Guidelines for Managing Visitation to Seabird Breeding Islands

Prepared by
WBM Oceanics Australia and Gordon Claridge

for the
Great Barrier Reef Marine Park Authority
and
Environment Australia-Biodiversity Group

GREAT BARRIER REEF
MARINE PARK AUTHORITY

Published 1997 by the Great Barrier Reef Marine Park Authority

ISBN 0 642 23029 3

ACKNOWLEDGMENTS

These guidelines were prepared for the Great Barrier Reef Marine Park Authority (GBRMPA) and Environment Australia–Biodiversity Group under terms of reference developed by representatives of Australian government nature conservation agencies and of the tourism industry. They were prepared under direction from GBRMPA and the Biodiversity Group by WBM Oceanics Australia, Brisbane, Queensland, with assistance from Gordon Claridge, environmental management consultant, Benalla, Victoria.

The compilation of these guidelines would not have been possible without the input, assistance and comments of many people. Tony Stokes of GBRMPA and Karen Weaver of the Biodiversity Group provided regular input and commented on all drafts of the guidelines. Extensive final proofing and editing was done by V. Bonanno and K. Clarke.

Key officers of government agencies also provided useful input, including Jim Reside, Ian Norman and Peter Menkhorst (Victoria), David Priddel, Geoff Ross and Nick Carlile (NSW), Nigel Brothers and David Pemberton (Tasmania), Peter Copley (SA), Ray Chatto (NT), Andrew Burbidge (WA), David Walker, Bruce Knuckey, Paul O'Neill, Margot Warnett and Fraser Muir (Queensland), and Des Pike, Tom Scotney, Andrew Roberts, Jim Crennan and Peter Bridgewater (Biodiversity Group).

During the field testing of the draft guidelines the following people provided detailed assistance in meetings and / or in the field. Queensland Department of Environment (QDoE) Cairns: Fraser Muir, Max Haste, Mike Short, John Cornelius; Great Barrier Reef Marine Park Authority: Tony Stokes, Lou Ewins, Janet Slater, Tania Adami, Gayle Jennings, Malcolm Turner; QDoE Townsville: Margot Warnett; QDoE Rockhampton: Paul O'Neill, John Toop; QDoE Gladstone: Bruce Knuckey.

Others who provided useful and constructive input were Nic Dunlop, Jeff Hardy, G. Pike and Paul Stevenson and all the questionnaire respondents listed in appendix 3.

Donna O'Daniel and Beth Flint (US Fish and Wildlife Service) provided useful information on approaches to managing seabirds in the Pacific and Andy Cox (Department of Conservation of New Zealand) shared his experiences of managing New Zealand seabird breeding islands.

Financial support for the preparation of these guidelines was provided by the Intergovernment Unit of the Federal Department of the Environment, Sport and Territories.

The consultant sincerely thanks all of the above people and apologises to anyone inadvertently not mentioned.

Cover photograph: Michaelmas Cay, north Queensland (GBRMPA)

GREAT BARRIER REEF
MARINE PARK AUTHORITY

PO Box 1379
Townsville Qld 4810
Phone: (077) 500 700
Fax: (077) 726 093

FOREWORD

The preparation of these Guidelines arose from a National Seabird Workshop in November 1993 which was organised by the Biodiversity Group of Environment Australia. At the workshop a paper by staff of the Great Barrier Reef Marine Park Authority, the (then) Queensland Department of Environment and Heritage and Griffith University was delivered on issues associated with the management of human visitation to seabird islands on the Great Barrier Reef. The paper has now been published in the proceedings of that Workshop.

Following the Workshop, staff of the Biodiversity Group and the Great Barrier Reef Marine Park Authority submitted a joint proposal to prepare national guidelines to manage human visitation to seabird islands. A committee was established comprising staff of Australian nature conservation agencies and a representative of the tourism industry, to advise the Great Barrier Reef Marine Park Authority on managing the development of the Guidelines.

The result is a very useful document which will assist in framing policy proposals and regulations for the management of human visitation to seabird islands wherever they occur in Australian waters.

Seabird islands around Australia are experiencing increasing pressure from visitors as a result of increasing development and mobility in the Australian population. The Guidelines fulfil an urgent need for summarised information about seabirds, their reactions to human visitors, and strategies to minimise risks associated with the visitors.

The Great Barrier Reef Marine Park Authority is pleased to publish the Guidelines and make them available for general use.

Ian McPhail
Chairperson
Great Barrier Reef Marine Park Authority

June 1997

PREAMBLE

These guidelines have been prepared based on considerable discussion and feedback from a range of island management agencies around Australia and on field testing on the Great Barrier Reef. The guidelines are therefore recommended for immediate use.

In any environmental management exercise, it is essential to monitor the effectiveness of management approaches and specific measures. These guidelines are no exception and they will benefit from further testing and from research and monitoring activities designed to provide clearer guidance on specific measures (see body of report).

To enhance the quality of information and the effectiveness of these guidelines, it is recommended that nature conservation and other island management agencies use the guidelines for twelve months and then meet to review and refine them.

At the same time, research on key questions, such as critical approach distances of species on islands subject to regular visitation, could be undertaken to assist in the review.

CONTENTS

Figures

Tables

SUMMARY

These guidelines have been developed for the Australian Government (in particular, the Great Barrier Reef Marine Park Authority and Environment Australia–Biodiversity Group) by WBM Oceanics Australia for use by all agencies that are responsible for the management of offshore islands around Australia, excluding external island territories.

These guidelines should be tested by island managers over a twelve-month period. A meeting of managers after this period to review and update the guidelines would be appropriate.

They are designed to guide island managers in formulating management strategies and techniques for minimising or eliminating the impact of human visitation (including boats and aircraft) on sensitive seabird breeding populations.

Information is provided to assist island managers to:

- understand the mechanisms of human impacts on breeding seabirds (chapter 3);
- place a value on aggregations of breeding seabirds (chapter 4);
- identify potential and actual impact sources and likely control / mitigation measures (chapter 5);
- identify relevant management concerns and approaches (chapter 6); and
- identify appropriate site- and region-specific ways of implementing control / mitigation measures (chapter 7).

A bibliography is provided of selected references related to the management of seabird breeding islands. This bibliography can be accessed on ProCite software within the Great Barrier Reef Marine Park Authority.

It is also important that some basic research be undertaken over this period, particularly to identify critical approach distances for a range of species and settings, so that more precise guidelines can be developed in future.

PART ONE

Background

CHAPTER 1

Introduction

WBM Oceanics Australia was retained by the Australian Government (the Great Barrier Reef Marine Park Authority and Environment Australia–Biodiversity Group) to develop guidelines for managing visitation to islands used by seabirds for breeding. This report is designed to be used by island users and planning, management, enforcement and permitting staff in island management agencies to develop specific approaches to managing the impact of visitation on breeding seabirds.

The remainder of this introductory chapter provides background information to the problem and guides the user of these guidelines through the report. The reader is encouraged to read this chapter before attempting to use the guidelines.

1.1 BACKGROUND

Australia has a vast coastline and hundreds of offshore islands used by seabirds for breeding. Ross et al. (1995) estimated that between 17 and 21.6 million pairs of seabirds of 42 species use the islands around Australia for breeding. Information gathered during this consultancy suggests that the maximum may be a little more than this (see chapter 2).

Most of these islands are relatively inaccessible and visitation is not considered to be especially heavy or to pose a serious threat to seabird population viability. Notwithstanding this, there are some regions near the more heavily populated parts of the Australian coast where visitation may be interfering with, or has the potential to interfere with, seabird breeding activities. Possible consequences are reduced breeding success and local population declines. Chapter 3 describes in detail the vulnerability of seabirds in Australia to human visitation.

Australia's coastal population is growing more rapidly than the population in other parts of the country (Resource Assessment Commission 1992). In future, more people will live close to the islands that are used by seabirds for breeding. The overwhelming recreational attraction of the coast and the level of boat ownership in coastal regions will mean that offshore islands, particularly those nearer to shore and with easy landing sites will be visited more often. The peak in seabird breeding in the warm months of the year predisposes seabirds to disturbance from recreational activities which peak at the same time.

The potential for increasing visitation to offshore islands may lead to greater disruption to seabird breeding activities. Consequently, there is likely to be a need to manage visitation to islands more rigorously than has been necessary until now. One area where the combination of amenable, reliable weather; human recreation and tourism; the ease of visiting islands and the presence of large numbers of breeding seabirds is causing great concern is in the Great Barrier Reef Marine Park. The Great Barrier Reef Marine Park Authority and the Queensland Department of Environment and Heritage (now the Queensland Department of Environment) have the best developed management, permitting and enforcement regime of any area of islands in Australia and a draft of the guidelines has been tested within their management regimes to determine if the guidelines are both appropriate and implementable. This current draft incorporates modifications indicated by this testing process.

1.2. PURPOSE AND SCOPE OF THE GUIDELINES

These guidelines are aimed at providing seabird island management agencies with technical information and management recommendations for decision making about human visitation to islands. The guidelines have been designed in such a way that they will:

- assist island managers in developing appropriate strategies for managing island visitation;
- assist management agencies in planning for appropriate visitor numbers and activities;
- provide guidance in the preparation and implementation of capital works programs on islands;
- assist permitting authorities in developing permit regimes and conditions that ensure maximum protection of breeding seabirds;
- provide enforcement staff with guidance on why and how visitor activities should be controlled; and
- provide works staff with an understanding of why particular infrastructure is being developed and how to develop it.

In this way, all management agencies and sections of management agencies with a role to play in seabird island management will have clear directions on how to manage visitation better.

The terms of reference for the preparation of these guidelines clearly identified the scope of the guidelines and the area to be covered. These guidelines are developed for the species and types of island and visitor situations that occur within 150 kilometres or so of the coast of Australia. The island territories of Australia are not specifically covered, although the guidelines would obviously be useful in some of these situations.

To ensure that the guidelines are useful and able to be implemented by island management agencies, they have been field tested within the Great Barrier Reef region. This extremely useful exercise has resulted in a significant recasting of the guidelines and a more universally applicable document.

These guidelines are interim and agencies are encouraged to field test them within their jurisdictions and provide feedback to the client organisations.

1.3 ORGANISATION OF THE GUIDELINES

These guidelines are organised to enunciate the nature of the problems, provide the solutions and give guidance on implementing the solutions.

PART ONE provides information upon which visitation management can be based.

Chapter 2 provides background information on the nature, location and timing of seabird breeding activities in Australia.

Chapter 3 provides information on the vulnerability of breeding seabirds. This deals with the impacts of visitors on breeding habitats and a detailed examination of the many ways in which human disturbance can cause significant disruption to breeding

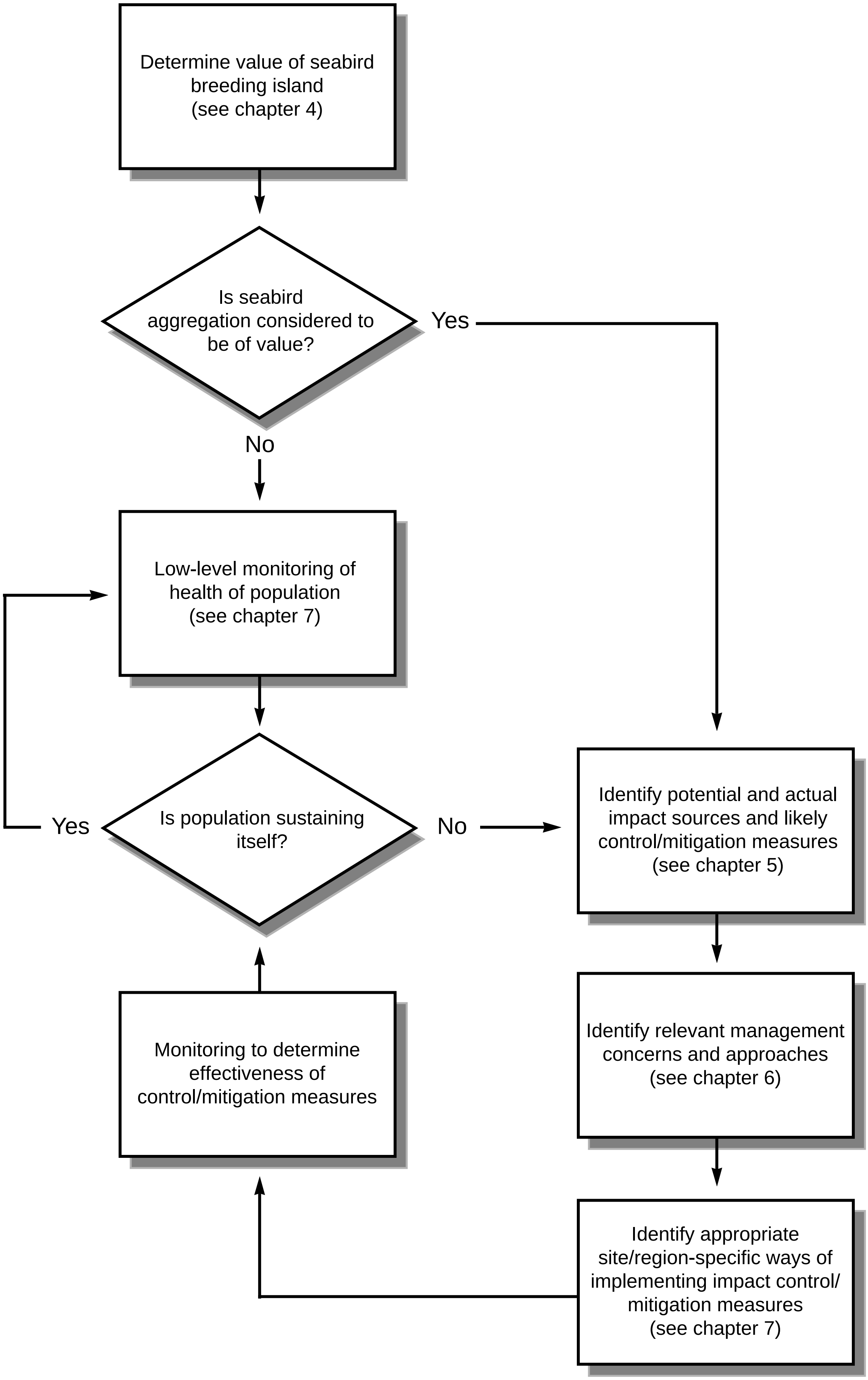

Figure 1.1 PROCEDURE FOR USING THE GUIDELINES

activities and mortality to eggs and young seabirds. This chapter provides information particularly important to understanding the guidelines in the following chapters.

PART TWO gives guidance on developing and implementing appropriate measures for managing visitation to seabird breeding islands.

Chapter 4 provides a summary of the features of species, colonies or sites that can be used in assessing the value of a seabird breeding island. Valuing seabird breeding sites is an important first step, enabling management approaches to be prioritised at a regional scale.

Chapter 5 gives information on the sources of impacts on breeding seabirds and on measures for controlling or mitigating these impacts.

Chapter 6 gives a means of identifying the principal management concerns and the measures that are appropriate in dealing with these concerns. This chapter provides a taxonomically based approach to predicting the likely impacts of human activities on breeding seabirds.

Chapter 7 gives a summary of the approaches that could be adopted for implementing the measures identified in previous chapters.

Chapter 8 provides a large, selected bibliography related to managing visitation to seabird breeding islands.

Figure 1.1 shows a procedure for using these guidelines. Some island managers may already have undertaken some of the tasks identified in this flow diagram, in which case, they could commence the procedure at the appropriate point.

CHAPTER 2

The Nature of Seabird Breeding

This chapter provides information on the distribution and population levels of seabirds that breed on Australia's islands and the ways in which they breed. The islands covered are those within approximately 150 kilometres of the mainland and of Tasmania.

Table 2.1
NUMBERS OF BREEDING PAIRS OF EACH SPECIES OF SEABIRD IN AUSTRALIA

SPECIES	TOTAL		PER CENT		NESTING HABIT B = burrow S = surface T = tree
	Minimum	Maximum	Minimum	Excluding Sh-t Shw*	
Little Penguin	166 643	292 047	0.97	3.83	B
Shy Albatross	6 900	8 500	0.04	0.16	S
Great-winged Petrel	33 050	84 100	0.19	0.76	B
Herald Petrel	3	3	0.00	0.00	S
Black-winged Petrel	3	3	0.00	0.00	B
Gould's Petrel	250	500	0.00	0.01	B
Fairy Prion	1 055 159	1 682 339	6.12	24.24	B
Wedge-tailed Shearwater	1 294 400	1 384 400	7.51	29.73	B
Flesh-footed Shearwater	105 150	311 150	0.61	2.42	B
Sooty Shearwater	596	1 210	0.00	0.01	B
Short-tailed Shearwater	12 888 692	16 389 062	74.75	-	B
Little Shearwater	27 060	61 540	0.16	0.62	B
White-faced Storm-Petrel	384 303	511 274	2.23	8.83	B
Common Diving-Petrel	129 220	184 020	0.75	2.97	B
Australian Pelican	1 021	1 701	0.01	0.02	S
Australasian Gannet	5 546	6 140	0.03	0.13	S
Masked Booby	3 752	4 270	0.02	0.09	S
Red-footed Booby	1 381	4 987	0.01	0.03	T
Brown Booby	59 923	73 840	0.35	1.38	S
Pied Cormorant	12 277	19 097	0.07	0.28	T / S
Little Pied Cormorant	142	197	0.00	0.00	T
Black-faced Cormorant	7887	9777	0.05	0.18	S
Great Frigatebird	1 607	1 611	0.01	0.04	T / S
Lesser Frigatebird	18 862	19 631	0.11	0.43	T / S
Red-tailed Tropicbird	294	381	0.00	0.01	S
White-tailed Tropicbird	0	2	0.00	0.00	T / S
Silver Gull	211 757	306 740	1.23	4.86	S
Pacific Gull	1 950	2 022	0.01	0.04	S
Kelp Gull	314	314	0.00	0.01	S
Caspian Tern	1 522	2 049	0.01	0.03	S
Roseate Tern	7 218	13 370	0.04	0.17	S
White-fronted Tern	44	44	0.00	0.00	S
Black-naped Tern	1 706	2 076	0.01	0.04	S
Sooty Tern	328 800	464 500	1.91	7.55	S
Bridled Tern	20 063	57 819	0.12	0.46	S / B
Little Tern	561	568	0.00	0.01	S
Fairy Tern	2 963	4 260	0.02	0.07	S
Crested Tern	82 685	115 635	0.48	1.90	S
Lesser Crested Tern	4 911	8 169	0.03	0.11	S
Common Noddy	174 500	214 100	1.01	4.01	S
Lesser Noddy	79 500	79 500	0.46	1.83	T
Black Noddy	119 500	132 000	0.69	2.74	T
TOTAL	17 242 115	22 454 948			

Source: derived from Ross et al. 1995 *Sh-t Shw = Short-tailed Shearwater

2.1 THE NUMBERS OF BREEDING SEABIRDS

Table 2.1 provides estimates of the numbers of pairs of each seabird species breeding on Australian islands (Ross et al. 1995). From this, it can be seen that the burrowing shearwaters, most notably the Short-tailed Shearwater, numerically dominate the Australian seabird fauna, comprising over 75 per cent of the total number of seabirds breeding on Australian islands. Even excluding the very abundant Short-tailed Shearwater, the other shearwaters still represent almost 60 per cent of the remaining breeding seabirds in Australia.

2.2 WHERE SEABIRDS BREED

Data have been obtained from a variety of sources on the numbers of seabirds breeding on islands off Australia (see appendix 1). These data were summarised for the eleven regions delineated by Ross et al. (1995), namely:

- Region 1: Cape Leeuwin to Shark Bay
- Region 2: Shark Bay to the Northern Territory border
- Region 3: Northern Territory and the Gulf of Carpentaria
- Region 4: Coral Sea
- Region 5: Cape York to the New South Wales border
- Region 6: New South Wales
- Region 7: Victoria
- Region 8: South Australia
- Region 9: SA–WA border to Cape Leeuwin
- Region 10: Bass Strait
- Region 11: Southern Tasmania

Table 2.2 provides a summary of the distribution of all seabirds by region around Australia.

Table 2.2
ABUNDANCE OF ALL BREEDING SEABIRDS IN AUSTRALIA BY REGION

REGION	MINIMUM	MAXIMUM
1. Cape Leeuwin to Shark Bay	1 609 628	1 770 996
2. Shark Bay to NT border	116 607	229 513
3. NT and Gulf of Carpentaria	35 614	44 114
4. Coral Sea	6 512	10 345
5. Cape York to NSW border	404 379	498 110
6. New South Wales	167 890	197 281
7. Victoria	2 066 558	2 083 293
8. South Australia	887 403	1 421 380
9. SA–WA border to Cape Leeuwin	161 569	443 167
10. Bass Strait	8 220 051	10 667 051
11. Southern Tasmania	3 565 904	5 089 698
TOTAL	17 242 115	22 454 948

Table 2.2 shows that the majority of breeding seabirds in Australia occur off Victoria and Tasmania. Notwithstanding this, there are significant populations of breeding seabirds off South Australia, in southern Western Australia (especially the Houtman Abrolhos) and on the Great Barrier Reef islands.

2.3 HOW SEABIRDS BREED

The breeding habits of Australia's seabirds are of interest because the vulnerability of seabirds to interference and disturbance from human activities differs depending on breeding habits.

2.3.1 Aggregations

Australia seabirds are, overwhelmingly, colonial breeders. They gather to breed on islands in numbers ranging from several pairs (e.g. Fairy Terns on the islands of Nooramunga in Victoria) to several hundreds of thousands (e.g. the Wedge-tailed Shearwaters of North West Island, central Queensland).

Seabirds breed mostly on islands and forage at varying distances offshore from the breeding islands. On any one island, there is usually a mix of breeding species. For example, in the Great Barrier Reef, based on data provided in King (1993), fourteen seabird breeding islands held one breeding species, fourteen held two species, fourteen held three breeding species, eight islands held four species, one island held five species and one held six species. One island (Raine Island) held eleven breeding species. This illustrates that most islands hold a mix of species.

These species usually occur in single species colonies, although it is not uncommon for some species (e.g. gull, some terns) to breed on the periphery of larger colonies of other species.

2.3.2 Nest Location

Seabirds choose a range of different breeding sites. Three broad classes of nesting habit have been identified for Australian seabirds:

- burrowing,
- surface nesting, and
- tree nesting.

There are variations on these themes but the three broad categories are useful from a management viewpoint. All burrowers and most surface nesters are obligate burrowers or surface nesters. However, the tree nesters will also nest on rocks and, rarely, on the ground (e.g. Pied Cormorant). Red-footed Boobies have been recorded nesting on shrubs and tussocks as well as in the more usual trees (Marchant & Higgins 1990), and Common Noddies regularly breed on top of dense shrubs or on grass tussocks, as well as almost at ground level on low herbaceous vegetation (Serventy, Serventy & Warham 1971).

The fact that one island can have seabirds that display two or more breeding habits means that an appropriate mix of management strategies will be necessary.

Most seabirds in northern Australia are surface nesters whereas most of those in southern Australia are burrowers. As figure 2.1 shows, the proportion of seabirds that are surface nesters decreases with increasing latitude (the latitude in this case being the latitude in the middle of the region in question). The reasons for this are both ecological (e.g. shelter from changeable weather) and taxonomic (e.g. the southern small to medium sized Procellariiformes are obligate burrowers). These systematic geographic differences in breading habit have implications for management discussed in chapter 6.

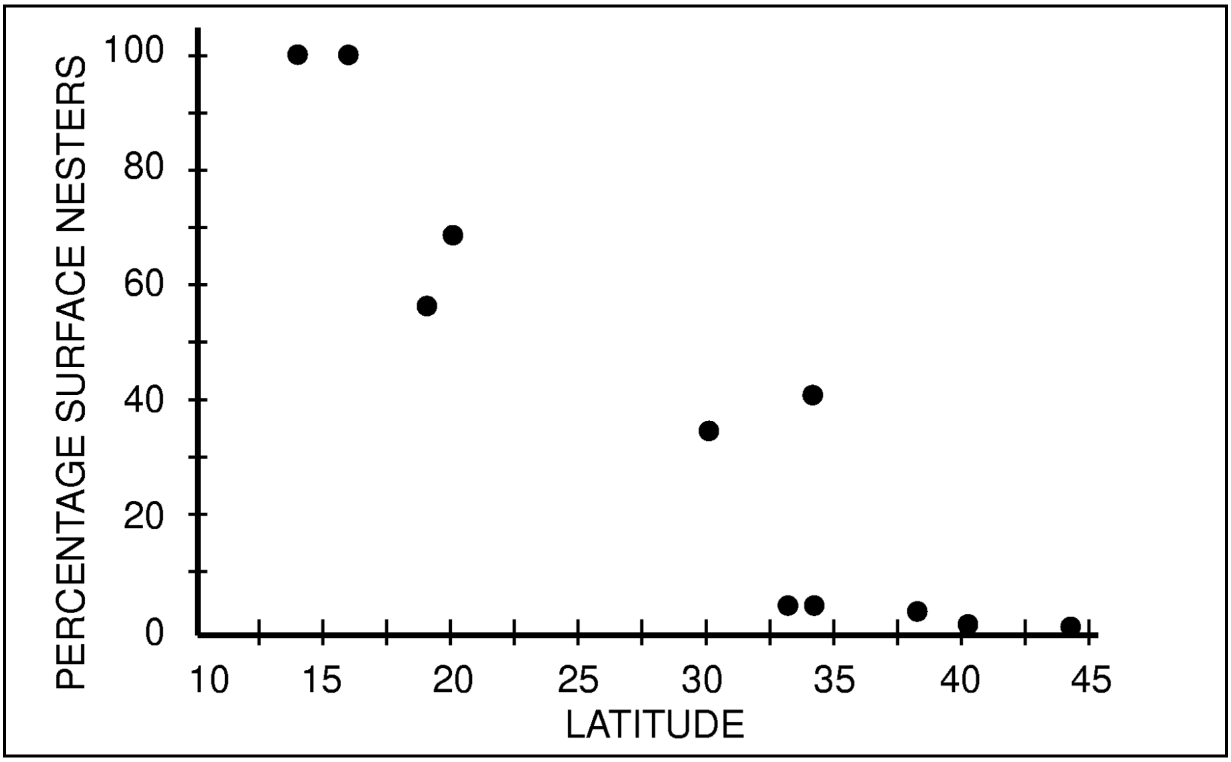

Figure 2.1
THE PROPORTION OF SURFACE-NESTING SEABIRDS IN COMPARISON WITH LATITUDE IN AUSTRALIA

2.3.3 Clutch Size

Seabirds generally lay between one and three eggs, with most laying one or two (see chapter 6). The burrow-nesting Procellariiformes generally lay one egg while the surface-nesting species lay two or three, although Australasian Gannet, Shy Albatross, some of the terns and the frigatebirds lay one egg. Seabird clutches are generally smaller than the clutches of other bird groups.

