

Impact of predation by Cape fur seals *Arctocephalus pusillus pusillus* on Cape gannets *Morus capensis* at Malgas Island, Western Cape, South Africa

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Cape fur seals *Arctocephalus pusillus pusillus* were estimated to kill some 6 000 Cape gannet *Morus capensis* fledglings around Malgas Island in the 2000/01 breeding season, 11 000 in 2003/04 and 10 000 in 2005/06. This amounted to about 29%, 83% and 57% of the overall production of fledglings at the island in these breeding seasons respectively. Preliminary modelling suggests this predation is not sustainable. There was a 25% reduction in the size of the colony, the second largest of only six extant Cape gannet colonies, between 2001/02

and 2005/06. There has been a large increase in predation by Cape fur seals on seabirds around southern African islands since the mid-1980s, coincidental with both an increase in the seal population, altered management of the islands and an altered distribution of prey for gannets and seals. At Malgas Island, most gannet fledglings were killed between 10:00 and 18:00, the period when most are in the water around the island, from mid-January to mid-March, the main fledging period. The Cape gannet is classified as Vulnerable.

Keywords: *Arctocephalus pusillus pusillus*, Cape fur seal, Cape gannet, fledgling mortality, Malgas Island, *Morus capensis*, predation

Introduction

Cape fur seals *Arctocephalus pusillus pusillus* increased off southern Africa throughout the 20th century, after having been exploited to low levels of abundance at the end of the 19th century (Shaughnessy 1984, Crawford *et al.* 1989, David 1989). The population in 1993 numbered 1.5–2 million animals (Butterworth *et al.* 1995, Best *et al.* 1997). Conversely, the conservation status of several seabird species deteriorated in the 20th century (Barnes 2000, BirdLife International 2000). For example, there were about 1.45 million adult African penguins *Spheniscus demersus* at Dassen Island in 1930, whereas the global population was <0.2 million adults in 2000 (Shannon and Crawford 1999, Hockey *et al.* 2005).

The Cape gannet *Morus capensis* breeds only in southern Africa — at three colonies in Namibia and three in South Africa (Crawford *et al.* 1983). The species is regarded as Vulnerable (Barnes 2000), following a decrease in the global population of 100 000 pairs, from 250 000 pairs in the late 1960s to about 150 000 pairs at present (Crawford *et al.* in press). At the close of the 20th century, it was observed that Cape fur seals, almost all young males, were inflicting heavy mortality on Cape gannet fledglings as they left Malgas Island (David *et al.* 2003). At that time there were about 50 000 pairs of Cape gannets on the island, one-third of the global population (Crawford *et al.* in press). It was uncertain whether such mortality was sustainable. Hence, observations were initiated in an attempt to quantify

the loss of fledglings to seals. This study examines the impact of the seals on the Cape Gannet population at Malgas Island.

Material and Methods

Malgas Island (33°03'S, 17°55'E) lies about 800m from the mainland on the west coast of South Africa. It is located at the northern entrance of Saldanha Bay in the Benguela upwelling system, which provides the abundant food resources on which Cape gannets feed (Berruti *et al.* 1993).

At Malgas Island, Cape gannets lay their first clutches from 15 August to 1 November, with a peak from 8 September to 12 October (Staverees *et al.* in press). Incubation lasts 43–44 days, commencing as soon as the egg is laid (Jarvis 1970). Chicks leave their nests 90–105 days after hatching (Jarvis 1970) and can spend up to six days at the colony edge before departing to sea (Hockey *et al.* 2005). Therefore, at Malgas Island, most chicks fledge from mid-January to mid-March.

Observations on gannet mortality around Malgas Island were undertaken in a systematic manner during three gannet breeding seasons, the austral summers of 2000/01, 2003/04 and 2005/06. In 2000/01, the island was visited during 24–27 November, 13–20 December, 12–19 January and 5–13 February. In 2003/04, it was visited during 8–12 December, 9–16 January, 23–29 January, 6–12 February,

20 February–5 March and 12–25 March. In 2005/06, observations were made during 23–31 January and 15 February–8 March. Binoculars were used to scan waters around the island for predatory activities by seals. Often, birds hovering overhead gave the first indication of an attack on a gannet by a seal (du Toit *et al.* 2004).

