Australian Government
Great Barrier Reef Marine Park Authority

Offshore and foraging pelagic seabirds

Information valid as of Feb 2012

Summary

Diversity

Twelve species that nest within the Great Barrier Reef World Heritage Area (the World Heritage Area).

Susceptibility

Life-history traits of offshore and pelagic foraging seabirds make them susceptible to a number of pressures occurring in the World Heritage Area. These traits include being long-lived (rely on low natural mortality); slow growth rates of young with high parental care; low reproductive output; high habitat and trophic specificity (most significantly, these species rely on a particular foraging behaviour that determines specificity in their diet and limits their ability to increase the rate of provision when food resources become scarce).

Major pressures

Climate change and the associated impacts on food supply and breeding habitat.

Cumulative pressures

Offshore and pelagic foraging seabirds are exposed to cumulative impacts of climate change in combination with increased pressure from commercial and recreational fishing of predatory fish that provide prey herding services to seabirds; direct disturbance by tourism and recreational visitors to islands, breeding habitat destruction; the introduction of exotic plants and animals to breeding habitats; and pollution and water quality degradation with associated impacts on the food web. If these pressures are not managed effectively they are able to act in combination and compound over time and/or when applied over the same space. They are often difficult to quantify due to the incremental nature of their effects which adds complexity to targeted management.

Management in the Great Barrier Reef and adjacent areas in Queensland

Legislative management tools for the conservation of offshore and pelagic foraging seabirds that occur in the Great Barrier Reef Region include assessment of actions that may impact seabirds and listing of threatened species under the *Environment Protection and Biodiversity Conservation Act 1999*; *Great Barrier Reef Marine Park Act 1975* (including planning provisions under the Cairns Area, Hinchinbrook and Whitsundays Plans of Management); spatial protection via the *Great Barrier Reef Marine Park Zoning Plan 2003* (only 34 per cent of the Great Barrier Reef Marine Park (the Marine Park) open to general use); *Nature Conservation Act 1992* (Qld); Action Plan for Australian birds 2000; and others (refer Management table, p. 13).

Existing management actions

Existing management actions: A number of management actions are in place in the World Heritage Area that 'operationalise' legislative management tools and provide additional guidance and/or strategic direction to Marine Park management operations. These include:

- the joint Great Barrier Reef Marine Park Authority (GBRMPA) – Queensland Government Field Management Program that applies management and

A male lesser frigate bird (*Fregata ariel*) displays its gular sac during courtship.

Black noddies (*Anous minutus*) can nest in *Pisonia grandis* trees and play an important role in dispersal of their seed.

conducts regular monitoring of seabird populations at key nesting sites to maintain status and trend information.

- projects under the *Great Barrier Reef Climate Change Action Plan 2007-2012*
- projects under the Raine Island Climate Change Adaptation Plan 2010-2070 (under development by the Queensland Government)
- Coastal Bird Monitoring and Information Strategy (to be reviewed and updated by the seabird vulnerability and resilience analysis project)
- state management plans for island national parks that have provisions for the protection of birds, including all seabirds
- GBRMPA Guidelines for managing visitation to seabird breeding islands;
- *Great Barrier Reef Biodiversity Conservation Strategy 2012*.

Great Barrier Reef Outlook Report 2009 assessment

Poor (overall assessment of the 20 seabird species known to breed in Great Barrier Reef).

Vulnerability assessment: High

- Pelagic and offshore foraging seabirds are particularly vulnerable to fluctuations in climate and oceanography that influence their access to prey of fish and cephalopods.
- Life-history traits, which are closely correlated with foraging ecology, mean that pelagic and offshore seabirds have limited capacity to increase their foraging rates. The majority of these species have single clutches meaning that in any given season they are, at best, able to rear a single chick. Some species do not nest every year. Therefore, for these species, reproductive viability is closely correlated with small changes in prey productivity or accessibility.

Red-footed boobies (*Sula sula*) displaying their two common adult morphs (white and brown) along with two juveniles (brown heads).

- Climate change impacts are likely to produce a steep decline in reproductive output of seabirds. During high and enduring El Niño Southern Oscillation (ENSO) cycles the abundance of prey for pelagic and offshore seabirds is significantly reduced. Once prey fish productivity is reduced below critical levels, or conditions at breeding sites become unsuitable, breeding colonies fail catastrophically and remain unviable as long as prey productivity remains low or the conditions at breeding sites remain unfavourable.
- Offshore and pelagic foraging seabirds rely on ecosystem services provided by pelagic fish such as tuna and mackerel which force prey fish species towards surface waters where they become accessible to seabirds of this foraging guild. This makes them vulnerable to indirect impacts that come from reduced abundance of these pelagic fish species through fishing.
- Knowledge of patterns that link seabird breeding site selection, prey resource use, foraging areas and foraging behaviour with climate variability and physical oceanography are currently insufficient to determine with certainty the most effective types of colony-specific management options that are required for different climate change scenarios.
- Despite the paucity of information on which to base management decisions, there is a need for a strategic approach to reduce the existing, potential and perceived stressors that could impact on the long-term viability of seabird populations, on a colony-by-colony or regional scale.
- Offshore and pelagic foraging seabirds in the Great Barrier Reef Region nest almost entirely on coral cays. Most of the preferred nesting cays of pelagic and offshore foraging seabirds are less than 2.5 m above the high water mark. Even slight increases in sea level and greater storm activity could have significant impacts through increased erosion and/or accretion, inundation of habitat, more frequent wave wash-over, and increased storm damage and vegetation loss (allowing weed species to invade).
- Other climate change pressures will affect island ecosystems and processes that seabirds rely on and contribute to. Such pressures will impact on island morphology, freshwater tables, vegetation composition, ocean-island nutrient cycling, disease and weeds. Impacts that climate change is exerting on corals has long-term implications for the supply of the building blocks required by coral cays (e.g. coral rubble and finer sediments from eroded corals). Current knowledge of the vulnerabilities of island ecosystems to climate change is fragmented and incomplete, and further research is required to determine correlations between these systems for implementation into management.[a]
- There are other significant pressures that threaten seabirds that need to be managed. These include, but are not limited to commercial and recreational fishing,

[a] Refer also to the Vulnerability Assessment for the Great Barrier Reef Islands.

Bridled tern (*Onychoprion anaethetus*)

direct disturbance by visitors to islands, the introduction of exotic plants and animals to important breeding colonies and ingestion of marine debris by seabirds.

Suggested actions to address vulnerabilities

- Continue long-term monitoring programs, such as the Queensland Government's Coastal Bird Atlas, which provide vital information on population trends and breeding success for inshore and coastal-foraging seabirds to inform management decisions. It is particularly important to maintain monitoring effort undertaken by the former Queensland Parks and Wildlife Service at Michaelmas Cay which provides the most valuable long-term data set on breeding seabirds in the Great Barrier Reef World Heritage Area; a monitoring effort with national and international significance.
- Continue natural resource management (control of pest flora and fauna and maintain the ecological influence of fire) and monitoring of key breeding sites through the Field Management Program to ensure impacts on breeding habitats are controlled. This effort should be informed by a review of the Coastal Bird Monitoring and Information Strategy.
- Review the Coastal Bird Monitoring and Information Strategy for the Great Barrier Reef World Heritage Area. This should establish a monitoring strategy that can provide the most cost effective data with the greatest statistical power (with guidance from Fuller and Dhanjal-Adams[1]). The review also needs to set priorities for localities to monitor in order to establish robust data on species condition and trend. Priority setting for localities to monitor must consider species that work as biological indicators and/or require a management focus due to their high risk conservation status.

  These locality/species monitoring priorities need to be established with consideration of:

  - The foraging ecology of the species which corresponds with a vulnerability to changing environmental conditions which impacts on the availability of prey
  - Latitudinal differences in breeding site selection
  - An ability to detect any spatial redistribution of breeding participants (to alternative locations) between breeding seasons.
- Undertake further species-specific vulnerability and resilience analyses of seabirds in the Great Barrier Reef to climate change impacts and apply this information to an adaptive management framework as proposed by Fuller and Dhanjal-Adams.[2] For certain aspects of seabirds' ecology and biology where data is lacking this will require further research and the development of models to predict current and future breeding and feeding distributions of the most vulnerable species. This may involve modelling colony size as a function of environmental suitability.
- Support and facilitate collaborations on inshore and coastal foraging seabird research and monitoring programs with data-set custodians and researchers. These collaborations should be guided by outcomes from processes such as the workshop on Seabirds and shorebirds in the *Great Barrier Reef World Heritage Area in a changing climate*[3] and the review of the Coastal Bird Monitoring and Information Strategy. Such collaborations should focus research on determining correlations between climate change impacts and seabird ecology, and their supporting habitats (e.g. islands and foraging grounds) and processes. Findings should be implemented within the framework of management actions currently in existence (refer above and the Management table, page 13).
- Identify and support research options that further improve knowledge of species and colony-specific foraging strategies, localities and trophic interplays within the Great Barrier Reef Region for inshore and

The Great Barrier Reef World Heritage Area Field Management Program monitors seabird populations at key nesting sites within the Marine Park. A juvenile red-footed booby (*Sula sula*) monitors the program at Raine Island, the most significant nesting colony for this species of pelagic foraging seabird in the Marine Park.

Red-tailed tropic bird (*Phaethon rubricauda*) on the nest beneath an overhanging crevice at Raine Island

Sooty tern (*Onychoprion fuscata*).

coastal foraging seabird species. This will be important to inform adaptive management strategies for Great Barrier Reef seabirds in a changing climate.

- Explore spatial and temporal management options that enable the protection of known important seabird forage-fish resources and trophic interplays (such as large predator fish driving prey species to the surface of the water), especially where they overlap with commercial or recreational fishing use.
- Continue to monitor other key threats to inshore and coastal foraging seabirds (as outlined in vulnerabilities above) through the joint Australian and Queensland Governments' Field Management Program for the Great Barrier Reef World Heritage Area and implement best-practice responses to minimise the impacts of these threats. Key threats that require a management focus within the World Heritage Area come from visitor disturbance and marine debris.
- GBRMPA Guidelines for managing visitation to seabird breeding islands should be periodically reviewed in line with current knowledge. The effectiveness of the management response must also be monitored and reviewed.
- Work to establish arrangements with key authorities and non-government organisations to prevent rubbish entering the marine environment; support the removal of discarded fishing gear/marine debris; raise public awareness and compliance activities to encourage the responsible disposal of fishing gear/rubbish; and, investigate the origins of fishing gear/marine debris. Guidance should also be taken from the national *Threat abatement plan for the impacts of marine debris on vertebrate marine life*.
- Work with the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and industry stakeholders to reduce the mortality of offshore and pelagic foraging seabirds within longline fisheries. Guidance should also be taken from the national *Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations*.

