SURVIVAL AND MOVEMENTS OF AFRICAN PENGUINS, ESPECIALLY AFTER OILING.

by

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ABSTRACT

Movements, survival, age of first recorded breeding and the success of rehabilitating oiled African Penguins were investigated using re-sightings of flipper-banded birds. Seventeen penguin colonies between Algoa Bay and Lambert's Bay, South Africa, were visited between March 1995 and October 1999. Flipper-band numbers were read using binoculars and a telescope and recorded along with details of the activity of the banded birds.

All sightings of banded penguins were entered into a database, providing details of 11 623 birds. The database was investigated for incidences of movements of penguins between different breeding colonies and for evidence of emigration and immigration. For birds of known age, i.e. those banded as chicks, the age at which they were first recorded breeding was calculated. The computer program MARK was used to evaluate annual survival rates for adult penguins and for those in their first year of life. The proportion of hand-reared, orphaned chicks that survived to breeding age was compared to that of naturally fledged chicks. Annual and long-term survival of oiled, cleaned and released penguins was compared to that of penguins that had not been oiled.

African Penguins were found to travel up to 1910 km in their first two years of life. Most travelled west and north along the coast. Adult penguins also visited other colonies to moult and to forage. Two percent of the penguins banded as chicks that were re-sighted alive had settled to breed at non-natal colonies. Fourteen percent were recorded breeding at natal colonies. Of 5968 penguins that were banded in adult plumage and subsequently re-sighted alive, eight were found to have attempted to breed at more than one locality. Breeding by African Penguins at more than one locality has not been previously recorded. All eight penguins had been cleaned and released following a major oil spill in 1994. Emigration of young penguins is considered to be the means by which the mainland colonies of The Boulders and Stony Point were established.

The mean age of first recorded breeding of African Penguins was found to be between four and five years old. Mean annual adult survival was estimated to be 0.81 for birds

banded at Robben and Dassen Islands, and ranged between 0.10 and 0.80, averaging 0.35, for first year birds. Hand-reared orphaned chicks survived equally well in the wild as naturally fledged chicks and similar proportions returned to breed. Annual survival rates of penguins that had been oiled, cleaned and released were similar to those of penguins that had not been oiled. Long-term survival of rehabilitated penguins was equal to that of non-treated birds. Rehabilitation of oiled African Penguins is considered to be a worthwhile conservation tool for a species that is still undergoing a long-term decline.

STATUS OF PUBLISHED CHAPTERS IN THIS THESIS

CHAPTER THREE: Movements of African Penguins to and from The Boulders, South Africa

This chapter formed the part for which I was mainly responsible of the following paper:

Crawford, R.J.M., Shannon, L.J., Whittington P.A. & Murison, G. 2000. Factors influencing growth of the African penguin colony at Boulders, South Africa, 1985–1999. *S. Afr. J. Mar. Sci.* **22**: 111–119.

RJMC initiated and wrote most of the sections of the published paper and co-ordinated the fieldwork.

LJS assisted with collection of data and information from The Boulders.

GM contributed data from her field study and wrote the section on nesting success in 1998.

PAW collected much of the data on flipper-band re-sightings and wrote the sections on inter-colony movements in the results and discussion, which form the substance of this chapter of the thesis.

CHAPTER NINE: A comparison of long-term survival of rehabilitated African Penguins with that of non-oiled penguins and other species of seabirds

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CHAPTER TEN: Establishment, growth and conservation of a mainland colony of African Penguins at Stony Point, Betty's Bay, South Africa.

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PAW: Performed the data analyses, wrote the entire text and produced the figures and tables.

JHH: Was responsible for the bulk of the fieldwork, with help from the Stony Point Advisory Committee, collected and collated the data and provided background information.

JC Provided additional reference material and background information, largely based on his personal experience with this colony in the years immediately following its establishment.

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CHAPTER ONE

INTRODUCTION

1.1 *Status*

The African Penguin is one of four species belonging to the genus *Spheniscus* and the only penguin found regularly on the African continent. It is the sole representative of the genus in the "old world", the other three species occurring in South America. The Humboldt Penguin *Spheniscus humboldti* breeds in Peru and Chile, the Magellanic Penguin *Spheniscus magellanicus* in Argentina, Chile and the Falkland Islands, and the Galapagos Penguin *Spheniscus mendiculus* is endemic to the Galapagos Islands, breeding mainly on the islands of Fernandina and Isabela (Williams, T.D. 1995, Boersma 1998, Luna-Jorquera 1998, Mills & Boersma 1998). Three of the four species are listed in the IUCN red data list. The African and Humboldt Penguins have both undergone large-scale declines and are considered "vulnerable" (Luna-Jorquera 1998, Crawford 2000, Whittington *et al.* 2000a), while the Galapagos Penguin, with a population of between 1500 and 4000, is listed as "endangered" (Mills & Boersma 1998).

1.2 *Nomenclature and distribution*

The name African Penguin has only recently come into widespread use. It was previously referred to as the Cape Penguin (Holmes 1976) and more commonly as the Jackass Penguin. The name Black-footed Penguin is also frequently used, particularly by zoos and aquaria (Brooke 1984). The species is endemic to southern Africa. All 28 breeding colonies are located in South Africa and Namibia, 24 of them being on offshore islands. Terrestrial predators are absent from these islands with the exception of Robben (33° 48′ S 18° 23′ E) and Dassen (33° 25′ S 18° 05′ E) Islands, where feral cats have been introduced by man. Marcus Island (33° 02′ S 17° 58′ E) in Saldanha Bay and Bird Island (32° 05′ S 18° 17′ E), Lambert's Bay, both on the west coast of South Africa (Figure 1.1), were joined to the mainland by causeways, which has made them accessible to terrestrial predators. Following a number of incidents of predation

of seabirds by terrestrial mammals at Marcus Island, a two-metre high wall was erected where the causeway joins the island, to try to prevent the animals from gaining access to the seabird colonies (Cooper *et al.* 1985). Although there have been incidences of Water Mongooses *Atilax paludinosus* getting onto Bird Island, Lambert's Bay, there have not been any reported cases of predation and the animals seem to be scavenging from carcases (V. Ward pers. comm.).

Of the four mainland colonies, those at Sylvia Hill (25° 10′ S 14° 50′ E) and Easter Cliffs (25° 22' S 14° 48' E), Namibia, are unique in that the penguins breed in caves at the base of a cliff (Loutit & Boyer 1985, P.A. Bartlett & R. Jones pers. obs). The other two mainland colonies, near Cape Town, South Africa, were only formed in the early 1980s (Broni 1982, Cooper 1985, Whittington *et al.* 1996, Crawford *et al.* 2000b). The Boulders (34° 11′ S 18° 27′ E) colony at Simon's Town is also unusual in that it is situated in a suburban coastal town. The penguins share some of the beaches with sunbathers and swimmers and appear to have become habituated to human presence. The Stony Point (34° 22′ S 18° 53′ E) colony is in a more rural situation and the penguins are subject to predation from indigenous mammals. This was considered to be the main cause of the decrease in size of this colony between 1990 and 1993 (Whittington *et al.* 1996, Chapter 10).

The breeding range extends from Hollams Bird Island (24° 38′ S 14° 31′ E) off central Namibia to Bird Island (33° 50′ S 18° 20′ E), Algoa Bay, South Africa (Figure 1.1). Non-breeding birds are regularly found to the east of this region up to the coast of KwaZulu-Natal (Wilkinson *et al.* 1999) and vagrants have reached as far as Gabon in the west and Mozambique in the east (Malbrant & Maclatchy 1958, 1959, Pinto 1958, Shelton *et al.* 1984).

1.3 *Population trends*

The first reliable estimates of the African Penguin population were made from aerial photographs in 1956 (Rand 1963a,b, Frost *et al.* 1976). The population at Dassen Island was thought to be at least 1.5 million birds at the start of the 20th century (Westphal & Rowan 1970, Frost *et al.* 1976). Other estimates of the Dassen Island population of nine million in 1906 (Pycraft 1910, Welty 1964) and of five million

made by Kearton (1930) were considered to be unrealistically high (Westphal & Rowan 1970, Frost *et al.* 1976). What is not in doubt is that the African Penguin population decreased throughout the 20th century reaching an estimated level of 296 000 adults in 1956 (Rand 1963a,b) and falling to about 220 000 by the late 1970s (Crawford *et al.* 1995c). By the early 1990s, numbers were estimated to be in the region of 180 000 (Crawford *et al.* 1995c) and had declined to about 176 700 by the end of the century (Kemper *et al.* 2001, Marine and Coastal Management unpublished data, Ministry of Fisheries and Marine Resources, Namibia, unpublished data). The species has now ceased to breed at five or more localities that were formally occupied (Crawford *et al.* 1995b).

King (1981) and Brooke (1984) list the African Penguin as "vulnerable" in the ICBP and South African red data lists respectively. It was considered "near-threatened" by Collar *et al.* (1994) and re-classified as "vulnerable" at the Conservation and Management Plan meeting following the Third International Penguin Conference in Cape Town, 1996 (Crawford 1998b). The species is included in Appendix II of the Convention on International Trade in Endangered Species (CITES), and in Appendix II of the Convention on the Conservation of Migratory Species (the Bonn convention). If the rate of decline noted between the 1970s and 1990s were to continue unabated, the species could become extinct in the wild during the 21st century (Crawford 1995, Whittington *et al.* 2000a).

1.4 *Causes of decline*

The main causes of the decline of the African Penguin population, prior to the 1960s, are thought to be related to human activities at breeding colonies. Early European explorers found penguins easy to catch for food and as a source of oil (Randall 1989, Williams, T.D. 1995). In 1497, the Portuguese explorer Vasco da Gama stated "We killed as many of them as we desired" (Shelton *et al.* 1984). The discovery of the beneficial properties of seabird guano as a fertiliser led to large-scale scraping of guano at South African and Namibian islands from March 1843 (Best *et al.* 1997). This activity caused severe disturbance to nesting seabirds and reduced their breeding success (Rand 1970). After the guano had been removed, there was no substrate for penguins to burrow into, forcing birds at many colonies to nest on the surface. Penguins nesting in the open are more susceptible to heat stress, particularly in the

summer months, and are thus more likely to desert their nests if temperatures remain high. Surface nesters are also more vulnerable to predation, especially from Kelp Gulls *Larus (dominicanus) vetula*. Burrows offer a more equable microclimate and afford some protection from predators. Frost *et al.* (1976) found that breeding success was significantly higher in burrows when compared to open nest sites. Exploitation of guano from South African seabird islands ceased in the 1990s (Best *et al.* 1997) but continues at one locality in Namibia (J.Kemper pers. comm.).

Another major factor in the decline of the African Penguin population was the large-scale collection of eggs for human consumption (Shelton *et al.* 1984), which began soon after the first European colonists arrived in 1651 (Westphal & Rowan 1970). This activity, along with the collection of birds for their oil, may have led to the extirpation of the penguin colony on Robben Island prior to 1800 (Westphal & Rowan 1970, Frost *et al.* 1976). Le Vaillant (1790) stated, "The government sends every year a detachment into the Isle of Roben to shoot mors and manchots (penguins) from whom they extract quantities of oil". Exploitation of penguin eggs was intense with over 13 million being collected between 1900 and 1930 (Frost *et al.* 1976). The majority were collected from Dassen Island, where an average of 452 670 eggs were collected each year during this period (Shelton *et al.* 1984). In addition, partially incubated eggs were discarded and well-incubated eggs destroyed to encourage birds to relay (Frost *et al.* 1976). This practice must have severely reduced the number of successful nesting attempts and been the primary cause of the decline, particularly at Dassen Island. Erection of walls on some islands, such as Dassen Island, prevented penguins from nesting in the interior. This made the collection of eggs easier because all the birds had to nest around the periphery, but it caused further disruption and reduced the amount of suitable nesting habitat available to the penguins (Frost *et al.* 1976). The collection of eggs became illegal in December 1969 (Frost *et al.* 1976, Moldan & Westphal 1994).

1.5 *Current threats*

The main threats to the African Penguin population have moved away from breeding areas and into the sea. The main problem that they presently face is considered to come from commercial exploitation of and increased competition for their prey. This mainly comprises pelagic, shoaling fish, especially Sardine *Sardinops sagax* and

Anchovy *Engraulis capensis* (Rand 1960, Randall & Randall 1986a, Crawford *et al.* 2001). Purse-seine fishing for Sardine off South Africa began in 1943 (Stander & Le Roux 1968) and intensified after World War Two, which had initiated a demand for canned fish (Payne & Crawford 1989). The resource was still abundant during the 1950s but the South African fishery collapsed in the mid-1960s (Stander & Le Roux 1968, Crawford 1998a). The same fate befell the Namibian Sardine fishery in the late 1970s (Crawford 1998a). Anchovy was first exploited off South Africa in the 1960s and dominated South African purse-seine catches for 30 years. In Namibia, Anchovy became the main contributor to the industry in 1978 but catches plummeted after reaching a peak in 1987 (Crawford 1998a). Reduction in size classes and egg production suggested that over-fishing was a major factor in these declines (Frost *et al.* 1976). The foraging ranges that penguins are able to exploit are limited by the birds' inability to fly: if food is short, they cannot greatly increase the area over which they forage without spending long periods away from the nest (Frost *et al.* 1976). This long-term reduction in the prey resource is thought to be responsible for the continued decline in the African Penguin population.

While pelagic fish stocks have declined, the competition for the resource has increased. The numbers of Cape Fur Seals *Arctocephalus pusillus pusillus* have increased throughout the 20th century (Crawford *et al.* 2001), particularly after the 1940s (David 1989). Pilchard and Anchovy are amongst the most important species in the diet of Cape Fur Seals off the south and west coasts of South Africa, and also figure prominently in the diet of those in Namibia (David 1989). Cape Fur Seals are also predators of African Penguins. Reported observations of such predation have recently increased and may even threaten the existence of smaller colonies of African Penguins (Crawford *et al.* 2001). Predation by Cape Fur Seals at Bird Island, Lambert's Bay was considered to be preventing recruitment of African Penguins to the breeding population (Crawford *et al.* 2001). Marks *et al.* (1997) estimated that 8.7% of the population of African Penguins at Dyer Island (34° 41′ S 19° 25′ E), based on the results of a census made in July 1996, were victims of seal predation during a period of 12 intermittent months of observation, in 1995 and 1996. This was considered to represent an unsustainable level of mortality (Crawford *et al.* 2001). Seal predation at Ichaboe Island (26° 17′ S 14° 56′ E), Namibia, was estimated to

account for 0.2% of adult and 0.25% of fledgling African Penguins between October 1998 and October 1999 (Du Toit 2001).

Marine pollution, especially from spillage of oil, represents another threat to the African Penguin population. The first documented oil pollution incident that affected African Penguins occurred near Dyer Island in 1948 (Green 1950). Since then, the number of oil pollution incidents in South Africa has increased. Frost *et al.* (1976) did not consider oiling alone to have had a major impact on the African Penguin. About 4% of the population was estimated to have been oiled between 1970 and 1976 (Frost *et al.* 1976). Between 1970 and 1980, the Southern African Foundation for Conservation of Coastal Birds (SANCCOB) cleaned and released an estimated 1.8% of the total African Penguin population, based on a population census of selected colonies made in 1972 (Frost *et al.* 1976, Morant *et al.* 1981). Approximately 3% of the population perished as a result of being oiled following the sinking of the bulk ore carrier *Apollo Sea* in 1994, and 1% died after the sinking of the MV *Treasure* in 2000. The adverse affect of marine pollution on the African Penguin has been ameliorated by the work of SANCCOB, which has cleaned, treated and released thousands of oiled penguins since its formation in 1968 (Moldan & Westphal 1994, Underhill *et al.* 1999). The *Apollo Sea* disaster affected over 5% of the total population, while the *Treasure* incident put 40% of the population at risk, oiled about 11% and caused the evacuation of a further 11% (Crawford *et al.* 2000a). The rescue effort in this latter incident prevented the death of up to 22% of the entire population. The efficacy of the rehabilitation of cleaned African Penguins is discussed in Chapters Eight and Nine. If support of SANCCOB and other international contributors, such as the International Fund for Animal Welfare (IFAW) and International Bird Rescue and Research Centre (IBRRC) were to cease, oil pollution could take on a more serious role in the decline of the African Penguin.

