# PREDATORY INTERACTIONS BETWEEN CAPE FUR SEALS AND SEABIRDS AT ICHABOE ISLAND, NAMIBIA

by

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## ABSTRACT

Cape fur seals (*Arctocephalus pusillus pusillus*) prey on Cape gannets (*Morus capensis*), Cape cormorants (*Phalacrocorax capensis*), bank cormorants (*P. neglectus*), and African penguins (*Spheniscus demersus*) at Ichaboe Island (26°17'22"S, 14°56'36"E), Namibia. Opportunistic observations were conducted from September 1991 to May 2001, and focal event sampling and continuous observations between November 1999 and May 2000. Predatory events total 2 989, involving 932 gannets, 560 Cape cormorants, 142 bank cormorants and 552 penguins; high annual variation is evident. Individual seals specialising in seabird predation did not conform to this pattern of predation, differing in predation rate and bird species targeted. Seabird predation may be learnt from other seals, or forms an extension of play behaviour; subadult males are predominantly responsible. Incidental observations introduce a potential bias in spatial sampling but may reveal diurnal and environmental trends. Seasonally abundant fledgling gannets and cormorants contribute one-third of predations noted. Seals do not eat birds as an alternative food resource. The deteriorating conservation status of these seabirds is cause for concern; the predation impact of seals should be quantified, taking into account individual variability, and compared with other causes of mortality.

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# CHAPTER 1. INTRODUCTION

## STUDY AREA

### *Namibian islands*

Between Walvis Bay and the Orange River along the Namibian coast are twelve small islands: Hollamsbird, Mercury, Ichaboe, Seal, Penguin, Halifax, Long, Possession, Albatross, Pomona, Plumpudding and Sinclair. Being located in the productive Benguela upwelling region, and inaccessible to terrestrial predators such as black-backed jackal (*Canis mesomelas*) and brown hyaena (*Hyena brunnea*), a number of these islands support breeding populations of both endangered and endemic seabird species (Boyera, Coleb & Bartholomaea 2000; Cordes 1998b).

After initially being occupied by Britain, the islands were administered by the Cape Provincial Administration of South Africa, and were declared nature reserves in 1987. This status was lost in 1994 when they were returned to Namibia with the reintegration of Walvis Bay (Cordes 1998b). Currently, the Namibian Ministry of Fisheries and Marine Resources (MFMR) manages the islands. Three of the islands (Mercury, Ichaboe and Possession) are staffed with personnel who conduct research with a view to the conservation of the seabirds. Access to the islands is strictly controlled (Cordes 1998b).

### *Ichaboe Island*

"Ichaboe Island is one of the most important and densely packed coastal seabird breeding islands in the world"

- Simmons *et al.* 1998: 326

The perennial wind-driven upwelling in the Benguela current is the most intensive and consistent in the vicinity of Lüderitz (24° – 28°S) and is one of the world's strongest upwelling systems (Berruti, Adams & Jackson 1989; Boyera, Coleb & Bartholomaea 2000; Crawford, Cruickshank, Shelton & Kruger 1985). Cold, nutrient-rich water is brought adjacent to the coast by equatorward wind, enhancing primary productivity (Crawford *et al.* 1985; Waldron, Probyn & Brundrit 1997) and resulting in a "highly productive food chain, culminating in large fish stocks" (Boyera *et al.* 2000: 123). These are exploited by both man and marine predators (Crawford *et al.* 1985; Berruti *et al.* 1989).

Ichaboe Island, at 26°17'22"S, 14°56'36"E, is situated within this intensive upwelling region. This 6.5 ha island lies *c.* 48 km north of Lüderitz and 1.4 km offshore (Nelson 1978; Simmons, Boix-Hinzen, Barnes, Jarvis & Robertson 1998). The island is rocky and unvegetated, with Mount Stromboli, at 7 m above sea level (a.s.l.), forming the highest point. Though coastal fog is prevalent, the annual rainfall is <10 mm (Simmons *et al.* 1998). Ichaboe is surrounded by a three-meter high sea-wall which prevents seals from gaining access and prevents guano, produced by the numerous seabirds, from being washed off. Ramps have been built to allow penguins access to the island over the wall; these form "landing stages" where the penguins congregate. The human settlement has been constructed on the northern tip of the island with a wall separating it from the birds' breeding area. An observation hut, at 9 m a.s.l., affords a 343° view of the sea around the island (Figure 1.1).

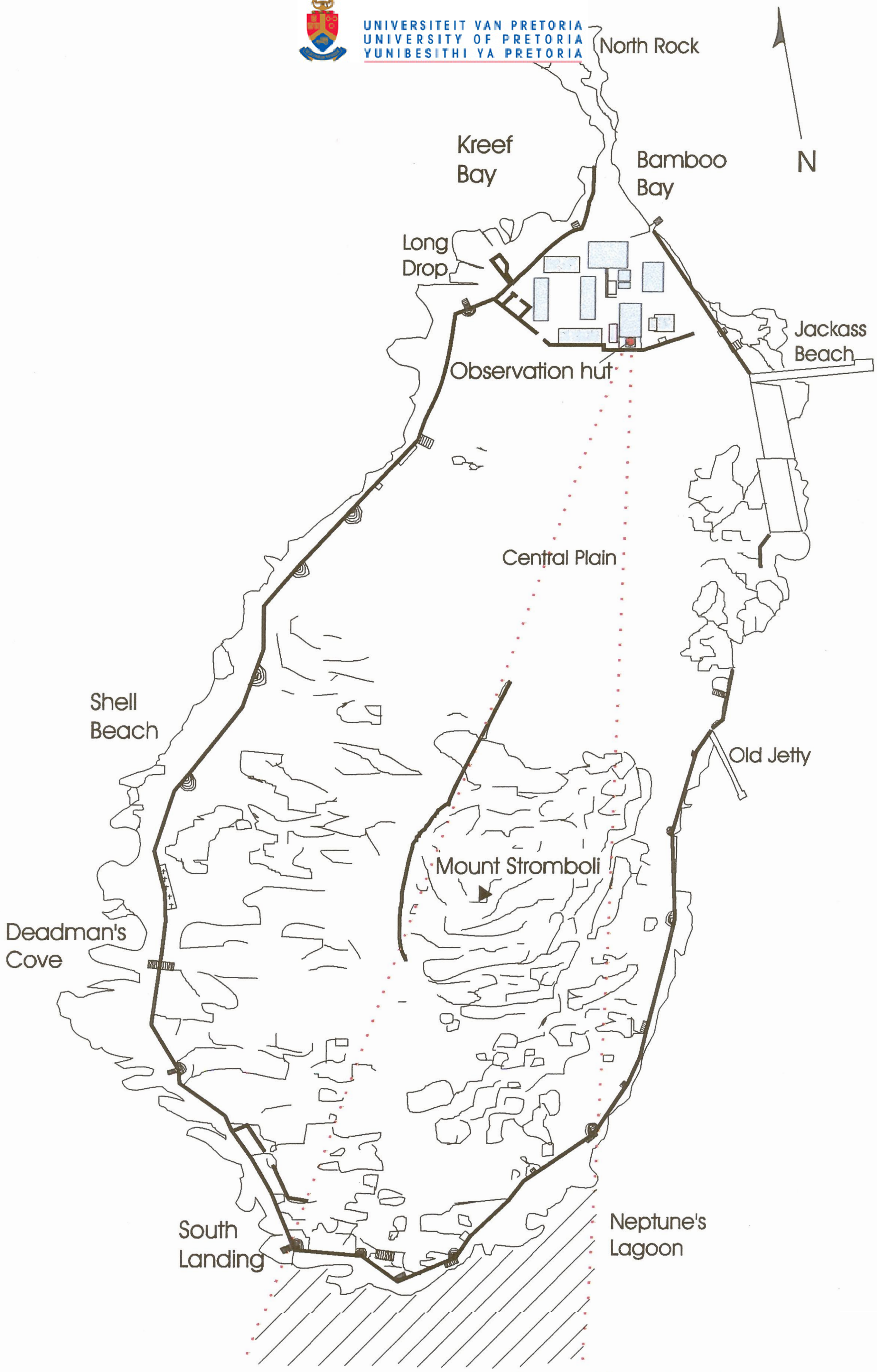



**Figure 1.1.** Map of Ichaboe Island (6.5 ha), showing position of settlement and observation hut (in red). The shaded area indicates the "summit shadow", which is the area (17°) of sea not visible from the observation hut.

*Seabird breeding populations*

Seabirds are long-lived birds with low adult mortality rates. They utilise the open ocean to obtain all or much of their food (Berruti *et al.* 1989). Ichaboe Island supports breeding populations of numerous seabird species (Table 1.1). More detail concerning these seabird species is summarised in Table 1.2.

**Table 1.1.** Peak active nest counts of seabirds at Ichaboe Island during the 1999-2000 breeding season (MFMR unpublished data).

| Species | Date | Breeding pairs |
| --- | --- | --- |
| Cape cormorants *Phalacrocorax capensis* | 18 Dec 1999 | 18 112 |
| Cape gannets *Morus capensis* | 17 Dec 1999 | 16 453 (aerial census) |
| African penguins *Spheniscus demersus* | 20 Oct 1999 | 1731 |
| Bank cormorants *P. neglectus* | 20 Jan 2000 | 737 |
| Crowned cormorants *P. coronatus* | 20 Nov 1999 | 260 |
| Kelp gulls *Larus [dominicanus] vetula* | 18 Dec 1999 | 74 |
| White-breasted cormorants *P. lucidus* | 20 Nov 1999 | 9 |

**Table 1.2.** Demographic and biological details of the seabird species breeding on Ichaboe Island, Namibia.

| Species | Endemicity, Conservation status | Global population | Breeding season | Clutch (mean) | Weight (mean): male; female (g) | References |
|---|---|---|---|---|---|---|
| Cape cormorant | Endemic, Near-threatened | 72 000 pairs (1996) | Sept - Mar | 2.4 | 1306; 1155 | Berruti 1995; Berruti *et al.* 1989; Cooper *et al.* 1982; Crawford 2000c; Crawford *et al.* 1999; Maclean 1985 |
| Cape gannet | Endemic, Vulnerable | 100 000 pairs (1997) | Aug - Mar | 1 | 2619; 2670 | Berruti *et al.* 1989; BirdLife International 2000; Crawford 2000d; Crawford 1997; Maclean 1985 |
| African penguin | Endemic, Vulnerable | 153 000 adults (2000) | year-round | 2 | 2836 | Berruti *et al.* 1990; BirdLife International 2000; Crawford 2000a; Maclean 1985 |
| Bank cormorant | Endemic, Vulnerable | 4888 pairs (1997) | Aug - Dec (Namibia) | 2 | 2107; 2150 | Berruti *et al.* 1991; Cooper 1981; Crawford 2000b; Maclean 1985 |
| Crowned cormorant | Endemic, Near-threatened | 2665 pairs (1981) | Oct - Mar (Namibia) | 2.8 | 800 | Berruti *et al.* 1989; Crawford *et al.* 1999; Barnes 2000; Maclean 1985 |
| Kelp gull | Endemic subspecies | 11 000 pairs (1981) | Sept - Mar | 2.1 | 924.3 | Berruti *et al.* 1989; Crawford *et al.* 1982; Maclean 1985 |
| White-breasted cormorant | Not threatened in SA | 2524 pairs (1981) | Sept - Jan (Namibia) | 3.1 | 3100; 2950 | Berruti *et al.* 1989; Maclean 1985 |

The current study focused on the species described below.

*- Cape cormorants*

In February 1980, there were 45 805 nests of Cape cormorants at Ichaboe (Berruti 1995); the 1999 peak count of 18 112 active nests represents a local decline of 60% over 19 years. However, it is not easy to determine population trends for this species, as the birds readily move between breeding areas, are known to desert their nests frequently, and have an extended breeding period (Berruti *et al.* 1989). In Namibia, the main breeding season is from September to April (Maclean 1985), after which these birds move outside their normal breeding range (Cooper, Brooke, Shelton & Crawford 1982).

The Cape cormorant is the most numerous of the guano-producing seabirds and is endemic to the southern African coast, breeding at 69 localities along the South African and Namibian coastlines (Crawford, Dyer & Upfold 1999). These birds move considerable distances outside the breeding range in winter, but are not generally found farther than 20 km offshore. The global breeding population is estimated to be 554 064 birds, 61.6% of which occur in Namibian waters. This population decreased from 247 000 pairs in 1977-1981 (Cooper *et al.* 1982) to 72 000 pairs in 1996 (Crawford 2000c). In the spring of 1991, more than 14 000 Cape cormorants died as a result of an outbreak of avian cholera *Pasteruella multocida* (Crawford, Allwright & Heÿl, 1992).

Cape cormorants are susceptible to disturbance while breeding and frequently desert their nests, leaving the eggs and chicks exposed to predation by kelp gulls; they also desert breeding colonies when food is scarce. These birds compete with commercial fisheries for sub-surface epipelagic fish. Pilchard *Sardinops occelatus* contributed 89-90% by mass to the diet of these birds in the 1950s (Crawford, Underhill, Raubenheimer, Dyer & Märtin 1992). After the collapse of pilchard stocks in 1974, gobies ***Sufflogobius bibarbatus*** formed their main prey (Cooper *et al.* 1982; Crawford 2000c), which they catch by pursuit diving (Berruti *et al.* 1989).

*- Cape gannets*

The breeding colony of Cape gannets at Ichaboe, one of only six world-wide, was once the largest gannetry in the world, numbering 144 000 in 1956 (aerial census count, Rand 1963; Nelson 1978); the 1999 count is 11% of this value. An 88% decline in this colony occurred between 1956 and 1980 (Berruti 1985). Likewise, the area occupied by breeding gannets decreased from 5.52 ha in 1956 to 0.56 ha in 1996 (Crawford 2000c), a decrease of 90% over 40 years. The global population fell by 31% during this time (Crawford 2000d); currently there are between 80 000 and 100 000 breeding pairs (Crawford 1997).

Gannets plunge from the air onto prey in the upper 13 m of the water column (Adams & Klages 1999; Berruti *et al.* 1989). These birds historically thrived on pilchard or sardine (Crawford, Shelton, Cooper & Brooke 1983), which are their preferred prey items (Berruti *et al.* 1989; Adams & Klages 1999). Pilchard contributed 93-99% by mass of the Cape gannet diet in the 1950s. The Namibian gannet population was adversely affected when the pilchard stocks collapsed in the late 1960s due to commercial fishing (Crawford *et al.* 1992; Klages, Willis & Ross 1992), as these birds were not able to effectively exploit the now abundant goby stocks (Crawford *et al.* 1985). Gannets now feed on anchovy and saury *Scomberesox saurus* (Crawford 2000d). They forage farther offshore than cormorants and are known to scavenge hake *Merluccius* spp. and other fish from demersal trawlers

(Crawford 2000d; Crawford, Cruickshank, Shelton & Kruger 1985; Crawford *et al.* 1992).

Cape gannets start breeding in August and September (Jarvis 1970; Maclean 1985); these birds usually breed for the first time at four years of age (Berruti 1985). The majority of fledglings leave the breeding islands during March and April; the adults also leave the islands once breeding has ended (Jarvis 1970).

The Cape gannet is classified as Vulnerable in the most recent BirdLife International / IUCN Red List, because of its small breeding range, a decline of the foraging quality of surrounding waters due to commercial fisheries over-exploiting its prey, and to marine pollution (BirdLife International 2000).

*- African penguins*

During the early 1990s, the breeding population of African penguins at Ichaboe island was estimated at over 9000 (Crawford *et al.* 1995; Randall 1995), but has decreased since then (Crawford, David, Shannon, Kemper, Klages, Roux, Underhill, Ward, Williams & Wolfaardt 2001). The Namibian population numbered 6800 pairs in 1985, 17% of the 1956 count (>40 000 pairs; Berruti *et al.* 1989). The number of adult African penguins has decreased from >1.45 million in 1910 to 153 000 in 1991-1994. A decrease of 13% per generation since 1976 qualifies the species as Vulnerable (Crawford 2000a), while they may be regarded as locally Endangered in Namibia (Crawford *et al.* 1990). Heat, flooding, predation by kelp gulls, disease, parasites and starvation cause mortality to eggs and chicks; oiling, entanglement, disease, predation (by Cape fur seals, killer whales and sharks) and starvation kill older birds (Best *et al.* 1997).

African penguins breed essentially throughout the year, peaking from September to November off central Namibia (Crawford *et al.* 1995; Randall 1995; Sparks and Soper 1987; Williams 1988). Penguins feed on anchovy and sardine, catching their prey by pursuit diving (Berruti *et al.* 1989; BirdLife International 2000); more recently gobies form their main prey (Crawford *et al.* 1985).

The African penguin is classified as Vulnerable in the most recent BirdLife International / IUCN Red List, because of the rapid decline in population numbers, attributable to habitat degradation from guano collecting, historical egg-collecting and at-sea factors such as oiling and scarcity of food (BirdLife International 2000).

*- Bank cormorants*

Ichaboe supported 46% of the world bank cormorant population in the 1970s (Cooper 1981). The breeding population numbered 2625 pairs on Ichaboe in 1995-97, down from 4345 in 1978-80 (Crawford, Dyer, Cordes & Williams 1999). The global population numbered 4888 breeding pairs in 1995-97, down from 8672 recorded in 1978-80. These losses occurred mainly at Ichaboe and Mercury Islands, where 68% of the global population was previously situated (BirdLife International 2000; Crawford *et al.* 1999).

Bank cormorants feed mainly on goby and rock lobster *Jasus lalandii* (Simmons *et al.* 1998). In 1994, natural factors (weather anomalies) resulting in the severe depletion of all fish stocks, including pelagic gobies, in the region of Ichaboe Island resulted in a loss of about 1800 breeding pairs between 93-94 and 94-95 (Crawford *et al.* 1999).

These birds breed from August to December in Namibia (Crawford *et al.* 1999; Underhill, Tree, Oschadleus, & Parker 1999). The birds seldom occur farther than 10 km offshore. In the non-breeding season dispersal by the juveniles is believed to be more extensive than the movement of the relatively sedentary adults (Underhill *et al.* 1999).

*- Kelp gulls*

In January 1993, there were 19 active nests of kelp gulls; this number has increased to 74 nests in December 1999 (MFMR, unpublished data). The kelp gull is the most numerous gull species in the southern hemisphere, where it is widespread, with over one million pairs estimated. The southern African population of the endemic subspecies *Larus [dominicanus] vetula* exceeded 11 000 breeding pairs in 1976-81, the majority of which (9000 pairs) occurred in South Africa (Crawford *et al.* 1982; Crawford, Nel, Williams & Scott 1997). Artificial supplementation of food for these birds, such as at rubbish dumps, have caused population increases. Kelp gulls prey on the eggs and chicks of other seabird species; human disturbance causes seabirds to desert their nests, which results in increased predation of exposed eggs and chicks by kelp gulls.

*Cape fur seals*

A small colony of Cape fur seals *Arctocephalus pusillus pusillus* (up to 1000) breeds on a rock 200 m to the south-west of the island (Figure 1.2), the annual pup production of which has increased from 41 in 1991 to over 200 in 1998 (MFMR, unpublished data). This colony was considered non-breeding by David (1995), on account of the small number of pups born there annually.

**Figure 1.2.** Aerial photograph of Ichaboe Island, showing the proximity of the island to the mainland (*c.* 1.4 km) and the position of the seal colony at Little Ichaboe (red circle), which lies 200 m south-west of the island. The picture is orientated with north to the left.

The Cape fur seal (*Arctocephalus pusillus pusillus*, Otariidae; Harrison & King, 1980; Shaughnessy 1979) is the only indigenous breeding pinniped in southern Africa, and is sexually dimorphic for size (Shaughnessy 1985). It breeds at 24 colonies between Cape Cross in Namibia and Algoa Bay in South Africa, with 65% of the population occurring in Namibia (David 1987; Miller, Oosthuizen & Wickens 1996). Population numbers of Cape fur seals have increased since their over-exploitation in the early 1900s (Shaughnessy 1985) and numbered about 1.5-2 million animals at the close of the 20th century (Butterworth, Punt, Oosthuizen & Wickens 1995). Juvenile and subadult seals form aggregations of their own age groups and congregate at non-breeding colonies (such as at Cape Frio), dispersing to breeding colonies upon reaching sexual maturity (David 1995; de Villiers, Oosthuizen, Roux & Kotze 1997). The adult males may have separate feeding grounds from that of the females (David 1995).

The diet of fur seals ranges "from marine invertebrates to penguins" (Bonner 1981:190); Cape fur seals fed mainly on medium-sized pelagic schooling fish such as Cape mackerel (*Scombus japonicus*), horse mackerel (*Trachurus trachurus*), and pilchard in the 1970s (Bonner 1981). More recently bearded goby, and the juveniles of horse mackerel and hake have become their main prey in Namibian waters (Shaughnessy 1985; Roux 1998).

## SEABIRD POPULATION DECLINES: HISTORICAL FACTORS

### *Guano collection*

In his memoirs published in 1832, an American sealing captain, Captain Benjamin Morrel Jr, noted that Ichaboe was covered in the manure of birds (guano) to a depth of 25 ft. The response to this by an astute businessman from Liverpool, Andrew Livingston, resulted in the "guano rush" between 1843 and 1845. During this time Ichaboe Island was scraped bare, and *c.* 300 000 t of this valuable nitrogenous fertilizer were shipped to Britain (Cordes 1998b; Williams 1988; Randall 1995).

"There's an island (Ichaboe) that lies on West Africa's shore,
Where penguins have lived since the flood or before,
And raised up a hill there, a mile high or more,
This hill is all guano, and lately 'tis shown,
That finer potatoes and turnips are grown
By means of this compost, than ever were known;
And the peach and the nectarine, the apple, the pear,
Attain such a size, that the gardeners stare,
And cry, "Well, I never saw fruit like that 'ere!"
One cabbage thus reared, as a paper maintains,
Weighed twenty-one stone, thirteen pounds and six grains,
So no wonder Guano celebrity gains."

- Ex-member of the Committee (1845); (Best *et al.* 1997)

Concessions were granted for guano harvesting at Ichaboe in 1847; these were terminated in the 1890s. The South African government managed the guano collection from then until 1975, when private concessions were again leased out (Best, Crawford & van der Elst 1997). From the early 1980s to 1991, guano was only taken from Ichaboe, which yielded *c.* 1200 t annually (Cordes 1998b). The harvesting of guano at islands ceased in the 1990s when these concessions were not renewed (Best *et al.* 1997). In 1994 the islands (listed previously) offshore of Namibia were returned to Namibia (Cordes 1998b), and guano was harvested from Ichaboe Island in the winter of 2000 by private enterprise under a concession granted by the MFMR.

Injudicious harvesting of guano results in habitat degradation and disturbance to breeding seabirds; this exacerbates the decline in their populations (Simmons et al. 1998). During the height of the guano rush (October 1844), up to 4500 labourers were ashore at Ichaboe. The constant human presence and intense disturbance disrupted breeding and possibly displaced the birds to Mercury, Halifax & Possession islands (Crawford *et al.* 1983, 1995). The commercial collection of guano reduced the breeding success of Cape gannets. Rain water accumulates and floods nests in areas that have become basin-shaped after removal of guano. The quantity of nesting material is limited, and onset of breeding can thus be delayed by more than a month (Crawford & Cochrane 1990; Jarvis 1970).

*Exploitation of birds*

From the early part of the 20$^{th}$ century (and probably before) until 1968, up to 700 000 penguin eggs were removed annually from islands where these birds breed (Cordes 1998a). Man has also contributed to seabird population decline by killing them in large numbers for food or sport, and for use as bait in rock-lobster traps; this may still occur off west Africa in the non-breeding range, but is difficult to assess, as is deliberate killing of birds by fishermen (Crawford *et al.* 1983; Jarvis 1970).

*Marine pollution and overfishing*

While most of the threats to seabirds at their breeding colonies are no longer of importance, or are being managed, at-sea factors contributing to population decline are more difficult to assess (Monaghan 1996). The main threat is reduced prey availability, especially of sardine and Cape anchovy, which are commercially fished by Namibia and South Africa (Best *et al.* 1997; BirdLife International 2000; Boyera *et* *al.* 2000; Cooper *et al.* 1982; Crawford *et al.* 1992, 1995; Cordes 1998a). Other threats include entanglement in marine debris and fishing gear – Cape gannets are sometimes caught in demersal trawls – and incidental mortality from swallowing or being caught by hooks from longline fishing activities (Jarvis 1970). The birds, specifically penguins, are affected by oil spills (chronic spills from fuel oil and bilge tanks, crude oil from tankers and fish oil from factories and fishing fleets), which remains a great hazard (Berruti *et al.* 1989; Best *et al.* 1997; Crawford 2000a; Crawford *et al.* 1995; Monaghan 1996).

### SEAL-SEABIRD PREDATION

Apart from competing with seabirds for food (Bonner 1981; King 1983; Miller, Oosthuizen & Wickens 1996; Shaughnessy 1979) and breeding space (King 1983; David 1987; Williams 1988; Best *et al.* 1997), individual seals of several species have developed a taste for seabirds, especially penguins (Bonner 1981; Rebelo 1984; Williams 1988; Hofmeyr & Bester 1993; Best *et al.* 1997; Cobley & Bell 1998).

