Our seabirds at risk

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ABSTRACT

Seabirds face a range of threats, both on land and at sea. Consequently, a high proportion of seabirds worldwide, are currently threatened. This paper reviews the principal threatening processes that affect seabirds in New South Wales. Thirteen of the fourteen species of threatened seabirds that breed in NSW do so only on offshore islands. Nesting habitat on many of these islands has been lost or degraded by introduced mammals such as the European Rabbit *Oryctolagus cuniculus*, and by invasive weeds such as Kikuyu Grass *Pennisetum clandestinum*. Predation of eggs, chicks and adults by introduced mammalian predators, particularly the Black Rat *Rattus rattus,* is the most significant threat that NSW seabirds face while on land. Small species—those weighing less than 600 g—are particularly at risk. At sea, the most potentially damaging threats are currently longline fishing and plastic ingestion. Throughout the oceans of the world, tens of thousands of seabirds are accidentally killed on longlines each year. Mitigation measures are effective for surface-feeding species, such as albatrosses and giant petrels, but are less effective for deep-diving species, such as shearwaters. Significant numbers of seabirds (primarily the Flesh-footed Shearwater) are caught by the domestic longline tuna fishery operating off eastern Australia. Plastic ingestion has a range of lethal and sublethal consequences for seabirds, and the Flesh-footed Shearwater appears particularly to be at risk. There is uncertainty regarding the extent and impact of many threats. This, together with the lack of basic ecological information for many species, currently precludes the development of effective conservation strategies for seabirds in NSW. The current out-of-sight-out-of-mind attitude to the problem must change. Research and conservation action are needed urgently, particularly for species like the Flesh-footed Shearwater that are known to be at risk.

Key words: Procellariiformes, albatross, petrel, longline fishing, plastic ingestion, threatening processes, conservation.

Introduction

Although seabirds spend much of their life at sea, far away from land, many species are currently at risk of extinction. Worldwide, the proportion of seabirds that are now threatened exceeds the proportion of threatened birds on land (Gaston 2001). Highly pelagic seabirds, such as the Procellariiformes (albatrosses, petrels, storm-petrels, fulmars and shearwaters), are among those species most affected. Globally, 91 species of Procellariiformes are threatened, and another 32 species are near-threatened (BirdLife International 2000).

The situation is no better in Australia. Forty-three species of Procellariiformes breed in Australia (Baker *et al.* 2002), of which 27 (63%) are nationally threatened (Garnett and Crowley 2000). Another 42 species visit Australian waters to feed (Baker *et al.* 2002) and of these, 59% are globally threatened (BirdLife International 2000). Fourteen species of threatened seabirds breed in NSW, all but one (the Little Tern *Sterna albifrons*) breed only on offshore islands.

Seabirds have dramatically different life-history traits from most land birds (Schreiber and Burger 2002). Typically, seabirds are characterised by low natural adult mortality (below 4% per annum), deferred sexual maturity (5 to 12 years), low reproductive output (at most, one young per annum), a long lifespan (20 to 60 years), relatively high breeding success, high recruitment rates, high mate fidelity, high site tenacity and high philopatry (Warham 1990, 1996; Tickell 2000). This suite of life-history characteristics means that populations may be imperilled by small increases in the rate of adult mortality (Croxall *et al.* 1990). Due to the high parental investment in raising a chick, any death of a parent bird causes a reduction in breeding success that may last several years. Procellariiformes often experience a considerable delay in establishing new partnerships and, once formed, new pairings generally have lower reproductive success (Bradley *et al.* 1995). For the Wandering Albatross *Diomedea exulans*, the loss of a mate reduces life-time reproductive potential by up to 15% (Jouventin *et al.* 1999).

While the basic biology of most Australian seabirds is known, information on population trends and demography is poor. Details of foraging ecology, essential to determine possible interactions with fisheries and to understand threats at sea, are known only for some of the larger species, such as the albatrosses. Information for the smaller, less charismatic species is lacking.

