications set by the land manager and consistency with other signs at the site. The sign needs to be obvious to beach visitors and the text large enough to read with ease. The text on the sign should not be too cluttered, so the more text you have, the larger the sign.

Materials

- Signs need to be made of materials that withstand coastal conditions (corrosion from salt spray), are durable over time and are graffiti resistant. Options include: anodised aluminium with acid etched text and pictures, or stainless steel (316 grade) laser etched, or digitally printed stickers on anodized aluminium backing (with the option of perspex covers to prevent stickers peeling or being vandalized), or 3 mm clear polycarbonate acrylic encapsulated print outs.
- Signs can be framed by timber or metal and mounted on one or two treated pine posts or metal posts anchored deep in the ground in cement.

Placement location

- Permanent signs should be located close to the access path and in a position where people will automatically pass by the sign. Research has shown that signs placed on the left side of the path are more likely to be noticed. If there are already multiple signs at the entrance of an access point, it is best to put the interpretive sign on its own further along the path at a natural junction, or at the end of the path which is closer to the beach and lends more relevance to the sign. There needs to be room for people to stand and read the sign and not block the path.
- Be wary of placing signs on permanent fencing as this will encourage people to approach the fence and if the birds nest or chicks hide behind the fence, then this will result in increased disturbance.
- Signs at adult eye height are effective, however to make the signs accessible to children and disabled people, it can be best to place them lower and angle them upwards.
- The sign should be in a well-lit environment, but in a position to minimise glare and reflection.
- Please visit: www.interpretivesigns.qut.edu.au/index.cfm for more information and examples about placement of interpretive signage.

Temporary notices to beach visitors

- **Placement**: the start or end of beach access paths nearest to the breeding pair; for horse or vehicle accessed sites, the nearest horse or vehicle access points; for boat accessible sites, the nearest boat launching areas.
- **Purpose**: to inform the public of an active nest or brood and of its progress: either that there is an active nest with eggs on the beach or dune, and later, a message that the nest has hatched (and to be vigilant for chicks) or failed.
- **Content considerations**: need to be accompanied by the date, which can be as broad as, for example, November to December, or when hatching and fledging dates are known, providing actual dates (± 5 days to be safe).

- **Advantages**: notices that are updated during the breeding season gain the interest of regular visitors and signal that the breeding pair is being monitored. Visitors know that the signs are current and relevant and that the change is only temporary, and thus will be more likely to comply.
- **Disadvantages**: Notices need updating so the pair must be regularly visited by the manager or volunteer/s. Difficulties mounting temporary noticeboards in a way that resists wind and tide damage.

Size and materials

- Laminated A4 (heavier paper, ~160 GSM) signs can be mounted onto exterior plywood (or offcuts of wood or packaging crates can be recycled as backing) to form temporary noticeboards. These can either be affixed to the infrastructure present (such as a fence or gate) or to a 1.5-1.8 m tomato stake, hammered into the ground.
- Signs that are colour printed and include photographs will be more attention grabbing.
- Alternatively a small blackboard can be mounted on a stake, or a larger A-frame blackboard used as a noticeboard.

Placement location

- The start or end of beach access paths nearest to the nesting pair; for horse or vehicle accessed sites, the nearest horse or vehicle access points; for boat accessible sites, the nearest boat launching areas.
- Noticeboards should be placed where visitors to the beach will pass by and see the sign. They should be high enough to read without stooping, for example by hammering the board angled upward on a waist-high fence.

Signs flanking the breeding site (otherwise termed 'temporary beach closure' signs)

- **Placement**: surrounding the breeding site (see below for advice about placement).
- **Purpose**: to inform the public of the location of an active nest or chick location, and to provide guidelines for minimising risk in this area.
- **Content considerations**: it is important to give context to the rules on the sign by providing some information on how the birds are threatened.
- **Advantages**: it is too much to expect the public to be able to detect and identify beach-nesting birds and act accordingly when sighted. By demarcating the general nesting area, beach goers can recognise exactly where they are being asked to be careful, and are more likely to comply with rules that apply across 100 m of beach compared with several kilometres or more. These signs can instill a sense of involvement and engagement among regular beach visitors.

- **Disadvantages**: these signs can require more effort to place (walking fair distances carrying heavy equipment) and must be put up and taken down in a timely manner (if they are not kept up-to-date, they can erode public interest). A common concern that has been voiced is that by signing the nest area, you enable vandals or egg collectors to know the location of the nest or you attract the curiosity of beach visitors which increases disturbance. There has been extensive research into the signing and fencing of nest areas (Maguire unpubl. data) and with 145 nests managed in this way, there was no evidence to suggest signage was detrimental to the fate of the nest. It was incredibly rare (7 of 3841 site visits) for members of the public to look for the nest within the signed area (and this was commonly from the boundary of a fence), but in none of these cases did the nest fail to hatch as a result of this disturbance. Instead, on busy beaches when nests are not signed, they almost inevitably fail due to crushing or disturbance from recreationists. The camouflage of the eggs and nest, together with strict guidelines for spacing of signs and dimensions of fencing, mean that the majority of people would be unable to locate the nest. Considering the attitude of the majority of beach visitors, it would be very rare that a person would actively want to harm the eggs. Signing the nest, serves to educate the majority of beach users.

Size

- The size of the sign will depend on its intended location. Signs can be located at the start of an access path, base of access path or surrounding the breeding site depending on how close the nest or brood site is to the access point. For nests/broods located in small coves that have only one to three access points, signs can be used at the start or base of each access path. For continuous stretches of beach, it is better to place signs either side of the breeding site, and if people access the beach via the dunes, behind the breeding site also. At an estuary or spit, it may be necessary to put signs on all four sides of the breeding site.
- Signs need to be placed above the high-tide mark to persist over time and thus the width of the beach is an important determinant of the sign dimensions.
- Signs need to be fixed securely so they don't blow or fall over and hurt somebody.
- If the breeding site is immediately past an access point, then it can be useful to place the sign at the base of the access point, positioned to the side where the nest or brood is. When positioned at the base of a path or where the beach turns a corner or narrows, the sign can be A4 or A3 sized – as people will have to funnel past the sign and it won't have to be detected from a great distance. However, when the sign is placed on a wide beach, it needs to be large enough to catch people's attention and thus sized between 50 and 120 cm.
- If the nest or brood location is a great distance from an access point, then it may not be possible to carry larger signs on foot for this distance and smaller signs should thus be

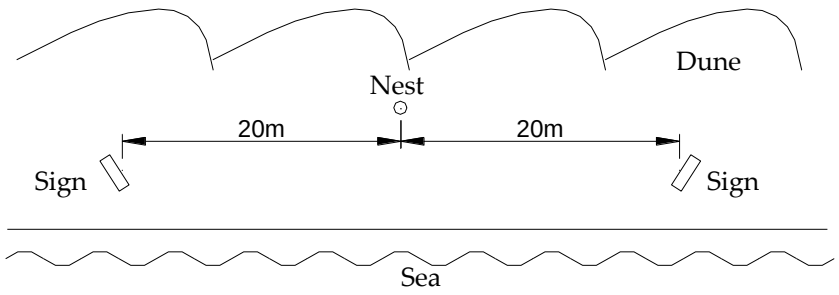
opted for. An authorized land manager may be able to drive their vehicle sensitively along the beach with materials.

Materials

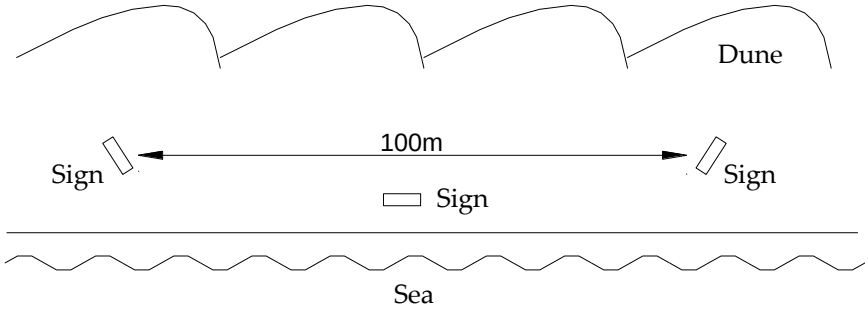
- A4 or A3 signs can be printed on heavy paper (~160 GSM) and laminated. This is a cheap and lightweight option. The laminated signs are easily glued or taped (exterior cloth or plastic tape) to exterior plywood affixed to 1.5-1.8 m tomato stakes.
- For the larger signs (50-120 cm), it is best to use a light weight plastic, such as corflute board (5 mm thick) with computer cut sign-writing and digitally printed stickers of photographs, illustrations or logos. A sign that is 90x120 cm with logos and a photo digitally printed costs approximately $120. The corflute board can either be framed with a lightweight, exterior wood and the frame affixed to wooden legs, or the corflute itself can be affixed with cable ties to three tomato stakes or plastic star pickets. Corflute tears easily and to lengthen the life of the sign, it is best to reinforce holes in the corflute with exterior tape or to use washers in between bolts.

Placement location

- A minimum of two signs flanking the breeding site should always be used so people know where the sensitive area begins and ends.
- Placement of the signs on the beach must consider how high the tide comes in. Preferably they should be closer to the waterline than to the foredune so that people do not have to walk higher on the beach to read the sign because this will increase disturbance, and because often people that walk up to the sign will continue on at the same level of the beach as the sign.
- The signs should be placed perpendicular to the water, or at an angle of 135 and 45 degrees to the water (see diagram below). They need to be dug in or hammered into the sand above the high-tide mark, at a depth of at least 15 cm for a tomato stake and 30-40 cm for a large corflute sign.
- The two signs need to be placed at a minimum distance of 20 m either side of the nest (so each sign is separated by at least 40 m). The signs are placed at this distance to reduce the likelihood that the incubating bird will have to come off the nest when people approach the sign to read it. This distance may vary according to the average flushing distance of the species or individual pair. Signs that are placed too close to the nest provide no buffer against disturbance and make the nest's location too obvious. At the same time, the signs should not be placed too far apart, as people should be able to see the start and end of the sensitive area.



During the egg face, signs should be spaced at least 20 m either side of the nest.



After hatching, signs can be placed along 100 m of beach where the chicks are frequently observed.

- If people access the beach from the dune side, then additional signs need to be placed at each of the access routes where people enter the dunes from the land side.
- Once the eggs hatch, it can be useful to dig signs deeply into the sand, placing these on or below the high-tide mark, signaling this area as a 'chick feeding zone' or in front of a fenced area specifying 'chick feeding zone between fence and sea'. Signs can be placed along 100 m of beach in an area where chicks are frequently observed, for example.
- Signs should be removed whenever a nesting or brood-rearing site is not in use, to ensure the public sees the restricted area as: 1) current and for a purpose, and 2) aimed at maximising coexistence between recreationists and birds.

Key points for positioning signs to flank the nesting site:

- Signs need to be placed above the high-tide mark and facing the direction from which people approach.
- A minimum of two signs is needed and these should be at least 20 m either side of the nest to provide a buffer against disturbance. Once the eggs have hatched, signs should be periodically spaced along the beach in the area where chicks spend most of their time.
- If people access the beach from behind the breeding site, that is, from the dunes, then signs need to be placed at each of the access routes on the land side.
- Signs need to be removed once the nesting attempt has ceased.

Sign content and design

- Consistency is the key to any broad reaching awareness raising program such as educating beach users about the needs of beach-nesting birds. It is highly probable that individuals will visit more than one site where breeding pairs are being managed, and it is therefore essential that the key messages be consistent across sites. This manual provides advice for maintaining consistency.
- Signs that purely instruct people to behave in a certain way will not be as effective as those that provide some context or education as to why a person should alter their behaviour. It is important to provide the reasoning behind compliance.
- A sign should try to include content about: 1) How threatened or rare the birds are (why should I care?); 2) What are the threats (how does this relate to my behaviour?) and 3) How can I help?
- Information needs to be accurate. The person researching sign text needs to source accurate information and the best sources will be the Handbook of Australian, New Zealand and Antarctic Birds (HANZAB), research papers published in peer-reviewed journals and recovery plans.
- Guidelines/instructions for protecting the birds should be clear and unambiguous. Drafts of the sign wording should be tested by a range of people from different backgrounds for clarity. Jargon and scientific expressions should be avoided, use simple English.
- Instructions should focus on the positive rather than the negative. For example, instead of saying 'Do not…' try 'You can help by…'.
- Instructions should use the active rather than passive voice; such as 'We can help by…' or 'You can help by…' are preferable over terms such as 'Ways to help'.
- Text on signs should be kept to a minimum, but at the same time, this should not be at the expense of accuracy or providing enough content to educate the beach user.
- Paragraphs should be kept short and lines of text between 40-65 characters.
- Font size should be large and attention grabbing. Bolding and italicizing text should be incorporated to break up the content and to reinforce important ideas: but avoid writing sentences in capital letters.
- There needs to be strong contrast between the writing and background.
- Information needs to flow in a logical order.
- Pictures that evoke sympathy or interest should be included on the sign. If pictures of the birds are to be included, it can be helpful to include a size scale.
- Signs need to include logos of land managers and funding bodies (after seeking permission to use the logos). It can be useful to provide a phone number or website for further information.
- Development of information for signage can benefit from social research on the targeted audience/recreational group. See, for example, the honours project of Stacey

Henry (University of Melbourne) into barriers to compliance with dog regulations in Victoria (contact Birds Australia for a copy of the thesis). Furthermore, the Western Snowy Plover recovery plan (US Fish and Wildlife Service 2007) provides details of information included on signage and in public education programs that have been developed in response to questions commonly posed by the public.

- ***Interpretive signs*** need to cover six key elements in order to be effective (for more information visit http://www.interpretivesigns.qut.edu.au/index.cfm):
  - Interpretation must be **relevant** to the intended audience: there must be a connection with previous experiences or knowledge.
  - Interpretation should provide novel, **varied experiences** and avoid repetition: multi-sensory or variation in style compared to other signs already present at the site.
  - Interpretation should be organised with **clear, easy to follow** structures: needs a distinct introduction (defining a beach-nesting bird and indicating their presence at the site), body (outlining why and how they are threatened) and conclusion (providing guidelines for helping beach-nesting birds).
  - Interpretation should be **based around a theme**: themes need to be specific, attract attention and generate interest.
  - Interpretation should **encourage visitors to get involved** and give them opportunities to take control of their own experiences: messages that are personalized or give the visitor opportunity to act on the information in the sign.
  - Interpretation should understand and **respect the audience**: knowing your audience is essential, for example, research into barriers to compliance with dog leashing regulations has shown that most dog owners do not understand the mechanisms by which dogs threaten nesting birds and the impacts of disturbance in particular. It is therefore essential this be explained on a sign placed at a dog walking beach.

Text options

Appendices 3-5 provide photographs and designs of a range of signs that are currently used in Australia for raising awareness about beach-nesting birds.

The text box below gives examples of ambiguous, misleading or ineffective text that can occur on beach-nesting bird signs, and examples of instructions to beach users that have proven successful.

Common mistakes on beach-nesting bird signs:

- To specify that the birds nest in the dunes: this is misleading because people will think they are only dune nesters while nests located on the beach above the high-tide mark are just as common. If there is a need to specify where the nest is, stipulate 'At this site, the birds nest in the dunes'.
- To place emphasis on the beach versus the dune or vice versa: both of these habitats are equally important to the survival of beach-nesting birds: they will nest either on the beach or dunes, and the beach will be essential for chick feeding, while the dunes will be an essential hiding place for chicks. It is important to get the message across that the chicks are mobile and use both habitats.
- To state that the adults feed the chicks: shorebird chicks are precocial and begin foraging almost immediately after hatching (tern chicks differ in that the parents feed them). They need to feed themselves down at the water's edge and along the high-tide mark amongst the beach wrack. It is for this reason that they are so incredibly vulnerable. This is why too much time in hiding can lead to starvation and why it is important people don't sit in front of fenced areas.
- To stress the issue of crushing but not to mention disturbance: these are equal killers of the eggs/chicks. Disturbance can operate at greater distances from the birds and is harder for people to understand. A person could be responsible for the death of the clutch or brood even when they keep out of a fenced area, simply because they sit too close to the fence.
- To state that the impact of unleashed dogs is through chasing and attacking/killing birds: this is not the only mechanism via which unleashed dogs threaten the eggs/chicks. If the sign states it is, then people with dogs that do not chase birds will believe their dog is of no threat, which is inaccurate. Again, disturbance has a huge and deadly impact and is intensified by the independent movement of an unleashed dog in relation to its owner.

Examples of requests that are ambiguously worded:

- Temporary beach closure: this was the original heading of the signs used to flank breeding sites. However, in some areas this wording generated much confusion, as the public were uncertain about whether they were allowed in the area at all.
- 'Control your dog' or 'Dogs must be under effective control': this can give the impression that if the dog is responsive to verbal control, then it is of no threat to the birds. A person will think that even if their dog is running all over the beach but will respond to them if called, then it is controlled and of no threat.
- 'Pass through the nesting area quickly': might give the impression that you can walk through the actual nesting area as long as you do it fast – it needs to be stressed that people should walk past along the water's edge.

- 'Be nice to the birds': a person who accidentally steps on a nest isn't a bad person and so we suggest using wording that is more educational and directional.

Examples of sign text that can create a negative image towards conservation:

- 'People are complaining that vehicles driven on this beach are a danger to wildlife': this wording could be viewed as antagonistic so that any guidelines on the sign may be unlikely to be followed as the user group feels they are unwelcome on the beach. We suggest alternative wording along the lines of 'Vehicles can pose a major threat to wildlife, but there are ways to avoid this'.
- 'Is your dog a nuisance? Four-legged friends have a devilish streak. Even a friendly dog can annoy other dogs and people and when allowed to roam free it can frighten and chase birds': words like "nuisance", "devilish" and "annoy" should be avoided, as they create hostility and will send the message that dogs and conservation are incompatible. Most dog owners say their dog doesn't chase birds so they don't feel a need to leash their dog; the above wording will reinforce the perception that if the dog isn't 'naughty' then it can stay off the lead. We suggest something along the lines of 'beach-nesting birds and their chicks perceive unleashed dogs as a great threat. Even if your dog isn't the type to chase, the birds don't know that!' or 'Unleashed dogs disturb incubating birds and foraging chicks for long periods which can lead to eggs overheating and chicks dying of starvation'.

Examples of sign text that have proven successful:

- Walk past this signed area along the water's edge.
- Walk past this signed area along the ocean's edge on the hard, wet sand.
- Do not linger near signed or fenced areas.
- Do not remain or sit in front of the area (their feeding zone)
- Do not walk on the upper beach or dunes.
- If you see a 'name of bird' during nesting season, do not settle within 100m.
- If you see a 'name of bird' during nesting season, walk 100 m along the beach before settling.
- Keep your dog on a lead during the nesting season (on permitted beaches). Even if your dog isn't the type to chase, the birds don't know that! When your dog is unleashed, the birds perceive you as doubly threatening.
- Keep your dog on a lead during the nesting season on permitted beaches. Beach-nesting birds and their chicks perceive unleashed dogs as a great threat. Even if your dog isn't the type to chase, the birds don't know that!
- Leash your dog when passing by the area.
- Dogs are not permitted on this beach for the protection of breeding birds.
- During dog permitted hours, keep your dog leashed and away from the signed area.

Language to appeal to youth:

- Life's a beach to a 'name of bird'
- Chicks on the beach… Look out!
- The beach is our crib...respect the Hood
- There's trouble for the Hood…

Interpretive signs (far left); Temporary noticeboard at access point; Temporary noticeboards on beach (far right); Photos: Grainne Maguire, Kelly Thomas (bottom right).

Corflute signs flanking nest site; Formalised access stairs; Fenced access path and stairs (Grainne Maguire).

Fenced access path with temporary notice; Fenced dune – ringlock and 3-strand wire (Grainne Maguire).


Temporary rope fence (bookend style) around nest with plywood sign; Temporary rope fence around nest backed by dune; Temporary rope fence and corflute signs. Photos: Grainne Maguire.



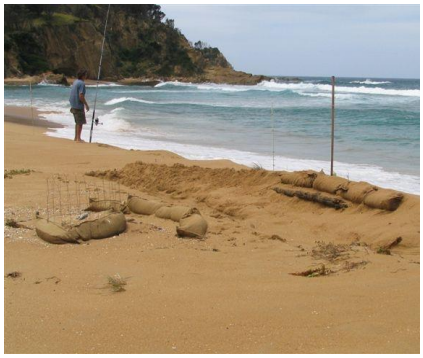
Temporary ringlock fence around nesting site x 2 (Grainne Maguire); Square shelter design (Mike Weston).



Square shelter in situ; Rectangle shelter in situ x 2. Photos: Grainne Maguire.



Triangle/tepee shelter in situ (Grainne Maguire); Shelter in use by Hooded Plover chicks (Glenn Ehmke).



Hooded Plover family behind rope fence and near tepee shelter (Glenn Ehmke); Little Tern nest on sandbags with nest cage, and sand bag wall to protect from inundation, NSW (Gary Whitley).

Fencing

Dodge *et al.* (in prep.) found that signs flanking the nesting site have an associated 93 % rate of compliance, while the addition of a fence increases compliance by a further 1 %. Contrary to this finding, monitoring of fenced and unfenced Hooded Plover nesting sites on the Victorian coast revealed that fences had a far greater compliance rate than signs alone, with fewer footprints recorded above the high-tide mark and fewer observations of people sitting between signs when a fence was present (Maguire unpubl. data). Fences protecting New Zealand Dotterel nesting sites are generally respected by the public (Wills *et al.* 2003). Fenced areas can provide a buffer from disturbance: Ikuta and Blumstein (2003) compared disturbance levels of 10 waterbird species in fenced areas compared to heavily visited and infrequently visited unfenced areas. They found that the levels of disturbance experienced by birds were similar for fenced sites and low visitation control areas, and that these were significantly lower than those at the high visitation site. Similarly, Lafferty *et al.* (2006) found that when a barrier was introduced at a Californian beach, this reduced disturbance to Snowy Plovers by half, led to reduced nest crushing rates and resulted in the birds re-inhabiting the area for breeding. One potential problem with fencing of all kinds is that it may provide perches for avian predators (Weston 1995).

Several options for fencing are available:

- Permanent fencing of access points
- Permanent fencing of dunes
- Temporary rope fencing around nest sites or chick foraging areas
- Temporary ringlock fencing around nest sites

Permanent fencing of access points

Permanent fencing of access points acts to formalize walking tracks through the dunes to beaches, so that people will be funneled along a specific path rather than making numerous trails through the dunes. This prevents crushing of nests in dunes, allows for an undisturbed dune refuge for birds and directs people to a central location on the beach, so that birds with chicks have the opportunity to move away from these highly concentrated areas of disturbance.

Access points are commonly fenced using treated pine posts (1.8-2.0 m tall) and either ringlock (11 x 15 cm mesh size) or three strands of wire (plain or encapsulated) between posts. These are low maintenance and easily erected. Sand movement may result in the requirement for fence realignment (Urquhart and Teoh 2001).

Permanent fencing of dunes

This type of fencing is to prevent access into the dunes from the seaward side. This can be as an extension of a formalized access point, by continuing on another 50-100 m either side of the access point. Alternatively a section of dune where the birds are known to nest can be permanently fenced. It is important that this type of fence extend inland at either end for approximately 5-10 m, so that it is clear that access behind the fence is prohibited. It may be necessary to fence an area on the landward side to prevent access, or to use vegetation plantings or brush matting for the same effect.

The base of the dunes are commonly fenced using treated pine posts (1.8-2.0 m tall) and either ringlock (11 x 15 cm mesh size) or three strands of wire (plain or encapsulated) between posts. It can be useful to leave a small gap (of 10-20 cm) under the ringlock to avoid seaweed and debris becoming entangled in the fence and to allow for space to fill with sand over time. This style of fencing will require maintenance over time.

Temporary rope fencing around nest sites or chick foraging areas

Rope fences are simple and while they do not provide a true barrier to access, particularly by unleashed dogs, they act as a visual cue to people about the area the signs refer to and where entry is prohibited. The fence has two purposes; first, to prevent people walking through the nest site and crushing the nest, and second, to provide a distance buffer between the incubating bird and beach visitors, so that disturbance is minimised.

Symbolic fencing is widely used around the world for species of beach-nesting bird, both to reduce the risk of crushing and to act as a buffer to disturbance. Installation of symbolic fencing at Coal Oil Point Reserve in California, in conjunction with a wardening program, has allowed management of recreational use and resulted in successful re-establishment of

a breeding population of Western Snowy Plovers at the site (Lafferty *et al.* 2006). Experience at many North American Atlantic Coast beaches where Piping Plovers nest, has shown that use of symbolic fences (one or two strands of light-weight string tied between posts) substantially improves compliance of beach-goers with signs and decreases people's confusion about where entry is prohibited (U.S. Fish and Wildlife Service 1996).

In order for the fence to act as a buffer to disturbance and to avoid the fence becoming a 'viewing area' that showcases the nest to people and to avian predators that may sit on fence posts, there are strict minimum dimensions for the width and length of the fence. Beach-nesting birds have been known to abandon a nest when fences that are too small have been erected around the nest (e.g. Hooded Plovers, Maguire unpubl. data).

Rope fences are more commonly used to protect the eggs, but can be useful at providing a protected area that chicks can run to when disturbed, where they are unlikely to be crushed. However, when there are chicks, people may mistakenly think that the chicks stay within the fenced area and therefore it may prove unbeneficial to keep the fence standing after hatching. To avoid this problem, ensure signage indicates that chicks are mobile and need to feed on the beach and at the water's edge, and if possible, expand the fence along a considerable section of beach giving the chicks a large area of protection.

When to erect and remove fencing

- Fencing should not be erected during laying, as the chances of abandonment are high. You must first determine the most common clutch size for the species and the average time interval between laying. For example, Hooded Plovers commonly lay three eggs, so when a nest with one or two egg/s is found, it should be visited two days later to see if the clutch size has increased. If the bird is observed incubating however, it can be assumed the clutch is complete.
- Days of mild weather, 20-24º C should be opted for. The fence should not be erected during extreme heat, cold, rain or windy conditions.
- If the nest fails before hatching and this is unrelated to the tide, then it is unlikely that the birds will nest again in the same location. The fence should therefore be removed soon after failure. If however, the nest failed due to the tide, or soon after hatching, then it is likely that the birds will nest close to the original nest location or in the same location if the latter applies. Therefore it may be wise to leave the fence standing for one to two weeks after failure to see if the birds make fresh scrapes within the fenced area.
- Once the eggs hatch, the decision to remove the fence will depend on the area that the chicks use to forage. It can be useful to alter the dimensions or the degree of openness of the fence (see below) or to move the location of the fence to a particular section where the birds are frequently observed.

- If the chicks roam across an area of 1-2 km, then it is wise to remove all fencing and to instead place signs periodically along the beach.
- The person removing or relocating the fence MUST have made a visual sighting of all chicks and know where they are hidden before walking above the water's edge. Even if this means leaving the area and watching from a distance for up to 30 minutes, this is safer than to risk walking up and accidentally crushing them. In the first week after hatching the risk of stepping on chicks is very high, as they crouch and don't move when you come toward them.