The increase in Cape fur seal numbers since their overexploitation in the 1800s has resulted not only in an increase in their (real or perceived) competition with local fisheries (Shaughnessy 1985; David 1987; Harwood 1992; Crawford *et al.* 1992; Wickens, Japp, Shelton, Kriel, Goosen, Rose, Augustyn, Bross, Penney & Krohn 1992), but also the decline in some seabird numbers, especially penguins (see earlier). Predation of seabirds by Cape fur seals at southern African offshore islands has been observed since the early 1900s (Shaughnessy 1978). If several seals specialise in seabird predation, the local seabird colony, such as the one on Ichaboe Island, may suffer the loss of hundreds of individuals per year (Williams 1988). On account of the continued decline in seabird population numbers, the relative importance of this mortality factor could increase.

## RATIONALE FOR STUDY

Though there are a number of studies on seal-seabird predation, these are predominantly short-term and opportunistic. Intensive studies on the predation of both adult and juvenile African penguins, Cape gannets, Cape cormorants and bank cormorants by Cape fur seals are lacking, if only for the reason that this has not been observed at one locality before. The existence of a detailed database consisting of eight years' incidental observations of seal-seabird predation at Ichaboe Island, essentially by the same observer (P.A. Bartlett, MFMR), presented the opportunity to investigate the behavioural aspects of this predation, as it relates to each prey species. The application of systematic methods of observation would enable the evaluation of the incidental data as well as the quantification of factors influencing seal-seabird predation.

### *Key questions*

This study aims to address a number of key questions that formed the focus of the research, each of which is addressed in a separate chapter:

× Does predatory behaviour vary between individual seals and bird species preyed upon?

× What is the difference between incidental and systematic observations regarding predation events?

× Which parameters affect predatory activity?

× Is there a difference in the relative impact of seal predation on different seabird species?

Each question has a corresponding null hypothesis.

*Null hypotheses*

× Predatory behaviour does not differ amongst individual seals or bird species preyed upon.

× There is no difference between incidental observations, focal event sampling and continuous observations as methods for observing seal-seabird predation.

× Environmental, spatial and temporal parameters do not influence seabird predation by seals.

× The impact of seal predation does not differ between seabird species.

Ichaboe is an important breeding site for seabirds, with the guano produced contributing to its economic importance; the decrease in population numbers of these birds therefore deserve urgent attention. This study serves as an exploratory investigation into seal-seabird predation as noted at Ichaboe Island over a ten-year period. A systematic form of sampling technique (focal event sampling) is applied for the first time in behavioural observations at sea.

In the process of testing the hypotheses relevant to the key questions for this study, additional questions are generated. The quest for answers will further enhance our knowledge of the behaviour in question.

# CHAPTER 2. SEAL-SEABIRD PREDATORY BEHAVIOUR

## INTRODUCTION

*Seal-seabird predation*

Several species of pinniped are known to prey on penguins (Hofmeyr & Bester 1993), to varying degrees. Leopard seals, *Hydrurga leptonyx*, have been recorded preying on gentoo penguins, *Pygoscelis papua*, macaroni penguins, *Eudyptes chrysolophus*, and Adélie penguins, *P. adeliae* (Penney & Lowry 1967, Rogers & Bryden 1995). Weddell seals, *Leptonychotes weddellii*, have been observed preying on gentoo penguins (Cobley & Bell 1998), as have Antarctic fur seals, *Arctocephalus gazella*, which also prey on macaroni penguins (Bonner & Hunter 1982) and king penguins, *Aptenodytes patagonicus* (Hofmeyr & Bester 1993). Other pinniped predators of seabirds include the Subantarctic fur seal, *A. tropicalis*, and the New Zealand fur seal, *A. forsteri*, both of which take rockhopper penguins, *E. chrysocome*. Magellanic penguins, *Spheniscus magellanica*, and little penguins, *Eudyptula minor* are preyed upon by the South American sea lion, *Otaria byronia*, and Australian sea lion, *Neophoca cinerea*, respectively (*vide* Hofmeyr & Bester 1993). Hooker's sea lions, *Phocarctos hookeri*, prey on gentoo penguins (Robinson, Wynen & Goldsworthy 1999).

The Cape fur seal, *A. pusillus pusillus*, is noted not only as a predator of the African penguin, *S. demersus* (Cooper 1974; Rebelo 1984; Randall *et al.* 1988; Williams 1988), but also of gannets (*Morus capensis*) and cormorants (*Phalacrocorax* spp.) (Shaughnessy 1978; Marks, Brooke & Gildenhuys 1997; Navarro 2000).

Seabird predation by seals has been hypothesised to be an extension of play behaviour (Bonner & Hunter 1982) and is described as an unusual event (Cooper

1974). Some individuals are regarded as regular penguin predators (Cobley & Bell 1998), exploiting a temporary food resource (Penney & Lowry 1967; Rogers & Bryden 1995) or exploiting a specialist niche (Walker *et al.* 1998).

It is also evident from the literature that the method of predation by pinnipeds differs between species as well as individuals.

*Predation at Ichaboe Island*

Predation by Cape fur seals on gannets, penguins, Cape and bank cormorants has been recorded; there is also a record of a white-breasted cormorant and Hartlaub's gulls (*Larus hartlaubii*) taken by seals. The regularity of incidental sightings of such predatory events has highlighted the need for further research, as the impact of seal-seabird predation may increase with the continued decline in local seabird population numbers.

This chapter deals with the behavioural aspects of seabird predation by Cape fur seals at Ichaboe Island, Namibia, and considers differences among bird species preyed upon, as well as between individual seals.

## METHODS

*Observations*

Seal-seabird predatory events were recorded opportunistically around Ichaboe Island from September 1991 to October 1999. Systematic (using scan sampling and continuous observations) as well as opportunistic observations were made from November 1999 to May 2000 (see Chapter 3 for detail on the methods of observation).

For all predatory interactions observed, the behaviour of the predator and the birds in the vicinity was identified, as well as other conditions associated with such predatory events. Specific behaviours indicative of predatory activity which served to attract the observer's attention were named "predation cues" (P.A. Bartlett, pers. comm.).

The most visible cue was a "gannet cloud", the formation of a group of gannets that maintain their position over a specific area with no fishing activity such as plunge-diving (P.A. Bartlett, pers. comm.). The term "gannet cloud" therefore refers to a group of gannets that are hovering, but not diving, and that are not necessarily in association with cormorants. Individual gannets fly out from the island to join the cloud, and others "peel off" (possibly once their curiosity is satisfied and no fish was seen) and return to the island. The cloud may therefore not be comprised of the same individuals but remains roughly the same size while the stimulus lasts. This behaviour was noted to be associated with seal-seabird predatory activity (P.A. Bartlett, pers. comm.). No specific reference to gannet clouds could be found in the literature. Kelp gulls swooping over something in the water below the gannet cloud confirm some form of predatory activity, as the gulls try to scavenge pieces of the prey. The number of gannets within a cloud was counted using binoculars and a tally-counter.

A seal thrashing prey (shaking it violently from side to side, or tossing the prey through the air) on the surface was positive confirmation of a predation and formed an important cue, as was a seal attacking a bird.

Further cues included:

- bird carcasses adrift with kelp gulls in attendance;
- washed up bird carcasses that had been preyed upon;
- a group of kelp gulls scooping or scavenging;
- pieces of prey brought ashore by kelp gulls;
- gull calls;
- other bird species scavenging (white-chinned petrels *Procellaria aequinoctialis* and giant petrels *Macronectes* spp.);
- an oily slick on the surface of the water (resulting from the fat of the bird);
- injured birds.

These were usually secondary cues serving to confirm predatory activity. No cues were used on their own (except for thrashing, attack and carcasses of birds that had been preyed upon by seals) to indicate seal-seabird predation. A combination of cues was used.

The date, time, direction and estimated distance from the island shore, weather and sea conditions, seal age and sex, bird species and age, and the duration of the predatory event were recorded whenever possible. Predatory events were observed using a pair of binoculars, and behavioural notes taken. During continuous observations, it was possible to identify whether the same individual seal carried out successive attacks. On a few occasions, predations were also filmed underwater, using a SONY DCR-VX1000E digital video camera. Where possible, carcasses were collected, in order to identify the species and age of the bird, and also to record the anatomical portion of the bird that was consumed or removed by the seal. Between

October 1999 and May 2000, 30 carcasses of birds taken by seals were collected and photographed. During the same period 50 injured penguins were observed ashore at Ichaboe. The extent of their injuries was recorded on injury sheets.

Juvenile birds were distinguished from adults by their plumage, in the case of gannets and penguins, and by their eye-colour (which is dark in juveniles) for cormorants. The species and ages of cormorants that fell prey to seals could only be confirmed upon collection and inspection of the carcass; this involved donning a wetsuit and often single-handedly launching a vessel to paddle or motor to the drifting carcass. For this reason, the prey was often only identified as a gannet, a penguin or a cormorant.

Seals were categorised according to easily recognisable size classes (large, medium and small) which correspond with adult, subadult and young seals. Male seals have a thicker neck and a more pronounced forehead than the females, and their flippers are larger and broader in relation to the body. In older males, the head and neck are also lighter in colour (Bonner 1981; King 1983).

Since 1991, only three of the seals that were seabird predators were individually recognisable by their fore-flipper characteristics (known as "Blunt Flipper", "Broad Flipper" and "Ragged Flipper"); another seal ("U") was recognisable by its age and specific behavioural patterns.

Between October 1991 and May 2000, eight seals (including the above-mentioned individuals) specialising in seabird predation were shot (MFMR policy) and seven were retrieved.

*Data analysis*

The data from predations carried out by known individual seals were analysed to determine patterns such as predation rate per hour ($h^{-1}$), time between successive predations involving a particular bird species, and individual seal preferences regarding bird species.

Predation rates ($h^{-1}$) were calculated from predation sessions by the same seal individual where more than three successive predations occurred less than an hour apart. The predation rates per day ($d^{-1}$) were calculated for those days on which predations took place (predation-days), and not averaged over the entire period. As the predatory behaviour is independent of the method of observation, all records were pooled.

The results are given as a mean ± one standard deviation (SD), and as percentages and ratios. Where more than two independent groups were compared, a Kruskal-Wallis ANOVA was used to test the null hypothesis that the means of the groups were equal.

## RESULTS

*Bird species preyed upon*

Between September 1991 and May 2000, 2774 predations were observed, of which 1217 involved cormorants, 932 gannets and 544 penguins (a ratio of approximately 5:4:2). These included 61 birds that were injured but not killed, 48 killed without the seal feeding on the carcass and 16 failed predation attempts. More than one seal attended the bird carcass on 25 occasions, and on 13 occasions more than one predation took place simultaneously. Though most predations were noticed only once the seal had already seized the prey, there were 161 incidents where the attack was witnessed. On six occasions a seal was seen chasing a penguin. Six incidents were noted of a seal taking a gannet from the air, shortly after take-off from the water. Three of these incidents occurred in wind speeds between 34 and 40 knots (Beaufort Scale 8). Thirty-six incidents took place within the surf zone adjacent to Little Ichaboe (where the seal colony is situated), where the seals often play (pers. obs).

*Predation cues*

Kelp gulls swooping or scavenging were a first cue indicating predatory activity in 41.1% of cases. Carcasses (23.7%) and gannet clouds (20.6%) were the next most abundant cues. Seals were seen attacking birds in 5.7% of the predations noted, and though thrashing of prey was rarely (4.2%) the first cue to attract the attention of the observer (Figure 2.1), but was noted in 35.2% of all predations seen. The presence of kelp gulls was an important cue for penguin and cormorant predations (58.5% and 48.9% respectively), and was the first cue in 24.4% of gannet predations. Cormorants formed 63.2% of carcasses seen as a first cue to predatory activity (Figure 2.1).

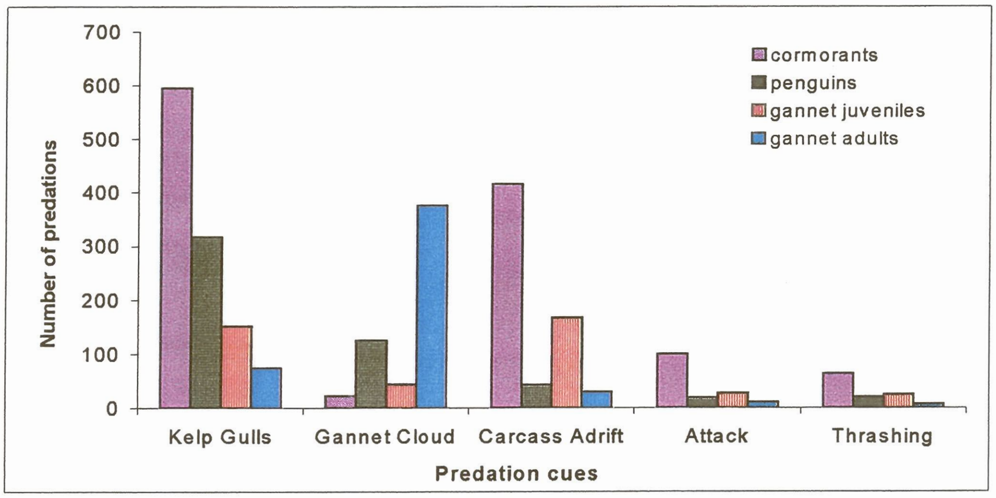



**Figure 2.1.** Number of predations per bird species associated with different predation cues.

A gannet cloud of up to 500 birds may form in less than a minute. The average size of 155 gannet clouds was 275 ± 92 individual birds (Figure 2.2). Gannet clouds were associated with 75.4% of predations involving an adult gannet and 10.7% of juvenile gannet predations had gannet clouds. Over 74% of gannet clouds indicated that a gannet had fallen prey to a seal and 80% of these involved an adult gannet (Figure 2.1). Gannet clouds were associated with over 70% of predations noted at wind speeds of 28 to 54 knots (7 to 10 on the Beaufort Scale; Figure 2.3).

**Figure 2.2.** An example of a gannet cloud. These birds are not involved in fishing activity but are investigating seal-seabird predatory activity.

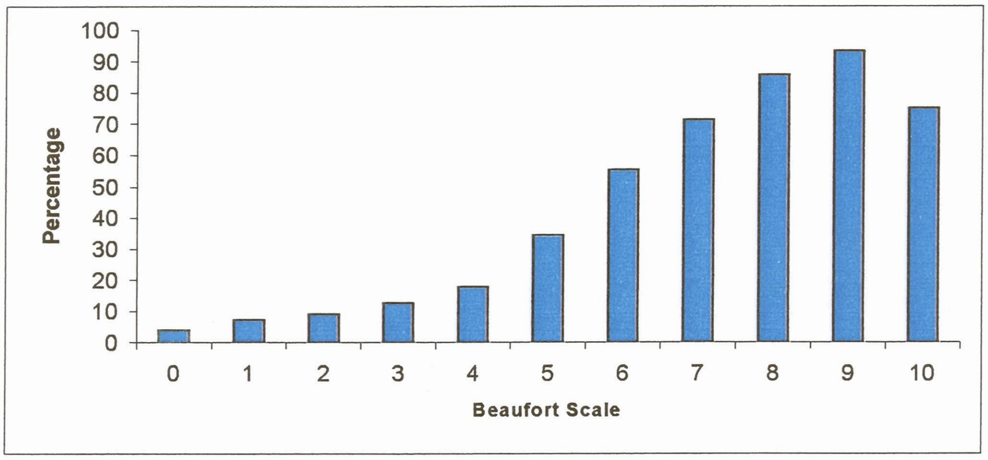



**Figure 2.3.** Percentage of predations associated with a gannet cloud at different wind speeds (as measured by the Beaufort Scale).

*Predation behaviour*

No seals were observed to attack a bird on land. On 18 December 1999, an adult penguin with a gash across its neck and shoulder (suspected to be an injury inflicted by a seal) had climbed out onto Little Ichaboe and was preening itself amongst the seals. The bird was ignored, even though it was the pupping season and the seals were more aggressive than usual.

After diving, gannets sit briefly on the water before taking off and joining the birds overhead, to plunge again. Gannets and cormorants often fish together, with the cormorants flying low over the fish shoal, and sitting on the water. When gannet fledglings go out to sea for the first time, they sit on the water singly, whereas fledgling cormorants sit on the water in groups (pers. obs). The phenomenon of seals killing birds without feeding, or only feeding partially on the carcass was observed more often in the case of cormorant predations than of other bird species.

All observed predations took place in the water. Typically, the seal would approach the bird from below, grabbing it by the chest, neck or head. The bird was then thrashed (shaken violently from side to side) on the surface, and "degloved" (Marks *et al.* 1997; Figure 2.4) to expose the viscera and breast muscles. Underwater video footage has also revealed that the seal may submerge with the carcass, trying to free pieces of meat underwater. Occasionally, young seals were seen in the company of a seal preying on birds. Seals seem to tolerate one another and do not fight over carcasses. Groups of two or three seals sometimes prey upon birds close to one another.

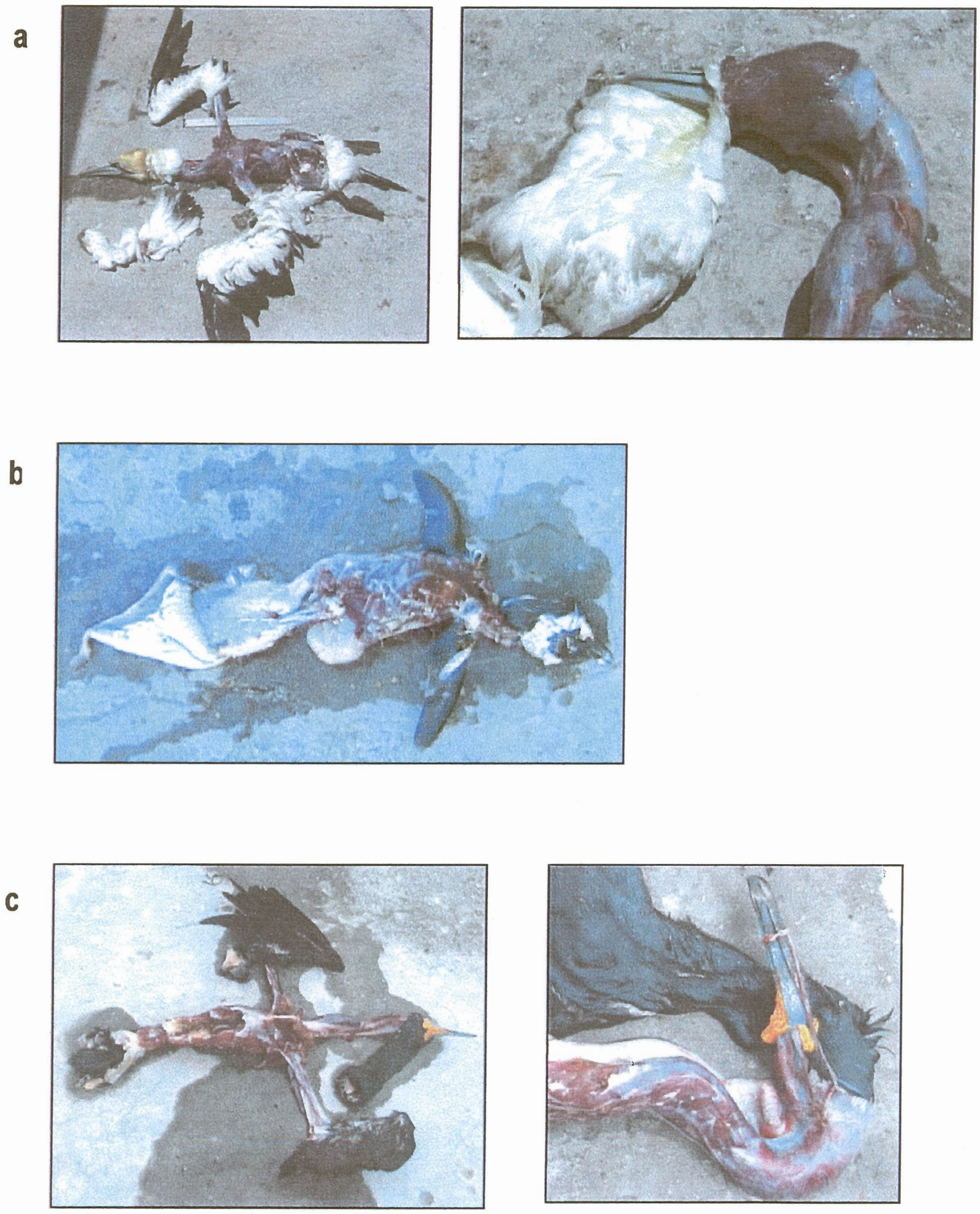



**Figure 2.4.** Bird carcasses "degloved" by seals: **a** - adult Cape gannets; **b** - adult African penguin; **c** - adult Cape cormorants. The skin has been torn loose and is flung over the head or legs during the seals' thrashing actions, exposing the breast muscles and viscera. This is typical of seal predation.

The age of the seal could be identified in 54% (n = 1497) of the predatory interactions seen. Seals of medium size (subadults) were responsible for 84.8% of these. No adult seals were seen taking cormorants, whereas 77.2% of birds taken by young seals were cormorants. The majority (63.2%) of seals preying on birds were identified as males; all the adult seabird predators were males (Table 2.1).

**Table 2.1.** Numbers of different bird species killed by seals of different size categories (age categories are in brackets).

| Seal sizes | Penguins | Gannets | Cormorants | Total | Percentage male |
|---|---|---|---|---|---|
| Large (adult) | 35 | 54 | 0 | 91 | 100 |
| Medium (subadult) | 307 | 390 | 560 | 1269 | 43.58 |
| Small (young) | 8 | 23 | 105 | 136 | 1.46 |

On 31 July 1997, a young seal attacked and killed an adult White-breasted cormorant; this is the only occasion this bird species was taken by a seal at Ichaboe Island. The seal seemed unsure, and made repeated passes, with the cormorant defending itself by pecking at the seal, but not flying off. The seal attacked from below and pulled the bird under, resurfacing further from the island to thrash the bird. There was not much bird activity on the water at the time.

*Seal specialisation*

Some individual seals target specific bird species, and may even prefer a specific anatomical portion of these birds. In April and May of 1993, carcasses of at least 13 gannet fledglings and one adult gannet were found with only the viscera removed. A further three fledglings were found alive with their abdomens ripped open. An adult male seal was believed to be responsible for these, and upon his removal on 2 May 1993 (see Table 2.2), no further gannets were found with such wounds.

"Blunt Flipper", a subadult male seal, was seen taking 230 birds, of which 41 were gannets (93% fledglings), 47 penguins (66% adults) and 142 cormorants (73% fledglings). Of the cormorants, one was identified as a bank cormorant and 103 as Cape cormorants. This seal was active from 25 March 1996 to 02 December 1998. On 25 March 1998, Blunt Flipper killed twenty-one Cape cormorant fledglings within the space of 160 minutes, a predation rate of 7.9 birds.$h^{-1}$. A mean of 3.4 ± 3.3 ($n$ = 67) birds fell prey to this seal per predation-day. The highest predation rates per hour were invariably when cormorants were preyed upon. On one occasion, Blunt Flipper killed four birds within nine minutes; this converts to a rate of 26.7 birds per hour.

Almost 90% (206 out of 230 birds) of predations by Blunt Flipper occurred less than 200 m from the main island. Cormorant predations occurred at distances of 250 m or less; penguin and gannet predations were seen as far as 700 m distant. The cormorant predations were predominantly to the northeast and east of the island. This seal was observed hunting birds up and down the channel east of Ichaboe, once chasing a group of penguins, and on one occasion seemed to play with a gannet fledgling before killing and eating it. Blunt Flipper preyed on birds throughout the day. The time between successive gannet predations was 37.8 ± 65.0 min ($n$ = 13); for penguins it was 33. 9 ± 32.1 min ($n$ = 18) and for cormorants 26.7 ± 52.3 min ($n$ = 74).

A subadult male seal, referred to as "U", preyed on 60 Cape cormorants, 20 bank cormorants and a further 14 cormorants which were not specifically identified, between 24 November 1992 and 2 May 1993. "U" caught up to 15 birds a day (5.9 ± 3.8 birds per predation-day; $n$ = 17) of which 95% were taken less than 100 m from the island, within "Bamboo Bay" (see Figure 1.1). This seal preyed on adult cormorants diving for nesting material, and made seven failed predation attempts. Nine birds were killed only and not fed upon; seven of these occurred on the same day. The time between successive predations by this seal was 34.2 ± 21.8 min (mean ± SD; $n$ = 6) for bank cormorants and 26.5 ± 16.9 min ($n$ = 46) for Cape cormorants.

Another subadult male, "Ragged Flipper" (Figure 2.5) preyed on 42 penguins (22 adults and 2 juveniles recognised) and one Cape cormorant between 15 January 1997 and 27 October 1998.