Background

Brief description of offshore and pelagic foraging seabirds

Seabirds may be divided into inshore, coastal, offshore and pelagic feeders on the basis of a suite of characteristics.[4,5] The adaptations of various seabird species enable them to venture away from their young for short periods (inshore and coastal feeders), for long periods (offshore feeders) and very long periods (pelagic feeders). These different adaptations determine how far from the colony parents may forage, feeding rates and hence reproductive capacity and the growth rates of their young.[5] This assessment addresses the vulnerabilities of offshore and pelagic foraging seabirds known to breed in the Great Barrier Reef Region (refer Table 1).

Table 1. Species list of offshore and pelagic foraging seabirds known to breed in the Great Barrier Reef Region

Species		Foraging guild	Management region most significant to breeding	Estimated population in the Great Barrier Reef Region	Nesting habitat
Herald petrel	*Pterodroma heraldica*	Pelagic	Raine Island only	3	Ground: scrape
Wedge-tailed shearwater	*Ardenna pacifica*	Pelagic	Mackay/Capricorn	560,000	Burrow
Red-footed booby	*Sula sula*	Pelagic	Far Northern	172	Trees/shrubs/ground
Brown booby	*Sula leucogaster*	Offshore	Far Northern, Mackay/Capricorn	18,500	Ground: low grass/scrape
Masked booby	*Sula dactylatra*	Pelagic	Far Northern, Mackay/Capricorn	1100	Ground: scrape
Great frigatebird	*Fregata minor*	Pelagic	Raine Island	20	Trees/ground
Lesser frigatebird	*Fregata ariel*	Pelagic	Far Northern, Mackay/Capricorn	2500	Shrubs/ground
Red-tailed tropic bird	*Phaethon rubricauda*	Pelagic	Far Northern, Mackay/Capricorn	100	Holes/crevices/tree roots/overhangs
Sooty tern	*Onychoprion fuscata*	Pelagic	Cairns, Far Northern	48,000	Ground: low grass/scrape
Bridled tern	*Onychoprion anaethetus*	Offshore	All management regions	13,900	Ground: low grass/scrape
Common noddy	*Anous stolidus*	Offshore	Cairns, Far Northern	46,000	Ground: low grass/scrape
Black noddy	*Anous minutus*	Offshore	Mackay/Capricorn	300,000	Trees

Source: Adapted from Congdon, 2008[4] and King, 1993[6]

Life-history

In general, seabirds are long-lived species that can be characterised by exhibiting deferred sexual maturity, small clutch sizes, slow chick growth rates and extended fledgling periods. Offshore and pelagic foragers usually have single clutches and much slower growing chicks with longer fledging periods than seabirds within other foraging guilds.[4] Pelagic foraging species such as sooty terns (*Onychoprion fuscata*) may live up to 32 years and larger species such as boobies and frigatebirds even longer.[4] Most offshore and pelagic foraging seabird species do not become sexually mature or return to breed for between five to 12 years after fledging. The nestling period for some species, such as frigatebirds, can be up to six months.[4]

Greatest mortality occurs during early life-history stages such as eggs and nestlings, and in the post-fledging and pre-reproductive periods.[4] Predation levels in seabird colonies are often significant and any disturbance by humans usually leads to increased levels of predation on exposed eggs or chicks by scavenging birds such as the buff-banded rail (*Gallirallus philippensis*) and silver gull (*Chroicocephalus novaehollandiae*).[7,8]

Habitat requirements

The habitat requirements of seabirds include access to suitable areas for breeding and foraging. These requirements are inter-dependent as without an adequate food supply parents are unable to raise their young to independence. Habitat requirements for breeding vary between species, but commonly include an area free from disturbance by terrestrial predators (including directly and indirectly, humans), storms and tide; presence of conspecifics, including potential mates; and suitable access to foraging grounds.[8]

Breeding and nesting

The timing of seabird breeding activity in the Great Barrier Reef is complex and under-studied.[4] For the majority of species, most peaks in breeding occur through summer between October and April, though for some species, such as the sooty tern and boobies, nesting can occur year round.[4,9] Restricting public access to key breeding sites during this peak breeding period is a conservation management tool used within the Marine Park. While there is variation amongst the offshore and pelagic foraging seabird guilds, breeding is generally seasonal, though sooty and bridled terns (*O. anaethetus*) can breed at sub-annual intervals,[9] and frigate birds are considered to breed biennially.[10] Terns and noddies tend to incubate eggs for a month, the young fledge after 30 – 40 days (though are reliant on parents for food for up to four months after fledging), and breed after 3 – 4 years.[9] Boobies generally breed annually and incubate eggs for approximately 45 days. The young fledge after about 100 days, but still rely on parents for food for around three months after fledging.[11] Masked booby (*Sula dactylatra*) first breeding has been recorded at three years.[12] Little is known of frigate bird biology, though first breeding and growth/fledging time scales are the longest of all the pelagic foraging seabirds that nest in the Great Barrier Reef Region.

Most seabirds breed on relatively remote islands, with different species tending to nest in specific habitat types (refer Table 1). Seabirds of the Great Barrier Reef Region prefer coral cays to other island types (from Hulsman 1997,[8] 73 per cent of the major seabird nesting sites were found to be coral cays). Most nest in dense colonies on the ground using either bare scrape nests or nests built among low lying vegetation, such as the masked booby and the sooty tern, respectively. Other pelagic foraging species, such as the red-tailed tropic bird (*Phaethon rubricauda*), use rocky overhangs. The wedge-tailed shearwater (*Ardenna pacifica*) digs burrows among vegetation that is dense enough to stabilise the soil structure. Still others, such as the red-footed booby (*S. sula*), build platform nests of sticks or leaves in trees or shrubs.

Foraging and diet

Offshore and pelagic foraging species may travel very long distances to obtain food and these foraging modes correlate strongly with the size of their breeding colonies. Characteristically, these species nest in large colonies, often spread over multiple, closely-spaced islands that are able to provide both proximity to an abundance of food and suitability of nesting habitat. They have adapted to feed on pelagic fish whose abundance and distribution is determined by oceanographic upwellings that provide nutrients to the food web.[8] The most significant example of such adaptation is displayed by the wedge-tailed shearwater where approximately 500,000 individuals breed in the 13 islands of the Capricorn and Bunker Groups and comprise a staggering 65.6 per cent of the biomass of breeding seabirds on the Great Barrier Reef.[8,13]

Chicks of many seabirds accumulate extensive body fat reserves to buffer themselves against long periods between adult feeding visits. This is particularly characteristic of offshore and pelagic foraging species that forage over very long distances creating extended periods of time between provisioning young.[14,15] Typically, these species hunt in large multi-species flocks in search of abundant prey of limited diversity.[16] This form of foraging requires these species to swallow and then later regurgitate food to their young, and therefore the distances travelled and limited capacity to carry food means that foraging rates cannot be increased. These foraging parameters mean that parents can only provide enough food to raise, very tenuously, single chick clutches that take longer to fledge as body reserves required for maintenance of body function are preferentially allocated at the expense of development during long periods between parental provisioning.[17]

The adaption to this mode of foraging has been demonstrated to predispose the seabird species of these guilds to be highly vulnerable to ENSO climatic processes that drive the food web supporting pelagic fish on which they prey.[18,19] Elevated ENSO conditions cause pooling of warm water in the eastern Pacific that reduces the amount of nutrients supplied to surface waters through cool deep ocean upwelling. This in turn reduces the westward flow of nutrient-rich water that would normally move to Australian shores, limiting the resources available to support the production of forage-fish that pelagic and offshore seabirds rely upon in the Great Barrier Reef.[20] In the Great Barrier Reef, these conditions are indicated by unusually high sea surface temperatures during the summer months.[20]

In the Great Barrier Reef Region, ENSO periods of unusually warm water have been linked with poor breeding seasons observed at black noddy (*Anous minutus*) colonies in the Capricorn and Bunker Groups,[13,21] brown boobies (*S. leucogaster*) in the Swain Reefs,[21] and sooty terns and common noddies (*A. stolidus*) on Michaelmas Cay.[22] In 2002, abnormally high sea-surface temperatures in the southern Great Barrier Reef coincided with the reproductive failure of the wedge-tailed shearwaters in the Capricorn and Bunker Groups, including the almost complete reproductive failure of the shearwater population of Heron Island.[19] These studies have shown both inter and intra-seasonal sea surface temperature variations associated with ENSO fluctuations to be significant in

influencing the foraging success of offshore and pelagic foraging seabirds and affect both inter-seasonal recruitment and breeding participation[20] and intra-seasonal reproductive output.[18,19]

Pelagic and offshore foragers are particularly reliant on large predatory fish, such as tuna (*Thunnus* spp.) and mackerel (*Scomberomorus* spp.), to drive prey to the surface. Studies have revealed that decreases in the abundance of sub-surface predators result in a decline in the availability of prey to pelagic foraging seabirds[23] and contribute to their poor foraging success and reproductive output,[18] which is then followed by poor recruitment and/or breeding participation two years later.[7] This trophic interaction has been thought to be responsible for the positive correlation between Catch Per Unit Effort (CPUE) in the Eastern Tuna and Billfish Fishery (longline) and breeding participation of the pelagic foraging sooty tern and offshore foraging common noddy at Michaelmas Cay, Queensland.[7] This study showed that increased CPUE in one year correlated to decreased breeding participation in these species two years later. However, discrepancies between this two year time frame lag and the biological breeding recruitment periods of these two species demonstrate the complexities and unknowns of the relationships between the abundance of forage fish, prey availability, breeding participation and reproductive success. These relationships require further investigation.[7] Increased sea surface temperatures (especially thermocline depth) that fluctuate seasonally directly influence the abundance of sub-surface predators such as tuna[24,25] and the cumulative impacts of elevated ENSO years and fishing pressure may be significant.

Male brown booby (*Sula leucogaster*) with single chick.