Dimensions of fenced area

Egg phase

- The seaward side of the fence needs to be at minimum 20 m long, running parallel to the water. The nest should be in the centre of this area, that is there should be at least 10 m of fence either side of the nest parallel to the water.
- The dimensions of the fence may need to be varied to suit the species or individual pair, as some are more prone to disturbance than others. It is best to get an idea of the average distance that the birds are disturbed from when approached. The fence dimensions presented here have been determined for Hooded Plovers, but these may need to be increased for more sensitive species such as Oystercatchers.
- Signs need to be placed at either end of the fence, at least 5-10 m from the fence so that people will not have to approach the edge of the fence, which potentially disturbs the incubating bird.
- The width of the sides of the fence will vary according to how wide the beach is above the high-tide mark. There needs to be space for people to walk past when the tide is highest.
- In cases where the nest is very close to the high-tide mark, the rope fence becomes more important for preventing crushing and may not be effective at reducing disturbance. The minimum widths that have been used successfully at Hooded Plover nest sites have been ~7 m and in some cases, the seaward length of rope has only been 1 m out from the nest.
- Fence posts need to be at a height that cannot be easily stepped over. A 1.65 m picket is ideal, as there is plenty of scope for driving these deep into the sand and still meeting the appropriate fence height.
- Fence posts should be placed at regular intervals, approximately every 7-10 m.

Chick phase

- Similar rules to those above should be applied when deciding on the width of the sides of the fence, the distance of signs from the fence, height of fencing and spacing of posts.

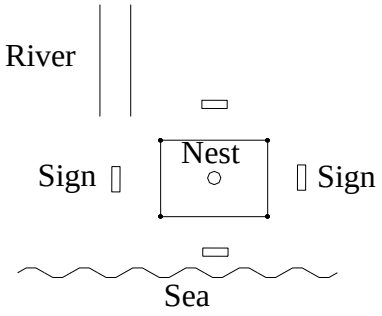
- The length of the fence should typically be longer given that chicks are highly mobile when feeding and they require a large area of protection. For example, fencing 100 m of upper beach in an area where chicks are frequently observed.

Configuration of the fence – fully enclosed or open on one or two sides

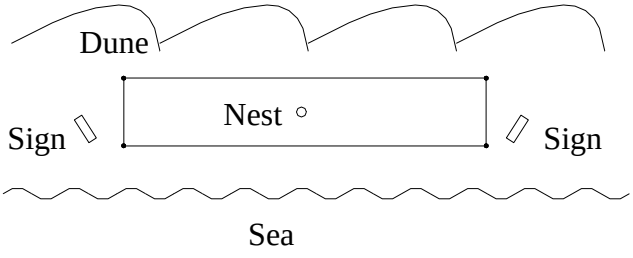
Egg phase

There are many styles of rope fencing that can be used to symbolically delineate the nesting area.

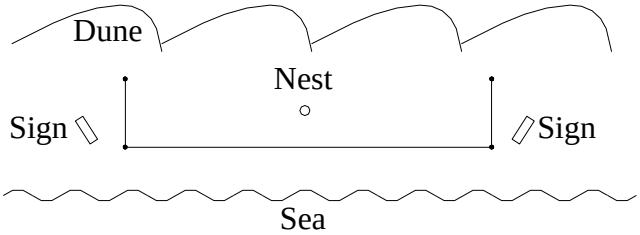
- The sides may be roped and the seaward side left open (see diagram below). This however, has proven less successful at preventing human access than when the seaward side is also roped (Maguire unpubl. data).
- Another option is roping the sides and seaward side of the fence and leaving the landward side open (see diagram below). This is only effective when the fence is backed by a steep dune and when people do not use this dune to access the beach.
- If the nest is on the beach and there is a flat foredune behind the nest, then the sides of the fence must extend up onto this foredune platform, as people commonly like to walk along these platforms and need to be prevented from walking behind the nest area.
- If the nest is on an estuary or when people access the beach from the dunes, the nest should be completely enclosed by a four-sided fence (see diagram below).
- Signs will need to be placed on all sides that people approach the fence from – although they are not usually needed on the seaward side.



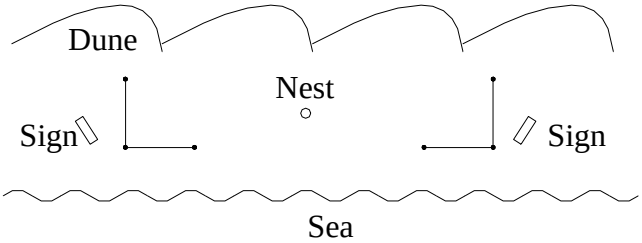
Estuary-located nest enclosed by fence and signs on all sides



Beach-located nest enclosed by fence on all sides



Beach-located nest enclosed by fence on three sides and backed by an inaccessible dune



Beach-located nest enclosed at either end by fence in a bookend configuration – also used for chick sites

Chick phase

- Given that the fence may need to be 100 m in length, it may not be economical to rope the entire lengths that run parallel to the water. Instead it may be useful to rope two edges that extend a short distance into the area, forming two 'bookends' to the area (see diagram below). It will then be necessary to place signs at the seaward side of the fence as well as at both ends.
- If chicks are using the end of an estuary or side of a river to feed, it can be useful to fence and block off access to the river mouth or one side of the river.

Materials

- The lightest and safest fence posts to use are plastic star pickets, such as 1.65 m tall Agripik fence posts (http://www.agripik.com/ or phone 1800 641 324 for suppliers within Australia). These do not have sharp edges (which can be a safety risk to beach users) and are easy to carry.
- Metal star pickets are cheaper, but are incredibly heavy and need to be capped.
- Wooden stakes can be used but need to have holes drilled in them for affixing the rope, and as a disadvantage, can be used as firewood.
- Brightly coloured nylon rope (4-6 mm diameter) is most desirable. The rope needs to be colourful so that it is visible to beach goers and there are no accidents, such as a horse rider accidentally riding into the rope.
- Plastic tape may be used as an alternative to rope, but the rope or tape used should not have flags or ties that flap in the wind, as this can disturb the birds.

Erecting the fence

- The fence should take no more than 40 minutes to erect because otherwise this could jeopardize the viability of the eggs.
- To save time, affix signs to posts before approaching the nesting site.
- If erecting the fence and signs is taking longer than 40 minutes, it is wise to take a break and walk far away enough from the nest so that the bird returns to incubate or chicks can come out of hiding and feed. Give the birds at least 20 minutes of undisturbed time, before returning and finishing off the construction.
- If a seagull or another avian predator lands in the area while you are erecting the fence and forages toward the nest location, then it is wise to leave the area and allow the adult bird to chase the predator away. Do not return until that predator has left the area.
- It is best to erect signs and fencing when there are few people on the beach, so that the birds can recover with minimal disturbance once you leave. It is suggested that no more than four people erect fencing at a time.

- The first step is to measure out the minimum of 10 m from one end of the nest. Beginning at this outer edge, begin to hammer in the fence posts using a rubber mallet. Make sure the fence posts extend another 10 m or more on the other side of the nest.
- Once all the fence posts are in, feed the rope from one end through the holes in the pickets. It is best to loop the rope around the pole once you have fed it through, keeping it tight (although some slack should be left in the rope so as not to put too much pressure on the posts), for added stability.
- Rope that is at least 2 mm thinner in diameter than the hole in the fence post will be quicker to feed through. Alternatively, cable ties can be fed through the hole and the rope fed through the tie, then tightened to speed up the process.
- It can be useful to use plastic or cloth tape to wrap around the post where the rope is tied off at the ends of the fence, so that it does not come undone and so it is harder to steal. Also, carry a knife to cut the end of the rope and a lighter or matches for melting the cut end of the plastic rope so it does not unravel.
- It is essential to make sure that the birds return to the nest after erecting the fence (observe from a distance through binoculars), and if they have not returned after one hour, the fence should be removed.
- These fences will stay standing for up to two to three months, with the exception of areas that are inundated by a king tide. They need occasional checking and maintenance.
- Equipment needed: posts, rope, knife, lighter or matches, plastic or cloth tape, rubber mallet, cable ties, signs affixed to posts.

Temporary ringlock fencing around nest sites

Rope fences are highly effective and should be used more commonly than ringlock fences as they are less intrusive to the nesting birds. Ringlock fences become necessary on beaches with high numbers of unleashed dogs and low compliance with protective regulations. There have been cases where ringlock fencing has been used around Hooded Plover nests and they have abandoned their nests. In one case, the mesh size was too small for the birds to walk through and they were therefore cut off from accessing their nest, as they were reluctant to fly to the nest due to the conspicuousness of flying to avian predators. In the other case, the ringlock fence was too small around the nest, essentially representing a cage and the birds abandoned their eggs.

Dimensions

- It is very important that the dimensions of each ringlock square be large enough (at least 11 x 15 cm, standard ringlock for small plovers) for the adult birds to move freely

in and out of the fenced area and even for a gap (of 10 cm for small plovers) to be left at the base of the fence, so they can also walk underneath.

- Anything finer than ringlock wire may pose a collision hazard to the birds (M. Weston pers. comm.).
- The fence itself needs to be large enough in length and width so that if the dimensions of the ringlock squares were to be reduced due to sand fill, then the birds could fly into the edge of the area without revealing the scrape's location. As for rope fencing, the ringlock fence should be a minimum of 10 m out from either side of the nest, that is 20 m in length and the width will vary according to beach width. At Inverloch in Victoria, ringlock fences of 8 m^2 have been used successfully around Hooded Plover nests, however, this is a sample of one pair and they may have a higher tolerance than other pairs. An outer fence of rope around the ringlock inner fence can add a buffer zone for minimising disturbance.

Configuration of the fence – fully enclosed or open on one or two sides

- When using ringlock fencing, the purpose is to enclose the nest and protect it from crushing or dog predation, and thus the fence needs to be fully enclosed on all four sides.
- Alternatively, fencing the base of the dune using ringlock can be effective in areas where the dune cannot be accessed from the landward side. It is important that the fence go landward at either end for approximately 5-10 m, so that it is clear that access behind the fence is prohibited.

Materials

- Standard ringlock is recommended, 11 x 15 cm mesh size
- For temporary ringlock fencing, metal star pickets capped with plastic are most effective as fence posts as they can hold the extra weight of the ringlock sheeting.

Erecting the fence

- As in the rope fence section above, mild weather conditions and working on the fence for a maximum of 40 minutes at a time is necessary to avoid reducing the viability of the eggs.
- Keeping an eye on any avian predators in the area is a must and workers must leave the area if a gull or other predator approaches the nest, so that the parents can return and defend the eggs.
- It is essential to make sure the birds return to the nest after erecting the fence. If they haven't resumed incubating after one hour, the fence should be removed.

- This style of fencing will require regular checking and maintenance over the nesting period.

Chick Shelters

Providing artificial shelter for chicks to use as cover to hide in or under when disturbed, or as shelter from extreme temperature conditions has been used widely for improving breeding success of terns around the world. For example, use of A-frame chick shelters for common terns reduced gull predation to zero (Burness and Morris 1992). Furthermore, Jenkins-Jay (1982) reported that chick shelters decreased avian predation in a Least Tern colony in Massachusetts. However, Kruse *et al.* (2001) used A-frame shelters for Piping Plover and tern chicks but found no increase in fledging success, this was however at sites that already had an abundance of natural cover. Typically, shelters are provided at sites where vegetation growth is lacking, but chick use of shelters has been observed at sites where sufficient vegetation appears to be present (Keane 1998).

Up until recently, it was not known whether shelters would be an effective tool for dispersed beach-nesting birds such as Hooded Plovers. The research of a Deakin University honours student, Andrew Duivenvoorden, revealed that over 50 % of Hooded Plover broods provided with an artificial shelter used the shelter to run to when disturbed by people or avian predators, or to rest in on days over 30º C. An adult and chick were also observed standing under a shelter during light rain. It is likely that shelter use would be much higher than observed, as observations only occurred for a few hours on a given day during the chick phase. Furthermore, in Andrew's study, only one shelter was placed on a territory and because chicks can move over the entire territory when feeding, it is likely that the brood was not always near a shelter when they needed to take cover. It is for this reason that we recommend using at least three shelters in order for them to make a reasonable difference to the survival of the brood, and also so as not to limit the brood to one area (which may also allow predators to target a specific area).

Design

- Andrew's research explored three different shelter designs prior to using these on Hooded Plover territories. These were a triangular teepee shape accessible from the front and rear, a cube with four narrow side entrances, and a rectangular box with wide front and rear openings on opposing sides (see photos on page 95).
- The aim of this research was to determine the best design based on: 1) persistence in a coastal environment; 2) the accessibility of shelter openings in light of sand movement over time; 3) thermal insulation properties; 4) the likelihood of detection by predators and people, and; 5) how practical the shelters are to make and transport.

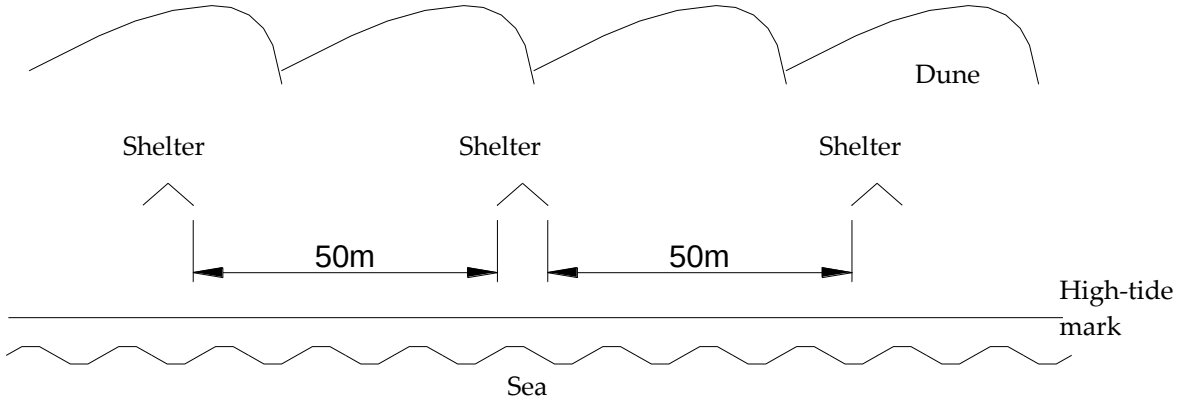
- The most important quality is number four, as it is essential that the shelter does not attract people/predators which would defeat their usefulness at minimising disturbance and acting as a refuge. Andrew observed 150 people passing by shelters at numerous sites and the shelters were rarely detected by people or their companion dogs. However, all shelters that were within 5 m of an approaching person were noticed (that is people moving above the high-tide mark), but it was extremely rare for that person to then approach the shelter (7 cases). The rectangle was the most noticeable of shelters, probably due to its size.
- Of 157 potential avian predators passing by the shelter, none noticeably detected or altered their course to explore the shelter.
- The triangular design came out at as the most persistent and accessible in a coastal environment, having the highest thermal benefit to chicks, cheapest and easiest to construct and transport, and attracting the least human attention.
- For a copy of Andrew's thesis, please contact Birds Australia.

Materials and dimensions

- Dimensions presented are for smaller plover species, such as Hooded Plovers or Red-capped Plovers. The size of the shelters would need to be increased slightly for Oystercatcher chicks.
- Teepee-shaped shelters are constructed of two 300-400 mm x 400 mm panels of 12 mm-thick exterior plywood screwed together via a wooden crossbeam (a 25 x 25 mm section piece of 'garden stake'). At least six screws should be used for stability.
- It is best to use exterior plywood (marine grade is too expensive for a shelter that may be taken by the tide) and to avoid treated pine as this could potentially poison the birds. Plywood also has the advantage of being sandy coloured, which acts to camouflage the shelter.
- It is useful to draw guidelines on the shelter for how deep it will be buried prior to use. It is recommended that at least 15 cm be buried to provide stability for the shelter from strong winds and tides and to allow for a height of 15 cm inside the shelters which will fit an adult Hooded Plover but limit the size of other birds that can enter the shelter.
- To prolong the life of the shelters, they should be stained with a clear, water-proof, non-toxic outdoor decking stain. Alternatively they can be painted with a non-toxic, outdoor paint that matches the colour of the local sand, and even sand can be collected and glued to the outer sides.
- The shelters take about 15 minutes to construct, cost approximately $9-10 each, weigh 1.5 kg and are very quick to place in the field.
- Multiple shelters can be stacked on top of one another easily, and do not take up much space.

Placement in the field

- A common misconception is that these shelters are placed over the nest when there are eggs. This would be disastrous because incubating beach-nesting birds need to be able to see the environment above and around them to know when people or predators are approaching. Never place a shelter over a nest.
- The best time to place the shelters in the field would be a few days prior to hatching, but if this is unknown then to wait until chicks are sighted. Only individuals with training in monitoring the birds should place the shelters on the territory because of the risks of an untrained person stepping on the eggs or newly hatched chicks.
- The person placing the shelters MUST have made a visual sighting of all chicks and know where they are hidden before stepping foot on the upper beach, and if this means leaving the area and watching from a distance for up to 30 minutes, it is safer than to risk walking up and stepping on them; in the first week after hatching the risks are high, as chicks crouch and don't move when approached.
- Ideally, 3-4 shelters should be placed on a territory, spaced apart across the area. The best locations for shelters on a territory depend on the layout of the beach, for example where natural shelter is limited, but also on knowing a little about where the birds usually feed - so the knowledge that the monitoring volunteers have is important for determining placement. This is a management technique that depends on interaction between volunteers and managers.
- The shelters should be placed half way between the base of the dune and the high-tide mark, and the opening needs to face the water (not parallel with the waterline). Shelters are not useful on beaches where the tide comes right to the base of the dune.



- Shelters should be dug into the sand, leaving a height of at least 15 cm inside the shelter for smaller beach-nesting bird species. The sand should be smoothed out and any crevices around the sides filled with sand. Both the front and rear opening should be clear, so on a beach that slopes from the dune down, the shelter will be dug in on that slope with the back being higher than the front.

- Signs need to be placed at all nearby beach access points to inform people of the presence of shelters and to keep their distance. This can simply be an additional line of instruction on the signs flanking the nesting sites or noticeboards at the access point 'Please keep your distance from small wooden shelters on beach – these provide a hiding place for chicks when disturbed'.
- It can also be useful to write a message on the shelters which identifies what they are (although the writing should be kept small so as to not to attract attention from a distance).
- Some chick shelters have been known to house spiders, and in the USA, Black Widow spiders (*Latrodectus mactans*) killed at least two Least Tern chicks (Keane 1998). Shelters may therefore have to be cleaned periodically.

It can also be useful to scatter some driftwood on the upper beach within the breeding area to offer natural cover to chicks, as is done for Little Terns in NSW (R. Kesby pers. comm.). This needs to be monitored, as on some beaches, driftwood may be collected as firewood or for the garden, thus increasing the risks of chick crushing. In addition to wooden structures, terracotta tiles (Keane 1998), clay pipes and even sand bags have been used as chick shelters (Liezebeit and George 2002).

Site Closures

Conservation of beach-nesting birds should aim to promote coexistence between recreationists and the breeding requirements of the birds. It would never be feasible to close the number of breeding beaches required to sustain a healthy population. However, in some circumstances it may be necessary to close a site or an access track to visitors to preserve conservation values or temporarily protect a vulnerable breeding site. This is a potentially controversial management option, and needs to be carried out with consultation and full support of the management agency. There are a number of site closure options:

Total permanent beach closure

Setting aside some beaches as conservation only areas and directing people to alternative beaches occurs on parts of the Californian coast for the protection of Western Snowy Plovers. In Victoria, some beaches where Hooded Plovers breed, such as at Point Nepean, are not open to the public for safety reasons (unexploded ordinance). It should be noted that the pairs breeding at Point Nepean have the highest breeding success of any on the Mornington Peninsula.

Seasonal site closures

In Canada, a seasonal wildlife sanctuary at Muriel Lake was created in 2003 to prevent disturbance to Piping Plovers (Alberta Piping Plover Recovery Team 2005). In Victoria, seasonal site closures were recommended at Corner Inlet and Nooramunga Marine and Coastal Parks for important migratory and resident shorebird sites (NRE 1996). Cove beaches, small peninsulas and estuaries would benefit the most from seasonal site closures, as these are sites where human recreation pressures are most heavily concentrated and where there is little room for the birds to adapt to pedestrian traffic and disturbance.

Temperature-relative temporary site closures

Weston (2000) suggested that temporary beach closures on very hot and very cold days could reduce thermal stress to Hooded Plover eggs and chicks and increase survival. This would be most practical for beaches with a limited number of access points. It would be necessary to implement signs that clearly state dates and reason for closure and that offer information on nearby alternative beach sites for recreation.

Temporary closure of an access track

When an access track leads directly onto a nest site, it may be necessary to close this track for the duration of the nesting attempt. This is most practical for informal tracks and for beaches where the next available access point is not so far away as to be an unreasonable imposition on beach visitors.

The Atlantic Coast Piping Plover – a conservation battle

taken from Discovery Channel news Aug 3, 2007 'Tiny beach bird makes huge comeback'

On the Atlantic coast, when Piping Plover numbers dramatically declined in 1985, the U.S. Fish and Wildlife Service reacted with strict policies to protect nesting pairs. Property owners were required to put up signs and fences marking a 50-foot barrier between people and plovers. Dogs had to be kept on leashes or were banned from beaches entirely, and off-road vehicles were banned from many plover beaches during the nesting season. The bans outraged beach users and there were "death threats to rangers and parades of vehicles in the streets shouting it was not going to happen." Nesting birds even forced the cancellation of a fireworks display in Ogunquit, Maine.

In the 1980s and 1990s, there were many angry debates. Anglers protested the beach buggy restrictions, while nudists in Rhode Island sued the federal government for severely curtailing access to their favorite beach. In the end, a federal judge decided that nude

sunbathing was not a constitutionally protected right. Federal agents were called in to investigate cases of suspected vandalism against plovers.

Much of the angst has died down now and the population has increased by 141 % due to protective efforts and bans on beach activities that endanger the birds. "George Cairns, president of the Massachusetts Beach Buggy Association, said the era of protest is over. He now describes his organization as a conservation group that wants the Piping Plovers to recover. Since the population is growing, Cairns said it is time to rebalance the rules. Rather than banning buggies, he proposes using a volunteer warden to wave buggies away from plover nests and sand-colored chicks. He's looking for a town willing to give the idea a trial run. "People are part of the environment, too", he said."

Nest relocation

Flooding of nests is a cause of nest loss and the frequency of flooding may increase with rises in sea level associated with climate change (Weston 2003). It has been suggested that nests could be moved higher on beaches to reduce the probability of flooding.

It is known that Hooded Plover nests on slopes can move naturally as far as one metre during an incubation period, but always downhill (M. Weston unpubl. data). Furthermore, Hooded Plovers have been observed incubating eggs that have been dispersed up to 2 m down the beach by high tides (Maguire unpubl. data; Weston pers. comm.). This suggests that the species has behavioural flexibility that may allow nests to be slowly moved. In NSW, managers have moved Pied Oystercatcher nests back from the tide mark by about 2 metres and the adults have continued incubating (NSW National Parks and Wildlife Service 2007). However, adult Hooded Plovers have been observed to abandon eggs after they have been moved; this occurred once when a Hooded Plover nest was moved 8 m higher on a beach (Maguire unpubl. data). Wills *et al.* (2003) found that of nine New Zealand Dotterel nests shifted to avoid flooding, eight survived flooding, but five of these were subsequently lost to predation by gulls or crushing.

This management option of relocating eggs has not been properly researched and for that reason, should not be considered unless absolutely necessary. Drawbacks with moving nests include the possibility of abandonment by parents, attracting predators to the site by adding human scent to the eggs, and excessively disturbing the parents. Furthermore, beach-nesting birds may need to learn through experience about the best locations for nests and thus by moving the nests of inexperienced birds, they may continue to nest close to the high-tide mark in future attempts and rely on human intervention. While it is important to

manage human-related impacts, natural causes of nest failure, such as king tides, should not be a priority for managers.

An alternative means of saving nests from tidal inundation is to elevate the area above flood levels using car tyres or sandbags. This has been used for Hooded Plovers, Little Terns and Pied Oystercatchers in NSW, although in a few cases, elevated nests were abandoned or failed due to fox predation (NSW National Parks and Wildlife Service 2007). It is suspected that this management technique increases the conspicuousness of the nest to predators and should be used with caution.

On the Chatham Islands, New Zealand, prior to the start of breeding, known oystercatcher breeding sites were elevated on platforms of plywood topped with car tyres and filled with sand, then decorated with seaweed and driftwood (Moore 2005). In the first year of this trial, one pair nested on the platform and the other 15 platforms were considered inappropriately placed. In the second year, better placement still only led to two pairs nesting on the platforms, while other pairs investigated but then chose alternative nest sites. In subsequent years, up to seven pairs used the platforms in a season. For nests found in areas that weren't on raised platforms, and that were at risk of inundation by high seas, nests were relocated by progressively recreating the nest scrape and surrounding pattern of seaweed and driftwood 1-2 m up the beach at a time. The decision to move the nest and total distance moved was based on the likelihood of the sea reaching the nest and the proximity to dune vegetation. In 1998/99, 11 nests were moved 2-4 m, but six were still washed away by high tides. Concerns were raised about tyres potentially attracting predators and the authors reported a cat investigating the tyres prior to them being covered with sand (Moore *et al.* 2001). The recovery team therefore phased out use of platforms and put more emphasis on relocating individual nests (Moore 2005).

Walls and Trenches

Digging of trenches and walls of sandbags around the nest may also block incoming tides, as has been carried out at Inverloch, Victoria and at Bateman's Bay, NSW. However, great care needs to be taken to ensure that these walls do not preclude vision from the nest and that once the nest hatches, the trenches and walls do not pose a risk to chicks that may fall into or become trapped in a trench or walled area. Further investigation into the effectiveness of this technique needs to occur before it can be used widely.

Habitat Management

Erosion control or dune stabilisation

- Erosion control should not be undertaken in dunes without first conducting an impact assessment on beach-nesting birds. Such assessments need to fully account for the use of the area by the birds during the breeding season. Birds Australia holds the most accurate and up-to-date data on shorebird breeding locations.
- Erosion control should never involve use of an invasive species, for example planting non-endemic, dune stabilising grasses such as Marram Grass.
- Where erosion control is not considered detrimental to resident shorebird breeding habitat (e.g., immediately next to a walking track), techniques such as laying brush should be used.
- Where proposed erosion control works overlap with the occurrence of resident shorebird breeding habitat, it is critical that the nesting requirements of that species are not jeopardised. For Hooded Plovers, this will mean that the dunes should only be sparsely vegetated, preferably with endemic grasses such as *Spinifex*, and open dune bowls and blowouts should be left untouched. If human access to these blowouts or sparsely vegetated dunes is problematic, the top of the blowout or landward edges could be laid with brush. Alternatively the area could be permanently fenced to prevent access and preserve habitat.
- Revegetation efforts should be monitored to ensure that the amount of vegetative cover is compatible with suitable breeding habitat for beach-nesting birds.
- Erosion control should seek to tackle the cause rather than to treat the symptoms. Managers should discourage activities that promote erosion, including dune boarding and informal access to the beach through the dunes. Formalised tracks should be well-defined and signage used to dissuade access into the dunes.
- Effective planning of coastal facilities can reduce the need for erosion controls. It must be recognised that dunes and beaches are naturally dynamic.
- The Atlantic Coast Piping Plover Recovery Team (U.S. Fish and Wildlife Service 1996) highlights that laying brush over dune blowouts and planting Marram Grass should be prohibited in areas where Piping Plovers occur.

Bollards and gates

- In order to limit vehicle access to sites, it may be necessary to place bollards or locked gates at access tracks. Bollards will not be effective at preventing trail bike access.
- It can be useful to space bollards perpendicular to the sea on the beach either side of boat ramps, to prevent vehicles driving beyond boat ramp access points.