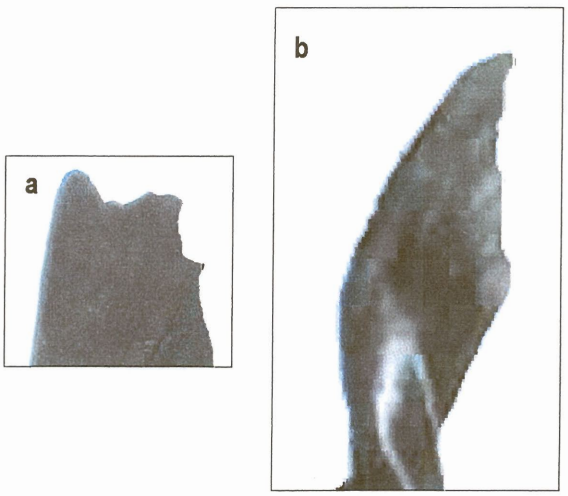



**Figure 2.5.** Ragged Flipper, a subadult male seal, specialised in taking African penguins and could be identified by the ragged tipped left fore-flipper (**a**). Its right fore-flipper (**b**) was normal.

A maximum of five penguins were seen to be taken by this seal in one day (1.5 ± 1.0 birds per predation-day; $n$ = 29). Forty out of forty-three predations (93%) by Ragged Flipper were between 100 and 200 metres from the island and fairly evenly spaced around the island. Penguins were ambushed as they approached the island in the late afternoon, although this seal was also seen preying on birds in the morning and early afternoon. The average time between successive predations recorded for Ragged Flipper was 35.6 ± 21.0 min ($n$ = 11).

"Broad Flipper", a large subadult male seal, was seen preying on 33 adult penguins on ten days between 6 January and 26 April 1992, catching up to seven birds on one day (3.3 ± 2.0 birds per predation-day; $n$ = 10). This seal operated only to the east and east north east of the island, with two out of three birds taken less than 100 metres from the shore. Broad Flipper would patrol the route for penguins returning to Jackass Beach (see Figure 1.1), one of the main access points for penguins, catching satiated adults in the late afternoon as they return to the island. The mean time between successive predations by Broad Flipper was 34.1 ± 16.6 min ($n$ = 22), and the rate of predation up to 3.6 birds.$h^{-1}$ (3.1 ± 1.9; $n$ = 5).

The minimum time between successive penguin predations by Broad Flipper was five minutes, by Ragged Flipper ten minutes, and Blunt Flipper fifteen minutes. The minimum time between successive cormorant predations by Blunt Flipper was two minutes and by "U" five minutes.

Among the seals shot were one adult and six subadult males; all were judged in good body condition, though two were noted to have worn canines. Their stomachs contained up to 6kg of bird remains (Table 2.2).

**Table 2.2.** Seals shot and recovered while preying on birds at Ichaboe Island.

| Date shot | Seal | Age | Sex | Stomach contents | Notes |
|---|---|---|---|---|---|
| 02-May-93 | "U" | subadult | male | 2.5 kg cormorant remains | |
| 02-May-93 | | adult | male | few gannet feathers | |
| 19-Aug-97 | | subadult | male | 1.5 kg penguin remains | |
| 20-Aug-97 | | subadult | male | 55 g penguin skin and feathers | |
| 27-Oct-98 | Ragged Flipper | subadult | male | 550 g penguin skin and feathers | Canines very worn |
| 02-Dec-98 | Blunt Flipper | subadult | male | 6 kg penguin and gannet remains | Canines very worn |
| 17-Mar-99 | | subadult | male | 1.35 kg penguin remains | |

*Predation rate and duration*

For those cases where a single seal was believed to be responsible for successive predations, the time between these differed significantly per bird species, as did the feeding time and predation rate per day (Table 2.3). The ratio between the average time a seal feeds on each prey species equals 1:0.7:0.5, while that for the time between successive predations (carried out by the same seal) equals 1:0.8:0.5 for penguins, gannets and cormorants respectively.

**Table 2.3.** Differences between predation rate and duration per prey species. P-values are the results of Kruskal-Wallis ANOVAs. SD = one standard deviation; *n* = sample size.

| | | Prey species | | |
|---|---|---|---|---|
| | | Gannets | Penguins | Cormorants |
| Time between successive predations (<60 min) | mean | 22.82 | 29.33 | 13.46 |
| | SD | 17.28 | 15.61 | 14.09 |
| | *n* | 95 | 110 | 227 |
| | $p < 0.0001$ | | | |
| Duration of predation (min) | mean | 7.90 | 11.7 | 5.9 |
| | SD | 4.41 | 6.06 | 2.54 |
| | *n* | 98 | 6 | 70 |
| | $p = 0.0004$ | | | |
| Number of predations per day (by same seal) | mean | 3.3 | 3.2 | 5.3 |
| | SD | 1.9 | 1.3 | 3.7 |
| | *n* | 55 | 61 | 61 |
| | $p = 0.0004$ | | | |

*Injured and preyed upon birds*

Seals did not consume entire birds. In most cases only the breast muscles and/or viscera were removed by the seal (Figure 2.6), and the carcass was further scavenged by kelp gulls. Some birds were killed but not fed upon by the seal (Figure 2.7). Figure 2.8 shows the breast muscle of a cormorant sliced by a seal, possibly with an upper canine. Gannets were preyed upon in the same manner as the cormorants, with the seal usually removing the breast muscle and viscera (Figure 2.9). Figure 2.10 shows two penguins that had been preyed upon by the same seal in close succession – one was well-eaten and the other had only part of the breast muscle removed.

Some birds, especially penguins, escaped with injuries of which they may have died later (Figure 2.11). However, many penguins were observed with old, well-healed scars, especially across the chest or lower abdomen (Figure 2.12). Of 211 injured penguins observed between September 1991 and May 2000, 109 are believed to have sustained their injuries during attacks by seals. A further 35 penguins died of various injuries, and seals were implicated in nineteen of these by the nature of the injury. Injuries such as straight slashes to the neck, chest and abdomen accounted for 44% of penguin injuries; these were attributed to seals.

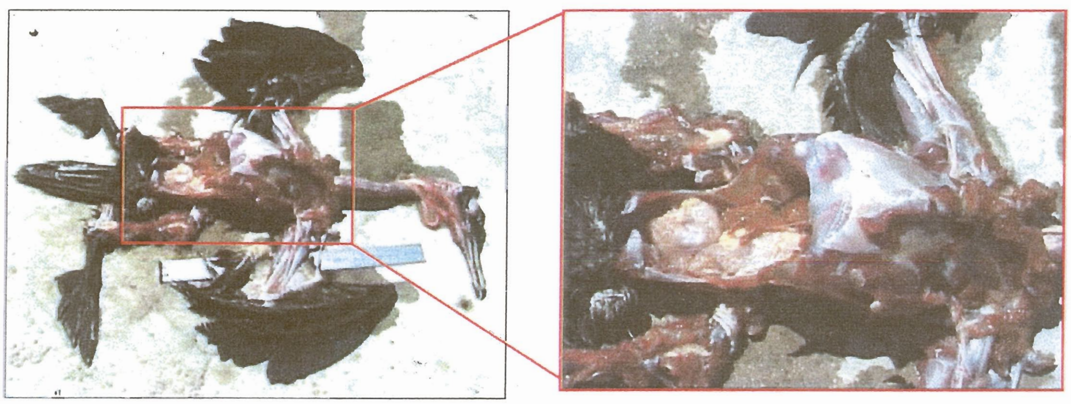


**Figure 2.6.** Photograph of the carcass of a bank cormorant fledgling, showing the extent to which the breast muscles and viscera were removed by the seal.

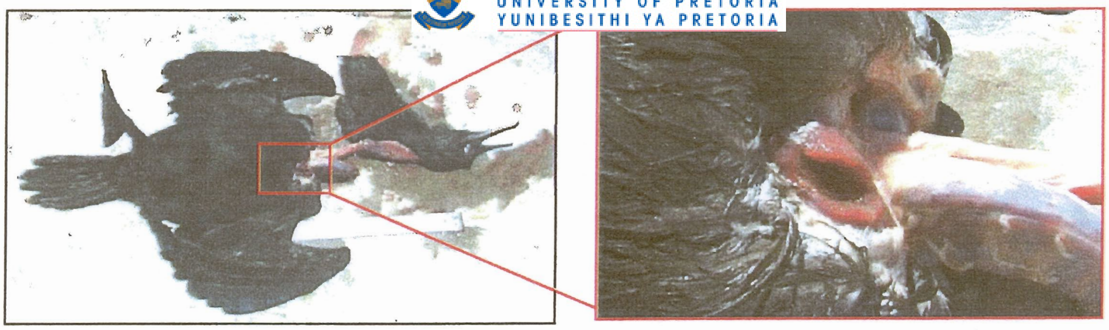


**Figure 2.7.** Bank cormorant fledgling killed by a seal – note the canine imprint in the breast muscle; this bird was not fed upon.

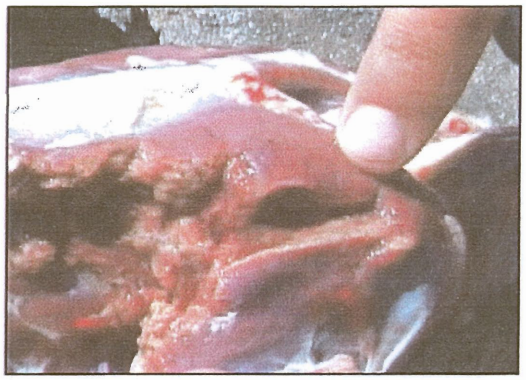


**Figure 2.8.** Cormorant breast muscle sliced by seal during predation.

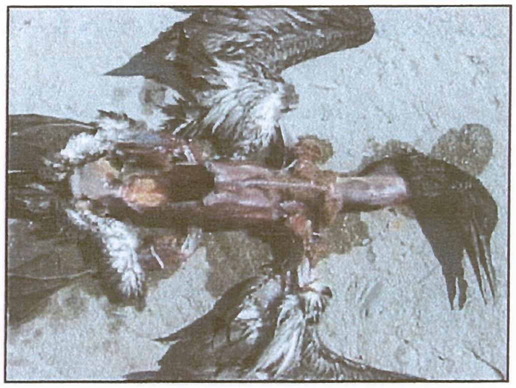


**Figure 2.9.** Carcass of gannet fledgling showing breast muscles and viscera removed by seal.

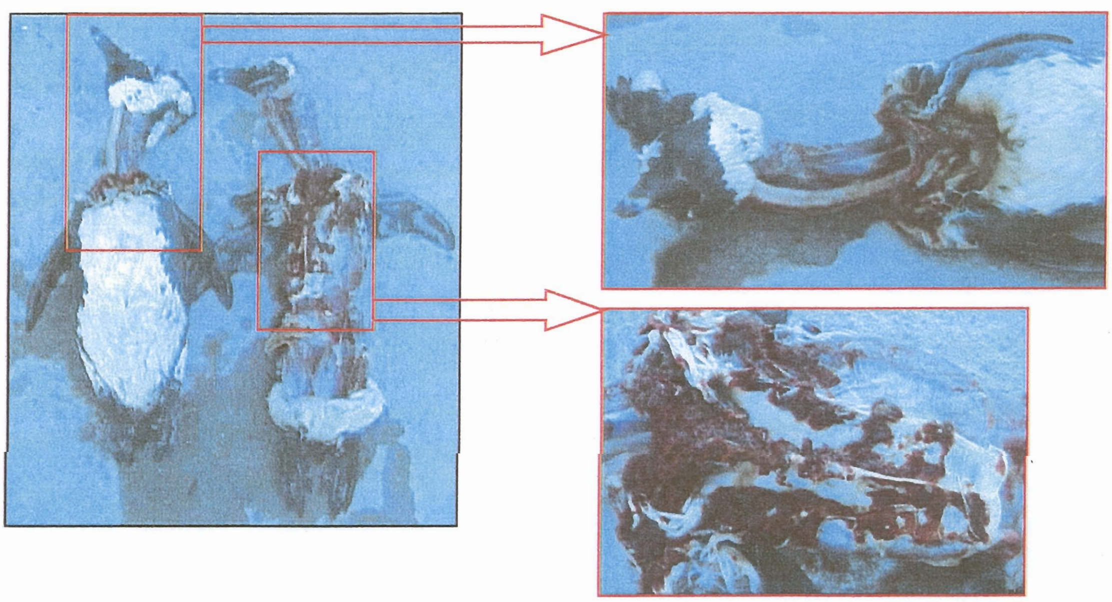


**Figure 2.10.** Two penguins killed by the same seal in close succession.

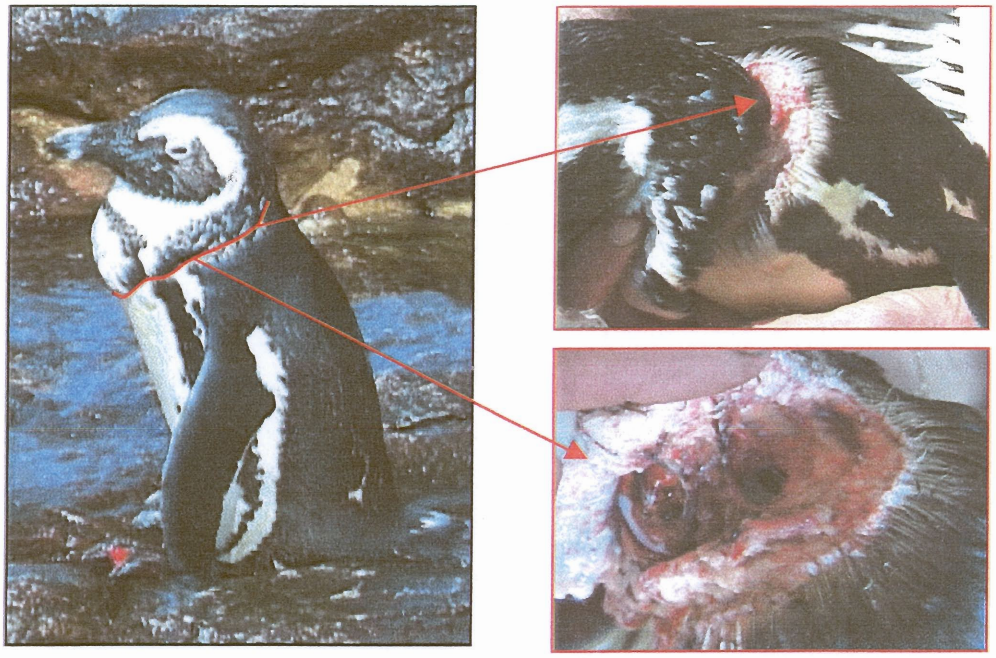


**Figure 2.11.** Adult penguin with suspected seal-inflicted injuries. The skin and muscles on the neck are ripped through with additional puncture holes in the neck and feet.

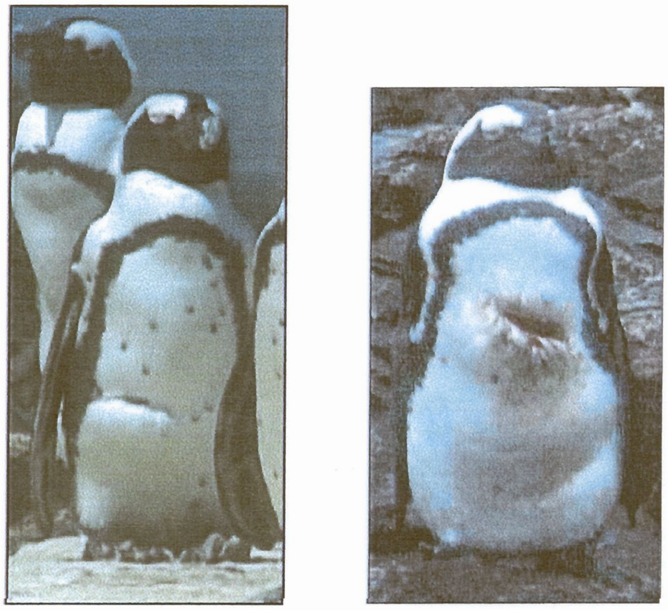


**Figure 2.12.** Adult penguins with suspected seal-inflicted injuries: **a** – old, well-healed scar; **b** – fresh injury.

## DISCUSSION

### *Seabird predation by seals*

While seal predation on penguins is well documented (see Introduction), reports concerning predation on gannets and cormorants are few (Shaughnessy 1978; Marks *et al.* 1997; Navarro 2000). Seal-seabird predation occurs at low levels, with small subgroups, such as subadult males, specialising in this behaviour (Marks *et al.* 1997). The current study supports this statement.

Not all seals at Little Ichaboe prey on seabirds – at least 80% of the predators identified fell in the subadult age-group, and the predators were predominantly male (Table 2.1).

### *Predation cues*

Though the predatory cues identified differed in terms of visibility, i.e. attracting the attention of the observer, they proved a valuable aid in recognising predatory events, especially for opportunistic observations (see Chapter 3). These cues were chosen specifically for their association with predatory events, so that an observer familiar with them will recognise such events and can tell them apart from normal bird or seal fishing activity.

A gannet cloud is conspicuous, especially when comprised of many birds. Because the majority of these clouds are associated with predatory events involving adult gannets, predations on these birds are less likely to be missed than cormorant or penguin predations. Gannet clouds will be discussed in more detail later in this chapter.

Kelp gulls swooping or scavenging was the most important predation cue, although not as visible as a gannet cloud in terms of attracting the observer's attention. The presence of kelp gulls confirms that there is something for these birds to feed on (such as a bird carcass), whereas gannet clouds sometimes form for reasons other than a predation. Marks *et al.* 1997 also note the presence of kelp gulls at predation events; indeed, for this study, activity by birds or seals in the water that was not attended by kelp gulls confirmed that the activity did not involve seal-seabird predation.

Thrashing is the most important indication of a predation currently taking place. Seals also thrash lobsters and large fish, so this cue is not necessarily indicative of a seal-seabird predation. The prey can be identified when thrashed by the seal, and even at considerable distances it is possible to distinguish between bird species, by the shape, size and colour of the prey. This is why thrashing is important not only as a predatory cue, but also to identify the seal and prey. However, thrashing is often only visible for a short period of time, and in some instances is not seen at all, when the seal feeds on the bird underwater.

Direct evidence of a predatory activity, such as a seal attacking a bird, is important to recognise, as the entire predatory event can be noted, and the duration more accurately recorded. Ideally, every account of such predatory activity should start with the seal attacking the bird, or even with the events leading up to the attack, by observation of the seal and the bird involved. However, due to the short duration of an attack, it is easily missed during incidental observations and even scan sampling, so only continuous observations would reliably record the start of a predation (see Chapter 3).

Though carcasses (usually adrift) are indicative of past predations, and do not necessarily provide data on the behavioural aspects of seal-seabird predation, they were nonetheless an important clue to predatory activity, especially for gannet and cormorant fledglings. During opportunistic observations not every predatory event would have been noted. In this case, a count of carcasses adrift provides information on the number and species of birds killed; upon inspection, the extent of injuries may be noted and a likely predator implicated. Moreover, on days when predatory activity occurs frequently and close inshore, it was more convenient to count carcasses than do continuous observations (see Chapter 3).

*Behaviour*

Unlike the incident noted by Rebelo (1984), no seal was observed attacking birds on land. The sea-wall surrounding Ichaboe Island generally serves to exclude seals from the island, though on occasion seals use the ramps provided for penguins to gain access to the island. A seal intent on taking a bird would be able to do so at the 'landing stages' of the penguins, where they congregate on the seaward side of the wall. The possibility of seals taking birds on land is therefore not excluded, though the incident of the injured penguin ashore on Little Ichaboe amongst the seals confirms that seals do not necessarily consider seabirds as prey.

Most observations only start once predation cues are seen, which usually means that the seal has already seized the prey. It is therefore not always possible to determine whether an ambush or active pursuit has preceded the predation, or whether the birds are taken opportunistically as opposed to being targeted. The nature of the attack may, however, be deduced from other behavioural characteristics as seen during continuous observations, as well as other circumstantial evidence. Simultaneous predations prove that more than one seal is involved in preying on birds; this is important when trying to discern whether a single seal is responsible for successive predations. Predations in the same area at regular intervals with no simultaneous activity noted, may be ascribed to only one seal individual; if in quick succession it may mean that the birds are only killed, and not eaten.

The hesitant behaviour on the part of the young seal that killed the white-breasted cormorant, suggested that the seal was inexperienced, at least in preying on this largest of the cormorants. It is possible that the cormorant did not regard the seal as dangerous, which is why it did not attempt to fly off. The number of white-breasted cormorants at Ichaboe is small (maximum of 11 breeding pairs), so seals would not encounter them as often as the other birds. Therefore, the predation level (one white-breasted cormorant predation noted in nine years) is not surprising.

No failed predation attempts on penguins were witnessed; however, these would not be as obvious as with the other birds. Penguins with suspected seal-inflicted injuries are more prevalent on the island than gannets or cormorants – 60.7% of injured birds were penguins. It is possible that predation evasion is higher for flying birds than for penguins. Furthermore, penguins, which are physically more robust, seem to survive severe injuries that would incapacitate flying birds (see Figures 2.11 and 2.12), hence the larger number of penguins with injuries and scars.

Seabirds generally recognise seals as a threat, and display anti-predator behaviour (Randall & Randall 1990). Penguins change direction and porpoise away from seals, while adult gannets and cormorants are reluctant to dive in the vicinity of seals, and take off from the water if approached by a seal. In contrast, gannet and cormorant fledglings do not associate seals with danger and even curiously approach a seal preying on another bird; therefore there are higher numbers of fledglings than adults preyed upon in quick succession, often by the same seal.

Surplus killing is defined as the "killing by a predator of prey, without the killing individual or its offspring or members of the same social unit eating anything from the kill, although there is free access to the carcass and usually the particular prey species would be eaten by that predator" (Kruuk 1972a: 234). Miller, Gunn & Broughton (1985) suggest the term "surplus killing" for cases where the prey is killed but not fed upon, and "excessive killing" if the carcass is partially consumed, both of which occur in excess of the short-term energy requirements of the predator. Specialisation in food selection may be a response to high prey densities, which could lead to surplus killing, often but not necessarily facilitated by unusual environmental conditions (Miller *et al.* 1985). Cape fur seals display selective consumption of seabirds (Cooper 1974; Navarro 2000; this study), and kill birds without feeding (Marks *et al.* 1997; this study). Therefore, seal-seabird predation involves both surplus and excessive killing, especially regarding cormorant and gannet fledglings. These highly vulnerable prey are abundant for a few months and are often killed in quick succession in a clumped distribution with at least some of the prey not having been fed upon. These are restrictions that Miller *et al.* (1985) believes should be applied to surplus killing. The curiosity of gannet and cormorant fledglings indicates that their anti-predator response regarding seals is absent, which may further expose them to surplus killing. However, surplus killing involves the typical prey of the predator (DelGiudice 1998), and is therefore not strictly applicable in this study.

Young seals that are inexperienced seem to prefer to attack cormorants, and are not always successful. On the other hand, experienced seals preying upon seabirds may have eaten their fill or preyed on a few birds already, subsequently killing birds without feeding on them. This behaviour may be instinctive, in that a seal that has become accustomed to killing birds may continue to do so once satiated. However, birds are not a common prey item for fur seals (Marks *et al.* 1997 and references therein) and at the individual level, deviation from expected behavioural patterns may be found. This suggests predation as an extension of play behaviour on the part of the seals (Bonner & Hunter 1982) as seals "playing" with birds would not necessarily consume them. The same was the case for two killer whales *Orcinus orca* "playing" with cormorants and penguins at Mercury Island (Williams, Dyer, Randall & Komen 1990).

King (1983) describes young male seals in particular as active and noisy, and engaging in play. Seals often play in the surf zone adjacent to Little Ichaboe; the 32 gannets and four cormorants killed in this area may have been taken opportunistically in the same way as pieces of kelp or floating objects are thrashed (Bonner & Hunter 1982). Curious seals investigating their environment "test-bite" objects. It is possible that some birds are killed in this way, and that seals may find birds to be "tasty morsels" (Navarro 2000:16), later taking them as prey.

Younger seals sometimes accompany seals that are regular bird predators and may assimilate this behaviour, and even continue feeding on the carcass once the main predator has left it. Marks *et al.* (1997) relate an anecdote of a seal he considered to be a female apparently trying to teach two juveniles how to feed on Cape cormorant fledglings at Dyer Island. A similar incident was noted at Malgas Island, where one seal was apparently trying to teach two younger ones to deglove Cape cormorant fledglings (R.A. Navarro, pers. comm.). Hiruki, Schwartz & Boveng (1999) noted incidents of leopard seals interacting while hunting, with one seal capturing and releasing fur seal (*A. gazella*) pups to another. Seals therefore seem to not only tolerate one another while hunting, but interact. It is likely that younger seals learn seabird predatory behaviour from more experienced seals by observing this behaviour and playing with the bird carcass. These young seals may then become regular bird predators themselves. Hiruki *et al.* (1999) could not confirm co-operative hunting but noted that leopard seals tolerated one another while hunting; the same holds true for this study regarding Cape fur seals preying on birds.

Only penguins were seen to be chased by seals. A seal can outswim a satiated penguin whereas gannets and cormorants would take off if pursued. Three out of six observations of this behaviour involved one seal individual, Blunt Flipper. On one occasion, the chase resembled a "cat-and-mouse game"; the seal chasing the penguin did not seem to be swimming at full speed, and once it caught up with the bird, killed it without feeding. This incident supports the concept of play behaviour culminating in a kill.