Laying so few eggs means that seabirds are generally unable to recover quickly from population declines due to disturbance or other chronic causes. Those species that have shown significant short- to medium-term recoveries (i.e. over 10–20 years) tend to have larger clutches (e.g. the terns and cormorants of the Great Lakes of North America (Blokpoel & Scharf 1991)). On the other hand, those species that lay two or more eggs might lose one to predation or some other influence related to disturbance yet still continue breeding. Species that lay one egg must start again (see below).

2.3.4 Replacement Laying

Australian seabirds fall into two groups: those that lay again if they lose a clutch; and those that will not lay again (see chapter 6). The first group tends to be the surface-nesting species with larger clutch sizes, while the last group tends to be the burrow nesters which lay one egg. As information in chapter 6 shows, there are exceptions to these two general groups. Species that lay one egg, and do not re-lay if this is lost, are particularly vulnerable to disturbance-related factors that cause egg or chick loss as they are not able quickly to recover in numbers. It is perhaps no coincidence that these species tend to be burrow or tree nesters, nesting habits that in themselves provide a degree of protection from predation, the usual cause of egg loss.

2.4 WHEN SEABIRDS BREED

Australian seabirds are generally seasonal breeders, with very little breeding activity occurring in the depths of the southern winter (June–July). Northern Australian breeders tend to have more extended breeding seasons than southern Australian breeders due to the persistence for longer in northern Australia of fine weather and the less highly seasonal nature of food supplies in more tropical latitudes (Nelson 1980). The most interesting documented example of non-seasonal breeding in Australia is the Sooty Tern on Michaelmas Cay which shows peaks in breeding numbers every nine months, regardless of the time of year (King, Hicks & Cornelius 1992) For related reasons, southern Australian breeders tend to show highly synchronous and predictable breeding activities. These differences have implications for the timing and intensity of management activities and the period over which a commitment to management is required, as discussed in chapter 6.

CHAPTER 3

The Vulnerability of Breeding Seabirds to Human Activities

Human disturbance of seabird breeding colonies has the potential to decrease juvenile recruitment into the population or to increase adult mortality. Since enough juvenile recruitment must occur in a population to ensure replacement of breeding adults lost through natural mortality, disturbance has the potential to wipe out breeding colonies, populations or even an entire species.

It is important to place human disturbance in perspective. There is no doubt that significant failures of seabird breeding attempts have occurred in Australia as a consequence of human disturbance. Indeed, the breeding of the Little Tern in south-eastern Australia has almost ceased – outside intensively managed colony sites in Victoria and New South Wales – due to human disturbance. The species is considered to be vulnerable as a consequence (Garnett 1992). A similar state of affairs affects the Fairy Tern in Victoria (B. Lane, WBM Oceanics Australia, pers. obs.). Human disturbance of seabird colonies in other countries has also significantly affected seabird breeding (Nelson 1980).

The breeding activities of seabirds are, nonetheless, sometimes characterised by quite high variability in natural mortality, particularly of chicks. Nelson (1980) provides examples of the normal level of mortality in seabird colonies. For example, Brown Boobies on Ascension Island in the Atlantic fledged 25 per cent of chicks that hatched while on Christmas Island in the Pacific, they fledged 81 per cent of chicks that hatched. Inclement weather and failure of food supplies due to shifts in ocean currents are the two greatest causes of breeding failure in seabirds (Nelson 1980) and both can lead to quite spectacular losses.

The consequence of this for management is that even with quite intensive management, breeding failure from time to time is inevitable, as is the natural loss of some chicks. While natural systems are more or less adapted to such losses, they cannot necessarily cope with additional losses resulting from human disturbance. Typically, major natural losses are episodic events which are well spaced in time, allowing populations to recover their numbers. Human disturbance can decrease the recovery time available by interposing additional major (episodic) losses, or can reduce or prevent recovery by adding ongoing, cumulative, small (chronic) losses.

General effects are listed below in order of their occurrence during the normal breeding cycle of nest establishment, egg laying and incubation, hatching, brooding and feeding of chicks, fledging and survival to breeding age:

- changes to ideal breeding habitat characteristics;
- deterrence from settling to breed;
- desertion of colony site by all or part of a breeding population;
- increased destruction or predation of eggs;
- increased mortality of young chicks from predation, exposure, trampling or disorientation;
- reduced number of young birds fledging; and
- reduced fledging weight, contributing to lower juvenile survival.

A range of factors contributes to the vulnerability of breeding seabirds to human disturbance. This chapter identifies and discusses these factors.

3.1 PHYSICAL/PHYSIOLOGICAL IMPACTS OF VISITATION ON BIRDS

The physical and physiological impacts of disturbance on seabird populations are discussed below and they involve a number of characteristics and responses, including:

- differences between species in sensitivity to disturbance;
- critical approach distances;
- desertion;
- shifts in colony distribution;
- delayed breeding;
- predation including human predation;
- exposure;
- 'stampedes';
- interruption to feeding; and
- stress effects and habituation.

3.1.1 Differences Between Species in Sensitivity

It has been commonly observed by seabird researchers that species differ in their sensitivity to disturbance. This has significant implications for managing visitation. A questionnaire (see appendix 2), circulated to people with experience in working in and managing seabird breeding areas, provided the opportunity for respondents to rate species based on their sensitivity to disturbance. The responses to the questionnaire on relative levels of sensitivity to disturbance are summarised in the species tables in chapter 6. These judgements were necessarily subjective, but the combined analysis did reveal some patterns that represent the pooled experience of a large proportion of Australia's seabird experts.

The most obvious distinction is between surface-nesting and burrow-nesting seabirds. Little information was available on tree-nesting species other than the frigatebirds. Not unexpectedly, burrow nesters were considered to be most affected by human activities where trampling and collapse of burrows occurred. Other than burrow collapse and predation, few of the effects described below affect burrow-nesting seabirds. This has significant consequences for management, described in chapter 6.

Based on these results, which cover only about half of the seabirds breeding in Australian waters, some consistency in response was found for some species. The most sensitive species indicated by respondents were the surface nesters, especially the Roseate Tern. Other 'very to extremely sensitive' species were Caspian Tern, Australian Pelican, Black-naped Tern, Bridled Tern and Little Tern. The tree-nesting frigatebirds were also considered to be 'extremely to very sensitive' at some places.

The questionnaire also asked respondents to provide information on specific examples they had observed of human disturbance at seabird breeding colonies distinguishing between surface nesters and burrowers. The results are provided in table 3.1.

These results show that by far the most frequently observed disruption occurs to surface-nesting seabirds as a consequence of the presence and/or approach of people and of burrow-nesting seabirds as a result of the trampling of burrows.

Table 3.1
QUESTIONNAIRE RESPONSES ON OBSERVATIONS OF PARTICULAR DISTURBING ACTIVITIES

Human Activity Causing Disruption	Surface or Burrow Nester?	Number of Respondents Observing Activity
Presence or approach (incl. walking, picnics, camping, fishing etc.)	surface burrow	28 4
Trampling	surface burrow	3 22
Handling adults/young	surface burrow	4 3
Ignorance of presence of breeding seabirds	surface burrow	3 4
Hunting/taking for food	surface burrow	3 2
Dogs with visitors	surface burrow	3 2
Lights on buildings	surface burrow	1 1
Feral cats	burrow	2
Fires	burrow	2
Helicopter flights/landings	surface	2
Buildings	burrow	1
Camera equipment and lights	surface	1
Too many people	surface	1
Research activities	surface	1
Vehicles	surface	1
Torches/spotlights	burrow	1
Rats	surface	1
Noise	surface	1
Fixed-wing aircraft	surface	1

3.1.2 Critical Approach Distances

The first obvious sign of disturbance in seabird colonies is when birds fly or walk away from their nests, exposing the eggs and young. Many of the mechanisms by which disturbance reduces juvenile recruitment occur as a direct consequence of this exposure (see section 3.1.6). Naturally, this impact is limited to surface- and tree-nesting species. Burrow-nesting seabirds are not susceptible to human approach during the day, unless trampling of burrows occurs.

There are critical approach distances at which surface-nesting seabirds will fly from their nests at colonies. Different species show strong differences in sensitivity to human disturbance. Erwin (1989) looked at this critical distance for a number of tern species in eastern North America and found the average distance to which people could approach before the first terns took flight varied depending on the species from 50 to 150 metres. Studies by Rogers and Smith (1995) showed that the approach distance for mixed tern colonies in Florida (USA) was about 180 metres. The most sensitive species took flight at the approach of a person to within 300 metres. Work on the Brown Pelican in California (Anderson 1988) shows that detrimental effects to breeding birds can result from approaches as far away as 600 metres or more. At the other extreme, work by Ollason and Dunnet (1980) on the Fulmar off Scotland revealed that some individuals stayed on their nests while researchers weighed and measured eggs and young from under them.

Very little other systematic work has been done on critical distances for other breeding seabirds, particularly in Australia. Experience in the Capricorn and Bunker Groups in the southern Great Barrier Reef (Hulsman 1984) suggests that 80 metres is the critical distance for Black-naped Terns which are considered to be one of the more sensitive surface nesters on tropical islands.

At two islands in Western Australia, critical approach distances for Bridled Terns have been compared (J.N. Dunlop, pers. comm.). At Penguin Island near Perth, birds flew off nests at the approach of people to an average distance of between 1 and 2 metres, whereas at Bridled Island off northern Western Australia, they flew at an average distance of about 4 metres. This difference is attributed to habituation to people as over 80,000 people visit Penguin Island each year. Bridled Island, on the other hand, is remote and infrequently visited.

More subtle differences may exist between individuals of the same species. Ollason and Dunnet (1980) found that in Fulmars, older, more experienced adults were less likely to leave their nests at the approach of an observer than younger breeders (< 3 years' breeding experience). Studies of breeding success in cliff-nesting auks in the northern hemisphere have shown that egg loss from panic among birds can be greater in smaller aggregations that are more prone to panic flights. Panic flights lead to eggs being knocked off cliff nests. Larger aggregations of birds were less prone to panic so egg loss was lower and breeding success greater (Nelson 1980).

Colonies can show spontaneous flights or panic reactions due to a whole range of natural disturbances (e.g. sea-eagles, peregrine falcons) or for no apparent reason at all. These disturbance events tend not to last as long as the equivalent event induced by human disturbance but they still lead to some of the effects described in the remainder of this section.

Tree-nesting species show perhaps the greatest variation in sensitivity to disturbance. Frigatebirds at Raine Island will leave their nests at the approach of a person within 50 metres and take up to 30 minutes to return to the nest (Smyth 1991). Black Noddies are known to sit on their nest until touched (Smyth 1991). Hulsman (pers. comm., October 1995) found that this approachability depends upon their location, and that Smyth's statement is accurate for birds in areas frequented by people or machines e.g. helicopters on Heron Island, however, birds in less disturbed areas are less approachable. In some places, e.g. Raine Island, Red-footed Boobies will remain on their nest until a person approaches to within 1.5 to 2 metres (Smyth 1991).

Significant differences in critical approach distances can occur for no apparent reason. For example, Red-footed Boobies on Ashmore Reef, off northern Western Australia, fly at the approach of people to within 50 metres while on the Coral Sea Islands, they can be touched while sitting on the nest (G.D. Pike, pers. comm.).

The critical distance used by managers elsewhere (Buckley & Buckley 1976), and one which seems to be borne out as the distance that will avoid disturbance to most seabirds is 300 metres (Erwin 1989). Closer than this can cause disturbance to some species of sitting seabirds, although many species will tolerate a much closer approach.

As critical approach distances vary between and within species and between sites, it is important to gear management of visitation to the particular circumstances of the island concerned. Some preliminary observations on critical approach distances at an island are necessary before any management prescriptions can be formulated for a particular setting.

3.1.3 Desertion

The results of the questionnaire (see appendix 2) responses, together with experience elsewhere has indicated that seabirds are generally more sensitive to disturbance in the early parts of the breeding cycle. If complete abandonment of nests occurs, it generally happens in the early part of the breeding cycle (Hockin et al. 1992), thus indicating that this is generally the most sensitive time for many species. In particular, birds will not commence breeding if disturbance occurs at the time of courtship. Regular disturbance at this time can prevent a significant portion of a colony from establishing (e.g. see Hobson & Hallinan 1981).

Disturbance in the first half of incubation can lead to desertion (Anderson & Keith 1980; Pierce & Simons 1986; Anderson 1988) (see tables in chapter 6 for incubation periods). However, susceptibility to desertion during early incubation shows strong differences between species, as indicated by many questionnaire respondents.

If disturbance becomes very heavy, many seabird species will cease to use a site and choose alternatives. As disturbance increases a higher proportion of nests are abandoned (e.g. Piatt et al. 1990). There are many examples of terns using dredge spoil islands as alternatives in regions where their natural breeding sites have become heavily disturbed (e.g. Buckley & Buckley 1976).

Terns are particularly prone to moving colony site if the current site becomes unsuitable, either due to food fluctuations, tidal flooding or disturbance. The Fairy Tern bred for many years in Port Phillip Bay, Victoria at one managed undisturbed site (Victorian Wader Study Group, pers. comm.). All other sites were unsuitable due to regular disturbance.

This tendency for terns to make successive breeding attempts at a number of sites in an area exacerbates the problems of managing human visitation as it means that human access may need to be controlled at a site unpredictably, something that can cause ill will among the public if visitation has been anticipated to a particular place at a pre-booked time.

3.1.4 Shifts in Colony Distribution

A more subtle effect related to disturbance has been observed in some cases. This has involved consistent disturbance leading to a shift in the distribution of a seabird breeding colony at a site. This has occurred at Taiaroa Head, near Dunedin (New Zealand), where after construction of a new observatory, first breeders have not settled near the observatory. A gradual shift of the colony away from the disturbance has resulted in many new pairs breeding in suboptimal breeding sites where exposure to adverse weather has reduced breeding success.

At Michaelmas Cay (QNPWS, pers. comm. to GBRMPA), Sooty Terns deserted part of a colony in response to a helicopter landing and moved to breed on a part of the cay that was subsequently eroded by the sea, causing nesting failure.

3.1.5 Delayed Breeding

Disturbance leading to significant losses of eggs can lead to adults attempting to breed for a second time (Anderson & Keith 1980). The period in which this could occur varies between species, with many species unable to do so at all (see chapter 6). The breeding success of seabirds that breed later due to disturbance has been found to be lower (Anderson & Keith 1980). This may be due to a range of factors as discussed below.

Adults may have already expended considerable energy on nesting activities before having to recommence and, depending on food availability, may not have sufficient reserves to meet the demands of the extended breeding cycle. Many albatrosses, petrels and shearwaters engage in a pre-breeding exodus from the breeding site for up to two weeks (Warham 1962) and this is thought to be to rich feeding grounds where they build up their reserves in preparation for breeding (Ollason & Dunnet 1980). A forced second breeding attempt may be initiated without this period of reserve build up.

The late-laid eggs of some seabirds are less likely to hatch successfully (e.g. Fulmars (Ollason & Dunnet 1980)). The extent to which this applies to all species is not known. Eggs laid at the beginning of a second breeding attempt may not hatch as successfully because the female's reserves have been depleted by the first attempt and the egg does not have sufficient reserves. Alternatively, the reserves of the incubating bird may be lower at the commencement of a second incubation period. This may result in poorer incubation (Nelson 1980) possibly because the bird may need to leave the egg to feed more often, increasing the chances of predation or exposure to adverse temperatures.

3.1.6 Predation

Most island-breeding seabirds are colonial and breed synchronously in aggregations of pairs. Synchronisation is thought to be an adaptation to the timing of sufficient suitable food supplies but breeding in aggregations also provides a group defence against predators, notably other avian predators (e.g. gulls). The aggregation of birds at seabird colonies therefore provides a rich, episodic food supply for a range of predators.

Predation of adults, eggs and young birds can occur at breeding islands. Eggs and chicks are particularly vulnerable to predation, although adult birds are often taken as well. When the adult is disturbed from its nest, it leaves the eggs or young unprotected from predators that may be less timid than the breeding species. The predator will reach the nest before the breeder returns and destroy most of the nest contents, causing the complete failure of a pair's annual breeding attempt.

Studies of the Fulmar (Ollason & Dunnet 1980) indicate that more experienced breeders (> 3 years' breeding experience) had a greater tendency to remain on their nests at the approach of a person than the less experienced ones. Thus, older breeders are probably less likely to fail in their breeding attempts due to predation than younger birds.

The ways in which predation can be increased through human disturbance are described below. A discussion of predation by exotic predators is given in section 3.2.2. The impact of these predators can be exacerbated for the same reasons described below.

Predation by Other Bird Species
Gulls are probably the most common predator of eggs and young seabirds in island colonies. It is common for gulls that have found food to attract many other gulls and this can rapidly escalate a minor disturbance into a major mortality incident (Anderson & Keith 1980).

In tropical areas, frigatebirds also take young. Nelson (1980) describes the activities of 50 to 100 frigatebirds at a breeding colony of Sooty Terns at Christmas Island in the Pacific Ocean. They took so many chicks that only 25 survived from an initial 600,000 eggs laid (cats and human disturbance were also involved).

On Cabbage Tree Island, off New South Wales, Pied Currawongs that live in the island's small forest regularly take adult Gould's Petrels on exposed nests (Priddel & Carlile 1995). Crows and Ravens have also been recorded taking adult seabirds as well as their eggs and chicks (B. Lane, WBM Oceanics Australia, pers. obs.)

Observations of species of a range of sizes (e.g. auklets (Piatt et al. 1990), pelican (Anderson & Keith 1980)) show that after a certain age, usually as they approach a size similar to the predator, chicks are able to defend themselves from most of these attacks. However, some gulls have been observed attacking pelican chicks until the chicks regurgitated fish, thereby diverting the attacker. On occasion, gulls also removed the eyes of the young pelican or, more often, the uropygial gland / entrails until the chick died (Anderson & Keith 1980).

In the White-faced Storm-Petrel, a burrow-nesting species of temperate Australia, adults are particularly vulnerable to predation by gulls at dusk when they return to the colony. On moonlit nights they will wait offshore until a cloud obscures the moon before returning in darker conditions when it is presumably harder for gulls to detect them (B. Lane, pers. obs.). The extent to which adults of larger burrowing species are predated by gulls in this manner is not known.

Predation by Indigenous Predators

One of the reasons seabirds breed on islands is to escape predation from the wide range of potential native predators on the Australian mainland. Notwithstanding this, there are still islands with populations of native predators. Perhaps the most famous of these in southern Australia are the various forms of the tiger snake (*Notechis ater* subspp.) that live on islands. On Flinders Island in Tasmania and Franklin and Hopkins Islands in South Australia, they feed almost exclusively on Short-tailed Shearwater, while on Revesby Island in South Australia, they feed mostly on White-faced Storm-Petrels (Mirtschin & Davis 1992).

Such predators are part of the normal environment of seabirds in Australia. However, normal seabird defences against such predation are likely to fail during disruption by human disturbance and interference.

Infanticide by the Same Seabird Species

It is not uncommon for wandering chicks to be attacked and killed by unrelated adults of the same species in the crowded conditions of a surface-nesting seabird colony (Gillett, Hayward & Stout 1975; Anderson & Keith 1980; Hand 1980). This is particularly prevalent among gulls. Occasionally chicks stray from their nests into the territories of adjacent breeding pairs and are attacked. Much higher numbers of chicks wander, or indeed flee, from their nests in the confusion created by human disturbance. This can significantly increase chick mortality and reduce juvenile recruitment.

Human Predation

Humans have exploited seabird colonies on islands for centuries as a source of food and natural materials. In the Gulf of California in Mexico, the Seri Indians of Sonora exploited seabirds on accessible islands for meat and skins (Anderson & Keith 1980). Several species of petrels were made extinct by the first human settlers of the Chatham Islands, off New Zealand, the Marioris, who ate seabirds and fish (Nelson 1980). The Marioris were subsequently themselves eaten by the more warlike Maoris.

Off the coast of Arnhem Land, Aboriginal people make trips to islands to collect seabird eggs which are considered to be a delicacy (R. Chatto, Parks and Wildlife Commission of the Northern Territory, pers. comm.). Similar harvesting by Torres Strait Islander people has lead to a decline in seabird numbers on Bramble Cay in Torres Strait (King 1993). Recent increases in affluence amongst indigenous peoples have lead to a move away from traditional technologies for hunting and the use of modern devices such as motorised boats and helicopters. This is likely to lead to greater efficiency of harvesting and, without proper control, to reductions in breeding seabird populations.

In Australia, since European settlement, seabirds have been exploited in Tasmania (the ‘Mutton Bird’ industry). A famous example of human predation on seabirds is the decline of the Cat Island gannetry in Bass Strait (Warham 1979), where a colony of several thousand gannets was reduced to nothing by the 1980s by commercial fishermen shooting adults and taking chicks as fishing bait.

3.1.7 Exposure

In surface-nesting seabirds, eggs and young are exposed to weather when the adult leaves the nest. Anywhere in Australia during the usual breeding seasons of seabirds (see chapter 2), the weather can be either cool or hot, wet or sunny. Any of these conditions can kill eggs and young if they are exposed to them for too long. Heat stress can arise quite suddenly and be difficult to stop once it sets in. As a consequence, there is considerable scope for causing mass chick mortality if adults stay away from the nest for too long. Chicks are usually most susceptible to hypo- or hyperthermia in their first three to four weeks after hatching (Nelson 1980).

3.1.8 ‘Stampedes’

In many instances, disturbance of surface-nesting seabirds leads to mass panic in the colony. In the larger, heavier birds that cannot take flight immediately, such as pelicans, cormorants and boobies, this can lead to trampling of eggs and small young by adults and larger chicks, leading to significant mortality (e.g. Anderson & Keith 1980; Hobson et al. 1989 in Hockin et al. 1992).

Similar panic can lead to chicks being impaled on sharp vegetation in the colony area (Anderson & Keith 1980) or other structures (Saliva & Burger 1989) or running into the water where they become prey for fish, gulls, frigatebirds and other opportunistic predators (D. O’Daniel, US Fish and Wildlife Service, pers. comm.).

‘Stampede’ reactions can lead to young chicks being attacked, injured and, in many cases, killed by adults of the same species. The confusion created by ‘stampede’ reactions can separate chicks from their parents. This has been found to be a potentially serious problem in Sooty Terns in the early post-hatching period before parent–offspring recognition has established (D. O’Daniel, US Fish and Wildlife Service, pers. comm.). In this case, lost chicks are taken by predators or starve to death.

3.1.9 Interruption to Feeding

Disturbance can result in a range of interruptions to feeding routines and food-intake rates. Disturbance of chicks also often leads to regurgitation of recently ingested food brought to them by adults. These effects can reduce chick growth rates (Pierce & Simons 1986) or, in extreme cases, lead to starvation.

Studies have shown that the farther away from the breeding colony the parent birds have to obtain food then the less frequently they feed their chick. Wandering Albatrosses feed their chick about once every 3.5 days, Atlantic Gannets about twice per day and some of the terns about once per hour (Nelson 1980). Disturbance leading to regurgitation of the chick’s last meal can, therefore, affect different species differently, although the likelihood of meal loss is probably lowered in species that are fed less frequently because of the long periods when no digestion is occurring.

Young seabirds are capable of ingesting seemingly enormous quantities of food at one sitting yet are equally capable of withstanding quite long periods of food deprivation if the adults have trouble finding food (Nelson 1980). Fasts of three and four weeks have been survived by older chicks of the larger species. Therefore, interruptions to feeding routine due to irregular disturbance are unlikely to cause an immediate problem. The problem may arise later in the breeding cycle, as explained below.

The survival of young seabirds in the early months after leaving the colony can be related to their weight when they leave the nest (e.g. Little Penguin (Reilly & Cullen 1982)). This is most probably because young birds at this time learn where and how to obtain food at sea. Estimates for mortality of juvenile seabirds once they leave the colony are generally high (e.g. 75 to 95 per cent, Nelson 1980). To assist the young in this difficult stage of life, adult seabirds feed their chicks well, often until they weigh more than themselves. Some burrow-nesting Petrel chicks reach twice the weight of the adult before leaving the colony (Nelson 1980). Regular disturbance that leads to significant interruptions to the feeding routine could significantly affect departure weight and therefore juvenile survival and recruitment into the adult, breeding population.

Disturbance of adults while feeding can lead to their shifting to less preferred feeding areas with potential impacts on breeding success through reduced food availability (Burger 1988 in Hockin et al. 1992).

Responses of birds to disturbance often involve activities which are energetically costly (e.g. flying) and this can reduce the effectiveness of foraging by adults, with consequent impacts on the survival of young (Hockin et al. 1992).

Another impact of disturbance on breeding birds at their feeding areas is that they may have to fly significant distances to find alternative feeding areas. This has ramifications in terms of their energy and the time available for feeding.

3.1.10 Stress Effects and Habituation

Concern about human disturbance to seabirds often focuses on birds taking flight at the approach of humans. The foregoing accounts of disturbance impacts relate to this type of reaction. In fact, more subtle effects may be taking place at greater distances than the critical approach distance.