Weed control

Beaches are sensitive environments in which to undertake weed control due to a range of issues, including Aboriginal heritage, non-target impact of herbicides and erosion potential, as well as disturbance to nesting birds. In the latter case, weed control should be carried out in the non-breeding season. However, if some weed removal must occur in the breeding months, it must be preceded by an assessment of the use of the site by beach-nesting birds. Areas where birds are actively nesting should be avoided completely.

The key to successful weed management is to 1) plan (i.e. areas, methods, timing and resources); 2) implement the weed control program; 3) monitor re-growth, and; 4) review methods in planning follow-up action. Integrated Weed Management, which uses a range of strategies and methods that focus on the protection of assets over the long term, will have the greatest chance of success (J. Fallaw pers. comm.).

Sea Spurge

Manual removal

- Damaged Sea Spurge produces a milky white sap that is toxic and causes irritation to skin and eyes upon contact. When removing the weed by hand, wear strong plastic coated gloves, long protective clothing, protective eye glasses and wash hands thoroughly afterwards.
- Sea Spurge can be manually removed but you must ensure that the entire taproot is removed (Urquhart and Teoh 2001). Small plants can be hand pulled but larger plants will need to be dug out. To prevent seed dispersal, the plants need to be placed in a bag and disposed of at a tip.
- Small Sea Spurge seedlings, which can occur in their thousands, are best left to thin out naturally before being pulled. Removal of seedlings needs to occur before flowering. Alternatively, they may be raked or buried.
- Follow up will be required as seeds germinate and fragments of broken tap roots re-sprout. Substantial declines in density of Sea Spurge can be achieved through this method, but it may take 4 or 5 years of concerted effort.

Applied examples

- Hand removal has been successful at keeping Sea Spurge under control in Mornington Peninsula National Park, although rangers must continue to hand pull the occasional plants that emerge (D. Mitchell pers. comm.).
- On the Bellarine Peninsula, manual removal is of limited practical application once an outbreak has taken hold. This is due to the building nature of dunes, as the long stems of the Sea Spurge simply get longer to keep their heads above ground, thus in order to manually remove the plants, it is necessary to tunnel under them (with associated damage and Occupational Health and Safety OH&S risks). Experience with volunteers

has generally shown that this is not highly successful on a large scale (A. Shackleton pers. comm.).

- Phillip Island Nature Park uses a combination of techniques for Sea Spurge control. For small infestations, difficult to access areas, as follow up after spraying or as an alternative to spraying in areas with sensitive vegetation, they manually remove seedlings, and cut and paint the stems of larger plants with glyphosate. For large infestations, they spray a suitable herbicide and put in place strategies to minimise off-target damage.

Mechanical removal

- Mechanical slashing is not recommended due to increased possibility of contact with the toxic sap.

Chemical removal

- Chemical control of Sea Spurge is another option, but is limited to qualified operators only.
- A number of off-label permits have been issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA), which currently allow a range of herbicides to be used for the control of Sea Spurge within Australia. The two most common chemicals for effective control of Sea Spurge are Metsulfuron Methyl (Brush-Off) and 2,4 D Ester (Belbin 1999).
- It is recommended that plants be spot sprayed only and the plant thoroughly sprayed so that all of the foliage is soaked.
- Utmost care must be taken to minimise contact with non-target plants, especially endangered native species (e.g. *Zieria prostarta* and *Zeiria smithii*). Brush-off cannot be used near plants from the Myrtaceae family, as they die within a year from the leaching of the chemical into the soil, once the target weed dies and its roots rot, releasing the chemical.

Applied examples

- Otway National Park conducted trials of spraying in 1993 and again in 1997, using 2,4-D Ester (Wilcock 1997; Wilcock and Westbrooke 1999). Researchers noted that Sea Spurge was quick to re-establish and that follow-up action over several years was necessary for total eradication.
- At Mornington Peninsula National Park, Amicide 500, a 2,4 D Amine chemical, has been used effectively. This however must be applied with caution, as it does affect non-target species. Any treatment must be followed up with hand removal as regeneration from the seed bank seems to continue annually.
- Similarly in WA, a hormone herbicide such as 2,4-D amine (0.05g in 10L with 10ml of wetting agent) is recommended for Sea Spurge control.

- Brush-Off has been used successfully in NSW for many years. Neil Tucker, of ConservAction Victoria, reports a commercially acceptable kill rate of more than 95 % of adult and juvenile Sea Spurge plants using a 0.1g/L mix of Brush-Off when used in combination with BS1000 Biodegradable Surfactant, with little off-target impact.
- On the Bellarine Peninsula, Brush-off (application rate of 1 g/10 L) is used along with Pulse as a surfactant and penetrant.

Sea Wheat-grass

Manual removal

- Digging out the rhizomes can control small areas of Sea Wheat-grass.
- Care must be taken to remove as much as possible and monitor regularly for re-emerging plants.
- It is best to replace removed plants with *Spinifex*, as Sea Wheat-grass is not invasive when it has foredune competition.

Chemical removal

- Effective aquatic registered herbicides such as Round-up are available for use on Sea Wheat-grass. Areas where control has been undertaken should be monitored annually for germinating seedlings, until no further plants are found for at least two years.

Marram Grass

A large scale operation to tackle the impacts of Marram Grass on Australia's coastal dune systems is not feasible due to the massive expense and effort involved. Restoration efforts should therefore be prioritised for key sites where available habitat for beach-nesting birds is severely reduced and where rising sea levels associated with climate change are likely to result in habitat loss. Areas that have been cleared of Marram Grass for Piping Plovers have been recolonised the following year, and then used for breeding in the second year (U.S. Fish and Wildlife Service 1996). Areas cleared of Marram have been used as refuge areas by broods of Snowy Plovers (Peterlein and Roth 2003; Hyland and Holloran 2005).

Manual removal

- The most labour-intensive part of manual control is the first dig, due to the large biomass, density of stems, and the difficulty of severing rhizomes.
- Manual control is only effective for small infestations of a few square-metres in area. Dig out all rhizomes to a depth of 50 cm if possible and repeat every 3 or 4 weeks until the rhizomes stop growing through to the surface. Monitor periodically thereafter.
- Van Hook (1985) recommended a regime of repeated digging of the above-ground portions of the plant in order to deplete underground stored nutrients. Following these

recommendations, a pilot restoration project was conducted by Humboldt State University and The Nature Conservancy at the Humboldt Bay site, using a refinement of Van Hook's method (Wiedemann and Pickart 1996). Isolated stands of Marram Grass, ranging in size from 50- 120 m^2, were dug to remove both aerial portions and rhizomes to a depth of approximately 30 cm (Pickart *et al.*1990). The stands were first dug as the plants emerged from dormancy, and then re-treated on a regular basis through two growing seasons. Complete eradication was achieved in 2 years, with an accompanying increase in native cover from a mean of 2.7 % before treatment, to 38 % one year after treatment ended. While no native plants were intentionally introduced, local native species began to recolonise the plot and increased dramatically in cover when released from competition with Marram (Pickart *et al.*1990).

- Pickart (1997) reports of a project in the USA, in which Marram was manually removed as plants emerged from dormancy using a shovel to sever rhizomes at a depth of about 20 cm (as most active rhizomes occurred to this depth). Grass was piled and later burned. Resprouting occurred throughout the season, more vigorously at first. Crews returned to pull and/or dig resprouts an average of eight times over the first season, and seven times the second season. By the end of the second season plants were largely eradicated.

Mechanical removal

- The use of machinery can greatly increase the size of the area that can be treated. However, this should not occur during the breeding season of local resident shorebirds.
- Mechanical removal is only suitable for sites that are easily accessible, relatively flat and without significant numbers of native plants.
- Heavy equipment has been used extensively to control Marram Grass at Oregon Dunes National Recreation Area (Pickart 1997). Here an area of 45 acres of Marram was excavated with a D-8 Caterpillar and buried to a depth of one metre in an adjacent trench (the depth of burial was spatially inconsistent and when less than one metre, proved ineffective). Moderate resprouting occurred in treated areas. A single follow-up dig was effective, although insufficient for complete eradication. The use of herbicide as a follow-up to mechanical burial is not effective because of the limited surface area exposed to the herbicide.
- At another site, Marram was treated with salt water and then a D-8 Caterpillar with a wing ripper was used to "subsoil" or "rip" rhizomes three feet below the surface. This was followed up by a single manual pulling treatment, where plants were easily pulled by hand. This combination of treatments appeared to be very effective (Pickart 1997). Treatment with salt water, however, can have adverse impacts on other plant and invertebrate species, and has not been proven to effectively eradicate Marram.

Chemical removal

- Chemical treatment is likely to be most cost-effective but has ramifications for non-target species and for contamination of the groundwater.
- The most effective period for herbicide treatment of Marram Grass is during its flowering stage (Wiedemann 1987) or periods of active growth (Pickart 1997). However, treatment in active nesting areas may need to be limited to the period outside the breeding season to avoid disturbance to nesting birds and risks of crushing nests.
- The effectiveness and efficiency of chemical control can be enhanced by reducing thatch and stimulating regrowth prior to herbicide treatment: a greater proportion of the chemical is delivered to receptive plant tissues that will then translocate it to the rhizomes. A control burn prior to chemical treatment is recommended by Hyland and Holloran (2005).
- Palermo (1998) recommends that a follow-up herbicide application within two weeks of the first application is critical to obtain optimum coverage and initial die-off rates (90 percent). Additionally, herbicide treatments were most effective when conducted consecutively over two to three years, depending on density.
- Glyphosate (Roundup and Rodeo) has been used with some success on Marram, although its effectiveness is dependent on consistency and thoroughness (Pickart 1997).
- The use of Roundup to control Marram was tested extensively by the California Department of Parks and Recreation, and the University of California Davis at several California dune systems. Although results have not been published, the investigator reports good success using a 10 % solution with added surfactant (0.5 %) (see Pickart 1997). Use of a surfactant is avoided in some areas due to concerns about groundwater contamination. Rodeo is approved for aquatic use because it lacks the polyethoxylated tallowarnine present in the surfactant in Roundup. Since these experiments were carried out, the surfactant in Roundup has been reformulated so that no additional surfactant needs be added to Roundup-Pro or Roundup-Ultra.
- Hyland and Holloran (2005) trialed a grass-specific herbicide (Fusillade) but this did not lead to adequate control, so they switched to 7 % glyphosate (Roundup) to treat Marram regrowth approximately one year after a burn. The delay enabled native plants, particularly annuals, to germinate, reproduce and disperse prior to herbicide treatment. Resprouts not killed in the initial herbicide treatment were then sprayed 6 and 12 weeks later in two additional treatments using 7 % glyphosate. Up to three additional follow-up treatments were required to achieve 100 % control. The amount of herbicide needed tapered off considerably in the subsequent treatments.
- Areas burnt and then treated with Roundup became increasingly used by Western Snowy Plovers as refuge for their broods (Hyland and Holloran 2005).
- Aerial spraying of large areas has occurred in New Zealand (Hilton *et al.* 2006). They concluded that control using herbicide provides the most effective and cost-effective method for managing grasses over areas larger than one hectare.

- Some areas that are treated and followed-up with herbicide are then covered with oyster shell hash to prevent regrowth (U.S. Fish and Wildlife Service 2007).

Fire

- By itself, fire is not an effective treatment as it stimulates regrowth (Pickart and Sawyer 1998), but by removing thatch it may under some conditions reduce the time required to conduct subsequent treatments (Miller 1998).
- A controlled burn could be used to reduce the labour intensity of manually removing dense stands of Marram. Burning is known to stimulate growth in Marram (Van Hook 1983), and will presumably increase resprout vigour or density. However, it is hypothesized that the increased labour required to remove resprouts after a burn may still represent a time saving over an initial dig of a mature stand of Marram (Pickart 1997).
- A controlled burn can also be used prior to chemical control, to increase the efficiency and effectiveness of herbicide treatment (Hyland and Holloran 2005).
- The burn would have to be carried out during the non-breeding season of resident shorebirds and at a time of year when it typically doesn't rain. Hyland and Holloran (2005) describe an effective burn prescription: relative humidity of 20-80 %, air temperature of 40-75° F (5-25° C), wind speed below 15 mph, and containment lines 5-m wide created by manually removing Marram from either end of the area.

Photos by A. Pickart, taken from Restoring the Grasslands of northern California's Coastal Dunes, Grasslands Quarterly publication of the California Native Grasslands Association Winter 2008, pp. 1-9.

1) A foredune dominated by Marram Grass at the Lanphere Dunes, California, in February 1992, prior to restoration (members of the California Conservation Corps are beginning the removal process); 2) The same location in July 2001, five years after restoration work was completed.

Habitat creation

Beach-nesting birds may colonise man-made habitats. At a nationally significant shorebird roost site in the USA, construction of a marina led to increased human and boat traffic that resulted in declines in shorebird numbers at the original roost site (Burton *et al.* 1996). This was partially offset by the creation of an island within the outer harbour, which then became the main roost site. The island was 25 m in diameter, 3 m higher than the highest spring tide, had sloping sides of rough slag and stone blocks to provide shelter and was covered in shingle to provide potential nesting substrate for terns. The island's attractiveness varied between species; the substrate, amount of shelter and orientation to the wind were deemed as important determinants of suitability for different species.

Hooded Plovers have bred on islets that have been made from dredge spoil, e.g., in the Gippsland Lakes and formerly at Sand Island, Queenscliff (Schulz 1992a; Reside 1998). Such habitat can only be practically created inside inlets or embayments. Weston (2003) suggested that the dispersed nature of beach-nesting bird populations, the relatively small proportion of birds using inlet areas for breeding, and the high expense associated with creating and maintaining habitat, means that this is not a suitable management technique.

Encouraging dune nesting

Nests located in dunes are generally less impacted by disturbance than those located on beaches (Weston 2000) and have a lower likelihood of being crushed (Dowling and Weston 1999). Dune nesting can be encouraged by sympathetic dune management (see erosion control specifications above) or planned removal of invasive dune stabilising grasses such as Marram and Sea Wheat (see above).

Restricted beach cleaning, kelp harvesting and driftwood collection

- Current and proposed beach cleaning practices should be reviewed in terms of potential impacts on beach-nesting birds or their habitat.
- Beach cleaning should be prohibited on beaches where beach-nesting birds are known to breed.
- The impacts of kelp harvesting on habitat should be assessed, and if these impacts are negligible, kelp harvesting should only be permitted during the non-breeding season.
- Driftwood collection should be prohibited year-round.

Predator control

Fox control

It is not possible to eliminate foxes entirely from the coast, and resources for controlling foxes are limited. In this context, fox control needs to be focused around core nesting areas.

Fox populations are very resilient to conventional methods of control. Rapid reinvasion of areas occurs after control measures are applied, suggesting that control is rarely or never achieved. To reduce rapid re-infestation and produce long-term population reduction, it has been suggested that control work should generally be carried out in early spring during the fox's reproductive phase (but note that peak fox breeding times may differ regionally). By targeting the breeding season, the breeding population and their potential or realised offspring can be removed (Urquhart and Teoh 2001). Early spring roughly coincides with the period before the main beach-nesting bird breeding season, and it has been suggested that fox control should occur before the breeding season begins. If resources permit, a control program in spring (October-November) followed by another in late summer (February-March) to target young dispersing foxes, would be ideal. It needs to be noted that not all areas will able to be baited at these times of year because of an influx of human and canine visitors and the associated problems with baiting or trapping in highly populated areas (e.g. around coastal camp grounds).

Recovery of the fox population is dependent on immigrant animals dispersing into the control area. The larger the area controlled, the longer it takes for foxes to reach the area to be protected (Urquhart and Teoh 2001). It may be useful to differentiate between three types of fox control:

1. Fox control on the mainland (e.g., Weston and Morrow 2000; Southern Ark project, Murray *et al.* 2006), where re-colonisation is likely to occur rapidly after population reduction.
2. Fox control on islands (e.g., Atkin 1998) where re-colonisation after population reduction will probably be slow, or may not occur. On islands, total eradication may be feasible.
3. Fox control on semi-isolated sections of the mainland, such as on peninsulas (e.g., Wilsons Promontory or the Coorong) is intermediate to the first two types of control. Anecdotal evidence suggests that fox control on these areas may be more effective.

There are best-practice guidelines for fox control available in the Threat Abatement Plan developed by the NSW NPWS downloadable from www.nationalparks.nsw.gov.au/npws.nsf/Content/ This plan sets priorities for fox control across all land tenures for biodiversity conservation (i.e. the species most vulnerable to impacts at the population level and the populations of these species that should be

targeted for fox control). The plan also has linked monitoring programs to measure native fauna response to fox control.

Options for lethal control

Most managers will recommend using a mixture of fox control options at any one time to effectively target the behavioural variation that occurs in fox populations: some foxes are trap shy and others are disinterested or wary of bait stations.

The Phillip Island Nature Park (PINP) runs a fox eradication campaign that targets the whole island using the following methods: a broad scale baiting program, spotlighting, hunting with hounds, trapping, den destruction and removal of weedy vegetation that harbours foxes. From June 2007-08, 34 adult foxes were eliminated from the island, with over 1,000 killed since 1980. The intensive fox program has reduced foxes well below the carrying capacity of Phillip Island (10,000 ha) with fox number down to 0.6-0.8 foxes/km^2. In comparison, the Western Treatment Plant (10,800 ha) adjoining Port Phillip Bay has 14-16 foxes/km^2; in urban Melbourne, some suburbs have 12-16 foxes/km^2; and on most agricultural land in Victoria, foxes occur at densities of 4-6/km^2. The effects of reduced fox numbers are seen in increases in the distribution and density of some native bird and animal species on Phillip island. PINP, in co-operation with the Phillip Island Landcare group and the local community, have developed a strategy that aims to eradicate foxes from Phillip Island over the next five years.

Baiting

- Baiting foxes is the most commonly used control option.
- Fox-baiting was one of the management techniques used to increase reproductive success in Hooded Plovers at Mornington Peninsula National Park (Dowling and Weston 1999). In the short term, fox-baiting showed promising results in terms of increasing hatching success (Weston and Morrow 2000). Fox-baiting combined with a beach closure on the Coorong, SA, is thought to have increased the number of Hooded Plovers, eggs and chicks located during surveys (Hockley 2000; Weston 2003).
- Baiting however, has some real limitations, particularly in coastal environments:

  - Baiting along the coast requires simultaneous fox baiting by adjacent landholders, as much of the Australian coast occurs as a very narrow, linear strip.

  - Baiting does not provide evidence of how many foxes have been removed from the environment. Instead the number eliminated is inferred by the number of baits taken. However, it is possible this is an overestimate as an individual fox could visit a number of bait stations and cache the baits before ingestion. Caching of baits also means that the 1080 poison could become sub-lethal over time.

  - The likelihood that baits will be taken in a coastal environment is reduced by the availability of alternative food sources: carcasses of seals, shearwaters, penguins, fish

and other wildlife are often readily available on beaches (e.g. Weston and Morrow 2000), as well as litter left by humans.

- Land managers can be reluctant to use baiting for fear of poisoning off-leash dogs. However, liability can be avoided if notifications are sent to residents and signs are placed clearly at beach access points.

- Bait stations are subject to flooding or take by ravens (see Weston and Morrow 2000).

Recommendations for fox baiting (compiled by Paul Mahon, NSW National Parks and Wildlife Service):

- Duration: One month prior to nesting. Aim to remove as many foxes as possible before nesting commences.
- Scale: Allow a buffer of 4 km radius from the nest site. Need to remove foxes BEFORE they get to shorebirds. This is based on diameter of two fox home range widths of approx 3.1 km^2.
- Spacing: 500 m between bait stations is sufficient (Pesticide Control Order allows 100 m). Need to have at least two bait stations in each home range and you must allow for smaller home ranges in resource-rich patches or for subordinate animals.
- Frequency of checking: One per week is ideal and one per fortnight is the minimum. Baits must be replaced regularly so that they are always available to kill foxes. Also, need to replace baits before 1080 dose becomes sub-lethal due to leaching. Data for FOXOFF says 2-3 weeks. This is lower with high rainfall.
- Frequency of replacement: one per fortnight minimum as above. Small property rule on Pesticide Control Order requires bait replacement every 3 days on properties less than 100 ha.
- Bait types: Meat baits are preferred over FOXOFF due to greater bait take. However, vary bait type where possible and investigate which bait types are most appealing to your local fox population. Weston and Morrow (2000) found that pilchards and livers increased bait uptake.
- Free feeding (non-toxic baits): No! Toxic baits should be used from Day 1. Minimise risk to domestic dogs through public notification and signs. [However, free feeding is often used in areas to determine whether non-target animals are taking the bait.]

Trapping

- Cage or soft-jaw traps are becoming more widely used techniques for fox control in coastal environments.
- Traps have the advantage of informing the manager of the exact number of fox kills.
- Trap lures that are commonly used include fox urine as a scent lure to attract alpha males, or baits as a food reward lure. The use of scent lures requires a highly trained trapper, as the utmost care needs to be taken to avoid contamination of the scent with

human scent. Use of scent lures will not be effective in areas where there are unleashed dogs roaming, as they will interfere with the scent, making it ineffective.

- The disadvantage of trapping is that traps need to be checked daily and thus require intensive resource allocation. This also limits the extent of a trapping area, e.g. to the number of traps that can be checked in a day.
- On Venus Bay Peninsula, a joint fox control venture ('Community Fox Control Forum') between community land holders and parks managers raised $18,000 to run a trial program. In October 2007, OUTFOXED Pest Control were contracted to use soft-jaw traps over a 1,700 Ha area and over 10 days, removed 36 adult foxes (19 alpha males, 17 alpha females).
- Within the Mornington Peninsula National Park, cage traps were trialed for the first time in October 2007. In a 14-day program, 15 foxes were trapped (including alpha males and females). The foxes in this area have a big food supply along the beaches, making them extremely difficult to trap. OUTFOXED Pest Control tried 10 different lures and baits to attract them to the trap sets, and now know which work successfully in the area. Throughout the duration of the program, there were regular interferences from dogs being allowed off their leads to roam freely, due to people ignoring the signage alerting them to the program. The weather would have reduced the number of foxes able to be caught in this period, as heavy downpours resulted in traps having to be dug up, reset, re-lured and re-baited in dry sand.

Den destruction and fumigation

- It can be a good idea to search dunes within 200 m of a nesting site for any fox dens. These should be fumigated and destroyed as soon as possible.
- It is also effective to search for thickets of weedy vegetation (such as African Boxthorn *Lycium ferocissimum* or Gorse *Ulex europaeus*) that may harbour foxes, and to remove these before the breeding season.
- Den fumigation is commonly carried out during the middle to end of the fox breeding season.
- Alternatively, rags soaked with Renardine 72-2™ can be placed inside the den and the surrounding sand soaked with the chemical to turn the fox off the den (Schmelzeisen *et al.* 2004).

Spotlight shooting

- Spotlight shooting is valuable for targeting foxes that cannot be controlled using conventional methods of baiting and trapping.
- This needs to be carried out by a qualified professional shooter.
- Shooting on beaches can be of great risk to humans and is generally avoided in populated areas.

- If shooting is to occur, this must be well-advertised to the community and on the night of the shoot, illuminated signage and wardens should be placed at all access points to prevent human access.

Cat control

- Community education and the promotion of responsible cat ownership plays an important role in reducing the impact of cat predation on wildlife. Many councils have regulations that require domestic cats to be kept indoors at night, and that they be desexed, which reduces the number of kittens dumped.
- Cage traps are most commonly used for capturing feral cats, and even domestic cats that roam too near to breeding sites.
- In New Zealand, large tunnel traps with drop-doors at each end, baited with fresh rabbit meat, were used to capture cats threatening New Zealand Dotterel breeding sites.
- Most control programs and ecological studies have demonstrated that cage trapping of cats is generally ineffective and impractical, with trapping successes less than 5 % being characteristic (e.g. Jones 1977; Berruti 1986; Bloomer and Bester 1992). Some cats can be reluctant to enter confined spaces (Veitch 1985). Trap successes of between 15 and 20 % have been recorded (e.g. Brothers *et al*. 1985; Rauzon 1985; Domm and Messersmith 1990) although this capture rate appears to be atypical.
- Cats are intelligent predators and can be difficult to catch. It may be useful to experiment with different baits to lure cats to the cage. Fresh fish and seabird flesh are common baits used on islands, and chicken is commonly used in areas where birds are the main source of prey for cats (Twyford *et al.* 2000). Dredge (1993) and Short *et al*. (1997) have investigated different bait types. In some areas, Kentucky Fried Chicken has proven to be a highly effective bait that lasts over a period of weeks without needing replacement.
- Spotlight shooting can be difficult in densely vegetated areas where visibility is poor.

Applied examples

- Each year between 60-95 feral cats are trapped in the Phillip Island Nature Park (an average of 78 per year over ten years). Trapping generally occurs during the winter months and mainly targets Hooded Plover breeding and over-wintering beaches, and Shearwater and Penguin rookeries.
- On Gabo Island in south-east Victoria (an important Little Penguin and Short-tailed Shearwater breeding site), cats were eradicated completely using a combination of techniques (Twyford *et al.* 2000). Treadle cage traps proved ineffective, with only one cat captured over 450 trap nights (1-day old chicken as bait and fresh shark placed under the cage as a lure). Spotlight shooting yielded 3 cats. The most effective method

of cat control was 1080 (4.5 mg) poisoning, using 1-day old, dead chickens as poison carriers. It was recommended that poisoning occur at a time when food availability was low to ensure bait uptake. A period of free-feeding was carried out to ensure raptors would not take baits. Caution needs to be taken with poisoning programs to ensure they are delivered in a target-specific manner.

Avian predator control

- Passive management actions include reducing beach litter (through clean up days and provision of closed bins in beach car parks), as well as ensuring nests are not approached for monitoring or management when predators are observed in the area, so that they are not inadvertently led to the nest (Weston 2003).
- Providing subsidized food at feeding stations so that avian predators shift their foraging away from sites (e.g. Garcelon 1999). Feeding stations are used in NSW to lure Silver Gulls away from Little Tern nesting colonies (R. Kesby pers. comm.).
- Trapping can be used at sites using food, stuffed decoys or playback calls as lures to the trap. Liebezeit and George (2002) review a range of available traps for corvids. Trapped birds can then either be translocated (up to 200 km away), held in captivity until the critical nesting period passes (although this is resource expensive) or lethally controlled where permitted.

Several other methods of avian control exist, including lethal and sterility control, but it should be recognised that these avian predators are native species that are protected by legislation, and so special dispensation will be required to use these techniques. Non-lethal options are preferable.

- Shooting is considered the simplest and most expedient way of removing problem avian predators. Playback calls or stuffed mounts of predators (e.g. owls or foxes) are often used to lure the avian predators into shooting range. Shooting can be difficult in highly urbanized areas and is not considered effective in the long term (Liebezeit and George 2002).
- Poisioning is also commonly used in the USA to control predators such as corvids, by injecting meats or boiled eggs with 3-chloro-4-methylbenzenamine HCL. This poison causes kidney failure or central nervous system depression, resulting in death within 4 days (Liebezeit and George 2002). Animal cruelty issues are likely to arise with this method.
- In the USA, gulls that impact Piping Plovers are controlled by reducing their breeding by either oiling eggs (with white mineral oil) so they fail to hatch or destroying gull nests (Schmelzeisen *et al.* 2004).
- In New Zealand, black-backed gulls are poisoned (placing baits of alphachloralose (8 %) and margarine spread on slices of bread at nests and roosting sites) and then buried.

Eggs are pricked and chicks killed within nesting colonies, and gulls are also shot (Wills *et al.* 2003).

- Selective removal of 'problem birds' is often effective (Caffrey 1993). In NSW, avian predators that persist at active shorebird nesting sites, and do not respond to other passive control methods, are shot (R. Kesby pers. comm.).