Seabirds face a range of threats, both on land and at sea, almost all of which are human in origin (Ross *et al.* 1996). This paper reviews the principal threatening processes that affect those seabirds which breed in New South Wales (NSW). It also presents some of the actions being taken to ameliorate these threats at the state, national and international level. By way of illustration the paper focuses on a single species, the Flesh-footed Shearwater *Puffinus carneipes*. This seabird is threatened in NSW, where the only breeding population is on Lord Howe Island (Marchant and Higgins 1990), a small (1455 ha) volcanic outcrop in the Tasman Sea, 770 km northeast of Sydney.

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Threats on land

Seabirds spend most of their lives at sea, coming ashore only to breed. They typically breed colonially on offshore islands, and lay a single egg, which is not replaced if lost (Warham 1990, 1996; Tickell 2000). The egg is incubated for 6 to 12 weeks by both parents in long alternating shifts. A few days after hatching the chick is left alone, with parents returning only to feed it. Chicks fledge up to 9 months after hatching and remain at sea for the first 3 to 5 years before returning to land. When seabirds come ashore to breed in NSW they encounter a range of potential threats, including loss or degradation of nesting habitat and mortality from introduced predators. Threats of lesser significance, not elaborated here, include inter-specific competition for nest sites, parasites and disease (for a discussion of these threats see the review by Baker *et al.* 2002).

Loss or degradation of nesting habitat

Domestic animals, such as sheep, goats, pigs and rabbits, have been liberated onto numerous islands around the globe, mostly with the intent of providing food for passing or stranded mariners. This practice resulted in many seabird nesting habitats being lost or severely degraded. The consequences for seabirds were increased mortality and reduced breeding success.

In 1906, European Rabbits *Oryctolagus cuniculus* were released onto Cabbage Tree Island, offshore from Port Stephens, NSW. The rabbits completely destroyed the rainforest understorey (Werren and Clough 1991), exposing the Gould's Petrel *Pterodroma leucoptera* (Australia's rarest endemic seabird) to predation by Pied Currawongs *Strepera graculina* and Australian Ravens *Corvus coronoides* (Priddel and Carlile 1995). Rabbits were eradicated from Cabbage Tree Island in 1997 (Priddel *et al.* 2000) and the understorey is currently regenerating. Once it is re-established, the understorey will help protect the nesting petrels from attack by currawongs and ravens.

On Lord Howe Island, Flesh-footed Shearwaters nest in burrows on sandy soils at low elevations. Much of this habitat has been affected by human habitation, some areas having been cleared for grazing and others developed to provide dwellings for the Island's residents and tourists. The demand to build new dwellings is escalating, putting further pressure on the shearwater population. On the other hand, a decline in the dependence on local pastoralism has created an opportunity to rehabilitate some grazing land as nesting habitat for the Flesh-footed Shearwater. This opportunity has yet to be realised.

Entanglement in exotic vegetation

Sections of some NSW islands have become so degraded that remedial action has been necessary. In the past, Kikuyu Grass *Pennisetum clandestinum* had been used to stabilise disturbed or eroded soils, often along tracks and in areas subjected to high usage. Kikuyu is a problem for many burrowing seabirds. It eventually grows so thick that it becomes impenetrable and the birds have difficulty accessing their burrows. While attempting to push through the grass, many birds get their legs or wings caught in the stolons, become hopelessly entangled, and die.

On several islands Kikuyu is spreading with such veracity that it is smothering and replacing the native vegetation and choking seabird burrows. On Montagu Island, offshore from Narooma, Kikuyu now covers 40% of the southern part of the island. The seabirds most affected include Little Penguins *Eudyptula minor*, Short-tailed Shearwaters *Puffinus tenuirostris*, Wedge-tailed Shearwaters *P. pacificus* and Sooty Shearwaters *P. griseus*. Kikuyu was introduced to Lord Howe Island as a pasture grass for cattle, but it has also been used to repair or stabilise walking tracks. In forested areas, shading by native vegetation has prevented the grass from spreading beyond the cleared areas. Native grassland, however, is highly vulnerable to smothering. Once grasslands are heavily infested with Kikuyu, it is difficult for burrowing seabirds to access their burrows. There is also a high risk that the birds will become entangled in the grass. The species most severely affected by Kikuyu on Lord Howe Island is the Flesh-footed Shearwater, particularly where birds continue to use burrows in areas cleared of native vegetation.