Wedge-tailed shearwaters (*Ardenna pacifica*) at entrance to the nest.

Male, female and juvenile lesser frigate birds (*Fregata ariel*) in a nesting colony and crèche.

Geographical distribution

Seabirds are highly mobile with a global distribution. There are no seabirds of any foraging guilds, including offshore and pelagic foragers, which breed in the Great Barrier Reef Region that are endemic to Australia.

Most seabird colonies in the Great Barrier Reef Region are found in the far northern, northern and southern areas where suitable nesting habitats are more common, with the most significant sites being Raine Island, Michaelmas Cay, the cays of the Swain Reefs and the islands of the Capricorn and Bunker Groups. At least 75 cays have been identified as seabird breeding colonies, with 56 considered to be key sites and 20 minor sites.[8] Hulsman and colleagues[8] found that a breeding colony's species richness was affected by the type of island and its location on the continental shelf. For example, vegetated sand cays on the outer continental shelf had the highest number of breeding species, representing pelagic, offshore and inshore feeders. Vegetated cays on the inner continental shelf also displayed high species richness of nesting inshore and coastal foraging seabirds. Differences in latitude, variations in reef morphology on the availability of prey, and proximity to the Coral Sea probably all have some influence on species composition of breeding colonies, and help illustrate the range of contributing factors that may influence where seabirds breed.[8]

Population status in the Great Barrier Reef Marine Park

The Great Barrier Reef Region supports more than 10 per cent of Australia's breeding seabird population (when excluding short-tailed shearwaters (*Ardenna tenuirostris*), which nest in huge numbers in southern Australia). Between 1.4 and 1.7 million seabirds from at least 20 species breed on islands and cays in the Great Barrier Reef Region each year. This represents more than 25 per cent of Australia's tropical seabirds, more than 50 per cent of offshore foraging black noddies (*Anous minutus*) and approximately 25 per cent of wedge-tailed shearwaters, brown and masked boobies and red-tailed tropic birds.[8] The population of non-breeding birds is estimated at 425,000 individuals, giving a total seabird population that may exceed two million.[26]

Raine Island

Of the 24 species of seabirds recorded breeding in Queensland, 14 regularly breed at Raine Island.[4] Within offshore and pelagic foraging guilds, the Raine Island area has a distinctive combination of several species, primarily red-tailed tropicbird, lesser frigatebird, three species of booby, and common noddy (Table 2). Since the 1980s, numbers of breeding seabirds on Raine Island have decreased by 70 per cent.[27] The annual average population observed at Raine Island decreased from 23,445 seen in 1979-1993, to an average of 7098 in the years between 1993 and 2003. Declines were evident in 13 of the 16 surveyed species including common noddy, brown booby and lesser frigatebird (*Fregata ariel*), which are the most common species in the region.[27] Between December 1995 and December 2000, a more detailed study was conducted on wedge-tailed shearwaters that suggested a population decline of over 40 per cent, based on the number of occupied burrows at Raine Island.[28]

Table 2. Species exhibiting the largest declines in abundance observed by long-term monitoring at Raine Island.

Species	Mean yearly population estimate 1979 – 1993	Mean yearly population estimate 1993 – 2003	Adult population decline 1979-2003
Common noddy	11,693	526	- 95.5%
Sooty tern	840	131	- 84.4%
Bridled tern	191	59	- 69.1%
Red-footed booby	467	150	- 67.9%
Lesser frigate bird	1851	599	- 67.6%
Brown booby	4435	2642	- 40.4%
Red-tailed tropic bird	104	64	- 38.5%

Source: Batianoff & Cornelius, 2005[27]

No evidence of habitat loss or degradation is apparent and the reasons for these population declines are unknown. Given the management of the island, the absence of localised disturbance or impacts suggests that the causes may be related to a reduction in the availability of suitable prey which may be attributable to variations in climatic and oceanographic systems or the reduced availability of pelagic fish to drive prey into surface waters as a result of fishing activity.[22,27]

Michaelmas Cay

The former Queensland Parks and Wildlife Service have conducted monthly bird counts on Michaelmas Cay since 1984, providing reliable long-term data for detecting population trends.[29] In fact, this is one of the most consistent and long-term data sets on seabirds in Australia and through analysis by Fuller and Dhanjal-Adams,[1] is providing very useful insights into the level of sampling (surveying) required to provide the robust statistical power to detect long-term trends in seabird abundances elsewhere. Further analysis of this data set may reveal previously unforeseen information on the correlation between key environmental drivers, such as climate driven impacts, and seabird abundances and thus illustrates the immeasurable value of maintaining such a long-term data set.

Common noddy and sooty tern are the two most abundant seabirds present on Michaelmas Cay. Monitoring data show that the number of birds recorded at Michaelmas Cay decreased during the 1990s, reaching a low point in 1994. Recovery was observed for the common noddy in 2000, and more recent analyses indicate some signs of recovery in sooty terns.[30] However, for the period up to 2001, the numbers of sooty terns and fully fledged young common noddies were still well below 1984 levels.

Swain Reefs

Long-term monitoring in the Swain Reefs has shown significant declines in numbers of brown boobies, but stable numbers (~1 100 individuals) of masked boobies. In the period between 1986 and 1993, brown booby numbers fell by 41 per cent from 3200 to 1300.[21] The decline may be associated with inadequate food supplies related to increased sea surface temperatures.[31] Masked boobies feed further offshore than brown boobies and thus, may have been better able to find food.

Capricorn-Bunker Group (North Reef to Lady Elliot Island)

The coral cays of the Capricorn and Bunker Groups are important seabird breeding sites that support 97 per cent of the Great Barrier Reef's black noddy population (~302,000 breed pairs) and the Pacific Ocean's largest breeding population of wedge-tailed shearwaters (~560,000 breeding pairs).[13,32] Approximately 79 per cent of the Capricorn and Bunker Group's population of wedge-tailed shearwaters breed on North West Island, making the island an internationally important site.

Long-term monitoring in the Capricorn and Bunker Groups recorded declines in black noddies and variable trends in wedge-tailed shearwaters. The number of black noddies reached a low point in 1998-1999 on all islands surveyed. On Heron Island, the number of black noddy nests declined from 72,000 in 1996 to 23,000 in 1998-1999. While some recovery was observed in 2000, numbers are still well below 1996 levels.[13] These declines were positively correlated with El Niño events and elevated sea surface temperatures.[19]

Ecosystem role/function

Seabirds play an important role in the Great Barrier Reef ecosystem. They are major consumers of marine organisms such as fish and cephalopods, and form an integral part of the marine food web. As key secondary and tertiary level predators in marine ecosystems, seabirds are thought to play a significant role in the regulation of lower marine trophic systems. Seabirds are also an important part of the nutrient cycle by linking reef, pelagic and island ecosystems.[33] Seabirds enrich island soils by depositing guano and carrion, and influence the growth of plants on coral cays. This in turn contributes to the cay's stabilisation and development.[34]

Birds also transport seeds from the mainland to offshore islands, which contribute to the establishment of island plant communities. Seabirds are essential for the dispersal of *Pisonia grandis* seeds,[35] and there is a demonstrated strong correlation between where the black noddy breeds and the distribution of *Pisonia*.[b] Walker[35] suggested that guano from the birds may provide the *Pisonia* trees with a competitive advantage over other plants. The herb, *Boerhavia repens*, is dispersed by seabirds and the plant forms meadows at some of the main seabird breeding islands, for example Raine Island, Michaelmas and Bell Cays.[35]

Ecosystem goods and services

Ecosystem goods and services category	Services provided by the species, taxa or habitat
Provisioning services (e.g. food, fibre, genetic resources, bio-chemicals, fresh water)	Seabird eggs and meat were once part of the regular diet of coastal Indigenous peoples. Today, although these customs are still practiced, anecdotal evidence suggests that this form of traditional use is negligible. The most common remaining traditional use of seabird provisions is thought to occur in the Far Northern inshore and coastal sector of the Marine Park. Quantitative species-specific information on traditional use of seabirds is lacking.
Cultural services (e.g. spiritual values, knowledge system, education and inspiration, recreation and aesthetic values, sense of place)	Some seabird species hold cultural significance for Indigenous peoples. Aesthetic and intrinsic conservation values provide a strong social and economic impetus for the conservation of seabirds. Observing seabirds provides significant input into the Australian economy. For many people, seabirds are iconic and can represent symbols of inspiration or have spiritual value.
Supporting services (e.g. primary production, provision of habitat, nutrient cycling, soil formation and retention, production of atmospheric oxygen, water cycling)	The significant abundance of offshore and pelagic foraging seabirds in the Great Barrier Reef Region means that they play an important role in the cycling of nutrients from offshore or pelagic areas to islands and reefs. For example, black noddies deposit an estimated 45 tonnes of guano on Heron Island per annum.[36] Although inshore and coastal foraging seabirds only comprise part of 20 per cent of the total biomass of breeding seabirds in the Great Barrier Reef Region, their role in nutrient cycling from sea to land is still considered significant.[4]
Regulating services (e.g. invasion resistance, herbivory, seed dispersal, climate regulation, pest regulation, disease regulation, natural hazard protection, erosion regulation, water purification)	As key secondary and tertiary level predators in marine ecosystems, offshore and pelagic foraging seabirds are thought to play a significant role in the regulation of lower marine trophic systems, and there are indications that they themselves are regulated by the abundance of underwater predators that influence the behaviour of the prey species they target.[7,37] They also play an important role in seed dispersal.[35]

[b] *Pisonia grandis* is a flowing tree within the Bougainvillea family, Nyctaginaceae, which is distributed throughout the coral cays of the Indian and Pacific Oceans. The species often dominates mature coral cay vegetation, growing in dense stands. *Pisonia* wood is rather weak and soft and decays rapidly when the trees fall.

Raine Island in the northern Great Barrier Reef is a major nesting site for most of the offshore and pelagic foraging seabirds that breed in the Marine Park. Photo courtesy of M. Read.