Predator training

Conditioned taste aversion (CTA) occurs when negative reinforcement by foul taste or illness induces an association in an animal that causes it to avoid subsequent consumption of that particular food (Gentle *et al.* 2004). CTA has useful applications in wildlife management where non-lethal control of predators is necessary, and has several advantages over traditional lethal control measures like shooting and poison baits. The technique has demonstrated effectiveness across a variety of taxa in different environments, including effectiveness in preventing bait caching in wild foxes (Saunders and McLeod 1999; Gentle *et al.* 2004), consumption of meat in captive foxes (Massei *et al.* 2003), reducing coyote predation on lambs (Ellins *et al.* 1977; Ellins and Catalino 1980), inducing bait shyness in brush-tailed possums (Clapperton *et al.* 1996) and wolves (Gustavson 1983), and reducing egg predation by badgers (Baker *et al.* 2005), corvids (Lowell *et al.* 1989; Conover 1990; Dimmick and Nicolaus 1990; Avery and Decker 1994; Avery *et al.* 1995; Liebezeit and George 2002) and gulls (Neves *et al.* 2006). One of the benefits of CTA is that individuals exposed to treated baits are not killed and given that learned avoidance behaviours from CTA are known to persist for extended periods, it is feasible that these behaviours are transferable within populations of social and intelligent species (Massei *et al.* 2003). Also, predators such as foxes that are trained using CTA may exclude naïve conspecifics through maintenance of territories, potentially amplifying the spatial and temporal effectiveness of a CTA program (Avery *et al.* 1995). In contrast, lethal fox control techniques like 1080 baiting are limited in their temporal and spatial effectiveness due to immigration of target species from unbaited areas, particularly in regions where baiting is not coordinated across the landscape (Gentle *et al.* 2007).

Research by Dejan Stojanovic (University of Sydney) into the effectiveness of CTA for reducing fox predation of Hooded Plover eggs revealed that this technique has the potential to be successful but still requires further research into the timing of exposure to the CTA. Stojanovic (2008) set up artificial nests containing quail eggs (a model for Hooded Plover eggs) intermittently along a 45 km stretch of beach in south-west Victoria. A selection of these nests contained sodium carbonate (an odourless, tasteless crystal that induces vomiting), while the rest contained untreated 'control' eggs. The experiment lasted 28 days (representing an incubation period) and nests and sand pads were checked every two days for evidence of fox predation. Empty nests were replaced with eggs from the appropriate treatment. Stojanovic found that at all nests, the time to the first predation

event by foxes was similar but once exposed to the treatment, the rate and likelihood of fox predation was significantly less in eggs treated with the CTA (sodium carbonate) than in untreated, control eggs. The experiment further showed that for nests where treated eggs were replaced by control eggs after a period of 14 days, the CTA training lost effectiveness. This suggests that the period of training was too short. It is thought that because foxes are familiar with eggs as a profitable prey type, a large number of encounters with eggs that are unprofitable is required to override previous positive experiences. Further research into the length of the training period therefore needs to be conducted. One further consideration revealed by the study was that at one site, a pair of Hooded Plovers began incubating the control quail eggs and continued even when these were moved 100 m down the beach. The eggs had to be removed completely from the territory. (These findings are in preparation for publication; in the meantime, for a copy of Dejan's thesis, please contact Birds Australia.)

Conditioned Taste Aversion training: Inserting sodium carbonate crystals in quail egg; treated quail eggs sealed with hot candle wax. Photos: Dejan Stojanovic.

Predator exclusion

Nest cages

- Mesh or wire cages over nests are called "nest cages" in Australia, but are often referred to as "predator exclosures" in the international literature.
- Nest cages have been used widely overseas for a range of plover species, including Piping Plovers, Snowy Plovers and Killdeer (*Charadrius vociferous*) (Rimmer and Deblinger 1990; Melvin *et al.* 1994; Vaske *et al.* 1994; Mabee and Estelle 2000; Schmelzeisen *et al.* 2004; Alberta Piping Plover Recovery Team 2005; U.S. Fish and Wildlife Service 2007).
- There is considerable variation in the reported effectiveness of nest cages:
  - Rimmer and Deblinger (1990) investigated effectiveness of triangular cages and revealed a 92 % hatching success for caged Piping Plover nests versus 25 % for uncaged nests; the latter failing largely due to predation.

- In South Dakota, Piping Plover nest success increased from 34.4 % to 61.6 % when cages were used (Kruse *et al.* 2001).
- In Alberta, Piping Plover nest success has ranged from 87-98 % for caged nests and 43-55 % for uncaged nests (Engley and Schmelzeisen 2002; Engley *et al.* 2004; Schmelzeisen and Engley 2003).
- No differences in nest success of caged versus uncaged Snowy Plovers (*Charadrius alexandrinus*) or Killdeer nests were reported in Colorado, however, higher numbers of small mammalian and reptilian predators were present in these areas (Mabee and Estelle 2000). Mabee and Estelle (2000) went further to state that previously reported positive results were artefacts of inappropriate experimental design or analysis.
- It should be noted that exclosures are often used in conjunction with symbolic fencing of a larger area and signage, so while they act to reduce predation rates, they also reduce crushing by people and vehicles and fencing provides a buffer to disturbance. It is thus difficult to separate the degree to which breeding success is boosted by excluding predators. Also, while hatching success is reported to be higher, rarely do studies present figures for fledgling rates.
- Vaske et al. (1994) investigated whether various cage designs evoked nest abandonment by Piping Plovers and found that only 10 % of 211 nests were abandoned. The probability of abandonment was greater for cages that were covered and those lacking fence posts (which are more likely to bend and move in heavy winds and storms), and also to the geographic location of the nesting pair (possibly related to storm frequency and correlated with lack of fence posts).
- Loegering (1992) reported loss of six nests in exclosures without covers as a result of avian predation, but nest loss stopped after string tops were added.
- Van Schoik (1993, cited in U.S. Fish and Wildlife Service 1996) documented loss of 12 nests over just a few days on Jones Beach Island, New York to Common Crows (*Corvus brachyrhynchos*) that entered exclosures covered with parallel rows of string; no further losses occurred when net tops were installed.
- Cross (1991) found that exclosed nests hatched significantly more often than unexclosed nests over three years on three sites in Virginia, but hatch rates were not significantly improved at all sites or in all years; furthermore, two instances of foxes depredating adult plovers occurred in the vicinity of exclosures. Foxes or coyotes systematically depredated 5-10 exclosures at each of three widely separated sites in 1995 (U.S. Fish and Wildlife Service 1996).
- Several instances of adult plover entanglement in string or net tops, with and without attendant mortality, have been reported (U.S. Fish and Wildlife Service 2007).
- Predator exclosures have been associated with abandonment of Western Snowy Plover nests on California beaches, where fox track patterns suggest that the birds were subjected to intense harassment by foxes (U.S. Fish and Wildlife Service 1996).
- Nol and Brooks (1982) observed that predators appeared to be attracted to exclosures.

- On several occasions depredations of adult Western Snowy Plovers by raptors have been documented in or near exclosures, and efforts have been made to establish exclosures later in the season after the peak migration of raptors (Brennan and Fernandez 2004; Lauten *et al.* 2006).
- On Phillip Island, caging of Hooded Plover nests was trialed over five years, where egg hatching rates increased from 24 % with no cages, to 61 % with cages (Dann and Baird 1997; Urquhart and Teoh 2001). Results indicated that despite increases in hatching, fledging success is still similar as cages offer no benefit to mobile chicks. Furthermore, on two territories where cages were used, resident goshawks predated the chicks and a few adults as they emerged from the cages (P. Dann pers. comm.). This suggests that their use needs to be carefully evaluated in terms of their contribution and risks to population dynamics.
- In Western Australia, caging of Hooded Plover nests was trialed at Yalgorup Lakes with limited success (France 2006, 2007). Of three nests caged, only one was successful (yet a later nest of the pair that was not caged, also hatched successfully) and in the other two cases, the adults abandoned the eggs after caging took place. The risk of abandonment caused researchers to cease future trials.
- In NSW, the Shorebird Recovery team use cages around Hooded Plover, Little Tern and Pied Oystercatcher nests, particularly in areas with foxes and ravens (NSW National Parks and Wildlife Service 2006, 2007, 2008). These have a high hatching success rate but often the chicks are then predated within the first week after hatching. At Wallaga Lake, six Hooded Plover chicks were hatched from cages in the 2007-08 season, but all were taken by resident birds of prey when they ventured outside the cage (NSW National Parks and Wildlife Service 2008). NSW Project officers also make note that some pairs of beach-nesting birds can have a distinct aversion to cages.

- The above experiences highlight that exclosures can be risky to the birds, and therefore must be carefully constructed, monitored and evaluated by qualified persons.
- Furthermore, the benefits of predator exclosures are likely to diminish over time as predators learn to associate the cages with potential prey (Austin-Smith *et al.* 1994).
- It would not be practical to use cages on all breeding units, but they might be useful in areas where predation is heavy. Cages would have to be dug into the ground to be effective against foxes.
- The issue of whether cages attract curious people or predators requires investigation. It is likely that cages provide predators with a useful cue to the exact location of the nest, enabling them to target the chicks when they hatch.
- It is recommended that when birds of prey are resident to a territory, cages should be avoided.
- Nests on slopes have been known to move within the cage resulting in the nest being very close to the edge of the cage, and thus exposed to predators that can reach within

the mesh (M. Weston pers. comm.). Caging nests is therefore only recommended for flat sites.

- Of utmost importance is that where nests are caged, the person who has erected the cage must watch from a distance to ensure that the bird returns to the nest and resumes incubation. If after one hour, the bird has not returned to the nest, the cage should be removed.

Exclosures will be more effective when used in conjunction with an integrated predator management program that includes selective removal of non-native predators and other individual problem predators. Otherwise, while exclosures may promote better hatching success, fledging success will continue to be low if predators, such as foxes, focus on adults protecting the nest or newly-hatched chicks that leave the exclosure to feed. A predator management program targeting foxes, feral cats, skunks and raccoons, was used in conjunction with nest exclosures to protect Snowy Plover nests (Strong *et al.* 2004; U.S. Fish and Wildlife Service 2007). This ongoing program has resulted in improved nest success and use of exclosures has subsequently been discontinued due to the success of the trapping program.

Guidelines for use of predator exclosures

Strict guidelines for the use of predator exclosures are detailed in the Atlantic Coast Piping Plover Recovery Plan (U.S. Fish and Wildlife Service 1996), Appendix F. Below are some of the key recommendations:

Cage materials and erection:

- Cage walls should be a galvanized wire mesh 5 x 5 cm or 5 x 10 cm to allow the adult plovers to enter freely [note adult Piping Plovers are 17 cm long and 19 cm high].
- Netting (2 x 2 cm or less) is preferred for covering the top, although with some deterrent for avian perching, such as cutting the top horizontal wire of the walls to leave a ring of spikes.
- If metal posts are used to support the cage, these should be driven in below the cage top, so that they can't be used as a perch by avian predators.
- The base of the cage should be buried to prevent predators digging it up.
- Cages should be set up within 20 minutes and if the incubating bird does not return to the nest within 60 minutes of the setup, then the cage should be removed.
- Cages should be monitored every second day and removed if they are suspected to be inhibiting nesting success.

Dimensions of cages:

- There is much debate over the optimal dimensions for nest cages.
- Larger cages (base 7-8 m^2; height 0.8-1.2 m) have been used successfully (Melvin *et al.* 1992; Engley 2001) but have also been noted to draw attention to the nest, attracting people, dogs and predators, and to be used as perches by raptors and scratching posts by cattle (U.S. Fish and Wildlife Service 1996; Engley 2001). The U.S. Fish and Wildlife Service (1996) were concerned that reducing the size of the cage to a base smaller than 7.3 m^2 and height of 0.9 m may be harmful to incubating adults that get startled off the nest and might hit the cage wall, or that predators may be able to reach the bird or eggs inside.
- The APPRT have used cages as small as base 0.3 m^2 and height 0.4 m and have not reported any of the aforementioned problems. They argue that the smaller the enclosure, the less conspicuous it will be to people and predators (Engley 2001).
- Nol and Brooks (1982), however, used a small (1 m^2) wire mesh exclosure for Killdeer nest protection with limited success. They observed that small mammalian predators could enter the exclosure through the side openings (7-12 cm) and that larger mammalian predators could reach through the same openings and take eggs.

The Great Lakes Recovery Plan (U.S. Fish and Wildlife Service 2003) also provides guidelines for construction and implementation of predator exclosures. Some important points are included below:

- Exclosures should be constructed after a full clutch of eggs is confirmed, during good weather (rainy, very windy, cold or extremely hot weather should be avoided) and preferably when people (who may become curious) are not around. Exclosures may be constructed earlier (after 2nd or 3rd egg) if experienced plover monitors determine there is a predator risk or the nest is located in an area where the eggs might be easily crushed.
- Symbolic (rope) fencing with signage should be used simultaneously with exclosures to prevent people from approaching cages out of curiosity.
- Behaviour of plovers should be monitored throughout exclosure construction and continued from a distance out of sight of the birds after the exclosure is complete. The nest should be monitored until an adult returns to nest, resumes incubation, and then exchanges with its mate. If neither adult returns to the nest within 60 minutes, or the bird's behaviour appears abnormal, the exclosure should be removed.

Predator-proof fencing

- Foxes and cats are agile animals capable of passing through, digging under, jumping over or even climbing various types of fences.
- Fences designed to exclude feral cats and foxes should be 1.8 m high, have an overhang that is at least 600 mm in circumference that is curved or shaped in such a way that prevents animals climbing over from underneath, and have an apron with a mesh hard enough to prevent foxes chewing through (Robley *et al.* 2007). Furthermore, the mesh size of the fence material should not exceed 88 mm, and if the fence does not have an apron, should be buried to a depth of at least 450 mm (Urquhart and Teoh 2001).
- Adding electrified outrigger wires to netting fences could help to discourage foxes from climbing (Urquhart and Teoh 2001). Poole and McKillop (2002) noted that foxes were unable to enter electrified fenced areas, despite regular attempts, although Robley *et al.* (2007) suggest that exclusion fences do not require electric wires to be effective.
- Fences around Piping Plover nests have black twine or monofilament line stretched across the top to exclude avian predators (Melvin *et al.* 1991).

Applied examples

- Hooded Plovers in eastern Victoria have successfully bred inside areas of beach that have been fenced to protect Little Terns from feral predators (e.g., Murray and Reside 1995). Feral predator control operations were also undertaken at these sites (Schulz 1992a; Reside 1998).
- Electric fencing has been used in NSW around Hooded Plover and Pied Oystercatcher nests for protection from predators, and also from roaming cattle (NSW National Parks and Wildlife Service 2006, 2007, 2008).
- Wire fences around Piping Plover nests have proved effective at increasing nesting success (Melvin *et al.* 1991).
- Electric mesh-wire fences have been used around nesting sites on lakes for Piping Plovers and have increased nest success by 71 % (Mayer and Ryan 1999). Schmelzeisen *et al.* (2004) note that the use of electric fencing is expensive and labour intensive and would be more useful for small areas, such as the tip of a peninsula. Furthermore, experience on the Atlantic Coast has found that large electric fences are very difficult to maintain in coastal areas where salt air corrodes battery terminals and where predators will often wade around fences through the surf zone (U.S. Fish and Wildlife Service 1996).

Deterrents

- Urine scent can be used to deter mammalian predators.
- The chemical Renardine 72-2™ is known to trick a fox into thinking there is a rival on its territory (Schmelzeisen *et al.* 2004).

- Scent deterrents have not been trialed in Australia.
- Various deterrents for avian predators are reviewed in Schmelzeisen *et al.* (2004) and Liebezeit and George (2002), including auditory (e.g. playback of alarm calls, sonic and ultrasonic devices, pyrotechnics) and visual repellants (e.g. kites, balloons, flags, effigies). However, these are considered to be of high risk or disturbance to the nesting birds themselves and are therefore not recommended. Furthermore, they lose their effectiveness relatively quickly.

Educational and Interpretive materials

Beach-nesting birds are likely to have great public appeal, for reasons similar to those listed by Goossen *et al.* (2002) for Piping Plovers, because they:

- bring about a thrill associated with observing a threatened or rare species in the wild;
- reside in habitat which brings them into close contact with people;
- can be used as a symbol for protecting the natural values of coasts and beaches;
- are of high value to bird watchers;
- have a large volunteer base that is directly involved in conservation efforts, and;
- experience media attention.

Educating the public about beach-nesting birds is fundamental to bringing about positive social change and to maximizing the effectiveness of protective measures implemented at nesting sites. A study by Wilson and Tisdell (2005) in their survey of Brisbane (QLD) residents, revealed that the public's support for conservation of different bird species depended on their knowledge of the birds' existence and status. When respondents were asked to hypothetically allocate funds to conservation of different species, they chose the common species that they were familiar with. Once they were given balanced information about the different bird species, they then changed their allocation toward the more threatened and vulnerable species.

Bridson (2000) surveyed beach visitors in an area with a long-running program for protecting New Zealand Dotterels and found that infrequent or first-time users of a beach, and younger visitors, were less likely to see signs, less likely to detect a distressed or disturbed shorebird, and less likely to move away when they did detect a distressed bird. Bridson (2000) found that while the majority of beach users were aware that nesting shorebirds were protected and that dogs were a threat to shorebirds, there was confusion about the ways in which they were threatened and how to detect disturbance. Most thought that only birds that squawked or showed aggression were disturbed, and that only big dogs or uncontrolled dogs were problematic. This study therefore identified the need

for changes to the wording and presentation of educational materials, highlighting the benefits of social research for improving and developing public education programs.

Common attitudes about beach-nesting birds

"Why can't they nest in the dunes rather than on the beach?"

While a nest might receive little disturbance in the dunes, a bird may choose to lay its eggs on the beach because here it may be less subject to predation, it may be less energetically expensive and less conspicuous to travel to and from the nest, and perhaps there may be problems with navigating a brood from the dune to the beach (Weston and Elgar 2007). Additionally, suitable dunes are not always available, often due to heavy Marram Grass infestations (Weston pers. comm.; Maguire pers. obsv.).

"Can't we just move the nest"

The beaches and dunes are the habitat of beach-nesting birds and they nest there for a reason; their eggs and chicks are highly camouflaged in these environments, they source their food from the beaches, rock platforms and seaweed, and when the chicks hatch, they need to start feeding immediately, thus need to be close to this feeding habitat.

"Stupid birds, why are they nesting right in our midst?"

In today's world, the majority of beaches are easily accessible to people and there are very few areas on our coast that are isolated from human impacts. The birds may select a site for nesting that appears relatively quiet or isolated because they have started nesting at a time of the week or time of year when visitors are scarce, but over the course of incubation, this can change dramatically, for example, when a public holiday occurs or the school holidays begin. It is important to remember that humans are visitors to the habitat of these birds.

My dog "wouldn't harm them", "doesn't chase birds", "is scared of birds!"

These are the most common reasons given for not leashing dogs when passing a nesting area. It is important to understand that beach-nesting birds perceive dogs as a great threat, regardless of the individual dog. They have either directly experienced being chased by dogs or have evolved this response to the pattern of movement that unleashed dogs exhibit (often unpredictable, swifter than a walker, low to the ground and on all fours). Your dog may not chase or even notice the birds, but the birds notice your dog. The impacts of disturbance from dogs are enough to cause breeding failure and because of this, we ask that dog owners leash their dogs to help protect these threatened birds.

Education can take on many forms and will be dictated by the time and resources available.

Media releases – newspapers and radio

- This is one of the most effective means of reaching a large audience, and for local newspapers and radio, of reaching the majority of beach users in that area.
- Articles can be an effective means of educating the public on threats they might not understand properly.
- The article should be written in a friendly, easy to read style, avoiding dry or scientific explanations. Articles should not be a means of merely self-congratulating the management team. There needs to be a message to the public about how they can help the birds.
- The article should focus on the issues that are of most concern in that area, outline these in a way that people can relate to, and include local perspectives.
- Articles should draw attention to the positives, but should be balanced by also noting the negatives and future work to be done to protect the birds. Conserving beach-nesting birds will be an ongoing issue and therefore if the public is told that the situation is fine one year, they may relax their behaviour the next, thinking the problem is solved.
- If local schools take part in beach-nesting birds' conservation activities, aim to have local media cover the story. Permission must be obtained by the parents prior to the day if photographs are to be taken.
- If compliance with regulations is particularly low in a given area, then it can be useful to release an article about the number of fines issued to draw attention to the fact that something is being done about this and to relate the need for the regulations directly to the fragility of the birds.
- Contact local newspapers with either an idea for a story or provide a story that you have already written. The article will get more exposure if you provide good photographs to complement the text.
- It is important to note that journalists can dramatically alter the text you provide them or quote you incorrectly – always insist on approving the final draft because wrong information can do more damage than good. If a serious error is made, ensure that a follow up story or correction appears in the next issue.
- Aim to have two articles on beach-nesting birds appear during the breeding season – preferably one that occurs around the start of the breeding peak and/or coincides with the start of the busiest time of year on the beach, for example, the start of the school holidays. This should act as a reminder to the public that it is the breeding season and that these birds need help. The second should appear at the end of the season and provide information about how the season went and the lessons learnt.
- Local radio can be a good avenue for discussing controversial issues, explaining threats in a conversational manner and/or for answering callers' questions.
- Appendix 6 provides a selection of media articles about Hooded Plovers.

Magazines and newsletters

- There are numerous coastal and conservation related magazines suited to publishing stories about beach-nesting birds, including Waves, Landcare magazine, Coast Action/Coast care magazine (see Appendix 7).
- Local community groups may have a newsletter interested in publishing stories and updates about local beach-nesting birds.
- In NSW, at the end of every breeding season, the shorebird recovery team produce a newsletter called 'South Coast Shorebird Recovery Newsletter *Sharing the Shoreline*' and in South Australia, 'Hoods on the Beach'.
- In Canada, the Piping Plover recovery teams produce and distribute an annual newsletter for cooperators, funding partners and other individuals and agencies.

Brochures

- Brochures are a great tool for providing more detailed information about threats to beach-nesting birds than can be afforded by signage.
- Brochures specific to given recreational activities can also be highly effective, such as 'Dogs and Leashes, Birds and Beaches' (dog walking, Appendix 8) or 'Taking Conservation by the Reins' (horse riding, Appendix 9) and provide more detail about how a particular activity impacts the birds, and how to coexist effectively.
- Brochures can be distributed through car park entry stations, beach kiosks, local caravan parks and beach-front accommodation, surf shops, fishing and bait stores, tourism information or visitor centres, pet stores, veterinary clinics, equestrian organisations, locations providing off-road vehicle permits, and other locations where they will be directly available to beach user groups.
- Interpretive information about beach-nesting birds can be included in the interpretive notes for coastal parks or walks, such as the Park Notes produced by Parks Victoria.
- It can be helpful for wardens or rangers to have brochures to hand out when they approach beach visitors, especially as the warden or ranger can make reference to the pictures on the brochure to better explain what beach-nesting birds are and where they nest.
- Another option is to temporarily establish a Perspex brochure dispenser at the beach access point during the breeding season or to make these available at National Parks offices and interpretive centres.
- See Appendix 10 for examples of brochures.

Posters

- Posters can be displayed in places frequented by beach users, such as coffee shops and pubs.
- Posters are also useful for display at coastal festivals, within parks and related departmental offices, tourist information centres, and even beach toilet blocks.

Interpretive displays

- Interpretive displays are attention-grabbing and highly valuable at helping people to visualize the fragility of beach-nesting birds. A display could include a nest scrape made in sand containing a clutch of two or three model eggs (quail eggs are a good model for Hooded Plover eggs), some seaweed, a chick shelter, even a papier-mache replica of an adult, and a range of interpretive posters and photographs.
- Local stores may be interested in displaying the materials in their window or tourist information centres or Parks offices may have an interpretive section.

Stickers, postcards and swapcards

- Having merchandise such as stickers, swapcards or postcards can help raise awareness by having a simple, catchy message and attractive photography or illustrations.
- These materials are especially handy for public festivals or school visits, as they attract children and people that might not necessarily pick up a detailed brochure.
- See Appendix 11 for examples.

Commissioned graffiti

- Toilet blocks and walls of surf clubs can become canvases for artwork of marine and coastal themes, which can be commissioned to local schools, youth clubs or graffiti artists.

Website information

- Land managers should include information about threats to beach-nesting birds and what is being done in their park to manage these threats on their websites.
- Birds Australia has a webpage dedicated to the 'beach-nesting birds' project which has interpretive information, maps of Hooded Plover locations along the Victorian coast and a range of reports for download: www.birdsaustralia.com.au/our-projects/beach-nesting-birds.html

- Parks Victoria has developed a children's web-based game: Ranger Roo's 'Hooded Plover Rescue' adventure game based in the Mornington Peninsula National Park: www.rangerroo.com.au click on Games, and then Adventure Game.

Mail-outs

- A mail-out to all residents of a coastal town or to the houses fringing a beach where the birds nest, can be an effective means of communicating with the audience that most frequently uses the beach in question.
- Australia Post provides a cheap service (15^{c} a standard unaddressed letter) for targeting residences according to postcode.
- If a coastal town has a local magazine, you can contact the editor to enquire about including a flyer as an insert.
- A mail-out can have a more personalized touch than an article in the local media, and there is the opportunity to provide more pictures and text. It can be useful to provide a map of the local area with locations of breeding pairs, so that people can visualize exactly where you are referring to.
- Letters can be a useful way of informing local communities about new signage or fencing, or changes to their local beach regulations and why these have come about.
- Alternatively, mail-outs can be used to target a specific recreational group, such as Surf Life Saving Clubs, Surf Rider, Horse Riding and Fishing groups. The aim being to provide information on how to enjoy that recreational activity but at the same time, minimise risks to breeding birds.
- Appendix 12 provides examples of flyers mailed to residents of some coastal towns in Victoria.

Events

- Face-to-face education can be one of the most effective ways of changing attitudes and relaying information to the public. This can be carried out in a number of ways:
  - Hosting public events which target beach visitors in general, such as an interpretive beach walk, a bird watching workshop, or camp-ground talks and activities. Parks Victoria has a "Camp Hosts" program which could serve as the delivery device for the latter approach.
  - Hosting public events which target specific groups of beach users, such as 'Dogs Breakfast' events. At a dogs breakfast, a free breakfast is provided for dogs and their owners, and local council representative/s, the land manager, a vet and someone with knowledge about beach-nesters (such as a volunteer or a Birds Australia staff member) chat with attendees about various dog related issues, including impacts of unleashed dogs on beach-nesting birds.

- Setting up an information stand at local coastal festivals.
- Hiring an environmental theatre troupe to perform and interact with beach visitors.

- Advertising is essential to the success of these events. It is important to advertise in local media, place posters in prominent areas around town and to sign-post the event location on the day.
- Advertising should incorporate fun and creative photos and artworks to attract the attention of the targeted group, such as the advertisements in Appendix 13 for a dog's breakfast event (courtesy Phillip Wierzbowski, Coast Action/Coastcare).

Speaking engagements and public meetings

- Presentations to community groups or advertised public meetings can be an effective means of educating the public about beach-nesting birds, especially when photographs and props (such as blown eggs or stuffed birds) are used to illustrate aspects of the birds' biology and plight.
- Public meetings provide a forum for questions and answers, and constructive discussions about managements that may conflict with some beach users' desires.
- Having people accompany a knowledgeable, enthusiastic expert into the field can be fundamental to rallying support for conservation of beach-nesting birds. A significant effort should be made to invite people such as community leaders, legislators, media, schools and conservation organisation leaders.