Introduced predators

Globally, predation of eggs, chicks and adults by introduced species is the most significant threat that seabirds face while on land. Small species—those weighing less than 600 g—are particularly at risk (Baker *et al.* 2002). Fortunately, with the advent of modern toxins, such as brodifacoum, it is now possible, with meticulous planning, to eradicate many introduced mammalian predators from islands (Veitch and Bell 1990; Veitch 1995).

The House Cat *Felis catus* is a major predator of seabirds, killing both adults and chicks. Since cats were recently eradicated from Lord Howe Island (only one domestic cat remains), all NSW offshore islands have been free of cats. A far more ubiquitous, but less obvious, predator of seabirds is the introduced Black Rat *Rattus rattus*, which occurs on numerous NSW islands. Seabirds are particularly vulnerable to rats because they nest at ground level and leave their young unattended for long periods. Rats, together with cats, have eliminated Kermadec Petrels *Pterodroma neglecta* and White-bellied Storm-petrels *Fregetta grallaria* from the main island of Lord Howe (Hindwood 1940; Hindwood and Cunningham 1950). Fortunately, these species still survive on nearby islets where rats and cats are absent. The impact of rats on other NSW islands has not been investigated, but rats are the likely cause of poor reproductive success of Sooty Oystercatchers *Haematopus fuliginosus* on Brush Island, approximately 15 km south of Ulladulla.

The rats on Lord Howe Island have been listed as a key threatening process under the NSW *Threatened Species Conservation Act 1995*. The eradication of these rats, together with the House Mouse *Mus musculus*, is now considered feasible (Saunders and Brown 2001) and a cost-benefit analysis for this initiative is currently being prepared. Although the process of removing rats is straightforward, it is complicated by the presence of human habitation, a tourist industry and several threatened endemic species that are at risk as possible non-target casualties.

Lord Howe Island is a haven for seabirds, no fewer than eleven threatened species breed there. (Photo: D. Priddel 1999)

A dead Laysan Albatross chick, its digestive tract full of plastics. Plastic ingestion is a major cause of chick mortality in many species of seabird. (Photo: N. Carlile 2000)

Flesh-footed shearwaters that nest on Lord Howe Island face threats from long-line fishing, plastic ingestion and urbanisation. (Photo: N. Carlile 2002)

The contents of Flesh-footed Shearwater burrows are inspected with the use of a burrow-camera. A large white egg is clearly visible on the LCD screen. (Photo: L. O'Neill 2003)

Threats at sea

Seabirds are highly pelagic and spend most of their life at sea, traversing the ocean in search of food. At sea they face a suite of threats including direct interactions with fishing operations, ingestion of plastics, entanglement in marine debris, depletion of prey species through over-fishing, chemical pollutants, pathogens and contamination from oil. These threats occur globally (see BirdLife International 2000 for an international perspective and Baker *et al.* 2002 for a review of these threats in Australia) but little is known about the impact that these threats have on seabird populations in NSW.

Heavily-used shipping routes run along the NSW coast, creating the potential for a major oil spill occurring in NSW waters. The recent grounding of the British warship *Nottingham* on Lord Howe Island demonstrates that even modern, well-maintained vessels pose some risk. Shipping disasters aside, the most potentially damaging threats to seabirds in NSW waters are probably longline fishing and plastic ingestion. Only these two threats are considered further in this review.