Gannets remain in the water only for a short while after plunge-diving for fish (Duffy, Berruti, Randall & Cooper 1984). When the seal approaches the bird from below, the bird may take off. The high wind speed at which three of the airborne attacks on gannets took place may be when the bird was aware of the seal, and able to take off from the water rapidly, aided by the wind. The seal then carries through the attack despite the bird having taken off.

Gannet and cormorant fledglings are inexperienced in taking off from the water, and are relatively heavy. Together with their inability to recognise seals as danger, and their curiosity (see above), they therefore become easy prey for seals. If these birds happen to be in the area where the seals play in the surf off Little Ichaboe, inquisitive young seals may take these birds as an extension of play behaviour and later learn to become active bird predators.

It cannot be assumed that those birds that were killed only or that managed to escape with injuries were necessarily preyed upon by inexperienced seals. Regular bird predators may also attack and injure birds, or kill them without feeding on the carcass.

Seals may find seabirds easy prey, and some individuals may become regular seabird predators. What may have initially started as play behaviour, or taking birds opportunistically, may develop into a habit with birds eventually forming a large part of the diets of those individual seals that specialise in seabird predation. The local seabird populations may not be able to sustain this added mortality factor (see Chapter 5).

*Time between predations*

The ratio of the average time between successive predations between the three bird species is equivalent to that of the average time a seal feeds on each species. Therefore, the time between successive predations carried out by the same individual seal may indicate the time spent with each carcass. Gannets and penguins are large and heavy compared with cormorants, and seals spend more time feeding on these birds. In a given period of time a seal can take almost twice as many cormorants as gannets or penguins. In addition, cormorants are far more abundant at Ichaboe and likely to occur in larger groups, whereas gannets and penguins would be encountered singly or in small groups. Thus a greater predation rate for cormorants would be expected. Moreover, inexperienced seals may take cormorants rather than the larger gannets and penguins.

The results report the time between successive predations by the same seal individual, and the number of birds taken by the same seal in one day. Hence, these results pertain only to those seals that are exploiting this food resource on a regular basis. These seals are therefore not taking birds opportunistically, but repetitively and deliberately. If it were only play behaviour, the birds would not be consumed, but possibly only injured or killed. Though not all bird carcasses could be inspected, the time lapse between the subsequent predations by these specialist seals suggests that the birds were fed upon. However, the majority of successive predations could not be attributed to any particular seal due to the difficulty in identifying individuals. The results reported here therefore represent a biased portion of the data (in only involving specialist seals and not those preying on birds opportunistically), and cannot be extrapolated to population level.

*Age and sex of seal*

It is difficult to identify the sex of a seal while it is preying on a bird, though seals often roll and put a fore-flipper in the air, or hang upside down in the water with the hind flippers visible after the predation. As the head and neck of the seal may be visible during the thrashing action, the age of the seal can often be estimated by judging the size of the seal's neck and flippers against the size of the bird carcass. Although adult and subadult males can be easily identified, adult and subadult females would be classed as "subadult" only – for this reason female seals cannot be ruled out as bird predators, though no females were positively identified. On the other hand, a seal perhaps needs to be large, with well-developed neck muscles in order to succeed in thrashing a bird. Harcourt (1993) suggests that adult male southern sea lions (*Otaria byronia*) are able to exploit a food source (South American fur seals, *A. australis*) that the smaller females are unable to exploit. Due to the marked sexual dimorphism of the Cape fur seal (Shaughnessy 1979), the females reach maturity before the males. Therefore, when females are physically large enough to prey on a penguin or gannet, they are involved in reproduction and may be pregnant or suckling their pups, which may explain why subadult seals appeared to be the most regular bird predators. However, if birds were a good source of food, female seals with pups ashore would be seen preying upon seabirds more often; though due to the difficulty in identifying female seals from a distance, this cannot be ruled out. Young male seals attain sexual maturity while still quite young, but cannot compete with the bulls for a territory until the age of about 10 years (David 1995), and are therefore not socially mature (Stewardson, Bester & Oosthuizen 1998). They form aggregations of their own age-groups and haul out on other outcrops of rock (David 1995; De Villiers *et al.* 1997). If these seals do not join the main body of seals at the fishing grounds, but remain in the vicinity of the island, they may develop such habits as taking birds. Other studies on seal-seabird predation also found the predators to be predominantly male (Bonner & Hunter 1982; Hofmeyr & Bester 1993; Rebelo 1984; Shaughnessy 1978; Williams 1988). A review by Riedman (1990) suggests that predation on birds (or other pinnipeds) are restricted to adult or subadult male pinnipeds, with the exception of leopard seals.

*Seal specialisation*

Navarro (2000) described the behaviour of a bull seal observed at Malgas Island in 1988 that killed at least 61 gannet fledglings using the same technique, a single abdominal bite. This is remarkably similar to the behaviour of the bull observed in April 1993 at Ichaboe. This is an indication of specialised behaviour, with the seal showing a preference for a particular portion of the bird (the viscera) and developing a technique that is used repeatedly. Had the seal involved in this behaviour at Ichaboe not been shot, it is likely that it would have been responsible for many more deaths of these birds. The same is true for the other seals that were culled.

Specialisation and individual preferences for specific prey were shown for leopard seals by Hiruki *et al.* (1999). Other authors (Bonner & Hunter 1982; Cobley

& Bell 1998; Cooper 1974; Hofmeyr & Bester 1993; Penney & Lowry 1967; Walker *et al.* 1998; Williams 1988) also ascribe seal-seabird predation to a few individuals whose techniques or preferences may differ (Cooper 1974; Bonner & Hunter 1982; Rogers & Bryden 1995).

The predatory behaviour of individual seals did not conform to the overall pattern of predation at Ichaboe Island. The predations carried out by seals that were individually recognisable were generally recorded close to the island, but this does not necessarily imply that these seals operated only in close proximity to the island. Most observations were island-based; it became increasingly difficult to identify seals at farther distances from the island. In addition, due to the incidental nature of the observations, it was not possible to ascertain how many of each bird species fell prey to each individual seal. Nevertheless, Broad Flipper appeared to prey only on penguins, Ragged Flipper on penguins and one cormorant, Blunt Flipper on gannets, penguins and cormorants, and "U" on cormorants only.

Though these four seals represent a small sample of the seals that prey on birds at Ichaboe, they offer insights into individual seal preferences and behaviours concerning seabird predation. Blunt Flipper was observed taking the most birds, notably juvenile cormorants between March and June, juvenile gannets mainly from March to April and penguins year-round. Therefore this seal took birds in accordance with their abundance (see Chapter 1). In contrast to this, Broad Flipper preyed on adult penguins during a time when cormorant and gannet fledglings, which may be relatively easier to catch, were abundant. Ragged Flipper, on the other hand, took penguins over a wider range spatially and temporally, while "U" was seen preying mainly on adult cormorants from November to January. Broad Flipper and "U" seemed to specialise more, each exploiting a particular niche - Broad Flipper ambushing satiated penguins in the late afternoon as they return to the island, and "U" preying on adult cormorants diving for nesting material within a small area called Bamboo Bay. Four very different strategies of predation are evident, indicating that this is not a common, stereotyped behaviour, but rather that individuals develop their own preferences and techniques.

For an hourly predation rate of over 20 birds, it is assumed that the birds were killed only, and not fed upon; this is the case for 15 cormorants preyed upon by Blunt Flipper. With such times as two to five minutes between successive predations by the same seal, it is assumed that the seal did not feed on the carcass, or ate very little. Such surplus killing and wastage from a carcass is not a common occurrence (Kruuk 1972b), and it seems that this behaviour is restricted to only a few individual seals. However, persistent over-predation could severely impact local seabird populations (see Chapter 5) and necessitate the removal of the particular seal individual responsible.

*Gannet clouds*

When gannets are hovering together in a group over something in the water, they are usually fishing, and individuals can be seen plunge-diving into the water, surfacing a short while later. Such a group may be a cue to fishing activity to other birds, which fly out from the island and join those in the group. Flying out (from the island) to hover over a seal preying on a bird is energetically costly for the gannets (Adams & Klages 1999), and seems to serve no purpose. However, a gannet cloud may serve as a visual cue to the presence of food to other gannets, similar to Black-browed Albatrosses in mixed-species feeding flocks (Silverman & Veit 2001).

If a seal attacks a gannet that has just surfaced after diving, and a few other gannets in the vicinity take flight, these birds hovering over the predation site may be a signal to other birds that there are fish. Other birds, gannets in particular, may fly towards the area to join in potential fishing, and in so doing attract the attention of still more birds. Individual birds may choose to remain within the cloud for a short while before flying off again, while the presence of the group of gannets in the air serves to continually attract more birds. The gannets may be reluctant to dive into the water due to the presence of the seal feeding on a bird; this behaviour may serve to further confirm predatory activity. When the seal no longer thrashes the carcass, the gannet cloud disperses.

When predation occurs regularly throughout the day, gannets may spend a large proportion of their time flying out to join gannet clouds to investigate the activity on the water, and return to the island a short while later. This may be repeated with every predation event, causing the gannets to expend energy unnecessarily and without gain.

While the majority of gannet clouds were associated with predations involving adult gannets at Ichaboe Island, they have been noted to form over juvenile gannet predations at Malgas Island (M.A. Meÿer, pers. comm.). It is interesting to note, however, that gannet clouds have also been seen to form over a person on the water (surfing, paddling, or in a dinghy) as well as over a person on the island (pers. obs). This behaviour may therefore also be associated with investigating anything unusual.

*Injured birds*

Gannets or cormorants that are injured may be unable to fly or swim back to the island, so the number of injured birds of these species is possibly under-represented.

On the other hand, penguins are still able to swim ashore provided their flippers are not too damaged, which may be why penguins with fresh or old injuries on the ventral body surface are common.

Though sharks and killer whales (*Orcinus orca*) have historically been noted or implicated as predators of the African penguin (Randall, Randall & Compagno 1988; Randall & Randall 1990), very few of these predators have been observed offshore at Ichaboe Island since 1991 (P.A. Bartlett, pers. comm.). These are therefore not responsible for the injuries seen on penguins at Ichaboe.

According to Randall *et al.* (1988), penguins often suffer broken bones when attacked by a seal. This was not the case in the current study, where birds preyed upon by seals hardly ever had broken bones. Cooper (1974) noted that seals usually removed the viscera of penguins they prey on. In the current study, this was more often the case with cormorants and gannets.

Kelp gulls find it difficult to penetrate the feathers and skin of an entire bird carcass that is adrift, but readily scavenge bird carcasses where the breast muscles and viscera are exposed. It is therefore not always certain which anatomical portion of a carcass had been consumed by a seal if the carcass was collected some time after the bird was preyed upon, as kelp gulls may have scavenged a considerable portion of the bird.

Though Randall *et al.* (1988) maintained that fur seals cannot produce narrow, deep cuts with their conical teeth, 68% of all penguin injuries recorded between October 1999 and May 2000 were of this type. Also, none of the obviously shark-inflicted injuries discussed by Randall *et al.* (1988) were seen on penguins at Ichaboe Island, except for straight slashes, which are regularly observed on carcasses preyed upon by seals. Penney & Lowry (1967) and Bonner & Hunter (1982) attribute deep

# CHAPTER 3: EVALUATION OF METHODS

## INTRODUCTION

### *Incidental sampling*

In order for a study to be scientifically valid, "the selection and appropriate use of sampling methods that yield unbiased estimates of behavior are critical" (Mann 1999:103). However, ethological studies often involve opportunistic recording of events, which may preclude quantitative evaluation. Such *ad libitum* sampling has inherent biases and assumptions, as outlined by Altmann (1974) and Mann (1999). Informal recording of events, such as during incidental observations, have an unknown dependency on the behaviour in question, as session onsets are not systematic. Events that are easily recognisable or visible may be recorded more frequently (Altmann 1974), with an under-representation of events that do not attract the observer's attention to the same degree.

In marine ecology, manipulative experiments are not often feasible and research is expensive (Bowen 1997). *Ad libitum* sampling – also referred to as incidental, opportunistic, informal or anecdotal sampling – is most often used for events that are significant, but rare, such as predation (Mann 1999). Despite such sampling being fraught with bias, it has heuristic value in planning systematic sampling and can be used as illustrative material (Altmann 1974).

If the relevant behaviour has been recorded and adequately described, this information is valid as long as the method of observation in no way affects the behaviour in question. Behavioural data can therefore be used irrespective of the actual method of observation (whether systematic or not). Information regarding spatial, temporal and environmental parameters may still be accurately recorded for each event. However, since sampling effort is unquantified, rates, frequencies and proportions cannot be accurately calculated (Mann 1999).

Predation by pinnipeds is most often recorded on an *ad libitum* basis. Hofmeyr & Bester (1993) interviewed observers who had incidentally recorded king penguins falling prey to Antarctic fur seals. Records of Cape fur seals preying on penguins (Cooper 1974; Rebelo 1984) and other seabirds (Shaughnessy 1978; Marks *et al.* 1997; Navarro 2000) use opportunistic sightings as the method of observation. Other incidental records of pinniped predation include: leopard seals preying on Adélie penguins (Rogers & Bryden 1995); Weddell seals feeding on gentoo penguins (Cobley & Bell 1998); Hooker's sea lion (*Phocarctos hookeri*) preying on fur seals (Robinson *et al.* 1999). Cetaceans (notably Killer whales *Orcinus orca*) and their interaction with seabirds (king penguins, African penguins and Cape cormorants) were also recorded opportunistically (Condy *et al.* 1978; Randall & Randall 1990; Williams *et al.* 1990).

*Scan sampling*

The systematic recording of events, as with scan sampling, permits the calculation of rates and proportions, because observer effort can be quantified. Session onsets are predetermined and independent of behaviour. Data are recorded from a subgroup of the population in question, rather than a focal individual. Each member in this group is observed in turn for the same length of time, and the current activity of each noted (Altmann 1974). The behavioural categories are chosen such that they are easily and rapidly distinguishable. Kovacs & Innes (1990) made use of this form of sampling in investigating the level of disturbance caused by tourists when visiting a harp seal (*Phoca groenlandica*) herd.

*Continuous observations*

If behavioural events are sufficiently "attention-attracting" (Altmann 1974:247), such that every event will be recorded, and if these events do not occur too frequently to record, all occurrences of some behaviours may be recorded during continuous observations. Such a sampling technique provides information regarding the rate of occurrence of the behaviour in question (Altmann 1974). This method was employed by Penney & Lowry (1967) while investigating leopard seal predation on Adélie penguins, as well as by Bonner & Hunter (1982) in their study of Antarctic fur seals preying on macaroni penguins.

In this chapter, eight years of incidental observations of seal-seabird predation are compared with the results from six months' intensive systematic observations as well as incidental observations, in order to investigate the differences between these methods.

## METHODS

*Historical incidentals*

Opportunistic observations of seal-seabird predation in the vicinity of Ichaboe Island were carried out by Mr. P.A. Bartlett between October 1991 and October 1999. The date, time, direction and estimated distance of the predation from the island, environmental parameters, seal age and sex, bird species and age, and the duration of the predatory event were recorded whenever possible. Indicators of predatory activity, identified at the start of the study, were used as cues to alert the observer to a predatory event (see *Predation cues*, Chapter 2). Any other relevant behavioural data were also noted.

These incidental observations (historical incidentals) were used to plan a systematic sampling method, which was carried out from November 1999 to May 2000.

*Scan sampling*

The method of scan sampling used in this study is an adaptation of the method described by Altmann (1974). Events were recorded in a systematic way; session onsets and termination were independent of the behaviour being investigated (in this case, predation). Due to the difficulty in identifying individual seals, the focal animal approach could not be strictly carried out. A subgroup of the seal population was therefore observed, specifically those involved in preying on birds. Therefore, behavioural criteria (i.e. predation) determined the focal individual; samples of animals and behaviour are therefore not independent. Furthermore, the same individual seal may have been responsible for more than one predatory event; such events would not have been independent. If no predation occurs during a particular scan, no focal animal was identified. This method may thus be more aptly described as "focal event sampling".

The beginning and end of interactions were discernible, with behavioural categories easily distinguishable. The start of a predation was identified when cues such as a seal attacking a bird, kelp gulls scooping, the formation of a gannet cloud or a seal thrashing prey were observed. When the kelp gulls settle on the water to scavenge the bird carcass, or when a gannet cloud disperses, this was taken as the end of the seal-seabird predatory interaction.

Focal event sampling involved scanning the coastal waters around the island for predation cues from an elevated observation hut (9 m a.s.l.) with 7 x 50 binoculars in a clockwise direction. Each scan lasted approximately two minutes. Scans were done every 15 minutes from dawn to dusk (DDU) on alternate days from 11 November 1999 to 11 May 2000, except in conditions of poor visibility such as mist or fog. When the visibility was less than *c.* 500 m, no scans were done, and as soon as the mist or fog cleared, scans continued as usual. It was assumed that every predatory event occurring at the time of a scan would be noticed.

These DDU surveys were carried out such that the first scan was done just before sunrise and the last scan once the sun had set. During the six-month fieldwork period, a total of 4 129 scans (which is equivalent to 137.63 hours of observation) were done over 86 days. An average of 48.6 (SD = 10) scans were carried out per day.

*Continuous observations and project incidentals*

In addition to the focal event sampling, 162.5 hours of continuous observations were done throughout the same season during 107 sessions over 57 days. These observations were usually carried out from the observation hut for periods lasting between 15 minutes and five hours (mean = 1.5 hours), searching in all directions for predation cues. It is assumed that all predatory events will be observed during continuous observations, even if they occur simultaneously and that those events occurring in the "summit shadow" (see Figure 1.1) are negligible due to the surf in this area.

Continuous observation periods were not decided upon before the study, and were prompted by predatory activity on four occasions. Focal event sampling continued as described above throughout these observation periods, where these ran concurrently. Apart from scanning and continuous observations, predations were also noted opportunistically (project incidentals) in the same manner as they had been over the previous eight years. Continuous observations and project incidentals were carried out from November 1999 to May 2000.

When observational methods ran concurrently, a predatory event would be recorded for only one method. Focal event sampling as a method of observation took preference, followed by continuous observations and then the incidental sightings. Therefore, if a particular predatory event was observed during a continuous observation period, as well as during a scan, the method would be recorded as focal event sampling rather than continuous observation. Also, if an individual predation lasted long enough to span two scans, it was recorded only for the first scan in which it was seen. It was assumed that all predatory interactions in the vicinity of the island (in a 1 km radius) would be noted during focal event sampling and continuous observations, both of which took place from the elevated observation hut.

The predation cues identified by P.A. Bartlett (pers. comm.) were used as indicators of predatory events, and the same information recorded for each event as listed previously (see *Historical incidentals* above).

*Proportion of predations represented in incidental records*

Between November 1999 and May 2000, when incidental observations of seal-seabird predation were complemented by systematic observations, it is assumed that the proportion of predations noted was greater than in years when all observations were incidental. During this period of intensive observations (denoted "project"), records were kept of those predations that were noted incidentally, regardless of whether or not the same predation event was noted during systematic observations. In this way, it was possible to calculate the proportion of predations noted incidentally (PI), and those that would have been missed, had no systematic observations been carried out. The sum of predatory events noted incidentally (TI, excluding the project records; i.e. October 1991 to October 1999, and June 2000 to May 2001), multiplied by PI, give adjusted values of predation, which are believed to be more realistic. The total number of predations for this ten-year period equals the sum of the adjusted values and the project records.

*Statistical analysis*

Frequency distributions were compared using non-parametric tests. Where more than two independent groups were compared, a Kruskal-Wallis ANOVA was used to test the null hypothesis that the means of the groups were equal. The Kolmogorov-Smirnov Test was performed to compare two groups, and the p-values used to give insight into the relationship. In the case of categorical variables, the Pearson Chi-square Test was used (Sokal & Rohlf 1998).

During continuous observations, few gannet and penguin predations were noted (see Table 3.1). These are excluded from the results due to their small sample sizes. The graphic representation of the results were simplified by grouping classes and using percentage instead of frequency distributions. For example, in Figure 3.2, predatory events that occurred between 06:00 and 08:59 were grouped in a class labelled 07:30, those between 9:00 and 11:59 were grouped and labelled 10:30, and so forth. However, the analyses were carried out on the original (ungrouped) data. Individual predatory events were assumed to be independent. Predatory events where only the carcass of the bird was found, were excluded from the calculations on the diurnal and spatial distribution of predation, because the exact time and location of predation could not be established.

## RESULTS

*Predations noted per method*

A total of 2774 seal-seabird predatory interactions were observed between October 1991 and May 2000 (Table 3.1).

**Table 3.1.** Numbers (with percentage of total in parentheses) of different bird species preyed upon by seals at Ichaboe Island, as recorded using different methods of observation (see text for details).

| Method of observation | Cormorants | Gannets | Penguins | Unknown | Total |
|---|---|---|---|---|---|
| Historical incidentals | 1033 (41.8) | 882 (35.7) | 523 (21.2) | 33 (1.3) | 2471 |
| Project incidentals | 79 (62.2) | 15 (11.8) | 13 (10.2) | 20 (15.7) | 127 |
| Focal event sampling | 64 (51.2) | 32 (25.6) | 7 (5.6) | 22 (17.6) | 125 |
| Continuous observations | 41 (80.4) | 3 (5.9) | 1 (2.0) | 6 (11.8) | 51 |

There is a significant difference between bird species preyed upon as observed by each method (Pearson Chi-Square, $X^2 = 99.96$; d.f. = 6; $p < 0.0001$).

Where focal event sampling and continuous observations ran simultaneously, 28 predations were noted during the continuous observations that would have been missed had only focal event sampling been used as a method of observation. Predations were noted in 3% of scans and in 23% of continuous observation sessions.

*Predation cues*

The first predation cue to attract the attention of the observer differed with each method (Pearson Chi-square, $X^2 = 113.5$; d.f. = 12; $p < 0.0001$). Seals attacking and thrashing birds were noted as a first cue the most often during continuous observations. While kelp gulls swooping was an important cue to predatory activity regardless of the method of observation, carcasses were only seen as a first cue during incidental observations (Figure 3.1).

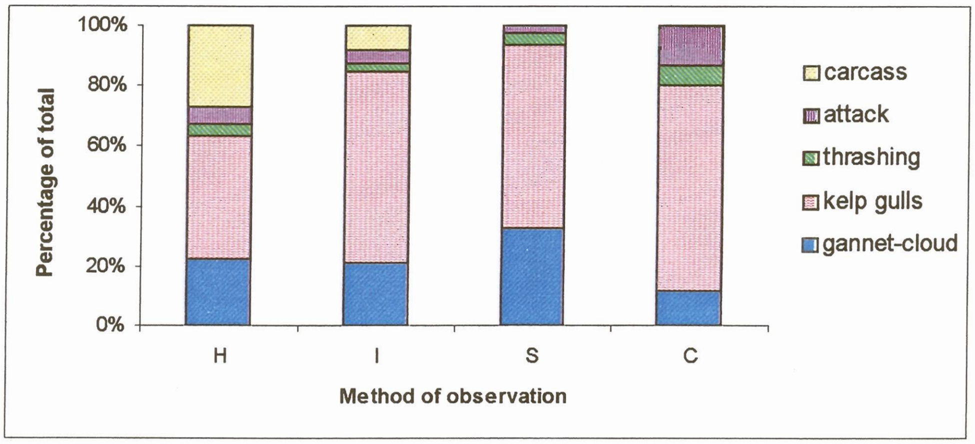



**Figure 3.1.** The number of predations (as a percentage of the total) associated with specific cues as noted during different methods of observation. Observation methods: **H** – historical incidentals; **I** – project incidentals; **S** – focal event sampling; **C** – continuous observations.

*Diurnal differences*

The time of day that birds were seen to be preyed upon during each of the observational methods, differed significantly for cormorants (Kruskal-Wallis ANOVA, H (3, n = 1177) = 16.49; p = 0.0009). However, the difference between historical incidentals, project incidentals and focal event sampling was not significant for gannet (Kruskal-Wallis ANOVA, H (2, n = 923) = 0.65; p = 0.72) and penguin (Kruskal-Wallis ANOVA, H (2, n = 538) = 1.01; p = 0.60) predations (Figure 3.2).

The majority of cormorant predations occurred in the morning as observed during historical incidental observations, while during focal event sampling more cormorants were preyed upon in the afternoon (Kolmogorov-Smirnov; $p < 0.001$) (Figure 3.2a). Gannet predations occurred throughout the day as observed through focal event sampling; incidental observations of these peak just after midday (Figure 3.2b). In contrast, the majority of penguin predation occurred after 15:00 for each method used (Figure 3.2c).

*Environmental conditions*

Environmental conditions, particularly wind speed as measured using the Beaufort Scale (hereafter denoted BS), differed significantly for each method of observation in the case of cormorant predations (Kruskal-Wallis ANOVA, $H(3, n = 1217) = 16.56$; $p = 0.0009$); no significant difference was seen in the case of gannet (Kruskal-Wallis ANOVA, $H(2, n = 921) = 0.78$; $p = 0.68$) and penguin (Kolmogorov-Smirnov; p = n.s.) predations (Figure 3.3).