School visits

- Working with school groups in coastal areas is an invaluable tool for public education, because not only do you deal directly with one section of the beach-visiting population (who will also be the next adult generation), but these children then take the message home to their parents.
- The visit can be from a volunteer, a bird expert or a land manager or a combination of representatives from these groups.
- When presenting information to the students, it is best to make this as interactive as possible and to question the students throughout to ensure they grasp the concepts. Every student should be able to relate to the topic of visiting the beach and by asking them questions about the activities they like to do at the beach, you can also learn a lot about local threats to the birds.
- A unit of work can be developed around beach-nesting birds, covering a whole range of topics including: endangered species, camouflage, dune erosion, habitat, nesting strategies, predators, ecosystems, social attitudes, etc…
- Students should be encouraged to participate in beach-nesting birds' projects and activities such as:

- Researching and creating posters about the birds and threats to their breeding (these can then be used in interpretive displays).
- Designing signs/notices to beach visitors (that can be laminated and then used when the birds are actively nesting). Appendix 14 provides examples of some of the posters created by children from Victorian primary schools.
- Building chick shelters.
- Using mathematics to estimate survival of eggs and chicks and to calculate viable population sizes.
- Learning about camouflage by painting eggs to match different substrates.
- Learning about nest monitoring and nest fates by setting up artificial nests and visiting these over time.
- Learning to use binoculars and identify birds.

- A Powerpoint presentation aimed at educating primary school children about the plight of Hooded Plovers is available on CD from Birds Australia.
- The Western Snowy Plover website has an amazing array of kids artwork and also an educational movie made for children: www.westernsnowyplover.org/

Adopt a beach program

- These programs stemmed from the UK and USA and are designed to enable community stewardship of a local beach, whereby the community group provides the public with education and information of the values of the local coast (Wooltorton and Marinova 2006).
- The Far south Coast Birdwatchers and the Eurobodalla Natural History Society, in conjunction with the New South Wales Hooded Plover Recovery Team, have instigated an "Adopt a Beach" program (Jones 2000).
- In Western Australia, an "adopt a beach or wetland" program seeks to monitor habitat and inform managers of when Hooded Plovers are breeding and what threats are present at the adopted sites (Raines 2001).
- In California, Adopt-a-beach programs include public education, clean-up and habitat enhancement activities that benefit Western Snowy Plovers and these are eligible for grants of $6000 per annum.

Liaison with local veterinary clinics

Coastal veterinarians should be informed of how to deal with any eggs and chicks that are brought in by the well-meaning public. Veterinarians should be trained to identify beach-nesting bird eggs and chicks, and asked to immediately return the chicks to the site of capture after any required treatment.

Site wardens

- The purpose of wardens is two-fold, firstly to protect the nesting site or mobile chicks by directing people past the sensitive area, and secondly to provide interpretive information to beach visitors.
- Wardens are best placed at sites that get very busy, particularly sites with large numbers of dog walkers. The best timing for wardens is on weekends or public holidays so they can interact with large numbers of visitors at once. It is also good to have a warden on a few early mornings or evenings (after work hours) on a weekday to interact with regular, local visitors.
- Wardens can be most valuable during the chick phase and particularly during the first week or two after hatching when the chicks are most vulnerable.
- Wardens should carry brochures and laminated photos of the birds to help with interpretation.
- Wardens need to wear an identification badge. In some parks, wardens have hats and/or tshirts that identify the program as well as a name badge.
- It is important that wardens be even-tempered and that they always approach beach visitors in a friendly manner. They should know the limits of their authority and when to call for help.
- A good approach may be to say 'Hi there, I just thought I'd let you know that you are about to enter an area where an endangered bird is nesting. It would be really helpful if you could walk past along the water's edge between the signs (and put your dog on a leash in this section) because the eggs or chicks are incredibly easy to step on and are very sensitive to disturbance…' or 'Hi there, I'm not sure if you are aware that this beach is a really important area for an endangered species, the '*name of bird*'. They have a really high rate of nest failure and so it would be so helpful if you could…'
- If the behaviour of a beach visitor is putting the survival of the nest or chicks at risk, it is important to remain calm and to remember that the visitor is usually unaware of the plight of beach-nesting birds and is thus not deliberately endangering the birds.
- If a member of the public becomes offensive, hostile or threatening, the warden should retreat and should be provided with supportive back-up for such situations, such as being able to ring the ranger or bylaws officer for assistance.
- If a dog is racing ahead of its owner into a nesting area, the warden should call the dog to them and keep it out of the area until the owners arrive. Wardens should have on hand spare leads in case an owner does not have a lead with them, or in case an unaccompanied dog is found on the beach.

Applied examples

- 'Hooded Plover Watch' began on Phillip Island following a community meeting in October 1998. Bessie Tyers a local Westernport Bird Observers Club member (WESBOC) became the first volunteer coordinator. Thirty-four volunteers from a range spent time on the beach that season, six chicks fledged compared with just three from the previous three seasons and since then between four and ten have fledged each year. More recently, the Phillip Island Nature Park has coordinated the volunteers in the 'Summer Nest Protection' program. Here volunteers look after breeding birds at the brooding and chick rearing phases and provide information to the public by handing out 'Where Can I Walk My Dog' brochures and Hooded Plover identification post cards. The roster is quite flexible with volunteers usually rostered on for two-hour periods at busy beaches and over high tide periods. As each nest progresses and at important times (hatching, early chick stages) more resources are allocated. Volunteers are supported by rangers who patrol and enforce regulations.
- Guardian programs for the Piping Plover involve wardens who further emphasize the request to keep out of signed areas and also provide information to interested members of the public. On the Acadian Peninsula in Canada, beaches with wardens had the highest nesting success, equivalent to beaches that were inaccessible to people (Goossen *et al.* 2002).

Regulations and enforcement

Stern (2000, 2005) advocates that effective laws and regulations encourage pro-environmental behaviour. Government laws and regulations can be used to encourage individuals' behaviour in the natural environment (Gardner and Stern 1996). On many beaches, regulations in place have direct benefits to beach-nesting birds, particularly those that regulate dog walking, horse riding and off-road vehicles. Compliance with these regulations can be fundamental to improving the survival of eggs and chicks, and to reinforcing on-ground management actions. Unfortunately, many of the regulations that complement shorebird conservation go unenforced and compliance is consequently low.

A key strategy to improving breeding success of beach-nesters is to patrol and enforce regulations when the birds are actively nesting, particularly near hatching. By increasing patrols and interacting with beach visitors, the public soon become aware of the significance and relevance of regulations. Because it is thought that humans are intrinsically egocentric, that is, they typically act in their own self interests (Hardin 1968), regulations that are enforced by a threat of penalty (e.g. fine) operate by making people behave in the public interest because it is in their own best interest to comply (Gardner and Stern 1996). 'Fear appeals' (sanction materials) differ from awareness-of-consequences messages, in that the former focus on harm to the person performing the behaviour, and the latter describe harm to others or to the environment arising from specific behaviours.

Sanctions are somewhat more effective than awareness-of-consequences messages (Gramann *et al.* 1995). However, with increasing emphasis being placed on the importance of biodiversity, climate change and habitat loss in today's society and media, it is important to accompany enforcement with education, as this can be particularly effective at changing behaviour of those already inclined to be sympathetic to the environment.

To a proportion of visitors, the enforcement of regulations can have a flow-on effect, as they may observe people complying with regulations and follow suit. There are two social norms described by Cialdini *et al.* (1990) that influence human behaviour: what is commonly done (our perceptions of how others behave) and what is commonly dis/approved of (our perceptions of behaviours that meet with social approval). Cialdini *et al.* (1990) conducted a series of experiments demonstrating that by subtly activating people's social norm against littering, this decreased littering behaviour: when people observed litter or observed other people littering they were inclined to also litter. On the contrary, when people observed a litter free environment in which they observed others placing rubbish in the bin, virtually 100 % of subjects also placed their rubbish in the bin. Changing social behaviour amongst even a small number of beach visitors through enforcement or education can thus have a broad-reaching, powerful impact.

Time and resource limitations can result in enforcement being low on the list of priorities for Shires and park rangers. In these circumstances, dedicating one or two periods within the breeding season to intensive patrol can effectively increase compliance. It can be wise to also have a few patrols out of normal business hours in order to reach a large number of offenders, such as non-compliant dog walkers that use the beach before and after work.

Many beach users, such as dog walkers, horse riders and off-road vehicles use substantial sections of the coast, and it is important that signs be placed on the beach at the boundaries of different management zones. Preferably, these signs should be in large fonts so they are noticeable from the water's edge, and should be kept simple, for example: No dogs beyond this point, Dogs must be on-leash from this point, Permits for horse riding required from this point…

Dogs on beaches

The range of regulations for dog access to beaches is similar across Australian states. Below information pertinent to Victorian dog regulations is outlined as an example:

- Under the guidelines set out by the Domestic (Feral and Nuisance) Animal Act (Vic) 1994, dog regulations are aimed at: promoting the responsible pet ownership of dogs, and protecting people and the environment from feral and nuisance cats and dogs (cited in Buchanan and Lord 2006). Certain dog laws set out under the Act are consistent throughout all of Victoria. Additional dog regulations are made by local

councils at the municipality level and vary from council to council including: leashing requirements; prohibition of dogs in certain public areas or at certain times; disposing of dog droppings, and; restrictions on the number of dogs allowed to be kept on any one premises (Buchanan and Lord 2006). These regulations are in place on many Victorian beaches, largely for the purpose of public safety and comfort.

- Parks scheduled in the National Parks Act (1975) and Regulations are classified as either 'Dog Access Areas' or 'No Dog parks'. Unless an area has been set aside or dogs are confined to a vehicle or vessel in transit through a public park, dogs are prohibited in Wilderness Parks, Wildlife reserves and National Parks, including Marine National Parks within Victoria. If some one is in contravention of the stated dog regulations (which may be 'dogs prohibited', 'dogs on leads' 'seasonal restrictions, etc, depending on the type of park) then the on the spot penalty is $165. If taken to court, the maximum penalty is $1,650 (see section 37 NP Regulations).
- In other reserves managed by Parks Victoria (e.g. Coastal Reserves), specific regulations need to have been written under the Crown Lands Reserve Act. These regulations will specify dog restrictions and associated penalties but may vary from reserve to reserve. If no regulations have been written then there will be no dog restrictions and dogs can run around off-lead at all times.
- There is not a consistent rule for dealing with offenders of dog regulations in parks. In some major National Parks, a fine ($165) will always be given because it is general knowledge that you can't take dogs into National Parks. In other types of parks, especially those that permit dogs in certain areas or at certain times, verbal warnings, official cautions or fines may be issued for a first offence. This depends on the officer, the time of year, number of other beach users and attitude of the offender. Official cautions are where the offender is officially reported to the Offence Management Unit of DSE/DPI and they are sent an Official Caution letter as well as having their details recorded on the system. This means if they offend again and the system is checked, the Parks Victoria Ranger will know they have already been cautioned and will therefore be more likely to issue a fine for a second offence.
- Municipal council by-law officers are responsible for the enforcement of dog regulations on land managed by local shires, councils and Committees of Management (Buchanan and Lord 2006).

There is considerable variation in dog regulations, ranging from:

Dogs prohibited at all times

- Dogs have been banned from some Hooded Plover breeding beaches at Phillip Island and Mornington Peninsula National Park (Schulz 1992a; Dowling and Weston 1999). Weston (2000) suggested that limiting recreational activity in breeding territories to walking without dogs would reduce disturbance to breeding Hooded Plovers. Experience has shown that one of the benefits of restricting dogs from a few beaches

with breeding Little Terns can be to enhance the tourist values of these sites (Schulz 1992a). Beaches promoted for their wildlife values provide opportunities for new tourism enterprises, personal satisfaction and biodiversity conservation.

Dogs prohibited at certain times of year

- Seasonal bans usually apply to a time period within November to April. These restrictions are largely derived for reducing disturbance to other beach user groups rather than for protection of breeding shorebirds. However, the summer period is the period of peak visitor use as well as the peak of the nesting season, and so reducing a proportion of the visiting population would confer benefit to nesting birds. It has been suggested that such regulations however, merely confuse dog owners and are more difficult for authorities to enforce (B. Baird pers. comm.). Birds Australia supports a 'promoting coexistence' policy for dog walking and shorebird conservation. However, prohibition of dog walking across the span of the resident shorebird breeding season is supported in the following cases: on small cove beaches or incredibly narrow beaches where the birds have little area to hide or respond to disturbance from dogs as well as humans; and where dog leashing regulations continue to have low compliance despite awareness raising and signage warning of impacts to nesting birds.

Dogs prohibited at certain times of day

- Time bans usually operate from late morning to late afternoon, allowing dog access to beaches during the early morning and evening which suits most local residents, particularly those that work normal business hours. This type of restriction has benefits to nesting birds by reducing disturbance during the hottest part of the day, when exposure to high temperatures can greatly reduce egg viability or dehydrate chicks.

Dogs must be under effective control

- Effective control refers to voice control and does not specify the need for a lead. This regulation is of no benefit to beach-nesting birds, because an off-leash dog disturbs nesting birds and foraging chicks by moving independently of its owner and the birds will thus perceive the dog as a threat.

Dogs must be on a lead

- This is the most effective regulation for reducing threats to beach-nesting birds. There are significant differences in the reaction of Hooded Plovers to dogs that are on and off the lead (see pp. 45-46). It is a minimum requirement of conserving beach-nesting birds to restrict dogs to the lead during the breeding season on beaches where nesting occurs. Birds Australia views leashing as the best means for promoting coexistence between an activity that has the potential to devastate breeding success, and the minimum survival requirements of a highly vulnerable suite of birds. Weston (2003), however, highlights that because compliance with leashing laws is so incredibly low, even where management is in place, it may not even be desirable to allow leash access to breeding beaches.

Unrestricted/Off-leash access

- This enables off-leash access to beaches and is the most detrimental to beach-nesting birds when off-leash access to breeding beaches is permitted. A review of current regulations needs to be carried out and any local council/shire needs to change their regulations accordingly to protect these threatened species. At the same time, dog owners must be provided with access to off-leash areas, including off-leash beaches, but the location of these should not overlap with conservation areas.

Problems with compliance

- Currently there is a lack of compliance with dog regulations on Victorian beaches (Dowling and Weston 1999; Weston 2003). Dowling and Weston (1999) report a compliance rate of 12 % with leashing in 693 observations of dog walkers in Mornington Peninsula National Park during 1991-1998. In seven years of intense education, awareness campaigns and enforcement of leashing laws in Mornington Peninsula National Park, compliance peaked with only 22.4 % of dogs leashed (see Dowling and Weston 1999).
- A range of ocean beach surveys were carried out in southern Victoria, 1995 -1998, in a study of suitable beach-nesting bird habitat (Weston unpubl. data). A total of 743 dogs were recorded of which only 6.1 % were leashed. Unleashed dogs were recorded in 18.9 % of the surveys, whereas leashed dogs were recorded in only 1.6 % of surveys. Although dog regulations varied between survey sites, most had leashing requirements (Weston unpubl data). Direct observations of breeding Hooded Plovers in southern Victoria also revealed most dogs encountered were off leash. Of 243 dogs observed passing incubating adults, 92.2 % were unleashed, and of 334 dogs that passed broods, 90.1 % were unleashed (Weston and Elgar 2005, 2007). Further observations of recreational activity and compliance with regulations on Victorian beaches revealed that dogs where present on beaches despite clear signs stipulating prohibition of dogs between the hours of observation (Dodge *et al.* in prep.). Furthermore almost all of the dogs observed were not on a lead.
- During the 'promoting coexistence' project, 2,622 records of threats within the vicinity of the pair were documented by volunteers visiting Hooded Plover breeding territories. In 813 of these visits, dogs were observed within 100 m of the breeding pair, and in 86 % of those visits, dogs off lead were present (compared with 31 % of visits where dogs on lead were present). Where management was in place to protect beach-nesting birds, this management was deemed ineffective to dogs (based on observations of dogs off-leash and evidence of dog prints within signed/fenced areas) in 62 % of visits where evidence of dogs on the territory was present (n=1058) (and only completely effective in 2 % of visits, i.e. dogs at water's edge and on leash).

Statistics for patrols and enforcement of dog regulations in Victoria's National Parks:

Cape Liptrap Coastal Park (Venus Bay):

- In the summer of 2008, the Foster Parks Victoria work centre visited the Venus Bay beaches approximately every 2-3 days throughout January and once a week in February. A key part of these patrols was ensuring compliance with dog regulations to protect Hooded Plovers. This equated to 12-16 patrols over Jan-Feb largely with Hooded Plover protection in mind.
- A total of 4 verbal warnings, 6 Official Cautions and 5 Infringement Notices (on the spot fines) were issued. This was the first season that fines were issued as clear signage was finally in place. While no official data was collected on compliance rates, it was noted by rangers that there was a big decrease in dog offences as the season progressed (J. Stevenson pers. comm.).

Mornington Peninsula National Park:

- When dog management (time restrictions and dog free zones) was first introduced to the Mornington Peninsula National Park in Victoria, Hooded Plover hatching success and the proportion of chicks successfully fledging increased (Dowling and Weston 1999).
- In the 2006-07 breeding season, 113 written warnings and 6 infringement notices were issued. In the following (2007-08) breeding season, visitation rates to the park increased by 2 % and at the same time, patrols were increased around critical nesting phases. A total of 230 written warnings and 11 infringement notices were issued. One ranger encountered 50 offenders and only one came up on the database as a second offence (D. Mitchell pers. comm.). It appears that there are few re-offenders; this may indicate non-compliance mainly comes from holiday makers and first time visitors, but also suggests that locals know when the park is patrolled and avoid these hours.
- The aim will be to increase out of hours operations during the coming breeding seasons.

Phillip Island Nature Park:

- In Phillip Island Nature Park, there are ten beaches where dogs are prohibited, nine beaches where dogs are permitted within time restrictions and one beach designated as an off-leash dog beach.
- In the 2007-08 breeding season, rangers gave many verbal warnings to people breaking dog regulations, one written warning and 23 infringement notices (J. Fallaw pers. comm.).
- All relevant PINP rangers are authorised under the Department of Sustainability and Environment to enforce dog regulations, but only recently this authorization has been extended under local laws and the Domestic and Feral Animals Act. This will strengthen the ability of management staff to respond to dog issues, and builds on the cooperative partnership with the local Bass Coast Shire Council.

Overseas case studies

- In the USA (e.g. Cape Cod), beaches where Piping Plovers breed are typically legislated as leash only, although it is stipulated that if pet owners fail to keep dogs leashed and under control, then dogs should be prohibited on these beaches. Furthermore, if dogs harass breeding Piping Plovers, owners can be taken to court and fined thousands of dollars under the Endangered Species Act.
- In 1995 the Sacramento Fish and Wildlife Office completed formal consultation with the National Park Service, Golden Gate National Recreation Area, on the effects of their management of Ocean Beach, San Francisco on the Western Snowy Plover. The consultation covered actions and policies the National Park Service had taken that resulted in unnecessary harassment of non-breeding Western Snowy Plovers. Most significant of these measures was their policy not to enforce regulations requiring pets to be leashed and under control by their owners on all National Park Service lands. Data collected by the National Park Service clearly identified that unleashed dogs were the most significant disturbance factor of the many sources of disturbance to Western Snowy Plovers on Ocean Beach. As a result of the consultation, the National Park Service began to enforce their "leash law" along 3.2 km of beach utilised by Western Snowy Plovers. The National Park Service implemented this policy despite vocal and persistent opposition by the San Francisco Society for the Prevention of Cruelty to Animals (!) and other local advocacy groups, including the "Rovers for Plovers", who organised themselves to challenge the National Park Service's leash law. These groups were successful in advocating their position in numerous television news stories and articles in local newspapers. At the height of this discourse, the local public radio station held a round-table discussion between the National Park Service, U.S. Fish and Wildlife Service, and Society for the Prevention of Cruelty to Animals, and solicited audience members to call in and identify their viewpoint. The overwhelming majority of callers supported leash law restrictions that would minimise harassment of Western Snowy Plovers (U.S. Fish and Wildlife Service 2007).
- The recovery plan for the Western Snowy Plover (U.S. Fish and Wildlife Service 2007) specifically states that "it is preferable that land managers prohibit pets on beaches and other habitats where Western Snowy Plovers are present, or traditionally nest or winter, because any non-compliance with leash laws can cause serious adverse impacts to Western Snowy Plovers. If pets are not prohibited, they should be leashed and under manual control of their owners at all times. Pets should be prohibited on beaches and other Western Snowy Plover habitats if, based on observations and experience, pet owners fail to keep pets leashed and under full control." Furthermore, "land managers should document the type and frequency of infractions of rules and regulations requiring pets on leash. This information, including the number of verbal warnings, written warnings, and notices to appear (citations), should be documented so that comparisons can be made between locations and to ensure that adequate effort is being made to enforce pet regulations."

Driving on beaches

- In Victoria, driving on beaches is illegal, with the exception of boat launching areas.
- On land managed by local councils and Committees of Management, this law is enforceable by Victoria Police. This attracts a fine determined by local council bylaws (e.g. $102 on Moyne Shire land), although fines increase if the vehicle is unregistered and then departs the beach via a bitumen road (plus $510).
- For parks managed under the National Parks Act (e.g. National Parks, State Parks, Coastal Parks, Marine and Coastal Parks, Marine National Parks and Marine Sanctuaries), the National Park (Park) Regulations 2003 provide for the control of vehicles including prohibiting them from accessing, driving or parking on beaches within parks (See sections 40 and 41 of NP regulations).
- The current on the spot penalty is $110. If it is deemed a major breach (e.g. deliberate hooning up and down dunes, destruction of barriers to gain access, etc) the matter can be taken to court where the maximum penalty a judge could deliver is about $1,100. (Note 1 penalty unit - $110)
- Furthermore the Land Conservation (Vehicle Control) Act 1972 and associated regulations (Land Conservation (Vehicle Control) Regulations 2003) prohibit the off road driving of any motorised vehicle on any type of Crown Land in Victoria, including areas managed under the National Parks Act. This means that vehicles are prohibited from driving along all beaches except for some minor exceptions where beach launching of boats is permitted at various locations. Under the Land Conservation (Vehicle Control) Act the on the spot penalty is $110 or a maximum of $550 if taken to court (see section 6 Land Conservation Regulations).
- Parks Victoria Rangers are authorised officers under the National Parks Act and most will also be authorised under the Land Conservation (Vehicle Control) Act. This means that they are authorised to issue the penalties without reference to the police. In fact, many police officers may NOT be authorised under the above two acts so therefore cannot issue the associated penalties.
- Illegal vehicle activity has the potential to grow into a bigger problem, so that land managers and authorities need to tackle the issue early on through adequate signage, enforcement of laws and publicising enforcement statistics.
- Where the problem is widespread, an integrated approach to tackling the problem is required. In south-west Victoria, a working group was established to tackle the issue, with members from the local Shire (Moyne), Parks Victoria, Coast Action/Coastcare, the Department of Sustainability and Environment, Victoria Police, the regional Catchment Management Authority (Glenelg-Hopkins CMA), local indigenous groups (Framlingham Aboriginal Trust) and Birds Australia. This has involved implementing signage which clearly states that driving on beaches is an offence and will attract a fine, publicising the vehicle blitz and increasing police response times and ability (including borrowing off-road vehicles from Melbourne).

- Elsewhere in Australia, local councils and parks authorities either prohibit or regulate driving on beaches through a permit system or by having a strict set of guidelines. These guidelines commonly specify:
  - Vehicle access through established or dedicated beach entry points only
  - Driving on the beach below the high-tide mark (e.g. Bundaberg Regional Council QLD, Shire of Bellingen NSW)
  - Registered vehicles only
  - A strict speed limit; often 50 km/hr slowing to 25 km/hr when within 100 m of people.
- Many NSW beaches have restricted vehicle access, i.e. either no access permitted or a permit system in place with clear user guidelines. However, there are also significant shorebird breeding beaches where vehicle access is completely unrestricted (Harrison 2005).
- Harrison (2005) identified specific issues that needed addressing at south Ballina beach in NSW, an important shorebird area, including the inappropriate use of vehicles on beaches, i.e. driving through and parking in foredune areas, speeding and driving recklessly on any beach zone and the use of unregistered vehicles. She recommended that:
  - a permit system by implemented that aims to limit the number of vehicles using the beach during the breeding season [in just one weekend, 169 vehicles were observed on the beach];
  - speed limits be set to 35km/hr;
  - the beach is closed to all vehicles two hours either side of high tide;
  - nesting areas be signed and closed for the duration of the egg and chick phases;
  - new signage be erected on the foredune as well as at access points, and;
  - a strong recommendation for a patrol warden to enforce such restrictions, particularly during weekends.
- Driving on many beaches in Queensland is prohibited, a major exception being Fraser Island. The QLD Environment Protection Authority has a webpage dedicated to guidelines for driving on beaches: www.epa.qld.gov.au/parks_and_forests/activities_in_parks_and_forests/fourwheeldriving/driving_at_the_coast/

  This largely focuses on protecting dunes from erosion and vegetation from being damaged and does not mention nesting shorebirds specifically but does refer to disturbance of wildlife. The guidelines however are relevant to protecting shorebirds as they encourage driving at low tide.
- In Tasmania, including King and Flinders Islands, driving on beaches is widespread and while National Parks and Coastal Reserves may have regulations, these are rarely

enforced. A brochure entitled Cruisin' without Bruisin' has been compiled by a cooperative of Tasmanian authorities and 4WD associations which provides a code of ethics for driving off-road in Tasmania. In this brochure, driving below the high-tide mark is recommended for the protection of beach-nesting birds. However, driving on dunes is mentioned as allowed in designated recreational areas, which is somewhat contradictory.

- In South Australia, under the Harbours and Navigation Act 1993, beaches (the land extending from the low water mark on the seashore to the nearest road or section boundary, or to a distance of 50 metres from high water mark) are vested in the ownership of the Minister for Transport. Other government authorities along with Local Government can enact their legislation or by laws over this area. Vehicle regulations are governed by the Road Traffic Act, and the Minister for Transport is currently investigating appropriate speed limits for beaches.
- A stretch of 110 km of coast at the northern end of the Coorong, South Australia, is closed to vehicles from 24 October to 24 December each year, specifically to protect Hooded Plovers (S.A. Government 1993).
- In Western Australia, driving on beaches within National Parks is prohibited, but still driving on these beaches continues and enforcement is rare. For example, the beaches in Yalgorup National Park are covered in four wheel drive tracks for at least 40 km from access. Only extensive barriers seem to keep vehicles out (M. Singor pers. comm.).
- The mining boom and the development of the BHP nickel mine near Jerdacuttup, Western Australia, has resulted in the Hopetoun beaches being inundated on weekends by 4 wheel drive vehicles (Singor 2007). The sensitive Hooded Plover beaches around Hopetoun have been damaged substantially (M. Singor pers. comm.).
- In Western Australia, Shire of Albany closed off some of their beaches to vehicles and this resulted in Bremer Bay, the next town along the south coast, being suddenly inundated by off-road vehicles on weekends.

Overseas case study

In the USA, Executive Order 11989 (Off-Road Vehicles on Public Lands) states that "the respective agency head shall, whenever he determines that the use of off-road vehicles will cause or is causing considerable adverse effects on the soil, vegetation, wildlife, wildlife habitat… immediately close such areas or trails to the type of off-road vehicles causing such effects, until such time as he determines that such effects have been eliminated and that measures have been implemented to prevent future recurrence." This enables the Piping Plover Recovery Team to ban driving on beaches in many areas or to implement temporary bans on vehicles from beaches during the chick phase (just prior to hatching and until fledging age or chicks are sighted flying), in the area 1000 m either side of nest site.