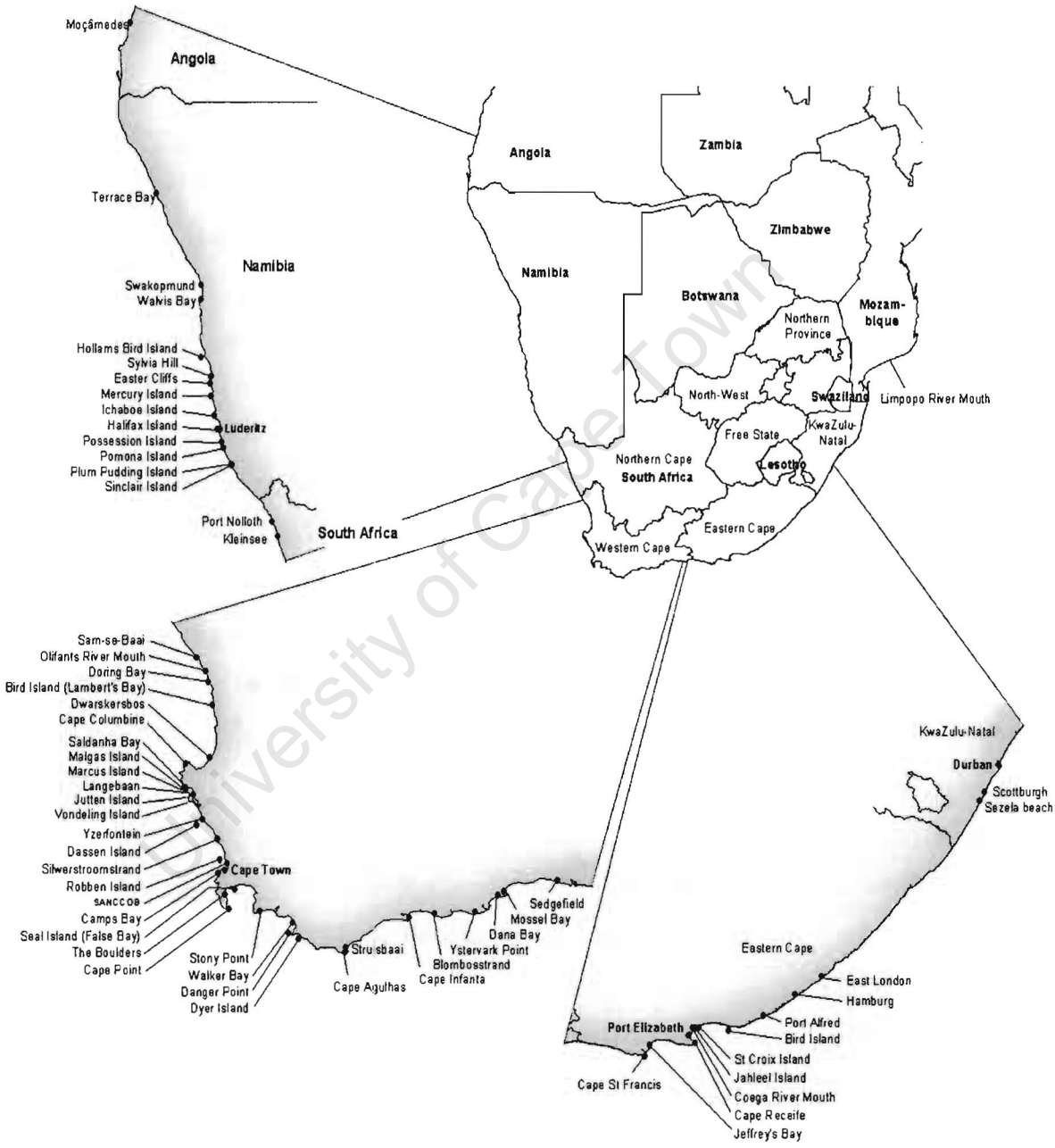
1.6 *Outline of study*

Compared with the other species in the genus, the African Penguin has been relatively well studied. Adults are non-migratory and remain in the vicinity of their breeding colonies for much of the time. As a legacy of the guano collecting days, there is accommodation available to researchers at 12 of the 24 island colonies. These factors greatly facilitate regular monitoring of the species. The main studies include work

done by Randall at St Croix Island (33° 48′ S 25° 46′ E) in the mid-1970s, the Percy FitzPatrick Institute of African Ornithology at Marcus Island in the 1980s and research into foraging behaviour by Wilson in the early 1980s. The Marine and Coastal Management division of the Department of Environmental Affairs and Tourism undertakes annual breeding censuses, regular counts of moulting birds and investigations into dietary composition of African Penguins at most South African breeding colonies.

The present study concentrates on aspects of population dynamics that have been investigated using large-scale flipper banding of African Penguins. The banding was not done specifically for this study but was undertaken at breeding colonies from 1970 and at rehabilitation centres, prior to the release of cleaned or treated penguins, from 1968. This large-scale banding has allowed an assessment to be made of the degree to which African Penguins move between breeding colonies (Chapter Two). Re-sightings of flipper-banded penguins have shed some light on the origins of the birds that are settling at the recently established mainland colonies of The Boulders (Chapter Three) and Stony Point (Chapter 10). The incidence of emigration from and immigration to colonies is discussed in Chapter Four. Estimation of parameters involved in population dynamics includes age at first recorded breeding (Chapter Five) and annual survival (Chapter Six). The success of cleaning oiled African Penguins and returning them to the wild and the role this plays in the conservation of the species forms an important part of this study. Short-term survival, measured in terms of the proportions of released birds that return to colonies and subsequently breed, forms the subject of Chapter Eight, while long-term survival is discussed in Chapter Nine. Annual survival of cleaned, rehabilitated penguins is compared to that of birds that have not been oiled or treated in Chapter Six. An initial investigation into the success of hand-rearing chicks that were orphaned as a result of major oil spills is made in Chapter Seven.

Figure 1.1 Southern Africa, showing the distribution of African Penguin breeding colonies, and other localities mentioned in the text.



CHAPTER TWO

MOVEMENTS OF AFRICAN PENGUINS BETWEEN COLONIES

2.1 INTRODUCTION

Although the African Penguin does not undergo regular migrations, it is known that individuals, particularly young birds, visit other breeding colonies and are sometimes recorded outside of the breeding range. Young birds fledging from their natal colonies may travel considerable distances (Randall *et al.* 1987, Randall 1989). Breeding adults are also known to visit other colonies, both during and outside of their breeding season. They may moult at colonies other than that at which they breed and may forage at some distance away from their colony when not breeding. Vagrants have been recorded as far north as Sette Cama, Gabon (2° 32′ south) (Malbrant & Maclatchy 1958, 1959, Shelton *et al.* 1984) on the west coast of Africa, and the Limpopo River mouth, Mozambique (25° 13′ south) on the east coast (Parker 1999, Wilkinson *et al.* 1999). In addition, first year birds are sometimes stranded on the coast of KwaZulu-Natal after following the eastward migration of sardines *Sardinops sagax* (Wilkinson *et al.* 1999).

Randall *et al.* (1987) found that post-fledging movements of African Penguins followed a strong clockwise movement around the coast of southern Africa. This finding and others are re-examined here.

2.2 METHODS

From the early 1970s, the use of stainless steel flipper-bands (Jarvis 1970, Cooper & Morant 1980) that can be read in the field with the aid of binoculars or a telescope, has allowed movements of African Penguins between colonies to be followed. A total of 52260 African Penguins was banded between 1970 and June 1999. Bands were placed on penguins from 19 of the 28 extant breeding localities and covered the main breeding range. Additionally, 15273 bands were placed on penguins that were rehabilitated and, in the case of adult and immature birds, whose colony of origin was seldom known.

The database held by the Avian Demography Unit contains information relating to movements of African Penguins between 1970 and 1999. Work was initiated on the Algoa Bay islands by the Port Elizabeth Museum in 1971 and continued until 1975, when the project was taken over and intensified by the University of Port Elizabeth for an eleven-year period from 1976 to 1986 (R.M. Randall *in litt.*). Port Elizabeth Museum resumed regular penguin monitoring at the Algoa Bay islands, principally Bird Island (33° 50′ S 26° 17′ E), from 1992 (N.T.W.Klages pers. comm.). Monitoring of the small, mainland colony of Stony Point at Betty's Bay, Western Cape, became more intensive from 1989 (Whittington *et al.* 1996). Re-sightings of flipper-banded penguins at Robben Island were made on a fortnightly basis by staff of Marine and Coastal Management from 1989. Intensive work on African Penguins was carried on at Dassen Island (33° 25′ S 18° 05′ E) from 1970 to 1972 (J. Cooper pers. comm.). Researchers from the Percy FitzPatrick Institute of African Ornithology were active at Marcus Island (33° 02′ S 17° 58′ E) in Saldanha Bay, Western Cape from 1979 to 1985 (La Cock *et al.*1987). Monitoring work in Namibia was done by staff of the Ministry of Fisheries and Marine Resources, Namibia, and was carried out principally on Possession, Ichaboe and Mercury Islands, with visits to Halifax Island made by staff based at Lüderitz (26° 39′ S 15° 09′ E). Regular re-sightings were made from 1988 at Ichaboe Island (26° 17′ S 14° 56′ E), from 1991 at Mercury Island (25° 43′ S 14° 50′ E), from 1995 at Halifax Island (26° 39′ S 15° 04′ E) and from 1996 at Possession Island (27° 01′ S 15° 12′ E), and continued throughout the study period (J. Kemper *in litt.*). There were, therefore, periods during which monitoring work was not carried out or it was done only on a local scale, especially in the late 1980s.

Re-sighting of flipper-banded penguins became much more intensive from August 1994, following the oil spill caused by the sinking of the bulk ore carrier, the *Apollo Sea* (Underhill *et al.* 1999). Intensified monitoring at Dassen and Robben Islands began after the release of 4000 cleaned, flipper-banded African Penguins between July and September 1994. Occasional visits were also made to Dyer Island and the islands in Saldanha Bay. Visits were made to penguin colonies in the Western Cape province of South Africa by P.A.W., and by staff of Marine and Coastal Management, between March 1995 and October 1999. During these visits, all flipper-banded penguins were recorded when found breeding or when observed within the colony or

on the shore. Regular visits were made to Robben Island on a quarterly basis and involved one thorough search throughout the breeding area per visit, along with evening searches on the shore for banded birds. Evenings were particularly productive for noting band numbers as breeding adults returned from their daily foraging trips. More emphasis was put on searching groups of moulting birds along the shore during summer, which is the peak period of moult activity (Underhill & Crawford 1999). Visits to Dyer Island and the islands in Saldanha Bay were made, on average, three to four times a year, usually in February, May and October. Western Cape Nature Conservation Board have been collecting sightings of flipper-banded African Penguins at Dassen Island on an almost daily basis since November 1994. Occasional sightings of flipper-banded birds by members of the public were reported to the South African Bird Ringing Unit (SAFRING) and incorporated into the database.

Using the database, an analysis was made of the direction of movements, distances travelled and whether movements showed any seasonal pattern. Breeding colonies were split into three regions: those in Algoa Bay (Eastern Cape province of South Africa), those between Dyer Island and Bird Island, Lambert's Bay (32° 05′ S 18° 17′ E) (Western Cape province of South Africa) and those in Namibia. Two age classes were investigated: birds banded as unfledged chicks at colonies and birds banded in adult plumage. Randall *et al.* (1987) found that most recoveries of dead birds banded as chicks that were reported more than two years from banding, were closer to natal islands, indicating that individuals had probably returned from post-fledging dispersal. Consequently, birds banded as chicks were further separated into two categories in this study: birds observed when two years old or younger and those observed when older than two years. Comparisons were made, where possible, between penguins banded at colonies and those treated and released by the Southern African Foundation for Conservation of Coastal Birds (SANCCOB). For chicks, rehabilitated birds generally referred to those that were hand-reared after being orphaned in major oil spills. Analysis of movements for birds banded in adult plumage was restricted to those whose breeding colony was known. This was deduced by investigating the database for evidence of breeding subsequent to the birds being banded (or released in the case of rehabilitated birds). Although many adults were banded when breeding, this was rarely recorded on the banding schedules.

Birds were said to have travelled clockwise if moving west or north and anticlockwise if moving east or south. Only outward movements from breeding colonies (natal colonies in the case of chicks) to other colonies or mainland sites were included in the analysis. If one bird was recorded at a locality in a clockwise direction from its breeding or natal colony and then subsequently recorded at a locality east or south of its breeding or natal colony, then these were treated as two separate movements for analysis purposes. A probability test was made for statistical significance of movement in either direction, assuming a normal distribution and 95% confidence intervals (see Underhill 1985). For birds banded as chicks, the proportions seen at natal and non-natal colonies were calculated, along with the elapsed time between banding and first re-sighting. This was also done for chicks that had been hand-reared and subsequently released. The numbers of movements recorded in each of four seasons (spring, summer, autumn and winter) were calculated for each age class. Spring was defined as September to November, summer as December to February, autumn as March to May and winter as June to August. The season of movement was taken as the season when the bird was observed at a new locality, though it was usually unknown during which season the bird had actually arrived there. A chi-squared test was performed to see if the numbers of movements per season followed a random distribution. Distances were calculated around the coastline using five sectors divided by the following four key points: north of Cape Point (34° 21′ S 18° 30′ E), Cape Point to Cape Agulhas (34° 50′ S 20° 01′ E), Cape Agulhas to Cape Recife (34° 01′ S 25° 41′ E), Cape Recife to East London (33° 01′ S 27° 55′ E) and east of East London. If both points were in the same section, the great circle distance was calculated between the two points. If the points lay in different sections, the great circle distance to the nearest key point was added to the standard distances between key points (Imboden & Imboden 1972). Distances travelled were compared between regions, direction and, for chicks, between those sighted when younger or older than two years.

2.3 RESULTS

Since 1970, there have been 42267 re-sightings of banded birds, and 1217 birds have been recovered dead.

2.3.1 Penguins banded as chicks

The database contained information for 3986 birds banded as chicks. Of these, 118 were either hand-reared orphans or were oiled at a later stage of their life. A total of 1409 chicks, 35% of those in the database, moved between colonies or was recovered dead at a locality other than the natal colony (Table 2.1).

2.3.1.1 *Direction of movements*

Tables 2.2 and 2.3 show the number of movements, based on re-sightings of live birds, in each direction for each of the three regions. Different patterns were noted between age groups and between regions. The pattern of movements of birds from the Eastern Cape differed from those of birds from the other two regions. Chicks banded in Namibia showed a tendency to travel southwards when aged two years or less, although this was not statistically significant (Table 2.2). For birds re-sighted when older than two years of age, there was a slight tendency for movements to be in a northerly direction, but again not significantly so (Table 2.3). Most birds banded at Western Cape colonies had moved in a clockwise direction, but this was only statistically significant in the case of birds re-sighted when aged two years or older (Table 2.3). Movements of birds banded as chicks at Eastern Cape colonies showed the clearest pattern, with 99% of birds re-sighted within two years of banding having moved west (Table 2.2). Movements from this region recorded when birds were over two years old when re-sighted were more even in each direction (Table 2.3).