Cormorants were seen to be preyed upon in conditions of both low (BS 3) and high (BS 7) wind speeds, except as observed during historical incidentals where 96.5% of cormorant predations occurred at wind speeds of less than 21 knots (BS 5); historical incidentals and focal event sampling differ significantly in this respect (Kolmogorov-Smirnov; $p < 0.01$) (Figure 3.3a). Gannet predations occurred at wind speeds of up to 47 knots (BS 9) (Figure 3.3b), while over 80% of penguin predations took place at wind speeds of 21 knots or less, regardless of observational method (Figure 3.3c).

*Spatial differences*

The distance from the island that predations were observed during each observational method, differs significantly with respect to cormorants (Kruskal-Wallis

ANOVA, H(3, $n$ = 1185) = 85.65; $p < 0.0001$), gannets (Kruskal-Wallis ANOVA, H(2, $n$ = 904) = 13.44; $p = 0.0012$), as well as penguins (Kruskal-Wallis ANOVA, H(1, $n$ = 528) = 7.62; $p = 0.0058$) (Figure 3.4).

With few exceptions, cormorant predations were observed closer than 600 m from the island (Figure 3.4a). During historical incidentals, almost 90% of these were closer than 200 m, while during focal event sampling cormorant predations were seen up to 400 m distant (Kolmogorov-Smirnov; $p < 0.001$). Whereas during project incidentals almost 40% of gannet predations occurred further than 600 m from the island, both historical incidentals and focal event sampling have less than 20% of observed gannet predations in this distance class (Figure 3.4b). Penguin predations were noted closer to the island during historical incidentals than in the course of project incidentals or focal event sampling (Figure 3.4c).

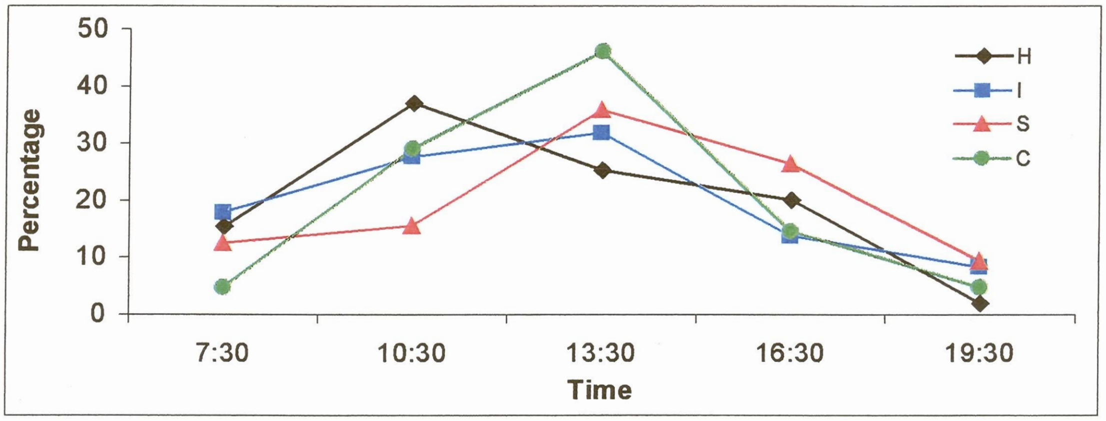



**Figure 3.2a**

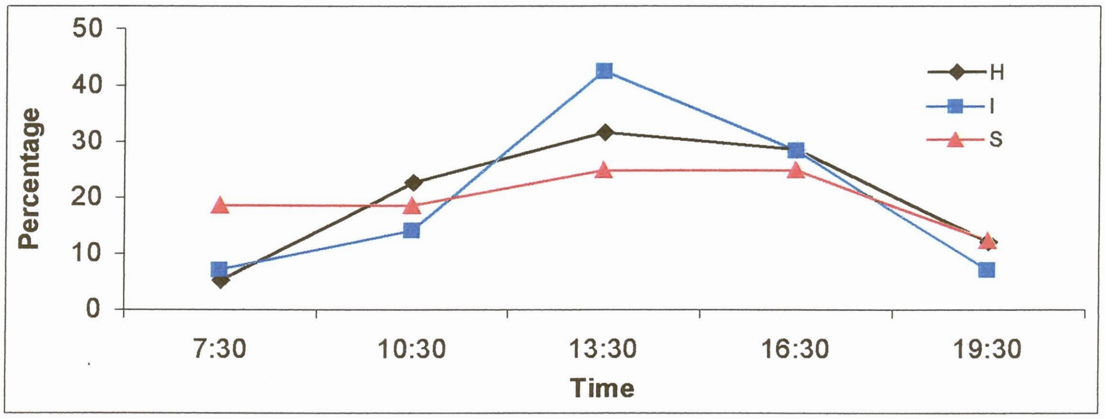



**Figure 3.2b**

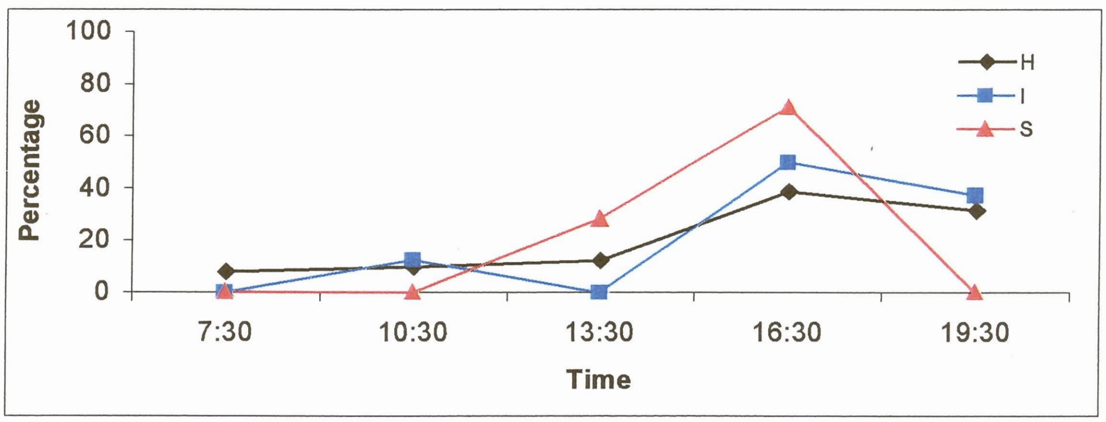



**Figure 3.2c**

**Figure 3.2.** Percentage distributions of the number of birds preyed upon by seals throughout the day, as noted during different methods of observation. Bird species: **a** – cormorants; **b** – gannets; **c** – penguins. Observation methods: **H** – historical incidentals; **I** – project incidentals; **S** – focal event sampling; **C** – continuous observations.

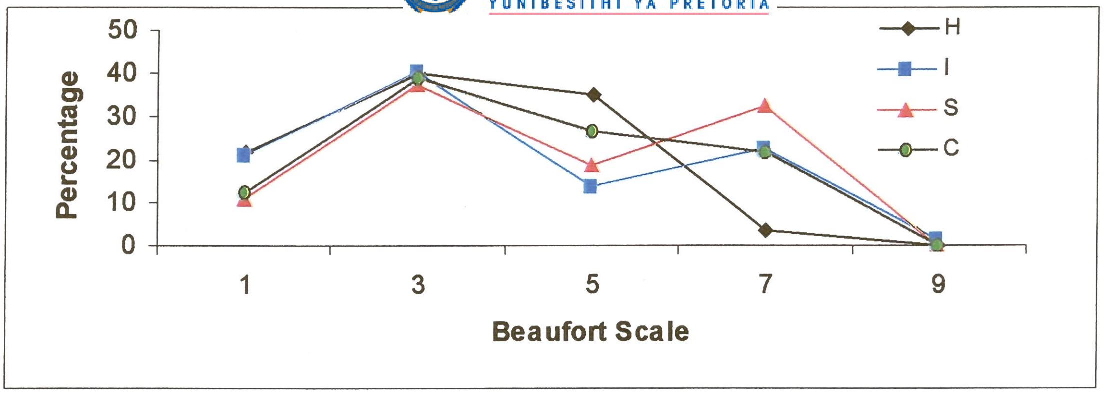



**Figure 3.3a**

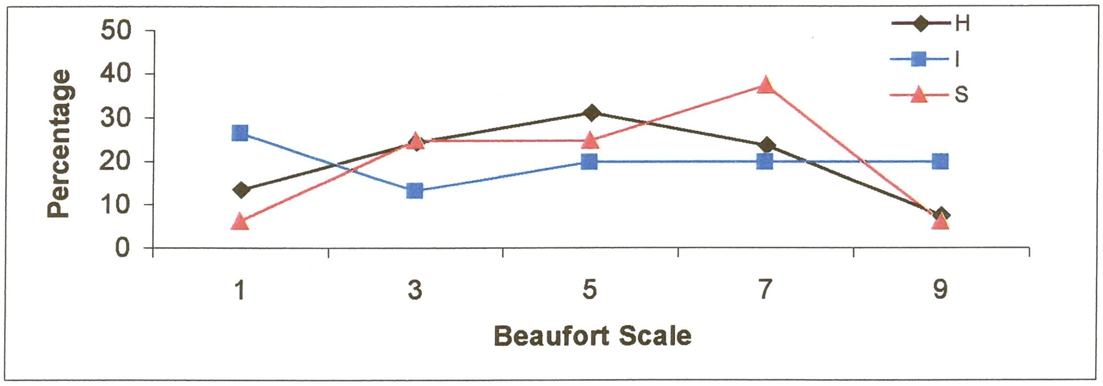



**Figure 3.3b**

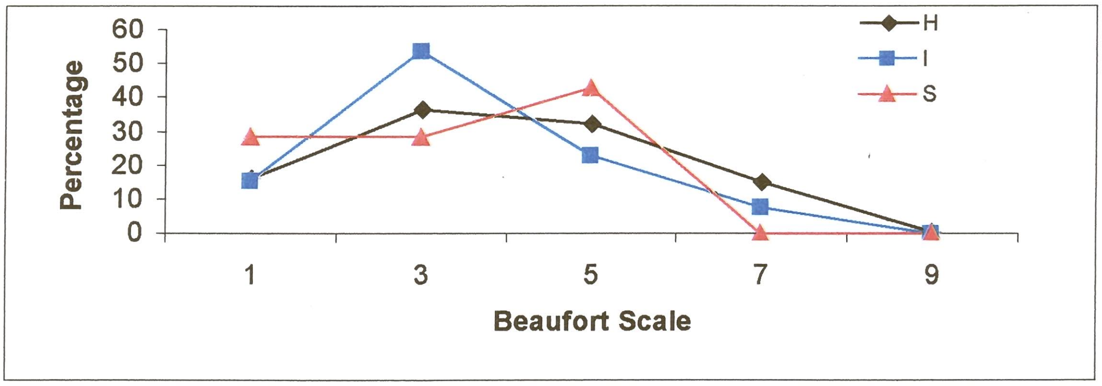



**Figure 3.3c**

**Figure 3.3.** Percentage distributions of the number of birds preyed upon by seals during different environmental conditions, as noted during each method of observation. Bird species: **a** – cormorants; **b** – gannets; **c** – penguins. Observation methods: **H** – historical incidentals; **I** – project incidentals; **S** – focal event sampling; **C** – continuous observations.

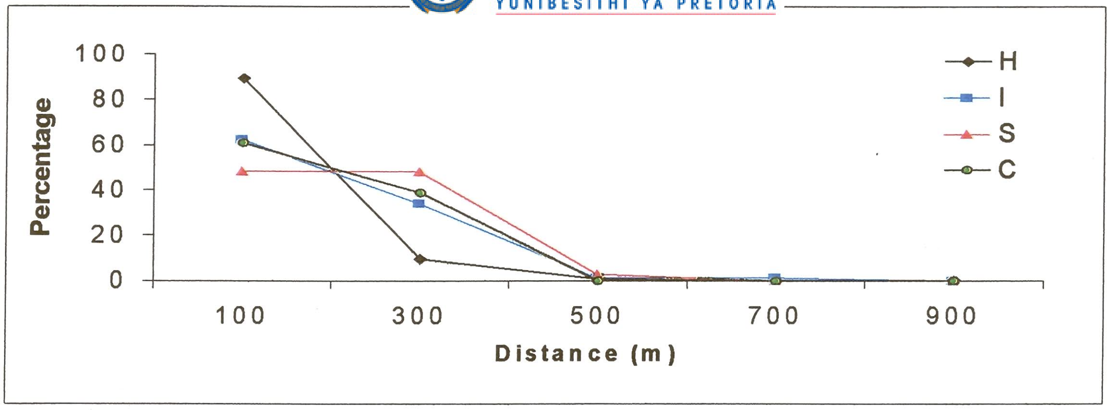



**Figure 3.4a**

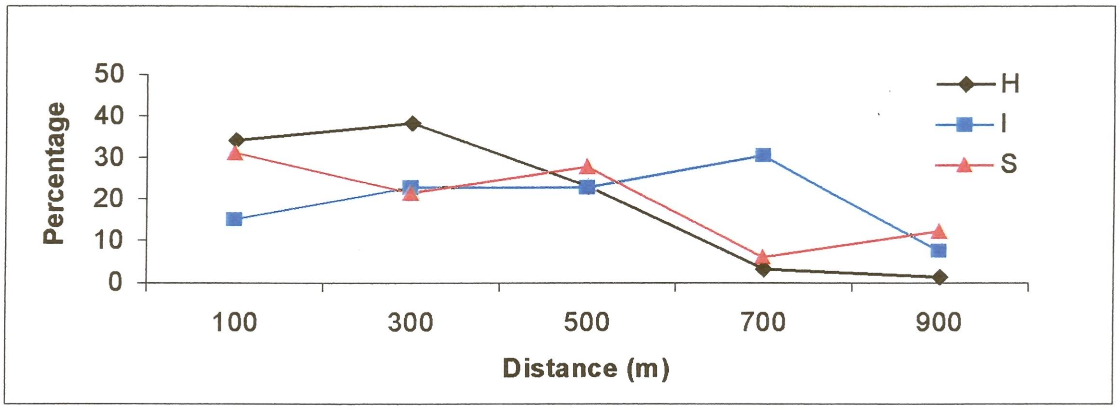



**Figure 3.4b**

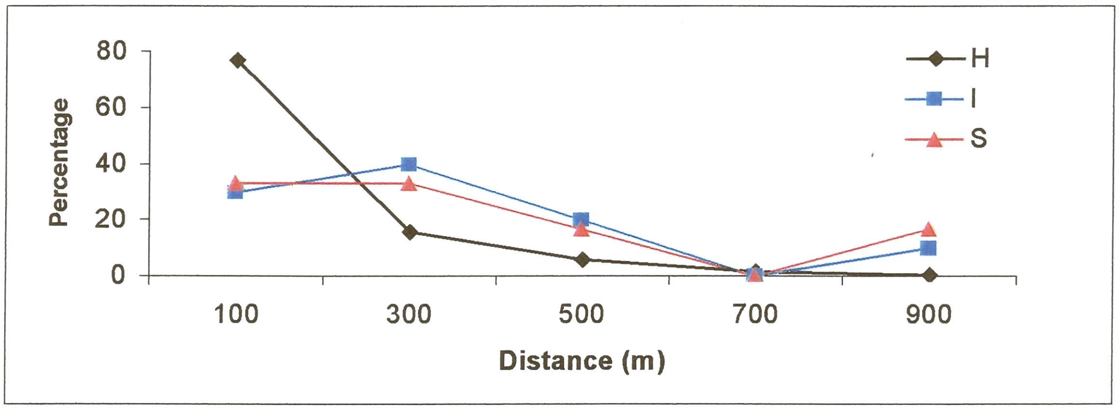
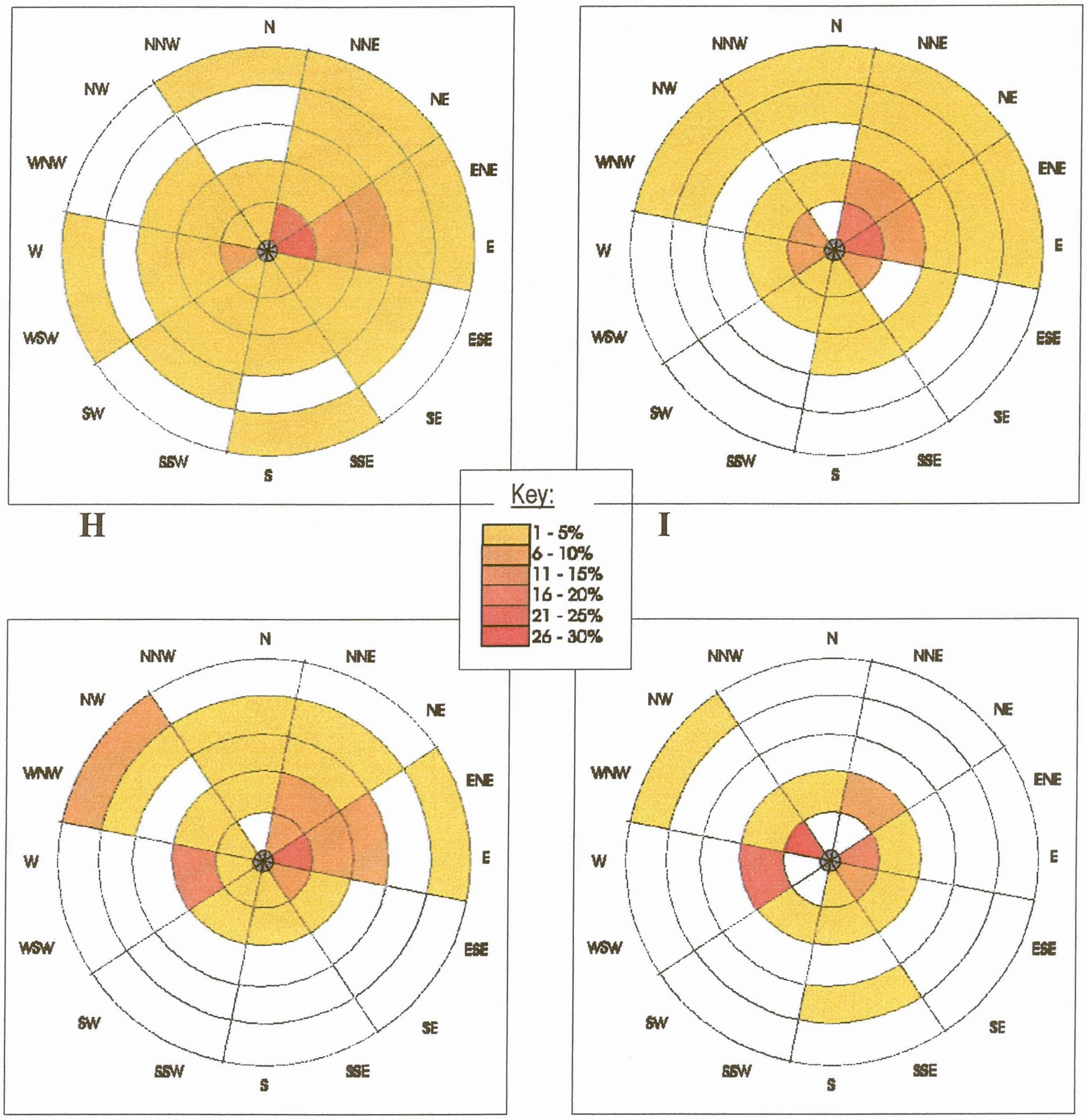



**Figure 3.4c**

**Figure 3.4.** Percentage distributions of the number of birds preyed upon by seals at different distances from the island, as noted during each method of observation. Bird species: **a** – cormorants; **b** – gannets; **c** – penguins. Observation methods: **H** – historical incidentals; **I** – project incidentals; **S** – focal event sampling; **C** – continuous observations.

Figure 3.5 is a graphic representation of the spatial distribution of seal-seabird predations around Ichaboe Island, as seen during each method of observation.




S C

**Figure 3.5.** Plots of the spatial distribution of the number of predations noted, as a percentage of the total, by each observational method. The dark centre circle in each graph represents the island; the concentric rings represent distances at 200m intervals from the island. Observation methods: **H** – historical incidentals; **I** – project incidentals; **S** – focal event sampling; **C** – continuous observations.

*Proportion of predations represented in incidental records*

Incidental observations of predation events, when compared with records of events that were recorded systematically, underestimate by up to 36% the number of birds taken by seals in a season (Table 3.2).

**Table 3.2.** The number of seal-seabird predations noted (N) during incidental observations and missed (M) by this method (but noted during systematic observations) between November 1999 and May 2000 at Ichaboe Island, and the calculated values for PI. Pr – total number of predations noted during this period.

| Bird species | N | M | Total (Pr) | PI |
|---|---|---|---|---|
| Cormorants | 136 | 48 | 184 | 0.74 |
| Gannets | 32 | 18 | 50 | 0.64 |
| Penguins | 16 | 5 | 21 | 0.76 |

The number of predations for the ten-year period increases from 2989 to 3995, when adjusted for events not recorded during incidental observations (Table 3.3).

**Table 3.3.** Calculation of the adjusted values of predation for the ten-year period under discussion. TI – sum of all incidental observations excluding project records; PI – proportion of predations represented in incidental records; Pr – predatory events noted between November 1999 and May 2000.

| | TI | PI | TI / PI | Pr | (TI/ PI) + Pr = Total |
|---|---|---|---|---|---|
| Cormorants | 1122 | 0.74 | 1518 | 184 | 1702 |
| Gannets | 975 | 0.64 | 1523 | 50 | 1573 |
| Penguins | 532 | 0.76 | 698 | 21 | 719 |

## DISCUSSION

*Bird species preyed upon*

The ratio of bird species preyed upon differs with respect to the method of observation; this may be due to the large annual variation in predatory activity (see Chapter 4). Moreover, if there are individual seals targeting specific prey species, this will further affect the species and numbers of birds preyed upon per annum. Because the methods did not all run concurrently, these cannot be compared adequately. However, regardless of the method of observation, cormorant predations were the most numerous, followed by gannets and then penguins, which reflect the abundance (or availability) of each species on the island (see Chapter 5).

The difference between bird species preyed upon as noted during each method of observation may reflect annual variation. Furthermore, cormorants (especially fledglings) may be taken by seals opportunistically (as opposed to being targeted) more often than the other species; such predation is bound to be variable.

*Continuous observations versus focal event sampling*

Because all predations within a given time will be noted during continuous observations, it is reliable as a measure of predation rate per hour. In contrast, focal event sampling cannot be used for calculating rates, but rather has value in investigating diurnal, seasonal and environmental influences on predation. In any case, predation rate cannot safely be extrapolated temporally, due to seasonal and annual variation, and the differences between prey species (see Chapter 4).

While the DDU focal event sampling systematically sampled diurnal and seasonal ranges, which other methods of observation lack, it nevertheless misses some predation. This method is complemented by continuous observations, which have poor diurnal or seasonal representation, but which noted all predatory activity during the observation period. A combination of these methods may therefore be best in investigating this behaviour.

*Predation cues*

Predation cues differ between methods due to the differences in bird species preyed upon as noted during each observational method. The presence of kelp gulls serve to confirm predatory activity, and formed the most important first cue for each method (Figure 3.1). These birds are observant, recognising a potential source of food and competing with other gulls for it. Kelp gulls scavenging bird carcasses that had been preyed upon by seals, alert the observer to these. Therefore, watching kelp gull behaviour may be easier and more reliable than looking for predatory activity (such as an attack or thrashing). Likewise, gannet clouds are an important cue – mostly associated with a gannet predation (see *Predation cues*, Chapter 2) – that contributed over 20% of first cues for each method except continuous observations. This may be due to the small number of gannet predations noted during continuous observations; moreover, cues such as an attack or thrashing would be noticed before a gannet cloud forms. Indeed, these cues (attack and thrashing) were more prevalent during continuous observations. Such cues, of short duration, are more likely to be missed during other methods of observation. Also, no carcasses were noted as a first cue during continuous observations; this is because other predation cues were noted before the seal left the carcass. In contrast, carcasses adrift were important as first cues for incidental observations (both historical and project). Due to the opportunistic nature of these observations, it is likely that predations will be missed, especially if occurring often throughout the day. As a result, it is more convenient and more reliable to count and identify carcasses in the absence of systematic observations. Besides, carcasses of birds that have been preyed upon by seals may remain visible long after the predation (and associated cues) have ended; this cue is therefore more likely to be noticed.

The use of specific cues indicating predatory activity proved valuable in this study. One of the main advantages of such a tool is that the attention of the observer is attracted to predatory activity in a number of ways, increasing the likelihood of recording the behaviour in question.

*Diurnal differences*

Incidental observations are influenced by observer activity and vigilance, which is not constant diurnally or seasonally, and can therefore not be quantified accordingly. For this reason, it is not in itself adequate to assess temporal variation in the behaviour in question. However, the accuracy and value of this method can be evaluated when compared with systematic methods of observation. Such systematic methods can be repeated over seasons and even applied to similar studies for comparison. However, regular, systematic observations (such as focal event sampling) are not always feasible, in the absence of which opportunistic records are still valuable.