Studies of Antarctic penguins (Wilson et al. 1991) and frigatebirds on the Galapagos Islands (Tindle 1979) show that although these birds do not appear perturbed by the approach of humans, they are stressed, as indicated by significant increases in heart rate. The consequences of this for juvenile recruitment and survival are unknown but frequent stress has the potential to disrupt normal activities. Jungius and Hirsch (1979 in Hockin et al. 1992) found that in response to someone walking toward them, Waved Albatross, Blue-footed Booby and Magnificent Frigatebird showed increased heart-beat rate before birds showed any change in behaviour.

There are often references to breeding seabirds having become ‘habituated’ to a particular disturbance. This is a term that is generally used in a non-scientific fashion, and usually means that the observer did not see any overt response to what would normally be regarded as a significant disturbance. In very few situations has there been any scientific study to determine whether the disturbance has led to any reduction in breeding success, or whether the disturbance is causing any physiological stress to the birds involved.

While there is no doubt that many species of birds can become so accustomed to a range of disturbances that they are no longer affected by them, it is not safe for conservation managers to assume in the absence of evidence either that a lack of overt response means no adverse impacts, or that a species will be able to become habituated to a proposed activity. Furthermore, perceived habituation alone should not be used as a basis for reducing critical approach distances.

3.2 ECOLOGICAL IMPACTS OF VISITATION

Human visitation can lead to ecological changes that are detrimental to breeding seabirds through a number of mechanisms, including:

- introduction of exotic plants,
- introduction of exotic animals, and
- trampling and vehicle activity.

These are described below.

3.2.1 Introduction of Exotic Plants

Visitors to seabird islands can introduce a range of plants as food or as seeds in their clothing, footwear or chattels. These plants can sometimes survive the conditions on offshore islands and establish themselves in areas where seabirds breed. For many seabird species, the structure of the vegetative cover of islands is critical to breeding activities. The introduction of exotic plants can have a number of effects on seabird breeding. The range of possible effects on seabird breeding islands are summarised for different introduced plant classes in table 3.2.

Many surface-nesting species require areas of ground on which to nest that are relatively bare or covered in low, sparse to medium density vegetation. These more open areas are susceptible to weed invasion and the introduction of new plant species can upset the balance of vegetation and bare ground that is available to breeding birds. Weed invasion has been responsible for the elimination of seabird breeding habitat on Pearl and Hermes Reefs in the Pacific Ocean (US Fish and Wildlife Service 1994).

Table 3.2
POSSIBLE IMPACTS OF INTRODUCED PLANTS ON SEABIRD ISLANDS

PLANT TYPE	CONSEQUENCE FOR VEGETATION	CONSEQUENCE FOR SEABIRDS
Herb/Forb	Increased ground cover Reduced recruitment of shrubs and trees Increase in shallower-rooted plants leading to less consolidated soil and greater erosion	Reduced open ground for surface-nesting seabirds Gradual reduction in shrubby cover and shade for chicks Erosion of burrowing substrate Greater incidence of burrow collapse
Shrub	Increased ground cover Reduced tree recruitment Increased shade and perching positions for predators	Reduced open ground for surface-nesting seabirds Gradual reduction in tree-nesting sites Greater predator efficiency through better visibility or concealment Changes in soil structure with consequences for burrow-nesting species
Tree	Increased shade and vegetation cover Increased perching and nesting sites for predators Reduced shrub and ground cover Greater vulnerability to loss of vegetation during storms leading to post-storm erosion	Reduced open ground for surface nesters Increased tree-nesting sites Greater predator efficiency through better visibility or concealment Erosion of burrowing substrate after storms

In southern Australia, some Short-tailed Shearwater breeding colonies have been severely affected, and in some cases eliminated, by introduced weeds. The introduced annual species die back in winter, exposing soil to erosion and removing burrowing substrate, or leading to an increase in burrow collapse (Marchant & Higgins 1990). This species has also stopped breeding in areas that have become colonised by introduced plants that are dense and impenetrable, such as boxthorn, blackberry or kikuyu grass (Marchant & Higgins 1990).

The introduction of species of plant that prevent the regeneration of trees used by tree-nesting seabirds would lead to a gradual reduction in nest sites for these species. The different root systems of some weeds could change the nature of soil and its consolidation on islands, leading to increasing difficulties for burrow-nesting seabirds.

3.2.2 Introduction of Exotic Animals

The vulnerability of islands to introduced animals is well known. They can lead to changes in vegetation, increased disease and increased predation pressure, particularly on eggs and vulnerable young birds.

Introduced rabbits at Phillip Island, near Norfolk Island denuded vegetation cover and eventually resulted in the erosion of a lot of soil from the island, removing a significant proportion of the breeding habitat for burrow-nesting seabirds. Rabbit control programs on some Victorian islands have lead to the recolonisation by breeding Short-tailed Shearwaters of regenerated areas (Norman & Harris 1980). Rabbits may also affect surface- and tree-nesting species through their impacts on vegetation (e.g. Harrison 1990).

Cattle graze in and trample the breeding areas of Common Diving-Petrels on the Falkland and South Georgia Islands (Croxall et al. 1984). Grazing on Victorian islands also leads to the destruction of Short-tailed Shearwater burrows (Harris & Norman 1981). Grazing of islands off South Australia by sheep and goats in the early part of the twentieth century resulted in significant trampling of burrows in exposed positions (Wood-Jones 1937). Such areas have since been made reserves and grazing animals have been removed (Blakers, Davies & Reilly 1984).

The introduction of a mosquito species on Midway Island, in the Pacific Ocean, caused avian pox virus to spread among seabirds in epidemic proportions (Harrison 1990; US Fish and Wildlife Service 1994).

Perhaps the greatest potential problem for breeding seabirds from exotic animals arises from the introduction of predators, particularly dogs (*Canis familiaris*), foxes (*Vulpes vulpes*), cats (*Felis cattus*) and rats (*Rattus rattus, Rattus norvegicus*).

On Ashmore Island in the Indian Ocean, G. Pike (pers. comm.) reports that where rats have been eliminated on West Island, the bushes such as *Sesbania cananiba* have become much more widely established due to the seed stocks not being eaten. On East and Middle Islands, each with a fluctuating population of mice (*Mus musculus*), the *Sesbania* bushes are sparse. This is of importance to seabirds, as the *Sesbania* offers Black Noddies the only viable nesting sites available to them on East and Middle Islands, as frigatebirds occupy all other sizeable bushes.

There are many instances of seabirds being taken by introduced predators (see review by Burger and Gochfeld (1994)). A particularly well known one is the loss of Little Penguins at the Phillip Island Penguin Parade in Victoria to foxes, dogs and cats (Reilly 1977).

In some instances (e.g. Common Diving-Petrel on Macquarie Island (Rounsevell & Brothers 1984)), some seabirds have become confined to small offshore islands and stacks that are free of introduced predators.

There is one instance, the case of the Guadalupe Storm-Petrel on Isla Guadalupe off the western Mexican coast, where predation by feral cats lead to the extinction of a species (Everett & Anderson 1991).

Cats are particularly effective predators, although smaller, burrowing species have burrows too narrow for cats to enter (e.g. Fairy Prion (Marchant & Higgins 1990)). Notwithstanding this, predation can be heavy when the birds first arrive on the colony at dusk.

Smaller seabirds are particularly vulnerable to predators, as are eggs and young chicks. The White-faced Storm-Petrel on the Furneaux Group, in Tasmania, suffers higher mortality and loss of eggs and chicks due to the introduction of rats (Marchant & Higgins 1990).

Studies at Christmas Island in the Indian Ocean (Stokes 1988) show that the populations of introduced predators can be limited in some settings due to competition from indigenous animals, thereby reducing their impact on breeding seabirds. However, for any particular island, there is no guarantee that an exotic animal will be limited in this way.

3.2.3 Trampling and Vehicle Activity

Trampling and vehicle activity on offshore islands can have a range of effects. In most instances, offshore islands have few well formed roads so walking and occasional off-road vehicle movement occurs across rough country where seabirds often breed. There are few documented examples of problems but from basic principles, it is possible to predict likely effects.

Trampling and vehicular traffic can lead to the localised denudation of vegetation cover and consequent erosion of soil. Soil erosion can reduce burrowing substrate and, during heavy rainfall, lead to the flooding and deposition of sediment in downslope breeding areas, changing vegetation and soil structure and possibly even disrupting current breeding activities.

Trampling of burrows has been reported in a colony of White-faced Storm-Petrels on Mud Island, near Melbourne (Marchant & Higgins 1990), which is accessible to large numbers of people.

PART TWO

Developing and Implementing Appropriate Management Measures

CHAPTER 4

Valuing Seabird Breeding Aggregations

Clearly there is not one single set of guidelines applicable to all seabird breeding islands. Many of the controls that might be put in place will vary in their stringency according to the value that is placed on the aggregations of breeding birds. A colony of Fairy Terns has a different value in the eyes of most people to a few pairs of breeding Silver Gulls, for instance. As a result, managers would apply different guidelines to the management of the Fairy Tern breeding site from those applied to the Silver Gull breeding site.

It is not possible to develop specific guidelines for managing visitation to a seabird breeding island until the values of the site have been defined. Managers are encouraged to develop clear and concise values statements for each seabird breeding island before attempting to prepare management guidelines. Box 4.1[1] gives examples of the values statements developed as part of the management of Raine Island on the outer edge of the Great Barrier Reef.

Managers of seabird breeding islands need to be aware that the 'defensibility' of a set of controls will be a product of the quality of the values statement and the evidence backing the individual control measures.

There is, however, no simple approach to placing a value on seabird breeding islands. The basis for valuing sites will be likely to vary from one management agency to another.

4.1 APPROACHES TO VALUING SEABIRD BREEDING

Broadly speaking, aggregations of breeding seabirds can be valued according to:

- the threat status of the species involved (rare, vulnerable etc.);
- the overall size of the colony (total number of breeding pairs) or the number of pairs of a particular species;
- the number of breeding species present;
- whether or not a species is breeding at its biogeographic limit;
- whether breeding aggregations of a particular species are common in the country, region or locality;
- the distance to other significant colonies of a particular species;
- the education / awareness opportunities at the site;
- tourism opportunities at the site; and
- the value of the aggregation of breeding species as a flagship or icon for conservation in the region / locality.

These values are considered in the rest of this section.

Not all of these values are likely to be present at any one site, and in fact some of the values are likely to be incompatible in a practical sense. For example, breeding colonies of species with a high threat status are unlikely to have high tourism values.

[1] Box 4.1 is from Claridge, G.F. 1995, *A Risk Assessment for Raine Island and Environs in Relation to Values of the Natural and Cultural Environments*, Consultancy report for Raine Island Corporation, Brisbane. References have been removed from the values statement. Reproduced with the permission of the Raine Island Corporation.

Box 4.1
SEABIRDS/LANDBIRDS – VALUES AT RAINE ISLAND

- Raine Island is the most significant seabird breeding location in the Great Barrier Reef region and possibly in Queensland.

- Herald Petrel (*Pterodroma arminjoniana heraldica*). Fewer than ten pairs of this species breed at Raine Island. However, this is the only Australian nesting site for what is regarded as a subspecies of the Trinidade Petrel (*P.a. arminjoniana*). Though the bird was first described from specimens collected at the Chesterfield Islands in the eastern Coral Sea during the last century, there have not been any further sightings in the Coral Sea. Other colonies of at least 250,000 birds occur elsewhere in the South Pacific.

- Raine Island is a major seabird roosting site for the north-west Coral Sea.

- Raine Island has the northern-most breeding colony of the Wedge-tailed Shearwater (*Puffinus pacificus*) which prefers south-tropical and subtropical waters. A reliable census is required to assist in an interpretation of the significance of this colony.

- With the exception of a few pairs at Moulter Cay, the population of Red-footed Booby (*Sula sula*) at Raine Island is the only one in the Great Barrier Reef region. Raine Island is the only cay on the Great Barrier Reef continental shelf edge with vegetation suitable (though not optimal) for nesting Red-footed Boobies from the northern Coral Sea.

- The Raine Island colony of Masked Booby (*Sula dactylatra*) is the largest in the Coral Sea and Great Barrier Reef region by a significant amount. On the Great Barrier Reef, nesting is restricted to a few outer cays.

- The Raine Island colony of Brown Booby (*Sula leucogaster*) is one of three principal colonies in eastern Australia. The fact that it is geographically remote from the other colonies has positive implications for survival of the species. The other colonies are in the Gulf of Carpentaria (Wellesley Islands) and the southern Great Barrier Reef (Bunker Island Group).

- The Raine Island colony of Least [Lesser] Frigatebird (*Fregata ariel*) is the only large colony in the Great Barrier Reef region and is one of only a small number of large Australian colonies. It is widely separated from other colonies.

- With the exception of a small number of pairs at Lady Elliot Island, the population of Red-tailed Tropicbird (*Phaethon rubricauda*) at Raine Island is the only one on the Great Barrier Reef. On the basis of limited evidence this colony appears to be approximately the same size as the large Coral Sea colonies.

  Raine Island is the only Great Barrier Reef continental shelf edge cay with sheltered sites for nesting Red-tailed Tropicbirds from the Coral Sea.

- The Raine Island breeding colony of Common Noddies (*Anous stolidus*) is one of three principal colonies in the Great Barrier Reef region.

- Of the seven shelf edge islands available to breeding Noddies, Raine Island is the largest, least subject to storm overwash and erosion, has the most developed vegetation, and (with the nearby Moulter Cay) is the northernmost and closest to the northern area of the Coral Sea.

- Raine Island is the only large concentration of breeding Rufous Night Herons (*Nycticorax caledonicus*) on an offshore island in Queensland. The colony has a special predatory relationship with the turtle hatchlings.

- The massed breeding seabirds are a flagship group for conservation. Images of the mass nesting are highly symbolic of the special nature of the area.

- The Raine Island birds and their mass nesting are of high human interest, both direct and vicarious.

- The birds and their ecology have very significant educational values.

- The existence of a long-term data set on the bird populations on Raine Island has special significance.

No comment is made on the worthiness of any of these bases for valuing seabird breeding aggregations. The basis for valuation is a matter for managers and the communities which they serve.

The following brief explanations of these potential values of seabird breeding are not meant to be an exhaustive treatment of the topic. Managers will need to refer to other sources and to have access to local, regional and national data in order to compile values statements for a particular site.

4.1.1 Threat Status

This section summarises information on the seabirds in Australia considered by Garnett (1992) to be rare, threatened or of special concern. The major threats to the species both in Australia and worldwide are described.

The classification of rarity used by the Royal Australasian Ornithologists Union in its report on threatened and extinct birds of Australia (Garnett 1992) is used here. This classification includes:

Endangered
- species and subspecies that are in danger of extinction and whose survival is unlikely if the causal factors continue to operate.

Vulnerable
- species of which most or all of the populations are decreasing due to over-exploitation, loss of habitat or other environmental disturbance and believed likely to move into the ‘endangered’ category if causal factors continue.

Rare
- species with small populations that while not ‘endangered’ or ‘vulnerable’ are threatened. Such species usually have a restricted distribution or are sparsely scattered.

Special Concern
- an unofficial category adopted by the International Council for Bird Preservation (now ‘Birdlife International’) for species not presently endangered or vulnerable or rare whose populations may be very small, have declined in certain areas, have previously suffered decline, or may warrant concern in the future.

Australian nearshore islands do not have any seabird species or subspecies that are considered to be endangered. On Christmas Island in the Indian Ocean, an area beyond the scope of these guidelines, the only colony in the world of Abbott’s Booby breeds and it is classified as endangered (Garnett 1992).

The nearshore islands of Australia have five species or subspecies of seabird considered to be vulnerable or rare. These are listed below and described in detail in the rest of this section.

Gould’s Petrel:	vulnerable
Little Tern:	vulnerable
Pacific Gull:	rare
Fairy Tern:	rare
Lesser Noddy:	rare

Gould’s Petrel (vulnerable)
The Australian subspecies of Gould’s Petrel (*Pterodroma leucoptera leucoptera*) breeds only on Cabbage Tree Island off the New South Wales central coast (Garnett 1992).

The breeding population is estimated at about 150 pairs (Davey 1990) and the total world population may not exceed 500 individuals (Marchant & Higgins 1990; Blaber et al. 1996).

Little Tern (vulnerable)
The Australian population of the eastern subspecies of Little Tern (*Sterna albifrons sinensis*) has suffered a significant decline in the south-eastern part of its range. The Australian subspecies also occurs throughout Asia (Blakers, Davies & Reilly 1984). Ross et al. (1995) have estimated that there are between 560 and 570 breeding pairs along the Australian coast and on Coral Sea islands. Starks (1992) summarises a national breeding census of Little Terns in Australia in 1989, in which over 4000 birds in non-breeding plumage were counted. Most of these are thought to be migrants from the northern hemisphere breeding population.

Pacific Gull (rare)
The population of the eastern subspecies (*Larus pacificus pacificus*) appears to have declined this century (Garnett 1992). There are 1800 to 1850 breeding pairs in eastern Australia (Ross et al. 1995) breeding mostly on offshore islands in Tasmania. It has declined in distribution over the last 60 or so years but the reasons for this are unknown.

Fairy Tern (rare)
The population of the Australian subspecies of the Fairy Tern (*Sterna nereis nereis*) is stable in Western Australia and South Australia, however an apparent decline in Victoria has warranted its classification as rare (Garnett 1992). It has been estimated that there are between 2000–3000 breeding pairs in Australia (Ross et al. 1995) of which around 200 are in Victoria.

Lesser Noddy (rare)
The Australian subspecies of the Lesser Noddy (*Anous tenuirostris melanops*) breeds on three of the Houtman Abrolhos Islands off Western Australia. There were about 48,900 pairs breeding on the three islands in 1993 (Fuller, Burbidge & Owens 1994).

4.1.2 Size of Colony/Number of Individuals of One Species

Colonies might be valued because overall they contain a large number of breeding pairs of seabirds, or because of the comparatively large number of pairs of a particular species. In order to make such a judgement it is necessary for managers to have an idea of the numbers present at other colonies in the area in which the comparison is being made. Section 4.2 provides information of this nature.

4.1.3 Number of Species Breeding/Present

Colonies of breeding seabirds can be valued for the high biodiversity values represented in the total number of breeding species. Again, managers need to have information on the numbers of species at other localities to form a basis against which a valuation can be made.

4.1.4 Breeding at a Biogeographic Limit

In some situations, breeding populations of seabirds are valued because they represent a biogeographical limit for breeding of a particular species. Examples might include the northernmost or southernmost breeding colonies of a species. Latitude and longitude limits for species that breed on Australia's nearshore islands are given in section 4.2.

4.1.5 Only Colony in a Country/Region/Locality

Where a colony is the only one in a geographical area it can assume value for this reason.

4.1.6 Isolated Significant Colony

Breeding colonies of a particular species can have a value because they represent a form of 'insurance' for the survival of the species through their remoteness from influences which might exterminate other breeding colonies.

4.1.7 Value for Education/Awareness

Where breeding seabirds occur in a situation which is readily accessible to the public and groups from educational institutions, the site can assume a value for its real or potential contribution to education and awareness raising. This value is not necessarily related to any other values the site may have.

4.1.8 Value for Tourism

Seabird breeding colonies which occur in situations where they are accessible to tourists can have value for this reason. Many seabird islands occur in remote localities and are therefore virtually inaccessible to large numbers of tourists.

4.1.9 Value as a Flagship/Icon

The image of massed breeding seabirds, whether sitting on nests, wheeling over a breeding island or flying onto the island at dusk, is a powerful one for capturing public attention. Whether conveyed to the public through visits to the site or through photographic images, artwork or as a stylised logo, this can become a focus for awareness of a range of conservation values and goals.

4.2 BASIC VALUES INFORMATION TABLE

The following table presents basic information which will be useful to managers in the preparation of values statements for seabird breeding islands. In all cases this will need to be supplemented by local and possibly regional information if a comprehensive statement of values is to be prepared.

Table 4.1
SUMMARY OF INFORMATION ON SEABIRD STATUS

Species	Status	Breeding Distribution within Australia*	Colony Location/Size – Major Colonies	Total No. in Aust. (based upon Ross et al. 1995)	Outside Australian Region
Little Penguin *Eudyptula minor*		32° – 44°S 114° – 153°E	Many islands with hundreds to thousands of breeding pairs	166,643–292,047 pairs	Common in New Zealand
Common Diving-Petrel *Pelecanoides urinatrix*	special concern	38° – 44°S 140° – 149°E	Region 7: Wilsons Promontory Islands, Lady Julia Percy Is., Lawrence Rocks Region 10: Georges Rock c. 50 pairs (1977) Region 11: Maatsuyker Is. c. 400 pairs (1975), Councillor Is. c. 20 pairs (pre-1972)	129,220–184,020 pairs	Breeds south of 38°S throughout subantarctic
Great-winged Petrel *Pterodroma macroptera*		33° – 36°S 116° – 125°E	Region 9: Recherche Arch. hundreds (1950–1982), Coffin Is. 2000–3000 (1976–79), Eclipse Is. 10,000–15,000 (1973)	33,050–84,100 pairs	Breeds south of 38°S in north New Zealand, most of subantarctic, wandering throughout Southern Ocean except off Sth America
Herald Petrel *Pterodroma arminjoniana*		10° – 14°S 142° – 155°E	Region 5: Raine Is. 10 pairs (1959)	< 10 pairs	Tropical S. Pacific Ocean and S. Atlantic Ocean and off Madagascar
Black-winged Petrel *Pterodroma nigripennis*		20° – 30°S 147° – 154°E	Region 5: Heron Is. (1961), Wilson Is. (1995) unconfirmed	< 10 pairs	Tropical S.W. Pacific Ocean
Gould's Petrel *Pterodroma leucoptera*	vulnerable	32° – 34°S 147° – 154°E	Region 6: Cabbage Tree Is. 250–500 pairs (1992)	250–500 pairs	Two other subspecies in tropical S.W. Pacific Ocean
Fairy Prion *Pachyptila turtur*	vulnerable (southern subspecies)	37° – 44°S 141° – 150°E	Region 7: Lady Julia Percy Is. 1000 pairs (1981) Region 10: Grassy Is. 100 pairs (1974) Region 11: Ile du Golfe 25,000 pairs, Tasman Is. 25,000 pairs, Flat Witch Is. 10,000 pairs	1,055,159–1,682,339 pairs	Circumpolar in Southern Ocean
Wedge-tailed Shearwater *Puffinus pacificus*		10° – 36°S 113° – 154°E	Region 1: Houtman Abrolhos (1992–94), 1.1 million pairs Region 5: North West Is. 300,000 birds (1994), Heron Is. Region 6: Muttonbird Is., Broughton Is., Montagu Is.	1,294,400–1,384,400 pairs	Tropical and subtropical Indian Ocean and Pacific Ocean
Flesh-footed Shearwater *Puffinus carneipes*		33° – 36°S 114° – 137°E	Region 8: Smith Is. (Eyre Pen.) 150 pairs (1982) Region 9: Eclipse Is., Recherche Arch.	105,150–311,150 pairs	Pacific Ocean and Indian Ocean, migrates north in southern winter
Sooty Shearwater *Puffinus griseus*		30° – 44°S 146° – 154°E	Region 6: Montagu Is. 150 pairs (1972) Region 11: Tasman Is. 1000 pairs (1978)	596–1210 pairs	Breeds New Zealand off Cape Horn (Sth America), migrates to N. Pacific and N. Atlantic Ocean in southern winter

Short-tailed Shearwater *Puffinus tenuirostris*		30° – 44°S 122° – 154°E	Region 6: Tollgates Is. 6500 pairs, Montagu Is. 12,500 pairs Region 7: Rabbit Is. 131,000 burrows, Anser Is. 251,700 burrows, Great Glennie Is. 400,300 burrows, Norman Is. 145,000 burrows, Phillip Is. 645,300 burrows Region 8: Penguin Is. 3000 Region 9: Figure of Eight Is. 150 burrows Regions 10 & 11: > 15 million pairs	12,888,692–16,389,062 pairs	Migrates to N. Pacific Ocean for southern winter
Little Shearwater *Puffinus assimilis*	special concern	27° – 36°S 114° – 122°E	Region 1: Houtman Abrolhos Is. 30,000 pairs (1991–93) Region 9: Eclipse Is. < 2000 (1973)	27,060–61,540 pairs	S. Pacific Ocean, southern Indian Ocean, N.E. Atlantic Ocean
Shy Albatross *Diomedea cauta*	special concern	39° – 44°S 140° – 148°E	Region 10: Albatross Is. 1500 nests (1973) Region 11: Pedra Branca 100 pairs (1978), Mewstone 1500–2000 pairs (1977)	6900–8500 pairs	Common breeding in New Zealand and wanders throughout subantarctic
White-faced Storm-Petrel *Pelagodroma marina*		27° – 44°S 113° – 154°E	Region 1: Houtman Abrolhos Is. 42,000 pairs (1991–93) Region 6: Tollgate Is. 7000–8000 pairs Region 7: Tullaberga Is., Mud Is., S. Channel Is. Region 8: Sir Joseph Banks Is., Investigator Group, Nuyts Arch. Region 9: Recherche Arch. Region 10: Chalky Is. 35,000 birds (1981)	384,303–411,274 pairs	S. Pacific Ocean, Indian Ocean, Atlantic Ocean
Red-tailed Tropicbird *Phaethon rubricauda*		10° – 24°S 142° – 154°E (currently)	Region 1: no recent records Region 4: Herald Group, Coringa Group Region 5: Lady Elliot Is. 6 (1995), Raine Is. 98 (1975–85)	294–381	Tropical Pacific Ocean, Tropical southern Indian Ocean
Australasian Gannet *Morus serrator*		34° – 44°S 140° – 152°E	Region 7: Lawrence Rocks 2463 (1986–87) Region 10: Cat Is. 4–10,000 (1908), 6 (1983–84) Region 11: Black Pyramid 900 (1961), Pedra Branca 500–1000 (1978), Eddystone Rock 46 (1978)	5546–6140	Common in New Zealand
Masked Booby *Sula dactylatra*	special concern	10° – 30°S 120° – 155°E	Region 2: Bedout Is. 560 pairs (1975), 240 (1982), Adele Is. 640 (1982) Region 5: Raine Is. 1500 pairs (1979), Swain Reefs 500 (1976)	3572–4270 pairs	A tropical species of deep water, widely distributed equatorial parts of all the world
Brown Booby *Sula leucogaster*		10° – 30°S 120° – 155°E	Region 2: Adele Is., Lacepede Group (West Is. 14,799, Middle Is. 20,600 (1982)), Bedout Is. 10,000 (1972), 1300 (1978), 10,000 (1982) Region 3: Ellis Is. Region 5: Raine Is. 7–9000 birds (1959), 4000 (1961), 12,000 (1979), Maclennan Cay 1840 (1977), Swain Reefs 1040 (1976)	59,923–73,840 pairs	Nests on islands in tropical seas around the world