Tables 2.4 and 2.5 show the patterns of movements recorded for birds recovered dead in each of the two age groups. In all three regions, the movement of birds when recovered dead at two years old or younger was predominantly in a clockwise direction. This was statistically significant in each case (Table 2.4). This was also the case for birds recovered when older than two years, with the exception of those from the Western Cape, which showed a slight tendency to move anticlockwise. Only the Eastern Cape showed statistically significant movements in this older age group, the sample size in Namibia being very small (Table 2.5).

Regional movements of birds banded as chicks and subsequently re-sighted alive are shown in Tables 2.6 and 2.7. For birds from the Western Cape and Namibia that were

banded and re-sighted alive when aged two years or younger, the majority of sightings (88% and 94% respectively) were made at other colonies within the same region. However, 86% of those from the Eastern Cape were re-sighted in the Western Cape, only 11% being re-sighted at other Eastern Cape colonies. Two Eastern Cape birds travelled to Namibia and one to the coast of KwaZulu Natal. Only two birds from the Western Cape were re-sighted in Eastern Cape colonies. Nineteen birds (10%) from the Western Cape were re-sighted in Namibia, while 12 (6%) from Namibia were re-sighted in the Western Cape.

For birds re-sighted when older than two years, the pattern of movements of birds from the Western Cape was almost identical to that of the younger birds. For Eastern Cape birds, the majority of sightings (63%) were at other Eastern Cape colonies, the remainder being in the Western Cape with two reaching Namibia. A greater proportion (23%) than that of the younger birds from Namibia was re-sighted in the Western Cape and two were seen in the Eastern Cape.

The pattern of recoveries of dead birds aged two years or under was very similar to that of live re-sightings (Tables 2.6 and 2.8). No birds from Namibia were found dead in the Western Cape, but one was recovered dead in the Eastern Cape. Another was found dead 638 km to the south in the Northern Cape (Tables 2.8 and 2.18). One bird from the Eastern Cape was found dead in KwaZulu Natal, while five from the Western Cape were recovered in the Northern Cape. There are no breeding colonies of African Penguins in either KwaZulu Natal or the Northern Cape. For birds older than two years when found dead, the pattern again reflected that for live re-sightings (Tables 2.7 and 2.9).

A total of 239 birds made return journeys between natal and non-natal colonies. Details of these are shown in Tables 2.10 to 2.12. As expected, most return movements of birds within the Eastern Cape were between Bird Island and St Croix Island (33° 48′ S 25° 46′ E), the two largest colonies in Algoa Bay (Table 2.10). Six birds from Algoa Bay made return visits to Dyer Island and eight to Dassen Island, both in the Western Cape. One bird, banded at Bird Island on 18 April 1994, was seen at Ichaboe Island, Namibia on 5 September 1996 and later returned to Bird Island,

where it was breeding in March 1999, a round trip of 3439 km. Within the Western Cape, most return journeys (75) were made between Robben and Dassen Islands (Table 2.11). Twenty-seven birds from those two colonies made return visits to The Boulders (34° 11′ S 18° 27′ E). A chick banded S1886 on Dassen Island on 26 October 1990, travelled to Bird Island, Algoa Bay, where it was seen when aged three years and seven months. Its next port of call was Ichaboe Island, Namibia 2 years and 3.5 months later. It settled to breed here, having travelled 2591 km after leaving its natal colony. Ten chicks banded in the Western Cape made return visits to Namibian breeding colonies (Table 2.11). The longest distance covered by these ten birds was of 2119 km made by a chick from Dyer Island, which visited Ichaboe Island. No fewer than seven birds completed the 1698-km round trip between Dassen and Ichaboe Islands, and the chick banded as S10416 completed this journey twice. Of the chicks banded in Namibia, 92 (94%) of return visits were made between Ichaboe and Mercury Islands (Table 2.12). Five birds were seen back at their breeding colonies after visiting colonies in the Western Cape, the longest distance travelled being the 1971 km from Ichaboe Island to The Boulders and back. Three birds made the return trip from Ichaboe to Dassen Island.

2.3.1.2 *Proportions of re-sightings*

Between 1970 and 1998, 23 401 African Penguin chicks were banded. A total of 3460 (15%) was subsequently re-sighted alive, mostly at breeding colonies. An additional 526 (2%) were found dead with no previous live re-sighting, 95 of them at breeding colonies. Table 2.13 shows the proportion of dead birds recovered at breeding colonies. Most recoveries of birds banded as chicks were made away from breeding colonies and submitted by members of the public to SAFRING. The proportion of those birds that were never seen alive after banding but were found dead at breeding colonies is low (18%). If all recoveries are included, the proportion is higher (33%). Of those birds re-sighted alive, 2581 (75%) were seen at natal colonies, of which 492 (14%) were recorded breeding, and 1006 (29%) were seen at non-natal colonies. Some birds were seen at both natal and non-natal colonies.

Of the 1006 birds that visited non-natal colonies, 239 (24%) were later recorded back at their natal colonies. Table 2.14 shows the time of first re-sighting of chicks banded

at breeding colonies. If all chicks are included, the number of first re-sightings increased with subsequent years after banding, most being made more than three years after birds were banded (54%). This pattern changes if the analysis is restricted to chicks banded from 1994 onwards. In this case, the bulk of first re-sightings (61%) were made within the first two years after banding. From 1994 to 1998, 2432 chicks were banded, of which 437 (18%) were subsequently re-sighted alive. Of these, 229 (52%) were seen at their natal colony, 18 (4%) were recorded breeding at natal colonies and 142 (32%) were seen at non-natal colonies. Most live re-sightings (62%) of the 533 hand-reared chicks that were flipper-banded between 1994 and 1998 were made within two years of banding (Table 2.14). Sixty-three (12%) were subsequently re-sighted alive, 47 (75%) at natal colonies, of which 6 (10%) bred, and 22 (35%) at non-natal colonies.

2.3.1.3 *Distance travelled*

Distances travelled by fledged chicks that were re-sighted alive are presented in Tables 2.15, 2.16 and Figure 2.1. Of the 36 movements within the Eastern Cape, 23 (64%) were made between St Croix Island and Bird Island, a distance of 48 km. All movements in an anticlockwise direction of birds older than two years at the time of re-sighting were from St Croix to Bird Island. The only anticlockwise movement recorded for a bird from this region, of two years or less when re-sighted, was of 610 km (Table 2.15). It was seen alive and well at Sezela Beach (30° 24′ S 30° 41′ E), KwaZulu-Natal, almost 15 months after banding, and subsequently returned to St Croix Island (its natal colony) to breed. The longest distance travelled by a bird from the Eastern Cape was of 1720 km, between Bird Island (Algoa Bay) and Ichaboe Island, Namibia. Four birds were known to have made this journey, one of which was subsequently seen back at Bird Island (Tables 2.15 & 2.16).

The proportion of Eastern Cape birds of two years or younger, which had travelled in an anticlockwise direction and been found dead, was higher than the proportion of live re-sightings in this direction (Tables 2.2 & 2.4, figures 2.1a and 2.2a). The maximum, mean and median distances travelled, of those recovered dead, were all less than those of birds that had travelled in a clockwise direction (Table 2.17). However, one bird travelled 625 km to Scottburgh (30° 17′ S 30° 46′ E), KwaZulu-

Natal where it was found dead, just 37 days after banding. For Eastern Cape birds found dead when aged over two years, the pattern was similar to that for birds aged two years or younger (Tables 2.17 & 2.18, figures 2.1b and 2.2b). However, mean and median distances travelled by birds found dead when aged two years or older were similar in both clockwise and anticlockwise directions (Table 2.18), and considerably lower than distances travelled by younger birds in a clockwise direction. Distances travelled in a clockwise direction tended to be less than those travelled by birds that had been re-sighted alive, but the converse was the case for journeys made in an easterly direction (Tables 2.15–2.18). The longest distance travelled by a bird that had been recovered dead was 1076 km (Table 2.17). It was banded at Bird Island and found dead at Sam-se-Baai (31° 33′ S 18° 05′ E) in the Western Cape.

Of 488 live re-sightings within the Western Cape, 173 (35%) were between Robben and Dassen Islands, a distance of 51 km. The mean distance travelled in a clockwise direction was less than that of corresponding birds from the Eastern Cape, but greater for birds travelling in an anticlockwise direction (with the exception of the single bird from the Eastern Cape re-sighted in KwaZulu Natal) (Tables 2.15 & 2.16). The longest distance travelled was 1292 km (Table 2.15), by a bird from Robben Island found injured at Swakopmund (22° 33′ S 14° 30′ E), Namibia. As with Eastern Cape birds, mean distances travelled by birds seen when over two years old, were less than those for birds seen when under two years old. Unlike birds from the Eastern Cape, the distances travelled by birds that were recovered dead were largely greater than corresponding distances travelled by those re-sighted alive (Tables 2.15–2.18). The maximum distance travelled was 1574 km (Table 2.17) by a bird banded at Dassen Island, whose skeletal remains were discovered at Terrace Bay (19° 59′ S 13° 02′ E), Namibia.

Within Namibia, the vast majority of movements recorded were between Ichaboe and Mercury Islands, a distance of 64 km. Of 359 live re-sightings of birds that had moved within the region, 272 (76%) were between these two localities. Clockwise movements tended to be shorter than those made from the other two regions but the reverse was true for movements in an anticlockwise direction. There was little difference in the distance travelled in a clockwise direction between the two age

groups, although the mean distance travelled by the younger birds was slightly greater. The mean distance travelled by birds seen when older than two years was greater than that of younger birds when heading in an anticlockwise direction (Tables 2.15 and 2.16). The longest distance travelled was 1782 km (Table 2.16) by a bird from Mercury Island, which reached Bird Island, Algoa Bay in the Eastern Cape four years and three months after banding. The distances recorded for Namibian birds that were recovered dead, tended to be greater than the corresponding distances travelled by birds that were re-sighted alive (Tables 2.15–2.18). The sample size was, however, small (22 birds) and only four had travelled southwards. The longest distance travelled was 1910 km, by a chick from Mercury Island that was found dead near Hamburg (33° 17′ S 27° 27′ E), in the Eastern Cape (Table 2.17).

The mean distances travelled by chicks re-sighted when two years old or younger were 327 km for those re-sighted alive and 390 km for those recovered dead. The corresponding means for birds seen when older than two years were 258 km and 255 km.

Tables 2.19 and 2.20 present the data from Tables 2.15 and 2.16 but omitting visits made between Bird Island and St Croix Island (Eastern Cape), Robben Island and Dassen Island (Western Cape) and between Mercury and Ichaboe Islands (Namibia). The only notable difference with the pattern of movements from the Eastern Cape is that there were no anticlockwise movements recorded for birds aged two years or over. The mean and median distances travelled by birds from the Western Cape is higher, as would be expected, but the only major difference is to birds from Namibia which travelled anticlockwise. Clearly the bulk of the journeys made in this direction were from Mercury Island to Ichaboe Island. When these journeys are excluded, the mean distance travelled was nearly six times higher for a bird aged two years or under, and almost doubled for birds aged over two years. The median distances travelled were 15 times and eight times higher, respectively.

2.3.1.4 *Seasonal patterns of movements*

Table 2.21 shows the number of live re-sightings and dead recoveries made in each of the four seasons. Most observations of chicks that had moved were made in the spring

and summer months (62%). There were 1507 movements of birds between colonies in the analysis. If detection of a bird that had moved was random, 377 movements could be expected in each season. The data suggest that this is not the case when subjected to a goodness of fit test ($\chi^2_3 = 94.324$, $P < 0.005$).

2.3.2 Penguins banded as adults

The database contained information for 6363 birds banded as adults, of which 4691 (74%) were rehabilitated birds. Of the total of 564 birds that moved between colonies, 309 (55%) were rehabilitated. The proportions of adults in the database that were recorded moving between colonies were 15% for non-rehabilitated birds and 7% for rehabilitated birds (Table 2.1).

2.3.2.1 *Direction of movements*

The directions of inter-colony movements made by birds banded in adult plumage are presented in Table 2.22, for those re-sighted alive, and Table 2.23 for those recovered dead. Data are presented both for birds banded at breeding colonies and those rehabilitated and released by SANCCOB. As was found for birds banded as chicks, adults banded at Eastern Cape colonies moved in a predominantly clockwise direction from their breeding colonies, although this was only statistically significant for birds that were recovered dead (Tables 2.22 and 2.23). A different pattern emerges in the Western Cape, where live re-sightings of adults banded at colonies were in a predominantly anticlockwise direction (Table 2.22). However, the reverse was the case for birds recovered dead, most of which had travelled clockwise (Table 2.23). The pattern of movements shown by rehabilitated birds that were re-sighted alive was similar but less pronounced (Table 2.22). Most rehabilitated birds that were found dead had travelled in an anticlockwise direction but the sample sizes were small (Table 2.23). Two birds banded as adults in Namibia and re-sighted alive showed some movement away from their "home" colony, both travelling southwards. Few birds have been rehabilitated in Namibia and none were recorded travelling between colonies.

Table 2.24 shows movements between regions of birds banded as adults and re-sighted alive or recovered dead. Although the sample size is six birds, 50% of the adults banded at Eastern Cape colonies were recorded visiting colonies in the Western

Cape. The remainder was recorded at other Eastern Cape colonies. All but one of these six birds was re-sighted on the mainland rather than at other penguin colonies (Table 2.25); three of them were found oiled and another was injured. The situation for birds banded in the Western Cape was different in that 90% of the 29 recorded movements occurred within the region. Most of these movements (14) related to birds from Robben Island, six of which visited colonies to the south and east between The Boulders and Dyer Island, and six of which visited colonies to the north, five of them being seen at Dassen Island (Table 2.25). Two birds banded at Western Cape colonies were recorded travelling to the Eastern Cape and one to Namibia (Table 2.24). Two adults banded at Namibian colonies were re-sighted in the Western Cape. There were three movements of birds within Namibia, but it was unclear whether the movements were from a breeding colony to a non-breeding colony or vice versa. They were therefore omitted from Table 2.22 but included in Tables 2.24 and 2.31. No movements of rehabilitated adults were recorded from Namibia. The only known movement of a rehabilitated adult from an Eastern Cape colony was to another colony within that region. Almost all movements of rehabilitated birds were from Western Cape colonies. Of 179 live re-sightings, 176 (98%) had visited other colonies within the region (Table 2.24). The majority of these were breeding birds from Robben Island or Dassen Island (Table 2.26), 132 being survivors of the *Apollo Sea* oil spill of June 1994. There was clear indication of a regular movement of birds between these two colonies. Fifty-four birds visited Dassen Island from Robben Island and 40 visited Robben Island from Dassen Island. A further 15 birds from Robben and Dassen Islands visited Dyer Island, seven of them being found oiled there. All seven had previously been oiled before, one having been released from SANCCOB just five days prior to being found oiled again at Dyer Island. Six birds from Dassen Island visited The Boulders. Langebaan (33° 05′ S 18° 02′ E) and Silverstroomstrand (33° 34′ S 18° 21′ E) (Table 2.26) are not penguin colonies but were used as release sites of cleaned birds from the *Apollo Sea* oil spill. Birds released at Silverstroomstrand were found oiled at Dassen Island or Robben Island, while those released at Langebaan had been found oiled at colonies in Saldanha Bay (Underhill *et al.* 1999). The movements recorded from these two localities relate to birds which initially went in the opposite direction to where they settled to breed, or overshot their breeding colony and later returned there. These overshoots were all of a relatively short

distance. From Silverstroomstrand, two birds visited The Boulders, 117 km to the south and east, before returning to Dassen and Robben Islands respectively. One visited Danger Point (34° 37′ S 19° 17′ E), a distance of 177 km away, before returning to Dassen Island. Another visited Dassen Island before returning to its colony on Dyer Island. All other birds released at Silverstroomstrand went to Dassen Island before returning to Robben Island or vice versa. Two of the birds from Langebaan went to Dassen Island before returning to Saldanha Bay, another visited Robben Island before returning to its colony at Dassen Island (Table 2.26). Rehabilitated birds that bred at Dyer Island visited five colonies to the west and north, the furthest reaching Jutten Island (33° 05′ S 17° 58′ E) in Saldanha Bay (Table 2.26). Three birds visited colonies outside of the Western Cape. One visited St Croix Island in the Eastern Cape and two went to Namibia (Table 2.24).