When comparing observational methods in terms of diurnal predation trends for each prey species, the overall pattern corresponds between methods, although there are significant differences. Focal event sampling, for instance, is more reliable in terms of observing predatory events throughout the day, specifically early in the morning, as evidenced by observations on gannet predations (Figure 3.2b). Diurnal variation in gannet predations as observed during project incidentals, may be ascribed to a low sample size ($n$ = 15). Penguin predation occurs mostly late afternoon, as shown by each method. This indicates that even incidental observations may reveal trends; penguin predation at this time of day is related to penguin activity (see Chapter 4). Cormorants were preyed upon throughout the day, though the diurnal distribution differs with each method used. These predations are often of short duration, and may be missed during both incidental and focal event sampling methods. Furthermore, the records with a carcass observed as first cue (which was the case only for incidental observations) were excluded from this analysis. Incidental observations would therefore not necessarily reflect the diurnal pattern of cormorant predations; 63.2% of records with carcass observed as a first cue involved cormorants. This explains the significant difference between methods for cormorant predations.

The most reliable method for assessing diurnal patterns is focal event sampling, with which the results from the other methods are compared. Incidental observations may be able to discern diurnal patterns, as indicated by the lack of any significant difference between methods regarding gannet and penguin predations.

*Environmental differences*

Trends in predation as recorded during incidental observations may be an artefact of observer activity while not necessarily providing information on seal or bird activity; this may explain the differences between incidental and regular sampling with regard to Beaufort Scale. Since focal event sampling was carried out irrespective of environmental conditions, predations were noted at high wind speeds that may have been missed had the observations been incidental. However, this does not seem to be the case for penguin predations, where incidental observations noted a higher percentage of these predations at high wind speeds than focal event sampling (Figure 3.3c).

Gannet clouds are more likely to form in conditions of strong wind (i.e. high BS), and these highly visible cues are most often associated with a gannet predation (see Chapter 2). For this reason incidental observations at high BS may be biased toward gannet predations, while cormorant and penguin predations are possibly under-represented.

For each method of observation, cormorant predations varied with BS, gannets were preyed upon during all conditions (including high BS), while the majority of penguin predations took place at a BS of less than 7. As with diurnal differences, there was a significant difference between methods regarding cormorant predations, but not for gannets and penguins, indicating that environmental patterns in predation may be adequately sampled during incidental observations, but that the accuracy may vary with bird species.

*Spatial differences*

Focal event sampling and continuous observations were carried out from an elevated observation point, such that these methods should observe predatory activity further from the island, as well as covering a greater area (343°). Furthermore, cues that are of short duration or not as easily visible will be noted more often and at greater distances during these systematic sampling methods than during incidental observations.

All cormorant predations were noted less than 600 m from the island; this is reflected in each method. Focal event sampling, however, noted a greater proportion of these between 200 m and 400 m than historical incidentals (see Figure 3.4a); this may be due to the reasons outlined above. As expected, gannet predations (which have more visible cues such as gannet clouds) were noted further from the island than cormorant or penguin predations during historical incidentals. Furthermore, this is the case for both focal event sampling and continuous observations, indicating that gannets are indeed taken at greater distances. Project incidental observations observed a greater percentage of gannet predations further than 600 m than the other methods; this may be ascribed to a small sample size ($n$ = 15). As for penguin predations, focal event sampling and project incidentals have similar percentage distributions (see Figure 3.4c); however, both these had low sample sizes (see Table 3.1). The historical incidental observations of penguin predations may therefore be a more accurate representation of the distance from the island that these birds are preyed upon by seals than the data obtained from systematic observations.

The glare of the sun on the water in the morning or late afternoon may have made identification of prey difficult, or even caused predatory events not to be noticed. However, this is believed to have been a problem only during incidental observations, as polarised eyewear was used during the systematic observations, alleviating the glare and enabling observations.

The paucity of observations further than 400 m and to the southern side (west through south-south-east) of the island during project incidentals, focal event sampling and continuous observations when compared with historical incidentals (see Figure 3.5), may be as a result of seasonal differences in the spatial distribution of predation (see Chapter 4). The majority of predations noted incidentally (this term refers to both historical and project incidentals) were recorded in the north-eastern and eastern sectors, which are easily visible from the settlement, where the observer would be spending the most time. Focal event sampling and continuous observations also recorded larger percentages of predation in these sectors, so this is not simply an artefact of incidental observations. Using these methods, however, a concentration of predation was noted in the western sector (west and west south west) between 200 m and 400 m offshore. This is the same sector where the seal colony is situated (see Figure 1.2); predations in this area are therefore under-represented in incidental observations.

The significant differences between methods concerning the distances that predation was noted from the island for each prey species suggest that the method of observation (especially incidental observations) may have introduced bias in these results.

*Evaluation of incidental observations*

The comparison of incidental observations with systematic observations of seal-seabird predation has highlighted possible sources of bias in the former. These concern diurnal, environmental and spatial biases that differ per prey species. Despite these, incidental observations may reveal trends in predation that are biologically significant. The value of the historical incidental observations in this study is increased as a result of these having been carried out by the same observer over a long period of time (eight years); short-term incidental observations by different observers might not have revealed biologically significant trends.

The quantification of the proportion of predatory events that are represented in incidental records allows for more realistic values of predation to be calculated for the period when observations were incidental. Though this has revealed that up to a third of predations may be missed during this method, it is nevertheless recommended that incidental observations be carried out in the absence of systematic observations, provided detailed records are kept, because every individual record is valuable in investigating this behaviour.

# CHAPTER 4: ENVIRONMENTAL, SPATIAL AND TEMPORAL VARIATION

## INTRODUCTION

Quantification of environmental, spatial and temporal variation in animal behaviour may provide insight into the behaviour in question. However, these may vary greatly both on the population and the individual level.

It has been established that seal-seabird predation is not a common, stereotyped behaviour, but rather that a few individuals develop their own preferences and techniques (see Chapter 2). Therefore, environmental, spatial and temporal aspects of predation may vary with individual predators, and would not necessarily be reflected as trends in overall predation. Nevertheless, bird activity is constrained by these factors, such that seals may encounter different bird species (or age classes of birds) depending on environmental conditions, location and season or time of day. For instance, seasonal variation in predation may be attributed to prey availability, especially newly fledged gannets and cormorants, which form a third of predations noted (see Results). Furthermore, observed environmental, spatial and temporal variation in seal-seabird predation is likely to be influenced not only by seal and bird behaviour, but also by the method of observation (see Chapter 3).

There is little quantitative information available in the literature concerning factors that influence seal-seabird predation. Penney & Lowry (1967) found that surf and sea conditions influence predation by leopard seals on Adelie penguins, but no diurnal pattern was evident. They made use of continuous observations, which are quantifiable (see Chapter 3). Other accounts of seal-seabird predation in the literature (see Chapter 2 for references) are descriptive rather than quantitative, primarily due to the incidental nature of the observations.

However, in the present study (as shown in Chapter 3), incidental observations – which form the bulk of the data – may reveal trends in predation despite the biases inherent in this sampling technique. The present attempt at quantifying aspects of seal-seabird predatory activity serves as an exploratory investigation to gain insight into the differences between prey species with respect to various factors, and is the subject of this chapter.

## METHODS

The methods of observation and recording of predatory activity are described in Chapter 3. Because environmental, spatial and temporal parameters are valid as measured for each event, regardless of the method of observation, all records of predation were grouped and these trends investigated.

Various environmental factors were recorded daily. The sea surface temperature (SST) was measured every morning at 08:00 by collecting a sample of seawater and measuring the temperature to the closest 0.1°C. The wind speed (according to the Beaufort Scale (BS)), and wind direction were recorded daily at 08:00, 14:00 and 20:00. For each predation record, the BS recorded at the time (08:00, 14:00 or 20:00) closest to the time of the predation was entered for the historical incidental data, whereas the BS at the time of the predation was used for the other methods.

### *Database*

The database used for the investigation of above-mentioned trends consists of 2989 individual records of seal-seabird predation, noted between 21 September 1991 and 17 May 2001 at Ichaboe Island. BS data were available for the period 16 July

1993 to 31 May 2000; these values were averaged to obtain a single value per day. Daily SST measurements from 6 September 1991 to 14 August 2001 were used.

SST anomalies were calculated as the difference between the individual value of a particular day within a year and the average SST of that day over the years. Therefore, a positive anomaly indicates that the temperature was warmer on the day in question than the average value for that day over the years for which the data is available. These records of ambient environmental conditions are referred to as "overall" conditions.

*Selection of records*

Records were grouped according to the parameter being investigated. A year was chosen such that it started on 1 July and ended on 30 June in order to incorporate the annual peak in predation. The years were numbered '1' to '10', such that year '1' runs from 1 July 1991 to 30 June 1992, year '2' from 1 July 1992 to 30 June 1993, and so forth. Each year was further divided into three periods (referred to as seasons): 1) July to October (winter); 2) November to February (breeding season); 3) March to June (fledging season).

Where bird ages are compared within species, only those records for which the age class of the bird was known, were used. Small sample sizes resulted for those species (such as penguins) where the age of the bird is difficult to determine during a predation.

*Statistical analyses*

Where more than two independent frequency distributions were compared, the Kruskal Wallis ANOVA was used; for only two groups the Kolmogorov-Smirnov

Test was used. Categorical variables were compared using the Spearman Chi-squared Test. Fisher's exact test was used to test for significance in 2 x 2 contingency tables (Summers & Underhill, 1987; see Table 4.2). Statistical significance was set at $p < 0.05$.

*Assumptions*

Individual records of predation are assumed to be independent. However, this assumption is violated on account of the fact that some seals may have been responsible for more than one predation. This departure from assumption will result in the calculated significance levels being too small, but the extent of the problem is impossible to quantify, due to the difficulty in identifying individual seals.

While observer effort is known to be inconsistent (see Chapter 3), it is assumed that there is adequate representation of sampling throughout the relevant environmental, spatial and temporal ranges under investigation.

## RESULTS

The prey could be identified in 96% ($n$ = 2876) of predatory events; of these, 75.6% of the victims could be allocated into age classes (Table 4.1).

**Table 4.1.** Number of adult and juvenile birds of each species preyed upon by seals between 21 September 1991 and 17 May 2001 at Ichaboe Island ($n$ = 2876). % - percentage of $n$. The sum of adults and juveniles differ from the total in cases where the species, but not the age of the bird, was identified.

| | Adults | Juveniles | Total | % |
|---|---|---|---|---|
| Cape gannets | 569 | 449 | 1021 | 35.5 |
| African penguins | 384 | 44 | 549 | 19.1 |
| Cormorants | 183 | 545 | 1306 | 45.4 |
| of which: | | | | |
| Cape cormorants | 99 | 456 | 555 | 19.3 |
| Bank cormorants | 53 | 89 | 142 | 4.9 |

*Temporal factors*

*- Annual*

There was marked inter-annual variation in the number of birds preyed upon (Kruskal-Wallis ANOVA: H (9, $n$ = 2904) = 586.48; $p < 0.001$) (Figure 4.1). Four distinct phases are evident in the annual pattern of predation:

- years 1 and 2, where 93.5% of predations noted involved adult birds;
- years 3 and 4, which together account for only 2.1% of predations and where 96.7% of birds preyed upon were adults;
- years 5 to 8, which incorporate a peak in predatory activity, and where predation on juveniles (71.6%) exceeds that of adults;
- years 9 and 10, during which more adult birds (54.7%) were preyed upon than juveniles.

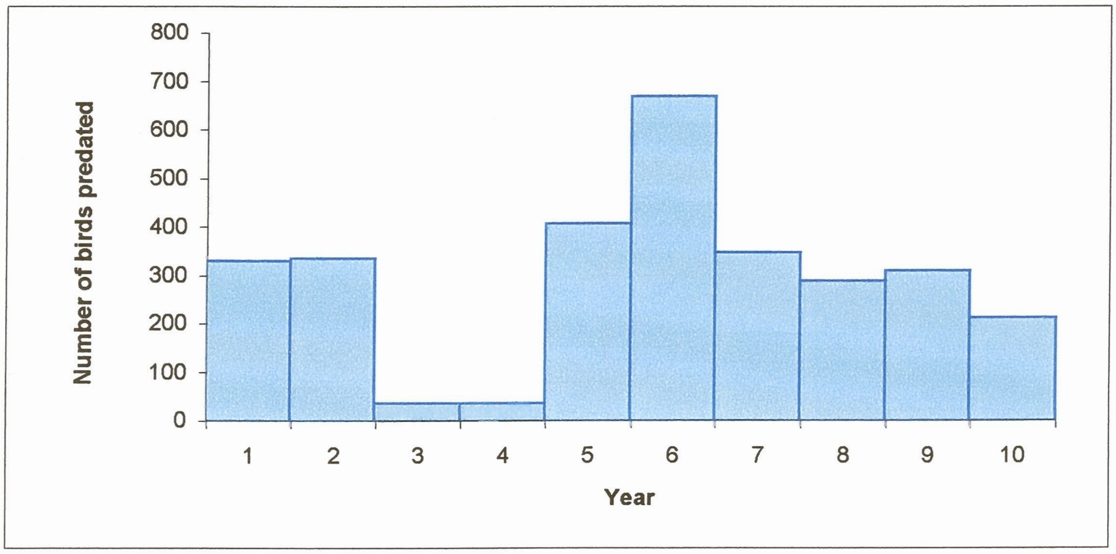



**Figure 4.1.** Frequency distribution of the number of birds preyed upon by seals at Ichaboe Island per year, where year '1' runs from 1 July 1991 to 30 June 1992, year '2' from 1 July 1992 to 30 June 1993, and so forth.

*- Seasonal*

When the total number of predations noted per year, as illustrated in Figure 4.1, is separated according to season as well as the respective prey species and ages (Figure 4.2), further differences are evident.

For each prey species, the number of adults and juveniles preyed upon, differed significantly with respect to season (Kolmogorov-Smirnov Tests: gannets: $p < 0.001$; penguins: $p < 0.05$; Cape cormorants: $p < 0.001$; bank cormorants: $p < 0.001$). Whereas 92.8% of predations involving a juvenile bird occurred in season 3 (March to June), the majority (65.5%) of adult birds fell prey to seals in season 2 (November to February). This, together with the four phases mentioned earlier, is illustrated in Figure 4.2.

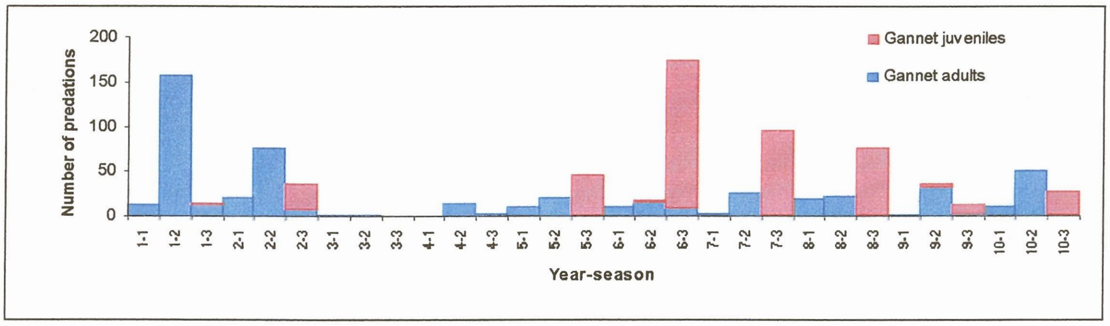



**Figure 4.2a**

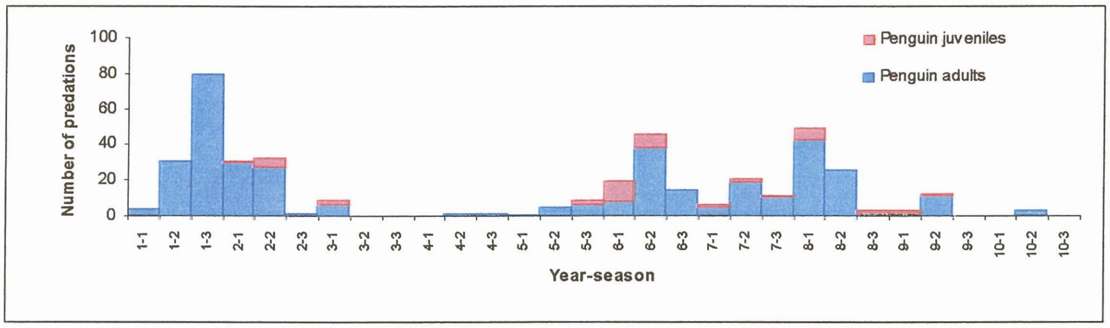



**Figure 4.2b**

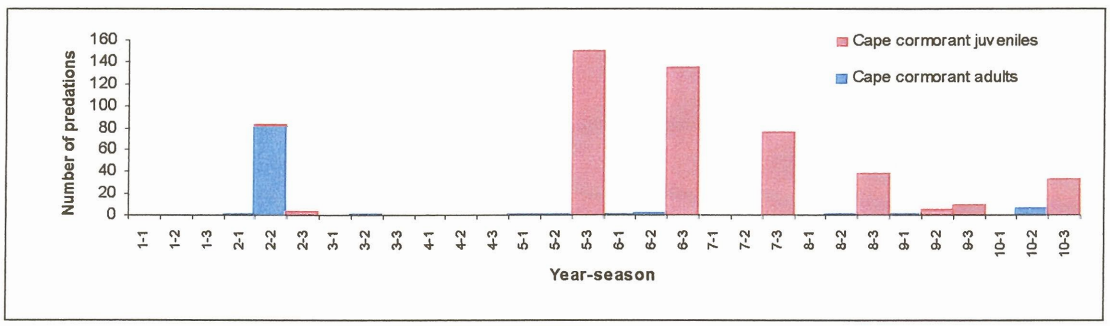



**Figure 4.2c**

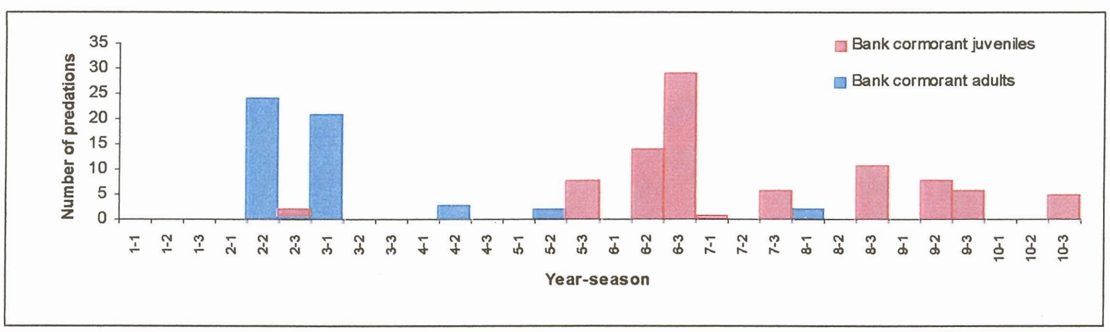



**Figure 4.2d**

**Figure 4.2.** Number of adult and juvenile birds preyed upon by seals in each season over ten years (see text for details). Bird species predated: **a** – gannets; **b** – penguins; **c** – Cape cormorants; **d** – Bank cormorants.

Peaks in predatory activity were evident during those times when the four seals that were individually identifiable (see Chapter 2) were actively preying upon birds. During year 2, seasons 2 and 3, at least 68.9% of Cape cormorant and 76.9% of bank cormorant predations were carried out by "U" (2-2 to 2-3, Figure 4.2c,d). Broad Flipper was active during the peak in penguin predation in year 1, seasons 2 and 3 (1-2 to 1-3, Figure 4.2b). The 1996/1997 peak in predatory activity falls within the period when both Blunt Flipper and Ragged Flipper were active. Blunt Flipper was observed killing all four bird species, and contributed to the number of predations from year 5, season 3 to year 8, season 2 (5-3 to 8-2, Figure 4.2). Ragged Flipper was seen preying on penguins only, and was active between season 2 of year 6 to season 1, year 8 (6-2 to 8-1, Figure 4.2b). The predations on gannet fledglings in April and May 1993 (2-3, Figure 4.2a) are likely to have been carried out by an individual seal which only removed the viscera of the birds.

*- Diurnal*

Within each prey species, the time of day that adults and juveniles were taken by seals differs significantly (Kolmogorov-Smirnov Tests: gannets: $p < 0.001$; penguins: $p < 0.05$; Cape cormorants: $p < 0.001$; bank cormorants: $p < 0.05$) (Figure 4.3). While gannet fledglings were taken predominantly at midday, adult gannets were seen to fall prey to seals throughout the day, peaking after midday (Figure 4.3a). Over 85% of penguins identified as adults fell prey to seals after midday; juveniles of the same species were also preyed upon predominantly in the afternoon (Figure 4.3b). Adult Cape and bank cormorants were preyed upon in the morning, and again in the late afternoon. Juvenile Cape cormorants were preyed upon by seals throughout the day; predations on bank cormorant juveniles peak at midday (Figures 4.3c, d).

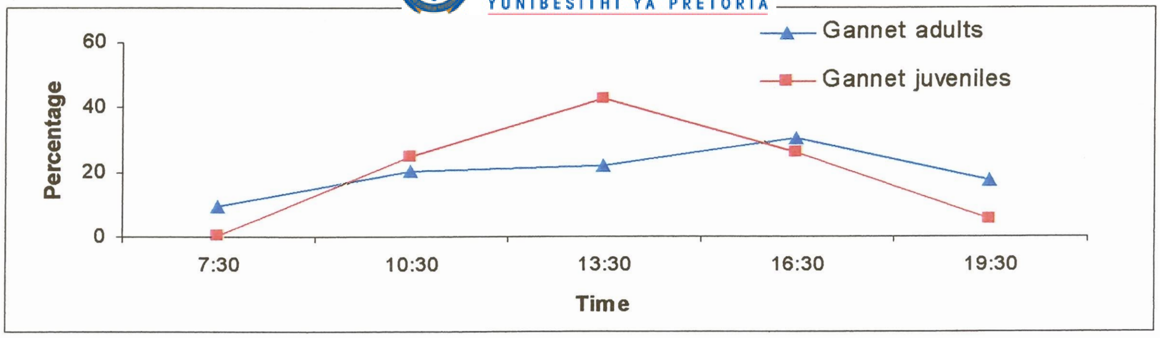



**Figure 4.3a**

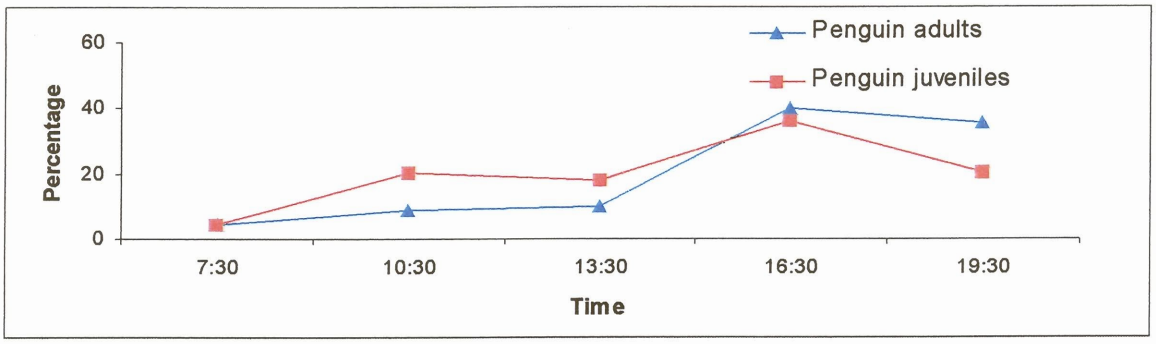



**Figure 4.3b**

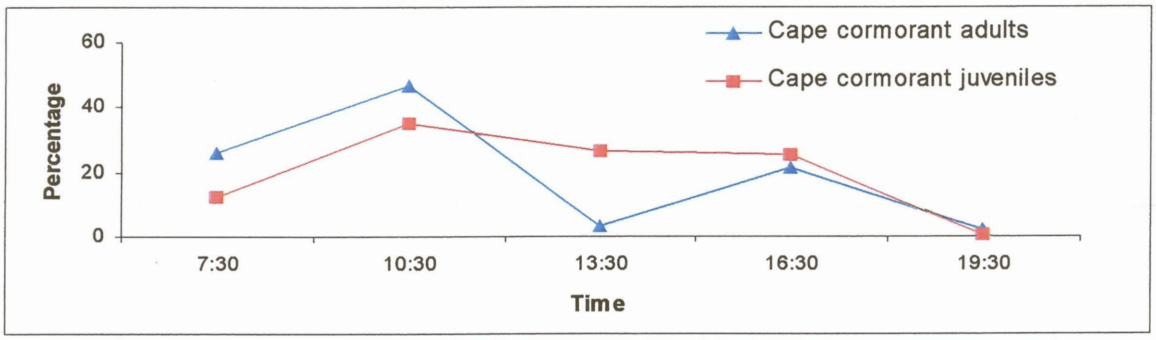



**Figure 4.3c**

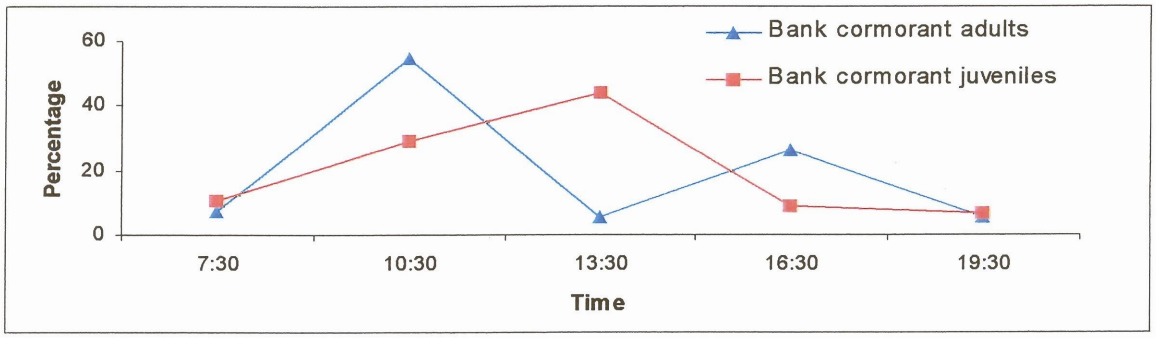



**Figure 4.3d**

**Figure 4.3.** Percentage distributions of the number of adult and juvenile birds preyed upon by seals throughout the day. Bird species: **a** – gannets; **b** – penguins; **c** – Cape cormorants; **d** – bank cormorants.