Longline fishing

Seabirds forage over vast tracts of ocean, making foraging flights of many thousand kilometres. While searching for food is mostly a solitary behaviour, foraging seabirds tend to congregate in specific areas (Hunt and Schneider 1987). These favoured areas are usually areas of high primary productivity, rich in prey for seabirds. They include warmer coastal waters, continental shelf breaks and upwellings of nutrient-rich waters such as occur along the Antarctic Convergence (Baker *et al.* 2002). These features also attract fishers, leading to potential adverse interactions between seabirds and fishing operations. The discards associated with fishing vessels also provide seabirds with a rich source of food, causing flocks of several hundred birds to congregate around fishing vessels (Harper 1987; Ryan and Moloney 1988), further increasing the potential for interaction.

The most significant fishing practice, in terms of its global impact on seabirds, is longlining. This technique is used principally to catch tuna and swordfish. The longlines are suspended a few hundred metres beneath the surface and carry baited hooks suspended on branch lines spaced about 50 m apart. Each longline may exceed 100 km in length and carry several thousand hooks. Every year hundreds of millions of baited hooks are set by tuna and swordfish longliners in the oceans of the world, and each year tens of thousands of seabirds are accidentally killed. The problem occurs because the birds are attracted to fishing vessels by discarded offal and baits. The birds follow the fishing boats and snap at baited hooks in a feeding frenzy as the longlines are being set. Birds that swallow baited hooks are pulled underwater and drown. Catch rates are variable, but limited data point to a typical catch of about 0.4 birds per thousand hooks set (Baker *et al.* 2002).

Declines in many seabird species have been attributed to high levels of mortality to longline-fishing operations. Longlining affects those species which are pre-disposed to follow ships. Those at most risk tend to be the larger species; birds weighing more than 600 g (Baker *et al.* 2002). Smaller species are less affected as they are less able to swallow the hooks.

Pelagic longline fishing within the Australian Fishing Zone (AFZ) was previously conducted by a Japanese fleet, but since 1998 it has involved only Australian vessels. The fleet consists of 160 vessels which operate largely within 100 nautical miles of shore, although a growing proportion of fishing takes place further offshore. In 2001, 11.2 million hooks were set in the waters off eastern Australia (east of 141°E longitude) and 6.2 million hooks in the AFZ on the western side of the continent (Department of Agriculture, Fisheries and Forestry - Australia 2002).

Until recently it was thought that longlining had little impact on seabirds in or near NSW waters. Recent observations have revealed that significant numbers of Flesh-footed Shearwaters are caught on longlines by the domestic tuna fishery operating off eastern Australia during the austral summer (Department of Agriculture, Fisheries and Forestry - Australia 2002). A total of 160 seabirds were caught on 10 1203 observed hooks—a seabird bycatch rate of 1.58 birds per thousand hooks. Almost all these mortalities (97%) involved Flesh-footed Shearwaters, and most occurred between latitudes 30°S and 32°S. Extrapolation of these data, indicate that approximately 5 000–6 000 Flesh-footed Shearwaters are killed annually in the Australian Eastern Tuna and Billfish Industry (Barry Baker, Environment Australia, pers. comm. 2002). These birds are likely to come from the Lord Howe Island population, which currently numbers about 12 500 pairs (Priddel and Carlile, unpubl. data) or from populations breeding in New Zealand, which number 25 000–50 000 pairs (Taylor 2000). Information on population trends for the Flesh-footed Shearwater is lacking.

Mitigation measures for longline fishing

The declaration of longline fishing as a key threatening process under Commonwealth legislation escalated it to the top of the marine conservation agenda. A national threat abatement plan was prepared in 1998 (Environment Australia 1998) and several measures to reduce the level of seabird bycatch from longlining have recently been developed. These include employing flagging lines (tori poles) to scare seabirds; setting longlines at night when seabirds are less active; thawing baits so they sink faster, thereby reducing the time they are available to seabirds; and retaining fish offal on board or discharging it in a manner that avoids attracting seabirds. The goal is to reduce mortality to less than 0.05 birds per thousand hooks (Environment Australia 1998).