As for birds re-sighted alive, the pattern of recovery of dead birds from the Eastern Cape showed a clockwise distribution for birds banded at colonies, (although this was not the case with rehabilitated birds) (Table 2.23). Most were found dead within the region, but 36% were found within the Western Cape (Table 2.24). The pattern in the Western Cape was also similar to that for live re-sightings, all birds being recovered at other localities within the region (Table 2.24).

2.3.2.2 *Proportions of re-sightings*

Between 1970 and 1998, 10440 African Penguins were banded in adult plumage at breeding colonies and 11436 were released after rehabilitation (Table 2.1). A total of 5968 (including 4453 rehabilitated birds) was subsequently re-sighted alive, comprising 15% and 39% of the totals respectively. If the analysis is restricted to birds banded from 1990 onwards, the proportions are 39% and 57% respectively. In addition, 157 adults banded at colonies and 238 rehabilitated adults were found dead with no previous live re-sightings, 104 and 80 respectively at breeding colonies. The proportions of adults found dead at breeding colonies were higher than those for birds banded as chicks (Table 2.13). For adults banded at colonies that were not seen alive after banding, the majority of recoveries were made at breeding colonies. This was not the case for rehabilitated adults, most of which were found dead away from breeding colonies (Table 2.13). The minimum, mean and maximum ages at death of birds banded at colonies and those that were rehabilitated are compared in Table 2.27.

The oldest rehabilitated adult in the database that was recovered dead was 527 days (1.4 years) older than the oldest of the adults banded at a breeding colony. However, the mean age at death was 489 days (1.3 years) higher for birds banded at colonies. For adults found dead at breeding colonies, the mean age of death was 1029 days for adults banded at colonies and 1073 days for rehabilitated adults. Table 2.28 shows the number of colonies visited by adults banded at colonies and those that were rehabilitated. The bulk of adults that made inter-colony movements visited two colonies. Just one adult banded at a colony and seven rehabilitated adults were recorded at three colonies, and none was seen at more than three colonies.

2.3.2.3 *Distance travelled*

Distances travelled by African Penguins banded as adults at breeding colonies and by rehabilitated adults, that were re-sighted alive, are presented in Tables 2.29, 2.30 and Figure 2.3. As for birds banded as chicks, the bulk of the movements within the Western Cape were between Robben and Dassen Islands (38% for birds banded at colonies, 52% for rehabilitated birds). One rehabilitated bird (S24616), a breeding bird from Robben Island, made three visits to Dassen Island between April 1995 and October 1998. Another, S1315, bred at Robben Island in both 1995 and 1997. In between, it was recorded moulting at Dyer Island, 165 km to the east, in November 1996. The longest journey undertaken by an adult from a Western Cape colony was 934 km from Dassen Island to Port Alfred (33° 36′ S 26° 54′ E), in the Eastern Cape (Table 2.29, Figure 2.3a). It was seen here five months after banding and may have been an Eastern Cape bird that was visiting Dassen Island when it was banded. A bird banded at Robben Island, and seen there several times over the next five years, was seen moulting at Ichaboe Island, Namibia, 899 km to the north, 5.5 years after banding (Table 2.29). The longest travelling rehabilitated bird from the Western Cape covered the 912 km between Dassen Island and Mercury Island, Namibia, where it was observed moulting (Table 2.30, Figure 2.3b). It had attempted breeding earlier the same year at Dassen Island. The longest distance travelled by an adult banded in the Eastern Cape was 368 km (Table 2.29) for a bird that went from St Croix Island to Dana Bay (34° 12′ S 22° 02′ E) in the Western Cape. The only rehabilitated bird from the Eastern Cape to move between colonies covered the 48-km journey between Bird and St Croix Islands in Algoa Bay (Table 2.30).

For birds recovered dead, the longest distance travelled by a non-rehabilitated bird was 1030 km from St Croix Island in the Eastern Cape to the Olifants River mouth (31° 42′ S 18° 12′ E) in the Western Cape (Table 2.31, Figure 2.4a). The furthest travelled by a rehabilitated bird was 211 km from Dassen Island to Dyer Island, within the Western Cape (Table 2.32, Figure 2.4b).

As might be expected, mean distances travelled by Eastern Cape birds in a clockwise direction were higher than those travelled by Western Cape birds, whereas the reverse was true for anticlockwise movements (Tables 2.29–2.32). There was little difference in the mean distances travelled by birds from the Eastern Cape that were re-sighted alive and those that were found dead. For birds from the Western Cape, distances travelled in an anticlockwise direction by birds re-sighted alive tended to be greater than for those recovered dead, but this trend was reversed when considering rehabilitated birds. For birds from the Western Cape, the mean distances travelled were higher for birds banded at colonies than for those that had been rehabilitated, though this was not always the case with the median distance travelled. Mean and median distances travelled by Eastern Cape birds banded at colonies and found dead elsewhere, was higher than for rehabilitated birds from that region, but the sample size of rehabilitated birds was very low (5 as compared to 89 for birds banded at colonies) (Tables 2.31 and 2.32).

There were very few instances of birds banded as adults in Namibia visiting other colonies. Only 10% of African Penguins banded in Namibia prior to 1999 were banded as adults, the remainder being banded as chicks (D. Oschadleus pers. comm.). Two birds visited The Boulders colony in the Western Cape, covering 900 km from Possession Island and 1049 km from Mercury Island (Table 2.29). An adult banded at Mercury Island was found dead at Swakopmund, 354 km to the north (Table 2.31).

2.3.2.4 *Seasonal pattern of movements*

Table 2.21 shows the number of live re-sightings and dead recoveries made in each of four seasons. In contrast to movements of birds banded as chicks, there was no clear pattern as to what season adult movements were detected. The difference between the

minimum and maximum counts was just 14 for adults banded at colonies and 12 for those that had been rehabilitated. A goodness of fit test made on the combined totals for all adults suggests that there is no seasonal pattern to these movements ($\chi^2_3 = 0.651$, $P > 0.8$).

2.4 DISCUSSION

There is an element of bias in the recorded movements resulting from variation in re-sighting effort in relation to when birds were banded. Although penguin chicks were being banded at some colonies through the 1970s and early 1980s, there was very little re-sighting effort at many colonies during this period. This would limit the possibilities of where those birds could be re-sighted. It is unlikely, for instance, that penguins banded at Dassen Island in the 1970s would be seen at penguin colonies in the Saldanha area or in Namibia, because there was little or no re-sighting effort going on there at the time. Although there were many penguins banded at Dassen Island in the 1970s and 1980s, there was very little effort put into re-sighting banded birds so there was little chance of penguins from other colonies being re-sighted at Dassen Island prior to the late 1980s and 1990s.

African Penguins that were banded as chicks were more likely to undertake inter-colony movements than those that were banded as adults. The proportions found to have done so were 35% and 9% respectively (Table 2.1). For birds banded as chicks that were recovered dead when two years old or younger, there was a significant movement around the coast in a clockwise direction (Table 2.4). This was also true for those from Eastern Cape colonies that were re-sighted alive at other localities (Table 2.2). These findings agree with those of Randall *et al.* (1987). In contrast to the latter study, birds in the above age category from the Western Cape did not show a significant clockwise movement, while those banded in Namibia, that were re-sighted alive, had mostly moved southwards (Table 2.2). Birds re-sighted when older than two years of age showed contrasting patterns of dispersal, in that patterns obtained from live re-sightings and dead recoveries were sometimes different. Birds banded as adults in the Eastern Cape again showed a strong clockwise direction of movement, but Western Cape birds showed differing patterns between live re-sightings and dead recoveries.

The clockwise movement of birds from Eastern Cape colonies is probably explained, to some degree, by the distribution of food resources. African Penguins feed principally on pelagic shoaling fish (Randall 1989), which are abundant in the productive areas of the Agulhas Bank off the south coast, and the Benguela upwelling system off the west coast (Randall *et al.* 1987). Both these areas lie to the west of the Eastern Cape penguin colonies in Algoa Bay. Further east, the warmer waters of the Agulhas current become dominant, and the principal, cool-temperate prey species of the African Penguin (Sardine *Sardinops sagax* and Anchovy *Engraulis capensis*) are replaced by species more typical of the tropical waters to the north (Armstrong and Thomas 1989). There is an annual migration of sardines, known as the "sardine run", eastwards along the coasts of Transkei and KwaZulu-Natal, which follows a band of cold water that extends eastwards during the austral winter (Armstrong & Thomas 1989, Wilkinson *et al.* 1999). The African Penguin recorded at Sezela Beach in KwaZulu-Natal, may well have followed the sardine migration (Tables 2.6 & 2.10). African Penguin colonies in the Western Cape lie within the Benguela upwelling system or on the Agulhas Bank, while those in Namibia are situated within the Benguela upwelling system. This gives birds from colonies in those regions the choice of finding adequate food resources in either direction. The movement of dispersing Eastern Cape chicks to the Western Cape and movement of Western Cape and Namibian chicks within those regions is in keeping with this. Chicks re-sighted when aged over two years were mostly within the same region as their natal colony, although there is evidence that some dispersing chicks from Namibia may stay for long periods in the Western Cape (Tables 2.6 & 2.7). This is similar to the regional movements shown by birds banded as adults (Table 2.24). The Sardine population off the coast of Namibia and that off the South African coast are normally kept separate by a large area of cold water in the vicinity of Lüderitz. However, some movement has been recorded between them, with some sardines moving from Namibia as far as Walker Bay (34° 30′ S 19° 20′ E) on the south coast of the Western Cape (Armstrong & Thomas 1989).

As documented by Randall *et al.* (1987), a high proportion (75% in this study) of dispersing African Penguin chicks returned to their natal islands, where 14% were recorded breeding. Almost a third of them (29%) were known to have visited other

penguin colonies prior to their return. The fact that most were not re-sighted alive until four years or more after banding can be best explained by observer effort. Intensive periods of penguin research, involving re-sighting of banded birds, was not continuous in all regions prior to 1994. Consequently, chicks banded prior to August 1991 were less likely to be re-sighted when younger than four years old. The pattern for chicks banded from 1994, when monitoring was intensified, shows that most were re-sighted within the first two years after banding (Table 2.14). Those that were not re-sighted during this period probably visited or returned to colonies that were monitored less frequently, and may have escaped detection for longer. Even where monitoring was most intensive, it is certain that some banded birds were not detected during field visits. Of 86 flipper-banded adults that were known to be alive at Robben Island in 1993 and 1995, 18 were not seen in 1994, giving a probability of 0.21 for a banded adult going unseen (Crawford *et al.* 1999). The pattern for hand-reared, orphaned chicks was similar to that for naturally reared ones (Table 2.14).

There were pairs of localities within each region that had regular movements between them. They accounted for 34%–76% of all movements and were of relatively short distances (48–64 km). Mean distances travelled by birds that were banded as chicks were generally higher for those under two years old when re-sighted than for those aged over two years. This did not hold true, however, for birds banded in Namibia that travelled southwards (see above, Tables 2.15 & 2.16). It is likely that most of the younger birds were seen during post-fledging dispersal, when they may wander for considerable distances (Randall 1989). Sightings of birds over two years old may relate more to shorter distance foraging movements or birds returning from post-fledging dispersal. Movements of birds banded as chicks in Namibia were generally of longer distances in a southerly than in a northerly direction (Tables 2.15–2.17). Long-distance movements in a northerly direction from Namibian colonies would take birds into remote areas of coastline thus reducing the likelihood of those birds being either re-sighted or reported. The influence of the Benguela system, which is rich in nutrients and associated prey species of African Penguins, extends approximately as far as Moçâmedes (=Namibe) (15° 10′ S 12° 09′ E) (Figure 1.1) in southern Angola (Shannon 1989). This is approximately 1125 km north of Hollams Bird Island (24° 38′ S 14° 31′ E), the most northerly African Penguin colony, and

1375 km north of the town of Lüderitz. Penguins venturing north of the Benguela system would encounter much reduced densities of prey, and this would presumably curtail most long-distance movements in a northerly direction.

Seasonal patterns of re-sightings are somewhat difficult to explain in the case of birds banded as chicks. The annual moult period in the Eastern and Western Cape falls within the months of October to January (spring and summer) (Randall & Randall 1981, Underhill & Crawford 1999), whereas in Namibia, the peak moult period is in April (J. Kemper pers. comm.). The autumn and winter months cover the peak period of breeding activity in the Eastern and Western Cape, but in Namibia, this peak usually falls between September and December (Crawford *et al.* 1995c), i.e. in spring and early summer. Re-sighting effort in the Western Cape was approximately even throughout the year, although the long, summer evenings allowed a greater number of birds coming ashore after foraging to be re-sighted. It is necessary for African Penguins to come ashore to moult for a period of about three weeks (Randall 1989). During this time, they do not go to sea and tend to remain in the same area on the shore, or occasionally in a burrow or under vegetation (pers. obs, Randall 1989). This increases the likelihood of these birds being re-sighted during this period. The average age at first breeding in African Penguins is between three and five years old (Randall 1989, Crawford *et al.* 1999, Chapter Five). It is likely that birds younger than this will not be breeding and may be absent from breeding colonies during the peak breeding months (autumn and winter in the Cape). This would explain the seasonal distribution of re-sightings of birds banded as chicks. There was no apparent seasonal pattern to movements of penguins banded as adults.

The proportion of rehabilitated birds that undertook inter-colony movements was lower than that of adults banded at breeding colonies. The directional pattern of movements also differed. Live re-sightings of rehabilitated birds showed no obvious directional pattern, while that of dead recoveries was opposite to that shown by birds banded at breeding colonies, although the sample sizes of rehabilitated birds recovered dead were low (Tables 2.22 and 2.23). This may indicate a degree of disorientation among rehabilitated birds, causing them to move relatively short distances in the "wrong" direction before returning to their breeding colonies, or in some cases, their being recovered dead. However, the pattern of movement between

regions by rehabilitated adults mirrored that shown by adults banded at breeding colonies, suggesting that they did not travel long distances after such disorientation.

The proportions of adults re-sighted alive, when compared to the number that were banded, were high. The proportions increased if the analysis was restricted to birds that were banded from 1990 onwards. This almost certainly reflects the increased observer effort from 1994. Many adults banded in the early years will have died without their having been re-sighted alive, due to the low intensity of observer coverage. With the intensification of re-sighting effort from late 1994, the likelihood of birds being re-sighted between banding and death increased. The proportion of rehabilitated adults that were re-sighted alive was greater than that of adults banded at colonies, whichever span of years was chosen. This may be due to the fact that the majority of rehabilitated birds have come from colonies that are frequently visited by researchers. Those banded at more remote and less visited colonies are less likely to be re-sighted. Also, the most intensive observer effort was mainly directed towards finding rehabilitated penguins, particularly those from the *Apollo Sea* and Cape Town Harbour spills (see Chapter Eight).

The proportion of birds banded as chicks that were found dead at colonies is less than that of adults. This is especially noticeable if recoveries of dead birds that were not seen alive after banding are considered (Table 2.13). This can best be explained by the fact that most birds banded as chicks died after post fledging dispersal and had not yet returned to breed. The more sedentary nature of breeding adults increases the likelihood of them being found dead at their breeding colonies. If all recoveries are considered, including those of birds previously re-sighted alive, the proportions are closer, as it includes chicks that returned to breeding colonies and later died there (Table 2.13).