*Environmental factors*

*- Beaufort Scale*

While the Beaufort Scale of wind speed as measured during gannet and cormorant predations differed significantly from the overall BS (Kolmogorov-Smirnov Test; $p < 0.001$ in each case), this was not the case for penguin predations (Kolmogorov-Smirnov Test; p = n.s.) (Figure 4.4). A peak in predatory activity was noted at BS 4 for each prey species. A greater percentage of gannet predations occurred in conditions of high wind speed than both penguin and cormorant predations; this is also evident in Figure 4.5.

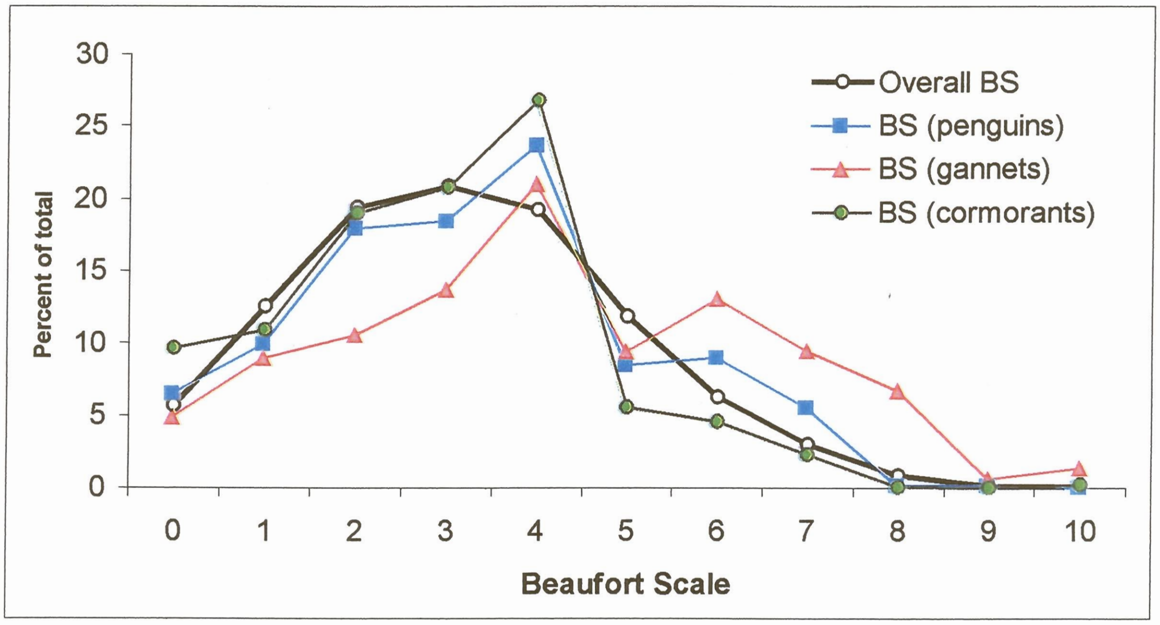



**Figure 4.4.** Comparison between overall Beaufort Scale and Beaufort Scale associated with predations by seals involving penguins, gannets and cormorants.

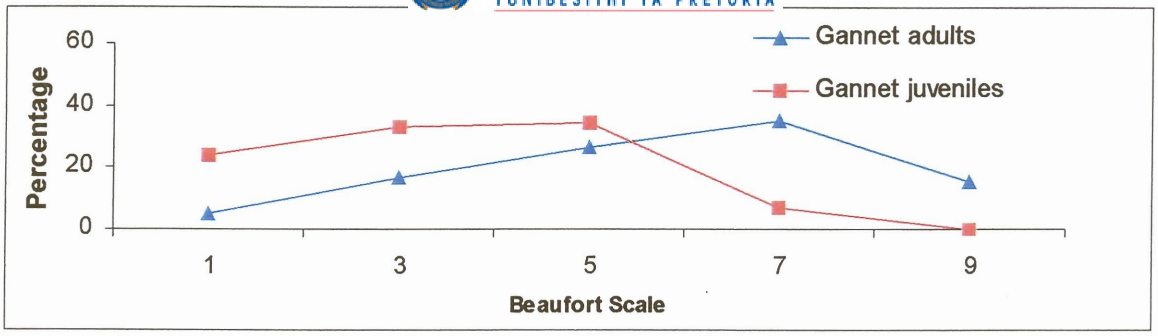



**Figure 4.5a**

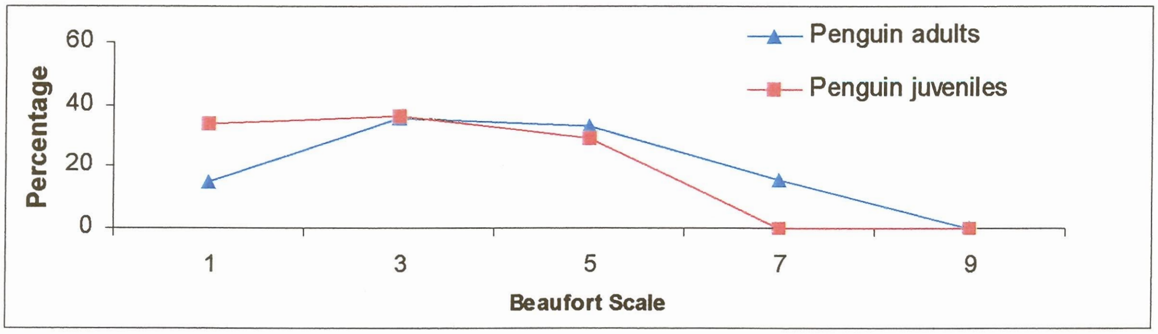



**Figure 4.5b**

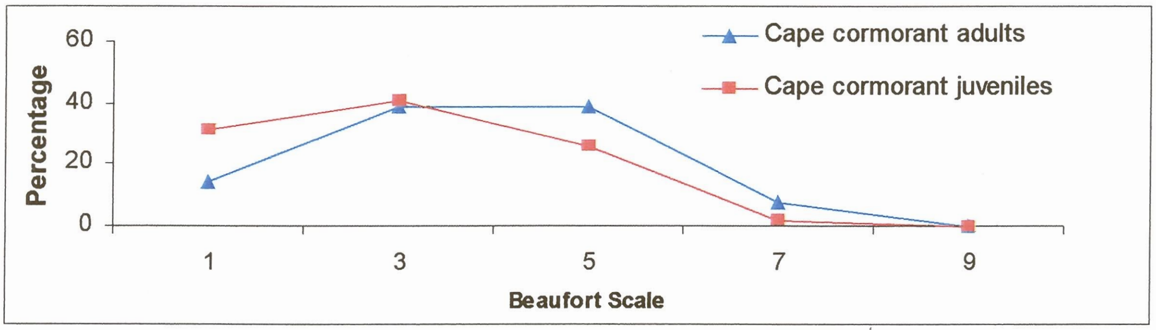



**Figure 4.5c**

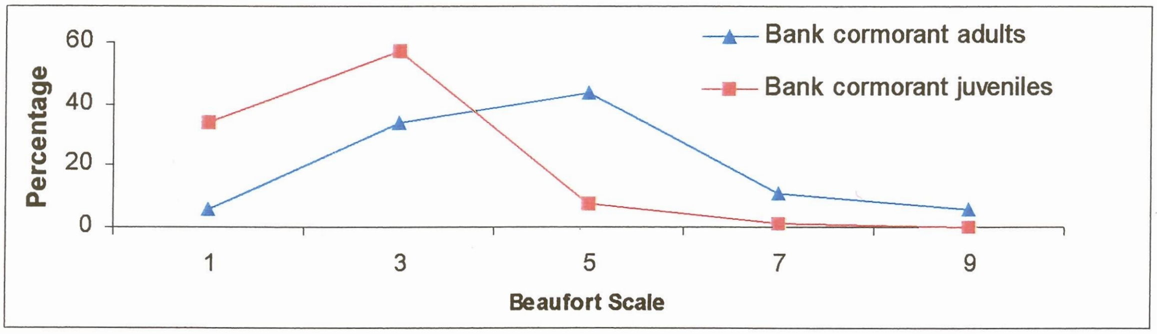


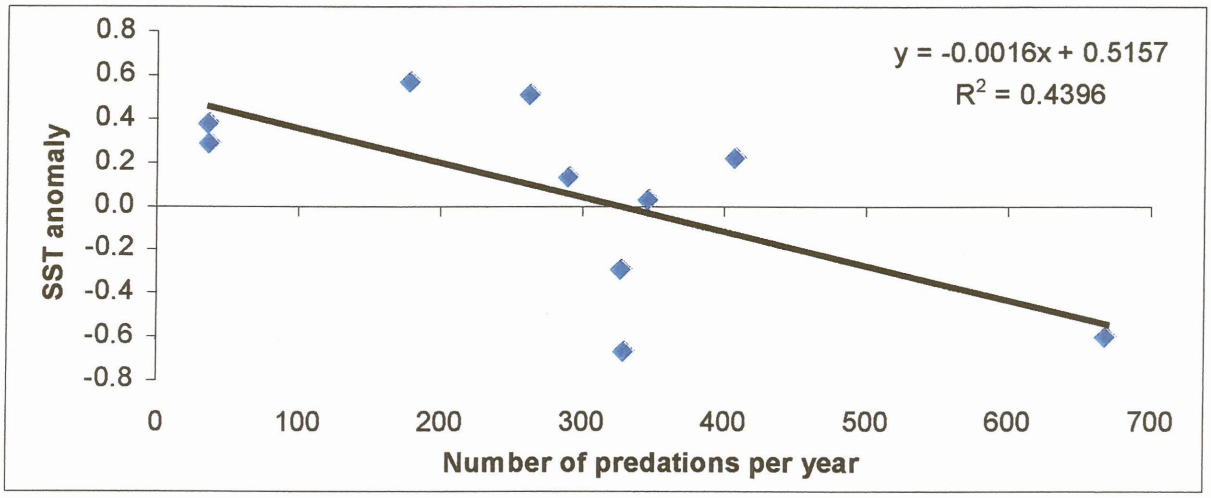

**Figure 4.5d**

**Figure 4.5.** Percentage distributions of the number of adult and juvenile birds preyed upon by seals at different wind speeds, as measured by the Beaufort Scale. Bird species: **a** – gannets; **b** – penguins; **c** – Cape cormorants; **d** – bank cormorants.

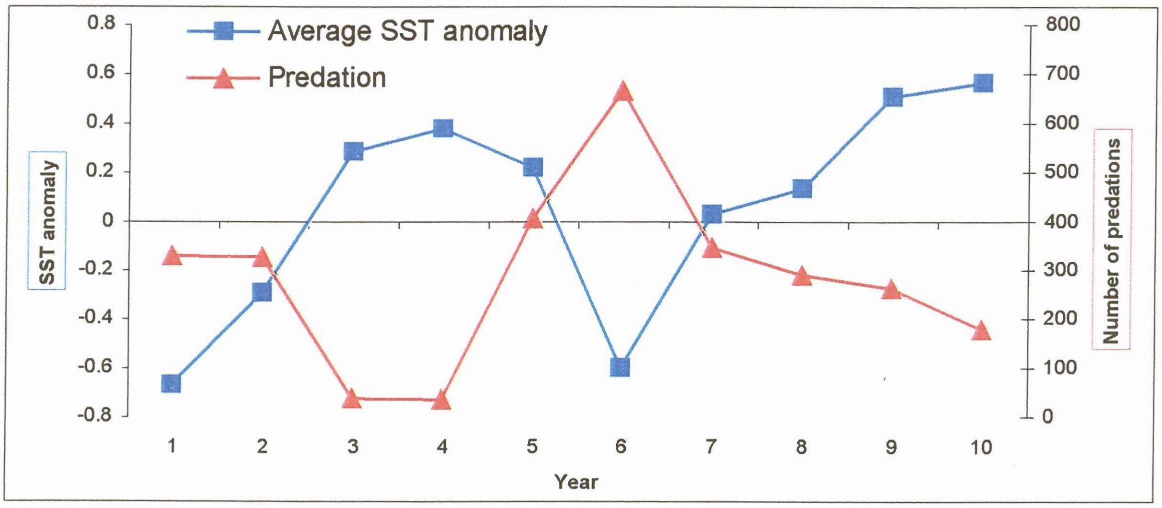
Adult gannets were preyed upon at higher wind speeds than juveniles (Kolmogorov-Smirnov Test, $p < 0.001$; Figure 4.5a); over 94% of predations noted at BS 8 and 9 involved adult gannets. Penguin predations were noted predominantly at BS 2 to 5; adults and juveniles differ significantly (Kolmogorov-Smirnov Test, $p < 0.01$; Figure 4.5b). Predation on newly fledged as well as adult Cape cormorants differ significantly (Kolmogorov-Smirnov Test, $p < 0.01$; Figure 4.5c) but were both noted almost exclusively at wind speeds of less than 27 knots (BS 6). Adult bank cormorants were seen to be taken by seals at higher BS than juveniles of the same species (Kolmogorov-Smirnov Test, $p < 0.001$; Figure 4.5d).

*- Sea Surface Temperature*

There is an inverse relationship between the annual average SST anomalies and the number of seal-seabird predations per year (Figure 4.6a). Annual predation rates of less than 300 birds all correspond with positive annual average SST anomalies, while during those years with a negative average SST anomaly, over 300 birds fell prey to seals. Figure 4.6b illustrates the annual trends in predation and SST anomalies. This relationship was found not to be significant when using high-low categories but significant when using the change between years, when examined using 2x2 contingency tables (Table 4.2).




a




b

**Figure 4.6.** The relationship between the annual average sea surface temperature (SST) anomalies and the number of seal-seabird predations noted per year. **a** – linear relationship; **b** – plot per annum.

**Table 4.2.** Relationships between the annual average SST anomaly and the number of predations per year. Contingency tables: **A** – using high-low categories, **B** – using change. Probabilities are based on Fisher's exact test (two-tailed).

**A**

| | Annual predation | |
|---|---|---|
| SST anomaly | High (>300) | Low (<300) |
| High (>0.2) | 1 | 4 |
| Low (<0.2) | 4 | 1 |
| Probability | 0.2064 | |

**B**

| | Annual predation | |
|---|---|---|
| SST anomaly | Rise | Fall or same |
| Rise | 0 | 7 |
| Fall | 2 | 0 |
| Probability | 0.0138 | |

*Spatial factors*

While the majority of penguin and cormorant predations was noted less than 200 m from the island, this is not the case for gannets, which were noted to fall prey to seals as far as 1000 m from the island. Over 42% of adult gannet predations (for which distance data is available) occurred at a distance greater than 400 m from the island (Figure 4.7a). In contrast, only 3.5% of predations on newly fledged gannets were recorded in this distance class (Kolmogorov-Smirnov Test, $p < 0.001$) (Figure 4.7a).

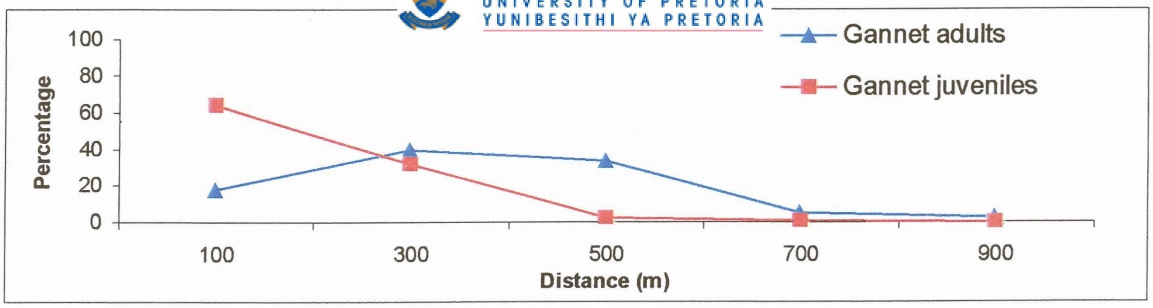



**Figure 4.7a**

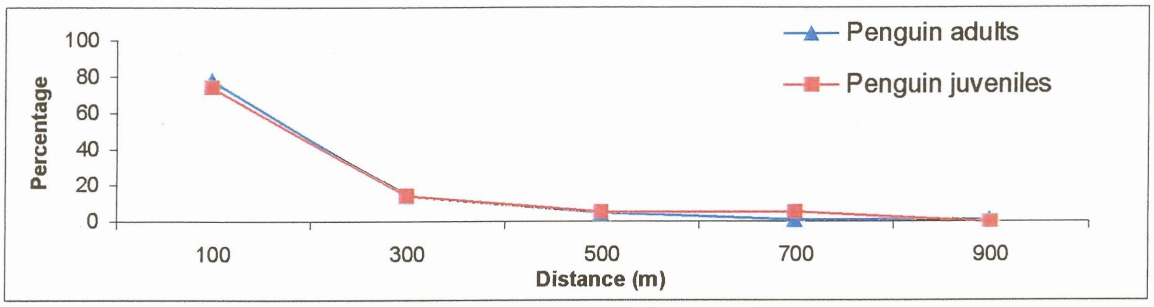



**Figure 4.7b**

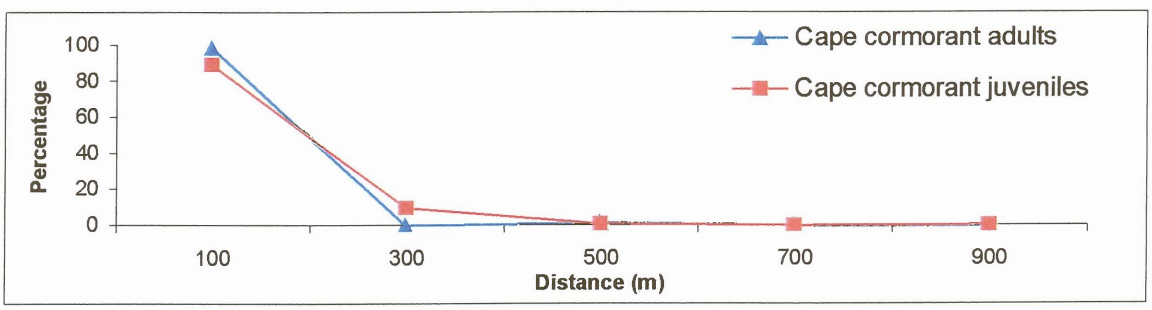



**Figure 4.7c**

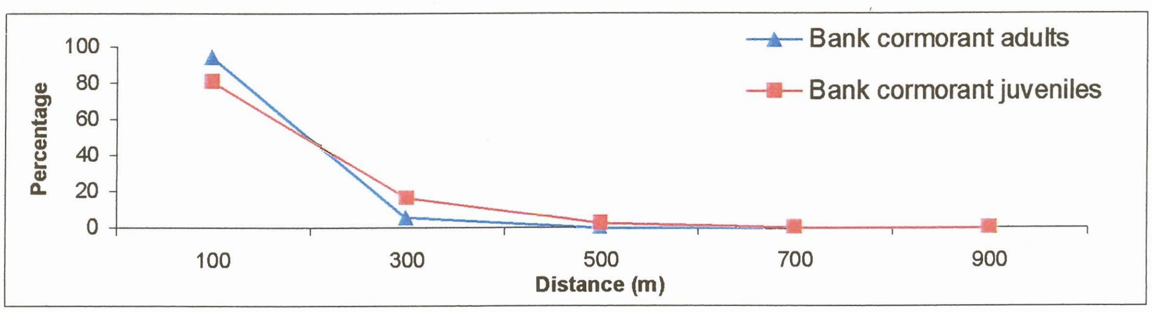



**Figure 4.7d**

**Figure 4.7.** Percentage distributions of the number of adult and juvenile birds preyed upon by seals at different distances from the island. Bird species: **a** – gannets; **b** – penguins; **c** – Cape cormorants; **d** – bank cormorants.

## DISCUSSION

### *Bird species preyed upon*

During the seal's thrashing action, and when the bird is tossed in an arc through the air, the prey may be identified by its size, shape and colour. For instance, the flailing wings of a cormorant being thrashed and its relatively small size confirms the genus but not the species of bird preyed upon. Only if the carcass is collected can the species and age be determined. Gannets, on the other hand, are easier to identify during a predatory event, or even when a drifting carcass is seen from a distance, due to their large size, and distinct colour difference between adults and fledglings. Penguins have a characteristic silhouette that can be identified at a distance if tossed by the seal; because this does not always occur, the identification of penguins falling prey to seals may be under-represented. Furthermore, adult penguins can be identified by the presence of white colouration on the carcass, while juveniles can only be positively identified upon inspection of the carcass.

Due to these differences in the probability of identifying the age and species of birds falling prey to seals, the numbers given in Table 4.1 are not an accurate reflection of the actual numbers of birds taken. Moreover, because the majority of the observations were incidental, this may further skew the observed numbers of different bird species preyed upon. Nevertheless, the environmental, spatial and temporal parameters recorded for each event are relevant to the particular prey species, the analysis of which may reveal biologically significant trends.

### *Annual trends in predation*

The large annual variation in the number of records of seal-seabird predation may be partly ascribed to the incidental nature of the majority of the observations.

However, this variation also serves to confirm that birds do not form part of the normal prey of these seals – opportunistic predation is bound to be variable. Despite this, a decrease in predatory activity is noted between years 6 and 10, which may coincide with the decline in bird populations over this time (see Chapter 5), as well as SST anomalies (see later). Furthermore, seals specialising in seabird predation and taking large numbers of birds in a particular year or season (see Chapter 2) may contribute to the annual and seasonal variation noted, especially if a particular prey species is targeted. It is likely that peaks in predation of a particular prey species and age – such as in year 1, season 2, where the highest number of adult gannet predations was recorded (Figure 4.2a) – are due to one or more seals targeting this prey. Such behaviour may also explain the predominantly adult prey prior to year 5. The small number of seal-seabird predations noted in years 3 and 4 may be linked to a rise in sea temperature at this time (see later). The removal of seals specialising in taking seabirds has unnaturally contributed to the seasonal and annual variation in predation.

The seal population at Little Ichaboe has grown over the past 10 years, with increased recruitment of young seals as well as an increase in pup production (MFMR, unpublished data), resulting in a larger subadult age-group around Ichaboe. Concomitant with the increase in breeding activity by seals on Little Ichaboe, larger numbers of subadult seals are displaced each year. As this age-group was responsible for the most seabird predations, an increase in predatory activity over the 10-year period is expected. That this was not the case suggests that not all seals prey on seabirds.

*Seasonal trends*

The seasons defined for this study, namely winter (July to October), breeding season (November to February) and fledging season (March to June), proved useful in highlighting the seasonality in the pattern of predation. Figure 4.2 shows that newly-fledged gannets and Cape cormorants fall prey to seals almost exclusively in season 3 (fledging season), while bank cormorants sometimes fledge earlier in the year. Penguins, on the other hand, are not as synchronised in their breeding, and juvenile penguins are present year-round. The paucity of juvenile penguin predations may be attributed to the difficulty in identifying the age of these birds during a predatory event. Trends may be obscured by the large variation resulting from small sample sizes.

Fledgling gannets and cormorants are easy prey for seals (see Chapter 2), and may be both targeted and taken opportunistically; hence their large representation in the predation records.

*Diurnal trends*

The large number of adult gannet predations in the afternoon may be linked to wind speed (see below). Newly fledged gannets leave the island throughout the morning, and are at peak numbers on the water at midday, returning to the island or swimming beyond the area of predatory activity by late afternoon. Their diurnal pattern of predation therefore corresponds with the number of birds sitting on the water and available for seals to take as prey.

Penguins return to the island in the late afternoon in groups, satiated and probably swimming more slowly than usual. Some seals capitalise on this (see

Chapter 2), ambushing these birds close to their haul-out sites on the island, hence the increase in observed penguin predations at this time.