Malgas Island is 8.5ha in extent (Rand 1963) and it is not possible to have a view of the entire island from any particular vantage point. In 2000/01, two observers kept watch over different areas of the island during every alternate hour. Vantage points near the sea were used and it was estimated that only two-thirds of the area around the island was covered. On one day observations began at 07:00 and ended at 18:00 and on the following day they commenced at 08:00 and finished at 19:00. This pattern was then repeated. Hence, on each day an observer conducted observations for six hours. To estimate the number of birds killed each day, the number observed killed was doubled (to account for periods when no watches were kept) and multiplied further by 100/67 (to account for that portion of the waters around the island that was not covered). This calculation makes the assumption that the predation rate was the same for all areas around the island.

In 2003/04 and 2005/06, a single observer kept watch from a different vantage point on top of a building, from which it was again gauged that only 67% of the waters around the island were covered. On each day, observations were made from 06:00 until 18:00, except for breaks totalling about one hour. Therefore, the numbers of gannet chicks observed to be killed in the 12h period were increased by factors of 12/11 and 100/67.

Based on observations made during 2000/01, it was assumed that no fledglings were killed by seals before 25 November. There were <200 gannet chicks on the island on 22 March 2005 (ABM pers. obs.), so it was also assumed that no fledglings were lost to seals after 31 March.

Estimates of total numbers of gannet fledglings killed by seals in the three breeding seasons were obtained by imputing values for days when no observations were made. Average daily predation rates were calculated for weeks when observations were made. For 2005/06, no observations were made before 23 January. Therefore, for 2005/06, the average value for 8–20 December was taken to be the average daily value observed during 13–20 December 2000 and 8–12 December 2003. For days when no observations were conducted, the average predation rates were estimated by interpolating linearly between the average values for the weeks immediately preceding and following the period with no information. For days before observations commenced, the interpolation was between zero on 24 November and the average of the first week of observations. For days after the last observations were conducted, it was between the average of the last week of observations and zero on 1 April.

To investigate the influence of time of day on predation rate, observations were made during the 2003/04 and 2005/06 breeding seasons from 05:00 to 20:00. Incidents of predation were pooled to calculate the total numbers of gannet fledglings seen to be killed by seals in intervals of one hour.

Numbers of gannet fledglings at Malgas Island in the three breeding seasons were estimated as the product of

the number of pairs of gannets breeding at the island and the average breeding success of each pair. Numbers of pairs breeding at the island were obtained from measurements of the area occupied by breeding birds and the density of nests. The area occupied by breeding birds was measured on aerial photographs taken in October or December of each year (Crawford *et al.* 1983, Crawford *et al.* in press). At Malgas Island, no trend in the density of gannet nests was observed during 1994/95–2005/06, so the mean density over that period (2.84 ± 0.19 nests m^{-2} , Crawford *et al.* in press) was applied to all three seasons.

The breeding success of gannets was obtained by monitoring the numbers of chicks fledged by a known number of breeding pairs (49 in 2000/01, 317 in 2003/04 and 215 in 2005/06), whose nests were monitored as described by Staveres *et al.* (in press). In 2005/06, the estimated production of fledglings was considerably less than the estimated loss to seals, suggesting that the production at monitored nests was not representative of the gannet colony as a whole. Therefore, the mean production of fledged chicks observed during the period 1987/88–2005/06 was applied to that season.

The sustainability of the rate of predation of seals on gannet fledglings was investigated in a preliminary manner by estimating the level of breeding success necessary to maintain a population of Cape gannets in equilibrium. The following equation was used (Crawford *et al.* 2006):

$$B = 2(1 - s_a)(1/s_a)^2(1/s_i)^2$$

where B = breeding success (chicks per pair per year), s_a is the proportion of birds older than two years surviving in any year, and s_i is the proportion of post-fledging birds younger than two years surviving in any year.