It is interesting that the proportion of rehabilitated adults found dead at breeding colonies is much lower than that of adults that were banded at breeding colonies. There are various possible explanations for this. Many of the adults banded at breeding colonies may have been established breeding birds and therefore most likely to be found dead at their colony. The origin and breeding status of rehabilitated birds is generally unknown. Although in adult plumage, some may be sub-adult birds that

are still engaged in post fledging movements and therefore more likely to be found dead away from colonies. The mean age at death is less for rehabilitated adults than for those banded at breeding colonies (Table 2.27), but it still exceeds two years from the release date. However, the median time between release and death is less than half of that pertaining to adults banded at colonies. This suggests that there are some rehabilitated birds that lived for a long time before being recovered, but more tended to be found dead relatively soon after release, presumably before they had returned to breeding colonies. Those that did return had a mean age at death that was slightly higher than that of adults banded at colonies.

The distances travelled by birds banded as adults tended to be less than distances travelled by those banded as chicks. However, an exception to this was found in the Western Cape, where the mean distance travelled in an anticlockwise direction was higher for adults banded at breeding colonies than it was for chicks (Tables 2.15, 2.16 and 2.29). This held true for those re-sighted alive but not for those recovered dead, and may indicate that distances travelled by non-breeding adults to forage were greater than those covered by post-fledging dispersal in this direction. There is evidence that penguins from Dassen Island often forage in the waters surrounding Dyer Island, 211 km away. Of a total of 578 birds oiled at Dyer Island in a spill in August 1995, 168 were subsequently re-sighted at Dassen Island following their release, 52 of which were recorded breeding. In July 2000, 19 500 penguins were evacuated to Port Elizabeth (33° 55′ S 25° 38′ E) following an oil spill caused when the bulk ore carrier MV *Treasure* sank between Robben and Dassen Islands (Crawford *et al.* 2000a). Three birds were fitted with satellite transmitters, which allowed the return to their breeding colonies to be monitored daily. One of these birds returned to its colony on Dassen Island then left to forage in the waters off Cape Infanta (34° 27′ S 20° 52′ E) (Figure 1.1), 290 km to the south and east for three weeks, before returning to Dassen Island again (Underhill 2000). In the Western Cape, the mean distance travelled by adults banded at breeding colonies, and then re-sighted alive elsewhere, was greater than that for rehabilitated adults (Tables 2.29 & 2.30), although the median distance for birds that travelled clockwise was the same. Whether this is an indication that rehabilitated birds are less inclined to forage far from their home colonies is difficult to say. The mean distances travelled by

rehabilitated birds was lowered due to the large number of relatively short movements between Dassen and Robben Islands, and to several short, post-release movements in the opposite direction to where the birds settled. Given also that the sample size of birds banded at colonies is comparatively small (Tables 2.29 and 2.30), the difference in mean distances travelled is probably not biologically significant.

The majority of the findings in this study agree with those of Randall *et al.* (1987). Both studies found post-fledging movements to be markedly clockwise for live re-sightings of penguins from the Eastern Cape and for all penguins that were recovered dead. However, in this study no obvious directional movement was found for birds fledging from the Western Cape or Namibia, when re-sighted alive at other colonies. Randall *et al.* (1987) found the proportion of chicks moving northwards from the Western Cape to be 88%, and from Namibia to be 85%. The proportions in this study were 56% and 48% respectively.

The analysis made by Randall *et al.* (1987) spanned the period 1952–1984. In the Western Cape, three "new" breeding colonies formed in the early 1980s. Stony Point (34° 22′ S 18° 54′ E) at Betty's Bay on the south coast and The Boulders on the False Bay side of the Cape Peninsula, were first colonised in 1982 (Broni 1982) and 1985 (Cooper 1985, Crawford *et al.* 2000b) respectively. Robben Island was re-colonised in 1983 (Crawford *et al.* 1995a). There would not have been any movements recorded to or from The Boulders and very few, if any, to and from Robben Island at the time of the analysis made by Randall *et al.* (1987). This may account for the difference in direction of post-fledging movements of Western Cape birds between the two analyses. Table 2.33 bears this out. By excluding all movements to and from both Robben Island and The Boulders, the proportion of Western Cape birds travelling north increases to 75% ($Z = 4.44$, significant at the 5% level). If the re-sightings of post-fledging movements between Ichaboe and Mercury Islands in Namibia are also excluded (Table 2.33), the proportion of chicks moving northwards from Namibian colonies increases to 79% ($Z = 4.28$, significant at the 5% level). It is possible that the small sample of 20 inter-colony movements from Namibia, used in the analysis of Randall *et al.* (1987), did not include many re-sightings from one or other of these two islands. In keeping with the study by Randall *et al.* (1987), it was found that

African Penguins from the Western Cape and Namibia rarely strayed to the Eastern Cape but remained within the area of the Benguela upwelling system or Agulhas Bank.

TABLE 2.1

Numbers of African Penguins banded as chicks or as adults, numbers re-sighted alive or recovered dead and proportions that had moved from their natal or breeding colony.

	Chicks	Adults banded at colony	Rehabilitated adults	All adults
Number banded 1970–1998	23 401	10 440	11 436	21 876
Number re-sighted /recovered dead	3986	1672	4691	6363
Number of birds recorded away from natal/breeding colony	1409	255	309	564
Proportion of re-sighted/recovered birds that moved (%)	35	15	7	9

TABLE 2.2

Direction of all movements of birds banded as chicks and re-sighted alive when two years old or younger. Z-values greater than 1.96, or less than –1.96, are significant at the 5% level; positive Z-values represent clockwise movements.

	Clockwise	Anticlockwise	Z-value
Eastern Cape	102	1	9.95
Western Cape	96	86	0.74
Namibia	85	111	-1.86

TABLE 2.3

Direction of all movements of birds banded as chicks and re-sighted alive when over two years old. Z-values greater than 1.96, or less than –1.96, are significant at the 5% level, positive Z-values represent clockwise movements.

	Clockwise	Anticlockwise	Z-value
Eastern Cape	22	18	0.63
Western Cape	209	155	2.83
Namibia	118	113	0.33

TABLE 2.4

Direction of all movements of birds banded as chicks and recovered dead when two years old or younger. Z-values greater than 1.96, or less than –1.96, are significant at the 5% level, positive Z-values represent clockwise movements.

	Clockwise	Anticlockwise	Z-value
Eastern Cape	89	20	6.61
Western Cape	102	27	6.60
Namibia	15	3	2.83

TABLE 2.5

Direction of all movements of birds banded as chicks and recovered dead when over two years old. Z-values greater than 1.96, or less than –1.96, are significant at the 5% level, positive Z-values represent clockwise movements.

	Clockwise	Anticlockwise	Z-value
Eastern Cape	31	5	4.33
Western Cape	15	19	-0.69
Namibia	3	1	1.00

TABLE 2.6

Movements of birds banded as chicks between or within regions and re-sighted alive when two years old or younger.

		To				
		KwaZulu Natal	Eastern Cape	Western Cape	Northern Cape	Namibia
From	Eastern Cape	1	11	89	0	2
	Western Cape	0	2	160	1	19
	Namibia	0	0	12	0	184

TABLE 2.7

Movements of birds banded as chicks between or within regions and re-sighted alive when older than two years.

		To		
		Eastern Cape	Western Cape	Namibia
From	Eastern Cape	25	13	2
	Western Cape	4	328	32
	Namibia	2	54	175

TABLE 2.8

Movements of birds banded as chicks between or within regions and recovered dead when two years old or younger.

		To				
		KwaZulu Natal	Eastern Cape	Western Cape	Northern Cape	Namibia
From	Eastern Cape	1	38	70	0	0
	Western Cape	0	4	99	5	21
	Namibia	0	1	0	1	16

TABLE 2.9

Movements of birds banded as chicks between or within regions and recovered dead when older than two years.

		To			
		Eastern Cape	Western Cape	Northern Cape	Namibia
From	Eastern Cape	24	12	0	0
	Western Cape	0	31	1	2
	Namibia	0	0	1	3

TABLE 2.10

Numbers of chicks banded in the Eastern Cape that made return visits to their natal colonies after being recorded at another locality.

			To						
		KwaZulu-Natal	Eastern Cape			Western Cape			Namibia
	Number banded	Sezela Beach	Bird Island	St Croix Island	Jahleel Island	Dyer Island	Robben Island	Dassen Island	Ichaboe Island
From Bird Island	1214	1	-	4	0	2	2	8	1
From St Croix Island	1438	0	3	-	2	4	0	0	0

TABLE 2.11

Numbers of chicks banded in the Western Cape that made return visits to their natal colonies after being recorded at another locality.

			To						
		Eastern Cape	Western Cape					Namibia	
	Number banded	Bird Island (Algoa Bay)	Dyer Island	The Boulders	Robben Island	Dassen Island	Bird Island (Lambert's Bay)	Ichaboe Island	Mercury Island
From Dyer Island	3162	0	-	5	2	3	0	1	0
From Stony Point	217	0	0	1	0	0	0	0	0
From Robben Island	2434	0	3	15	-	45	0	1	1
From Dassen Island	7451	1	2	12	30	-	1	7	0

TABLE 2.12

Numbers of chicks banded in Namibia that made return visits to their natal colonies after being recorded at another locality.

			To				
			Western Cape			Namibia	
		Number banded	The Boulders	Robben Island	Dassen Island	Ichaboe Island	Mercury Island
From	Possession Island	1301	0	0	0	1	0
	Ichaboe Island	3595	1	0	3	-	34
	Mercury Island	2211	0	1	0	58	-

TABLE 2.13

Proportions (%) of African Penguins banded as chicks or as adults that were found dead at breeding colonies.

	Proportion of all dead recoveries including those previously seen alive	Proportion of dead recoveries of birds that were not previously seen alive
Banded as chicks	33	18
Banded as adults at breeding colonies	46	66
Rehabilitated adults	38	34

TABLE 2.14

Elapsed time, in years, between banding (and approximate fledging) and first re-sighting of chicks banded at breeding colonies and of orphaned, hand-reared chicks.

	Years after banding				
	< 1	1–2	2–3	3–4	>4
Number of first re-sightings (chicks banded after 1970)	329	518	680	674	1140
Number of first re-sightings (chicks banded after 1993)	128	98	49	62	31
Number of first re-sightings (orphaned chicks)	16	23	11	6	7

TABLE 2.15

Distances (km) travelled by chicks, from each of three regions, that were re-sighted alive at other localities when two years old or younger.

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	6	1720	102	698	825
anticlockwise	610	610	1	610	610
Western Cape: clockwise	13	1292	96	275	111
anticlockwise	5	871	86	132	100
Namibia: clockwise	43	487	85	91	64
anticlockwise	64	1060	111	154	64

TABLE 2.16

Distances (km) travelled by chicks, from each of three regions, that were re-sighted alive at other localities, when over two years old.

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	3	1720	22	578	634
anticlockwise	48	48	18	48	48
Western Cape: clockwise	5	1122	209	227	105
anticlockwise	6	910	155	113	51
Namibia: clockwise	43	513	118	78	64
anticlockwise	64	1782	113	501	106

TABLE 2.17

Distances (km) travelled by chicks, from each of three regions, that were recovered dead at other localities, when two years old or younger.

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	6	1076	89	434	424
anticlockwise	8	625	20	183	165
Western Cape: clockwise	10	1574	102	324	124
anticlockwise	5	1090	27	231	143
Namibia: clockwise	86	504	15	351	402
anticlockwise	140	1910	3	815	394

TABLE 2.18

Distances (km) travelled by chicks from each of three regions that were recovered dead at other localities, when over two years old.

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	9	663	31	189	109
anticlockwise	30	271	5	145	107
Western Cape: clockwise	10	849	15	142	59
anticlockwise	6	345	19	147	138
Namibia: clockwise	64	450	3	268	290
anticlockwise	638	638	1	638	638

TABLE 2.19

Distances (km) travelled by chicks, from each of three regions, that were re-sighted alive at other localities when two years old or younger, omitting movements between Bird Island and St Croix Island (Eastern Cape), Robben Island and Dassen Island (Western Cape) and Mercury Island and Ichaboe Island (Namibia).

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	6	1720	100	711	825
anticlockwise	610	610	1	610	610
Western Cape: clockwise	13	1292	83	310	140
anticlockwise	5	871	72	148	138
Namibia: clockwise	43	487	44	116	86
anticlockwise	86	1060	12	896	980

TABLE 2.20

Distances (km) travelled by chicks, from each of three regions, that were re-sighted alive at other localities when aged over two years, omitting movements between Bird Island and St Croix Island (Eastern Cape), Robben Island and Dassen Island (Western Cape) and Mercury Island and Ichaboe Island (Namibia).

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	3	1720	19	662	634
anticlockwise	0	0	0	0	0
Western Cape: clockwise	5	1122	136	322	211
anticlockwise	6	910	82	167	138
Namibia: clockwise	43	513	42	102	86
anticlockwise	106	1782	57	931	899

TABLE 2.21

Number of movements recorded in each of four seasons for birds banded as chicks and adults.

	Summer	Autumn	Winter	Spring	Total
Banded as chick	425	275	300	507	1507
Banded as adult at colony	69	56	66	70	261
Rehabilitated adult	98	110	99	108	415
Total adults	167	166	165	178	676

TABLE 2.22

Direction of movement of birds banded as adults and re-sighted alive at places other than their breeding colony. Z-values greater than 1.96, or less than –1.96, are significant at the 5% level, positive Z-values represent clockwise movements.

Banded at colony	Clockwise	Anticlockwise	Z-value
Eastern Cape	5	1	1.63
Western Cape	9	20	-2.04
Namibia	0	2	-1.41
Rehabilitated			
Eastern Cape	1	0	1.00
Western Cape	84	95	-0.82
Namibia	0	0	-

TABLE 2.23

Direction of movement of birds banded as adults and recovered dead at places other than their breeding colony. Z-values greater than 1.96, or less than –1.96, are significant at the 5% level, positive Z-values represent clockwise movements.

Banded at colony	Clockwise	Anticlockwise	Z-value
Eastern Cape	62	27	3.71
Western Cape	17	12	0.93
Namibia	1	0	1.00
Rehabilitated			
Eastern Cape	2	3	-0.45
Western Cape	3	6	-1.00
Namibia	0	0	-

TABLE 2.24

Movements of birds banded as adults and re-sighted alive or recovered dead between or within regions.

		To					
	Banded at colony	Eastern Cape		Western Cape		Namibia	
		Live	Dead	Live	Dead	Live	Dead
From	Eastern Cape	3	57	3	32	0	0
	Western Cape	2	0	26	29	1	0
	Namibia	0	0	2	0	3	1
	Rehabilitated						
From	Eastern Cape	1	5	0	0	0	0
	Western Cape	1	0	176	9	2	0
	Namibia	-	-	-	-	-	-

TABLE 2.25

Live re-sightings of birds banded as adults at breeding colonies, showing colonies visited and colony where breeding was established.

		Colony visited									
		Eastern Cape		Western Cape						Namibia	
		BI	MAIN	DYI	SP	BB	RI	DAS	MAIN	II	TOTAL
Breeding colony	EC BI		1								1
	EC SCI	1	1						3		5
	Western Cape DYI							1			1
	Western Cape SP	1		2			1	1			5
	Western Cape RI			1	2	3		5	2	1	14
	Western Cape DAS		1	2			1		3		7
	Western Cape MGI								1		1
	Western Cape MCI							1			1
	N PSI					1					1
	N MYI					1					1
	TOTAL	2	3	5	2	5	2	8	9	1	37

Abbreviations used in Tables 2.25 and 2.26

EC	Eastern Cape	II	Ichaboe Island	MYI	Mercury Island
N	Namibia	JI	Jutten Island	PSI	Possession Island
BB	The Boulders	L	Langebaan	RI	Robben Island
BI	Bird Island (Algoa Bay)	MAIN	mainland site, not a breeding colony	SCI	St Croix Island
				SP	Stony Point
DAS	Dassen Island	MCI	Marcus Island	SS	Silverstroomstrand
DYI	Dyer Island	MGI	Malgas Island	VI	Vondeling Island

TABLE 2.26

Live re-sightings of rehabilitated adults at breeding colonies, showing colonies visited and colony where breeding was established.