Rules for essential/management vehicles

The following procedures were developed by the U.S. Fish and Wildlife Service (1996) for essential (non-emergency) vehicles (e.g. SLSC or management vehicles) so that the risks of crushing eggs/chicks are minimised:

- Essential vehicles should travel through chick habitat areas only during daylight hours, and should be guided by a qualified monitor who has first determined the location of all unfledged plover chicks.
- Speed of vehicles should not exceed five miles (8 km) per hour.
- Use of open 4-wheel motorized all-terrain vehicles or non-motorized all-terrain bicycles is recommended whenever possible for monitoring and law enforcement because of the improved visibility afforded to operators.
- A log should be maintained by the beach manager of the date, time, vehicle number and operator, and purpose of each trip through areas where unfledged chicks are present. Personnel monitoring plovers should maintain and regularly update a log of the numbers and locations of unfledged plover chicks on each beach. Drivers of essential vehicles should review the log each day to determine the most recent number and location of unfledged chicks.
- Essential vehicles should drive below the high-tide mark and at times of low tide.
- Travel should be infrequent enough to avoid creating deep ruts that could impede chick movements. If essential vehicles are creating ruts that could impede chick movements, use of essential vehicles should be further reduced and, if necessary, restricted to emergency vehicles only.

These rules could be adopted in Australia by SLSC and management agencies such as Parks Victoria, who drive on beaches as part of their work. Sometimes managers use quad bikes to survey long stretches of coastline for beach-nesting birds or to carry fencing equipment and signs to nest sites that need protecting.

Horses on beaches

- On the Australian coast, horse access to beaches is regulated and these regulations vary from complete prohibition to seasonal or time of day restrictions or specific permit conditions.
- The minimum requirements that should exist for horse riders using beaches where resident shorebirds are located are:
  - that horses enter and leave the beach at designated access points only (and these should be designated appropriately, that is, should not lead directly onto nesting sites);

- that horses be ridden below the high-tide mark on beaches; particular care needs to be taken not to cut corners, but to stick to the water's edge on winding beaches;
- that horses be permitted only at times of low tide (two hours either side), and;
- that riders slow their horses to walking pace when within 200 m of a signed or fenced nesting area.

- Furthermore, for narrow beaches where dunes are inaccessible to shorebird chicks due to heavy vegetation barriers, horse riding should be prohibited from beaches either for the duration of the nesting season or during active chick phases if all pairs in this section are regularly monitored, whichever is more feasibly implemented.
- An educational CD for horse riders on beaches is available from Birds Australia.

Overseas case study

The Snowy Plover recovery plan (U.S. Fish and Wildlife Service 2007) implement restrictions on horseback riding in nesting areas through annual coordination with commercial and private equestrian operations and groups. Strategies to reduce adverse impacts of horse riding on beaches include: (1) use of designated trail systems or, when absent, use of the wet sand area in areas not closed to the water line* and avoid high-tide periods; (2) advance coordination with local resource agencies regarding locations of nests and broods; (3) compliance with closed or restricted areas and strict enforcement of these restrictions; and (4) informing riders of the need for restrictions to protect habitats used by Western Snowy Plovers and other sensitive coastal dune species. * The recovery team close the entire beach to the water line during the chick phase.

Coastal Planning Considerations

- The planning of new coastal developments should account for effects on local resident shorebirds. This does not only include the direct impact of the development itself, but should incorporate flow-on effects in terms of an increase in the size of the local human (and pet) population and associated impacts and the necessity for greater coastal infrastructure (e.g. access points) and associated dune stabilisation, which reduce habitat availability and suitability.
- Impacts of coastal developments are often greatly expanded by concerns for protecting and maintaining access roads. It may be possible to substantially reduce the overall impacts of coastal property protection on habitat by rethinking how access is provided. Planners should weigh the economic and environmental costs of maintaining overland access, and compare them with costs and environmental effects of alternative modes and routes of access (U.S. Fish and Wildlife Service 1996).
- Any proposed beach access points should be considered carefully at the planning stage in terms of their potential impact on beach-nesting bird populations. For the protection

of the Piping Plover, the U.S. Fish and Wildlife Service (1996) recommends that the number of access points to beaches be limited and their location be distanced from nesting sites, as it is known that people commonly congregate closest to parking areas.

- Managers should monitor any proposed developments, and seek advice on the potential impacts of developments. Incorporation of beach-nesting bird management and conservation issues into planning proposals could also help minimise the impact of any developments on these vulnerable birds. This is particularly important given that the recreational use of beaches is likely to increase in the future.
- Development on the primary dune should not be permitted. However, if residential developments are approved, residents should not be permitted to have cats, dogs should be confined to the backyard and residents informed of the importance of leash-only access to breeding beaches.
- There are currently many beaches which are 'grey' areas of management due to land status issues. Land tenure can differ for below the high-tide mark, above the high-tide mark and then the foredune/dune. This has potential to affect regulations and their enforcement.
- Agencies and community groups should make submissions that ensure the needs of beach-nesting birds are addressed, whenever there are proposed changes to local laws or management plans concerning recreational activities on beaches, such as dog walking or horse riding. Recommendations for regulations are considered in the previous section on regulations and enforcement.

Legislative protection for Piping Plovers in Maine, USA

In Maine, there are multiple legislative acts that restrict activities for the protection of Piping Plovers, including:

- Municipalities have to maintain beach and dune systems as open space and to abide by laws and regulations pertaining to sand dunes.
- No major projects can be carried out on beaches in the nesting season, and further residential development is subject to consultation with biologists from the recovery team.
- Tax abatements and incentives are used to protect important habitat on private land.
- Pets and off-road vehicles are banned from beaches during nesting season, and there are specified distances from nesting sites for kite flying, fireworks and volleyball areas.

Captive breeding and population augmentation

- Captive breeding and release does not address the threatening processes that cause low reproductive success or loss of habitat, and so do not offer a long-term solution to conserving beach-nesting birds.
- Captive breeding can be incredibly expensive and birds in captivity may experience health and behavioural problems (e.g. Hooded Plovers, M. Weston pers. comm.).
- It is not known whether shorebird chicks that are hand raised would be successful if released into the wild, as they may lack many of the behavioural adaptations learnt from their parents that are necessary for survival and future breeding success. For example, often captive bred individuals lack effective anti-predator responses due to a period of isolation from predators (Griffin *et al.* 2000).

Emergency response

Although the likelihood of an oil spill is low, the threat can be reduced by ensuring that there is an emergency plan in place to contact and employ suitably qualified and experienced people who can capture, handle and rehabilitate shorebirds in the event of a spill. Threatened species should receive priority in any oil spill treatment.

The Oil Spill Response Atlas (OSRA) is a national geospatial database combining logistical, environmental, geomorphological and biological data from varied sources into a single integrated database. OSRA can be easily and quickly interrogated and used in contingency planning and to respond to oil spill emergencies. Visit: www.amsa.gov.au/ and follow the links Marine Environment Protection > National Plan > General Information Oil Spill Response Atlas.

At least five people in each state should be trained in trapping and handling beach-nesting shorebirds; a workshop over 3-4 days could be run and a manual for trapping and handling birds developed.

This training will also be valuable for responding to reports of beach-nesting birds entangled in fishing line, plastics or man-made fibres.

A response framework should be formulated to establish protocols for response to events such as oil spills, including communication networks, provision for rapid approval to catch and having enough traps available for capturing birds.

Chapter 4. Monitoring beach-nesting birds, threats and the success of management

Why monitor?

Monitoring is the repeated, comparable measurement of a variable of interest (e.g., the abundance or occurrence of birds or threats). Monitoring populations is essential to recognising declines or increases in numbers, changes in distribution or habitat use, and local extinctions or colonisation of new areas. This can enable the recognition of threatened or overabundant species, or even the extent of habitat, and will drive management priorities and resource allocation. For land managers, having an understanding of which animals are found in an area, their abundance and status, and what proportion of the state's or nation's population occurs in the area are very useful to prioritising management objectives. Once management of single or multiple species commences, monitoring must be carried out to determine just how effective that management is – are numbers changing in the desired direction; is this affecting any other wildlife in the area; is breeding success improving? In order to justify resource allocation to management, you will need to know if targets are being met, and hence monitoring must form part of any species management program.

What are the key considerations of a monitoring program?

Field *et al.* (2007) review the key considerations for making monitoring meaningful, highlighting three important criteria:

- Objectives: As with any monitoring program, you must decide what you need to monitor – single or multiple species, presence/absence, species abundance, adult numbers, juvenile numbers or fledgling production. This will all depend on the objectives of monitoring. For example, if you are interested in determining the effectiveness of fox control, you may wish to monitor fox numbers, but also pest species whose numbers are regulated by foxes such as cats and rabbits. If you are controlling foxes for the purpose of protecting threatened prey species, then you may wish to

monitor a suite of small mammals or ground-nesting birds, or focus on a few 'flagship' species (representative of other species in that ecological group, e.g. small terrestrial mammals or beach-nesting birds, or those most sensitive to fox predation). Once you have decided which species you will monitor, the next step is investigating which aspects of its biology are important to the monitoring program (see text box below). This will dictate the variables you monitor, the time of year or even the time of day you survey, and how often surveying needs to be done. Furthermore, you will need to specify what degree of change (i.e. effect size) in the variable/s monitored would be considered sufficient to trigger a management response or to determine the effectiveness of management already in place.

- Funding: monitoring programs need to be funded over a long period. Few ecological variables would show change in less than 5 years, while 10 years appears to be the suitable minimum target for most ecological variables. Power analysis can be used to identify the best monitoring duration for a project.
- Sampling design: In order to have confidence in the data you collect and to make conclusive statements, you will need to ensure that data is collected from an appropriate sample size (that is, there is replication). Collecting data on the breeding success of two pairs from a population of 200 for example, is unlikely to capture the variation that exists within that population. Furthermore, sampling population size over two years for example may show an increase or decrease in numbers, but is this a natural level of variation or indicative of a real change associated with the variable of interest? In order to make comparisons between sites or management regimes, you will need 'controls', that is, to determine the effectiveness of management, 'control' sites will be where no management occurs, or to determine the impact of human disturbance, 'control' sites will be isolated or inaccessible sites. Field *et al.* (2007) provide detailed advice on how to determine appropriate sample sizes that give your results strong statistical power. They also suggest that data collected should be analysed promptly and, if they point to deficiencies, used to refine the sampling regime so that it becomes progressively more efficient. The early years of data can be used to predict how the level of statistical power will change over time, and thus estimate the duration over which the monitoring must be maintained in order to yield a meaningful result.

Deciding what to monitor – questions and answers addressing the Hooded Plover in its eastern range

Is the species in question a permanent resident of the park or a mobile species?
Hooded Plovers are a non-migratory, resident species.

Does the species hold distinct territories, occur in pairs or in groups?
They pair off at the start of the breeding season (August) and defend distinct territories up to 2km in length. During the non-breeding season (April-July), they tend to flock in larger

groups and be more mobile. They will flock on ocean beaches or around saline lakes, and some areas tend to be more common as flocking locations.

Is the species nocturnal, diurnal or crepuscular?
We do not completely understand the temporal behaviour of Hooded Plovers, whether they actively feed or roost at night, but we do know that they are highly visible in the daytime, when they frequently forage at the water's edge, at the high-tide mark or on rock platforms, engage in nesting behaviours and territorial disputes, and shelter on the beach by seaweed, flotsam or jetsam, or in the dunes.

What time of year does the species breed?
They typically breed from August to March, although the season can extend into April. The peak of breeding occurs during November-December.

Are there multiple breeding attempts and how long does a single attempt last?
Hooded Plovers have a long breeding season, during which they have time to raise two broods successfully. The incubation phase lasts for 28 days and the chick rearing phase for 35 days, a total of 63 days. If a nest is unsuccessful, the pair will have another attempt and will often continue to try until the season ends. The maximum number of nests for a given pair observed in a season was seven.

What time of year do juveniles disperse?
Chicks can disperse from the territory in which they hatched at any time after they fledge (that is, are capable of flight). Timing of fledging will depend on whether the parents are aggressive to the young and are keen to evict them from the territory so they can have another attempt at nesting. Juveniles are capable of dispersing long distances.

If the species is threatened, is this through habitat loss, adult mortality or breeding failure leading to declines?
Hooded Plovers are long-lived (estimated to live for 10-17 years) and adults have a high rate of survival (>90 %). They experience incredibly low breeding success, both at the egg and chick phase and juveniles have only a 55 % chance of survival. The low recruitment of new individuals to the population thus accounts for the decline in population numbers. Numbers can remain stable for years, due to the longevity of Hooded Plovers, but then they can suddenly drop as older individuals die and there are few young to replace them. Habitat loss is another likely cause of decline for Hooded Plovers, distinct from the former demographic mechanisms of decline.

Monitoring population numbers – how frequently should monitoring occur?

There are several options available for monitoring bird population numbers, including monthly, seasonal/quarterly, biannual, yearly or biennial counts. The frequency of surveying depends on the rate that the population is estimated to change in abundance, and whether single or multiple estimates are required for any particular period. If a species is long-lived and adult survival is high, then changes to population size are likely to occur slowly. Therefore it would be more sensible to space the survey counts in years rather than months. In this case, yearly or biennial counts should always be carried out at the same time of year to avoid seasonal biases. If the species is long-lived, but threats to adult survival are high (for example, predators or vehicle collisions impact the adult population) then more frequent surveys would be necessary, such as biannual, seasonal or monthly counts. Seasonal or monthly counts would be useful for revealing when declines or peaks occur in the population, and how these relate to seasonal variation. It may be necessary to begin with a finer resolution of monitoring and then evaluate the rate of change, to assess whether this surveying frequency is appropriate.

It is also important to evaluate how detectability might vary amongst habitat types and observers. A new observer might detect a lower proportion of birds than someone with prior knowledge of the birds and nest locations, which could lead to the conclusion that the population is declining. Furthermore, the detectability of birds may differ depending on habitat type, for example Hooded Plovers can be readily detected in flat and exposed sites such as beaches, while individuals that nest, roost or forage in dunes may be overlooked, even by experienced observers (M.A. Weston 2006 pers. comm.). Only by assessing detectability can we conclusively determine whether such a change represents an actual decline in population size.

Below are examples of existing beach-nesting bird count programs:

Hooded Plover biennial counts

Birds Australia designed a population survey aimed at monitoring Victoria's Hooded Plover population numbers over time. In more recent years, these have been expanded to South Australia. There is a definite need to monitor this threatened species to establish whether the problem is worsening or improving, to recognise areas of the coast where local extinctions may occur or where numbers are most stable, and to determine whether the threatened status of the species needs to be upgraded so that more protective action can occur. The following features of the survey resulted from consideration of the species ecology (see text box on pp. 157-158):

- The population survey is conducted biennially (every two years) because population declines are predicted to be slow but also to accommodate the logistics of organising such a large survey. There is very little benefit to conducting annual counts over

biennial counts in terms of the ability to detect population changes (Weston and Morrow 2000; Weston 2003).

- The survey takes place on one weekend in mid-November because at this time of year the birds will be settled in established territories and unlikely to be moving around – this will keep the probability of recounting individuals low but will also tell us exactly where these birds breed on our coast. The survey needs to take place over the one weekend to minimise the likelihood of missing or double-counting individual birds.
- The coast is divided into zones, each headed by a regional organiser to ease the workload of a single coordinator and to provide local advice to volunteers.
- Within each zone, smaller sections of coast are allocated to volunteers and the regional organiser ensures there is no overlap in count areas*.
- Volunteers are recruited and trained in detecting and identifying Hooded Plovers, or paired with a trained observer.
- Volunteers are supplied with a set of guidelines for carrying out the survey (see Appendix 15) so that a degree of consistency can be achieved and to minimise safety risks to observers and the birds themselves.
- Specific forms are used by volunteers when carrying out the survey (see Appendix 16) so that all of the required information is collected in a consistent way, and data is not easily misplaced.

* Recent analysis of population count data has revealed that consistency of areas monitored is crucial to comparing densities over time, and that if sections are missed, or starting and finishing points altered from survey to survey, then it makes it very hard to compare the data.

Piping Plover annual counts

While counts of the entire breeding range of Piping Plovers are conducted every 5 years (due to the enormity of the task), population counts occur annually in parts of Canada. Annual counts are organised over a 9-day census window during the breeding season where all sites are counted. This short count window is to avoid double-counting. It is a priority to survey all previously surveyed sites within this window (or as soon as possible thereafter; yet to adjust data analysis to account for late count data) and only to survey new sites if time and resources permit. Annual counts are deemed necessary as habitat loss and modification is a major contributor to species decline, and changes can occur across this temporal scale.

Knowledge of the number of breeding pairs is critical to meeting the Recovery Plan objectives (1996), and thus care is taken to identify unmated territorial adults (which are

excluded from this part of the analysis), and to prevent counting incubating adults and their non-tending mates as separate pairs.

Annual counts have been conducted since 1986 but due to variation in survey effort over time, population sizes cannot be directly compared. Direct comparison would actually show greater population numbers after the species was declared Endangered, but this is a result of increased survey coverage. Productivity measures have also been recorded differently over time for the species (e.g. number of fledglings vs. number of nests fledging young) or defined differently (e.g. chicks reaching 25 days counted as fledged vs. chicks known to have fledged at 25 or more days), so they cannot be compared. Thus, emphasis is placed on the need for consistency across counts in both timing and coverage of surveys, and the way in which data is recorded and defined.

Hooded Plover biannual counts

In Western Australia, the behaviour of Hooded Plovers is remarkably different in comparison to the eastern population. Here, Hooded Plovers occur coastally and inland as far as several hundred kilometres (Birds Australia New Atlas Project 1998-2008). Their movements are largely unknown; it is thought that the birds migrate inland at the end of summer once the coastal lakes begin to dry up, and the Autumn rains begin (Singor 1999). There are records of birds breeding year round in W.A. (Singor 1999). The Western Australia Birds Australia group coordinates biannual surveys, one in February and one in September in an attempt to understand how numbers fluctuate between coastal and inland habitats in Spring and at the end of Summer.

Hooded Plover quarterly and monthly population counts

On the Mornington Peninsula and on Phillip Island, volunteers survey Hooded Plover numbers along the entire coastline on a monthly and quarterly (February, April, July and November) basis, respectively, to gather information on population size and movements. On Phillip Island this is useful because many birds are colour-flagged and can be individually indentified – this enables managers to determine fidelity to a site and to their breeding partner and to gain a better understanding of dispersal, mortality and breeding success. Volunteers are well-trained at identifying nesting birds and detecting chicks, so that the monthly survey helps managers locate nests and chicks in need of protection. In other parts of the state, where the population is largely unbanded, monthly counts will be of limited value. Furthermore, when volunteers have limited skills for reading colour bands and detecting nests, monthly counts offer data of limited value to land managers, and it is therefore recommended that either the frequency of regular counts be reduced or volunteer training be reinvigorated.

Colour-marked populations/individuals

There are two methods for colour-marking birds:

- Colour flagging involves attaching a small plastic colour tab or flag to the leg of the bird. These marks look like a colour band with a trailing tab. Colour flags are used to mark cohorts and are mainly used for studies of migration or dispersal, however they can replace colour-bands in such a way as to permit individual identification (e.g. engraved with alphametrics).
- Colour banding refers to the use of coloured bands applied to the legs of birds. Each bird is marked with a unique combination of coloured bands. Banding is used extensively in breeding and behavioural studies where there is a need to identify a large number of individuals. The durability and colour stability of colour bands is dependent on the material used.

Whenever a shorebird is sighted (resident or migrant), it is important to look for bands or flags. Always try to get a good look at the bird's legs and record the following in addition to the bird species, location, time and date (it is important to record all of the below features in order for the banding authority to be able to identify the individual):

- Type of marking system: bands or flags - all birds should have at least a metal (appearing silver or grey) band.
- Colour of bands or flags including Red (R), Dark Blue (B), Dark Green (G), Light Green (Lg), Orange (O), Yellow (Y), Black (Bk), White (W), Mauve (M), etc. Be aware that colours may fade or become tinted, so a red might fade to appear pink and a white band may be tinged almost yellow.
- The leg (left or right) for each band.
- The order of bands and/or flags – always reading from the body to the foot – e.g. Red flag over metal band.
- The position of bands and/or flags: above or below the 'knee' (upper or lower leg known as tibia and tarsus respectively).

In recent years, there has been a gradual move to using engraved leg flags and therefore observers should be look out for any two or three digit alpha-numeric codes present on flags - these enable a bird to be identified as an individual. Almost all species are now fitted with engraved leg flags in north-west Australia and Queensland, but at present (June 2008) only Pied and Sooty Oystercatchers and Ruddy Turnstones (*Arenaria interpres*) in Victoria, South Australia and King Island.

The majority of Wader Studies Groups in Australia carry out regular flagging and banding of waders (see Appendix 17 for shorebird ID cards produced by World Wildlife Fund WWF Australia). The main wader banding activities are located in Victoria, the south-east part of South Australia and King Island Tasmania (VWSG: around 8,000 per year), north-

west Australia at Broome and 80 Mile Beach (AWSG/NWWSG: 4,000 – 5,000 per year), and Moreton Bay Queensland (QWSG: 1,000+ per year) (C. Minton pers. comm.). Migratory species are predominantly the object of banding activities, however all resident shorebirds captured are also marked. The flag combinations used at each Australian location are: orange (Vic), orange over yellow (SA), orange over blue (King Island), yellow (NWA), and dark green (QLD). Flags would normally be on the right leg, usually on the tibia. The metal band would usually be on the left tarsus. The conventions for flagging birds within the east Asian-Australasian Flyway followed by the AWSG can be downloaded at: www.awsg.org.au/pdfs/ColourFlaggingProtocol2001updated2007.pdf And an easy to use colour chart is downloadable from: www.shorebirdnetwork.org/leg-flags.html A colour identification chart used by Phillip Island Nature Park appears in Appendix 18.

In addition to the banding activities of the AWSG, some examples of smaller resident shorebird banding projects around Australia are:

- Hooded Plovers around Perth (Mike Bamford): Individual combinations of flags and/or colour bands are being used.
- Hooded Plovers on Phillip Island (Peter Dann and Roz Jessop) and other parts of the Victorian coast (Mike Weston): Various combinations of colour flags (Phillip Island) or bands may be used.
- Pied Oystercatcher chicks in northern New South Wales (Greg Clancy): engraved yellow leg flags.
- Red-capped plovers in Victoria (Mike Weston): engraved orange leg flags.

Pied Oystercatchers, front bird flagged yellow, engraved 4B, above the knee on left leg; metal on right. Photo: Dean Ingwersen.

Hooded Plover, green flag over red flag on right tarsus; red flag over metal band on left tarsus. Photo: Geoff Jones.

Monitoring reproductive success

For species that are long-lived, such as Oystercatchers, population counts are inappropriate for predicting future population trends and identifying threats to the species' persistence. Beach-nesting birds experience threats to their breeding success rather than adult survival, thus, it is important to monitor this breeding success. This can be a more difficult task than conducting a population census, but the data will be useful for establishing local management priorities. Breeding data is incredibly valuable for documenting the severity of the problems that beach-nesting birds face, and in identifying sites that regularly produce young and those that experience the most threat from human recreation and require urgent management attention. It is important we identify breeding sites and whether birds nest in regular places within the territory over time. If the latter is the case, it becomes easier to inform the public of the location of the sensitive areas on their local beach or estuary, and if possible, we can investigate permanent signage and fencing of these areas. Monitoring breeding success will also be an essential part of any management program that focuses on protecting nesting sites and improving breeding success.

Reproductive output / juvenile numbers

One way to monitor breeding success would be to conduct a population count at the end of the breeding season to determine the proportion of juveniles. For Hooded Plovers in their eastern range, a census conducted in Autumn (April or May) would be beneficial for estimating juvenile numbers from the season just passed. It must be noted that this type of census will not provide information on the locations where these juveniles came from, as post-fledging, juveniles are highly dispersive. Furthermore, because many beach-nesting birds become highly dispersive and flock at wintering sites once the breeding season ends, the count is likely to suffer from inaccuracies, as the likelihood of double counting or missing birds is increased. If juvenile survival is low, as it is for Hooded Plovers (55 % survival rate; Weston 2000), then interpreting the count data will be difficult as actual reproductive output is likely to be much lower. Some of these flaws can be overcome with careful planning and coordination of surveys (e.g. visiting beaches and wintering sites that include inland wetlands/lakes), and by creating a formula for interpreting count results that corrects for survival, the likelihood of detection in different habitats and the probability of double-counting.

Nesting success / fledgling production

The most common misconceptions that exist about monitoring nesting success of beach-nesting birds revolve around risk to the birds, for example: "*We don't want to disturb the birds as they suffer enough disturbance*", "*It is too risky to the birds and will result in more nest*

failures" and "*Approaching the nest will lead predators to the nest*". There are definite risks associated with monitoring threatened birds, which is why we have developed very strict guidelines for actively searching for nests and for monitoring nests and chicks. The guidelines which follow have been developed for Hooded Plovers, based on the extensive research of Dr Mike Weston into the mechanisms of disturbance to Hooded Plovers and experiences in the field. The 'Promoting coexistence between recreationists and beach-nesting birds' project monitored over 300 Hooded Plover nests using these guidelines and there was no evidence to suggest that monitored nests had an increased risk of failure, nor was predation a major cause of nest failure, or in any way related to the frequency of visits to the nest.

The following methods can be applied for other species of beach-nesting birds, however, minimum approach distances will vary, e.g. Oystercatchers can be far more sensitive to disturbance and can flush from hundreds of metres, while Red-capped Plovers can be more likely to actively defend the nest and flush from shorter distances, sometime just 4-5 m (M.A. Weston pers. comm.). Blumstein *et al.* (2005) revealed that larger species commonly have the greatest alert distances (that is, the distance at which an approaching person/predator is detected) and tended to move away from disturbances immediately compared to smaller species that were more likely to remain and become motionless, and this may relate to the greater conspicuousness of the larger birds to predators.

Hooded Plover adult with a brood of four chicks, Mornington Peninsula. Photo: Glenn Ehmke

Guidelines for monitoring nesting success of Hooded Plovers

What time of year should monitoring occur?

- Pairs will need to be monitored over the course of the breeding season: from the last week in August or first week of September, right through to March or even April.
- The birds may not show up on their territories until September (occasionally as late as November) and may disappear or flock as early as late January or early February. From late January onwards, once they begin to flock, visits for the season can end.

How frequently should monitoring occur?

- The first objective of monitoring nesting success will be determining when the pair begins to nest. The incubation period spans 28 days and so a visitation frequency of at least every 27 days is suggested. Ideally, a pair should be visited fortnightly to detect when they first show signs of nesting, especially considering that some nests can fail within a short period.
- Once a nest has been located, the next objective is to determine whether it hatches successfully. If the nest wasn't found during laying, then this date will be unknown and thus a visit at least weekly or even every 4 days would be ideal. Chicks commonly disappear within the first week after hatching, so the frequency of visits is often increased just prior to and after the predicted hatching date, so that we can determine whether the eggs actually hatch.
- After hatching, the chicks are flightless for 35 days. It is best to visit the chicks most frequently (every 3 days) during their first two weeks because mortality is much higher during this time, and then at least once a week until fledging. A final visit at 37 days is a good idea to ensure the chick reached flying age (and possibly to see it flying).
- Evidence of nest failure, such as the carcass of a dead chick or fox prints in the sand around a nest, disappears very quickly in a beach environment. Therefore, it is important that a nest with eggs or a pair with chicks be visited as often as every 2-5 days if causes of nest failure are of interest.
- If the interval between nest visits is kept frequent, then we can use a special formula (Mayfield's nesting success formula) based on this visitation rate to better estimate the probability of nest success – with infrequent visits we are likely to detect only the successful nests and to underestimate the true nesting effort of birds. The minimum number of visits that are useful for analysis are at least 3 during the egg phase (1. initial find, 2. visit, 3. hatching or failure) and a further 3 during the chick phase (1. hatching; 2. visit; 3. fledging). This equates to approximately 3 visits per month to a pair.