The activity of adult cormorants diving for nesting material peaks at mid-morning (pers. obs); the number of these birds falling prey to seals follows the same trend. The second spurt of predation on adult cormorants in the late afternoon may be attributable to the presence on the water of birds washing themselves after being relieved from their nests by partners that have returned from a day's fishing (pers. obs).

Juvenile cormorants gather in groups on the beaches in the morning, and are present in large numbers on the water by mid-morning, hence the observed peak in predatory activity. As the juvenile Cape cormorants disperse later in the day, or take off from the water, aided by an increase in wind, a peak in predation on newly-fledged bank cormorants is noted, which are heavier and possibly have more difficulty in take-off. A further consideration in the observed diurnal pattern of juvenile cormorant predation is the collection of carcasses by the observer. Juvenile cormorants can only be accurately identified upon inspection of the carcass; the peak in mid-morning predations of these may be partially attributable to the preferred time of the observer to go out onto the water and collect carcasses preyed upon by seals.

*Beaufort Scale*

Newly-fledged gannets are unable to take off from the water unless aided by wind, due to their heavy fledging weight (Navarro 2000), so at low wind speeds cannot escape predation by seals. Adult gannet fishing activity increases with wind speed (Nelson 1978; pers. obs), which generally increases through the day. Furthermore, gannet clouds tend to form in conditions of strong wind; because these are highly visible cues mostly indicating gannet predations (see Chapter 2), observed predation in these conditions may be biased toward gannets.

Because penguin activity is not influenced by wind to the same extent as the activity of flying birds, predation on this species at different BS is not expected to differ from overall conditions, which was indeed found to be the case (see Figure 4.4).

During conditions of strong wind, sea conditions may obscure cormorant predations, which are of short duration and not associated with conspicuous cues (see Chapter 2). These may therefore be under-represented at high BS. However, cormorant activity also increases with wind, such that these birds may be further afield during conditions of greater wind speed.

The observed peak in predatory activity for each prey species at BS 4 is an artefact of the method of recording this data for the records during the historical incidental observations, which form the bulk of the data. Predation events occurring between 11:00 and 17:00 (which constitute the majority of the records) would have been assigned the BS as recorded at 14:00. The general increase in wind speed after 14:00 would therefore not be reflected in predation records.

*Sea surface temperature*

The differences in the p-values as calculated using Fisher's exact test, in Table 4.2 are ascribed to the small sample size; however, the biological significance is of more importance.

Negative SST anomalies are associated with cold water upwelling, which culminates in large fish stocks (Boyera *et al.* 2000). When daily SST anomalies are averaged over a year, and the result is negative, this indicates that more upwelling occurred in that particular year than average. A negative annual average SST anomaly may therefore indicate that there was more fish available for both seals and birds during that year, and vice versa. If this is the case, predation on seabirds is apparently greater in years when there is abundant fish (see Figure 4.6). During years 3 and 4, when seal-seabird predation was at its lowest at Ichaboe, oxygen-poor water was widespread, and an estimated 300 000 seals – almost a third of the total Namibian population – died of malnutrition (Roux 1998). This may serve to confirm that seals do not prey on birds as an alternative food resource.

It is possible that seabird predation is energetically more costly for seals than preying on fish, and that in "poor" years (positive average SST anomaly) seals are searching for fish rather than taking birds. This also supports the hypothesis that seabird predation by seals may be an extension of play behaviour, which is energetically costly (Nunes, Muecke, Anthony & Batterbee 1999). King (1983) describes the young males in particular as active and noisy, also engaging in play.

Roux (1998) relates an incident in 1988 when an increase in the SST in the Lüderitz region due to a lack of wind resulted in seals being unable to find enough fish in the vicinity of their breeding colonies. Therefore, in "poor" years, both seals and birds would be searching further afield for fish, such that seal-seabird predatory interactions are unlikely to be observed from the island.

The above explanation for the relationship between the SST anomalies and the number of birds predated by seals per year is speculation, as no evidence of the same could be found in the literature.

*Distance*

Gannet clouds, being a highly visible cue to predatory activity (see Chapter 2), are likely to been seen at great distances. Because these are mostly associated with predatory events involving adult gannets, the distribution of observed predations may be skewed toward these birds at greater distances from the island. Furthermore, the large size and white colouring of adult gannets may make carcasses of these birds visible at up to 1000 m. However, the fishing activity of these birds occurs mostly farther than 500 m from the island, which may account for the observed distances at which these birds were seen to be taken by seals. Newly-fledged gannets were taken while swimming out from the island, or while sitting on the water, where they spend a large proportion of their time at this stage of their lives.

Though penguin and cormorant predations were less visible than those involving gannets, the large number of these birds falling prey to seals close to the island can be explained in terms of the birds' behaviour. Penguins were caught close to the island when leaving or returning in groups from their haul-out sites, and may form a larger target for seals, especially in the afternoon when satiated. Some seals ambushed and killed penguins close to these haul-out sites (see Chapter 2). Cormorant adults were taken while they are diving for nesting material in the shallows around the island, while the fledglings were targeted by seals while they are sitting on the water in large groups close to the island.

# CHAPTER 5: IMPACT OF SEAL-SEABIRD PREDATION

## INTRODUCTION

In order to investigate the impact of seal-seabird predation on populations at Ichaboe Island, it is important to compare this with other mortality factors that influence the bird populations. These include insufficient food resources, oiling, kelp gull predation, heat stress, diseases and deliberate or accidental human-induced mortalities (see Chapter 1). Seabirds have low adult mortality rates and are generally long-lived (Berruti *et al.* 1989). Factors contributing to the mortality of especially the breeding populations need to be addressed in attempting to improve the conservation status of these birds.

The predation impact by seals on penguins at Lambert's Bay (20% of chicks fledged and 4% of adults annually) is believed to be unsustainable, as recruitment to the breeding population is prevented. Seal predation alone may cause the extinction of this colony in 23 years' time. Therefore, predation by seals threaten the survival of small populations of seabirds (Crawford *et al.* 2001).

Cape cormorants were the most numerous seabird species breeding on Ichaboe for each of the ten years covered in this study, followed by Cape gannets, African penguins and Bank cormorants (MFMR unpublished data). The total observed predation by seals on gannets ($n$ = 1021) exceeds that of Cape cormorants ($n$ = 555) for this period, implying a greater predation pressure on the gannet population. However, predatory events involving cormorants are under-represented in the data at hand due to the inherent difficulties of observation at high wind speeds and possibly at greater distances from the island, whereas those involving gannets are more readily noted (see Chapter 4). Therefore, incidental observations would note a greater proportion of gannet than cormorant predations. It is necessary to address such bias in results when using the figures to calculate predation pressures. Furthermore, the number of birds that fledge per nest may be site specific and differ per season (MFMR, unpublished data); this may introduce further error in the calculation of predation pressure.

An unknown cause of mortality in gannets, particularly the adults, unknown (or unreported) except at Ichaboe Island, is that of "soaking", where these birds lose their waterproofing and may die of hypothermia and loss of condition (du Toit & Bartlett, 2001). This added mortality factor was investigated in order to assess its relative importance.

## METHODS

*Calculation of predation impact per species*

The sum, over a one-year period (July to June), of counts of the number of adult penguins in the feather shedding stage of their moult, made at 14-day intervals, is used as a conservative estimate of the number of adult penguins (Crawford & Dyer 1995; Crawford *et al.* 1990). Peak active nest counts of Cape and bank cormorants (MFMR unpublished data) are used to estimate the numbers of these birds on the island. Active nest counts are multiplied by two to give a conservative estimate of the number of adult cormorants and gannets. It was assumed that 0.74 gannets fledged per nest (Nelson 1978), and 0.47 penguin chicks (Crawford & Boonstra 1994).

Aerial census counts of gannets on Ichaboe on 17 December 1999 were done by enlargement of black-and-white aerial photographs and counting individual birds (not flying) by marking each with a pen. These counts were compared with counts done on the same photographs that were scanned into computer on high resolution, and the zoom and contrast enhanced digitally to distinguish individual birds with greater accuracy.

The predation impact per species was calculated as the percentage of birds that fell prey to seals, using the adjusted values for predation numbers.

*Other causes of mortality – soaked gannets*

Between December 2000 and April 2001, an intensive ringing and retrap study was conducted on soaked gannets at Ichaboe Island. Soaked gannets can be recognised by their inability to take off from the water. They are less buoyant, and sit deeper in the water than healthy birds. If strong enough, they will swim to land, or even attempt to haul out on a boat. The plumage is wet, and often with a yellow tinge; severe contamination results in a deep yellow discolouration, with the feathers being sticky to the touch and smelling slightly fishy. The feathers do not interlock, and the birds have a scruffy appearance (Figure 5.1).

The number of soaked birds was recorded, with data concerning the environmental conditions, and the severity and localised area of soaking. A total of 93 soaked birds were ringed, and regular searches made for birds with rings, which were then caught and the ring number noted. Where feasible, the bird was weighed ($n$ = 86) when wet, and in a few cases ($n$ = 21) kept in a pen until dry, and weighed again.

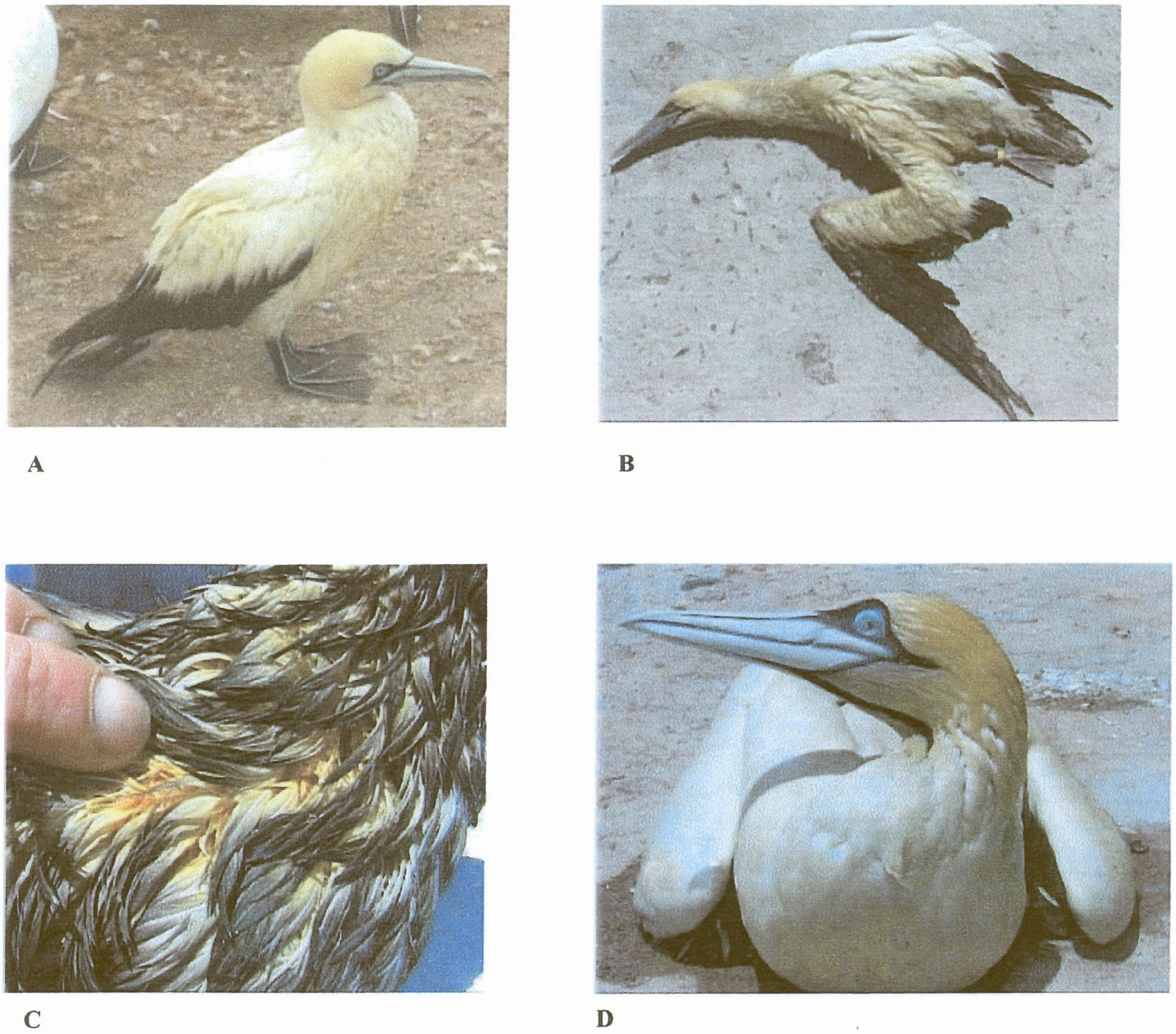



**Figure 5.1.** Soaked, or waterlogged gannets. **a** – note the scruffy appearance and yellow discolouring of the feathers; **b** – the left-hand-side of this bird was contaminated and it died of poor condition; **c** – the neck of a gannet fledgling showing a severe case of soaking, where the feathers are sticky and do not interlock and the down has a deep yellow discolouring; **d** – this bird is soaked through but not discoloured.

## RESULTS

### *Aerial census counts*

The count from the aerial photographs done on enlarged prints, resulted in a total of 14 291 individual gannets. The same count done with the aid of a computer, totalled 16 453, representing a 13.1% discrepancy.

### *Impact of predation*

In 1996, the breeding colony of gannets on Ichaboe occupied 0.56 ha (Crawford 2000c); density counts conducted on the same day (MFMR, unpublished data) gave a total of 25 034 nests. Therefore, 18 525 gannets would have fledged in the 1996-1997 season. A total of 167 gannet fledglings were taken by seals during this time, a predation rate of 0.9%; that for the adults was 0.08% (40 adult gannets fell prey to seals during this time). Using the higher of the aerial census counts for 1999 mentioned above, and interpreting these as representing nests, 11 517 gannets would have fledged from Ichaboe during the 1999-2000 season. During this time, 13 gannet fledglings fell prey to seals, a predation rate of 0.1%; the adult predation rate was the same.

In January 1993, the peak count of active nests of bank cormorants numbered 5182; the predation impact on adults for year 3 equals 0.2%; these are believed to have been carried out by a single seal ("U"; see Chapter 2). After this seal was shot, predation on adult cormorants declined to less than five per year (see Figure 4.2c,d).

The predation pressure on adult penguins in year 9 equals 0.2% when using moult counts to estimate the number of these birds on the island during that time. That of fledgling penguins is estimated to be 0.25% for the same period.

*Soaked birds*

A total of 744 soaked gannets were recorded between April 1996 and May 2000. A further 97 gannets that were soaked, were found dead during this time. Out of 170 soaked birds noted between December 2000 and May 2001, two were Cape cormorants adults, 135 Cape gannet adults and 33 gannet fledglings. A total of 80 adult and 13 juvenile gannets were ringed. The average difference between the wet and dry weight (i.e. weight of water absorbed) was 191.67 g; the maximum was 400 g. On average, soaked birds weighed 266.6g less than healthy birds (which weigh, on average, 2645g; Maclean, 1985), despite being waterlogged.

The majority of the birds were contaminated on their wings, back and belly, with the sides and tail the next most abundant as areas of localised waterlogging. Seventeen birds were soaked on one side only; one bird in particular was discoloured, soaked through and sticky on only the left hand side – this bird was later found dead (see Figure 5.1b).

Out of the 93 birds ringed during this study, 14 were resighted. Of these, 11 birds were resoaked – one was resoaked three times – and two resoaked birds were found dead. Only one gannet that had been soaked was seen in good condition at least one month later. In addition to the live soaked birds, 14 soaked gannets were found dead on the island, and a further 11 adrift. Another soaked bird (not ringed) had a long-line hook embedded in its neck, and died one day later. Almost 90% of the soaked gannets observed were at wind speeds of less than 10 knots.

## DISCUSSION

### *Bias in results*

Though counting individual animals on aerial photographs may be more accurate than ground counts, while also allowing for repeat counts (Lowry 1999), the method used to count from the aerial photographs may affect the accuracy of the count. Counting birds on aerial photographs with the aid of a computer is believed to be more accurate than counting from enlarged photographs; the difference found between these methods indicate a potential source of error in such data. Due to the large temporal variation in predation by seals on seabirds at Ichaboe Island (see Chapter 4), the predation pressure calculated for one year cannot be extrapolated or used for predictive purposes. The number of predations that occurred cannot be accurately determined due to the bias in the methods of observation (see Chapter 3). The adjusted values of predation may be more realistic, but such extrapolation is similarly based on assumptions that introduces further bias. Furthermore, the number of birds that fledge per nest may differ seasonally and spatially (at different breeding localities). Therefore, the assumptions of accuracy of the data needed to calculate the predation pressures are violated. For the same reason, calculating a mean predation pressure for each prey species over the ten year period would not be meaningful. Values of predation pressure therefore need to be treated with caution.

In addition, the identification of the species (and age class) of cormorant is only possible upon collection and inspection of the carcass, which could not be carried out during systematic observations, as the observations would have to be interrupted. Therefore, the identification of cormorant species and age classes falling prey to seals were carried out when these predations were noted incidentally, as the observer was in a position to collect and identify the carcass. This involved donning a wetsuit and often single-handedly launching a vessel and paddling or motoring to where the predation event was seen and searching for the carcass.

*Impact of seal-seabird predation*

Though seal-seabird predation seems to have a minimal impact on the seabird populations at Ichaboe, the number of predations reported on here should be regarded as the minimum, because it is certain that predations would have been missed regardless of the method of observation. Furthermore, it cannot be assumed that seal-seabird predation is restricted to the area around breeding colonies, and a substantial number of such events probably occur farther offshore; such incidents would not be recorded in island-based observations. Additional losses of both eggs and chicks would result from the loss of breeding adults; this mortality is difficult to assess (Penney & Lowry 1967).

Individual seals that prey on seabirds sometimes display significant preference for specific species (see Chapter 2). During the time when such seals are active, they may have a significant impact on the species targeted (see Chapter 2; Williams 1988); the removal (under licence) of such seals, if positively identified, may be considered necessary in some cases. Best *et al.* (1997) maintain that "there is some potential for control through culling animals that feed on seabirds around breeding localities" (p. 198).

Due to the higher number of adult gannets that fell prey to seals, in comparison with the other bird species, predation pressure on gannets is believed to be greater, because factors influencing adult mortality are important. However, predatory events involving adult gannets are the most visible (see Chapter 2), such that the database may under-represent predations involving adults of the other bird species. For this reason, the impact of predation per species cannot be accurately calculated or compared amongst species. This is supported by a statement by Mann (1999), who explains that because the sampling effort during incidental observations is unquantified, rates, frequencies and proportions cannot be accurately calculated.

The local populations of gannets and bank cormorants at Ichaboe form substantial proportions of the global populations of these threatened species (see Chapter 1). As suggested by Williams *et al.* (1990), it may be necessary for conservation authorities to safeguard these populations from causes of population decline.

*Kelp gull predation*

In January 1993, there were 19 active nests of kelp gulls; this number has increased to 74 nests in December 1999. Kelp gulls take unguarded eggs of other birds, and also prey on young chicks. This is exacerbated by human disturbance (such as with tourism, uncontrolled access to breeding colonies of birds and other human activities in the vicinity), when birds desert their nests, leaving them exposed to kelp gulls (Cooper 1974; Simmons *et al.* 1998). This form of mortality has the greatest impact on gannets and penguins, which lay one and two eggs respectively. Though some birds may relay if a clutch or young chicks are lost, this is not always the case (Maclean 1985). The increase in kelp gull recruitment to the island through the increase in breeding numbers is cause for concern. Furthermore, kelp gull numbers are increasing as a result of the provisioning of additional food in the form of rubbish dumps, offal etc. Breeding kelp gulls as well as large numbers that roost on the island (up to 300) prey on eggs and chicks (pers. obs). Though difficult to quantify, kelp gull predation is another potentially important mortality factor that puts added pressure on already declining penguin and gannet populations.

Whereas birds do not form part of the natural diet of seals, the taking of eggs and chicks of other birds by kelp gulls forms part of their natural diet. As established in this investigation, not all seals prey on seabirds, and this behaviour seems to be restricted to certain localities. Therefore, it is believed that the impact of kelp gull predation on seabird populations may exceed that of seals; this needs further investigation.

*Soaked gannets*

It is suspected that the birds become contaminated by fish oil. Gannets often scavenge hake and other offal at demersal trawlers (Crawford *et al.* 1985), which forms an oily slick when dumped at sea. Feeding chicks with the same may be messy, resulting in the contamination of their plumage too. Repetitive contact with the contaminant may result in a loss of waterproofing.

The amount of time spent in the water plays an important role, as these birds find it difficult to take off from the water when there is little wind. On the other hand, whatever is contaminating the birds may remain longer on the surface of the water in the absence of wind. Guano on the feathers may aggravate the contamination and subsequent waterlogging. Dirty or soaked gannets often try to wash themselves, which is unsuccessful as it leads to becoming resoaked.

In the light of the number of dead soaked gannets found ($n$ = 124), the general poor condition of soaked gannets, and the likelihood that a bird will become repetitively soaked, it may be speculated that a large proportion of soaked gannets that were ringed and are unaccounted for may have died out at sea. If birds that become soaked eventually die, this is an important mortality factor – that exceeds predation pressure – to consider in the decline of the Ichaboen gannet population.

It is interesting to note that seals specialising in seabird predation do not seem to target soaked gannets, which are vulnerable as they are unable to take off from the water.

*Human-induced mortality*

The exploitation of the prey of seabirds, commercial collection of guano, and deliberate or accidental pollution of the marine environment by humans are believed to be causing unsustainable declines in the population numbers of the seabirds under investigation (see Chapter 1). The impact of predation by seals at Ichaboe cannot account for the decline in seabird numbers and research efforts should be directed to at-sea factors such as fisheries interactions.

## SUMMARY

*Seal-seabird predatory behaviour*

- Seabird predation by seals at Ichaboe Island seems restricted to a few individuals that differ with respect to intensity of predation, bird species targeted and diurnal factors. Some seals prey on birds on a regular basis, exploiting a specialist niche, while others take birds opportunistically. Seals may learn the predatory behaviour from other seals, or initially take birds as an extension of play behaviour.

- The predation cues identified were adequate to attract the attention of the observer and indicate seal-seabird predatory activity. The use of these cues proved valuable, and the same concept could possibly be adapted to other behavioural studies.

- The tagging of seals by marks distinguishable from a distance would greatly improve the accuracy of identifying the sex and age of seals that prey on birds. The four seals that were individually identifiable provided valuable insight into seal-seabird predation at Ichaboe Island.

- Gannet clouds are an interesting behavioural phenomenon that deserves further investigation.

- Predation by seals on gannets, cormorants and penguins differed in terms of the time between predations, number of birds taken per day as well as behavioural aspects. Seals are implicated in inflicting injuries to penguins.

*Evaluation of methods*

- Predations noted during each method of observation differed significantly in terms of bird species preyed upon; this may be ascribed to seasonal differences as well as predation cues.

- Cormorant predations differed significantly between methods for diurnal, environmental and spatial distributions. This may be due to the grouping of species (Cape and bank cormorants) and may also be partly attributable to seals taking these birds opportunistically, as such behaviour is bound to be variable.

- Gannet and penguin predations did not differ significantly between methods in the case of diurnal or environmental distributions, suggesting that incidental observations may reveal trends despite the inherent bias in this method.

- Observational methods differed with respect to the spatial distribution of predation; this highlighted a potential bias in spatial sampling during incidental observations in particular.

- Up to 36% of predations may be missed during incidental observations; this method is nevertheless recommended in the absence of systematic observations.

*Environmental, spatial and temporal variation*

- The large annual variation in the seal-seabird predation records at Ichaboe Island over a ten-year period may result from: the observations being incidental; seals taking birds opportunistically; seals specialising in seabird predation; the number of birds available as prey. Environmental factors also contribute to the observed variation.

- The distinct seasonal pattern in predatory activity is attributed to fledgling gannets and cormorants, which form a temporary, abundant food resource; they are easy prey for seals and form one-third of all predations noted.

- Observed diurnal trends in predatory activity for each species and age class of bird can be accounted for by the behaviour of the birds and are therefore biologically significant.

- While the effect of BS on seal predatory behaviour can be explained in terms of bird activity, it is possible that cormorant and penguin predations may be under-represented at high BS.

× The relationship between SST and seal-seabird predation seems to confirm that seals do not eat birds as an alternative food resource; this relationship deserves further attention.

× The distances from the island that birds of different species and ages are preyed upon can be explained in terms of bird activity. However, the distance and the size of the bird affect the likelihood of observing predatory activity.

*Impact of seal-seabird predation*

× The impact of seal predation on seabirds at Ichaboe Island seems negligible; however, the actual level of predation is higher than the reported level.

× The available data does not allow for the calculation of predation rates or pressures by seals per bird species, due to the biases introduced through the incidental nature of the observations.

× Predation on chicks and eggs of seabirds by kelp gulls, and the phenomenon of "soaked" gannets are believed to be greater mortality factors than seal-seabird predation.

× Seal-seabird predation pressure cannot account for the decline in seabird numbers; other factors of mortality – notably at-sea factors such as interactions and competition with commercial fisheries, and oiling – are therefore implicated.

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