		Colony visited												
		EC	Western Cape									Namibia		
		SCI	DYI	SP	BB	RI	DAS	VI	JI	MCI	MAIN	II	MYI	TOTAL
Breeding colony	EC: BI	1												1
	EC: SCI					1								1
	Western Cape: DYI				1	1	1	1	1					5
	Western Cape: BB					1								1
	Western Cape: RI		8	1			54			1	1	1		66
	Western Cape: DAS		7		6	40		2	3		2		1	61
	Western Cape: JI						1							1
	Western Cape: MCI					1								1
	Western Cape: L					1	2							3
	Western Cape: SS				2	21	15				2			40
	TOTAL	1	15	1	9	66	73	3	4	1	5	1	1	180

TABLE 2.27

Minimum, mean, median and maximum ages (in days) at death for adults banded at colonies and for rehabilitated adults.

	Minimum	Maximum	Mean	Median
Birds banded at colonies	1	6699	1470	954
Rehabilitated birds	4	7226	980	455

TABLE 2.28

Number of colonies visited by adults banded at colonies and by rehabilitated adults.

	Number of colonies visited		
	2	3	4
Banded at colonies	121	1	0
Rehabilitated	282	7	0

TABLE 2.29

Distances (km) travelled by adults banded at breeding colonies, in each of three regions, that were re-sighted alive at other localities.

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	65	368	5	228	245
anticlockwise	48	48	1	48	48
Western Cape: clockwise	51	899	9	182	51
anticlockwise	44	934	20	222	113
Namibia: clockwise	64	86	3*	78	86
anticlockwise	900	1049	2	974	974

*These birds had moved in a clockwise direction from their place of banding but it was not clear at which colony they had settled.

TABLE 2.30

Distances (km) travelled by rehabilitated adults, in each of two regions, that were re-sighted alive away from their breeding colonies.

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	48	48	1	48	48
anticlockwise	0	0	0	0	0
Western Cape: clockwise	30	912	84	86	51
anticlockwise	18	312	95	81	51

TABLE 2.31

Distances (km) travelled by adults banded at breeding colonies, in each of three regions, that were recovered dead at other localities.

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	6	1030	62	265	229
anticlockwise	8	308	27	133	124
Western Cape: clockwise	10	335	17	103	78
anticlockwise	6	431	12	148	101
Namibia: clockwise	354	354	1	354	354
anticlockwise	0	0	0	0	0

TABLE 2.32

Distances (km) travelled by rehabilitated adults, in each of two regions, that were recovered dead away from their breeding colonies.

	Minimum	Maximum	No. of birds	Mean	Median
Eastern Cape: clockwise	27	196	2	111	111
anticlockwise	12	107	3	54	43
Western Cape: clockwise	22	149	3	79	66
anticlockwise	6	211	6	129	171

TABLE 2.33

Direction of movement of birds banded as chicks and re-sighted alive when two years old or younger. Excludes all movements to and from both Robben Island and The Boulders, and all movements between Mercury and Ichaboe Islands. Z-values greater than 1.96, or less than –1.96, are significant at the 5% level, positive Z-values represent clockwise movements.

	Clockwise	Anticlockwise	Z value
Western Cape	58	19	4.44
Namibia	44	12	4.28

Figure 2.1 Distances travelled by African Penguins banded as chicks in the Eastern Cape, Western Cape and Namibia and re-sighted alive when a) two years old or younger and b) over two years old.

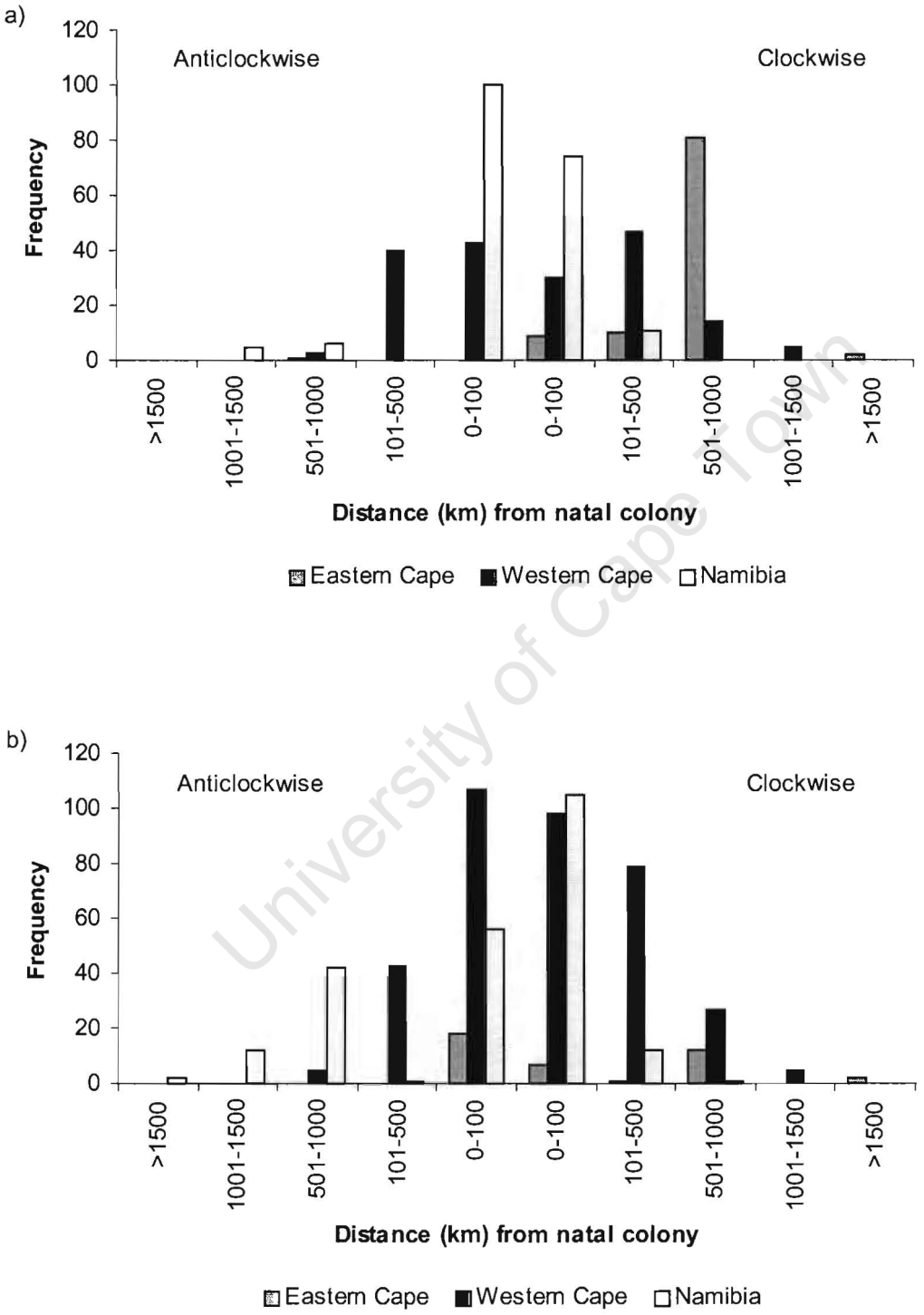
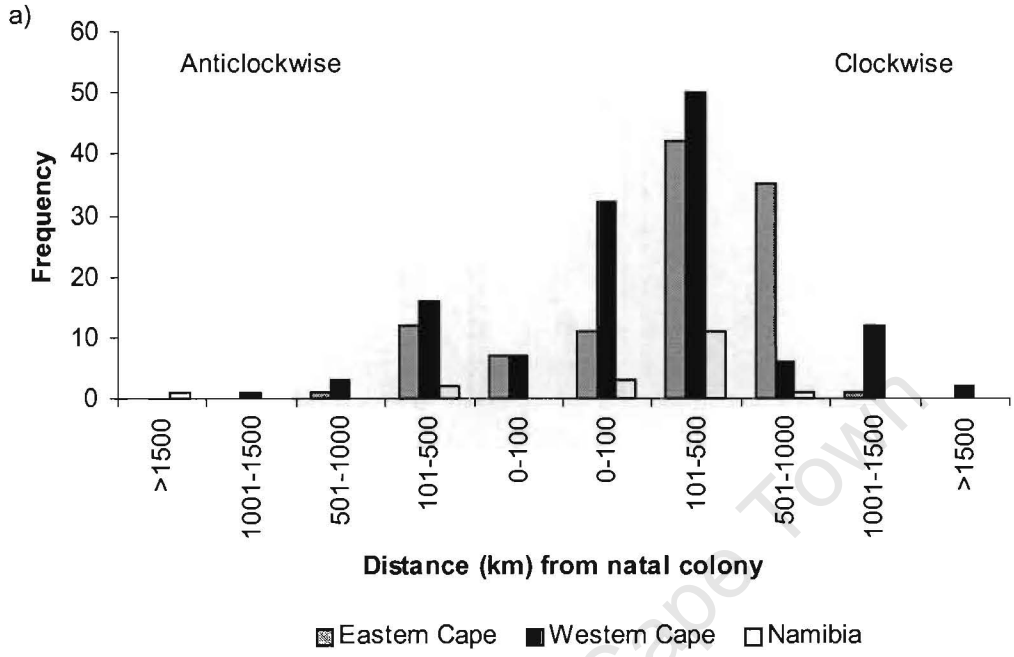


Figure 2.2 Distances travelled by African Penguins banded as chicks in the Eastern Cape, Western Cape and Namibia and recovered dead when a) two years old or younger and b) over two years old.



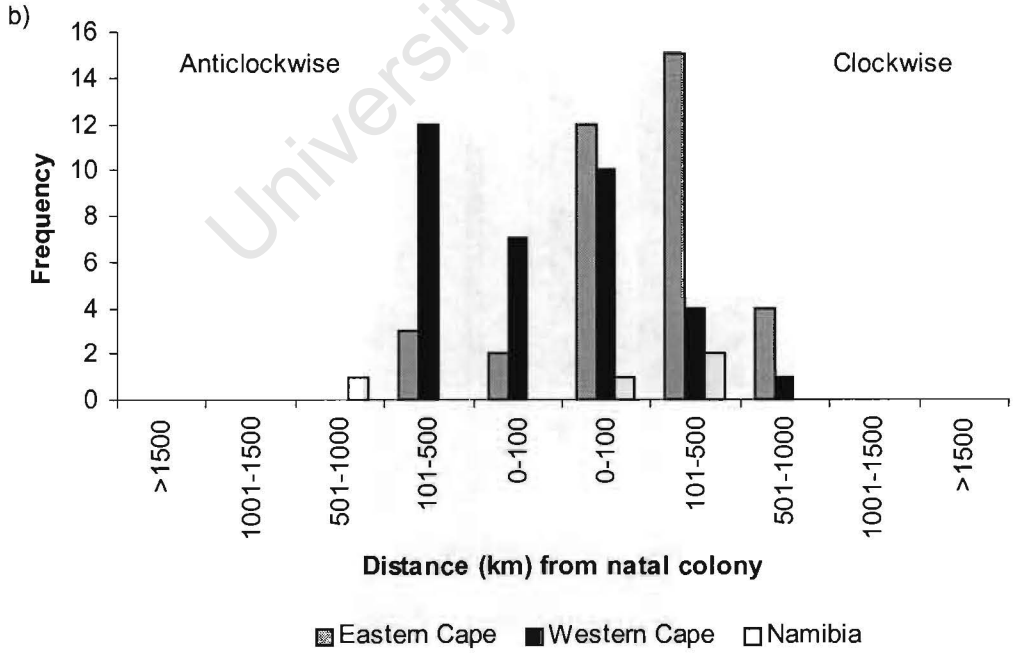
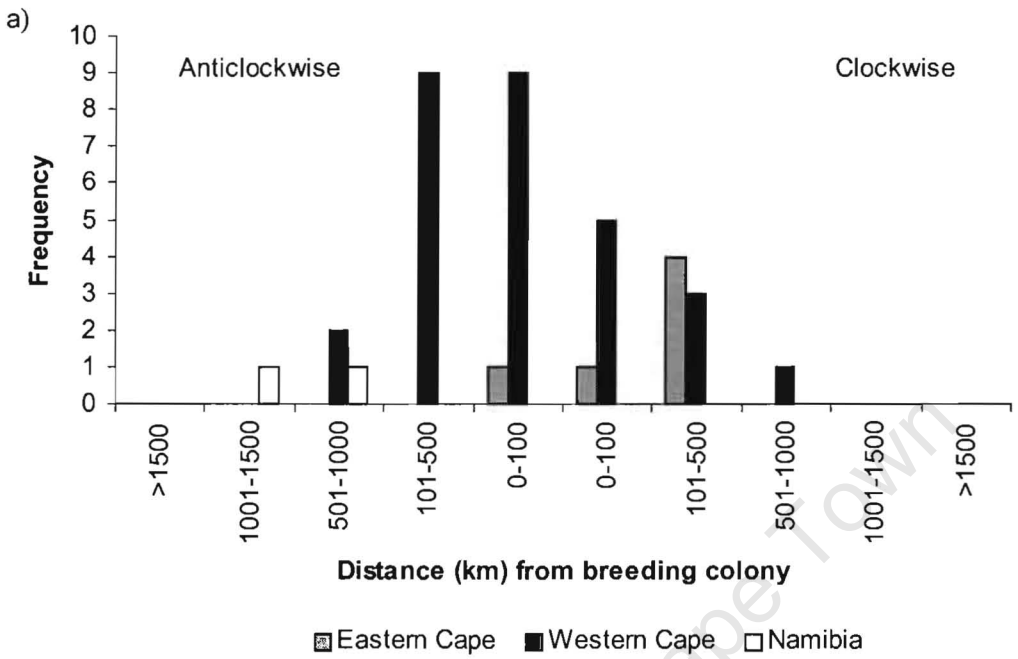


Figure 2.3 Distances travelled by African Penguins that were banded as adults and re-sighted alive at localities other than their breeding colony after being a) banded at a breeding colony and b) rehabilitated.