Pressures influencing offshore and pelagic foraging seabirds in the Great Barrier Reef Marine Park

Pressures

Offshore and pelagic foraging seabirds are exposed to a range of pressures, most significantly the availability of prey species due to climate change drivers.[38] They also face threats at local and regional scales from commercial and recreational fishing, direct disturbance by visitors to islands, degradation and destruction of breeding habitat (in the short-term, from impacts that result from the increased intensity and frequency of storms and cyclones, and also long-term climate related impacts on the geomorphology and vegetation of islands[39]), the introduction of exotic plants and animals to important seabird breeding colonies, ingestion of garbage and marine debris, pollution and associated water quality degradation and trophic disturbance.[4] A more detailed description of the range of pressures that impact on these seabirds in the Great Barrier Reef Region is provided in the vulnerability assessment matrix.

Vulnerability assessment matrix

The *Great Barrier Reef Outlook Report 2009*[40] identified a number of commercial and non-commercial uses of the Marine Park, along with habitat loss and degradation as a result of climate change, coastal development and declining water quality due to catchment run off as the key pressures reducing the resilience of the ecosystem.

From the *Great Barrier Reef Outlook Report 2009*[40] it was considered that pressures such as climate change, coastal development, catchment run-off and direct use are the key factors that influence the current and projected future environmental, economic and social values of the Great Barrier Reef. These pressures can impact directly and/or indirectly on habitats, species and groups of species to reduce their resilience. Using the vulnerability assessment framework adapted by Wachenfeld and colleagues,[41] this Vulnerability Assessment aims to provide an integrated assessment of social, ecological, economic and governance information. For each key pressure in the Marine Park, exposure and sensitivity is assessed in relation to each other to reach a level of potential impact. The potential impact is then reassessed having considered the level of natural adaptive capacity that offshore and pelagic foraging seabirds have to respond to the pressure and the adaptive capacity that management has, or can apply, to reduce the potential impact from the pressure.

This provides managers and stakeholders with an understanding of the key elements that each pressure can impose on these species to reach a final assessment of the overall residual vulnerability of offshore and pelagic foraging seabirds to that particular pressure. This allows for the formulation of suggested actions to minimise the impact of the pressures which offshore and pelagic foraging seabirds are most vulnerable to.

A summary of the assessment of impacts of pressures is tabled below, however, for the detailed assessment and explanatory notes refer to Appendix 1.

Vulnerability assessment matrix summary for offshore and pelagic foraging seabirds

		Exposed to source of pressure (yes/no)	Degree of exposure to source of pressure (low, medium, high, very high)	Sensitivity to source of pressure (low, medium, high, very high)	Adaptive capacity – natural (poor, moderate, good)	Adaptive capacity – management (poor, moderate, good)	Residual vulnerability (low, medium, high)	Level of confidence in supporting evidence (poor, moderate, good)
Pressures	**Commercial marine tourism**	Yes; locally (with regional significance)	High; locally	High	Moderate	Good	High	Good – effects on populations Poor – ecological and ecosystems processes
	Defence activities	Yes; locally	Low	High	Moderate	Good	Low	Good
	Commercial fishing	Yes; Reef -wide	Medium	High	Poor*	Moderate	High	Poor
	Recreational fishing	Yes; developing coast	Medium	High	Poor*	Moderate	Medium	Poor
	Ports and shipping	Yes; locally (with potential for regional significance)	Low	Low	Moderate	Moderate	Low	Good – effects of oil spills Poor – cumulative effects
	Recreation (not fishing)	Yes; regionally	High	High	Moderate	Good	High	Good – effects on populations Poor – ecological and ecosystems processes
	Traditional use of marine resources	No	Low	Low	Good	Good	Low	Moderate
	Climate change	Yes	Very high	Very high	Poor	Poor	High	Moderate
	Coastal development	Yes; developed coast	High	High	Poor	Moderate	High	Good
	Declining water quality due to catchment run-off	Yes; developed coast	Medium	Medium	Poor	Moderate	High	Good

* In this assessment, the rating relates more to the indirect impact that commercial and recreational fishing is thought to have on reducing predatory fish that provide ecosystem services to seabirds by driving prey towards surface waters where they become available to forage upon.

Key concerns

- Most offshore and pelagic foraging seabird species that breed in the Great Barrier Reef Region have single clutches. Some of these species do not breed annually. They are long-lived and chicks have long fledgling periods requiring provisioning maintenance from the parents. These life-history traits make them vulnerable to population declines when provisioning capacities are threatened or habitats they are reliant upon are degraded or lost.
- Climate change stressors are likely to be contributing to the steep declines that can occur in the reproductive output of pelagic and offshore foraging seabirds. Once prey productivity is reduced below critical levels, or conditions at breeding sites become unsuitable, breeding colonies fail catastrophically and remain unviable as long as prey productivity remains low or breeding site conditions remain unfavourable.
- The climate change phenomena and associated climate variabilities that are considered most likely to impact on seabirds in the Great Barrier Reef Region, particularly offshore and pelagic foragers, are: El Niño Southern Oscillation (ENSO) extremes; sea surface temperature variability (within and across seasons); increased cyclone and storm activity (related to ENSO cycles); sea level rise; variable rainfall and increased catchment run-off. Knowledge is lacking on the thresholds at which breeding populations of offshore and pelagic foraging seabirds will be affected by climate change impacts.
- Knowledge of the relationships between seabird breeding site selection, diet requirements and foraging behaviour with climate variability and physical oceanography are currently inadequate to determine with certainty the most effective types of colony-specific management options that are required for different climate change scenarios.
- Current knowledge suggests that when considering short-term and within season temporal scales, fluctuations in average sea surface temperature or the number and duration of large hot water incursions into the Great Barrier Reef are likely to cause repeated and catastrophic reproductive failure of many seabird species.[38] This requires further detailed investigation to better understand these relationships at species and colony-specific scales.
- Offshore and pelagic foraging seabirds rely on ecosystem services provided by pelagic fish such as tuna and mackerel which force prey fish species towards surface waters where they become accessible to seabirds of this foraging guild. This makes them vulnerable to indirect impacts that come from reduced abundance of these pelagic fish species through fishing.

  It will be necessary to explore spatial, temporal or fisheries related management options that enable the protection of known important seabird forage-fish resources and trophic interplays (such as large predator fish driving prey species to the surface of the water), especially where they overlap with commercial or recreational use, and particularly during ENSO warm years when prey abundance is reduced.
- An ecosystem-based management approach will be required to manage these impacts as they are considered to take effect through the interplays of trophic orders from microbes through to forage-fish and between island and ocean ecosystems, which have been demonstrated to be strongly influenced by physio-chemical oceanographic processes and changing climate patterns.
- Most of the preferred nesting cays used by offshore and pelagic foraging seabirds are less than 2.5 metres above the high water mark.[8] Even slight increases in sea level and greater storm activity could have significant impacts through increased erosion and/or accretion,[42] inundation of habitat and freshwater lenses, more frequent wave wash-over, and increased storm damage.[39,43] This would alter the morphology and vegetation composition of islands and cays within the Great Barrier Reef Marine Park. In the short-term cays may accrete, while continental islands may erode.[43] Seabirds nesting on the ground or in burrows could lose critical nesting habitat, and the loss of vegetation could reduce the suitable habitat for birds that nest or roost in trees or in amongst ground vegetation. This would have significant effects on seabird breeding participation and reproductive success, with potentially catastrophic impacts on populations and the dynamics of island ecosystems which support them. Direct intervention may be required to mitigate these impacts at key sites.
- Other climate change pressures will affect island ecosystems and processes that seabirds rely on and contribute to. El Niño Southern Oscillation events are expected to continue as a source of high inter-annual climate variability in northeast Australia under predicted climate change scenarios.[44] Climate variability that produces reduced rainfall and longer periods of drought may lead to vegetation loss, greater weed invasion, and lowered water tables with salt water intrusion. Increased rainfall periods will have direct and indirect impacts that will alter short and long-term island processes.[39,45] In the short-term many coral cays are expected to accrete under predicted climate change scenarios creating increased rates of sea level rise.[42,44] the long term, however, increased catchment water run-off that provides poorer water quality to the Great Barrier Reef reefal lagoon, along with climate-related changes to physio-chemical oceanography (acidification of the oceans), may disrupt calcium-accumulating organisms, most notably, coral reefs.[45,46] This would eventually impact on island formation which is critical in providing nesting habitat and staging locations for seabirds.[43] While it is anticipated that in the long term some cays may erode, determining which will erode is the key to understanding threats to cay habitat and the seabirds they support. Symbiotic relationships between seabirds and island vegetation may also breakdown.[39,45] Reduced seabird provisioning will mean alterations to ocean-

island nutrient cycling and seed dispersal, affecting the generation of island vegetation which in turn could reduce suitable nesting habitat for seabirds, developing a negative feedback loop.[39,45] Current knowledge of the vulnerabilities of island ecosystems to climate change is fragmented and incomplete, and further research is required to determine correlations between these systems for incorporation into management. (Refer also to the Vulnerability Assessment for the Great Barrier Reef Islands).

- Despite the paucity of information on which to base management decisions, there is a need for a strategic approach to mitigate existing, potential and perceived stressors in the ecological systems that underpin the long-term viability of seabird populations, on a colony-by-colony or regional scale. Such approaches are being developed through processes such as the Raine Island Climate Change Adaptation Plan 2010 – 2070 currently under development by the Queensland Government. A greater focus is required on the protection of known important forage-fish resources and the trophic interplays that pelagic seabirds rely on, especially where they overlap with commercial or recreational use, and particularly during ENSO warm years. Such considerations may need to include adaptation of temporal and spatial management practices to increase protection of pelagic predatory fish species, most importantly tuna and mackerel; taxa that pelagic and offshore foraging seabirds rely on to drive prey species into the surface waters (refer to background information above). Research and monitoring has also demonstrated that direct disturbance by visitors of some species of nesting seabirds affects their breeding success. Research needs to inform policy and regulation for the management of approach distances to colonies and individual species that may nest as small colonies or isolated pairs, which should also be applied to research and monitoring protocols.
- There are other significant pressures that threaten seabirds, which need to be managed. These include, but are not limited to; commercial and recreational fishing, direct disturbance by visitors to islands, degradation and destruction of breeding habitat, the introduction of exotic plants and animals to important breeding colonies, as well as ingestion of marine debris and water quality degradation. These pressures are cumulative and can also impact the food web and habitats seabirds rely on.

Management of offshore and pelagic foraging seabirds in the Great Barrier Reef Marine Park

Management agencies with responsibilities for managing these species or impacts on these species within the Great Barrier Reef World Heritage Area and the statutory and non-statutory tools that influence the conservation management of these species.