It was assumed that all Cape gannets breed for the first time when four years old and in every subsequent year thereafter (Crawford 1999). The equation shows the number of chicks that must successfully fledge in order to replace the number of breeding adults that die. The factor 2 is included because it is pairs of birds that produce chicks. The proportion of adults dying each year is $(1 - s_a)$. The terms $(1/s_a)^2$ and $(1/s_i)^2$ are included to account for mortality between the ages of two and four and from fledging to Age 2 respectively, both periods of two years. Values used for s_a and s_i were 0.93 and 0.71 respectively (Crawford 1999).

Results

Numbers of fledglings killed

Numbers of Cape gannet fledglings estimated to be killed by seals are shown in Figure 1 for each day on which observations were made, for each of the three seasons during which information was collected. Interpolated estimates for days on which no observations were made are also shown. In 2000/01, there was an increase in numbers of fledglings killed between late November and February. In 2003/04, the highest mortality was observed from 20 February to 5 March, with the estimated numbers of fledglings killed per day decreasing on either side of that period.

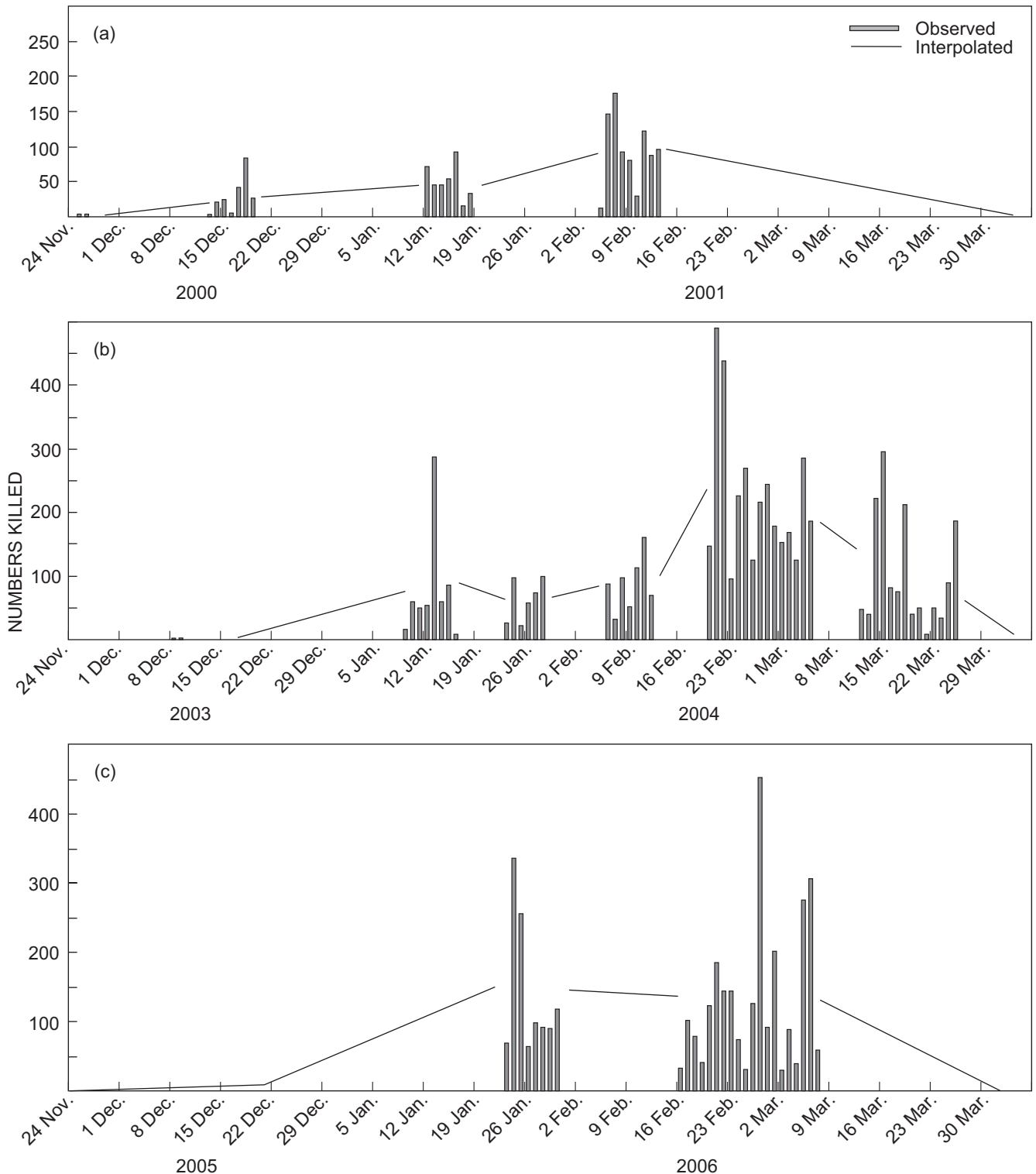


Figure 1: Estimates of numbers of Cape gannet fledglings killed at Malgas Island during (a) 2000/01, (b) 2003/04 and (c) 2005/06

In 2005/06, there was little difference in the mean numbers of fledglings killed in late January and late February/early March. It was estimated that seals killed about 5 700, 10 800 and 10 100 Cape gannet fledglings during the 2000/01, 2003/04 and 2005/06 breeding seasons respec-

tively. In all three seasons, there was substantial variability from one day to the next in the loss of fledglings to seals (Figure 1). The maximum estimated number of fledglings killed by seals on any one day was 491 on 21 February 2004. The mean predation was ± 11 chicks per day.

Diurnal trend and location of gannet fledglings killed

Few Cape gannet fledglings, 4.1% and 1.5%, were killed by seals before 10:00 or after 18:00 respectively (Figure 2). Most (94% of the total number observed in the 2003/04 and 2005/06 seasons) were killed between 10:00 and 18:00, with the highest rates of predation observed from 13:00 to 17:00 (3 918 or 62%).

Almost all fledglings were killed in the sea after leaving the island at a distance of about 80m from the island. However, seals came ashore to kill two fledglings on land in 2004 and about 20 were taken in 2006 between 10m and 50m from the shore.

Proportions of fledglings killed