* excludes Australian island territories

Table 4.1 (cont'd)

Species	Status	Breeding Distribution within Australia*	Colony Location/Size – Major Colonies	Total No. in Aust.	Outside Australian Region
Red-footed Booby *Sula sula*		10° – 27°S 143° – 155°E	Region 5: Raine Is. 300 birds (1959), 350 (1979); Pandora Cay, up to 20 birds present, but only 1–2 pairs breeding	1381–4987 pairs	A tropical species breeding in the Indian, Atlantic and Pacific Oceans. Thought to be the world's most abundant booby.
Little Pied Cormorant *Phalacrocorax melanoleucos*		10° – 44°S 113° – 154°E	widespread	142–197 (on offshore islands)	New Zealand, New Guinea, Indonesia, S.W. Pacific Ocean
Pied Cormorant *Phalacrocorax varius*		10° – 39°S 113° – 154°E	Region 1: Carnac Is. c. 500 pairs (1981) Region 2: North Turtle Is. 1500 pairs (1975) Region 3: Edward Pellew Group Region 5: Facing Is. Region 7: Mud Is., Swan Is. 32+ pairs (1978) Region 8: Little Goose Is., Winceby Is.	12,277–19,097	New Zealand
Black-faced Cormorant *Phalacrocorax fuscescens*		32° – 45°S 120° – 149°E	Region 7: Dannevig Is. 30 nests (1978–80), Notch Is. 20 pairs (1978) Region 8: Dangerous Reef 100–2500 nests (1966–76), English Is. 3000 pairs (1970), 2000 birds (1981–82), Winceby Is. 3000 nests (1981,83) Region 9: Lion Is. 50 pairs (1970)	7887–9777	endemic
Australian Pelican *Pelecanus conspicillatus*		10° – 44°S 113° – 154°E	Region 1: Pelican Is. Region 2: North Turtle Is. 1200 pairs (1981) Region 3: Rocky Is. 200+ nests (1965) Region 6: Five Is. Region 7: French Is. 57 pairs (1983) Region 8: Kangaroo Is., Pelican Is. 200 pairs (1929) Region 10: Clarkes Is. 100 nests	1021–1701 (on offshore islands) 10,000's inland	New Guinea
Great Frigatebird *Fregata minor*		10° – 23°S 143° – 153°E	Region 3: Manowar Is. 1 (1982) Region 5: Raine Is. 10 pairs (1982)	1607–1611	Tropical Pacific Ocean, Tropical Indian Ocean, off Brazil
Lesser Frigatebird *Fregata ariel*		10° – 24°S 122° – 154°E	Region 2: Adele Is. 5700 pairs (1982), Bedout Is. 2290 pairs (1982), West Lacepede Is. 2700 pairs (1982) Region 3: Manowar Is. 1049 nests (1982) Region 5: Raine Is. 2000 pairs (1975–85), Bell Cay 187 pairs (1976–86)	18,862–19,631	Tropical Pacific Ocean, Tropical Indian Ocean, off Brazil

Pacific Gull *Larus pacificus*	rare (eastern subspecies) special concern (western subspecies)	25° – 44°S 113° – 152°E	Region 1: Houtman Abrolhos 51 pairs (1991–93) Region 7: Wilsons Prom. Islands 800 birds (1978–80) Region 8: Kangaroo Is. 20 pairs (1980–90), Albatross Is. 35 pairs (1982) Region 9: Recherche Arch. Region 10: Cat Is. 40–60 birds (1957), Little Chalky Is. 74 birds (1979) Region 11: Green Is. 32 birds (1978)	1950–2022	endemic
Kelp Gull *Larus dominicanus*		24° – 44°S 113° – 155°E	Region 11: Green Is., Visscher Is., Lachlan Is.	314 pairs	South America, South Africa and New Zealand
Silver Gull *Larus novaehollandiae*		10° – 44°S 113° – 155°E	Region 1: Carnac Is. 6000–8000 (1979), Green Is. 8000–10,000 birds (1977) Region 7: Mud Is. 50,000 pairs (1979) Region 8: Troubridge Is. c. 10,000 pairs (1981)		South Africa, New Zealand, New Caledonia
Caspian Tern *Sterna caspia*		10° – 44°S 113° – 155°E	Region 1: Leo Is. Houtman Abrolhos 70 pairs (1991–93), Raine Is. 100 to < 1000 pairs (1976–91) Region 7: Box Bank 25+ pairs (1984) Region 8: Coorong National Park c. 400 birds	1522–2049 pairs	North America, Europe, Asia, Africa, New Zealand, New Guinea
Lesser Crested Tern *Sterna bengalensis*		10° – 21°S 113° – 155°E	Region 5: Pelican Is. 1000 to < 10,000 pairs (1976–91), Michaelmas Is. 1000 to < 10,000 pairs (1976–91)	4911–8169 pairs	Tropics of Indian Ocean, south-east Asia to New Guinea
Crested Tern *Sterna bergii*		10° – 44°S 113° – 152°E	Region 1: Pelsaert Is. Houtman Abrolhos 1013 pairs (1991–93) Region 5: Bountiful Is. 10,000 to < 100,000 pairs (1976–91) Region 7: Mud Is. 2000 pairs (1991) Region 8: Halfway Is. 3865 nestlings (1985–86), Stonywell Is. 2676 nestlings (1983–84) Region 10: Georges Is. 4000 birds (1977)	82,685–115,635 pairs	Throughout Indian Ocean, south-east Asia, Pacific islands, New Guinea
Roseate Tern *Sterna dougallii*	special concern	10° – 33°S	Region 1: Houtman Abrolhos (19 islands) 3441 pairs (1991–93) Region 2: Ashmore Reef up to 2656 pairs Region 3: Haul Round Is. c. 4000 birds (1972) Region 5: Wallace Is. 5000 pairs (March 1985), Magra Islet 2700–3100 nests (1992–93)	7218–13,370 pairs	Widespread and patchy distribution throughout world
White-fronted Tern *Sterna striata*	special concern	28° – 44°S 137° – 155°E	none recently	44 pairs	New Zealand
Black-naped Tern *Sterna sumatrana*		10° – 21°S 130° – 150°E	Region 5: Swain Reefs 400 birds (1975)	1705–2076 pairs	Tropics of the Indian and Pacific Oceans
Little Tern *Sterna albifrons*	vulnerable	10° – 44°S 122° – 155°E	Region 5: Coquette Point 40 nests (1989) Region 7: Rigby Is. 91 nests (1989)	561–568 pairs	Worldwide

* excludes Australian island territories

Table 4.1 (cont'd)

Species	Status	Breeding Distribution within Australia*	Colony Location/Size – Major Colonies	Total No. in Aust.	Outside Australian Region
Fairy Tern *Sterna nereis*	rare	15° – 36°S 113° – 15-°E	Region 1: Houtman Abrolhos (14 islands) 481 pairs (1991–93), Rottnest Is. 200 pairs Region 8: Kangaroo Is. up to 100 pairs (1979), Stonywell Is. Coorong National Park c. 200 pairs with chicks (Jan. 1969)	2953–4250 pairs	New Zealand, New Caledonia
Bridled Tern *Sterna anaethetus*		10° – 36°S 113° – 152°E	Region 1: North Fisherman Is. 4000 birds (1976), Gun Is. Houtman Abrolhos c. 1000 pairs (1991–93), Pelsaert Is. Houtman Abrolhos c. 1000 pairs (1991–93), Suomi Is. Houtman Abrolhos c. 1000 pairs (1991–93) Region 5: Swain Reefs 1100 birds (1976), Eshelby Is. 1000 to < 10,000 pairs (1976–91)	20,063–57,819 pairs	Indian, Pacific and Atlantic Oceans
Sooty Tern *Sterna fuscata*		10° – 29°S 113° – 153°E	Region 1: Alexander Is. Houtman Abrolhos c. 40,000 pairs (1991–93), Pelsaert Is. Houtman Abrolhos 208,700 pairs (1991–93) Region 5: Bramble Cay 40,000 birds, Michaelmas Cay 15,000–20,000 birds	328,800–464,500 pairs	Throughout tropics
Common Noddy *Anous stolidus*		10° – 28°S 113° – 152°E	Region 1: Pelsaert Is. Houtman Abrolhos 132,000 pairs (1993) Region 5: Bramble Cay > 10,000 birds, Raine Is. > 10,000 birds (July 1980), Michaelmas Cay 15,000 birds (May 1978)	174,500–214,100 pairs	Throughout tropics and subtropics
Black Noddy *Anous minutus*		12° – 23°S 143° – 151°E	Region 5: North West Is. 100,000 to 1 million pairs (1976–91), Masthead Is. 170,000 birds (1972), Heron Is. c. 63,000 birds (1993)	119,500–132,000 pairs	Tropical Pacific and Atlantic Oceans
Lesser Noddy *Anous tenuirostris*	rare	28°S 113°E	Region 1: Pelsaert Is. Houtman Abrolhos 34,895 pairs (1991–93)	79,500 pairs	Indian Ocean islands

* excludes Australian island territories

CHAPTER 5

Impact Sources and Control/Mitigation Measures

This section examines the range of human activities that occur on offshore islands in Australia with particular attention to their impacts on breeding seabirds. Possible control and mitigation measures are also suggested.

Human activities on Australian islands fall into a number of categories, principally including:

- tourism,
- recreation,
- boating,
- fishing,
- navigation,
- defence, and
- research.

Each of these is considered separately below. Because of the range of responses by seabirds to disturbance, even within the one species, it is usually not possible to generalise about control and mitigation measures for any particular activity. Managers will need to take into account the sensitivity of particular species and the values of the seabird breeding aggregation at a site in order to derive an appropriate management regime.

Within each of these activity classes is a range of interactions between humans and breeding seabirds. The questionnaire carried out in the preparation of these guidelines (appendix 2) identified a range of common impacts described below.

For surface-nesting birds:

- ignorance on the part of the intruder of the presence of a colony; handling of eggs and young chicks; trampling of eggs and young chicks; and the presence with intruders of pet dogs that chased and caught chicks and, occasionally, adult birds.

For burrow-nesting birds:

- presence or approach of people; ignorance on the part of the intruder of the presence of a colony; handling of eggs and young chicks by the intruder; and the activities of dogs accompanying intruders and fires.

Insufficient responses were received on tree-nesting species.

Managers need to keep in mind that the option of not allowing access, or of not allowing a particular activity always exists but has not been canvassed in the following sections. It is taken for granted that where a sufficiently high value is placed on a site, or where managers do not judge alternatives to be realistic, the decision will be taken to close the island to visitation.

5.1 TOURISM

Tourism involves perhaps the most regular visitation to Australia's islands and the largest numbers of people. The last two decades have seen an enormous expansion in Australia's tourism industry. For example, in the last eight years alone, the number of overseas visitors to Australia has increased by almost 230 per cent (Bureau of Tourism Research 1993). The number of domestic trips rose in the same period by a more modest eight per cent (Bureau of Tourism Research 1993).

Steady growth in tourism is leading to increasing demand for a range of tourism activities, from accommodation to daytrips and outdoor activities. In some regions of Australia, it is likely that visits to islands will increase and that they will require careful management if seabirds are not to be affected.

The biggest tourism drawcard amongst Australia's islands is the Great Barrier Reef, where most seabirds are surface nesters and are particularly vulnerable to disturbance.

5.1.1 Resorts

Impacts of Resorts

The impacts of tourist resorts on seabird breeding populations commence in the preconstruction phase and continue throughout the constructional and operational phases. In the construction phase there are obvious dangers associated with the location of the site. It is assumed that these will be taken into account, generally through the impact assessment process, before permission is granted to proceed.

Significant impacts from preconstruction activities and construction are likely to come from:

- the presence of surveyors, geotechnical and environmental survey staff on the island;
- the presence of construction workers on the site;
- noise from machinery;
- use of explosives;
- use of lights on the site at night;
- disposal of overburden, dredge spoil etc.;
- introduction of pest species (possibly as 'stowaways' in loads of building material) and exotic plants (either as deliberate introductions for landscaping or in mud and dust on machinery and equipment); and
- disposal of wastes from catering for workers leading to increases in gull populations.

Many impacts during the operational phase of the resort arise from particular activities and are covered in the following sections. However, particular attention should be given to:

- unstructured activities of guests,
- waste disposal,
- introduction of exotic plants by gardeners or staff, and
- introduction of pets by staff or guests.

Control/Mitigation Measures for Resorts

The measures which might be taken to avoid or mitigate the impacts of resort construction on seabird breeding include:

- preparation of education/awareness programs for workers on the site;
- inclusion of environmental protection clauses and codes of behaviour in contracts of contractors and subcontractors on the site;
- marking the boundaries beyond which personnel and machinery may not move;
- requiring maximum noise reduction on equipment operated on the site;
- prohibiting the use of explosives;

- planning with architects and site managers the location and nature of lighting used on the site;
- including satisfactory arrangements for spoil disposal in construction plans;
- requiring inspection and, if necessary, steam cleaning of equipment and materials brought onto the site; and
- requiring catering waste to be stored in covered bins and ultimately to be buried, incinerated or removed from the site.

Appropriate measures during resort operation include:

- use of signs, brochures, videos and other awareness tools to make guests aware of appropriate codes of behaviour;
- developing appropriate codes of behaviour for staff;
- requiring catering waste to be stored in covered bins and ultimately to be buried, incinerated or removed from the site;
- development of a list of acceptable plants for use in landscaping and rehabilitation; and
- prohibition enforced through employment contracts on the private introduction of plants or animals to the island.

5.1.2 Daytrips

Impacts of Daytrips

Daytrip visits to islands involve impacts resulting from both the mode of transportation used and the activities of visitors on the islands. Impacts of modes of transportation are covered under the relevant headings below. Some impacts resulting from the activities of visitors are related to particular recreational activities such as watersports. These are dealt with below. Other impacts arise because of human presence in particular areas or as a result of particular aspects of behaviour. These include:

- people walking into seabird colonies or to within less than the critical distance of the most sensitive species in the colony – leading to adults flying off nests with resultant impacts including stampedes of adults or young, trampling of eggs and nests, increased opportunistic predation etc.;
- trampling of nests / burrows – leading to death / suffocation of young;
- disturbance of the adult birds when they are departing from or returning to the colony – possibly leading to regurgitation of food carried for chicks;
- littering with food scraps which attract gulls; and
- risk of fire from discarded cigarette butts.

Control/Mitigation Measures for Daytrips

Appropriate management measures for reducing the impacts of daytrips to seabird breeding islands include:

- establishment of activity zones located to limit the movement of visitors to the least sensitive parts of seabird breeding islands and designation of these with fences, markers, signs etc.;
- erection of screen fences to avoid disturbance of birds;
- construction of appropriate viewing facilities to reduce random access to the breeding area;
- restriction of human presence to the beach so that this is not visible to the nesting birds;
- restriction of daytrip visits so that people do not arrive less than two hours after sunrise and do depart at least two hours before sunset;
- brochures, videos, talks and other awareness tools to make visitors aware of the potential for disturbance;

- restriction of access to the breeding island to only those daytrip operators who are marketing the breeding seabirds as a major attraction; and
- provision of appropriate waste bins and education about the dangers of carelessly disposing of cigarette butts.

In some situations it may be advisable to prohibit visits to the island during colony formation or nest establishment periods for sensitive species.

5.2 RECREATION

Recreation covers a wide range of activities, many of which are included in following sections. In some situations, it will not be possible to ensure that the level of management appropriate to the value of the breeding site is provided. Such instances include remote high value sites, and situations where the necessary management or infrastructure is beyond the budget of the management agency. In such situations, access might be permitted where parties are accompanied by experienced, accredited guides.

5.2.1 Camping

Impacts of Camping
The majority of the impacts of camping are the same as for daytrips. The main difference is that people spend more time on the island and are generally less supervised.

The impacts of campers can include:

- significant effects on seabird behaviour at sensitive times, such as the pre-sunrise departure and post-sunset return of burrow-nesting species;
- camping in well-used bird access ways between the beach and burrows;
- the lighting of fires with associated increased risk of uncontrolled fire in colonies;
- the use of lights at night that confuse night-flying seabirds (e.g. shearwaters);
- walking at night with torches through seabird colonies that are difficult to detect in the dark with subsequent trampling of burrows or eggs / chicks; and
- greater likelihood of ‘curiosity’ forays by day or night into colony areas by visitors.

Control/Mitigation Measures for Camping
The management measures for camping on seabird breeding islands are generally the same as those for daytrips. The major addition is that open fires should be banned and all cooking done on gas or electric stoves. Clear advice on night behaviour should be provided and there should be minimal use of lights. Tents and shelters should be located so as not to obstruct birds returning to the island particularly at night. Structures such as radio aerials should be positioned to minimise the risk of injury to birds.

5.2.2 Watersports

The range of watersports likely to be undertaken near to seabird islands generally shares the characteristics of involving noisy and / or fast moving objects. Examples include waterskiing, jet skis, paraflying and windsurfing. There is very little information available on the impacts of these activities on breeding seabirds. Dietrich and Keopff (1986 in Hockin et al. 1992) found that windsurfers flushed Common Terns on islands at greater distances than did rowing or motorboats. However, as a generalisation, these are not appropriate activities in the vicinity of breeding seabirds. The only exceptions might be where the birds are all burrow breeders, in which case these activities might be allowed from two hours after sunrise to two hours before sunset.

5.2.3 Off-road Vehicles

Impacts of Off-road Vehicles

Off-road vehicles cause impacts on breeding seabirds through:

- running over surface nests, eggs and chicks;
- collapsing burrows;
- disturbing birds and chicks through their presence and noise;
- causing direct destruction of vegetation in which seabirds breed;
- initiating erosion which degrades nesting / burrowing habitat; and
- allowing people and domestic animals to access otherwise remote breeding areas.

Beach-nesting birds such as terns are particularly susceptible to impacts from off-road vehicles.

Control/Mitigation Measures for Off-road Vehicles

Off-road vehicles should not be allowed on seabird breeding islands.

5.2.4 Walkers

Impacts of Walkers

The impacts of walkers are the same as for daytrips and include:

- people walking into seabird colonies or to within less than the critical distance of the most sensitive species in the colony – leading to adults flying off nests with resultant impacts from stampedes, trampling and / or opportunistic predation;
- trampling of nests / burrows – leading to death / suffocation of young;
- disturbance of the adult birds when they are departing from or returning to the colony – possibly leading to regurgitation of food carried for chicks;
- littering with food scraps which attract gulls; and
- risk of fire from discarded cigarette butts.

Control/Mitigation Measure for Walkers

Appropriate measures for reducing the impacts of walkers on seabird breeding islands are described in section 5.1.2 on daytrips.

5.3 BOATING

5.3.1 Impacts of Boating

Although many Australians own boats and use them to visit areas where seabirds are likely to be breeding, little work has been done on the impact of boats approaching islands being used by seabirds for breeding. Most available information is anecdotal and summarised below.

Intuitively, it can be assessed that boat disturbance is likely to have the same effects as on-site human disturbance. This is because the act of flushing birds from their nests sets in train a range of effects that reduce juvenile recruitment and survival (see chapter 3).

Hicks, King and Chaloupka (1987) undertook one of the few systematic studies but their results were not conclusive. They found that on Michaelmas Cay, near Cairns, Sooty Terns and Common Noddies did not fly up in response to the presence of large catamarans carrying many people on tourist visits to the cay. These boats approached to within 200 metres of the cay.

Dunnet (1977) observed the effect of aircraft on cliff-nesting seabirds on the Scottish coast and, in the course of observations, noticed the close approach of crayfish boats to a nesting colony. This did not cause any change in adult nest attendance.

Hulsman (undated) indicated that colonies of Black-naped and Roseate Terns on southern Great Barrier Reef islands could be approached to within 30 metres by small boats offshore, compared with 80 metres when walking on the beach, before breeding birds flew up from the colony. The motor should be idling or turned off to allow a closer approach. Approaches to within about 30 metres of colonies were possible by rowing very slowly towards them and dropping anchor chains with minimal noise.

Rogers and Smith (1995) found that some species of colonial waterbirds (e.g. cormorants) could be approached closer by boat than on foot before flushing from their nests. Although by no means comprehensive, this information strongly suggests that a boat can approach a seabird colony closer than a pedestrian without causing noticeable disturbance.

Observations of the activities of sailing boats (D. Pemberton, Parks and Wildlife Service, Tasmania, pers. comm.) near seabird breeding islands have shown that if they approach close to a shore where seabirds are breeding and lower their sails, which flap noisily in the wind, this can create significant disturbance.

Managers need to be aware that impacts associated with boats often arise not so much from the presence of the vessels as the activities of their skippers. For example, some years ago at least one tourist vessel visiting Michaelmas Cay sounded a klaxon on its approach so that passengers could enjoy the spectacle of massed seabirds taking flight over the island. Management of boating activities needs to recognise the potential for such occurrences.

5.3.2 Control/Mitigation Measures for Boating

Management measures to reduce the impact of boating activities on seabird breeding islands include :

- establishment of fixed offshore boating zones around sensitive islands, including the establishment of a boat-free zone for a distance of 200 metres from high water mark around the island (if small) or from high water mark where colonies occur close to shore (if larger);
- locating specific moorings (if and where they are provided) sufficiently far from any seabird colony to ensure that disturbance of seabirds by or from boats does not occur; and
- brochures, videos and other awareness tools targeted at boat owners/operators making them aware of the potential for disturbance and providing guidance on appropriate boating behaviour.

5.4 FISHING

5.4.1 Impacts of Fishing

Fishing activities comprise both commercial and recreational fishing. Commercial fishermen can, at times, cause deliberate destruction of seabirds, especially of well-known fish-eating species such as pelicans and gannets. They also occasionally light fires on islands which can disrupt breeding activities and kill many birds. In other cases commercial fishermen inadvertently or thoughtlessly cause major impacts through their use of remote islands for recreational activities between bouts of fishing.

In the past, commercial fishermen have been implicated in the decline of sizeable seabird colonies (e.g. the Cat Island gannetry (Warham 1979)) due to regular killing of seabirds for fishing bait (e.g. for crayfish pots). It is likely that this practice is now considerably less widespread than in earlier years (Ross et al. 1995).

Some commercial fishermen farm oysters close to beaches on islands or use island beaches from which to catch fish. Such activities have the potential to cause significant disturbance to breeding seabirds.

Recreational angling is a popular activity in Australia. Fishermen regularly visit islands to fish near them or to land and fish from the shoreline. Recreational anglers have the potential to cause significant disturbance to nesting seabirds on islands. Although there are no confirmed instances of this occurring in Australia, the impact of fishermen landing or approaching close is the same as that of any visitor to a seabird breeding island. Because recreational anglers are sometimes accompanied by pet dogs there is the danger that these animals will be allowed ashore on seabird breeding islands. In addition, discarded fishing line and tackle is a well-known problem for coastal birds due to entanglement.

5.4.2 Control/Mitigation Measures for Fishing

Where there is significant demand from fishermen to land on islands, a set landing site and fishing zone should be designated for this activity, provided that this is consistent with conservation goals and it is possible to identify such an area within the general management guidelines adopted for the site.

If it is not possible for fishing to be conducted without disturbance to breeding seabirds then fishing should be restricted to offshore activities from boats and the boating control measures should apply.

All fishermen should ensure that all waste, including any discarded fishing line and tackle is taken with them off the island on their departure.

Interpretation and public education activities should ensure that fishermen who are likely to approach or visit seabird breeding islands are targeted.

5.5 NAVIGATIONAL AIDS AND METEOROLOGICAL STATIONS

5.5.1 Impacts of Navigational Aids and Meteorological Stations

Islands and associated rocks and reefs represent a significant hazard to shipping, and navigational aids have been established on many of them. Some remote islands have automatic meteorological stations. Most of the navigational facilities are automatic, unmanned lights. The inhabitants of manned lighthouses have, in the past, been responsible for the introduction of feral predators and weeds that have dramatically affected the ecology of islands with significant consequences for seabird breeding.

Monitoring and maintenance visits to the unmanned navigational aids and meteorological stations on islands, although not frequent, have the potential to disrupt significantly the breeding activities of seabirds, unless carried out during the non-breeding season. Urgent visits to repair malfunctioning lights are not uncommon, and since helicopters are commonly used for these visits, there is considerable potential to cause harm to breeding seabirds.

In general the impacts of constructing and servicing navigational aids arise from the transport used in the exercise. Typically this will be helicopters, LARCs or all-terrain-vehicles. Impacts include:

- disturbance to breeding birds,
- collapsing of burrows by vehicles,
- destruction of vegetation by vehicles, and
- erosion resulting from the tracks of vehicles.

5.5.2 Control/Mitigation Measures for Impacts Associated with Navigational Aids and Meteorological Stations

Control and mitigation of impacts associated with the installation and servicing of navigational aids depends chiefly on the establishment of a good understanding on the part of the responsible agency of the necessary procedures. In many cases these will have to be developed on a site-by-site basis and agreed between agencies. Servicing is often done by contractors, so that liaison with relevant companies may also be necessary.

The measures which will avoid or mitigate impacts include the following.