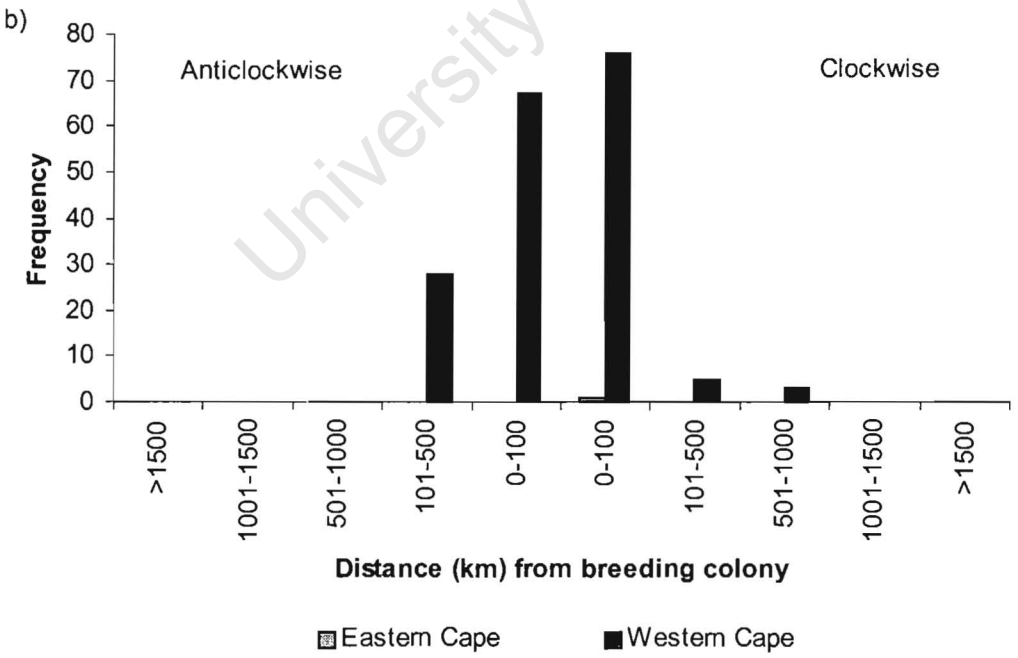
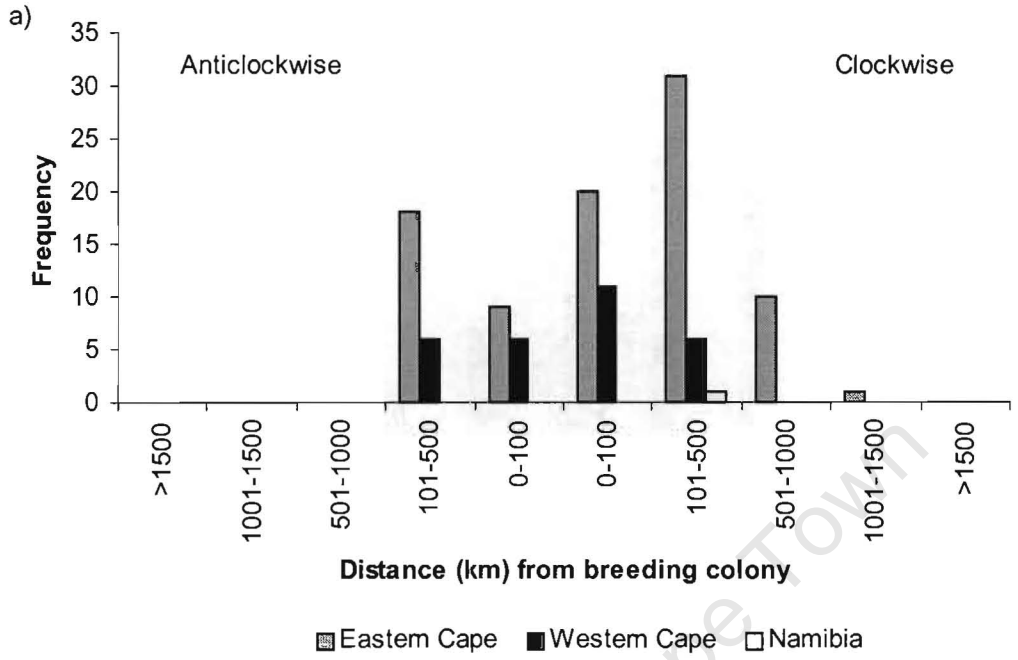
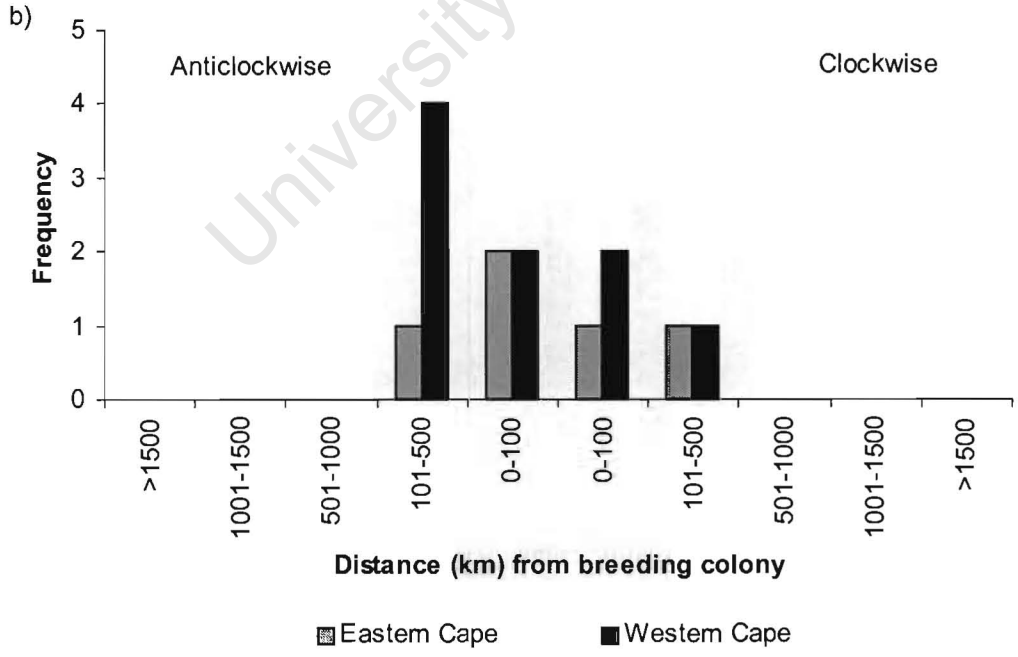


Figure 2.4 Distances travelled by African Penguins that were recovered dead after being a) banded as adults in the Eastern Cape, Western Cape or Namibia and b) rehabilitated.





CHAPTER THREE

MOVEMENTS OF AFRICAN PENGUINS TO AND FROM THE BOULDERS, SOUTH AFRICA.

3.1 INTRODUCTION

While on a trip to Simon's Bay in November 1687, Governor Simon van der Stel wrote in his diary that he had seen "penguins so tame they can be taken by hand" (McKenzie 1998). From his description in the diary, Becker (1987) was of the opinion that van der Stel was referring to a rock known as "Noah's Ark", a well-known landmark in Simon's Bay, named after its unusual shape. There is no indication whether or not penguins were breeding in the vicinity at the time. The reported presence of seals and penguins on this rock (Burman 1977) is unexpected, according to Shaughnessy (1984), because the sides of "Noah's Ark" are very steep. Until 1985, all but two breeding colonies of the African Penguin were on islands. The mainland sites were at Sylvia Hill (25° 10′ S 14° 50′ E), Namibia (Finkeldey 1984, Loutit & Boyer 1985, Whittington *et al.* 1996), and at Stony Point (34° 22′ S 18° 54′ E), about 75 km south-east of Cape Town, South Africa (Broni 1982, Whittington *et al.* 1996). An egg was laid in a rocky outcrop at Cape Recife (34° 02′ S 25° 42′ E), South Africa in June 1981 (Every 1983), but there were no further nesting attempts at this locality. The Boulders (34° 11′ S 18° 27′ E) became the third mainland colony, and the second in South Africa, when a pair hatched a single egg there in May 1985 (Cooper 1985). It is an atypical site when compared with other colonies of African Penguins. In addition to the fact that mainland sites are seldom chosen, presumably because of the dangers of predation by terrestrial mammals, The Boulders is situated on the edge of suburban Simon's Town (34° 12′ S 18° 27′ E). The coastal belt of rocky areas and bushes is backed by large houses and gardens and has a public right of way, Willis Walk, running through it. The penguins can be found nesting among rocks along the shore and in the bushes adjacent to Willis Walk. Prior to the erection of a fence along the coastal side of Willis Walk in December 1996, many penguins nested in the private gardens on the landward side. The whole area is frequently visited by members of the public and by residents for recreation. The penguin colony itself now attracts approximately 350 000 visitors annually (F. Dinee, South African National Parks pers. comm.).

Since penguins were first discovered breeding at The Boulders in 1985, the colony has shown a steady increase (Crawford *et al.* 2000b) to a population of 950 breeding pairs by 2000 (R.J.M. Crawford pers. comm.). The growth rate of the colony greatly exceeded the rate possible by natural reproduction alone (Ryan 1998), as was found to be the case at Robben Island (Crawford *et al.* 1999), indicating that immigration of birds into the colony was mainly responsible for its continued growth. Trends in numbers of African Penguins nesting and moulting at The Boulders were found to correlate closely with trends in the spawner biomass of Anchovy *Engraulis capensis* (Crawford *et al.* 2000b). At Robben Island, between 1989 and 1995, breeding success of adults and estimated immigration of immature birds were significantly positively related to the biomass of Anchovy (Crawford *et al.* 1999, 2000b). The diet of penguins was not investigated at The Boulders. Anchovy formed the bulk of the food of African Penguins at Robben Island in the 1990s (Crawford & Dyer 1995, Crawford *et al.* 2000b) and is likely to have been the main prey species of penguins at The Boulders.

This chapter discusses movements of flipper-banded penguins to and from The Boulders colony and suggests a likely origin for immigrants in the colony.

3.2 METHODS

Twenty-six visits were made to The Boulders between March 1995 and September 1999 to search for flipper-banded penguins. Visits were made approximately on a quarterly basis, but eight were made in 1999 between the months of March and September. Fieldwork was normally restricted to areas where access was open to the general public. During breeding censuses, carried out by staff of Marine and Coastal Management, the entire area of the breeding colony was searched for flipper-banded birds. Staff of Cape Peninsula National Park began regular contributions of details of flipper-banded birds from June 1999. Members of the public, SAFRING and staff of Marine and Coastal Management contributed additional sightings of banded birds. Sightings of banded birds prior to 1995 were contributed by staff of Marine and Coastal Management (85), SAFRING (17), J.J. Brossy and A. Plos (7), V. Keller (1) and the Benguela Ecology Project (1).

3.3 RESULTS

Until August 1999, there were 198 records of birds moving between The Boulders and other breeding colonies. Eleven of these related to birds banded at The Boulders being seen elsewhere, while 187 had been banded or released at other colonies and were subsequently sighted at The Boulders.

3.3.1 *Penguins banded as chicks*

This group provides the most interesting information because the age and colony of origin of the birds are both known. A total of 141 chicks banded at colonies other than The Boulders were subsequently recorded at The Boulders colony, of which 133 were re-sighted alive (Table 3.1, Appendix 3.2). Seventy-eight of these were two years old or younger when first seen or found dead at The Boulders. Chicks that undertake post-fledging movements normally return to their natal colony prior to their first attempts to breed (Randall *et al.* 1987). Of the 78 chicks recorded within two years of banding, 42 were not seen again after being seen at The Boulders. Eighteen were later recorded back at their natal colonies including one bird (S06154) that returned to Ichaboe Island, Namibia, a round trip of almost 2000 km (Appendix 3.2). A further ten penguins were found sick, injured or oiled and six were recovered dead (S05066, S05326, S12255, S14968, T2878 and V2902). A chick that had been banded at Bird Island, Algoa Bay (S25406), was later recorded at Dassen Island and another, banded as S14962 at Seal Island (34° 08′ S 18° 35′ E) in False Bay, was later seen at Stony Point (Appendix 3.2). Of those that were banded at Dassen Island, two were later seen at Robben Island (S01396 and S10492), one at Ichaboe Island (S03375) and seven returned to Dassen Island (S01741, S01907, S05789, S10158, S10283, S10396 and S13306). Of the nine birds banded at Dyer Island, three (S05869, S10820 and S10916) were known to have returned there from The Boulders. The others (S01422, S00506, S05392, S05527, S05570 and S10913) were not seen again. One bird (S25974), banded at Stony Point, later returned there. Six of the 22 penguins banded at Robben Island (S04638, S09314, S10611, S10697, S11027 and S11299) returned there after appearing at The Boulders, one (S04555) was later recorded at Seal Island (False Bay) and S11196 was subsequently found injured at Camps Bay (33° 57′ S 18° 22′ E) (Appendix 3.2). Twenty-one of the chicks under two years of age came from colonies to the east of The Boulders while 51 had come from a northerly direction.

In addition, 63 birds banded as chicks were recorded at The Boulders when aged two years or older, 61 of which were seen alive (Table 3.1). Twenty-nine of these were not seen subsequently and 18 are known to have returned to their natal colonies. Four (S07650, S09367, S11071 and S25354) were found sick, injured or oiled and one (V3085) was found dead. The only record of S12378, banded at Bird Island, Algoa Bay, was when its flipper-band was found at The Boulders. Twenty-eight of the penguins seen alive at The Boulders came from an easterly direction while 33 arrived from farther north. One of the two birds from Bird Island, Algoa Bay (S25354), was found injured; the other (S18470) was recorded as being present. Three of the birds banded at Dyer Island (S01408, S02198 and S05337) are known to have returned to their natal colony. Of those birds from Robben Island, eight (S01675, S05457, S05480, S08363, S10597, S11666, S11689 and S14004) were later seen back there, S14004 having moulted at The Boulders (Appendix 3.2). Six of the Dassen Island birds (S03497, S05742, S07002, S09367, T2985 and T2988) later returned and one of the Ichaboe Island birds (S17849) seemed to be on its way back, being reported both from Dassen Island and Bird Island, Lambert's Bay. A chick, which hatched at The Boulders, that had been hand reared by the Southern African Foundation for Conservation of Coastal Birds (SANCCOB) and released at Robben Island, was seen moulting at Dassen Island before returning to The Boulders. Thirty-six penguins aged three years or over were recorded visiting The Boulders between 1992 and 1999 (Figure 3.1). Re-sighting effort increased substantially after mid-1994, explaining the paucity of observations prior to 1995. The largest number of visitors to the colony in this age group occurred in 1995.

Banding of African Penguin chicks also gives an indication of where breeding birds at The Boulders originally came from. Seven chicks fledged from other colonies were found to be breeding at The Boulders (Table 3.2), and a further five may have been settling there, though they were not confirmed as breeders. Two of these five birds (S09732 and S14506) were seen defending empty nest sites, the latter together with its mate. An unbanded bird was seen courting S09796, S13346 was seen on three occasions at The Boulders and S14777, on its fifth sighting at The Boulders, was seen picking up nest material (Appendix 3.2). None of these five birds was seen at their natal colony following their first sighting at The Boulders. The natal colonies of the

12 birds breeding or apparently settling at The Boulders were Dyer Island (6), Seal Island, False Bay (1), Robben Island (2), Stony Point (1) and Dassen Island (2) (Figure 3.2).

3.3.2 *Penguins banded as juveniles and those of unknown age status*

Fifteen birds banded as juveniles, (i.e. post-fledging), were later recorded at The Boulders colony (Appendix 3.3). All had been rehabilitated by SANCCOB, ten having been oil spill victims. S09962 was found breeding at The Boulders, S16980 had previously been seen at Bird Island, Algoa Bay, and S23982 was subsequently recorded at Dyer Island (Appendix 3.3). Four (S02870, S14553, S21191 and S22813) were later seen at Dassen Island, S21191 having been oiled for the second time at The Boulders (Appendix 3.3). S25226 was seen at The Boulders following its release at Robben Island, but then returned to the release locality (Appendix 3.3) Five birds (A02363, S00798, S17016, S23928 and S26410) were seen at The Boulders following their release but were not recorded subsequently. S09969 and S23000 were seen at The Boulders on several occasions following their release (Appendix 3.3). Two birds of unknown age, both rehabilitated by SANCCOB, were later seen at The Boulders. G05993, a breeding bird from Dyer Island, was found dead. T1137, found stranded on a beach in KwaZulu-Natal was later released at Cape Recife, Eastern Cape Province, and was found injured at The Boulders. It was taken to SANCCOB and later released again at The Boulders (Appendix 3.3).

3.3.3 *Penguins banded in adult plumage*

Eighteen African Penguins were recorded at The Boulders having been banded in adult plumage at other breeding colonies. However, their true colony of origin remains uncertain because the breeding status of birds at banding was not always known or recorded on banding schedules. A bird banded at Bird Island, Algoa Bay as S12116, was found sick at The Boulders five years and eight months later, having been seen 10 days previously at Dyer Island. It subsequently died (Appendix 3.4). S14252 was banded at Dyer Island and subsequently found at a nest at The Boulders (Appendix 3.4). Three were banded at Stony Point (S06509, S06514 and S26013), S06514 later breeding at The Boulders, one was banded at nearby Seal Island in False Bay (S10757), and 10 were banded at Robben Island, two of which (T2566 and T2581) subsequently bred at The Boulders. Two birds made the journey from

Namibia, one from Possession Island (V1472), *c.* 900 km away, and one from Mercury Island (V1669), a distance of just over 1000 km. Of four birds banded as adults at The Boulders, one (T2578) moulted at Dassen Island, while three (T2570, T2613 and V6141), one of which was moulting (T2570), were seen at Robben Island (Appendix 3.5).