The areas occupied by breeding Cape gannets were 1.69ha in 2000/01, 1.09 in 2003/04 and 1.47 in 2005/06. The estimated numbers of gannets breeding in these three seasons were 48 000, 31 000 and 42 000 pairs respectively. Average numbers of chicks fledged per pair of Cape gannets were 0.41 in 2000/01, 0.42 in 2003/04 and 0.02 in 2005/06. Therefore, some 19 680 chicks fledged in 2000/01, 13 020 in 2003/04 and 840 in 2005/06. The average breeding success of Cape gannets at Malgas Island during 1987/88–2005/06 was 0.42 chicks fledged per pair (RJMC, unpublished data). If this average is used for 2005/06, 17 640 chicks would have fledged.

The proportions of fledglings killed by seals were 29% in 2000/01, 83% in 2003/04 and 57% in 2005/06. The proportion of fledglings killed decreased as the area occupied by breeding gannets increased (Figure 3).

Sustainability of predation

The necessary average breeding success to maintain a population of Cape gannets in equilibrium, based on survival rates and age at breeding as estimated by Crawford (1999), is 0.32 chicks per pair per year. Once the estimated rates of mortality caused by seals (29%, 83%, 57%) have been incorporated, the average numbers of chicks success-

fully fledged by each pair (chicks/pair \times (1 - M), where M is the proportion of fledglings killed during fledging) is reduced to 0.07–0.30, which in each instance is less than the production required to sustain the population. In a deterministic model, a mortality of 24% of chicks fledging from the island would be sustainable, given the parameters used above.

Discussion

The need to impute data to estimate the overall numbers of Cape gannet fledglings killed by Cape fur seals around Malgas Island results in uncertainty in the estimates of proportions of fledglings that are killed. There were substantial gaps between periods in which observations were made, and there was also considerable day-to-day variation in numbers of fledglings observed to be killed (Figure 1). This variation could be attributable to wind conditions. On windy days, the chicks fledge by flying, and it is mainly on calm days that they swim and are killed by seals (ABM pers. obs). It was earlier estimated, using a conservative method of imputing missing values, that, in the 2000/01 season, seals killed 4 785 gannet fledglings around Malgas Island (David *et al.* 2003), a value lower than the 5 700 estimated in this study. In spite of the uncertainty, it is clear that, in each of the three breeding seasons investigated, a substantial proportion of Cape gannet fledglings (>20%) was killed by seals and that this mortality, particularly in 2003/04 and 2005/06, is not sustainable. This suggests the need to implement measures to reduce the mortality. From 1993–2001, 153 seals seen killing seabirds were shot around Malgas Island, leading to short-term decreases in mortality of Cape gannet fledglings (David *et al.* 2003).