- On islands that hold only burrow-nesting seabirds, navigational aid maintenance should only be done between sunrise and sunset and it should not be done in the sensitive colony establishment period (which will vary around Australia).
- On islands holding surface- and tree-nesting seabirds, maintenance and construction of navigational aids should be conducted outside the breeding season, or during the period when the least breeding occurs.
- All works crews involved in navigational aid maintenance should be informed clearly of the limits on their activities while on the seabird breeding islands.
- Where a new operator is visiting an important site for the first time, an officer of the island management agency should accompany the works crew and provide an on-site briefing on the agreed code of behaviour.
- The agency responsible for navigational structures should make a relevant maintenance planning officer responsible for ensuring that the necessary liaison occurs with the island management agency and that relevant guidance is sought from that agency for maintenance planning purposes.

5.6 DEFENCE ACTIVITIES

5.6.1 Impacts of Defence Activities

Military exercises are an activity that has significant potential to affect seabird breeding islands. Islands can be used for firing / bombing practice, for personnel exercises, for landing practice and a range of other activities. In addition, defence force activities sometimes include the placing of navigational beacons and other equipment on islands, possibly outside of exercise areas.

In some situations, gunnery and bombing ranges may include rocks and islands which have sporadic nesting by different species.

Managers should be aware that helicopter-equipped naval vessels may fly off helicopters for various activities while steaming through an area. In such situations coordination with local wildlife and conservation agencies may be overlooked.

5.6.2 Control/Mitigation Measures

It is important that managers of seabird breeding islands establish liaison with local **and** national defence offices to make them aware of the significance of particular sites and of the restrictions that should apply. Because defence activities are planned at different levels it should not be assumed that contact with the local office will ensure that appropriate measures will be applied.

The measures for walkers, boating and aircraft may be applicable to defence activities. In addition, the following measures will help to reduce the impacts of defence activities on seabird breeding islands.

- Where rocks or islands are included in gunnery and bombing ranges it should be required that there is a check for significant nesting before these ranges are used.
- Defence activities on seabird breeding islands should be confined to those activities that will not cause disruption to breeding seabirds.
- In general, defence activities should only occur at a distance of greater than 300 metres from any surface-nesting seabirds and outside the colony area of burrow-nesting seabirds.
- Any aerial manoeuvres should be conducted in accordance with established guidelines for aircraft movements at the site.
- The Defence Department should ensure that the staff planning defence exercises contact the relevant island and wildlife management agencies to determine if activities are appropriate.
- Any Defence Department personnel who land for the first time on a significant seabird breeding island should be accompanied by an officer of the island management agency who will provide an on-site briefing on the appropriate code of behaviour.

5.7 AIRCRAFT

5.7.1 Impacts of Aircraft

There have been many anecdotal observations and a number of systematic studies that indicate that aircraft activities can seriously disrupt seabird breeding activities.

Hicks, King and Chaloupka (1987) found that Sooty Terns and Common Noddies breeding on Michaelmas Cay took flight in reaction to the landing and departure of seaplanes within 400 metres. They were far more likely to take flight in response to the plane taking off than to it landing. As a consequence of this study, seaplane visits to the island have been stopped and are now not allowed in a number of other seabird breeding islands in the Great Barrier Reef Marine Park.

On Lady Elliot Island in the southern Great Barrier Reef small commercial aircraft regularly land on an airstrip which bisects the island. This is within several tens of metres of breeding Crested and Bridled Terns and Common Noddies. Apart from occasional bird strikes caused by birds roosting on the runway there does not appear to be any ongoing negative impact of aircraft operations. However, it needs to be stressed that there are no studies of pre-aircraft conditions to determine whether any species have been displaced, and neither are there any studies of breeding success rates for birds near the runway.

Helicopters land regularly on the end of North West Island in the Capricorn–Bunker Group of the Great Barrier Reef. There are no ground-nesting birds on the island and the landings have no apparent impact on the breeding burrow-nesting species. The approach to the landing is over the sea and there is no overflight of the island. The landing area is screened by vegetation from the breeding area. No studies have been done of the impact of the landing on breeding success of the burrow-nesting species on the island.

On Heron Island, helicopters regularly land within metres of breeding noddies and shearwaters with no apparent effect. No assessment of breeding success is known and neither is there any data on species which may have deserted the island as a result of human activities.

In a study of the reactions of cliff-nesting seabirds in Scotland, Dunnet (1977) found that there was little effect on adult nest attendance due to fixed-wing and helicopter overflights.

In more remote situations, where birds are not habituated to disturbance, the impacts of aircraft can be severe. In the Swains, on the outer southern Great Barrier Reef, breeding seabirds lifted off their nests at the approach of an aircraft before the sound of the aircraft was audible to human observers on the islands (P. O'Neill, QDEH, Rockhampton, pers. comm.).

Work by Wilson et al. (1991) on Adelie Penguins in Antarctica showed that when moving between their breeding sites and the sea, penguins reacted to and fled from aircraft at heights of over 1000 feet and at distances greater than one kilometre. At the breeding colony however, birds generally sat tight, even when helicopters landed at a distance of about 30 metres. Telemetry work indicated however, that the heart rate of birds approached closely like this was four times the resting rate in the colony in the absence of disturbance. These findings indicate that there is a significant stress caused by the approach of aircraft, even if the birds do not flee.

In a study of the Crested Tern breeding at an island in the northern Great Barrier Reef, it was found that the reaction to aircraft noise increased with increasing noise (Brown 1990). Reactions varied but up to 20 per cent of the colony studied flew up at a noise level of 95 decibels.

Burger (1981) found in wetland habitats near Kennedy International Airport in New York, many species of birds, including gulls and terns appear to habituate to noise from subsonic jet aircraft.

Supersonic aviation is thought to have a more serious impact on seabird breeding activities than subsonic aviation. Buckley and Buckley (1976) indicated that planes travelling at supersonic speeds had caused problems in a breeding colony of terns on the Dry Tortugas off the southern United States of America. The ground breeding Sooty Terns suffered almost complete hatching failure while the bush-nesting Common Noddies were unaffected. This may have been due to the transmission of the sonic boom to the eggs of the ground-nesting species, vibrating embryonic membranes loose.

The foregoing observations show that responses to overflying aircraft are to some extent specific to:

- the species,
- the location,
- the history of exposure to disturbance of the populations involved,
- the aircraft type, and
- aircraft activities.

Some species may be more sensitive to aircraft whereas at a site regularly exposed to aircraft the disturbance may be nowhere near as serious due to habituation.

However, there are too few studies on the long-term impacts of stress on breeding success to allow any clear conclusions to be drawn about the benefits of habituation in any given species.

5.7.2 Control/Mitigation Measures for Aircraft Disturbance

The impacts of aircraft on breeding seabirds are potentially very serious and can lead to considerable disruption and mortality. However, it must also be recognised that there is considerable difference between reactions of different species and the same species at different locations. Because of the general lack of reliable and pertinent information a precautionary approach is recommended. In the Great Barrier Reef Marine Park, there is a move to standardise controls on aircraft so that there is no overflight of seabird breeding islands at less than 1500 feet and no lateral approach closer than one kilometre. Where seaplanes are permitted to operate in the vicinity of breeding seabirds they are not permitted to take off or land within 300 metres of the island.

Managers of seabird breeding islands are recommended to establish an ongoing relationship with aviation authorities, local commercial aviation operators and aero clubs. In general, commercial aviation authorities are reluctant to adopt restrictions on aviation for nature conservation reasons, so that other approaches (publicity, awareness/education) should be included in the management regime.

The following management measures are recommended as a general approach to controlling the impacts of aircraft operations on seabird breeding islands.

- Unless on a specific reconnaissance of the island for coastal surveillance or as part of an approved research project, no aircraft should fly across a seabird breeding island at less than 1500 feet altitude.
- Unless on a specific reconnaissance of the island for coastal surveillance or as part of an approved research project, no aircraft should fly within 1000 metres laterally of a seabird breeding island.
- Where flights over breeding colonies are permitted, research or coastal surveillance planes should fly over a seabird breeding island no more than once within any 3 minutes within any 30-minute period with minimal circling or other such manoeuvres.
- Where burrow-nesting species occur, helicopter landings and take-offs should occur only between sunrise and sunset.
- Helicopter landings and take-offs should only occur on the edge of an island, with the approach being over the sea and the landing site screened from and located at least 300 metres from any surface-nesting seabirds.
- Helicopters should not be permitted to land on a seabird breeding island with surface- or tree-nesting species other than noddies, and then only where a formalised program for monitoring of impacts is undertaken.
- Where it is essential for helicopters to land on seabird breeding islands or for seaplanes to land offshore from such islands (e.g. for emergency medical evacuation or for emergency servicing of navigational aids), use should be made of topography and vegetation to screen aircraft movements from the breeding area and in the case of servicing navigational aids, a staff member from the island management agency should accompany the first visit to brief the repair crew.

5.8 RESEARCH ACTIVITIES

5.8.1 Impacts of Research Activities

Many scientists and some amateur ornithologists regularly visit seabird islands to undertake research on the birds and on other aspects of the natural history of islands. For example, in the last ten years, the Australian Bird and Bat Banding Scheme has had 29 bird banders on its books, who regularly visit seabird breeding islands.

Research activities are an essential aspect of managing seabird breeding islands. They provide answers to questions about the effectiveness of management and provide an early warning of problems. In the same way as tourists or fishermen, the activities of research personnel can cause significant disruption to seabird breeding activities.

Occasionally, the activities of researchers can affect seabird breeding success and there is a need to control activities and provide clear guidelines for research activities on seabird breeding islands.

5.8.2 Control/Mitigation Measures for Research Activities

The following guidelines are provided to help island managers determine the impact of research activities and to set useful controls on the activities to minimise impacts.

- Research activities should only be undertaken by investigators from bona fide research organisations or whose activities are endorsed by either the Royal Australasian Ornithologists Union (or their nominated body in the jurisdiction concerned) or are experienced ‘A-class’ bird banders within the Australian Bird and Bat Banding Scheme (ABBBS – part of the Australian Nature Conservation Agency).
- All research activities must be undertaken as part of a well planned and designed research program and, where there is any question about the sensitivity of the species on the site then, as much as possible, focus on solving problems of seabird biology that relate to the conservation of the population.
- Banding activities should only be undertaken under the strict supervision of appropriately qualified and licensed bird banders (ABBBS licence type) and the code of behaviour described below should be followed.
  - When banding seabirds on their breeding islands in most parts of Australia, banders should work in colony areas during the early morning and late afternoon, and not in temperatures greater than 22°C[2] at other times of day, to avoid exposing chicks to high temperatures.
  - Banding activities should be carefully planned to minimise the area of the colony to be disturbed and the time spent in the colony area. No more than half an hour every hour should be spent in the colony area.
  - Banding should only be done at a stage of chick development where colony desertion does not occur and so that eggs and younger vulnerable chicks are not exposed to predation, to high or low temperatures, or to getting lost if parents cannot yet recognise them. If species of surface-nesting seabird in the same colony area as the species to be banded are not yet at an appropriate stage of chick development, then banding should not proceed in areas where these species occur or within 80 metres of them. In cormorants and other tree-nesting seabirds, banding should be done when the chicks are still young enough not to react to the bander by jumping out of the nest. The advice of

[2] This is the air temperature above which small birds show reactions to heat (e.g. panting) if they are sitting on ground exposed to direct sunlight in the middle six hours of the day without a breeze (B. Lane, WBM Oceanics Australia, pers. obs.).

experienced banders on the appropriate time for banding should be sought before approving banding activities.
  - Banding of adults should involve holding individual birds for the shortest possible time to minimise the time spent away from the young and no more than 20 minutes from the time of capture.
  - Banding of young chicks should be done in a manner that does not move them from where they were before banders entered the colony area. Chicks within two weeks of flying (and once parental recognition is assured) can be moved by as much as 50 metres, enabling mass banding of chicks to occur using a carefully managed ‘progressive corralling’ method; this method should not be used for gannets, albatrosses or cormorants.
  - The ABBBS recommends against the banding of frigatebird chicks and this may evolve into a formal moratorium (T. Scotney, ABBBS, pers. comm.).
- Island management agencies should require researchers to provide a report on their activities, including the area of the colony in which they worked, the dates, nature and daily duration of activities, and any information they can provide on the impact of their activities on seabird breeding and actions taken to minimise this.
- The same restrictions should apply to researchers during the time when they are not actually conducting research as apply to other users of the area. For example, see camping, walking etc.

CHAPTER 6

Identifying Concerns and Management Measures

This chapter provides information to enable island managers to identify concerns and management measures for their particular setting. The chapter therefore, reviews aspects of seabird breeding biology and the nature of seabird breeding islands and the way that this affects the consequences of visitation and the management measures adopted. The final section of this chapter provides a table summarising the impacts of disturbance and relevant aspects of the breeding biology of each species.

6.1 MANAGEMENT CONCERNS RELATED TO SEABIRD BREEDING BIOLOGY

6.1.1 Burrow-nesting Species

A total of eleven species of Australian breeding seabirds breed in burrows. These species are indicated in section 6.3. The tables in section 6.3 also provide information on aspects of breeding biology and behaviour that are relevant to management.

A significant feature of the burrow nesters is that, apart from the Little Penguin, their clutch consists of one egg and, apart from the Little Penguin and the Common Diving-Petrel, they do not lay replacement clutches. Therefore, burrow-nesting species have one chance per year to reproduce and disruption leads to a complete failure of an annual breeding attempt.

For most of the time burrow-nesting seabirds are on land they are underground and, therefore, relatively safe from human disturbance. Based on the questionnaire responses, the greatest concern is burrow collapse due to trampling by wandering pedestrians.

From the tables in section 6.3, it can be seen that incubation in the burrow nesters usually lasts up to two months and the time from hatching to fledging is between two and four months. The birds are therefore using their burrows for between three and six months. This is the period during which management activities may be necessary to prevent disruption by human activities.

The islands that support large numbers of burrow-nesting seabirds (e.g. Wedge-tailed and Short-tailed Shearwaters) present a spectacular sight every evening as thousands of birds form rafts immediately offshore from their breeding island and then, over the space of half an hour, fly to shore and descend into their burrows. This represents a significant attraction for sensitively managed tourism.

Burrow-nesting seabirds are potentially most sensitive to disturbance when they are entering their burrow in the early evening. Sensitivity appears to vary significantly however. On Heron Island, off central Queensland, where thousands of Wedge-tailed Shearwaters breed, the birds will happily sit outside their burrows, calling and displaying to one another at the edge of well-used walking paths among buildings in a tourist resort. Provided people do not attempt to handle the birds, they continue with their normal activities seemingly oblivious to the presence of people. Other species may not be so adaptable.

When arriving at dusk and, particularly, when leaving at dawn, burrow-nesting seabirds often walk along fixed runways through island vegetation to reach the beach in order to take off. Campers can sometimes place their equipment across these runways and disrupt this behaviour.

Generally speaking, there appear to be no problems in allowing controlled and properly directed human access to islands that hold burrow-nesting seabirds, provided a number of measures are adopted to prevent any adverse impacts. The possibility of human injury from collapsing burrows should also be considered.

Measures to avoid problems with burrow-nesting species include:

- the construction of hard surface pathways or boardwalks through colony areas to prevent trampling of burrows;
- clear instructions to island visitors to keep to pathways and to avoid handling or disturbing any birds on the ground;
- clearly defined camping areas and associated instructions on use of fire, lighting etc. (see chapter 5);
- limiting numbers of people on the island after sunset and before sunrise and confining the activities of campers to designated areas on the shores of the island;
- that no pets or off-road vehicles should be permitted; and
- that human activities should not be permitted or should be limited to less vulnerable parts of the island during the sensitive colony establishment phase of the breeding cycle (timing varies around Australia).

6.1.2 Surface-nesting Species

A total of 23 species of seabirds breeding in Australia nests on the surface of islands or on low vegetation close to the ground. As chapter 3 demonstrated, the surface nesters are most vulnerable to the effects of human disturbance. Furthermore, most of Australia's surface nesters breed in the warmer latitudes of Australia and on islands that are more accessible and on which it is easier to land a boat. Accordingly, they are the most vulnerable to human disturbance. It is noteworthy that questionnaire respondents indicated considerable differences in the vulnerability of surface-nesting seabirds to human disturbance. The questionnaire response results are given in section 6.3.

Section 6.3 summarises information on the breeding biology and behaviour of each species that is relevant to management. From this, it can be seen that the surface-nesting seabirds display more variation in the duration of incubation period and time to fledging. The Little and Fairy Terns, require only about two months in which to complete a breeding cycle, although they feed their young for some time after leaving the colony. By contrast, Masked Boobies require up to six months to complete a breeding cycle. In surface-nesting seabirds, larger birds generally have longer breeding cycles. For this reason, the period of visitor management will vary between species.

Measures to avoid problems with surface-nesting seabirds include:

- confining activities to designated areas, including camping grounds, pathways and boardwalks, boat landing sites, moorings and fishing areas;
- closing sections of islands if they become occupied by sensitive species;
- closing the smallest islands to visitation if monitoring work shows that they cannot accommodate visitors at a sufficient distance from breeding seabirds without detrimental effects;

- erecting educational signs on seabird breeding islands informing visitors of the ways in which they can avoid affecting breeding seabirds;
- where a closure of access is discontinued during the non-breeding season, re-establishing of this closure 3–4 weeks before the arrival of breeding birds (based on previous monitoring results); and
- working with commercial operators (e.g. tour operators, resort managers) to ensure that they work with the island management agency to prevent the activities of their patrons from adversely affecting seabird breeding activity.

Unlike burrow and tree nesters, whose colonies can cover almost an entire island, surface-nesting seabirds tend to occur in localised, dense colonies, although there are notable exceptions, such as Red-tailed Tropicbirds, Bridled Terns and the gulls. Exceptions aside, this means that it is possible on larger islands to allow controlled access without visitors needing to go to within the critical distance of breeding surface-nesting seabirds.

6.1.3 Tree-nesting Species

A total of seven species of seabird breeding in Australia nests in trees. They build a nest of varying size and complexity, usually from twigs and leaves collected from under the nesting trees. There is some evidence that nest material may be in short supply in larger colonies (e.g. Black Noddy colonies in the Capricorn–Bunker Group off central Queensland) as stealing and fighting over nest material is commonplace (B. Lane, WBM Oceanics Australia, pers. obs.).

Tree nesters tend to occur in tropical regions and they generally require a long period in which to complete the breeding cycle. For example, the frigatebirds require up to seven months in which to complete a breeding cycle, probably due to the fact that they can only gather food at a fairly slow rate to feed to the chicks (Nelson 1980).

Measures to avoid problems with tree-nesting seabirds are the same as for surface nesters. The exception is the Black Noddy, which in some places is very tolerant of human presence and activities (southern Great Barrier Reef), whilst in others it is not (Coral Sea Islands and Ashmore Reef).

6.2 MANAGEMENT CONCERNS RELATED TO THE ATTRIBUTES OF ISLANDS

This section discusses the range of factors influencing the likelihood of human visitation to islands used by seabirds for breeding. Ross et al. (1995) provide an illuminating analysis of the Seabird Island Series in the journal *Corella*, covering 215 islands off the Australian coast. From the accounts, about 47 per cent of these islands are subject to one or more direct or indirect human threats.

The factors likely to influence human visitation include:

- distance from mainland (or Tasmania),
- ease of landing,
- physical island type and topography,
- size of island,
- vegetation,
- distance from major coastal settlements/cities, and
- boating conditions

Each of these factors is discussed separately below.

6.2.1 Distance from Mainland (or Tasmania)

Distance from the shore obviously influences the likelihood of an island being visited and Ross et al. (1995) found that the average distance from the shore of islands on which it was easy to land (see section 6.2.2 below) was 28.5 kilometres. This was greater than that for islands which were moderately difficult (23.2 kilometres) or difficult (12.7 kilometres) to land on. It is unlikely that most boating people would visit islands more than several kilometres offshore so the proportion of islands likely to be subject to disturbance based on ease of landing combined with distance offshore is likely to be considerably lower than the proportion that have easy landings (see below).

6.2.2 Ease of Landing

Of the islands analysed by Ross et al. (1995), 30 per cent (n = 64) were considered difficult to land on, 22 per cent (n = 47) moderately difficult and 48 per cent (n = 104) easy to land on. If these results apply to all islands around Australia, then they suggest that about half of the seabird breeding islands around the Australian coast may be able to be visited by most people using boats. However, the same analysis also revealed that the average distance offshore of islands on which it was easy to land was greater than for other islands (see section 6.2.1 above). Therefore, it seems likely that significantly less than half of Australia's seabird breeding islands would be visited regularly by people.

The significant differences in boating conditions in southern versus northern climates also contributes to southern islands being less vulnerable.

6.2.3 Physical Island Type and Topography

Island type contributes to both the ease with which landing can occur and the types of seabirds that breed. Classifications of islands are most well developed for coral reef ecosystems (see Mather & Bennett 1993). Elsewhere in Australia, islands are difficult to classify.

In coral reef environments of northern Australia, the following generalised island types are found:

- cays, which consist of coral rubble and sand, built up by wave action on top of reef platforms;
- low isles, which comprise some coral and sand, as well as some mangrove; and
- continental islands, which are usually larger and consist of rock outcrops and hills within the body of the continental shelf.

Coral cays and low isles are generally easy to land on with a small boat and, as they occur in an amenable climate, are frequently accessed by visitors, including substantial numbers that visit as part of organised tour groups, usually run by private or corporate operators.

Continental islands are less frequently visited in northern Australia as they are not as popular as the cays.

Most of the offshore islands of southern Australia fall into the category of continental islands, being the hills and outcrops of the land surface isolated by the most recent sea-level rise.

They often have rugged, wave-washed shorelines and are less frequently visited due to problems associated with changeable weather and the higher proportion of islands that are difficult to land on.

Islands which have greater topographic relief provide more opportunities for screening human activities from aggregations of breeding seabirds, though in practice minor changes in relief can sometimes provide substantial screening at a distance.

6.2.4 Size of Island

Larger islands tend to have a greater diversity of substrate and habitat types for breeding seabirds. Visitors to larger islands affect a much smaller proportion of an island. Together, these attributes of larger islands make them more able to absorb visitation. On larger islands, there is scope for preventing visitation to the more sensitive parts of the island and for directing visitation to areas with few or no breeding seabirds.

Small islands are particularly vulnerable to human disturbance as one small boat landing can potentially result in the failure of a breeding attempt by all the seabirds breeding there.

6.2.5 Vegetation

Vegetation type varies on islands. Islands can grade from parched, sandy deserts to lushly forested hills. Vegetation influences the species of birds that breed in an area. For example, tree nesters and burrowers tend to dominate forested islands, while surface nesters tend to dominate on sparsely vegetated islands.

Vegetation also provides a screen or cover between visitors and sensitive parts of a breeding colony. Provided visitation can be limited effectively, islands with the right mix of vegetation may sustain some visitation despite the presence of highly sensitive breeding seabird species.

6.2.6 Distance from Human Settlement

An island close to shore but a long way from a coastal boating harbour or launching place is likely to be visited very rarely. An island close to human settlement is likely to be visited more frequently than one in a remote area. Islands close to larger towns and cities would receive more visitors than those in less populated settled coastal areas.

6.2.7 Boating Conditions

Boating activities are affected by weather conditions. In southern Australia, windy or stormy days with rough seas preventing most boating activities are more frequent during the seabird breeding season than elsewhere. The changeability of sea conditions in southern Australia generally keeps most boat operators close to port. Generally only commercial fishermen have boats able to operate in difficult conditions.

In northern Australia, apart from tropical cyclones, wind and sea conditions are reasonably safe for most boat types (except small dinghies) all year. Furthermore, wind conditions are more predictable. This means that offshore islands in the tropical latitudes have a higher probability of being visited (all other factors being equal), than those in higher latitudes.

6.3 MANAGEMENT CONCERNS RELATED TO SPECIES AND GROUPS

Tables 6.1 to 6.12 provide detailed information on attributes (as described below) of seabird breeding biology, together with accounts of incidents of human disturbance of the species or a related species and their consequences for seabird breeding.

Nest location indicates whether the species is a burrow, surface or tree nester.

Clutch size indicates the number of eggs laid and whether the species will re-lay.

Incubation provides information on the duration of the incubation and fledging periods.

Breeding season gives the months in which the species breeds together with an indication of the variation in breeding season around Australia. This information is not comprehensive and breeding outside the indicated months is possible in regions where this has not been consistently studied.

Rating refers to the questionnaire responses to the question on the sensitivity of seabirds to human disturbance. A score of 7/2/-, for example, indicates that seven questionnaire respondents thought that the species was moderately sensitive to disturbance, two respondents thought that it was very sensitive and no respondent thought that it was extremely sensitive.

Table 6.1
PENGUINS

General Information:

- Studies of Antarctic penguins show that although these birds do not appear perturbed by the approach of humans, they are stressed, as indicated by significant increases in heart rate (Wilson et al. 1991).
- Work by Wilson et al. (1991) on Adelie Penguins in Antarctica showed that when moving between their breeding sites and the sea, penguins reacted and fled from aircraft at heights of over 1000 feet and at distances of greater than 1 kilometre. At the breeding colony however, birds generally sat tight, even when helicopters landed at a distance of about 30 metres. Telemetry work indicated however, that the heart rate of birds approached closely like this was four times the resting rate in the colony in the absence of disturbance.

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Little Penguin *Eudyptula minor*	Burrow	1–2 eggs second and occasional third clutches laid second broods raised in good years	33–37 day incubation 7–9 weeks to fledging	July–December in east, May–September in west Not synchronised Small colonies	7 / 2 / -

Other factors to take into account:

- burrows < 50 centimetres
- burrows vulnerable in areas that have been altered, prone to trampling by livestock and people
- vulnerable to domestic animals (cats and dogs); loss of Little Penguins at the Phillip Island Penguin Parade in Victoria to foxes, dogs and cats was documented by Reilly (1977)
- 20–40% fledging success is normal

Table 6.2
ALBATROSSES

General Information:

- Polynesian rats occasionally attack incubating albatrosses on Pacific islands (Harrison 1990).
- At Taiaroa Head, near Dunedin, where a new observatory was built next to a colony of Royal Albatrosses, adults remained in the vicinity of the observatory but first breeders did not settle near the observatory. A gradual shift of the colony away from the disturbance has resulted in many new pairs breeding in suboptimal breeding sites where exposure to adverse weather has reduced breeding success (A. Cox, NZ Department of Conservation, pers. comm.).