What is the best time of day for monitoring?

It is imperative that we do not compromise the safety of the eggs or chicks when monitoring nests.

- Avoid times of high-tide - for your own safety and to reduce the chance of crushing a nest when walking higher up on the beach.
- Avoid the hottest part of the day (mid-afternoon), particularly on hot days when the air temperature gets above 25ºC. Birds that are not nesting will often be resting during this period and will therefore be harder to spot. Birds that are nesting should not be disturbed during the hottest part of the day, as this increases the chances the eggs will overheat and fail to hatch. If the temperature is going to be high, visit the territory early

in the morning, or late in the evening (although if light is fading, please ensure the pair see you leave the territory before darkness falls).

What is the best weather for monitoring?

- Mild conditions, such as a still day or only a light breeze, and a temperature of 20-24ºC.
- Avoid cold days with high wind chill. If the birds are disturbed during very windy days, the nest can rapidly fill with sand.
- Avoid rain, and especially hail.

How long should a visit to the pair last?

- In order to reduce the risk of causing disturbance to nesting adults, visits to the pair should only last long enough to determine whether the pair are nesting, and even in the mildest of weather conditions, should not exceed 35 minutes once the birds are aware of your presence. Visits to the nest or brood should be much shorter – leave as soon as you have the information you need.
- If you have a spotting scope or a good view from a distance using binoculars, you may be able to observe the pair for longer, providing they are not disturbed by your presence, for example, adults continue to incubate eggs on the nest or chicks are observed foraging.

How should you search for Hooded Plovers?

- Walk slowly along the firm sand near the water's edge.
- As you go along, scan the water's edge and along the beach to the base of the dunes. It is best to take it slowly and scan the whole 90 degrees ahead of you as you go (not really useful to scan out to sea).
- By using binoculars, you are more likely to detect Hooded Plovers from a distance and to see their behaviour before it has been impacted by your presence. It is best to scan with the naked eye and then stop every so often and search ahead with binoculars.
- Don't be fooled – Hooded Plovers may be boldly marked but they can be very difficult to find. If the day is windy, they will often shelter behind or next to clumps of seaweed, flotsam or jetsam, or even sink down in depressions made by footprints, vehicle ruts or horse prints. When their white breast and stomach is hidden from view, they are very well camouflaged.
- It is also a good idea to look closely at the sand for Hooded Plover footprints -their prints are often a dead giveaway as to the location of the nest. When a dune face is particularly bare, it can be very easy to see lines of Hooded Plover prints leading from the beach up the face to a nest.

How do you recognise nesting?

Hooded Plovers (similar to most beach-nesting shorebirds) have distinctive behaviours that will be a giveaway to the presence of a nest or chicks. Below is a description of behaviours that you are likely to observe and what each of these indicate:

Diagnostic of nesting

- Distraction display: One or both birds perform a broken wing distraction display, typically feigning intense injury by crouching or lying on the ground, lowering or fanning the tail, calling, and flapping one or both wings – this is usually performed during the chick rather than egg phase. The bird might stay in the one place or hobble along the ground dragging its wing and raising and flapping the other wing.
- Incubating/shuffling: The adult has been observed incubating on the nest, or settling onto a nest to incubate. The settling behaviour of an incubating bird is distinctive from a bird that sits on the sand to rest or sun itself. The adult will shuffle and wriggle from side to side as it settles on eggs.
- Brooding: The bird has been observed sitting all puffed out on the sand, presumably huddled over chicks, brooding them. Watch carefully to see if chicks emerge from under the parent. When an adult goes to brood chicks, it will approach them and peck gently at the ground in front of the chicks.

Indicative of nesting

- Leading: One or both birds run ahead of you and try to lead you out of their territory. This is generally along the beach parallel to the water's edge and involves both birds. They keep their tail and head down, and will pause if you pause, and wait for you to catch up and follow. Occasionally they will stop to false-brood (see below) or peck at the sand to pretend they are foraging, but they remain very aware of you, and continue moving ahead of you.
- False-brooding: if you are near to a nest, the adult might run over and falsely crouch or sit on the sand, pretending it is on the nest.
- Vigilance: One or both birds are spending most of their time being vigilant and not feeding, and this might include them calling. This behaviour is typical of adults with chicks.
- Bowing/head-bobbing: a bird will run rapidly over to the nest and bob its head at its partner, when it is time to change over at incubating the eggs. The departing bird will often remove or rearrange nest material and will quietly leave the nest. Head-bobbing also occurs when a nesting adult is alarmed.
- You might only sight one of the pair, and therefore the other might be on a nest.

Where is the nest likely to be located?

- A nest can be located anywhere above the high-tide mark - on the beach, at the base of the foredune, on the slope of the foredune or dune, or in a dune blowout - and can occur up to ~600m inland from the water. Occasionally, pairs may nest on pebbles or rocky outcrops. Below is a selection of photographs of Hooded Plover nest locations.
- Pairs prefer open areas where they have a wide field of view, usually away from vegetation.
- Some pairs have a tendency to situate their nest near a stick or driftwood, and to line the nest with shells.
- Nests often occur on a slightly more elevated section of ground on the beach, such as that which occurs on the leeward side of seaweed.
- Nests that occur on steep dune faces are often situated on small ledges stabilised by sticks, tree roots or low growing vegetation.
- Pairs generally re-nest near previous nesting sites, and specific pairs might be more likely to be beach-nesters than dune-nesters, or vice versa. Local knowledge of previous nest sites is invaluable information to have and this is known for many areas within Victoria - contact Birds Australia.

Hooded Plover nest scrape locations. Photos: Grainne Maguire.

Who should search for nests/chicks?

- You should only search for the nest if you have previous experience at finding nests or if you have been trained at locating nests. Without proper training or experience, the risks of crushing the eggs or chicks, leading a predator to the nest, or disturbing the adults are extremely high.
- If you suspect the pair have a nest, you should direct the information to the land manager or arrange for an experienced person to locate the nest.
- Guidelines for searching for nests occur on page 177-179.

How do I monitor the progress of a nest? (see figure2, p. 174)

- Once the nest has been located by a trained person, and the location has been shown to you, regular visits need to be made to track the progress of this nesting attempt. If you are not a land manager, you will need to wear a volunteer identification badge when visiting a nesting site so that the public can recognise that you have specific training for this monitoring.
- Adults will usually leave the nest when a person is within 50-100m of the nest, but this can vary between pairs – some are more adapted to people than others. You will learn to recognise the sensitivity of the pair/s you monitor.
- **Always keep in mind that the nest might have already hatched before you arrive** and so you should **never confidently stride towards the nest** assuming to find eggs. The first task should always be to locate the adult birds. If you see them and they are not sitting on the nest, the nest has either failed or hatched. If they are very relaxed and do not lead or show distraction behaviours, you might assume that failure has been the more likely outcome.
- If you suspect chicks are present, it is best to walk past the adults and turn back and look through binoculars to see if any hidden chicks emerge; you might only see them when you walk past again when leaving the area. You may have to wait 10 minutes or more from a distance before chicks emerge from hiding.
- The best way to check a nest is from a distance of 15-50m using binoculars or a spotting scope. The precise distance can vary depending on your view of the nest and the reaction distance of the birds. It can be better to go closer (up to 15-20m) for a brief period to get a good view, than to spend a long time trying to observe the nest from 50m (which is still potentially disruptive).
- Please **ensure that there are no predators** (e.g. ravens, magpies, gulls or birds of prey) **in the area** when you approach the nest – you do not want to lead them to the nest. Also, check that other people are not watching – they may follow you out of curiosity.
- When visiting a pair that has a known nest, you are simply trying to attain whether the nest still has eggs. If you can see the adult sitting on the nest, then you can leave under the assumption that it is still incubating eggs. If the adult is off the nest, you can either

walk away and once you are at a distance, turn to see whether a bird returns, or you may want to approach the nest and check to see if the eggs are still present and intact.

- Do not approach nests that are situated on steep dune faces, you may destabilise the dune and cause the collapse of the nest site, or you may create a conspicuous trail of footprints to the nest that a predator can follow or that will attract the curiosity of people. You must ask yourself whether it is that important to record clutch size, and if you think the nest has failed, you may have to confirm this over several visits during which no bird is seen on the nest, or by climbing up a nearby section of dune and looking with binoculars into the nest.
- If the birds are nowhere in sight when you arrive, you might want to have a closer look to see if the eggs have hatched or the nest has failed. Sometimes the parents are absent because they are fighting with the neighbours or seeing a predator off – their absence does not necessarily mean breeding has failed. You should only have to approach to within 5-10m of the nest, it is best not to leave a trail of footprints any closer. **Move slowly and check for eggs that might have rolled out of the nest, or for chicks, when you take each step.** Young chicks often crouch on the sand or amongst seaweed on the beach and are almost impossible to spot.
- Only spend a few minutes in the immediate vicinity of the nest.
- If it appears the nest has failed and you are reluctant to approach, it may be best to come back later that day or the following day to confirm this. If the nest has failed, the pair will attempt to re-nest – though not in the same nest scrape: they will usually only re-use a nest scrape if it has successfully hatched in the past. Pairs can nest again and again following failures, sometimes up to seven times a season, until they are either successful or the breeding season ends.
- Once the nest has been checked, walk away from the nest along the open beach in full view of the adults, so that they know that the disturbance has ceased.
- **When you expect to see chicks on a territory**, it is best to enter the territory cautiously. Chicks are highly mobile, and can move up to 2km from the nesting site with their parents. Remember that the parents don't feed their young, but the chicks need to forage on the beach and because they cannot fly, this makes them very vulnerable. You won't be able to predict where the chicks will be, so it is best to be very careful and to walk slowly along the water's edge, looking through your binoculars for the adult birds. The adults will generally be close to their chicks. The best way to sight chicks is from a distance, before the adults alert them to danger and they either crouch on the spot, or run up the beach to cover.
- If you don't see chicks, this either means they are hidden or have died prior to your visit. Walk slowly towards the parents along the water's edge and see whether they are acting protectively. Continue past and then turn back to see whether any chicks emerge from hiding. You might want to sit at a distance that is not disruptive and wait for the

chicks to emerge. Do not spend more than 35 minutes in the area. You may need to visit the site at another date to see whether the chicks have truly disappeared.

- If you do see chicks, it is best never to approach them as you run the risk of accidentally stepping on them.

How do I locate the nest again on my next visit?

- It is best to keep the location of the actual nest scrape as inconspicuous as possible, to avoid curiosity from predators and beach goers. Fencing and signage occurs at a large radius around the area and will not make nests conspicuous.
- Perhaps establish a small wooden stake or piece of driftwood in the sand at least 10m from the nest or tie a ribbon to a nearby shrub/grass tuft, as a marker by which you can carry out regular nest checks using binoculars or a spotting scope. Ensure that anything tied to the wood or shrub to make it visible will not flap in the wind. Count the number of paces to the nest upon first locating it, and take note of the landmarks around it (e.g. vegetation, clumps of seaweed), so that you can remember its position. Write down this information and make a sketch (or take a photo) of the nest in relation to landmarks.
- If the nest is successful, then the presence of an incubating bird and Hooded Plover footprints should enable you to locate the nest on most visits.

Risks to the birds and guidelines for avoiding/minimising these:

- There is a risk that you might accidentally **crush** eggs or chicks. To avoid this, keep to the hard sand, near the water's edge, when moving through the territory. If you leave the water's edge to search for or check a nest, **move slowly** and take care with **every step** you take. **Look at each bit of sand before taking a step!**
- If you suspect the pair has a nest and you have no experience or training in finding nests, please **do not take unnecessary risks**. A lack of information is preferable to causing harm to the birds. Search the list of contacts and report your suspicions.
- Please **do not touch or move eggs or chicks** if you happen across them.
- There is a risk that you might **lead a predator or curious person to a nest**. Do not approach a nest if there are predators (e.g. ravens or gulls) or people in the area.
- You may **indirectly disturb the adults** from incubating or brooding, **or chicks** from feeding. The adults will go out of their way to pretend that they do not have a nest, and therefore you might be convinced you are doing no harm. Please only spend short periods of time (maximum 35 minutes) in the vicinity of the adults and/or nest.
- It is **not recommended that you take your dog with you**, especially due to the risks involved when there are eggs or chicks on a territory. If you are going to take your dog on a lead with you, you should not leave the water's edge.

Broken wing distraction displays. Photos Mike Weston, Glenn Ehmke

Incubating shuffle. Glenn Ehmke.

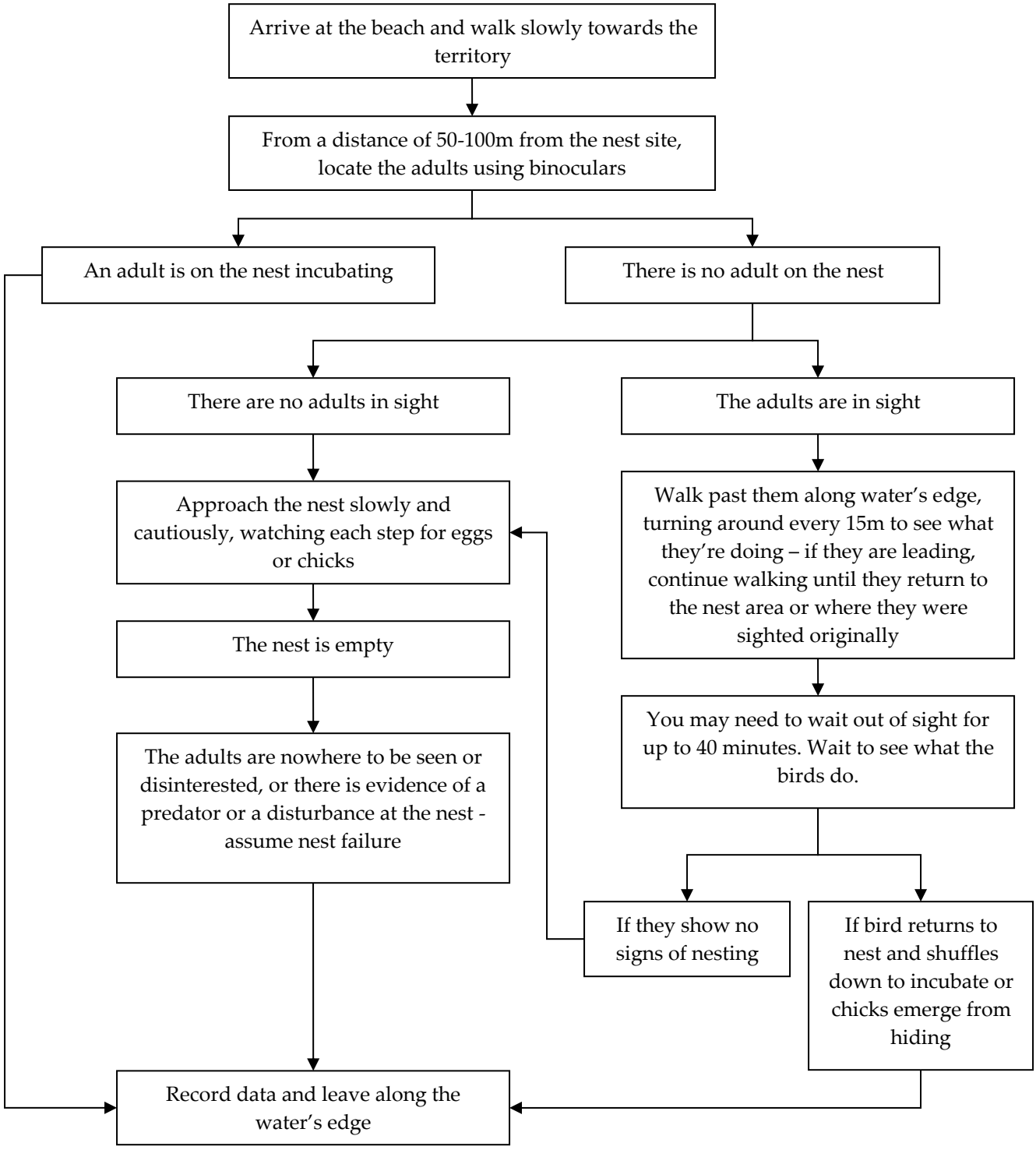
Incubating shuffle. Photos: Glenn Ehmke.

Brooding. Photos: Glenn Ehmke.

Leading. Photo: Ian Sutherland.

Hooded Plover chick hiding next to cuttle fish; Hooded Plover chick hidden in rock crevice; Hooded Plover chick crouching on the beach. Photos: Glenn Ehmke.

Figure 2. Guidelines for checking on pairs that are known to have a nest.



How do I record information?

- Examples of data sheets and instructions for filling these out can be found in Appendix 19.
- As a minimum, record the date, number of adults sighted (and band/flag details if applicable), whether adults were nesting or exhibit behaviour indicative of a nest/chicks, whether eggs or chicks were present and how many, location of the nest and if a nest has failed, whether there is evidence of what caused this failure.
- It is useful to record some additional information that can help with evaluating the success of managements – such as the number of people, unleashed dogs, horses, vehicles present, and whether there is evidence of foxes. If there is fencing, it is useful to note whether there are footprints or dog prints within the fenced area.
- Finally, if you have a positive or negative experience with a beach user that you speak to, it is good to keep a record of this for the purposes of social research. Furthermore, to keep record of any problems observed regarding managements in place.

How do I report information?

- It is important to report sightings of nests or chicks to the land manager or to the group or organisation that is running a monitoring project. If you find a nest in a vulnerable area, your report may lead to protective management that can help improve the likelihood of chicks hatching and surviving.

Coordinating the monitoring effort

Monitoring nesting success can require considerable effort. However, there are numerous ways to make this task easier including:

- Incorporating monitoring into another activity: for example, land managers can check on a nest during patrols or site maintenance/upkeep visits, and volunteers or coastal residents during their daily walk or a regular social outing (volunteers).
- Trained volunteers assisting land managers with monitoring.
- Groups of volunteers sharing the monitoring of single pairs.
- A community group or special interest group conducting all monitoring and reporting to the land manager.
- If your area has a large number of pairs, you may wish to select some for regular monitoring (e.g. those most threatened, which are likely to experience frequent nest failures) and others for occasional visits (e.g. those least threatened, which are likely to be successful and hence a monthly visit is likely to detect nesting).

Training Volunteers

Volunteers should be provided with an information pack containing detailed guidelines on monitoring, but often this is not nearly as valuable as actually visiting the site and experiencing the environment and the behaviour of the birds firsthand. The most efficient way to train volunteers is to run a workshop with a presentation containing lots of photos and examples, to actively go through the instructional manual and answer questions and if possible, to finish with a walk along the beach. See page 184 for more details.
Organisations like Birds Australia may be able to help with the workshop.

Monitoring threats

Records of breeding success can be difficult to interpret without knowledge of the threats the pair experience while breeding and the effectiveness of managements aimed at reducing or eliminating these threats. The most important threats to record are:

- The number of people, dogs (distinguishing between leashed and unleashed), horses and vehicles within a 100 m radius of the nest site. This is likely to vary with season, time of day and weather.
- Evidence of horse prints above the high-tide mark, foxes (prints or scats) or vehicle tracks.
- If there is fencing, whether there are footprints or dog prints within the fenced area.
- If the nest fails, evidence around the nest including prints, tracks, egg shells, or evidence of a high tide.
- It may be useful to note large flocks of gulls, ravens or magpies, frequent sightings of magpies/ravens foraging above the high-tide mark in the area or the presence of raptors.

If surveying a population for the purpose of choosing sites on which to concentrate management actions, it is best to record additional information, including:

- Distance from an access point: the easier a site is to access, the more threats it will receive
- Number of formal and informal beach access points
- Presence of stock or cats on beaches and dunes – rare in Victoria on beaches, but likely to be an issue elsewhere, such as on King Island
- State of the dunes – whether they are heavily vegetated by Marram Grass (unsuitable), whether they have been laid with brush (unsuitable), or whether there are open blowouts or sparse native vegetation such as Spinifex grass (suitable)
- Presence of natural chick shelter: driftwood, flotsam/jetsam, spinifex overhanging dune base, dunes not too steep to run up

- Any existing managements in place – are these consistent at nearest access points, are signed regulations consistent, is it clear what regulations are present at the site; see Appendix 16.

Guidelines for searching for nests

Guidelines for locating nests are similar to the guidelines for pair monitoring and checking on a nest. Figure 3 outlines the key points for minimising risks of crushing and disturbance during nest searching.

The presence of the bird at the nest is the best cue to use for locating the scrape and it is best to use the distance from natural landmarks (e.g. high-tide mark or base of dune, notable dune vegetation, cuttlefish, driftwood or flotsam/jestsam on the beach, etc) to remember where the bird was sitting as you approach. As you near the area where the bird was sitting, the bird's tracks will become very evident in the sand (unless it is a very windy day) and these should lead to the nest, with lots of paths radiating from the scrape. Figure 4 goes into detail about how to look for the nest.

Figure 3. Key points to remember during each stage of nest searching.

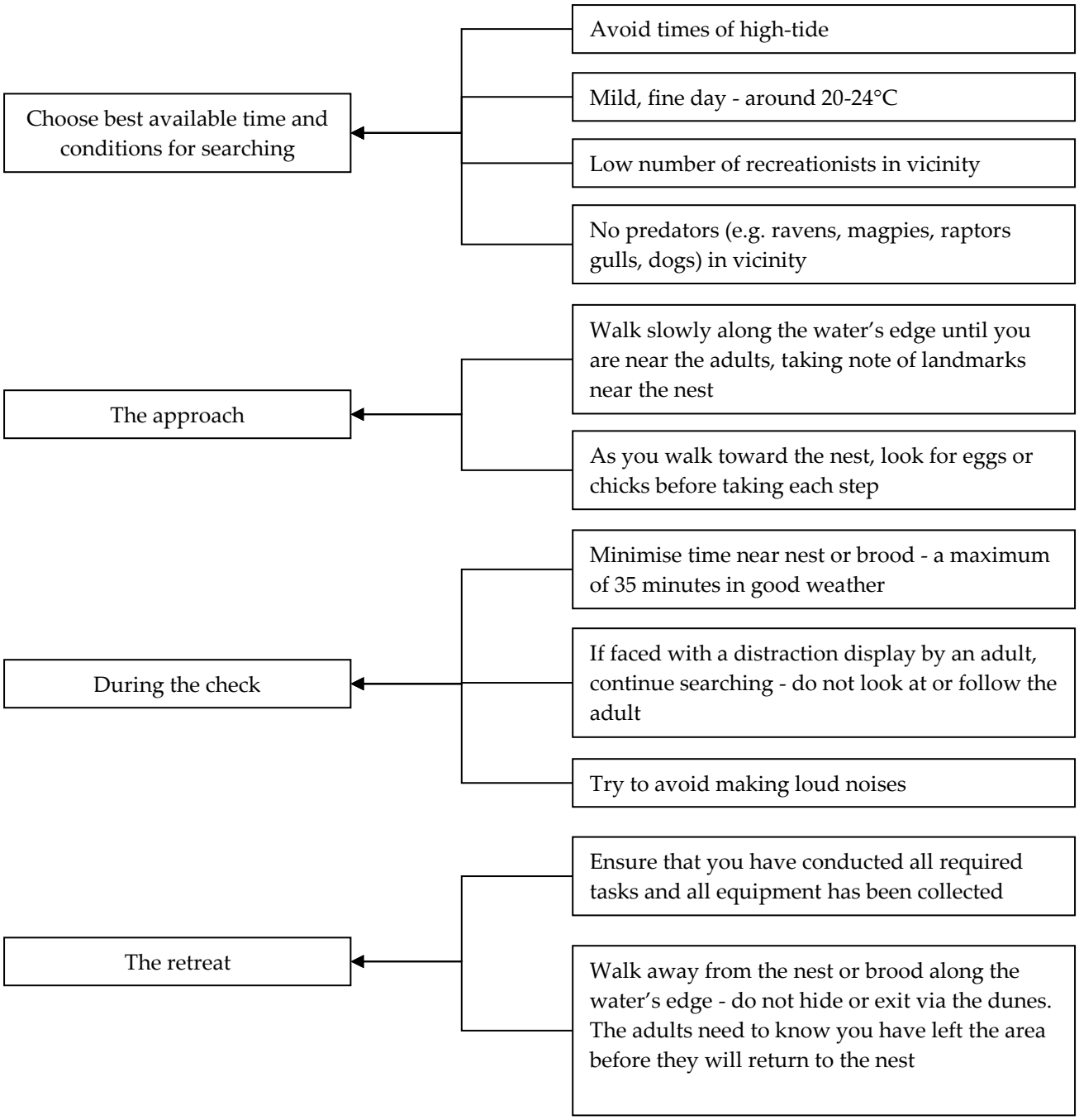
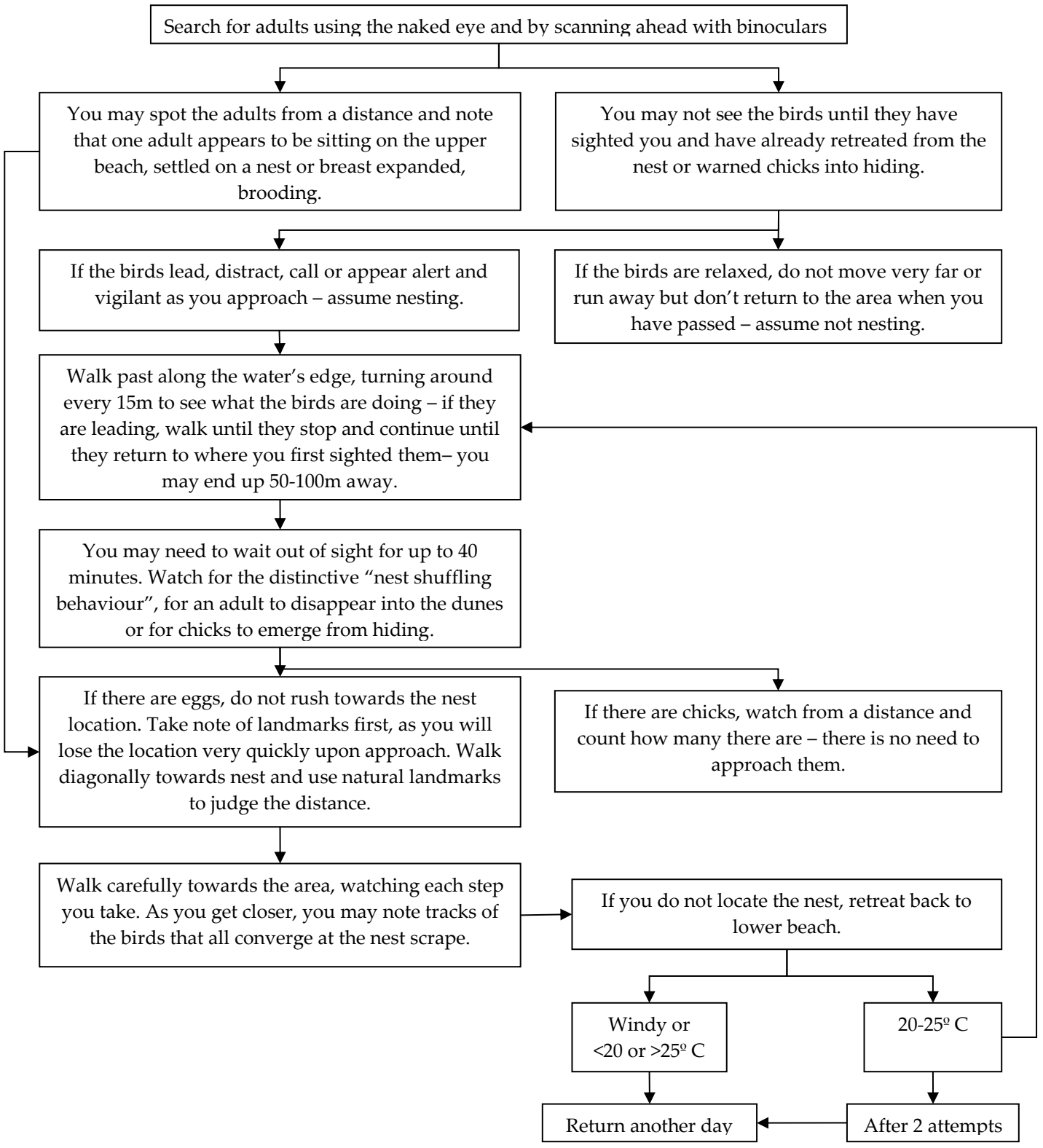


Figure 4. Guidelines for locating nests or chicks to minimise disruption and risk of abandonment or crushing.