No single mitigation measure works in isolation, usually a combination of measures is required. The deployment of bird-scaring lines, such as streamers to keep birds away from baited hooks can reduce seabird bycatch by 30-70% (Brothers 1991; Klaer and Polacheck 1997). Setting longlines at night can reduce the incidental catch of the larger species by 60–90% (Murray *et al.* 1993; Klaer and Polacheck 1997; Brothers *et al.* 1999), but this technique is less effective on moonlit nights (Hedd *et al.* 1998) and largely ineffective for the smaller species, which tend to

feed at night. Mitigation measures under development include the use of weighted lines and underwater setting devices. Adding weight to the lines increases the rate at which the baits sink. As most birds caught on longlines are hooked during setting of the lines, setting them underwater through a pipe or chute has the potential to eliminate much of the problem, at least for species that feed close to the surface, such as albatrosses and giant petrels. Many of the smaller petrels, however, are proficient swimmers and dive to depths of 70 m (Weimerskirch and Sagar 1996; Weimerskirch and Cherel 1998). These species are able to retrieve the baits as they sink, even when they are set underwater.

When used in combination, mitigation measures work well, at least for the larger species. The mortality of albatrosses and giant petrels has been significantly reduced, particularly on ships fishing legally within the Southern Ocean. If mitigation measures are unsuccessful, prohibition of fishing operations during the periods of high seabird abundance may be required. This restriction has been used in some overseas fisheries, typically in the vicinity of seabird breeding colonies at times when foraging ranges are restricted. At South Georgia, reluctance by fishers to adopt appropriate mitigation practices resulted in closure of the Patagonian Toothfish Fishery during the albatross breeding season (September-April). Currently fishing is only permitted in winter when most vulnerable seabird species have left South Georgia waters. Closing the fishery for much of the year has reduced the number of seabirds killed to less than 50 per annum (Graham Robertson, Australian Antarctic Division, pers. comm. 2002).

Ingestion of plastics

Chemical contamination of the marine environment has adverse effects on most marine life. Plastic pollution probably has greater consequences for seabirds than for any other faunal group. Plastic particles floating on or near the surface of the ocean often resemble the adults and larvae of crustaceans (Mauchline 1980; Raymont 1983) or the eggs of pelagic fish (Colton *et al.* 1974). Mistaking this debris for food, many seabirds ingest large quantities of plastics. This has a range of lethal and sublethal consequences. Plastics can impair gastrointestinal function or cause physical damage to the bird's gastrointestinal tract, including perforation, blockage or internal ulceration of the proventriculus. Plastics can also release toxins during digestion (Ryan and Moloney 1988). These toxins generally lower fitness, reduce survival and disrupt reproduction. Chlorinated hydrocarbon plastics, for example, lower steroid hormone levels and delay ovulation (Peakall 1970).

There is a higher incidence of plastic ingestion in surface feeders than diving birds, and in plankton feeders compared to fish feeders. Procellariiformes are especially susceptible to the effects of plastic ingestion (Azzarello and Van Vleet 1987) because they not only have a relatively small gizzard in which to accommodate any extraneous material, but they also have a constriction between the gizzard and proventriculus that makes it more difficult for the gizzard contents to be expelled (Furness 1985). Chicks are at greatest risk because of their low propensity to regurgitate indigestible material. Adult seabirds habitually regurgitate indigestible parts of their food—items such as shell and fish bones (Hays and Cormons 1974). Chicks tend not to regurgitate until they are almost fully fledged, so plastics accumulate in their gut. The physical presence of plastic in the gut prevents the bird from receiving a full load of food at each feed. Also, by preventing stomach contraction—an important cue in the stimulation of hunger—chicks may have depressed appetite and diminished feeding activity (Sturkie 1965). The lower nutrient intake results in reduced fitness or death.