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Shy Albatross *Diomedea cauta*	Surface	1 egg no replacement laying	incubation 68–75 days over 4 months to fledging	September–April	

Other factors to take into account:

- nest on cliffs, ledges and slopes
- numbers reduced by feather collectors last century

Table 6.3
PETRELS, PRIONS AND SHEARWATERS

General Information:
- Disturbance should be minimised or avoided during the colony establishment phase.
- Introduced mongooses, cats, pigs, dogs, rats and barn owls have significantly affected at least 19 species of petrels and shearwaters worldwide (Burger & Gochfeld 1994).
- Fires in dense fern have destroyed some shearwater colonies on Hawaii (Harrison 1990).
- Newell's Shearwaters are attracted to lights and many disoriented birds crash and die in urbanised parts of Kauai each year (Harrison 1990).
- Black Rats eliminated a colony of 600 Bulwer's Petrel on Eastern Island (Midway), and have severely depleted populations of Bonin Petrels, Wedge-tailed Shearwaters and Christmas Shearwaters in the Midway Islands (Harrison 1990).
- Devegetation of colonies can eliminate shaded nest sites and lead to soil erosion which destroys burrows.
- Predation by feral cats lead to the extinction of the Guadalupe Storm-Petrel on Isla Guadalupe off the western Mexican coast (Everett & Anderson 1991).

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Great-winged Petrel *Pterodroma macroptera*	Burrow	1 egg no replacement laying	53–57 days incubation 4 months to fledging	February–November Not synchronised	
	Other factors to take into account: - burrows in coastal forest, under bushes and between rocks - 0–40% fledging rate - desertion a major cause for failure				
Black-winged Petrel *Pterodroma nigripennis*	Burrow	1 egg	little information	November–May	
	Other factors to take into account: - burrows 1.5–2.0 metres and in rock crevices on vegetated coastal slopes				
Herald Petrel *Pterodroma arminjoniana*	Surface	1 egg	little information	February–August	
	Other factors to take into account: - nests amongst low dense mat of vegetation on sloping sand ridge high on cay - egg laid on bare sand				
Gould's Petrel *Pterodroma leucoptera*	Surface	1 egg no replacement laying	6–7 weeks incubation 11–12 weeks to fledging	Late November–April	
	Other factors to take into account: - nests on ground and among rocks - 26–57% fledging success - many fatalities from entanglement with sticky *Pisonia* seeds - On Cabbage Tree Island, off New South Wales, Pied Currawongs that live in the island's small forests regularly take adult Gould's Petrels on exposed nests (Priddel & Carlile 1995). - Gould's Petrel breeds in rock crevices under fallen cabbage tree palms (*Livistona australis*) in two steep gullies on Cabbage Tree Island. This nesting site renders it vulnerable to predation. Significant numbers of adults are taken each year by the small number of Pied Currawongs that live on the island (Priddel & Carlile 1995). - Sticky seeds of the *Pisonia* tree entangle the plumage of adults and fledglings, incapacitating them and leaving them prone to predation by raptors. Rabbits present on the island may play a role in determining the distribution of the palms by reducing regeneration (Werren & Clough 1991). - One of the most significant potential threats to the breeding population is the introduction of rats and cats to Cabbage Tree Island.				

Fairy Prion *Pachyptila turtur*	Burrow	1 egg no replacement laying	45+ days incubation approx. 7 weeks to fledging	August–February Synchronised Colonial	
	Other factors to take into account: - burrows in soft soil among low vegetation - nesting areas threatened by erosion, making surface soils less suitable for burrows (Blakers, Davies & Reilly 1984) - little data on breeding success				
Flesh-footed Shearwater *Puffinus carneipes*	Burrow	1 egg no replacement laying	approx. 60 days incubation approx. 3 months to fledging	Late September–May Well synchronised Colonial	
	Other factors to take into account: - burrows under forest, scrubland, grassland, gentle to steep slopes - needs clear area to take off - susceptible to disturbance and predation				
Wedge-tailed Shearwater *Puffinus pacificus*	Burrow	1 egg no replacement laying	54 days incubation 3–4 months to fledging	September–April Synchronised Colonial	3 / 2 / -
	Other factors to take into account: - burrows in generally level ground - susceptible to trampling and predation - 78% chick survival at Muttonbird Island, NSW (Marchant & Higgins 1990) - rats and cats have been responsible for significantly reducing breeding numbers (Burger & Gochfeld 1994)				
Sooty Shearwater *Puffinus griseus*	Burrow	1 egg no replacement laying	57 days incubation about 3 months to fledging	September–April Synchronised Colonial	
	Other factors to take into account: - burrows in soil among coastal plants - late hatchlings less likely to survive				
Short-tailed Shearwater *Puffinus tenuirostris*	Burrow	1 egg no replacement laying	53 days incubation 3 months to fledging	Late September–early May Highly synchronised Colonial	2 / 1 / -
	Other factors to take into account: - trampling a problem during harvesting - success high in the absence of feral cats - In southern Australia, some Short-tailed Shearwater breeding colonies have been severely affected and, in some cases, eliminated, by introduced weeds. The introduced annual species die back in winter, exposing soil to erosion and removing burrowing substrate, or leading to an increase in burrow collapse (Marchant & Higgins 1990). This species has also stopped breeding in areas that have become colonised by introduced plants that are dense and impenetrable such as boxthorn, blackberry or kikuyu grass (Marchant & Higgins 1990). - Rabbit control programs on some Victorian islands have lead to the recolonisation by breeding Short-tailed Shearwaters of regenerated areas (Norman & Harris 1980). - Grazing on Victorian islands also leads to the destruction of Short-tailed Shearwater burrows (Harris & Norman 1981). Grazing of islands off South Australia by sheep and goats in the early part of the 20th century resulted in significant trampling of burrows in exposed positions (Wood-Jones 1937). Such areas have since been made reserves and grazing animals have been removed (Blakers et al. 1984). - The tiger snake (*Notechis ater* subspp.) on Flinders Island in Tasmania and Franklin and Hopkins Islands in South Australia, feeds almost exclusively on Short-tailed Shearwater (Mirtschin & Davis 1992).				

Little Shearwater *Puffinus assimilis*	Burrow	1 egg no replacement laying	55 days incubation 10–11 weeks to fledging	June–November Not synchronised Colonial	- / 2 / -
	Other factors to take into account: - nests in burrows, crevices and rock cavities - numbers affected by introduced predators				

Table 6.4
STORM-PETRELS

General Information:
- Disturbance should be minimised or avoided during the colony establishment phase.
- The most serious threat to Sooty Storm-Petrels in the Hawaiian Islands is the potential introduction of rats or other predators (Harrison 1990).
- Sooty Storm-Petrel population on Torishima Island has declined to near extinction two decades after the introduction of rats (Harrison 1990).
- Large-scale human activities near Sooty Storm-Petrel colonies are regarded as likely to increase mortality because of the attraction of the birds to lights (Harrison 1990).
- The Guadalupe Storm-Petrel on Isla Guadalupe off the western Mexican coast became extinct due to predation by feral cats (Everett & Anderson 1991).

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
White-faced Storm-Petrel *Pelagodroma marina*	Burrow	1 egg no replacement laying	approx. 50 days incubation 8 weeks to fledging	October–February Not synchronised Colonial	1 / 2 / -
	Other factors to take into account: - shallow burrow in dense vegetation - On the Furneaux Group, in Tasmania, this species suffers higher mortality and loss of eggs and chicks due to the introduction of rats (Marchant & Higgins 1990). - Trampling of burrows has been reported in a colony of White-faced Storm-Petrels on Mud Island, near Melbourne (Marchant & Higgins 1990) which is accessible to large numbers of people. - high fledging success from hatched eggs - Adults are particularly vulnerable to predation by gulls at dusk when they return to the colony. On moonlit nights they will wait offshore until a cloud obscures the moon before returning in darker conditions when it is presumably harder for gulls to detect them. - On Revesby Island in South Australia, the tiger snake (*Notechis ater* subspp.) feeds mostly on White-faced Storm-Petrels (Mirtschin & Davis 1992).				

Table 6.5
DIVING-PETRELS

General Information:
- Disturbance should be minimised or avoided during the colony establishment phase.

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Common Diving-Petrel *Pelecanoides urinatrix*	Burrow	1 egg able to re-lay	53 days incubation 7 weeks to fledging	July–December Not synchronised Colonial	1 / - / -

Other factors to take into account:
- islands with peat or stable soil under vegetation
- burrows coastal plains and slopes, among boulders and scree
- high survival from hatching to fledging but significant mortality associated with fledging
- first breed at 2–3 years old
- average life expectancy 3–5 years
- Cattle graze in and trample the breeding areas of Common Diving-Petrels on the Falkland and South Georgia Islands (Croxall et al. 1984).
- Common Diving-Petrel on Macquarie Island has become confined to small offshore islands and stacks that are free of introduced predators (Rounsevell & Brothers 1984).

Table 6.6
PELICANS

General Information:
- Brown Pelicans suffered nest abandonment and increased predation, and chicks were caught in cactus plants, as a result of people walking in the vicinity of colonies (Anderson & Keith 1980 in Hockin et al. 1992).
- *Pelecanus erythrhynchos* suffered high rates of egg loss due to adults crushing eggs when disturbed by aircraft (Bunnell et al. 1981 in Hockin et al. 1992).
- Work on the Brown Pelican in California (Anderson 1988) shows that detrimental effects to breeding birds can result from approaches as far away as 600 metres or more.
- Gulls have been observed attacking pelican chicks until the chicks regurgitated fish, thereby diverting the attacker. Gulls have also removed the eyes or, more often, the uropygial gland / entrails until the young pelican died (Anderson & Keith 1989).

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Australian Pelican *Pelecanus conspicillatus*	Surface	generally 2 eggs replacement laying uncertain	32–35 days incubation 3–4 months to fledging	Most months Not synchronised	1 / 1 / 2

Other factors to take into account:
- susceptible to predation following falling water levels
- disturbance by people affects breeding success

Table 6.7
GANNETS AND BOOBIES

<table>
<tr><td colspan="6">General Information:
- Cats have eliminated boobies on the main island at Ascension, killing adults and juveniles (Harrison 1990).
- Rats prey on booby eggs, young and adults on Kure and Midway Islands and may have contributed to the demise of the Brown Booby colony on Eastern Island (Harrison 1990).
- Pigs trampled and destroyed Masked and Brown Booby colonies on Clipperton Island (Harrison 1990).
- Stampedes resulting from mass panic in the colony can lead to trampling of eggs and small young by adults and larger chicks, resulting in significant mortality.
- Human consumption of booby adults, eggs and chicks on the islands and atolls of the western Indian Ocean has caused the populations of all booby species to decline there during the past century. At least half the colonies have been eliminated and the remainder are greatly reduced. This has been especially difficult to control because harvests are for home consumption rather than commercial purposes (Harrison 1990).
- At the Cat Island gannetry in Bass Strait a colony of several thousand gannets was reduced to nothing by the 1980s by commercial fishermen shooting adults and taking chicks as fishing bait (Warham 1979).</td></tr>
<tr><th>Species</th><th>Nest Location</th><th>Clutch Size</th><th>Incubation</th><th>Breeding Season</th><th>Rating</th></tr>
<tr><td rowspan="2">Australasian Gannet
Morus serrator</td><td>Surface</td><td>1 egg
replacement laying</td><td>44 days incubation
14–15 weeks to fledging</td><td>October–May
Poorly synchronised
Colonial</td><td></td></tr>
<tr><td colspan="5">Other factors to take into account:
- previously prey by crayfishermen for pot baits
- eggs taken by gulls during disturbance
- 75% fledging success, 85% mortality before breeding age</td></tr>
<tr><td rowspan="2">Masked Booby
Sula dactylatra</td><td>Surface</td><td>2 eggs
little known</td><td>43 days incubation
17–18 weeks to fledging</td><td>All year, peak in spring
Often well synchronised
In colonies</td><td>1 / 3 / -
(boobies)</td></tr>
<tr><td colspan="5">Other factors to take into account:
- require open space for nesting; introduced vegetation can reduce nesting areas (Harrison 1990)
- not generally in areas visited
- nest on bare ground or using available debris
- success affected by El Niño related food decline</td></tr>
<tr><td rowspan="2">Brown Booby
Sula leucogaster</td><td>Surface</td><td>1–2 eggs
some replacement laying</td><td>43 days incubation
14–15 weeks to fledging</td><td>All year, peak in autumn
Poorly synchronised
Colonial</td><td>1 / 3 / -
(boobies)</td></tr>
<tr><td colspan="5">Other factors to take into account:
- require open space for nesting; introduced vegetation can reduce nesting areas (Harrison 1990)
- nest on ground in various terrains of oceanic islands, atolls and cays
- success affected by El Niño related food decline</td></tr>
<tr><td rowspan="2">Red-footed Booby
Sula sula</td><td>Tree</td><td>1 egg
replacement laying 10–40 days after egg loss</td><td>45 days incubation
15–16 weeks to fledging</td><td>April–October
Not synchronised
Colonial</td><td>2 / - / -</td></tr>
<tr><td colspan="5">Other factors to take into account:
- Rabbits ate out shrubbery on Manana Island (Hawaii) removing Red-footed Booby nesting habitat (Harrison 1990).
- nests in the terminal branches of available trees and shrubs
- eggs and chicks taken by Silver Gulls
- in some places e.g. Raine Island, Red-footed Boobies will remain on their nest until a person approaches to within 1.5 to 2 metres (Smyth 1991).</td></tr>
</table>

Table 6.8
FRIGATEBIRDS

General Information:

- Probably the most significant conservation problem for Great Frigatebirds is the loss of nesting material. In the past this has resulted from the introduction of rabbits (Harrison 1990).
- Cats on Christmas Is. (Pacific Ocean) completely destroyed a nesting colony of Great Frigatebirds, eating all eggs and chicks (Harrison 1990).
- Frigatebirds are particularly disturbed by human intruders in their colonies. Uncontrolled human activities not only cause reproductive failure in the year of the disturbance but can result in the abandonment of an entire colony. The Great Frigatebird colony on Aldabra Island was deserted as a result of the activities of tourists from the MS *Lindblad Explorer*. It was re-established several years later (Harrison 1990).
- Studies of frigatebirds on the Galapagos Islands show that although these birds do not appear perturbed by the approach of humans, they are stressed, as indicated by significant increases in heart rate (see Tindle 1979).
- Frigatebirds will leave their nests at the approach of a person to within 50 metres and take up to 30 minutes to return to the nest (Smyth 1991). On remote North Keeling Island (Indian Ocean), Lesser Frigatebirds have been seen to lift off from their nests when the observer is about 200 metres away and not return for up to 50 minutes.
- The Australian Bird and Bat Banding Scheme recommends against banding frigatebird chicks at present and this may evolve into a formal moratorium (T. Scotney, ABBBS, pers. comm.).
- There is a high risk of eggs/chicks being dislodged by adults hurriedly taking flight (G. Pike, pers. comm.).

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Great Frigatebird *Fregata minor*	Tree	1 egg probable replacement laying	55 days incubation 22–23 weeks to fledging	March – early July Synchronised Colonial	1 / 1 / 6 (Frigate-birds)
Lesser Frigatebird *Fregata ariel*	Tree	1 egg probable replacement laying	41 days incubation 22–23 weeks to fledging	April–July Not synchronised Colonial	1 / 1 / 6 (Frigate-birds)
	Other factors to take into account: - vegetated isolated oceanic islands, sand cays and atolls - nests on trees, bushes and shrubs - nest of sticks and grass - success affected by El Niño related food decline				

Table 6.9
CORMORANTS AND SHAGS

General Information:

- *Phalacrocorax auritus* are susceptible to disturbance by people, boating and sailing. Impacts include adults leaving nests, egg losses due to adults standing on eggs and predation by gulls (Kury & Gochfield 1975, Verbeek 1982, Hobson et al. 1989 – all in Hockin et al. 1992).

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Pied Cormorant *Phalacrocorax varius*	Tree	2–4 eggs probable replacement laying	27–33 days incubation 7–8 weeks to fledging fed 80 days after	Mainly autumn Not synchronised Colonial	- / - / 1
	Other factors to take into account: - 26% total success rate is usual				
Black-faced Cormorant *Phalacrocorax fuscescens*	Surface	usually 2–3 eggs	little information	September–January Colonial	
Little Pied Cormorant *Phalacrocorax melanoleucos*	Tree	3–5 eggs	little information	All year, dependent on food supply	
	Other factors to take into account: - usually nest in trees on a platform of sticks and debris - some predation by crows and whistling kites - cormorant chicks older than about two weeks of age are more likely to jump from nests and drown, fall or be lost or predated than younger chicks which tend to cling to the nest				

Table 6.10
TROPICBIRDS

General Information:

- Rats and other predators are reported to have eaten nesting adults, eggs and young in some places (Harrison 1990).

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Red-tailed Tropicbird *Phaethon rubricauda*	Surface	usually 1 egg	41–48 days incubation 90 days to fledging	Summer in subtropics, winter in tropics.	
	Other factors to take into account: - Nesting generally requires adequate shade. When Laysan Island was devegetated by rabbits in the 1920s, it became impossible for Red-tailed Tropicbirds to breed there (Harrison 1990). However, G. Pike (pers. comm., 1995) reports that on Bedwell Island, an unvegetated cay at Clerke Reef in the Rowley Shoals off Western Australia, a colony of about 50 birds nest on the bare sand unprotected from the tropic sun. Visiting tourists have erected stone shelters as nesting sites for these birds, but many still prefer to nest in the open. - On Lady Elliot Island around ten pairs breed successfully in close proximity to tourist accommodation units, with some nests within five metres of units and pathways.				

Table 6.11
GULLS

General Information:

- Incubating Herring and Greater Black-backed Gulls reacted at greater distances when approached directly than when approached tangentially to the nest (Burger & Gochfeld 1981 in Hockin et al. 1992).
- A number of gull species (Herring Gull, Ring-billed Gull) suffer from intraspecific predation when disturbed by researchers or people walking near the colony. Ring-billedGull chicks were observed to get lost and die following disturbance by researchers (Gillett et al. 1975, Hand 1980, Anderson & Keith 1980, Fetterholf 1983 – all in Hockin et al. 1992),
- It is not uncommon for wandering chicks to be attacked and killed by unrelated adults.

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Silver Gull *Larus novaehollandiae*	Surface	1–3 eggs replacement clutches laid	21–27 days incubation 6 weeks to fledging	All year Colonial	3 / 1 / -
	Other factors to take into account: - highly adaptable species making use of a wide range of breeding habitats - numbers increasing dramatically in southern Australia due to availability of garbage for food near large cities				
Pacific Gull (RARE) *Larus pacificus*	Surface	2–3 eggs	26–28 days incubation time to fledging not documented	Spring and early summer Nest singly or in small colonies	
	Other factors to take into account: - nest on ground of grass and seaweed - generally solitary nesting - Islands holding more than five breeding pairs should be closed during the breeding season unless site hardening and awareness activities are implemented. - The Pacific Gull inhabits gently shelving beaches protected from ocean waves on offshore islands, bays, estuaries and inshore lakes. Disturbance by humans and attacks by Kelp Gulls where mixed colonies are established are the most significant factors contributing to mortality (Garnett 1992).				
Kelp Gull *Larus dominicanus*	Surface	2–3 eggs	incubation 29 days time to fledging not documented	September–December Nest singly or in small colonies	
	Other factors to take into account: - nest well formed of available material on ground in sheltered area				

Table 6.12
TERNS AND NODDIES

General Information:

- Tern and noddy eggs are frequently collected as food. In the Dry Tortugas (Florida), Sooty Tern colonies were almost eliminated during the nineteenth century when eggs were sold to wholesale bakeries (Harrison 1990).
- Rats and cats have wiped out many tern colonies throughout the world. Islands with rats tend to have the smallest tern colonies in the Hawaiian islands (Harrison 1990).
- The populations of Brown Noddies, Sooty Terns and Grey-backed Terns have declined at Midway Island since black rats were introduced in 1943 (Harrison 1990).
- Terns nesting on open beaches are susceptible to off-road-vehicle traffic.
- Little Terns (*Sterna albifrons*) have been reported to become habituated to Harrier Jets and to nest on take-off pads despite their frequent use (Altman & Gano 1984 in Hockin et al. 1992).
- Erwin (1989) looked at critical distances for a number of tern species in eastern North America and found the average distance to which people could approach before the first terns took flight varied depending on the species from 50 to 150 metres. The most sensitive species took flight at the approach of a person to within 300 metres.
- There are many examples of terns using dredge spoil islands in regions where their natural breeding sites have become heavily disturbed (e.g. Buckley & Buckley 1976; Kotliar & Burger 1986 in Hockin et al. 1992).
- Some tern species feed their chicks about once per hour (Nelson 1980).

Species	Nest Location	Clutch Size	Incubation	Breeding Season	Rating
Caspian Tern *Sterna caspia*	Surface	1–3 eggs	20–22 days incubation 4–5 weeks to fledging	September–December Most singly or in small colonies up to 100+ pairs	- / 3 / -
	Other factors to take into account: - usually small colonies from one or two pairs up to 20+ pairs				
Roseate Tern *Sterna dougallii*	Surface	1–2 eggs replacement clutches laid asynchronous	21–25 days incubation 4–5 weeks to fledging	September–January in east, February–May in west Synchronised Colonial	- / 2 / 5
	Other factors to take into account: - on islands, on ground in slight depression in sand or coral - disturbances during nesting can lead to abandonment - Hulsman (undated) indicated that colonies of Black-naped and Roseate Terns on southern Great Barrier Reef islands could be approached to within 30 metres by small boat from offshore, compared with 80 metres when walking on the beach.				
White-fronted Tern *Sterna striata*	Surface	2–3 eggs	25 days incubation 4–5 weeks to fledging	October–January Colonial	
	Other factors to take into account: - on islands, on ground amid tussock grass				

<table>
<tr><td rowspan="2">Black-naped Tern
Sterna sumatrana</td><td>Surface</td><td>2 eggs
replacement clutches laid</td><td>25 days incubation
time to fledging not documented</td><td>September–December
Colonial</td><td>1 / 3 / 2</td></tr>
<tr><td colspan="5">Other factors to take into account:
- heavily predated by Silver Gulls
- lost to high tides
- suffer from people disturbance
- Experience in the Capricorn and Bunker Groups in the southern Great Barrier Reef (Hulsman 1984) suggests that 80 metres is the critical distance for Black-naped Terns, considered to be one of the more sensitive surface nesters on tropical islands.
- Hulsman (undated) indicated that colonies of Black-naped and Roseate Terns on southern Great Barrier Reef islands could be approached to within 30 metres by small boat from offshore, compared with 80 metres when walking on the beach.</td></tr>
<tr><td rowspan="2">Sooty Tern
Sterna fuscata</td><td>Surface</td><td>1 egg</td><td>24–26 days incubation
4–5 weeks to fledging</td><td>Peaks in spring and autumn
Breed in very large colonies</td><td>2 / 3 / -</td></tr>
<tr><td colspan="5">Other factors to take into account:
- large colonies on islands on ground under low vegetation
- common
- At Michaelmas Cay (QNPWS, pers. comm. to GBRMPA), Sooty Terns deserted part of a colony in response to a helicopter landing and moved to breed on a part of the cay that was subsequently eroded by the sea, causing nesting failure.
- Nelson (1980) describes the activities of 50 to 100 frigatebirds predating a breeding colony of Sooty Terns at Christmas Island in the Pacific Ocean. They took so many chicks that only 25 survived from an initial 600,000 eggs laid (cats and human disturbance were also involved).
- Stampeding has been found to be a potentially serious problem in Sooty Terns in the early post-hatching period before parent–offspring recognition has established (D. O'Daniel, US Fish and Wildlife Service, pers. comm.). In this case, lost chicks are taken by predators or starve to death.
- Hicks et al. (1987) found that on Michaelmas Cay, near Cairns, Sooty Terns did not fly up in response to the presence of large catamarans carrying many people on tourist visits to the cay. These boats approached to within 200 metres of the cay.
- Hicks et al. (1987) found that Sooty Terns and Common Noddies breeding on Michaelmas Cay took flight in reaction to the landing and departure of seaplanes within 400 metres. They were far more likely to take flight in response to the plane taking off than to it landing.</td></tr>
<tr><td rowspan="2">Bridled Tern
Sterna anaethetus</td><td>Surface</td><td>1 egg</td><td>28–30 days incubation
7–9 weeks to fledging</td><td>September–January
Breed in loose colonies</td><td>2 / 4 / 1</td></tr>
<tr><td colspan="5">Other factors to take into account:
- on ground under a rock or bush</td></tr>
</table>