Legislation or policy	Object as it applies to the species	Tools for conservation	Who administers it
World Heritage Convention	• Four natural heritage criteria with associated conditions of integrity. Criteria focus on (i) geological processes and phenomena, including the evolution of the earth; (ii) ongoing ecological and biological processes; (iii) linked aesthetic components of the natural world; (iv) the biological diversity and habitats of threatened species • Natural heritage Criteria iv states that the natural heritage asset must contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.	• Provides State Parties to the Convention with definitions of natural and cultural heritage, measures for the protection of natural and cultural heritage; the means of administration and obligations of the Convention; funding arrangements, educational programs and reporting obligations.	United Nations Educational, Scientific and Cultural Organization (UNESCO)

Convention on Biological Diversity (CBD)	• The three main objectives of the CBD are:
	  • The conservation of biological diversity
	  • The sustainable use of the components of biological diversity
		• Provides State Parties to the Convention with global principles, objectives and obligations for the conservation of biodiversity.
		• Guides Australia's strategic planning to achieve national priority actions for biodiversity
			United Nations Environment Programme (UNEP) – CBD Secretariat

	• The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources.	conservation through a range of objectives and targets for each.	
International wildlife conventions: CITES - Convention on International Trade of Endangered Species of wildlife fauna and flora CMS – Convention on Migratory Species.	• There are no listing of offshore or pelagic foraging seabirds that breed in the Great Barrier Reef Marine Park within the CITES or CMS.	• Future assessments for inclusion of species onto these lists will be made as required information becomes available.	United Nations Environment Program (UNEP)

International migratory bird agreements
 	
Bilateral:
Japan-Australia Migratory Bird Agreement (JAMBA);
China-Australia Migratory Bird Agreement (CAMBA)
Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)
 	
Multilateral:
East Asian-Australasian Flyway Partnership (EAAFP)
	• JAMBA and CAMBA agreements require the parties to protect migratory birds by:
	  • limiting the circumstances under which migratory birds are taken or traded
	  • protecting and conserving important habitats
	  • exchanging information; and
	  • building cooperative relationships
	• The ROKAMBA formalises Australia's relationship with the Republic of Korea in respect to migratory bird conservation and provides a basis for collaboration on the protection of migratory shorebirds and their habitat
	• The EAAFP represents the major international framework for the conservation of migratory waterbirds and their habitat in the flyway, promoting dialogue, cooperation and collaboration between a range of stakeholders. International cooperation is essential for the conservation of migratory waterbirds by providing for their protection throughout the flyway.
		• Migratory bird agreements are classed as Matters of National Environmental Significance under the *Environment Protection and Biodiversity Conservation Act 1999* and species listed are protected under the Act (refer to EPBC Act section below)
		• Reporting requirements on implementation progress for migratory bird agreements and partnerships
		• Offshore or pelagic foraging seabirds listed as 'Migratory' and 'Marine' under the EPBC Act due to their listing in migratory bird agreements:
		  • *Anous stolidus*
		  • *Sterna anaethetus*
		  • *Fregata minor*
		  • *Fregata ariel*
		  • *Ardenna pacifica*
		  • *Sula dactylatra*
		  • *Sula leucogaster*
		  • *Sula sula*
		• Objectives of the Flyway Partnership (EAAFP) are to:
		  • develop the Flyway Network of sites of international importance for the conservation of migratory waterbirds
		  • enhance communication, education and public awareness of the values of migratory waterbirds and their habitats
		  • enhance flyway research and monitoring activities, build knowledge and promote exchange of information on waterbirds and their habitats
		  • build the habitat and waterbird management capacity of natural resource managers, decision makers and local stakeholders
		  • develop, especially for priority species and habitats, flyway wide approaches to enhance
			Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)

		the conservation status of migratory waterbirds • Under the EPBC Act , no actions taken in relation to listed species must be inconsistent with a migratory bird agreement.	
International Union for the Conservation of Nature and Natural Resources – Red List of Threatened Species (v. 2010.2)	• Species listed as 'least concern': • *Pterodroma heraldica* • *Ardenna pacificus* • *Anous minutus* • *Sula sula* • *Sula leucogaster* • *Sula dactylatra* • *Fregata ariel* • *Fregata minor* • *Sterna fuscata* • *Sterna anaethetus* • *Phaethon rubricauda.*	• These taxa are considered widespread and abundant by IUCN Redlist assessors or populations have not declined at a rate justifying a vulnerability listing • Processes of review and re-assessment as required.	International Union for the Conservation of Nature and Natural Resources (IUCN)
Action Plan for Australian Birds, 2000.[47]	• The Action Plan presents assessments of the status of individual bird species • Herald petrel, *Pterodroma heraldica*, listed as Critically Endangered • Masked booby, *Sula dactylatra,* listed as vulnerable • Red-tailed tropicbird, *Phaethon rubricauda*, listed as near threatened.	• Action Plan describes the conservation status, key threats and existing conservation measures for a large number of species and makes recommendations for further management actions • Processes of review.	DSEWPaC
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and *Environment Protection and Biodiversity Conservation Regulations 2000.*	• Legislative framework for environmental protection in Australia • The Great Barrier Reef Marine Park is one of eight matters of national environmental significance in Australia • Provides means of assessment of 'actions' (often called a proposal or project) within Australian marine and terrestrial environments that are likely to impact on a matter of national environmental significance protected under the EPBC Act • Legislative role includes the listing and regulation of threatened and protected species and communities, the preparation of recovery plans for threatened and protected species, the identification of key threatening processes and, where appropriate, the development of threat abatement plans (e.g. incidental catch of seabirds during oceanic longline fishing operations, harmful marine debris, introduced pests) and recovery plans • See comments in Migratory bird agreements above regarding species listed as 'Migratory'	• An action will require approval if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance protected under the EPBC Act. The action must be referred to the Minister and undergo an assessment and approval process • The Significant Impact Guidelines have been developed as a resource for the support of assessment and approvals process for actions • An action likely to have a significant impact on seabirds could be deemed to be a 'controlled action' under the EPBC Act and require a greater level of scrutiny through an environmental impact assessment before consideration of approval • Strategic assessment is an alternative to a case by case approach and is considered a better way to address cumulative impacts over a landscape scale which may stem from a policy, plan or program or multiple projects providing combined impact	DSEWPaC

	under the EPBC Act • Under this legislation it is illegal to harm, interfere with or disturb birds except for traditional use.	• Threat Abatement Plans: • guide industry regulation and outline the necessary research and management actions required to address these threats • reviews existing policies, codes of practice, conventions and activities to determine their effectiveness • coordinates abatement strategies identified in separate marine animal Recovery Plans • Penalties for non-compliance • Processes of review.	
Great Barrier Reef Marine Park Act 1975 and *Great Barrier Reef Marine Park Regulation 1983*	• Legislative framework for the management of biodiversity conservation through zoning, issuing of permits and implementation of plans of management that collectively enable management of human activities in the Great Barrier Reef Marine Park.	• Regulation 29, Table 29 of the Regulation provides a list of Protected Species including all birds • Parts 10, 11, 12 of the Regulations provides controls for human interactions with seabirds at key seabird nesting sites within the Cairns Area, Whitsundays and Hinchinbrook Plans of Management regulations respectively • Under this legislation it is illegal to harm, interfere with or disturb birds except for non-commercial traditional use • Regulation provides for the creation of Special Management Areas within the Marine Park • Regulation of scientific research in the Marine Park • Regulation of activities and development within the Marine Park • Regulation on the discharge of waste into the Marine Park • Penalties for non-compliance.	Great Barrier Reef Marine Park Authority (GBRMPA)
Great Barrier Reef Marine Park Zoning Plan 2003	• A multiple-use marine protected area management tool that protects biodiversity by the regulation of activities within the Great Barrier Reef Marine Park • The Representative Area Program that provided the basis for the Zoning Plan spatial planning decisions, described 70 broad-scale habitats, or bioregions, and as such provides the basis for ecosystem-based management in the Marine Park.	• Special Management Areas can be created under certain circumstances • Restricted Access Special Management Areas (SMA) provide protection of sites considered important to seabirds (and other marine animals and ecosystems) (e.g. Michaelmas Cay, Raine Island) • Thirty-four per cent of the Marine Park is dedicated as Marine National Park (green) or Preservation (pink) zones in which no extractive activities are permitted • Penalties for non-compliance.	GBRMPA
Great Barrier Reef Marine Park Act 1975 - plans of management (PoM)	• Plans of Management are generally prepared for intensively used, or particularly vulnerable groups of islands and reefs, and for the protection of vulnerable	• PoMs outline the values, issues and strategies for the conservation of seabirds in the respective management areas (includes seasonal closures of	GBRMPA

	species or ecological communities
	• Plans of Management complement zoning by addressing issues specific to an area, species or community in greater detail than can be accomplished by the broader reef-wide zoning plans
	• Regulations for bird conservation are found in:
	  • Cairns PoM – Part 1, Div. 2, subdiv. 6;
	  • Whitsundays PoM - Part 1, Div. 2, subdiv. 5;
	  • Hinchinbrook PoM – Part 1, Div. 3, subdiv. 4.
		important nesting sites and restriction on visitor numbers)
		• PoMs reviewed on regular basis in line with changes to management requirements, legislation and national guidelines
		• Penalties for non-compliance.	