In 1987, it was estimated that 45 000 tons of plastics were discarded at sea annually, and the density of plastic on our oceans was as high as 4 000 pieces per km^2 (Azzarello and Van Vleet 1987). There are now international protocols that restrict the dumping of plastics at sea. Improved waste disposal practices, both from ships and in rivers and estuaries, are also helping to address this problem. The extent and impact of plastic ingestion by seabirds in NSW has yet to be ascertained. A species that has been shown to be severely affected by plastic ingestion is the White-faced Storm-petrel *Pelagodroma marina* (Furness 1985). Up to 53 particles of plastic (equivalent to 96% of the relaxed gizzard volume) have been extracted from a single bird breeding in the Northern Hemisphere. This species also breeds in NSW, but has disappeared from several islands along the NSW coast. Although the cause of this decline has yet to be investigated, plastic ingestion could be a major contributing factor. The Flesh-footed Shearwater is also at risk. Plastic particles litter the nesting grounds of this species on Lord Howe Island and the carcasses of dead chicks often contain substantial quantities of plastics.

Discussion

Seabirds in NSW face many threats, both on land and at sea. Despite the enormity of these threats, most go unnoticed, the problems being essentially *out of sight, out of mind*. To date, national and international attention has focused largely on the mortality of seabirds caused by longline fishing. Australia has prepared and adopted a *National Policy on Fisheries Bycatch* which has proven to be effective within Australia's Exclusive Economic Zone (Baker *et al.* 2002). Australia is rapidly moving toward sustainable fishing practices that have minimal impact on seabird populations. The long-term survival of Australia's seabirds, however, depends not only on effective conservation programs operating within Australian waters, but it also requires international action to secure the protection of these species when they forage in waters of other jurisdictions or on the high seas. Australia has taken a lead in developing international policy and legislation to minimise seabird bycatch (see review by Baker *et al.* 2002).

Regulations now apply to longlining vessels fishing in waters south of 30°S. At these latitudes, vessels are required to adhere to a suite of measures designed to reduce seabird mortality, including setting lines at night, the use of bird-scaring lines (tori poles) and the use of thawed baits (Department of Agriculture, Fisheries and Forestry - Australia 2002). Vessels must also refrain from

discharging offal while setting lines. In waters north of 30°S, however, the risk to seabirds from longlining operations was thought to be minimal. Consequently, regulations in these waters are not as stringently applied. Fishing vessels operating at these latitudes are required to use a bird-scaring line, but other measures are not mandatory (Department of Agriculture, Fisheries and Forestry - Australia 2002).

The original assessment of the extent of potential interaction between seabirds and fishing vessels operating in NSW waters came from data obtained from the Japanese fishing fleet. Recent data from Australian vessels indicate that there is greater potential for seabirds to interact with longline fisheries operating at these latitudes than was initially envisaged. Although this recent reappraisal is based on a limited number of hooks observed during an experimental trial of underwater-setting of hooks, the data allow the conclusion to be drawn that seabird bycatch in the domestic tuna fishery is unacceptably high. During the summer months there is a significant seabird bycatch issue in the fishery, particularly in relation to Flesh-footed Shearwaters in waters near Lord Howe Island (Department of Agriculture, Fisheries and Forestry - Australia 2002). Hopefully, this issue will be addressed in the *National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries* that is currently in preparation, and in the next update of the *National Threat Abatement Plan for the Incidental Catch (or Bycatch) of Seabirds during Oceanic Longline Fishing Operations* (Environment Australia 1998).

If humankind is not to deplete the world's oceans of seabirds, the current out-of-sight-out-of-mind attitude to the issue must change. Unfortunately, the problem is exacerbated by the uncertainty regarding the extent and impact of many threats. This uncertainty, together with a lack of basic ecological information for many species known to be at risk, currently precludes the development of effective conservation strategies for many NSW seabirds. Knowledge of the foraging ecology and at-sea distribution of vulnerable species is essential to identify key foraging areas and potential overlap with fisheries operations. For some species, the situation is complicated by age and sex-specific differences in their pelagic distribution.

Research is urgently needed, particularly for species like the Flesh-footed Shearwater that are known to be at risk. The focus of this research should be to identify the nature and scale of threats, determine population trends, and investigate at-sea distribution and foraging ecology. As seabirds are long-lived, this research needs to be long-term, requiring sustained political and financial support.

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References

Azzarello, M.Y. and Van Vleet, E.S. 1987. Marine birds and plastic pollution. *Marine Ecology Progress Series* **37**: 295-303.