That the present rate of mortality of fledglings is not sustainable is borne out by a decrease of 25% in the size of the Cape gannet colony at Malgas Island between 2001/02 and 2005/06 (Crawford *et al.* in press), following a period of growth between the mid-1980s and the mid-1990s (Figure 4). Because Cape gannets commence breeding when aged about four years (Crawford 1999), a reduction in colony size could be expected about four years after rates of predation by seals became unsustainable. This would be subject to the

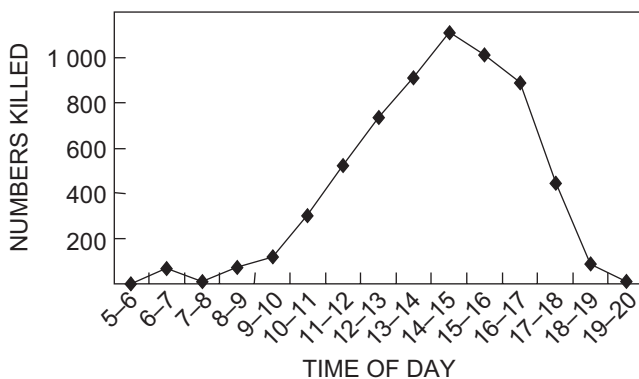


Figure 2: Overall number of Cape gannet fledglings observed to be killed at Malgas Island in relation to time of day, 2003/04 and 2005/06

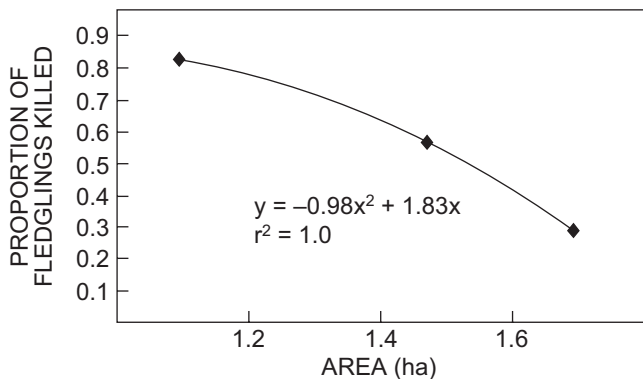


Figure 3: Relationship between the proportion of Cape gannet fledglings killed by seals and the area occupied by Cape gannets during breeding at Malgas Island

provision that space was not limiting and that all mature gannets were breeding, which probably was the case, because even when the colony peaked at about 2ha in 1996/97 there were areas of the island that were not occupied by gannets or other breeding seabirds (RJMC pers. obs).

The increase of the Cape gannet colony at Malgas Island up until the mid-1990s suggests that before about 1990 any predation by seals on Cape gannet fledglings was sustainable, i.e. that seals killed less than about 24% of fledglings leaving the island. This in turn points to an increase in the rate of predation by seals on fledglings in recent years. In this regard, it is interesting to note that, in spite of intensive research on seabirds in southern Africa since the early 1950s, losses of seabirds to seals was not considered a major problem before the late 1980s.