Marine Parks Act 2004 (Qld) *and Marine Parks Regulation 2006*	• The object of this Act is to provide for the conservation of the marine environment by:
	  • declaring State marine parks
	  • establishing zones, designated areas and highly protected areas within marine parks
	  • developing zoning and management plans
	  • recognising the cultural, economic, environmental and social relationships between marine parks and other areas
	  • applying the precautionary principle.
		• Aims to involve all stakeholders cooperatively
		• Coordination and integration with other conservation legislation
		• Penalties for non-compliance
		• Processes of review.
			Queensland Government

Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004 (Qld)	• A multiple-use marine protected area management tool that protects biodiversity by the regulation of activities within the Great Barrier Reef Coast Marine Park. • The Representative Area Program that provided the basis for the Zoning Plan spatial planning decisions, described 70 broad-scale habitats, or bioregions, and as such provides the basis for ecosystem-based management in the Great Barrier Reef Coast Marine Park.	• Spatial management of activities within State waters of the Great Barrier Reef based on protection of representative bioregions • Penalties for non-compliance • Complements spatial management zones and certain regulatory provisions established under the *Great Barrier Reef Marine Park Zoning Plan 2003.*	Queensland Government
Queensland *Nature Conservation Act 1992* and *Nature Conservation (Wildlife) Regulation 2006*; and *Nature Conservation (Wildlife Management) Regulation 2006*	• Act provides for the conservation of nature, including wildlife, in Queensland jurisdiction • Provides for the protection of birds, including seabirds. Under this legislation it is illegal to harm, interfere with or disturb coastal birds except for non-commercial traditional use • Regulation lists the plants and animals considered presumed extinct, endangered, vulnerable, rare, common, international, and prohibited. It discusses their significance and states the declared management intent and the principles to be observed in any taking and use for each	• Provides for the preparation of Conservation Plans for native wildlife and their habitat under Ministerial discretionary powers • No Conservation Plan for any species of seabird currently in force • Section 332 of the Wildlife Management regulation prohibits tampering with protected animals' place of breeding being used to incubate or rear the animal's offspring • Penalties for non-compliance • Processes of review.	Queensland Government

	group • *Pterodroma heraldica* listed as endangered • *Paethon rubricauda* listed as vulnerable.		
Coastal Bird Atlas	• The Coastal Bird Atlas database includes records for seabirds, migratory shorebirds and other bird species that occur on Queensland islands and coastal areas • The data predominantly relates to the Great Barrier Reef islands, cays and reefs and the coastal waters but data is also present from the Gulf of Carpentaria.	• Provides managers with data on population estimates and trends in order to assess risks and gauge the effectiveness of conservation efforts.	Queensland Government (jointly funded by the GBRMPA through the Field Management Program)
Coastal Bird Monitoring Strategy for the Great Barrier Reef World Heritage Area, 2002.	• The coastal bird monitoring strategy for the Great Barrier Reef World Heritage Area outlines the value of coastal bird monitoring and sets out the minimum monitoring required • Also provides information on legislative and international obligations and threatening processes.	• Strategy reviewed on regular basis in line with changes to management requirements, legislation and national guidelines. Currently under review and will be re-identified as the Coastal Bird Monitoring and Information Strategy for the Great Barrier Reef World Heritage Area • Strategy intended to assist managers to plan and program, as well as assist staff monitoring the birds, to conduct their responsibilities.	Queensland Government and GBRMPA
Great Barrier Reef Climate Change Action Plan 2007-2012	• Establishes a strategic approach to the development of resilience within Great Barrier Reef ecosystems as a means to enable those systems to adapt to climate change impacts.	• Resilience analysis identifies the means to reduce human impacts and disturbances, and conserve the Great Barrier Reef 's biodiversity and ecological processes.	GBRMPA
GRBMPA guidelines and programs.	• Guidelines for managing visitation to seabird breeding islands • Best Environmental Practices for reef visitors to minimise their impacts when observing birds or visiting permitted nesting sites • Responsible Reef Practices – a tool developed to educate tourism industry staff about minimising their impacts of their operations on birds • Best Environmental Practices on the correct disposal of waste • Sea Guardians program to educate and build stewardship capacity with regards to marine pollution and fishing best practice.	• Industry and public education tools reviewed in line with best practice and current knowledge.	GBRMPA
Great Barrier Reef Biodiversity Conservation Strategy 2012	• Identifies offshore and pelagic foraging seabirds as a species 'at risk' in the Marine Park • Grades the level of risk experienced by offshore and pelagic foraging seabirds through a vulnerability assessment process.	• The Biodiversity Conservation Strategy outlines a Framework for Action with three strategic objectives aimed at building or maintaining ecosystem resilience and protecting biodiversity: 1. Engage communities and foster stewardship 2. Building ecosystem resilience	GBRMPA

		in a changing climate 3. Improved knowledge • Objectives are comprised of program-level outcomes with key actions and contain targets for measuring success • Implementation of the Strategy will be undertaken through a multi–Agency, multi-stakeholder collaborative approach.	
Policy on managing activities that include the direct take of a Protected Species from the Great Barrier Reef Marine Park. June 2005. Additions September 2008.	• Provides a framework for the consistent and effective management of activities that include the direct take of a Protected Species from the Great Barrier Reef Marine Park. Permissions unlikely to be granted for take of birds unless for research.	• Justifications and assessment guidelines on the take of protected species for certain anticipated (and unanticipated) uses • Review of policy.	GBRMPA
GBRMPA Position Statement on managing access to the Restricted Access Special Management Areas surrounding Raine Island, Moulter Cay and Maclennan Cay.	• Restricts activities been undertaken under permit to low impact that cannot reasonably be undertaken elsewhere and provide benefits that outweigh any potential disturbance, in order to protect significant natural values of the island and cays, including seabirds.	• Review of position statement in line with current knowledge.	GBRMPA
Back on Track Biodiversity Action Plans	• The Back on Track Species Prioritisation Framework identifies priority species for conservation management, regional threats, and suggested recovery actions • No offshore or pelagic foraging seabirds are listed as priorities for action	• Identifies regionally-appropriate management actions to mitigate the risks to these species • Process of review.	Queensland Government with regional Natural Resource Management groups and other stakeholders for implementation of identified management actions.
Reef Water Quality Protection Plan 2009	• An overarching framework to achieve a sustainable future for the Great Barrier Reef and the industries in the Reef's catchment by improving water quality that flows into the Great Barrier Reef lagoon.	• Improve water quality that flows into the Reef by targeting priority outcomes, integrating industry and community initiatives and incorporating new policy and regulatory frameworks.	Joint Australian Government and State of Queensland initiative
Great Barrier Reef Protection Amendment Act 2009 (Qld)	• A framework for reducing the levels of dangerous pesticides and fertilisers found in the waters of the Great Barrier Reef by 50 per cent in four years.	• Mix of strict controls on farm chemicals and regulations to improve farming practices.	Queensland Government
Coastal Protection and Management Act 1995 (Qld) and *Coastal Protection and Management Regulation 2003*	• Provides the legislative framework and regulations for the coordinated management of the diverse range of coastal resources and values in the coastal zone. This framework includes provisions that establish the Queensland Coastal Plan.	• Queensland Coastal Plan outlines directions for effective protection and management of the coastal zone.	Queensland Government
Queensland Coastal Plan (prepared under the *Coastal Protection and Management Act 1995*	• The Queensland Coastal Plan has two parts: State Policy for Coastal Management and the State Planning Policy 3/11: Coastal Protection (SPP).	• The State Policy for Coastal Management provides policy direction for natural resource management decision-makers about land on the coast, such as	Queensland Government

and includes a state planning policy under the *Sustainable Planning Act 2009*)		coastal reserves, beaches, esplanades and tidal areas • The SPP provides policy direction and assessment criteria to direct land-use planning and development assessment decision making under the *Sustainable Planning Act 2009*.	

Sustainable Planning Act 2009 (Qld) and *Sustainable Planning Regulation 2009*	• Establishes process for land-use planning and development assessments. Identifies state legislation that may be triggered by development assessments and the process by which developments must be assessed against each piece of legislation
	• Establishes the framework for the development of Regional Plans.
		• Regional plans operate in conjunction with other state planning instruments, usually taking precedence over them
		• Regional plans must conform to policies established within the Queensland Coastal Plan
		• Regional plans identify:
		  • desired regional outcomes
		  • policies and actions for achieving these desired regional outcomes
		  • the future regional land use pattern
		  • regional infrastructure provision to service the future regional land use pattern
		  • key regional environmental, economic and cultural resources to be preserved, maintained or developed.
			Queensland Government

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Appendix 1. Vulnerability assessment matrix

	Pressures									
	Commercial marine tourism	**Defence activities**	**Commercial fishing**	**Recreational fishing**	**Ports and shipping**	**Recreation (not fishing)**	**Traditional use of marine resources**	**Climate change**	**Coastal development**	**Declining water quality due to catchment run-off**
Exposed to source of pressure (yes/no)	Yes; locally (with regional significance)	Yes; locally	Yes; Great Barrier Reef-wide	Yes; predominantly developing coast south of Cooktown	Yes; locally (with potential for regional significance)	Yes; regionally	No	Yes	Yes; developing coast south of Port Douglas	Yes; predominantly developing coast south of Cooktown
Degree of exposure to source of pressure (low, medium, high, very high)	High. Exposure at the local scale could be very high at significant locations as tourism operators (and recreational users) visit significant nesting sites that are experiencing seabird population declines which can be partly attributed to human disturbance. Such localised pressure may have regional impacts significant to certain offshore and pelagic foraging seabird populations.	Low. Offshore and pelagic foraging seabirds are not thought to be significantly impacted by Defence activities in the Great Barrier Reef as Defence operations avoid key nesting sites.	Medium. Overfishing can reduce the availability of seabirds' prey. Overexploitation of large predatory fish, especially tuna and mackerel, taxa that seabirds (mostly pelagic and offshore foraging species) rely on to drive prey into surface waters, may impact on the availability of forage food. Quantifiable effects on seabird prey from commercial fisheries are currently undetermined.	Medium. Recreational fishing may significantly reduce the abundance of mackerel (and to an unknown, but presumably lesser degree, tuna) that provide ecosystem services to seabirds by driving prey to surface waters to enable predation. Hooking of some seabird species by recreational fishers apparent and although the level of impact is unknown, it is expected to be low.	Low. Offshore and pelagic foraging seabirds are not thought to be widely impacted by the activities of ports and shipping in the Great Barrier Reef as they mostly nest on offshore cays and islands. The risks presented by potential shipping incidents and resultant pollution could be serious for seabirds and their nesting and foraging sites.	High. Exposure at the local scale could be very high at significant locations as recreational visitors approach and visit significant nesting sites that are experiencing seabird population declines. In some localities within the Great Barrier Reef these declines can be partly attributed to human disturbance. Such localised pressure is likely to occur on a regional scale and have regional impacts significant to certain offshore and pelagic foraging seabird populations. Considering these aspects,	Low. Offshore and pelagic foraging seabirds are not considered to be under pressure from traditional use.	Very high. Climate driven processes have been shown to negatively impact the ecologies of all seabird foraging guilds. Climate driven processes that determine the availability of prey for offshore and pelagic foraging seabirds have the potential to cause sudden and catastrophic population decline amongst those species. Extremes of El Niño Southern Oscillation events are expected to occur more frequently under predicted climate change scenarios. Impacts from these extremes include rainfall variability, higher sea-surface temperatures, and increases in the frequency and intensity of storms	High. Coastal development and related human population increase will increase human-induced pressures that have been identified as impacting on the populations of offshore and pelagic foraging seabird species (habitat loss and degradation, increased visitation/disturbance of nesting sites, increased fishing pressure on pelagic service-provider species, increased pollution and marine debris, greater capacity for the spread of weeds, pests and disease).	Medium. Discharge and run off into the lagoon affects water quality that determines ecosystem health of the Great Barrier Reef. This has many direct and indirect impacts on seabird ecology and the habitats and processes they rely upon. Such impacts may include detrimental effects on food webs and long-term island formation processes. Marine debris has been identified as a source of pressure for all seabirds. Although most garbage located on the remote islands of the Great Barrier Reef is found to come from vessels, increased catchment run-off could contribute to increases of marine debris that impact on seabirds.