Baker, G.B., Gales, R., Hamilton, S. and Wilkinson, V. 2002. Albatrosses and petrels in Australia: a review of their conservation and management. *Emu* **102**: 71-97.

BirdLife International 2000. *Threatened Birds of the World.* Lynx Edicions and BirdLife International, Barcelona and Cambridge.

Bradley, J.S., Wooller, R.D. and Skira, I.J. 1995. The relationship of pair-bond formation and duration to reproductive success in short-tailed shearwaters *Puffinus tenuirostris*. *Journal of Animal Ecology* **64**: 31-38.

Brothers, N. 1991. Albatross mortality and associated bait loss in the Japanese Longline fishery in the Southern Ocean. *Biological Conservation* **5**: 255-268.

Brothers, N.P., Cooper, J. and Lokkeborg, S. 1999. The incidental catch of seabirds by longline fisheries: worldwide review and technical guidelines for mitigation. FAO Fisheries Circular no. 937. Food and Agriculture Organization of the United Nations, Rome.

Colton, J.B., Knapp, F.D. and Burns, B.R. 1974. Plastic particles in surface waters of the northwestern Atlantic. *Science* **185**: 491-497.

Croxall, J.P., Rothery, P., Pickering, S.P.C. and Prince, P.A. 1990. Reproductive performance, recruitment and survival of wandering albatrosses *Diomedea exulans* at Bird Island, South Georgia. *Journal of Animal Ecology* **59**: 775-796.

Department of Agriculture, Fisheries and Forestry - Australia 2002. Seabird Interactions with fisheries in the Australian Fishing Zone. National plan of action for reducing the incidental catch of seabirds in longline fisheries: assessment report. Department of Agriculture, Fisheries and Forestry - Australia, Canberra.

Environment Australia 1998. Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations. Biodiversity Group, Environment Australia , Canberra.

Furness, R.W. 1985. Plastic particle pollution: accumulation by Procellariiform seabirds at Scottish colonies. *Marine Pollution Bulletin* **16**: 103-106.

Garnett, S. and Crowley, G.M. 2000. *The Action Plan for Australian Birds 2000.* Environment Australia, Canberra.

Gaston, A.J. 2001. Taxonomy and conservation: thoughts on the latest Birdlife International listings for seabirds. *Marine Ornithology* **29**: 1-6.

Harper, P.C. 1987. Feeding behaviour and other notes on 20 species of Procellariiformes at sea. *Notornis* **34**: 169-192.

Hays, H. and Cormons, G. 1974. Plastic particles found in tern pellets on coastal beaches and at factory sites. *Marine Pollution Bulletin* **5**: 44-46.

Hedd, A., Gales, R., Brothers, N. and Robertson, G. 1998. Diving behaviour of the shy albatross *Diomedea cauta* in Tasmania: initial findings and dive recorder assessment. *Ibis* **139**: 452-460.

Hindwood, K.A. 1940. The birds of Lord Howe Island. *Emu* **40**: 1-86.

Hindwood, K.A. and Cunningham, J.M. 1950. Notes on the birds of Lord Howe Island. *Emu* **50**: 23-35.

Hunt, G.L. and Schneider, D.C. 1987. Scale-dependent processes in the physical and biological environment of marine birds. Pp. 7-41 in *Seabird Feeding Ecology and Role in Marine Ecosystems* edited by J.P. Croxall. Cambridge University Press, Cambridge.

Jouventin, P., Lequette, B. and Dobson, F.S. 1999. Age-related mate choice in the wandering albatross. *Animal Behaviour* **57**: 1099-1106.

Klaer, N. and Polacheck, T. 1997. Bycatch of albatrosses and other seabirds by Japanese longline fishing vessels in the Australian Fishing Zone from April 1992 to March 1995. *Emu* **97**: 150-167.

Marchant, S. and Higgins, P.J. 1990. *Handbook of Australian, New Zealand and Antarctic Birds. Volume 1: Ratites to Ducks.* Oxford University Press, Melbourne.