During a parliamentary enquiry into the running of the Government Guano Islands and the sealing industry in 1906 and 1907, certain witnesses reported that seals killed penguins. The headman at Possession Island, one of the Namibian gannet colonies, had seen seals catching gannets 'but very rarely' (Shaughnessy 1978). In 1937, during the sealing season, Hewitt (1937) reported that examination of the stomach contents of seals indicated they had fed on penguins; he also observed penguins with wounds attributable to seals. Thereafter, occasional predation of seabirds around islands in southern Africa was reported in 1937 (a single event regarded as unusual; Rand 1959a), in the 1960s (Bourne and Dixon 1973), in the 1970s (Cooper 1974, Shaughnessy 1978) and in the early 1980s (Rebelo 1984). In the 1950s, a few seal stomachs examined contained seabird feathers, but Rand (1959a) considered some of these seals had scavenged on dead carcasses of birds. Rand (1959b, p 32) noted that 'young gannets evacuate their breeding grounds with great success. Only very few are drowned when they leave the islands for the first time.' Had seals killed large numbers of gannet fledglings at that time, it would not have been unnoticed by Rand, especially because many fledglings, after being attacked by seals, return to Malgas Island to die from their injuries (Navarro 2000). Considering the conservation status of seabirds at Bird Island, Lambert's Bay, where Cape gannets breed, Jarvis and Cram (1971) made no mention of losses of gannets to seals. An assessment of the conservation status of Cape gannets in the early 1980s also made no mention of losses to seals (Crawford *et al.* 1983).

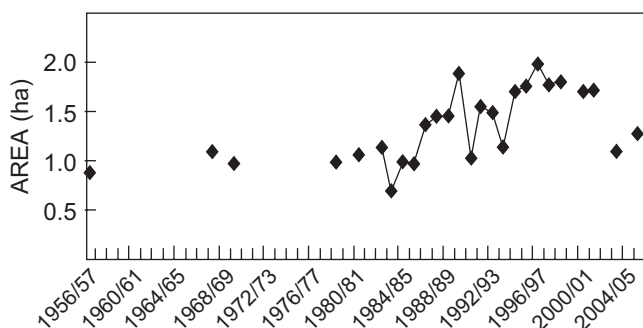


Figure 4: Trends in the area occupied by breeding Cape gannets at Malgas Island, 1956/57–2005/06 (from Crawford *et al.* in press)

At Ichaboe Island, Namibia, between September 1991 and May 2000, 2 774 predation events by seals on seabirds were noted, including 932 on Cape gannets, many of which were fledglings (du Toit *et al.* 2004). In the 1994/95 and 1995/96 breeding seasons, seals killed 2 461 Cape Cormorant *Phalacrocorax capensis* fledglings around Dyer Island, Western Cape. In 1994/95, it was estimated that 7.3% of fledglings were killed at this locality (Marks *et al.* 1997). From 1987 to 2000, predation of African penguins at Lambert's Bay was deemed unsustainable (Crawford *et al.* 2001). From September 1997 to October 2002, seals killed 1 154 Cape gannets around Bird Island (Ward and Williams 2004).

In February 1987/88, seals killed at least 89 gannet fledglings as they left Malgas Island (Navarro 2000). In 1989/90, seals killed 1.2% of gannet fledglings at Malgas Island that had been banded but, because not all carcasses were retrieved, a value of 2.5% was considered more likely. A minimum of 21 fledglings was killed on one day, and this rate was maintained throughout February, suggesting the loss of some 600 fledglings (Crawford and Robinson 1990). In 2000/01, some 30% of fledglings were being killed by seals, with the proportion taken increasing above 50% in 2003/04 and 2005/06.

Generally, seals have killed seabirds in the sea. The first observation in southern Africa of a seal killing a seabird ashore was of a bull catching an African penguin at Halifax Island in 1983 (Rebelo 1984). In 1995, a bull seal was observed killing an adult Cape gannet at Malgas Island (Crawford and Cooper 1996). In 2005, bull seals killed 200 adult Cape gannets at Lambert's Bay and caused abandonment of the entire colony there, some 11 000 pairs (Wolfaardt and Williams 2006).

The foregoing discussion suggests that there has been a large increase in the predation of seabirds by seals in southern Africa since the early 1980s, and especially in the last decade. Why this should be so is not entirely clear. While the islands were administered as guano islands, headmen at the islands had firearms and some shot seals that were seen preying on seabirds (RMJC pers. obs). The last collections of guano at South African islands were made at Malgas Island in 1985, Algoa Bay in 1988 and Lambert's Bay in 1991. The immediate shooting of seals seen killing seabirds would mean that the behaviour would not be learned by other animals. Some young seals were seen swimming with adults that were killing gannet fledglings (ABM pers. obs).