<table>
<tr><td rowspan="2">Little Tern (VULNERABLE)
Sterna albifrons</td><td>Surface</td><td>2–3 eggs
replacement clutches laid</td><td>21 days incubation
3 weeks to fledging
fed 2–3 months afterwards</td><td>October–January east and south-east Australia
Autumn and winter in Gulf of Carpentaria
Nest singly or in small colonies</td><td>- / 3 / 1</td></tr>
<tr><td colspan="5">Other factors to take into account:
- on sand or shingle beaches
- threatened by encroaching vegetation, human activities, industry and predation – lead to decline in NSW breeding population
- In the case of Little and Fairy Terns on small islands close to shore in mainland estuaries, wardening is necessary to ensure minimal disturbance by visitors. This wardening can be done cost-effectively by one employee and a team of volunteers or, in less accessible sites, volunteers with costs provided (J. Reside, Department of Conservation and Natural Resources, Victoria, pers. comm.).
- Little Terns nest on beaches and sand spits near estuaries, preferring areas of unvegetated beach between the high tide mark and shore vegetation. Breeding success in these areas is reduced by storms and associated large waves.
- The major threats to the Little Tern in Australia are from disturbance by people and domestic animals, development and vegetation encroachment (Hill et al. 1988; Blaber et al. 1996). Nesting birds that are disturbed generally leave the nest, exposing eggs or chicks to extremes of temperature and to heavy predation by gulls (Hill et al. 1988).</td></tr>
<tr><td rowspan="2">Fairy Tern (RARE)
Sterna nereis</td><td>Surface</td><td>2–3 eggs
replacement clutches laid</td><td>20 days incubation
3 weeks to fledging</td><td>November–February
Nest in small colonies < 100 pairs</td><td>2 / 2 / 1</td></tr>
<tr><td colspan="5">Other factors to take into account:
- small colonies, egg laid on sand
- on islands, shores of lagoons and beaches
- threatened by encroaching vegetation, disturbance expanding, Silver Gull colonies
- The Fairy Tern bred for many years in Port Phillip Bay, Victoria at one managed, undisturbed site (Victorian Wader Study Group, pers. comm.). All other sites were unsuitable due to regular disturbance.
- In the case of Little and Fairy Terns on small islands close to shore in mainland estuaries, wardening is necessary to ensure minimal disturbance by visitors. This wardening can be done cost-effectively by one employee and a team of volunteers or, in less accessible sites, volunteers with costs provided (J. Reside, Department of Conservation and Natural Resources, Victoria, pers. comm.).
- Fairy Terns breed on coral shingle on islands and cays, on open beaches and on sandy islands inside estuaries. The natural rate of nest failure is believed to be high due to flooding from high tides and smothering from shifting sands. Disturbance by people and domestic animals allows predation by gulls and corvids and, in some instances, may cause abandonment of the colony (Hill et al. 1988).</td></tr>
<tr><td rowspan="2">Crested Tern
Sterna bergii</td><td>Surface</td><td>1, occasionally 2 eggs
sometimes two broods per year</td><td>25–30 days incubation
5–6 weeks to fledging</td><td>October–January
Synchronised
Colonial</td><td>5 / 5 / -</td></tr>
<tr><td colspan="5">Other factors to take into account:
- ground nesting in large colonies on sand or shingle
- suffer from disturbance and predation by gulls
- 85% fledging success
- In a study of the Crested Tern breeding at an island in the northern Great Barrier Reef, it was found that the reaction to aircraft noise increased with increasing noise (Brown 1990). Reactions varied but up to 20% of the colony studied flew up at a noise level of 95 decibels.
- The habit of Crested Tern chicks forming groups on the beach almost immediately they are mobile, makes them more vulnerable to the impact of human visitation, as visitors usually drive the birds before them as they walk along the shore (G. Pike, pers. comm.).</td></tr>
</table>

<table>
<tr><td rowspan="2">Lesser Crested Tern
Sterna bengalensis</td><td>Surface</td><td>1 egg</td><td>26–30 days incubation
4–5 weeks to fledging</td><td>October–December (GBR); April–June
Breed in small colonies (north-west Aust.)</td><td>- / 3 / 1</td></tr>
<tr><td colspan="5">Other factors to take into account:
- on ground, no nest constructed
- disturbed by human activities
- food and eggs preyed upon by Silver Gulls</td></tr>
<tr><td rowspan="2">Common Noddy
Anous stolidus</td><td>Surface</td><td>1 egg</td><td>32–35 days incubation</td><td>July–January
Colonial</td><td>3 / 4 / -</td></tr>
<tr><td colspan="5">Other factors to take into account:
- seaweed and stick nest on ground or on a low shrub
- preyed upon by lizards, Silver Gulls and Eastern Reef Egrets
- disturbed by humans
- Hicks et al. (1987) found that on Michaelmas Cay, near Cairns, Common Noddies did not fly up in response to the presence of large catamarans carrying many people on tourist visits to the cay. These boats approached to within 200 metres of the cay.
- Hicks et al. (1987) found that Sooty Terns and Common Noddies breeding on Michaelmas Cay took flight in reaction to the landing and departure of seaplanes within 400 metres. They were far more likely to take flight in response to the plane taking off than to it landing.</td></tr>
<tr><td rowspan="2">Lesser Noddy (RARE)
Anous tenuirostris</td><td>Tree</td><td>1 egg</td><td>unknown</td><td>September–December
Colonial</td><td></td></tr>
<tr><td colspan="5">Other factors to take into account:
- nest in trees; seaweed cemented by excreta
- The large population of this subspecies cannot be considered at immediate risk. However, due to the very limited distribution of the population it is susceptible to catastrophic destruction by cyclones, oil spills or similar events. The species also relies on the local fish stocks and so will be susceptible to any changes associated with the fisheries.</td></tr>
<tr><td rowspan="2">Black Noddy
Anous minutus</td><td>Tree</td><td>1 egg</td><td>unknown</td><td>September–December
Colonial</td><td></td></tr>
<tr><td colspan="5">Other factors to take into account:
- nest in trees; seaweed and grass
- large colonies; expanding on Heron Is.
- preyed on by Silver Gulls and Eastern Reef Egrets
- Black Noddies are known to sit on their nests until touched (Smyth 1991). Hulsman (pers. comm., October 1995) found that this approachability depends upon their location, and that Smyth’s statement is accurate for birds in areas frequented by people or machines e.g. helicopters on Heron Island, however, birds in less disturbed areas are less approachable.</td></tr>
</table>

CHAPTER 7

Implementation of Guidelines

This chapter examines ways in which the guidelines presented in chapters 5 and 6 can be implemented through the various regulatory and management systems that island management agencies might have at their disposal. Obviously, the ways in which the guidelines are implemented will differ between jurisdictions which tend to have a unique arrangement for island management. For example, for most offshore islands in the Northern Territory, it will be necessary to implement the guidelines jointly with the Aboriginal communities that own the islands. In South Australia, where most islands are nature reserves with one agency (Department of Environment and Heritage) having jurisdiction, the guidelines can be implemented through the normal management planning and implementation process for nature reserves.

Implementation of the guidelines can be achieved within most jurisdictions through a number of mechanisms, including:

- codes,
- site hardening,
- closure,
- signs,
- brochures, videos etc.,
- permits,
- wardening and the use of volunteers,
- monitoring of seabird breeding,
- training,
- accreditation,
- education, and
- liaison with other agencies.

These are discussed in the remainder of this chapter.

Once a set of management measures has been developed for a particular site there is a need for ongoing monitoring and evaluation of its success and for using the results of this to improve the management approach. The last section of this chapter explores this further.

7.1 CODES

7.1.1 Codes of Conduct

Codes of conduct are voluntary codes developed for the public at large by island management agencies, often in conjunction with environmental, research and educational bodies with an interest in seabird protection or in visiting seabird breeding islands.

They are a convenient way of packaging the message to visitors about the correct behaviour on seabird breeding islands.

An example of what a code of conduct for burrow-nesting seabirds might include, is provided below. Changes would be necessary to this code to adapt it to particular species or settings but it is provided for general guidance. The code of conduct would include:

- confining activities to designated areas and paths, or the shores of the island;
- leaving the island before dusk or, if camping, confining activities after dusk to designated camping areas, viewing areas or the shores of the island;
- no pets whatsoever;
- no off-road vehicles whatsoever;
- no handling of or interference with birds on the ground or in burrows;
- campers using lights at night only within the designated camping areas; and
- no open fires to be allowed.

7.1.2 Codes of Practice

Codes of practice refer to a set of rules and procedures that prescribe human activities on seabird breeding islands. They would relate to particular visitor types and would be developed as part of self-regulatory approaches. Groups of island visitors that would most likely benefit from codes of practice include, but are not limited to:

- the resort industry,
- day-visitor operators,
- camping tour operators,
- boat tour operators, and
- commercial fishermen.

Codes of practice are broader in scope than a simple code of conduct as they enunciate the accepted, negotiated requirements that particular groups of island users have agreed to adopt. Therefore, they have policy weight within the organisations that subscribe to them as well as clear procedures for self-regulating activities on islands. Although they do not have the weight of law, serious breaches of codes of practice might result in expulsion from membership of the association that developed the code and, if visitation to seabird breeding islands is linked to this membership or 'accreditation' (see section 7.10), this would give them considerable practical weight.

The advantage of a code of practice is that it can be developed, by the island users themselves, to be consistent with the legal requirements covering their use of the islands and with input from the island management agency. Users would, through this process, have a sense of ownership of the code.

Codes of practice are most suited to industry associations and research organisations and they cannot govern the activities of the casual island visitor. The latter is better served by a code of conduct promoted by the island management agency itself.

7.2 SITE HARDENING

Site hardening involves the provision of infrastructure that controls the activities of people and minimises their potentially detrimental effects on the natural environment. On seabird breeding islands, site hardening can include a number of different types of infrastructure, namely:

- landing points,
- camping areas,
- viewing areas and hides,

- paths, and
- fences.

In particular situations, a unique combination of infrastructure might be necessary to control human activities adequately to ensure minimal impact on breeding seabirds. These infrastructure types are described below.

7.2.1 Landing Points

Some islands are easier to land on than others. Some have only one landing point, whereas others can be landed on from any direction. Islands in northern Australia tend to have more landing options than those in the more windswept southern latitudes where rough seas and mostly continental islands combine to limit options.

Where landing points are not limited, it may be necessary to designate such points based on patterns of seabird usage of the island and the relevant critical distances for the particular setting. These could be indicated on maps, tide tables, local newspapers and other promotional avenues. Regular publicity may be necessary where landing points might change in response to the erratic behaviour of species that move colony site each year.

7.2.2 Camping Areas

Where camping is permitted on an island, it is important to limit it to designated areas. These need to be located carefully to avoid breeding seabirds. Before finalising the location of camping areas, a complete review of breeding seabird usage of the island and the relationship of this to likely suitable landing points should be undertaken and camping areas chosen to avoid sensitive species and locations, or the need for island visitors to walk through these locations between the landing point and the camping ground.

Where possible, natural topographic or vegetation features should be used to screen camping areas from the bulk of birds, particularly from surface-nesting species.

A code of conduct should be developed for campers and appropriate limits placed on the number of campers at any one time. Both will vary, depending on the species, the nature and size of the island, and the geographic setting.

7.2.3 Viewing Areas/Hides

Public viewing facilities should be provided at strategic, low impact sites on the regularly visited islands. Particular attention should be paid to ensuring that these are located in such a manner as to:

- provide good views of seabird breeding areas;
- allow for the movement of the sun so that good light conditions for observation exist for most of the day; and
- ensure adequate distance from the breeding seabirds so that no disturbance is caused.

Sometimes, if seabird breeding occurs too close to permanent viewing facilities, they may need to be closed temporarily.

Information should be provided in the viewing area on:

- the species of seabird present and how to identify them;
- interesting information on the biology and behaviour of seabirds (e.g. breeding, migration, feeding behaviour, location of nearby feeding areas etc.);

- the significance of the seabirds breeding on the island;
- the vulnerability of the seabirds to human disturbance; and
- information on the relevant code of conduct for visitors.

7.2.4 Paths

An important way of restricting the movement of people on seabird breeding islands is through the provision of paths. These have the following functions:

- restricting visitors to designated low impact parts of the island;
- providing visitors with an opportunity to view, from a distance, the seabird colonies;
- preventing visitors from approaching surface-nesting seabirds too closely; and
- keeping visitors off areas where burrow-nesting seabirds might otherwise be trampled.

Paths in colonies of predominantly burrow-nesting species should consist of raised boardwalks that allow birds to burrow in the soil beneath them. Alternatively, hard surface tracks could be provided but these are vulnerable to undermining by burrowing seabirds and, in some settings, may restrict burrowing opportunities.

Temporary tracks might be provided by roping off a trail through a low impact area should mobile, surface-nesting species be found to nest very close to permanent paths in a particular year.

7.2.5 Fences

Fences are the most conspicuous way of stopping people from approaching sensitive seabird breeding colonies. It is always desirable to provide signs explaining why fencing has been installed in particular locations. This is likely to increase significantly the effectiveness of the fencing.

Many seabirds fly low over their colony area and, during the day, they are generally able to avoid collisions with fences. Many of the burrow-nesting species however, return in the post-dusk gloom and are still flying around in complete darkness. In such conditions, there is a danger of birds colliding with fences. Fence location and design is therefore important.

Where possible, fencing should not be so high as to protrude significantly above the level of vegetation. Wherever possible, the location of fences within the colony area should be avoided. Wire fencing should not be used under any circumstances as it is difficult to see in the dark and birds could strike it and kill themselves. Barbed wire should not be used as birds can impale themselves on it. This is particularly critical for wandering chicks of surface-nesting species where barbed wire is placed close to the ground or bushes.

Loose, rope fencing, using thick rope that is visible and moves if struck by flying birds is likely to be the safest type of fencing.

Temporary fencing of colonies of mobile species can be done to prevent disturbance. Star pickets with rope strung between them have proved useful on islands in the Great Barrier Reef Marine Park.

Anti-predator fencing can also be used if necessary, although a detailed account of this management tool is beyond the scope of these guidelines. It is important to ensure that the design of anti-predator fencing does not lead to night-time bird fatalities as described earlier.

Fencing has significant advantages in showing the public that the island management agency is active in protecting breeding seabirds. This is a further reason why it is desirable for explanatory signs to accompany fences.

7.3 CLOSURE

Prohibiting visitation to seabird islands is a useful and commonly used way of ensuring that seabird breeding activities are not disrupted. Such closure can be total, seasonal, for part of the day or of part of an island. In the absence of other approaches, closure remains effective. The options for closure are discussed below in more detail.

Total closure is not unusual on particularly significant seabird breeding islands and human access is usually only permitted for research purposes. At Wreck Island, in the Mackay / Capricorn Section of the Great Barrier Reef Marine Park, the zoning calls for total closure of the island to protect a turtle colony and breeding seabirds, including Wedge-tailed Shearwaters, Roseate Terns and Black-naped Terns. Eshelby Island, off Bowen, is also permanently closed except for permitted research and maintenance activities, to protect the largest colony of Bridled Terns on the Great Barrier Reef.

Seasonal closure is more common and in the Great Barrier Reef, many islands are closed seasonally from October to March, the main period over which seabirds breed. Seasonal closure is a very effective approach, in principal, to protecting breeding seabirds. However, enforcement of such closures may be beyond the resources of some island management agencies.

Closure of an island for part of the day (e.g. from sunset to sunrise) may be a useful way of controlling human disturbance impacts in the case of burrow-nesting species.

On islands where site hardening has been undertaken, it may be necessary from time to time to close part of the island to human access. Paths, viewing facilities, camping areas or landing points may need to be closed temporarily to control human access. Such an approach is useful when the mobile surface-breeding species move into an area to breed.

7.4 SIGNS

Signs are an essential tool in effectively managing visitation to seabird breeding islands. Signage should be concise and located appropriately to ensure that the following aspects are clearly explained:

- the seabirds present and why they are of conservation significance,
- the vulnerability of seabirds to disturbance, and
- how visitors should behave to prevent disruption to breeding activities.

Signs could be placed on islands at regularly visited sites (e.g. camping grounds, landing points) and at the edges of regular breeding areas. It may be necessary to move signs from year to year when the mobile, surface-nesting species appear in a new location. Signs could also be placed in the vicinity of boat-launching areas and marinas to inform potential island visitors.

As parts of Australia are subject to heavy visitation by overseas tourists, some of whom may not speak English, or by people of non-English speaking backgrounds, the use of international symbols or languages other than English on signs may be essential to get the message across.

Signs should be placed in such a manner that they do not offer predatory birds (e.g. raptors, ravens, crows) a convenient perch from which to hunt as this can lead to excessive localised predation and, in some instances, the desertion of a colony (D. Priddel, NSW National Parks and Wildlife Service, pers. comm.). In this respect, they should not rise above the level of surrounding vegetation (location at the edge of vegetation is therefore appropriate) or, if possible and effective, be located near existing higher objects such as rocky outcrops or buildings.

7.5 PUBLICITY TOOLS

Publicity tools are important means of conveying information to island visitors or potential island visitors about the need for appropriate conduct on seabird breeding islands. They are the main way in which voluntary codes of conduct can be communicated to visitors and they include brochures, videos and other publicity.

Brochures, as well as other explanatory information, can be used to communicate the codes of conduct for a particular island or group of islands. Brochures should include concise, readable information and make maximum use of pictures to get the message across. In some situations, it may be appropriate to produce brochures in a number of languages or multi-lingual brochures.

Brochures can be distributed through a range of avenues, including, but not limited to:

- local angling, boating and sailing clubs (e.g. as supplements to their newsletter or at their clubhouse),
- boat launching areas and marinas,
- from dispensers on the islands,
- via ranger patrols that visit islands, and
- via tour group operators.

Explanatory information and codes of conduct related to visitation to seabird islands can be incorporated into other literature or items that boat owners/users and other potential island visitors regularly use, for example:

- the backs or margins of charts and maps,
- inside tide table booklets and brochures,
- on the lids of ‘eskies’ or on drink holders,
- on bait bags, and/or
- in boating and fishing magazines.

Videos are another way of promoting appropriate visitor behaviour on seabird breeding islands. They are perhaps more suited to tour groups, including educational groups, where there is a captive audience with little to do on the boat trip out to the island. Such pre-visit videos have been produced by the Great Barrier Reef Marine Park Authority on a range of topics for use by tour operators on boats and they have proved very popular and effective.

Videos are also a useful way to train tour operators and their guides on how to conduct visitors on seabird breeding islands.

With all publicity tools, there is considerable scope for collaboration and joint funding by Government, local businesses and community groups.

7.6 WARDENING AND THE USE OF VOLUNTEERS

Some seabird colonies are very accessible to large numbers of people. This is especially true of small islands in mainland estuaries or islands that are linked to the mainland in some way or are close to big cities. In these circumstances, great success has been achieved in improving seabird breeding success, particularly of surface-nesting species such as terns, by regular wardening of colony sites.

Wardening involves the presence of a ranger or authorised volunteer at the approaches to an active colony to inform people of the presence of sensitive breeding seabirds and to ensure that they do not disrupt breeding activities.

In the case of Little and Fairy Terns on small islands close to shore in mainland estuaries, wardening is necessary to ensure minimal disturbance by visitors. This wardening can be done cost-effectively by one employee coordinating a team of volunteers or, in less accessible sites, volunteers with costs provided (J. Reside, Department of Conservation and Natural Resources, Victoria, pers. comm.).

7.7 PERMITS

Visitors to many offshore islands in Australia require a permit from the relevant island management agency. There is scope for incorporating visitor codes of conduct and other restrictions on activities into conditions of the visitor permit in a situation like this. In jurisdictions where there is no visitor permit regime in place, law reform may be necessary to allow this.

The most developed island visitation permitting system in Australia is that operating in the Great Barrier Reef Marine Park off Queensland, jointly managed by the Great Barrier Reef Marine Park Authority and the Queensland Department of Environment.

Here, permits are issued to all visitors to most islands with the exception of private individuals in their own boats. Permits are required for any commercial tourism operation and for any primary industry activity. The permit system operates in parallel with a zoning plan for the Park, which defines the range of activities allowable in particular parts of the Park. Permit conditions are generally defined on the basis of the zone-use restrictions.

Currently, permits are issued for commercial operations in the Great Barrier Reef Marine Park and for camping on offshore islands. However, private day visitors and visitors staying on boats anchored near islands are not required to obtain a permit.

In most other States, permits are required for commercial operations on any island that comes under the ambit of the State's relevant nature conservation legislation.

7.8 MONITORING OF SEABIRD BREEDING

Monitoring of seabird breeding for insight into numbers and trends must form part of a well-designed program aimed at allowing statistically valid analysis. It is an essential part of managing seabird populations. Monitoring can be done for different purpodes:

- to gather information on the breeding numbers and success of seabirds to monitor their breeding distribution and the health of their populations;
- early breeding season monitoring to determine the location of sensitive colonies of the mobile species so temporary management measures (described earlier) can be implemented as soon as necessary; and
- before and after monitoring to determine the effectiveness of management approaches.

All islands holding vulnerable and rare species should be monitored at least twice per month to track breeding activity and to check that feral predators have not been introduced by any visitors.

The intensity of monitoring can be increased by involving volunteer groups in the activity and by encouraging tour operators to report sightings of seabird breeding activities to the island management agency.

7.9 TRAINING

Staff of island management agencies, staff who are running tours to offshore islands, and other visitors are usually not familiar with many elements covered by these guidelines. It is recommended that relevant interpretation, management and enforcement staff be trained in the implementation of these guidelines through the development and implementation of relevant training programs.

7.10 ACCREDITATION SCHEMES

In the guidelines, mention is made of the need for visitors to be accompanied on seabird breeding islands that lack site hardening by an experienced and accredited guide. There are efforts under way to develop an ecotourism accreditation scheme. Any guides for visitors to seabird breeding islands should obtain accreditation within this scheme, with a specific endorsement for operating at seabird breeding islands that lack the facilities referred to in the guidelines. All jurisdictions would need to recognise and use this accreditation and endorsement. A training module could be developed for such guides (similar to that for interpretation staff in island management agencies) that is approved by the relevant jurisdictions.

7.11 EDUCATION

Educational activities can significantly increase public awareness of the significance of breeding seabirds, their vulnerability to human disturbance, and of local, relevant codes of conduct for island visitation. The scope of such activities is enormous and the mix of activities chosen will depend on the particular situation. It is important that any community educational activities are:

- unambiguous,
- clearly target relevant (potential island visitor) groups, and
- encourage appreciation of the significance of breeding seabirds.

Where islands are managed by nature conservation agencies, these usually already have in-house groups that have the expertise to develop educational campaigns and materials. Resources should be made available to enable educational activities to be implemented as part of strategies to manage visitation to seabird breeding islands. The opportunity for collaboration with other relevant Government agencies, local businesses and community groups should be fully explored.

7.12 LIAISON WITH OTHER AGENCIES AND BODIES

Island management agencies will, from time to time, need to liaise with a range of other agencies and bodies. Table 7.1 provides a list of these agencies and bodies and the matters about which they will need to be consulted.

7.13 MONITORING, EVALUATION AND IMPROVEMENT OF MANAGEMENT MEASURES

The relevant management agency in each jurisdiction should require assurance that appropriate visitor management is being implemented and enforced and to this end should develop auditing, compliance, non-conformance and reporting procedures to ensure complete implementation and that visitors are complying with them. Such procedures should be built into the work programs and overall management systems of the organisational units responsible for implementing and enforcing the guidelines. The outcomes of the reporting can be used to refine the guidelines for particular situations.

Table 7.1
LIAISON WITH OTHER AGENCIES AND BODIES

AGENCY/BODY	MATTER
Department of Defence	military training exercises need for responsible officer to consult with island management agency need for island management agency officer to be present on first visit presence of seabird breeding activity on potential target or bombing range site
Civil Aviation Authority	aircraft movements, and height and distance restrictions over seabird islands
Local airports	aircraft movements, and height and distance restrictions over seabird islands
Local aero clubs	development of a code of practice for pilots in the vicinity of local seabird breeding islands
Commonwealth or State agencies responsible for navigational aids	maintenance or any emergency repair of navigational aids need for responsible officer to consult with island management agency need for island management agency officer to be present on first visit
Meteorological stations	maintenance or data collection from island-based meteorological stations need for responsible officer to consult with island management agency need for island management agency officer to be present on first visit
Fishermen’s organisations	opportunities for educational activities and the dissemination of promotional materials to potential island visitors
Tour operators	development and implementation of codes of practice for tourism or seabird breeding islands development and implementation of accreditation scheme covering guides for visits to seabird breeding islands information on seabird breeding activities
Community environmental groups	volunteer wardens for wardening seabird colonies information on seabird breeding development of collaborative publicity tools and educational activities
Local businesses	dissemination of publicity tools development of collaborative publicity tools and educational activities

BIBLIOGRAPHY

Ainley, D. G. & Lewis, T. J. 1974, The history of Farallon Island marine bird populations, 1854–1972, *Condor* 76: 432–446.

Anderson, D. W. 1988, Dose–response relationship between human disturbance and Brown Pelican breeding success, *Wildlife Society Bulletin* 16: 339–345.

Anderson, D. W. & Keith, J. O. 1980, The human influence on seabird nesting success: conservation implications, *Biological Conservation* 18: 65–80.

Barnes, A. & Hill, G. J. E. 1989, Census and distribution of Black Noddy (*Anous minutus*) nests on Heron Island, November 1985, *Emu* 89: 129–134.

Benson, C. W., Beamish, H. H., Jouanin, C., Salvan, J. & Watson, G. E. 1975, The birds of the Iles Glorieuses, *Atoll Research Bulletin* 176: 1–34.

Blaber, S., Battam, H., Brothers, N. & Garnett, S. 1996, Threatened and migratory seabird species in Australia: an overview of status, conservation and management, in *The Status of Australia's Seabirds: Proceedings of the National Seabird Workshop, Canberra, 1–2 November 1993*, eds G. J. B. Ross, K. Weaver & J. C. Greig, Biodiversity Group, Environment Australia, Canberra, pp. 13–27.

Blakers, M., Davies, S. J. J. F. & Reilly, P. N. 1984, *The Atlas of Australian Birds,* Melbourne University Press, Melbourne.

Blokpoel, H. & Scharf, W. C. 1991, Status and conservation of seabirds nesting in the Great Lakes of North America, in *Seabird Status and Conservation: A Supplement,* ed. J. P. Croxall, ICBP Technical Publication No. 11, Cambridge.

Boellstorff, D. E., Anderson, D. W., Ohlendorf, H. M. & O'Neill, E. J. 1988, Reproductive effects of nest-marking studies in an American White Pelican colony, *Colonial Waterbirds* 11: 215–219.

Bourke, W. L. J. 1974, The environmental impact of aircraft operations at Sydney Kingsford-Smith Airport, *SAE Australasia* 34: 233–244.