Mauchline, J. 1980. The biology of mysids and euphausiids. *Advances in Marine Biology* **18**: 1-681.

Murray, T.E., Bartle, J.A., Kalish, S.R. and Taylor, P.R. 1993. Incidental capture of seabirds by Japanese Southern Bluefin Tuna longline vessels in New Zealand waters, 1988-1992. *Bird Conservation International* **3**: 181-210.

Peakall, D.B. 1970. p,p'DDT: effect on Ca metabolism and concentration of estradiol in the blood. *Science* **168**: 592-594.

Priddel, D. and Carlile, N. 1995. Mortality of adult Gould's Petrels *Pterodroma leucoptera leucoptera* at the nesting site on Cabbage Tree Island, New South Wales. *Emu* **95**: 259-264.

Priddel, D., Carlile, N. and Wheeler, R. 2000. Eradication of European rabbits (*Oryctolagus cuniculus*) from Cabbage Tree Island, NSW, Australia, to protect the breeding habitat of Gould's petrel (*Pterodroma leucoptera leucoptera*). *Biological Conservation* **94**: 115-125.

Raymont, J.E.G. 1983. *Plankton and Productivity in the Oceans. Zooplankton, Vol 2, 2nd Edition.* Pergamon Press, New York.

Ross, G.J.B., Weaver, K. and Grieg, J.C. 1996. The status of Australia's seabirds: proceedings of the National Seabird Workshop, Canberra 1-2 November 1993. Biodiversity Group, Environment Australia, Canberra.

Ryan, P.G. and Moloney, C.L. 1988. Effect of trawling on bird and seal distributions in the southern Benguela Current. *Marine Ecology Progress Series* **45**: 1-11.

Saunders, A. and Brown, D. 2001. An assessment of the feasibility of eradicating rodents from the Lord Howe Island Group. A report to the Lord Howe Island Board. Endangered Species Recovery Council, Hamilton.

Schreiber, E. A. and Burger, J. (Eds) 2002. *Biology of Marine Birds*. CRC Press: Boca Raton.

Sturkie, P.D. 1965. *Avian Physiology.* Cornell University Press, New York.

Taylor, G.A. 2000. Action plan for seabird conservation in New Zealand. Part B : non-threatened seabirds. Threatened species occasional publication no. 17. Department of Conservation, Biodiversity Recovery Unit, Wellington.

Tickell, W.L.N. 2000. *Albatrosses.* Yale University Press, New Haven.

Veitch, C.R. 1995. Habitat repair: a necessary prerequisite to translocation of threatened birds. Pp. 97-104 in *Reintroduction Biology of Australian and New Zealand Fauna* edited by M. Serena. Surrey Beatty & Sons, Chipping Norton.

Veitch, C.R. and Bell, B.D. 1990. Eradication of introduced mammals from the islands of New Zealand. Pp. 137-146 in *Ecological Restoration of New Zealand Islands* edited by D.R. Towns, C.H. Daugherty and I.A.E. Atkinson. Department of Conservation, Wellington.

Warham, J. 1990. *The Petrels: Their Ecology and Breeding Systems.* Academic Press, London.

Warham, J. 1996. *The Behaviour, Population Biology and Physiology of the Petrels.* Academic Press, London.

Weimerskirch, H. and Cherel, Y. 1998. Feeding ecology of short-tailed shearwaters: breeding in Tasmania and foraging in the Antarctic? *Marine Ecology Progress Series* **167**: 261-274.

Weimerskirch, H. and Sagar, P.M. 1996. Diving depths of sooty shearwaters *Puffinus griseus*. *Ibis* **138**: 786-794.

Werren, G.L. and Clough, A.R. 1991. Effect of rabbit browsing on littoral rainforest, Cabbage Tree Island, New South Wales - with special reference to the status of the Gould's petrel. Pp. 257-277 in *The Rainforest Legacy: Australian National Rainforests Study, Vol. 2 - Flora and Fauna of the Rainforests* edited by G. Werren and P. Kershaw. Australian Government Publishing Service, Canberra.