	Pressures									
	Commercial marine tourism	**Defence activities**	**Commercial fishing**	**Recreational fishing**	**Ports and shipping**	**Recreation (not fishing)**	**Traditional use of marine resources**	**Climate change**	**Coastal development**	**Declining water quality due to catchment run-off**
	Considering these aspects, on a regional scale the exposure to this pressure is thus considered high.					on a regional scale the exposure to this pressure is thus considered high.		and cyclones. They present serious threats to seabird populations and island ecosystems and processes which they rely upon. Altered ocean chemistry, temperature and sea level rise under predicted climate change scenarios also present serious threats to seabird populations and island ecosystems and processes which they rely upon. When considering the combined effects of other known pressures, the degree of exposure to climate change pressures is at critical levels.		
Sensitivity to source of pressure **(low, medium, high, very high)**	High. Visitation disturbance is known to discourage nesting site selection and reduce breeding participation and success and foraging ability to varying degrees for different	High. Many seabird species are easily disturbed by intrusive activity and this is known to discourage nesting site selection and reduce breeding participation and success and foraging	High. Offshore and pelagic foraging seabirds have a relatively narrow diet and have been shown to rely upon pelagic predatory fish to drive prey into surface waters in areas where prey aggregate. The breeding participation and success of these	High. Offshore and pelagic foraging seabirds have a relatively narrow diet and have been shown to rely upon pelagic predatory fish to drive prey into surface waters in areas where prey	Low. Offshore and pelagic foraging seabirds do not regularly use habitat that is under most pressure from increased ports and shipping development and activity. Given the distribution of offshore and pelagic foraging	High. Visitation disturbance is known to discourage nesting site selection and reduce breeding participation and success and foraging ability to varying degrees for different species.	Low. The exposure to this source of pressure is expected to continue to remain low. This means that sensitivity to this source of pressure is also low.	Very high. Most offshore and pelagic foraging seabird species have single clutches, at best rearing one chick successfully. Some of these species do not breed annually. These life history traits make them sensitive to population declines that may result from their very high	High. Many offshore and pelagic foraging seabirds are known to have very specific habitat requirements for foraging and breeding. Pressures that reduce the availability or productivity of these supporting habitats have been shown to cause breeding colonies to fail	Medium. Many offshore and pelagic foraging seabirds are known to have very specific habitat requirements for foraging and breeding. Pressures that reduce the availability or productivity of these supporting habitats have been shown to cause breeding

	Pressures									
	Commercial marine tourism	**Defence activities**	**Commercial fishing**	**Recreational fishing**	**Ports and shipping**	**Recreation (not fishing)**	**Traditional use of marine resources**	**Climate change**	**Coastal development**	**Declining water quality due to catchment run-off**
	species.	ability to varying degrees for different species. However, The foraging mode and location of key nesting sites which are remote from high-use military areas provide offshore and pelagic foraging seabirds with low sensitivity to defence pressures.	seabird species are highly sensitive to the abundance of these pelagic predatory fish. Therefore, offshore and pelagic foraging seabirds are highly sensitive to over exploitation of these fisheries.	aggregate. The breeding participation and success of these seabird species are highly sensitive to the abundance of these pelagic predatory fish. Therefore, offshore and pelagic foraging seabirds are highly sensitive to over exploitation of these fisheries.	seabird breeding colonies and foraging grounds, the sensitivity of these species to ports and shipping pressures is low on a Great Barrier Reef-wide scale.			exposure to climate change pressures. When considering the combined effects of other known pressures such as tourism/recreation disturbance, fishing, habitat loss and coastal development, the very high degree of exposure to climate change pressures leaves inshore and coastal foraging seabirds highly sensitive to those pressures.	catastrophically and remain unviable as long as prey productivity remains low or breeding site conditions remain unfavourable.	colonies to fail catastrophically and remain unviable as long as prey productivity remains low or breeding site conditions remain unfavourable.
Adaptive capacity – natural **(poor, moderate, good)**	Moderate. The mobility of offshore and pelagic foraging seabirds may enable them to select other suitable habitat localities to nest if necessary. This needs to be assessed cumulatively with pressures from climate change, coastal development	Moderate. The mobility of offshore and pelagic foraging seabirds may enable them to select other suitable habitat localities to nest if necessary. This needs to be assessed cumulatively with pressures from climate change, coastal development and catchment	Poor. Offshore and pelagic foraging seabirds have foraging ecologies and life history traits that mean that their adaptive capacity to on-going shortages of food is not good. Should commercial fishing provide such pressure, population collapse is predicted from which recovery would be prolonged or difficult.	Poor. Offshore and pelagic foraging seabirds have foraging ecologies and life history traits that mean that their adaptive capacity to on-going shortages of food is not good. Should commercial fishing provide such pressure, population collapse is predicted from which recovery would be	Moderate. Offshore and pelagic foraging seabirds are not considered to be directly impacted by ports and shipping in the Great Barrier Reef World Heritage Area. However, impacts could be significant if a spill from a shipping incident made landfall at a key seabird nesting site or had severe impacts on a key foraging ground used by offshore and pelagic	Moderate. The mobility of offshore and pelagic foraging seabirds may enable them to select other suitable habitat localities to nest if necessary. This needs to be assessed cumulatively with pressures from climate change, coastal development and catchment run-off that may degrade or reduce the availability of alternative suitable nesting	Good. On-going low exposure to this source of pressure.	Poor. This needs to be assessed cumulatively in light of pressures from habitat loss, coastal development and catchment run-off that may degrade or reduce the availability of alternative suitable nesting or roosting habitat, or the productivity of foraging grounds. The mobility and foraging ecology of inshore and coastal foraging seabirds may enable them to select alternative suitable habitat localities to nest if	Poor. This needs to be assessed cumulatively in light of pressures from climate change, habitat loss and catchment run-off that may degrade or reduce the availability of alternative suitable nesting or roosting habitat, or the productivity of foraging grounds. The mobility and foraging ecology of offshore and pelagic foraging seabirds may enable them to select alternative suitable habitat localities to nest if	Poor. Needs to be assessed cumulatively with other pressures that impact on the ability of offshore and pelagic foraging seabird species to source food or locate suitable nesting habitat. It is anticipated that long-term reductions in Great Barrier Reef water quality or increased scale and severity of freshwater bleaching may disrupt calcium-accumulating organisms that underpin the

	Pressures									
	Commercial marine tourism	**Defence activities**	**Commercial fishing**	**Recreational fishing**	**Ports and shipping**	**Recreation (not fishing)**	**Traditional use of marine resources**	**Climate change**	**Coastal development**	**Declining water quality due to catchment run-off**
	and catchment run-off that may degrade or reduce the availability of alternative suitable nesting or roosting habitat, or the productivity of alternative foraging grounds. The actual adaptive capacity of offshore and pelagic foraging seabirds to disturbance pressure is not sufficiently understood with regards to individual species' foraging ecology and nesting locality requirements. It is not known what the thresholds of pressure may be, or what population decline may occur, if	run-off that may degrade or reduce the availability of alternative suitable nesting or roosting habitat, or the productivity of alternative foraging grounds. The actual adaptive capacity of offshore and pelagic foraging seabirds to disturbance pressure is not sufficiently understood with regards to individual species' foraging ecology and nesting locality requirements. It is not known what the thresholds of pressure may be, or what population decline may occur, if seabirds were forced to transition to less disturbed, though		prolonged or difficult.	foraging seabirds foraging seabird species.	or roosting habitat, or the productivity of alternative foraging grounds. The actual adaptive capacity of offshore and pelagic foraging seabirds to disturbance pressure is not sufficiently understood with regards to individual species' foraging ecology and nesting locality requirements. It is not known what the thresholds of pressure may be, or what population decline may occur, if seabirds were forced to transition to less disturbed, though marginally suitable nesting localities. The ecologies and life history traits of offshore and pelagic foraging seabirds means they are not well adapted to respond to the cumulative		necessary. The actual adaptive capacity of inshore and coastal foraging seabirds to these pressures is not sufficiently understood with regards to individual species' foraging ecology and nesting locality requirements. It is not known what the thresholds of pressure may be, or what population decline may occur, if seabirds were forced to transition to alternative nesting localities if previous localities were lost or degraded beyond suitability or were not productive enough to support provisioning. The ecologies and life-history traits of offshore and pelagic foraging seabirds means they are not well adapted to respond to the cumulative impacts presented by the range of pressures they face.	necessary. The actual adaptive capacity of offshore and pelagic foraging seabirds to these pressures is not sufficiently understood with regards to individual species' foraging ecology and nesting locality requirements. It is not known what the thresholds of pressure may be, or what population decline may occur, if seabirds were forced to transition to alternative nesting localities if previous localities were lost or degraded beyond suitability or were not productive enough to support provisioning. The ecologies and life history traits of offshore and pelagic foraging seabirds means they are not well adapted to respond to the cumulative impacts presented by the range of pressures they face.	habitats that seabirds rely upon. The ecologies and life history traits of offshore and pelagic foraging seabirds means they are not well adapted to respond to the cumulative impacts presented by the range of pressures they face.