All 94 seals shot around Malgas Island, because they were preying on seabirds, were males aged 2–10 years (David *et al.* 2003). Predation of seabirds by Cape fur seals recorded by Shaughnessy (1978), Rebelo (1984), Navarro (2000) and du Toit *et al.* (2004) was mainly by males. In a study off Namibia by Mecenero *et al.* (2005), very few scats of female seals contained remains of seabirds. Therefore, it appears that only a portion (young males) of the Cape fur seal population is responsible for the mortality inflicted on seabirds. For other species of seal, predation of seabirds has also been mainly by males (Bonner and Hunter 1982, Childerhouse *et al.* 2001).

It should also be noted that numbers of Cape fur seals increased throughout the 20th century, markedly so after

the mid-1980s (Butterworth *et al.* 1995, Best *et al.* 1997). South African harvests of seals decreased in the early 1980s and stopped in 1990 (Best *et al.* 1997, David *et al.* 2003). The higher numbers of seals may have led to increased interactions with seabirds.

Seals are opportunistic animals that utilise food discarded by fishing boats and take food from fishers (Wickens *et al.* 1992). Following the removal of large terrestrial predators from much of the southern African coastline, they have formed large mainland colonies (David 1989). Therefore, it is possible that their numbers are now higher than before the arrival of Europeans in southern Africa in the 1600s. By contrast, several seabirds, such as the African penguin, that are specialist feeders and compete with fisheries for food (Crawford 1998, 2004), had their breeding habitat altered through *inter alia* the removal of deposits of guano for agricultural use, and their populations decreased substantially during the 20th century (Hockey *et al.* 2005). Cape gannets construct their nests almost entirely from guano (Hockey *et al.* 2005), so the removal of guano leads to a loss of nesting material. Attempts were made to offset this by adding phosphatic sand to areas where Cape gannets breed (Ross and Randall 1990). However, in spite of this, the removal of too much guano sometimes reduced breeding success (Jarvis 1971, Randall and Ross 1979). The recent interactions between seals and seabirds off southern Africa are exacerbating the population decreases of seabirds caused by human perturbation of the marine ecosystem.

After 2000, there was a marked eastward shift in the distribution of sardine *Sardinops sagax* off South Africa (van der Lingen *et al.* 2005, Fairweather *et al.* 2006), reducing its availability to predators along South Africa's west coast. Sardine are fed upon by both Cape fur seals (Rand 1959a) and Cape gannets (Berruti *et al.* 1993). The eastward displacement of prey may have caused seals to feed more intensively on alternative prey, such as seabirds and especially fledglings which are easily caught (Navarro 2000). However, the surplus killing of seabirds by Cape fur seals observed in some studies (Navarro 2000, du Toit *et al.* 2003) indicates that killing may not be solely for food but possibly an extension of play behaviour on the part of the seals (Bonner and Hunter 1982).

Marks *et al.* (1997) recorded 12 attacks by seals on seabirds between 09:45 and 17:25. This is similar to the time of day when most gannet fledglings were killed at Malgas Island in this study (Figure 3), and corresponds to the time when most are leaving to sea (ABM pers. obs.). Most mortality on gannet fledglings at Malgas Island is inflicted from mid-January to mid-March, the main fledging period (Figure 1).

At several sub-Antarctic islands, fur seal populations have also been increasing after reductions of populations caused by harvesting (Bester *et al.* 2003). Other *Arctocephalus* species have been recorded feeding on seabirds, especially penguins (Bonner and Hunter 1982, Hofmeyr and Bester 1993). The recovery of seal populations may increase the frequency of such interactions and, as in South Africa, adversely affect the status of seabirds that are already of conservation concern (Crawford and Cooper 2003).

Acknowledgements — We thank our research institutes (listed under addresses), the National Research Foundation (SANAP programme) and WWF-SA for supporting this research. We are grateful to all who assisted with observations of mortality of Cape gannet fledglings, including V Brookes, DAE Crawford, PJM Crawford, BM Dyer, JE Underhill and L Upfold. The Department of Environmental Affairs and Tourism, South African National Parks and South African Navy provided logistical support for the surveys. We thank S Mecenero and WA Montevecchi for valuable comments on the manuscript. This paper is a contribution to the project LMR/EAF/03/02 of the Benguela Current Large Marine Ecosystem (BCLME) Programme.

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