Bourne, W. R. P. 1972, Threats to seabirds, *International Council for Bird Preservation Bulletin* 11: 200–218.

Boyle, S. A. & Samson, F. B. 1985, Effects of nonconsumptive recreation on wildlife: a review, *Wildlife Society Bulletin* 13: 110–116.

Brown, A. L. 1990, Measuring the effect of aircraft noise on seabirds, *Environment International* 16: 587–592.

Buckley, P. A. & Buckley, F. G. 1976, *Guidelines for Protection and Management of Colonially Nesting Waterbirds*, National Parks Service, Boston.

Burbidge, A. A. & Fuller P. J. 1994, *The Western Australian Department of Conservation and Land Management Seabird Breeding Islands Database*, Department of Conservation and Land Management, WA.

Burbidge, A. A., Johnstone, R. E. & Fuller, P. J. 1994, *The Status of Western Australian Seabirds*, Department of Conservation and Land Management, WA, pp. 1–39.

Bureau of Tourism Research 1993, *Australian Tourism Data Card*, BTR, Canberra.

Burger, J. 1981a, Behavioural responses of Herring Gulls (*Larus argentatus*) to aircraft noise, *Environmental Pollution* (Series A) 24: 177–184.

Burger, J. 1981b, The effect of human activity on birds at a coastal bay, *Biological Conservation* 21: 231–241.

Burger, J. 1983, Jet aircraft noise and bird strikes, why more birds are being hit, *Environmental Pollution* 30: 143–152.

Burger, J. 1984, Colony stability in Least Terns, *Condor* 86: 61–67.

Burger, J. & Gochfeld, M. 1994, Predation and effects of humans on island nesting seabirds, in *Seabirds on Islands: Threats, Case Studies and Action Plans*, eds D. N. Nettleship, J. Burger & M. Gochfeld, Birdlife International, Cambridge, pp. 39–67.

Croxall, J. P., Evans P. G. H. & Schreiber R. W. 1984, *Status and Conservation of the World's Seabirds*, ICBP Technical Publication No. 2, Cambridge.

Davey, C. 1990, *A Report on the Numbers and Distribution of Gould's Petrel* Pterodroma leucoptera *on the John Gould Nature Reserve, NSW*, New South Wales National Parks and Wildlife Service.

Domm, S. & Recher, H. F. 1973, The birds of One Tree Island with notes on their yearly cycle and feeding ecology, *Sunbird* 4: 63–85.

Duffy, D. C. 1979, Human disturbance and breeding birds, *Auk* 96: 815–817.

Duncan, N. 1978, The effects of culling Herring Gulls (*Larus argentatus*) on recruitment and population dynamics, *Journal of Applied Ecology* 15: 97–713.

Dunnet, G. M. 1977, Observations on the effects of low-flying aircraft on seabird colonies on the coast of Aberdeenshire, Scotland, *Biological Conservation* 12: 55–63.

Dwyer, T. J. 1979, Effects of helicopter censuses on wading bird colonies, *Journal of Wildlife Management* 43(3): 756–759.

Erwin, R. M. 1980, Breeding habitat use by colonially nesting waterbirds in two mid-Atlantic US regions under different regimes of human disturbance, *Biological Conservation* 18: 39–51.

Erwin, R. M. 1989, Responses to human intruders by birds nesting in colonies: experimental results and management guidelines, *Colonial Waterbirds* 12: 104–108.

Erwin, R. M., Haramis, G. M., Krementz, D. G. & Funderburk, S. L. 1993, Resource protection for waterbirds in Chesapeake Bay, *Environmental Management* 17: 613–619.

Everett, W. T. & Anderson, D. W. 1991, Status and conservation of the breeding seabirds on offshore Pacific Islands of Baja California and the Gulf of California, in *Seabird Status and Conservation: A Supplement*, ed. J. P. Croxall, ICBP Technical Publication No. 11, Cambridge, pp. 115–139.

Feare, C. J. 1984, Seabirds as a resource: use and management, in *Biogeography and Ecology of the Seychelles Islands*, ed. D. R. Stoddart, W. Junk, The Hague, pp. 593–606.

Forshaw, J. M. 1971, The birds of Great Britain, *International Council for Bird Preservation Bulletin* 1: 1–20.

Fuller, P. J., Burbidge, A. A. & Owens, R. 1994, Breeding seabirds of the Houtman Abrolhos, Western Australia: 1991–1993, *Corella* 18: 97–113.

Garnett, S. (ed.) 1992, Threatened and extinct birds of Australia, *RAOU Report No. 82*.

Gillett, W. H., Hayward, J. R. & Stout, J. F. 1975, Effects of human activity on egg and chick mortality in a Glaucous-winged Gull colony, *Condor* 77: 492–495.

Hand, J. L. 1980, Human disturbance in Western Gull (*Larus occidentalis livens*) colonies and possible amplification by intraspecific predation, *Biological Conservation* 18: 59–63.

Harris, M. P. & Norman, F. I. 1981, Distribution and status of coastal colonies of seabirds in Victoria, Australia, *Memoirs of the National Museum of Victoria* 42: 89–106.

Harrison, C. S. 1990, *Seabirds of Hawaii: Natural History and Conservation*, Cornell University Press, Ithaca & London.

Hegerl, E. & Hulsman, K. 1982, Wilson Island – an unsuitable site for tourist development, *Bulletin of the Australian Littoral Society* 5: 1–8.

Hicks, J. T., King, B. R. & Chaloupka, M. Y. 1987, Seaplane and vessel disturbance of nesting seabird colonies on Michaelmas Cay, *Queensland National Parks and Wildlife Service Management Report* No. 1. 8 pp.

Hill, G. J. E. & Barnes, A. 1989, Census and distribution of Wedge-tailed Shearwater (*Puffinus pacificus*) burrows on Heron Island, November 1985, *Emu* 89:135–139.

Hill, G. & Rosier, J. 1989, Wedgetailed Shearwaters, White Capped Noddies and tourist development on Heron Island, Great Barrier Reef Marine Park, *Journal of Environmental Management* 29: 107–114.

Hill, R., Bamford, M., Rounsevell, D. E. & Vincent, J. 1988, Little Terns and Fairy Terns in Australia – an RAOU conservation statement, *RAOU Report No. 53*.

Hobson, P. A. R. & Hallinan, J. 1981, Effect of human disturbance on the breeding behaviour of Jackass Penguins (*Spheniscus demersus*), *South African Journal of Wildlife Research* 11: 59–62.

Hockin, D., Ounsted, M., Gorman, M., Hill, D., Keller, V. & Barker, M. A. 1992, Examination of the effects of disturbance on birds with reference to its importance in ecological assessments, *Journal of Environmental Management* 36: 253–286.

Hulsman, K. 1977, Breeding success and mortality of terns at One Tree Island, Great Barrier Reef, *Emu* 77: 49–59.

Hulsman, K. 1984, Survey of seabird colonies in the Capricornia Section of the Great Barrier Reef Marine Park. III Population parameters and management strategies, Report for the Great Barrier Reef Marine Park Authority, 66 pp.

Hulsman, K., Submission to the GBRMPA on seabirds and their colonies in the Capricornia and Bunker Groups, Griffith University, Nathan.

Hunt Jr., G. L. 1972, Influence of food distribution and human disturbance on the reproductive success of Herring Gulls, *Ecology* 53: 1052–1061.

Kikkawa, J. 1976, The birds of the Great Barrier Reef, in *Biology and Geology of Coral Reefs*, volume 3, eds E. A. Jones & R. Endean, Academic Press, New York, pp. 279–341.

Kikkawa, J. & Boles, W. 1976, Seabird islands – Heron Island, Queensland, *Australian Bird Bander* 14: 3–6.

King, B. R. 1993, The status of Queensland seabirds, *Corella* 17: 65–92.

King, B. R., Hicks, J. T. & Cornelius, J. 1992, Population changes, breeding cycles and breeding success over six years in a seabird colony at Michaelmas Cay, Queensland, *Emu* 92: 1–10.

Koford, R. R., Dunning, J. B., Ribic, C. A. & Finch, D. M. 1994, A glossary for avian conservation biology, *Wilson Bulletin* 106: 121–137.

Kury, C. R. & Gochfeld, M. 1975, Human interference and gull predation in cormorant colonies, *Biological Conservation* 8: 23–34.

Kushlan, J. A. 1979, Effects of helicopter censuses on wading bird colonies, *Journal of Wildlife Management* 43: 756–760.

Lane, S. G. 1991, Some problems during the exodus of young shearwaters from Muttonbird Island, New South Wales, *Corella* 15: 108.

Latta Hand, J. 1980, Human disturbance in Western Gull (*Larus occidentalis livens*) colonies and possible amplification by intraspecific predation, *Biological Conservation* 18: 59–63.

Lavery, H. J. & Grimes, R. J. 1971, Sea-birds of the Great Barrier Reef, *Queensland Agricultural Journal* 97: 106–113.

Marchant, S. & Higgins, P. J. (eds) 1990, *Handbook of Australian, New Zealand and Antarctic Birds*, volume 1, Oxford University Press, Melbourne.

Mather, P. & Bennett, I. (eds) 1993, *A Coral Reef Handbook: A Guide to the Geology, Flora and Fauna of the Great Barrier Reef*, 3rd edn, Surrey Beatty & Sons, Chipping Norton.

Mathers, R. 1987, The effect of aircraft noise on the behaviour of Crested Terns (*Sterna bergii*) in the late incubation phase, BSc (Honours) thesis, School of Australian Environmental Studies, Griffith University.

Milton, D. A., Smith G. C. & Blaber, S. J. M. 1996, Variable success in breeding of the Roseate Tern *Sterna dougallii* on the northern Great Barrier Reef, Emu 96: 123–131.

Mirtschin, P. J. & Davis, R. 1992, *Snakes of Australia: Dangerous and Harmless*, Hill of Content, Melbourne.

Morris, R. D., Blokpoel, H. & Tessier, G. D. 1992, Management efforts for the conservation of Common Tern (*Sterna hirundo*) colonies in the Great Lakes: two case histories, *Biological Conservation* 60: 7–14.

Muir, F. & Chester, G. 1992, Managing tourism to a seabird nesting island in the Great Barrier Reef Marine Park – management of Michaelmas Cay and Reef, in *Ecotourism, Incorporating the Global Classroom*, ed. B. Weiler, Bureau of Tourism Research, Canberra, pp. 184–191.

National Parks and Wildlife Service, *Guidelines for Tourist Operations at Macquarie Island Nature Reserve 1993/94*, Tasmanian National Parks and Wildlife Service, Hobart, 5 pp.

Nelson, B. 1980, *Seabirds: Their Biology and Ecology*, Hamlyn, London.

Norman, F. I., Dann, P. & Menkhorst, P. W. 1993, *The Status of Seabirds in Victoria*, Department of Conservation and Natural Resources.

Norman, F. I. & Harris, M. P. 1980, Recent changes in the flora and avifauna of Rabbit Island, Wilsons Promontory, Victoria, *Proceedings of the Royal Society of Victoria* 92: 209–212.

Ogden, J. 1993, Population increase and nesting patterns of the Black Noddy (*Anous minutus*) in *Pisonia* forest on Heron Island: observations in 1978, 1979 and 1992, *Australian Journal of Ecology* 18: 395–403.

Ogilvie, P. S. & King, B. R. 1993, The conservation and management of seabird populations on the Great Barrier Reef, in *Birds and Their Habitats*, eds C. P. Catterall, P. V. Driscoll, K. Hulsman, D. Muir & A. Taplin, Queensland Ornithological Society Inc., Brisbane, pp. 70–78.

Ollason, J. C. & Dunnet, G. M. 1980, Nest failures in the Fulmar: the effect of observers, *Journal of Field Ornithology* 1: 39–54.

Piatt, J. F., Roberts, B. D., Lidster, W. W., Wells, J. L. & Hatch, S. A. 1990, Effects of human disturbance on breeding Least and Crested Auklets at St Lawrence Island, Alaska, *Auk* 107: 342–350.

Pierce, D. J. & Simons, T. R. 1986, The influence of human disturbance on Tufted Puffin (*Fratercula cirrhata*) breeding success, *Auk* 103: 214–216.

Priddel, D. & Carlile, N. 1995, Mortality of adult Gould's Petrel *Pterodroma leucoptera* at the nesting site on Cabbage Tree Island, New South Wales, *Emu* 95(4).

Prys-Jones, R. P., Prys-Jones, M. S. & Lawley, J. C. 1981, The birds of Assumption Island, Indian Ocean: past and future, *Atoll Research Bulletin* 248: 1–16.

Reilly, P. N. 1977, Gabo Island, Victoria, *Corella* 1: 51–53.

Reilly, P. N. & Cullen, J. M. 1982, The Little Penguin *Eudyptula minor* in Victoria. III: Dispersal of chicks and survival after banding, *Emu* 82: 137–142.

Resource Assessment Commission 1992, *Coastal Zone Inquiry Background Paper*, Australian Government Publishing Service, Canberra.

Robert, H. C. & Ralph, C. J. 1975, Effects of human disturbance on the breeding success of gulls, *Condor* 77: 495–499.

Rogers, J. A. & Smith, H. T. 1995, Set-back distances to protect nesting bird colonies from human disturbance in Florida, *Conservation Biology* 9: 89–99.

Ross, G. J. B., Burbidge, A. A., Brothers, N., Canty, P., Dann, P., Fuller, P. J., Kerry, K. R., Norman, F. I., Menkhorst, P. W., Pemberton, D., Shaughnessy, G., Shaughnessy, P. D., Smith, G. C., Stokes, T. & Tranter, J. 1995, The status of Australia's seabirds, in *The State of the Marine Environment Report for Australia Technical Annex: 1,* eds L. P. Zann & P. Kailola, Great Barrier Reef Marine Park Authority, Townsville, pp. 167–182.

Rounsevell, D. E. & Brothers, N. P. 1984, The status and conservation of seabirds at Macquarie Island, in *Status and Conservation of the World's Seabirds,* eds J. P. Croxall, P. G. H. Evans & R. W. Schreiber, ICBP Technical Publication No. 2, Cambridge, pp. 587–592.

Safina, C. & Burger, J. 1983, Effects of human disturbance on reproductive success in the Black Skimmer, *Condor* 85: 164–171.

Saliva, J. E. & Burger, J. 1989, Effect of experimental manipulation of vegetation density on nest site selection in Sooty Terns, *Condor* 91: 689–698.

Schlusser, K. & Jackson, S. 1990, *Roseate Terns* Sterna dougallii *and Their Management with Special Reference to One Tree Island,* One Tree Island Field Station Report, University of Sydney, pp. 1–4.

Serventy, D. L. Serventy, V. & Warham, J. 1971, *The Handbook of Australian Sea-Birds*, Reed, Sydney.

Shurcliff, K. & Williams, A. 1992, Managing ecotourism in the Great Barrier Reef Marine Park – can we manage it together, in *Ecotourism, Incorporating the Global Classroom,* ed. B. Weiler, Bureau of Tourism Research, Canberra, pp. 178–183.

Smith, G. C. 1992, Silver Gulls and emerging problems from increasing abundance, *Corella* 16(2): 39–46.

Smith, G. C. & Carlile, N. 1993, Methods for population control with a Silver Gull colony, *Wildlife Research* 20: 219–226.

Smith, G. C., Carlile, N. & Tully, S. 1992, Breeding and movements of wing-tagged Silver Gulls (*Larus novaehollandiae*) at the largest colony in New South Wales, *Wildlife Research* 19: 161–167.

Smith, J. W. & Renken, R. B. 1991, Least Tern nesting habitat in the Mississippi River Valley adjacent to Missouri, *Journal of Field Ornithology* 62: 497–504.

Smith, P. 1990, The biology and management of waders (suborder Charadrii) in New South Wales, *NSW National Parks and Wildlife Service, Species Management Report No. 9*, NPWS, Sydney.

Smyth, A. 1991, Report on visit to Raine Island, Raine Island Corporation, Brisbane.

Southern, L. K. & Southern, W. E. 1982, Effect of habitat decimation on Ring-Billed Gull colony and nest site tenacity, *Auk* 99: 328–331.

Starks, J. 1992, National breeding census of the Little Tern *Sterna albifrons* in northern and eastern Australia in 1989, *RAOU Report No. 78*.

Stoddart, D. R. 1984, Breeding seabirds of the Seychelles and adjacent islands, in *Biogeography and Ecology of the Seychelles Islands,* ed. D. R. Stoddart, W. Junk, The Hague, pp. 575–592.

Stoddart, D. R., Gibbs, P. E. & Hopley, D. 1981, Natural history of Raine Island, Great Barrier Reef, *Atoll Research Bulletin* 254: 1–44.

Stokes, T. A. 1988, A review of the birds of Christmas Island, Indian Ocean, *Australian National Parks and Wildlife Service Occasional Paper No. 16*.

Stokes, T., Hulsman, K., Ogilvie, P. & O'Neill, P. 1996, Management of human visitation to seabird islands of the Great Barrier Reef Marine Park region, in *The Status of Australia's Seabirds: Proceedings of the National Seabird Workshop, Canberra, 1–2 November 1993*, eds G. J. B. Ross, K. Weaver & J. C. Greig, Biodiversity Group, Environment Australia, Canberra, pp. 45–56. Also in *Corella* 20: 1–13.

Thomas, G. J. 1972, A review of gull damage and management methods at nature reserves, *Biological Conservation* 4: 117–127.

Tindle, R. W. 1979, Tourists and the seabirds in Galapagos, *Oryx* 15: 68–70.

United States Department of Agriculture Forest Service 1992, *Potential Impacts of Aircraft Overflights of National Forest System Wilderness*, Report to Congress.

Van Heezik, Y. & Seddon, P. J. 1990, Effect of human disturbance on beach groups of Jackass Penguins, *South African Journal of Wildlife Research* 20: 89–93.

Walker, T. A. 1991, Tourism development and environmental limitations at Heron Island, Great Barrier Reef, *Journal of Environmental Management* 33: 117–122.

Warham, J. 1962, Bird islands within the Barrier Reef and Torres Strait, *Emu* 62: 99–111.

Warham, J. 1979, Cat Island, Tasmania, *Corella* 3: 43–45.

Watkins, D. 1993, A national plan for shorebird conservation in Australia, *RAOU Report No. 90*.

Weiler, B. (ed.) 1992, *Ecotourism, Incorporating the Global Classroom*, Bureau of Tourism Research, Canberra.

Werren, G. L. & Clough, A. R. 1991, Effect of rabbit browsing on littoral rainforest, Cabbage Tree Island, NSW – with special reference to the status of the Gould's Petrel, in *The Rainforest Legacy, Australian National Rainforests Study, Volume 2 – Flora and Fauna of the Rainforests*, eds G. Werren & P. Kershaw, Australian Government Publishing Service, Canberra, pp. 257–277.

Wilson, R. P., Culik, B., Danfeld, R. & Adelung, D. 1991, People in Antarctica – how much do Adelie Penguins (*Pygoscelis adeliae*) care? *Polar Biology* 11: 363–370.

Wood-Jones, F. 1937, The breeding of the White-faced Storm-Petrel *Pelagodroma marina* on South Australian islands, *South Australian Ornithologist* 35–41.

Zell, L. 1983, Low flying aircraft, Great Barrier Reef Marine Park Authority Minutes.

APPENDIX 1
SOURCES OF INFORMATION ON SEABIRD POPULATIONS AND DISTRIBUTION IN AUSTRALIA

STATE	SOURCE	CONTACT DETAILS
Queensland	Queensland Seabird Atlas	Department of Environment 160 Ann Street Brisbane Qld 4000
New South Wales	-	New South Wales National Parks and Wildlife Service 43 Bridge Street Hurstville NSW 2220
Victoria	-	Department of Conservation and Natural Resources Flora and Fauna Branch 240 Victoria Parade East Melbourne Vic. 3002
Tasmania	-	Parks and Wildlife Service 134 Macquarie Street Hobart Tas. 7000
South Australia	-	Department of Environment and Natural Resources GPO Box 1047 Adelaide SA 5001
Western Australia	Western Australian Seabird Database	Department of Conservation and Land Management WA Wildlife Research Centre PO Box 51 Wanneroo WA 6065
Northern Territory	Northern Territory Seabird Database	Parks and Wildlife Commission of the Northern Territory PO Box 496 Palmerston NT 0831

APPENDIX 2
QUESTIONNAIRE SENT TO SEABIRD ISLAND RESEARCH AND RANGER STAFF

NB These two pages are an example only: please do not complete or return.

IMPACTS OF VISITATION ON SEABIRD BREEDING ISLANDS

How many times have you visited seabird breeding islands?..

Over what period have you been visiting seabird breeding islands?..........................years

In which part(s) of Australia have you most visited seabird islands?

• • • • • • •

How often and over what period does disturbance need to occur to cause a significant reduction in breeding success or desertion / breeding failure? (Estimate only if you have observed such events)

Species: No. of Disturbance Events: Over a Period of:

• • • • • • •

Are some species of surface-nesting seabirds more sensitive to visitor disturbance than others? If so, please list them below and indicate whether they are extremely, very or moderately sensitive.

• • • • • • •

Please describe how, in your experience, visitors have caused the failure or disruption of breeding by surface-nesting seabirds.

• • • • • • •

How often, where and over what period have you observed such problems?

• • • • • • •

On Australian islands you have visited with surface-nesting seabirds, is any form of visitation possible by people such as scientists, tourists and private visitors with minimal risk of seabird breeding disruption or failure? If so, what controls would be needed to ensure minimal risk?

• • • • • • •

Are some species of burrow-nesting seabirds more sensitive to visitor disturbance than others? If so, please list them below and indicate whether they are extremely, very or moderately sensitive.

• • • • • • •

Please describe how, in your experience, visitors have caused the failure or disruption of breeding by burrow-nesting seabirds.

• • • • • • •

How often, where and over what period have you observed such problems?

• • • • • • •

On Australian islands you have visited with burrow-nesting seabirds, is any form of visitation possible by people such as scientists, tourists and private visitors, with minimal risk of seabird breeding disruption or failure? If so, what controls would be needed to ensure minimal risk?

• • • • • • •

In your experience, what aspects of **seabird biology/breeding behaviour** contribute to the vulnerability of breeding seabirds to disruption by visitors?

• • • • • • •

In your experience, what aspects of **visitor behaviour** contribute to the disruption of seabird breeding activity on islands?

• • • • • • •

In view of increasing demands to visit islands, what sorts of measures do you think should be taken to prevent disruption of breeding seabirds by visitors?

• • • • • • •

Are you aware of any guidelines that have been produced to manage visitation to seabird islands to prevent disruption to breeding? If so, could you please indicate where a copy can be obtained, or enclose a copy if it is immediately available.

• • • • • • •

Please write any other comments or suggestions on the back of these sheets or on an attached sheet.

Thank you for taking the time to provide this information.

Completed questionnaires were returned to:
Brett Lane, WBM Oceanics Australia, PO Box 203, SPRING HILL QLD 4004

APPENDIX 3
RESPONDENTS TO THE QUESTIONNAIRE

Mr Ricky Baird	Department of Environment and Heritage, Heron Island, Queensland
Mr H Battam	Engadine, New South Wales
Mr John Bracken	National Parks and Wildlife Service, Victor Harbour, South Australia
Mr Nigel Brothers	Parks and Wildlife Service, Hobart, Tasmania
Mr Don Cameron	Department of Environment and Heritage, Townsville, Queensland
Mr Ray Chatto	Parks and Wildlife Commission of the Northern Territory, Darwin, Northern Territory
Mr C G Cooper	Portland, Victoria
Mr Peter Copley	Department of Environment and Natural Resources, Adelaide, South Australia
Mr John Cornelius	Department of Environment and Heritage, Cairns, Queensland
Mr Peter Dann	Penguin Reserve Committee of Management, Cowes, Victoria
Mr Terry Dennis	Department of Environment and Natural Resources, Kingscote, South Australia
Mr Philip Du Gueschlin	Department of Conservation and Natural Resources, Colac, Victoria
Dr Nick Dunlop	East Victoria Park, Western Australia
Mr M Fortescue	Australian Nature Conservation Agency, Jervis Bay, New South Wales
Mr Mark Hallam	Australian Nature Conservation Agency, Canberra, Australian Capital Territory
Mr Michael Hines	Stafford Heights, Queensland
Mr Peter Kendrick	Department of Conservation and Land Management, Karratha, Western Australia
Dr Nick Klomp	School of Environmental Sciences, Charles Sturt University, Albury, New South Wales
Mr Bruce Knuckey	Department of Environment and Heritage, Gladstone, Queensland
Mr Bill Lane	Moonee via Coffs Harbour, New South Wales
Montague Island Nature Reserve	National Parks and Wildlife Service, Narooma, New South Wales
Dr David Nicholls	Armadale, Victoria
Mr Barry Nolan	Department of Environment and Heritage, Airlie Beach, Queensland
Dr Ian Norman	Department of Conservation and Natural Resources, Heidelberg, Victoria
Mr Paul O'Neill	Department of Environment and Heritage, Rockhampton, Queensland
Mr David Pemberton	Parks and Wildlife Service, Hobart, Tasmania
Ms Kira Schlusser	Raine Island Corporation, Brisbane, Queensland
Mr Tom Scotney	Australian Bird and Bat Banding Scheme, Canberra, Australian Capital Territory
Mr Irynej Skira	Parks and Wildlife Service, Hobart, Tasmania
Mr Derek Spielman	National Parks and Wildlife Service, Grafton, New South Wales
Mr Tony Stokes	Great Barrier Reef Marine Park Authority, Townsville, Queensland
Mr Malcolm Turner	Great Barrier Reef Marine Park Authority, Townsville, Queensland
Ms Margot Warnett	Department of Environment and Heritage, Townsville, Queensland
Mr Max Waterman	St Agnes, South Australia
Dr Ron Woller	Department of Biological Sciences, Murdoch University, Perth, Western Australia
Mr Albert Zepf	National Parks and Wildlife Service, Ceduna, South Australia