Chapter 5. Engaging communities in conservation management

The success of conservation efforts for beach-nesting birds will rest largely on the attitudes of the local community and on the potential for social change to occur. Conservation management can be improved by involving the community directly and building the capacity of communities to actively participate. Chamala and Mortiss (1990) noted that four conditions are necessary for community-based conservation or resource management initiatives (or indeed, for any change action) to succeed:

- **A pressure for change**: the local community must feel a genuine need to improve or change the existing situation. Without this, the community might feel management efforts are of low priority and therefore will not support or may even resist conservation efforts.
- **A shared vision**: social barriers, such as economic or social status, can lead to reduced social cohesion within communities and stand in the way of effective communication and management of conservation efforts. In order to jointly tackle an issue, members of the community need to overcome these barriers and work together towards a common goal. This will take time and will require a facilitator to guide community forums and assist with structuring realistic goals.
- **Capacity for change**: the goal of conservation management should be realistic and able to be changed at the community level, that is, should be at a local scale and not rely on changes to government policy for example.
- **Actionable first steps**: the community should identify a relevant, non-threatening issue which affects everybody, can be tackled locally, in which most people can participate, and which has a high chance of being resolved through community action.

Fitzgerald (1999) outlined key positive and negative features of a community that were likely to contribute to the success of community-based conservation initiatives: these have been slightly modified for application to beach-nesting bird conservation initiatives:

Positives

- An historical sense of community identity based on a long-term connection and familiarity with the land and its problems;
- Reasonable homogeneity in the type of land use;
- A commonly expressed attachment to the local lifestyle and environment;
- Strong networks of social relations and friendship, especially among women;
- A relatively stable population;
- A history of positive experiences of working together on issues and of people willing to champion issues and causes;
- A wide recognition of the need for the community to be re-energised;
- A generally shared view that there is a need for a more broadly representative and participatory forum for the community;
- A shared perception of the key environmental problems facing the area or species;
- The invitation from community representatives for researchers to work with the community, and;
- An almost universal willingness to at least attempt a community-based approach to considering local issues, facilitated initially by the researchers.

Negatives:

- A relatively strong sense of class and social division within the community;
- The marginalisation and non-involvement of certain residents in the community;
- Underlying, unresolved social tensions, some based on short-term issues, others on longer-term divisions;
- Some scepticism about the proposal to initiate a community-based approach to dealing with issues;
- A lack of familiarity with participatory approaches to meetings and decision making;
- A general low level of community energy;
- Disengagement of individuals that may feel uncomfortable with working in groups; and
- The potential for conflict over certain management issues.

Fitzgerald (1999) outlines the key steps that a facilitator of community-led conservation projects should adopt:

- Learn about and profile the community through social research: opinion polls, interviews, and population statistics, which can either be gathered from existing agency databases or collected specifically for the project.
- Identify and involve key people: facilitate the relationship between managers and communities, involve representatives of all key stakeholder groups, and develop a

group of actively interested participants that feel comfortable working with one another.

- Remain neutral, learn and transfer skills: it may be necessary for management agencies to work through a facilitator in order to build community trust and to mediate potential conflicts (see role of a state coordinator or facilitator below), and to engage a facilitator with the skills and expertise suited to the conservation issue.
- Be flexible and responsive: when communities become actively involved in conservation initiatives, they need to be given some level of control over the project. Managers need to be responsive to their ideas and flexible in the direction management will take. However, this flexibility can only be within the range of conservation priorities for the species and when there are specific guidelines for conservation management that have been developed by experts, these need to be followed.
- Use a flexible methodology and creative techniques: people learn and communicate in different ways, and thus a diversity of communication techniques should be employed to encourage everyone to be involved.
- Accept the challenges and rewards of community-based conservation: it can be a challenge for agencies to maintain effective, lasting, working relationships with community members, and to step outside of the normal practice of being wholly responsible for management. The rewards, however, can be profound and long-lasting.

Volunteer Management[1]

The Value of Volunteers

Volunteers for beach-nesting birds provide assistance with conservation efforts that could not be carried out wholly by the agencies and organisations charged with this responsibility. Most agencies or organisations have limited resources and funds, thus restricting the types and range of on-ground works and monitoring, and number of pairs that can be logistically/feasibly managed.

Volunteers provide land managers and agencies with valuable insight into community attitudes towards management, broadening their perspective of possible management strategies beyond institutional norms. While managers provide support and motivation to volunteers, the reverse is also true. It can be comforting for managers, who sometimes are faced with public contention, to have this support.

[1] The detailed 'volunteer program' of the Snowy Plover Recovery Team was heavily drawn upon when compiling this section (U.S. Fish and Wildlife Service 2007), as were the experiences of volunteer coordinators from around Australia.

Volunteering provides members of the local community the opportunity to become actively involved with beach-nesting bird management, thus enabling a sense of local ownership of the project to develop. This in turn helps increase public support for species protection measures and helps the public to better understand coastal management issues and decisions.

Volunteers can be involved on a temporary basis (for just one season or project) or make a long-term commitment. A long term commitment ensures greater consistency in monitoring and data collection, and for expertise to develop, reducing the effort managers need to expend each season in the training of new volunteers.

Appendix 20 provides insight into the perceptions that managers and volunteers involved in beach-nesting bird conservation have about the roles each should have and the best models for a good working relationship.

Volunteer management requirements

The costs and benefits of a volunteer program should be carefully weighed to determine whether this will be a worthwhile avenue. Volunteer management can place unexpected demands on staff and impact program funding. There must be time and resources available for:

Recruiting participants

- Interested participants are likely to be found within a range of pre-existing groups, such as: Field Naturalist groups, Friends groups, Bird Observers Clubs, Birds Australia members, Threatened Species Network members, and Coastcare or Landcare groups. Contacting these groups, sending an advertisement through their email networks or arranging to give a talk to members at one of their regular meetings can be a good way of recruiting new participants. At meetings, a presentation introducing the species, conservation issues, threats and managements should be made, using photos and examples. This should be followed by a focus on local areas where surveying or monitoring of breeding will occur, and opportunities for volunteers.
- Coastal communities are likely to have many interested individuals, and articles in local newspapers introducing the project, the plight of beach-nesting birds and the need for volunteers, can elicit strong responses.
- University students can be reached via posters on noticeboards in relevant departments (such as Zoology, Botany, Environmental Studies) or email alerts.
- Advertising for volunteers should also focus on websites, newsletters and other media that will target people with an interest in the coast, conservation or wildlife.

Registering volunteers

- Project managers are not required to accept all who volunteer their services.
- People under the age of 18 may need to provide acceptable parental or guardian consent.
- Background checks are only necessary for duties that involve supervising or having exclusive control over minor children when no other adult supervision is present.
- Volunteers need to reveal any medical conditions that could impact their involvement in the project. If the volunteer has indicated a medical condition, activities should be tailored to their physical abilities.
- Volunteers should register with the participating agency. This may simply be a matter of filling out a registration form, but could involve an induction and/or signing a disclaimer to meet with OH&S standards and insurance requirements.
- All personal information collected from volunteers or volunteer applicants must be kept confidential.
- Volunteers have rights and responsibilities similar to employees and these can be sourced from: www.volunteeringaustralia.org/

Training participants

- Training can take considerable time and effort, and is therefore best limited to one or two training sessions a year, for example prior to a survey, or prior to the breeding season and again once the breeding season is at its peak.
- It can be useful to run training workshops located according to where the most volunteers occur. At these workshops, a presentation introducing the species, conservation issues, threats and managements should be followed by step by step explanations of volunteer activities and the procedures that need to be followed to minimise risks to the birds. Volunteer registration forms can be distributed along with information packs that contain guidelines for monitoring/surveying, data sheets, maps, species identification sheets, and volunteer identification badges. A workshop is best followed by an interpretive walk along the beach or wetland, where aspects of the birds' biology, habitat and threats can be pointed out, volunteers can ask questions and there can be a practice run filling out data sheets.
- It can be valuable to run refresher courses for pair monitoring at the peak of the breeding season, so that examples of threats, management and the birds' behaviour can be experienced.
- Training workshops can also be held for staff or volunteers who are likely to participate in on-ground management activities, such as fencing and signing nest sites. These are best carried out either using presentations with photos and diagrams to help explain the layout of fencing and signage, or through a field visit during which a fence and signs are set up around a fake nest site.

Risk Management

To reduce the risk of accidents and injuries, managers should:

- provide adequate training, initially and ongoing if necessary;
- ensure they have an insurance policy that covers volunteers;
- give proper supervision where applicable, and;
- not assign volunteers to work which they have not agreed to perform or do not feel comfortable completing.

Personal safety issues should be addressed through compiling risk assessments of field activities (checklists of possible risks, exposure to risks and opportunities for ameliorating risks). A fieldwork risk assessment checklist may include an assessment and exposure to risks associated with, for example:

- Location: e.g. isolated locations may require a volunteer to be accompanied by at least one other person or for volunteers to be in mobile phone contact with the volunteer coordinator or local land management agency.
- Travel arrangements: for surveys conducted by boat or quad bike, considerable safety precautions will need to be taken.
- Security: beaches sometimes attract undesirable persons and thus it is recommended, especially for isolated beaches, that volunteers be accompanied by another person.
- First aid: in particular, for heat exhaustion, snake bite, dehydration, etc…
- Communication: volunteers should always inform somebody of intended visits to the coast/wetlands, and if visiting areas without mobile phone coverage, have access to a satellite phone or an Emergency Position-Indicating Radio Beacon (EPIRB).
- Biological hazards: relevant to weed control, the use of herbicides and exposure to dead animals.
- Tide conditions: if beach access is tide dependent, volunteers must be aware of the times of high tide and plan their visits for low tide.

All accidents, injuries and near misses should be reported immediately to the volunteer manager, thoroughly investigated, documented and analysed to determine what factors, conditions, or practices contributed to the incidents, so that action can be taken to prevent reoccurrence. Information recorded in the event of an accident may include:

- the type of incident (e.g. injury/illness, near miss, security breach, property damage, fire or violence/aggression);
- incident details (e.g. date, time, location and description);
- details of the person reporting the incident and who it was reported to;
- details of the person injured or ill;
- the outcome or treatment following the incident or injury, and;
- controls taken to prevent an injury or control the hazard.

Coordinating volunteers

- It is necessary to coordinate volunteers and to provide them with direction throughout the course of a project.
- Volunteers need to be given clear instructions about their task, maps of the task's location to avoid possible overlap or confusion, data sheets to ensure consistency in recording data, and guidelines that specify the frequency and duration of tasks, which have been determined with respect to minimising risks to beach-nesting birds.
- If several volunteers are participating at the same location, it can be useful to coordinate their activities.

Leadership, supervision and communication

- For many aspects of beach-nesting bird conservation, supervision will not be required. However, activities involving minors, activities that have potential OH&S risks (e.g. weed removal) or activities that are invasive (e.g. banding/flagging birds) will require a supervisor.
- It is important to provide leadership to volunteers so that direction, focus and consistency can be maintained. Volunteers need to be provided with a clear set of goals and feedback (Weston *et al.* 2003).
- Communicating with volunteers is essential to keeping them motivated, focused and committed. When there are large numbers of volunteers to manage, the most efficient means of communication are regular group email updates throughout the breeding season, and distribution of an end of season report. An end of season gathering is also beneficial to go over the season's highs and lows, evaluate changes that need to be made to improve conservation actions, and to thank the volunteers for their involvement.

Motivation, Recognition and Rewards

Motivating volunteers to regularly participate, to remain with the project, and to return year after year can be a challenge. Volunteers will generally stay with the project if they feel that it has worthwhile goals, that they are instrumental in helping the project reach those goals, that the project leadership is effective and if they are enjoying the experience. If volunteers are to return to a project, they must remember their experience positively.

Volunteers should feel comfortable discussing their work or expressing their concerns. Constructive feedback that flows both ways between volunteers and managers is essential. It can also be useful to provide variety to volunteers, such as involving them in other related projects or increasing their responsibility.

Special recognition and rewards can be useful tools to help increase volunteer consistency and retention. It is always important to acknowledge, both to the volunteers and to other staff, that volunteers are providing an important and valuable service. Volunteers can be invited to return in the future to see the changes they have helped bring about. Some programs have used specially designed T-shirts, hats, badges or patches that can be given after a specified amount of volunteer work is done as a form of recognition and reward, and also to signal their belonging to the project. Providing snacks or drinks to volunteers, taking them to lunch, or organising a volunteer get-together barbeque or morning tea can be another form of recognition. Stories in a newsletter or local newspaper highlighting the volunteers' efforts and the impact they have on conservation of beach-nesting birds can be both recognition and an effective recruiting tool. Photos of volunteers participating in projects should be taken so they can be used in publicity. Certificates and plaques are even awarded in some programs when a volunteer puts in a designated number of hours.

The role of a regional coordinator/facilitator

The dispersed nature of beach-nesting birds means that they will occur across multiple land tenures and involve multiple management agencies and volunteer groups. A regional or statewide project coordinator or facilitator's role can therefore be fundamental to:

- Maintaining and facilitating effective communication between the agencies and volunteers involved;
- Initiating and supporting manager involvement;
- Recruiting and coordinating volunteers;
- Responding to enquiries that require detailed knowledge of the species;
- Training managers and volunteers to ensure a safe, effective and responsive monitoring and management effort;
- Coordinating statewide population surveys;
- Maintaining consistency in the way data is collected, stored and reported, and keeping this in a centralised, accessible database;
- Providing an information referral service;
- Maintaining consistency in educational and interpretive materials;
- Applying for funds for multi-regional projects;
- Working on policy changes through submissions or liaison with regional, state or federal agencies and policy makers;
- Seeking advice from experts and making this available to managers to ensure safe and effective management;
- Coordinating and communicating research, and;

- Enabling a broad and balanced perspective of the threats that impact the population as a whole, their management and of conservation objectives that ensure long-term population viability. The facilitator will be able to recognise common threads in species management and recovery across the board, but will also be able to recognise problems unique to a given area, and help advise the management adaptations required.

Hooded Plover chicks (4 weeks old). Photo: Glenn Ehmke.

Information for Volunteers

This section is for individuals, groups or communities interested in assisting with conservation of beach-nesting birds. This section covers:

- Opportunities for involvement; including skills, training and time commitment requirements
- Communication and record keeping
- Sharing the load – forming groups and working with managers
- Funding opportunities

Why Volunteer?

Volunteers are people who give freely of their time and effort to support a cause they believe in (in this case, the protection of a highly vulnerable species or suite of birds). People may volunteer for many reasons, for example:

- An interest in wildlife, birding and/or a specific bird species
- An interest in coasts and beaches
- Pride for local environmental values
- To learn more about wildlife and habitat protection
- To share in the hands-on responsibilities of wildlife managers
- To make a difference to conservation
- To spend more time outdoors

- To meet new people
- To participate in something that is purposeful and worthwhile
- For students or recent graduates, volunteering can provide the opportunity to gain practical work experience, get future job references, add to their curriculum vitae, make contacts in the field or formalise their participation as an internship.

Volunteer Opportunities

There are numerous ways that volunteers can become involved with beach-nesting bird conservation. These will vary in the time, commitment, skills and training required of volunteers. Below a series of volunteer opportunities are presented:

Population counts

Description: surveying a beach, section of coast, lake or wetland for a focal species, with an aim to count all individuals present.

Skills: good eyesight, at least moderate fitness, observational skills, concentration and attention to detail (to avoid double-counting or overlooking birds, and for band identification), basic record keeping skills.

Training needed: finding and identifying the target species, distinguishing the target species from similar species, distinguishing juveniles from adults and males from females (if applicable), basic knowledge of the species' behaviour and biology, interpreting and filling in data sheets, and minimising risks to the target species and environment.

Timing and commitment: depends on the surveying frequency, which might be biennial (every two years), annual, biannual (twice yearly, e.g. breeding and non-breeding season), seasonal (spring, summer, autumn, winter) or monthly. For data to be consistently collected through time, a long-term commitment to population counts is desirable. It is possible to take part in a count as a one-off or irregularly, but in order for the integrity of the survey data to be maintained, new volunteers should be accompanied by a regular participant.

Pair monitoring during the breeding season

Description: visiting a specific pair/s during the breeding season to detect nesting, locate nests and follow the progress of nesting attempts, including monitoring chicks and threats.

Skills: observational skills, patience, concentration and attention to detail (to detect fine differences in behaviour), compliance with instructions, cautiousness, record keeping skills.

Training needed: identifying nesting behaviour, locating nests or chicks, recognising threats to nesting birds, distinguishing causes of nest failure (e.g. recognising prints around nest), strong knowledge of the species behaviour and biology, interpreting and filling in data sheets, and minimising risks to the focal species and environment.

Timing and commitment: volunteers should commit to at least 4 months of a breeding season to gain the necessary experience and become familiar with the pair/s they are monitoring. Furthermore, a nesting attempt should ideally be followed through by the same volunteer for consistency. Overall, a minimum of 3 visits per month should be made to a pair; if there are multiple volunteers sharing this monitoring, the commitment required from each individual is greatly reduced. Because many shorebirds breed multiple times during a lengthy breeding season, this task may involve frequent checks over many months of the year. It is preferable that volunteers live close to the pair they monitor, because monitoring effort will need to be frequent (even so much as on a daily basis) during certain phases (pre- and post- hatching) in order to be most effective.

Research

Description: there may be opportunities to become involved in research or observational studies that help further our knowledge of beach-nesting bird biology, threats and/or management. Examples include making detailed observations of chick shelter use, interviewing beach users for social research, or monitoring visitor compliance with regulations. Such research is generally in association with a non-government organisation or a university.

Skills: variable, but usually observational skills, patience, concentration and attention to detail, record keeping skills.

Training needed: dependent on the project specifications.

Timing and commitment: dependent on the project specifications, but usually short-term.

Education and Interpretation – passive involvement

Description: this can take many forms, including helping to design signage, updating nest progress notices, writing media releases, distributing interpretive/educational materials through letterbox drops or distribution to local businesses, or if you own a local business, displaying brochures or setting up a temporary interpretive display. If you are artistic, you might be able to supply artwork or photographic images for use in educational material.

Skills: general interest, but can include artistic and written communication skills.

Training needed: advice on content of signs, interpretive displays or media releases.

Timing and commitment: variable, from once-off to every year.

Education and Interpretation – active involvement

Description: this can take many forms, including wardening of nest sites (two-fold task of advising people of rules for protecting birds and providing information of interest), staffing an information stand, e.g. at a beach access point or festival, or participating in school talks.

Skills: strong verbal communication skills, interpersonal skills, even temper, diplomacy, confidence, integrity.

Training needed: strong knowledge of species biology, behaviour, threats and management, conflict resolution and effective communication.

Timing and commitment: variable; wardening takes place when there is an active nest and usually after hatching. Volunteers need to have experience or a commitment to the project to gain the knowledge required for answering the range of questions the public may ask. This role can be challenging at times.

On-ground management actions

Description: this can include erecting and/or maintaining temporary signs or fences at nesting sites, or placing chick shelters at a site after hatching.

Skills: manual labour, physical strength, observational and practical skills, compliance with instructions, cautiousness.

Training needed: fencing, sign and shelter placement specifications and guidelines, identifying nesting behaviour, locating nests or chicks, recognising threats to nesting birds, strong knowledge of the species' behaviour and biology, and minimising risks to the focal species and environment.

Timing and commitment: volunteers participating in on-ground managements usually participate in pair monitoring (see above) and thus are committed to one breeding season or more. Alternatively, a volunteer can make themselves available to assist land managers when needed. What goes up must come down (!), so a willingness to follow through, maintain and remove fences and signs is preferred.

Habitat restoration

Description: this can include weed control (e.g. hand pulling of Sea Spurge) or restoration activities such as Marram Grass removal and/or revegetating the dunes.

Skills: manual labour, moderate fitness. Chemical control can only be conducted by qualified people.

Training needed: botanical identification, OH&S requirements, minimising risks to the focal species and environment.

Timing and commitment: Variable commitment, usually conducted outside the breeding season.

Carpentry

Description: includes making chick shelters or frames for signs.

Skills: basic carpentry and wood work, OH&S.

Training needed: specifications for dimensions and materials.

Timing and commitment: short-term, usually one-off.

Data entry

Description: entering monitoring or observational data into a centralized database.

Skills: high level of concentration, attention to detail, computer literacy, database management, interpretive skills (i.e. deciding what behaviour descriptions mean).

Training requirements: database layout and operations.

Timing and commitment: Short-term, one-off or regular commitment.

Coordinating volunteers

Description: a volunteer could assist the manager or project facilitator with organising population surveys, managing other volunteers (e.g. answering email inquiries), or training new volunteers.

Skills: organisational and interpersonal skills, computer literacy, database management, experience with Powerpoint presentations.

Training requirements: database layout and operations, strong knowledge of species behaviour, biology, threats and management.

Timing and commitment: regular commitment during breeding season.

Colour marking birds

Description: under careful supervision, there may be opportunities for volunteers to be involved in capture and banding/flagging activities. This may be needed particularly in circumstances such as oil spills.

Skills: precision, concentration and attention to detail, cautiousness.

Training requirements: capturing (including safe and effective use of traps), banding/flagging, measuring and releasing birds, ethical considerations and relevant permits and qualifications from State and Federal Governments.

Timing and commitment: generally high; dependent on the project.

Communication and record keeping

Good communication and record keeping skills are essential to volunteering. Volunteers need to keep records of their sightings and experiences so that this information can be put to use for improving conservation of beach-nesting birds. There will often be specific data sheets that volunteers are asked to fill in, and volunteers should always be encouraged to contact their coordinator or land manager with queries about the value of other information they may note. Delays in setting up protective measures for nests or chicks on busy beaches can lead to nest failure, and so it is essential that volunteers pass on information of nest finds or chick sightings to the appropriate manager or volunteer coordinator as soon as possible.

Sharing the load

Volunteering to work with beach-nesting bird conservation takes commitment and can at times be emotionally draining in terms of experiencing the struggle these birds endure to produce young. Volunteers should never feel like they are battling this experience alone. This is one reason why volunteers should work closely with the local land managers. At times, volunteers may feel that the decisions made by local management are not aligned with the best interests of beach-nesting bird conservation, or with their own views of what is best for the birds. If communication isn't kept open between volunteers and managers this can lead to frustrations and conflict. The relationship can benefit from having a volunteer coordinator who operates at a regional or statewide level, to provide direction and perspective, and mediate any conflicts that occur. Further to that, it can be highly worthwhile to share participation, such as pair monitoring, with a friend or neighbour, or as part of a group. This can make involvement more enjoyable, and provide support, a sense of belonging and improved communication.

Recovery teams for threatened species that have a widespread, multi-regional distribution, often divide volunteers into small regional groups, each with their own regional coordinator, which then report to a centralised facilitator or recovery leader. This helps lessen the workload of the centralised facilitator and provides volunteers with a local, more readily accessible contact.

Funding opportunities

Belonging to a group can also have many advantages in terms of funding opportunities. If a group becomes incorporated, they are eligible to apply for many grants that are not available to informal groups or individuals, which rely on having an incorporated sponsor. Beach-nesting bird volunteers do not necessarily need to form new groups, but can align themselves with existing groups with similar interests or purpose, such as Birds Australia,

Field Naturalist groups, Bird Observer Clubs, Friends groups, Landcare or Coastcare groups.

Small grants can be used to fund local projects such as improving coastal environments through habitat restoration and weed removal, buying materials for fencing and signing nest sites, and producing interpretive materials.

There are many funding opportunities available to groups involved with threatened species conservation, habitat restoration and on-ground works related to conservation. The Australian Government's Department of the Environment, Water, Heritage and the Arts (DEWHA) lists available grants at www.environment.gov.au/programs/index.html. Within each state, it is worth checking whether the following offer volunteer or community grants: State Government; Parks and Wildlife agencies; Departments of Environment; Coast Action/Coastcare; Regional NRM or CMAs; Field Naturalist Clubs.

The following questions will be relevant to grant applications:

- Does your group have the capacity to conduct a particular project? If you become unavailable, will the group still be able to successfully complete the project?
- Does your project meet the priorities of funding bodies?
- Does your project fit soundly within the framework of Government policy initiatives relevant to shorebird conservation or habitat restoration?
  - Caring for Country funding priorities - www.nrm.gov.au/funding/future.html
  - Commonwealth Environment Protection and Biodiversity Conservation Act 1999 - www.environment.gov.au/biodiversity/threatened/index.html
  - Ramsar Conventions on Wetlands - www.ramsar.org/
  - National Objectives and Targets for Biodiversity Conservation 2001-2005
  - Flora and Fauna Guarantee Act 1988 (Victoria) – www.dse.vic.gov.au/dse/index.htm following the links through Plants and Animals > Native Plants and Animals > Threatened Species & Communities > Flora & Fauna Guarantee Act
  - Threatened Species Conservation Act 1995 (NSW) - www.threatenedspecies.environment.nsw.gov.au/legislation.aspx
  - National Parks and Wildlife Act 1972 (SA) - www.environment.sa.gov.au/biodiversity/threatened.html#Protection_within_SA
  - Nature Conservation Act 1992 (QLD) - www.epa.qld.gov.au/about_the_epa/legislation/nature_conservation/ www.epa.qld.gov.au/nature_conservation/wildlife/threatened_plants_and_animals/
  - Threatened Species Protection Act 1995 (Tasmania) – www.dpiw.tas.gov.au/ following the links through Native Plants and Animals > Threatened Species

- Wildlife Conservation Act 1950 (Western Australia) - www.naturebase.net/ following the links through Nature & Biodiversity > Plants and Animals > Threatened Species

- Does your project have financial or in-kind support from other stakeholders with an interest in your activities/site (eg. landholders, State Agencies, Local Government, community interest groups)?

Useful websites about funding

Grants Link - www.grantslink.gov.au – search for grants provided by the Australian Government.

Our Community - www.ourcommunity.com.au – search for grants available to community groups, government, individuals and businesses.

Landcare - www.landcareonline.com – follow links to funding opportunities for information on Landcare, Australian Government and Regional funding.

GrantSearch Australia - www.grantsearch.com – search for grants available for community projects.

Guide to Community Grants - www.aph.gov.au/library/intguide/sp/spgrants.htm - search for grants available to community groups in each State.

Queensland Government incentives for improved natural resource management - www.regionalnrm.qld.gov.au/funding/incentives - search for incentives available to landholders, community groups and regional NRM bodies.

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Appendices