	Pressures									
	Commercial marine tourism	**Defence activities**	**Commercial fishing**	**Recreational fishing**	**Ports and shipping**	**Recreation (not fishing)**	**Traditional use of marine resources**	**Climate change**	**Coastal development**	**Declining water quality due to catchment run-off**
	seabirds were forced to transition to less disturbed, though marginally suitable nesting localities. The ecologies and life history traits of offshore and pelagic foraging seabirds means they are not well adapted to respond to the cumulative impacts presented by the range of pressures they face.	marginally suitable nesting localities. The ecologies and life history traits of offshore and pelagic foraging seabirds means they are not well adapted to respond to the cumulative impacts presented by the range of pressures they face.				impacts presented by the range of pressures they face.				
Adaptive capacity – management **(poor, moderate, good)**	Good. Management strategies currently in place have been shown to provide a level of effectiveness for reducing visitor disturbance impacts. For example, at Michealmas	Good. Defence activities are well managed and limited in extent, duration and geographic distribution.[40] Further management could be applied as required.	Moderate. The *Great Barrier Reef Marine Park Zoning Plan 2003* may be providing some protection of food resources and predatory fish service providers for species of these foraging guilds. However, the capacity to adapt the Zoning Plan	Moderate. The *Great Barrier Reef Marine Park Zoning Plan 2003* may be providing some protection of food resources and predatory fish service providers for species of these foraging	Moderate. GBRMPA has strategies (e.g. Environmental Management Plans) and statutory tools to lower the risk of vessel related oil spills and pollution incidents. However, the risks can only be lowered and not	Good. Management strategies currently in place have been shown to provide a level of effectiveness for reducing visitor disturbance impacts. For example, at Michealmas Cay, in the Cairns Area of	Good. On-going low exposure to this source of pressure.	Poor. Options for local or regional scale management of climate impacts on seabirds remain very limited because most impacts are directly linked to large-scale global climate phenomena rather than more local threatening	Moderate. The *Great Barrier Reef Marine Park Act 1975* provides limited scope to manage activities outside the Marine Park. To achieve good water quality and coastal ecosystem outcomes for the Great Barrier Reef, the GBRMPA facilitates the development of	Moderate. The *Great Barrier Reef Marine Park Act 1975* provides limited scope to manage activities outside the Marine Park. To achieve good water quality and coastal ecosystem outcomes for the Great Barrier Reef, the GBRMPA facilitates the

	Pressures									
	Commercial marine tourism	**Defence activities**	**Commercial fishing**	**Recreational fishing**	**Ports and shipping**	**Recreation (not fishing)**	**Traditional use of marine resources**	**Climate change**	**Coastal development**	**Declining water quality due to catchment run-off**
	Cay, in the Cairns Area of management, limiting visitor numbers and visitation hours, 'fencing' off the seabird breeding colony, and providing regulatory signage and education to inform visitors has provided some measurable mitigation of impacts. These management actions require ongoing monitoring and review.		to meet changing spatial management requirements is limited. The Eastern Tuna and Billfish Fishery is the main commercial fishery (other than the charter game fishing industry) that impacts of the abundance of tuna that offshore and pelagic foraging seabirds rely on for ecosystem services. As it operates outside of the jurisdiction of the World Heritage Area, it is only through consultative and advisory relations with the Australian Fisheries Management Authority that adaptive management arrangements can be discussed for the sustainable use of this fishery.	guilds. However, the capacity to adapt the Zoning Plan to meet changing spatial management requirements is limited.	eliminated. Environmental impact assessments made under the EPBC Act provide a process to assess the impacts of proposed port developments. Final approvals are subject to political processes.	management, limiting visitor numbers and visitation hours, 'fencing' off the seabird breeding colony, and providing regulatory signage and education to inform visitors has provided some measurable mitigation of impacts. Regulations restricting seasonal access to key seabird breeding sites provide a degree of protection to nesting birds. Outcomes require ongoing monitoring and review.		processes. Complexities can also occur when initiatives to manage climate change impacts require cross-jurisdictional collaborations with agencies with somewhat divergent objectives. The GBRMPA's current framework for managing climate change impacts and building the resilience of species and habitats to those impacts has been developed to implement new information as it becomes available.	partnerships with industry, the community, local and state government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures, developing and maintaining a culture of mutual obligation. This is undertaken by providing input into the Queensland Coastal Plan policies and statutory Regional Plans which plan for coastal development in Queensland. The GBRMPA also provides input into environmental assessments for projects referred under the EPBC Act.	development of partnerships with industry, the community, local and state government and other Australian Government agencies to influence the management and planning of catchment and coastal pressures, developing and maintaining a culture of mutual obligation. This is undertaken by fostering partnerships through the *Reef Water Quality Protection Plan 2009* and Reef Rescue Program.
Residual vulnerability **(low, medium, high)**	High	Low	High	Medium	Low	High	Low	High	High	High

	Pressures									
	Commercial marine tourism	**Defence activities**	**Commercial fishing**	**Recreational fishing**	**Ports and shipping**	**Recreation (not fishing)**	**Traditional use of marine resources**	**Climate change**	**Coastal development**	**Declining water quality due to catchment run-off**
Level of confidence in supporting evidence **(poor, moderate, good)**	Good – effects on populations. Devney & Congdon 2009;[48] Devney *et al.* 2009;[48] Hulsman *et al.* 1997[8,32] Poor – ecological and ecosystems processes.	Good. O'Neill 2009.[49]	Poor. Unknown. Knowledge is lacking on the foraging ecologies of offshore and pelagic foraging seabirds and how they interact with commercial fisheries to affect breeding participation and reproductive success. Evidence shows the negative effects of fishing on pelagic foraging seabird populations.[50] The extent to which fishing within and adjacent to the Marine Park affects food web interactions, or the ability of seabirds to source food, requires more investigation. Devney *et al.* 2009[7]{; Erwin & Congdon 2007;[18] Hulsman *et al.* 1997[8,32]	Poor. Unknown. Knowledge of food web interactions between both seabirds' prey and the pelagic predatory fish that may provide ecosystem services to offshore and pelagic foraging seabirds is not well understood and requires more investigation. Devney *et al.* 2009[7]; Hulsman *et al.* 1997[8,32]	Good. The impacts from an ill-directed oil spill are widely understood to have serious implications for breeding seabirds. Evidence of cumulative impacts of ports and shipping in combination with other pressures is poor.	Good – effects on populations. Devney & Congdon 2009;[48] Devney *et al.* 2009;[48] Hulsman *et al.* 1997[8,32] Poor – ecological and ecosystems processes.	Moderate. Networking amongst Traditional Owners suggests that traditional use of offshore and pelagic foraging seabirds is not common in the Great Barrier Reef.	Poor. Fuller and Dhanjal-Adams 2012;[1,2] Congdon *et al.* 2007;[38]{{1286 Congdon, B.C. 2007}} Turner & Batianoff 2007;[39] Smithers *et al.* 2007;[43] Lough 2007;[44] Webb & Kench 2010;[42] Devney *et al.* 2009;[7] Devney *et al.* 2009;[22] Erwin & Congdon 2007;[18] Hulsman *et al.* 1997[8,32]	Poor. Congdon *et al.* 2007;[38]{{1286 Congdon, B.C. 2007}} Turner & Batianoff 2007;[39] Devney *et al.* 2009[7]	Poor. Congdon *et al.* 2007;[38] Turner & Batianoff 2007;[39] Hutchings *et al.* 2005[51]

The pressures addressed in this Vulnerability Assessment were identified in the *Great Barrier Reef Outlook Report 2009*.[40]

* Coastal habitats (reefs, foreshores, rivers and estuaries) are under increasing pressure from human activities. More than 85 per cent of Queensland's population live on the coastal fringe. Predicted strong population growth means that the intensity of activity and development in coastal zones is likely to persist or increase.[52]

The purpose of the vulnerability assessment process is to provide a mechanism to highlight key concerns and make assessments of the vulnerabilities that species, groups of species or habitats have to known sources of pressure within the Great Barrier Reef World Heritage Area (the World Heritage Area) using a standardised and transparent process. This was undertaken using a standard approach to assess exposure and sensitivity and adaptive capacity to potential impacts (Figure 1) based on the best-available information on that particular habitat, species or group of species.

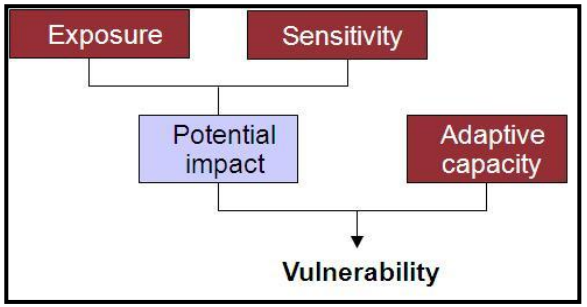

Figure 1. The key components of vulnerability assessments (Adapted from Wachenfeld *et al*., 2007)

To achieve this objective it has been necessary to apply a linear relationship to comparisons that are sometimes non-linear by nature. For example, when applying the potential impact matrix[c] to create a combined score for exposure and sensitivity, if a species, group of species or habitat has a very high level of exposure to a pressure but low sensitivity to it, it is scored as having a medium-high potential impact score. This medium-high score may be the same as determined for another assessment where there may be a low level of exposure but a very high level of sensitivity. This implies a linear relationship for the sensitivity a species or habitat has to a given level of exposure, which may not necessarily be the case. However, it does provide managers with the required level of resolution on these relationships for the purpose of the vulnerability assessments that inform the *Great Barrier Reef Biodiversity Conservation Strategy 2012*.

The methods used to determine the degree of exposure or sensitivity of offshore and pelagic foraging seabirds of the World Heritage Area against each source of pressure are described within the vulnerability assessments page of the GBRMPA website.

The natural capacity of offshore and pelagic foraging seabirds to adapt to pressures in the Great Barrier Reef, and the capacity of management to intervene (which in turn may assist offshore and pelagic foraging seabirds to adapt to these pressures), are considered as two dynamics that affect their residual vulnerability to any of the identified pressures. These two dynamics are then combined to produce an overall rating for adaptive capacity and then applied to the potential impact rating to provide a score for the residual vulnerability that offshore and pelagic foraging seabirds may be expected to experience for the given pressure. An explanation of the procedure by which this process has been applied and qualifying statements for the assessment of adaptive capacity (natural and management) scores are provided within the vulnerability assessments page of the GBRMPA website.

[c] The potential impact matrix is described within the vulnerability assessments page of the GBRMPA website.

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