3.3.4 *Penguins rehabilitated by SANCCOB*

In addition to those penguins in section 3.3.3, there were re-sightings of 69 birds that had been banded in adult plumage and released by SANCCOB, 51 having been victims of oil pollution. Their colonies of origin were not known but in some cases can be deduced from where they subsequently settled to breed. In addition, nine rehabilitated penguins (A01757, A02385, A06841, A06842, A10143, A10201, A10207, A10456 and A10602) were released at The Boulders and were then re-sighted at other localities (Appendix 3.6), probably those from which they had originally come. Twenty of the 69 rehabilitees were seen once or twice at The Boulders but not recorded again. Another thirty-two were almost certainly birds from The Boulders that re-settled there following their release from SANCCOB. The remaining 17 rehabilitated penguins arrived via or continued on to other penguin colonies. Four (S14713, S20745, S23765 and S24689) subsequently settled to breed at Dassen Island and one (S24647) at Robben Island (Appendix 3.6). Both S21253 and S21478 were known breeding birds from Dassen Island that visited The Boulders and then returned to Dassen Island. S17058 was released at Robben Island in July 1993, was diet sampled there nearly four years later and had settled to breed at The Boulders by May 1998 (Appendix 3.6). S12789 was seen with a week-old chick on Dyer Island, five months prior to its sighting at The Boulders. A01067 was seen at The Boulders following its release and then continued on its travels to Bird Island, Lambert's Bay. Oil spill victim A06827 moulted at The Boulders before being seen at Robben Island. Three other survivors from oil spills (A01084, S14725 and S14844) moved to Dassen Island after being re-sighted at The Boulders. A05069 and S21116 called in at The Boulders after being sighted at Dassen Island and Robben Island respectively. S24462 was present at Dassen Island from September 1995 to June 1997 before being seen at The Boulders in September 1997 (Appendix 3.6). S14713, S14725, S14844 and S23765 were all released at Walker Bay, near Hermanus, on the

south coast of the Western Cape, and presumably called in to The Boulders on their way back to Dassen Island, where two of them subsequently bred.

3.4 DISCUSSION

From sightings of banded birds, it is apparent that The Boulders forms an important "stopping off" point for wandering young birds and for rehabilitated birds following their release. Other movements of birds to the colony probably relate to birds coming in to forage. An adult fitted with a satellite transmitter in 1996, which had two large chicks in a nest on Dassen Island, spent a night at The Boulders before returning to Dassen Island to feed its chicks (Crawford & Whittington 1997).

Based on observations made between 1952 and 1984, Randall *et al.* (1987) considered that African Penguin chicks normally move in a westerly or northerly direction from their natal colonies. However, 49 of the chicks arriving at The Boulders, were banded at colonies to the east and 84 from colonies to the north. Randall *et al.* (1987) found that overall, 88% of penguin chicks from Western Cape islands moved in a northerly direction, 12% having presumably moved southwards or eastwards. In this example, 63% of birds from these colonies moved southwards to The Boulders, although some later moved north again. The explanation for this change over time is not clear, but is probably due in part to changes in banding effort. Of 7199 chicks banded between 1971 and 1984, 2272 (32%) were banded at colonies to the east of The Boulders. This proportion was reduced to 20% for chicks banded between 1985 and 1999 (Table 3.3). Therefore, a higher proportion of penguins had been banded at colonies to the west and north of The Boulders prior to the current study than was the case in 1984, when the analysis by Randall *et al.* (1987) was made. It should be noted that the observations used in the analysis by Randall *et al.* (1987) were made prior to the discovery, in 1985, of a breeding colony at The Boulders.

The small sample of banded birds breeding at The Boulders that have emigrated from other colonies, suggests that 71% could have come from Dyer Island. The latter colony has declined by 90% during the growth period of The Boulders colony, and this decline is thought to be related to a shift in the distribution of prey (Crawford 1998a). However, it should also be noted that single birds from Robben and Dassen

Islands, both also showing an increase in numbers, have relocated to The Boulders. The ages of chicks from other colonies settling to breed at The Boulders ranged from four and a third years to just over seven years. It is possible that the first attempt at breeding by some of these birds was missed, but none were known to have attempted breeding at their natal colony. It has been suggested that first-time breeders have the flexibility to move from their natal colony to one where feeding conditions are more favourable (Crawford 1998a, Crawford *et al.* 2000b). It would appear that chicks under two years old recorded at the colony were most likely to be transient wandering individuals, whereas those over three years old were potential immigrants to the colony. Of chicks banded at other colonies that were older than two years when first seen at The Boulders, 34% had come from Dyer Island, whereas the proportion of birds from Dyer Island seen at The Boulders when two years old or younger was 13%. This would suggest that the proportion of birds banded as chicks at Dyer Island and arriving at The Boulders as potential immigrants, exceeds the proportion from that colony that are merely passing through. This lends weight to the argument that immigrants settling at The Boulders are probably mostly pre-breeding birds from Dyer Island.

TABLE 3.1

Natal colony of African Penguins that were banded as chicks and later recorded alive at The Boulders between September 1991 and August 1999.

Colony of origin	Distance (km) and direction from The Boulders	Number of chicks < 2 years old seen at The Boulders	Number of chicks >2 years old seen at The Boulders
Bird Island, Algoa Bay	725 East	6	2
Dyer Island	100 East	9	21
Stony Point	50 East	3	2
Seal Island, False Bay	17 East	3	3
Robben Island	90 North	22	16
Dassen Island	140 North	26	13
Saldanha Bay islands	190 North	2	0
Ichaboe Island	1000 North	1	4

TABLE 3.2

African Penguins banded as chicks at other colonies and recorded breeding at The Boulders between September 1991 and August 1999.

Band number	Banding date	Natal colony	Date first seen at The Boulders	Date of first breeding at The Boulders	Age when first seen at The Boulders	Age when first recorded breeding at The Boulders
A01973	25 Apr 1991	Dyer Island	4 Nov 1997	3 Jul 1998	6 years 6 months	7 years 2 months
S01466	27 Mar 1991	Dassen Island	23 May 1998	23 May 1998	7 years 2 months	7 years 2 months
S05076	8 Aug 1991	Dyer Island	3 Nov 1993	18 Aug 1995	2 years 2 months	4 years 0 months
S05407	21 Aug 1991	Dyer Island	21 Jun 1995	23 May 1998	3 years 10 months	6 years 1 month
S10826	4 Oct 1992	Dyer Island	10 Oct 1993	3 Jul 1998	1 year 0 months	5 years 9 months
S13492	29 Jul 1992	Robben Island	20 Sep 1995	23 Apr 1998	3 years 1 month	5 years 9 months
S20493	5 Oct 1995	Dyer Island	13 Apr 1999	8 Feb 2000	3 years 6 months	4 years 4 months

TABLE 3.3

Numbers of African Penguins banded as chicks at breeding colonies to the west and north and to the east of The Boulders between 1971 and 1999.

	West/north of The Boulders	East of The Boulders
Banded 1971–1984	4927	2272
Banded 1985–1999	14806	3804
Total	19733	6076

FIGURE 3.1. Frequency of occurrence of African Penguins, aged three years or older, visiting The Boulders between 1992 and 1999. Excludes recently rehabilitated birds.

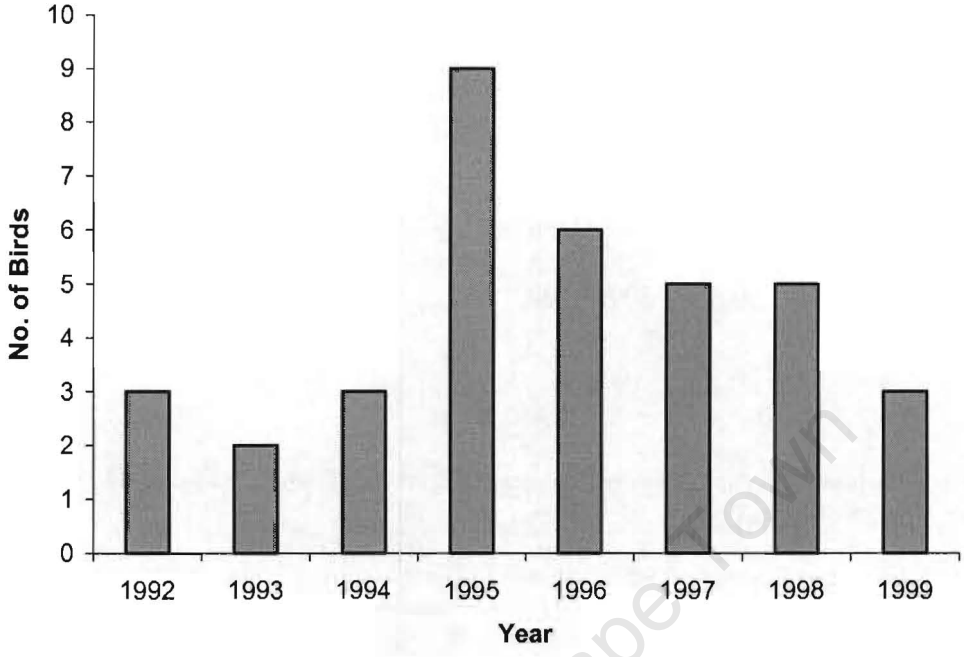
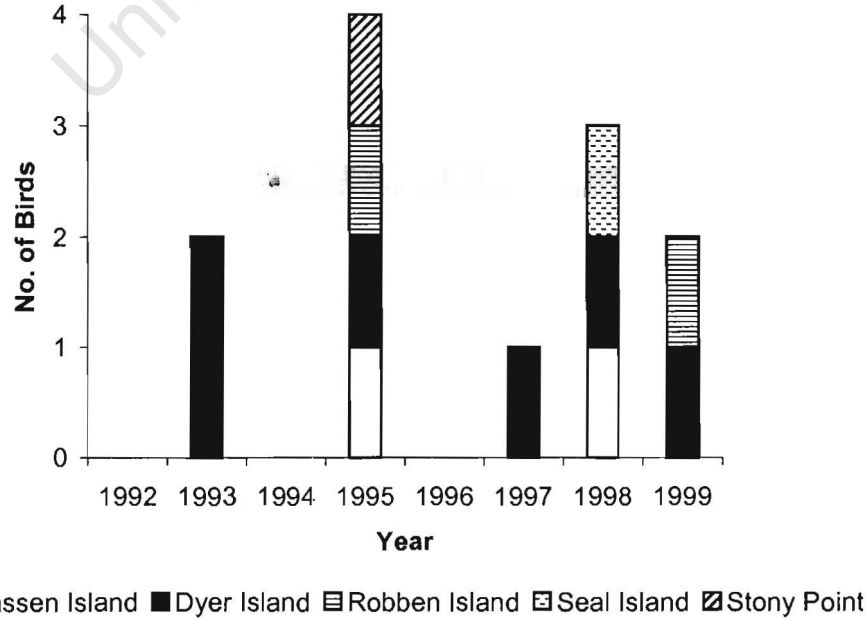


FIGURE 3.2. African Penguins settling at The Boulders between 1992 and 1999 with natal colonies indicated.



APPENDIX 3.1

Explanation of abbreviations and codes used in Appendices 3.2–3.6.

Locality Codes

BB	The Boulders
BI	Bird Island, Algoa Bay
CAM	Camps Bay
CR	Cape Recife
DAS	Dassen Island
DYI	Dyer Island
II	Ichaboe Island
JB	Jeffrey's Bay
LB	Bird Island, Lambert's Bay
M	Melkbosstrand
MGI	Malgas Island
MYI	Mercury Island
PSI	Possession Island
RI	Robben Island
SI	Seal Island, False Bay
SP	Stony Point
VI	Vondeling Island
WB	Walker Bay
YST	Ystervarkfontein

Activity Codes

B	blood sampled
C	with downy chick(s)
D	found dead
E	incubating egg(s)
F	with feathered chick(s)
G	going to sea
H	diet sampled
I	injured/sick
L	loafing
M	moulting
N	on nest
O	oiled
P	present
R	returning from sea
S	at empty nest site
U	pre-moult condition
X	other

Rehabilitation (Rehab.) status

0 = not rehabilitated
1 = oiled, cleaned and released
2 = rehabilitated but not oiled
3 = rehabilitated, no further details

The area codes, e.g. area A, area B, referred to under the "Comments" column in Appendices 3.2–3.6, represent names assigned to discreet areas of penguin colonies by Marine and Coastal Management, and are used principally for monitoring and census purposes. For those relating to Dassen Island see Crawford *et al.* (1997).

APPENDIX 3.2

African Penguins banded as chicks at colonies other than The Boulders and later re-sighted at The Boulders. The first line for each bird represents the ringing date and locality. See Appendix 3.1 for abbreviations

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
A01940	**1997**	**10**	**28**	**RI**	**2**		
A01940	1998	12	8	DAS	2	M	juvenile on beach, area G (chick from The Boulders)
A01940	1999	6	17	BB	2	L	boardwalk, gate 5
A01973	**1991**	**4**	**25**	**DYI**	**0**	**O**	**originally S01410**
A01973	1997	11	4	BB	0	I	released from SANCCOB on this date
A01973	1998	7	3	BB	2	F	with 1 feathered chick
A01973	1998	8	2	BB	2	R	Foxy Beach. Injured left leg
A01973	1999	5	18	BB	0	E	incubating 1+, area A
A01973	1999	6	7	BB	0	E	incubating 2, Foxy Beach
A01973	1999	6	10	BB	0	C	with 1 egg, 1 downy chick, Foxy Beach
A01973	1999	6	24	BB	0	C	with 1 downy chick, Foxy Beach
A01973	1999	7	2	BB	2	N	collecting nest mat. Limping
A01973	1999	7	8	BB	0	C	with 2 downy chicks, Foxy Beach
A01973	1999	7	13	BB	2	C	feeding chick
A01973	1999	7	29	BB	2	C	with one chick
S00324	**1989**	**8**	**1**	**DYI**	**0**		
S00324	1995	3	9	BB	0	P	alive and well
S01396	**1991**	**8**	**27**	**DAS**	**0**		
S01396	1992	1	8	BB	0	P	alive and well
S01396	1994	1	12	RI	0	P	alive and well
S01408	**1991**	**4**	**25**	**DYI**	**0**		
S01408	1994	2	3	BB	0	P	alive and well
S01408	1995	10	22	DYI	0	P	present in colony
S01422	**1991**	**4**	**25**	**DYI**	**0**		
S01422	1992	1	1	BB	0	P	alive and well
S01434	**1991**	**4**	**25**	**DYI**	**0**		
S01434	1995	10	25	BB	0	L	loafing at "hotel"
S01466	**1991**	**3**	**27**	**DAS**	**0**		
S01466	1998	5	23	BB	0	C	with 1 large downy chick, Nest 13
S01492	**1991**	**3**	**27**	**DAS**	**0**		
S01492	1993	9	24	BB	0	P	alive and well
S01518	**1991**	**3**	**27**	**DAS**	**0**		
S01518	1992	10	25	BB	0	P	alive and well
S01641	**1990**	**11**	**5**	**RI**	**0**		
S01641	1993	8	29	BB	0	P	alive and well
S01675	**1990**	**11**	**5**	**RI**	**0**		
S01675	1993	9	22	BB	0	P	alive and well
S01675	1995	5	29	RI	0	L	loafing, area V
S01675	1999	3	11	RI	0	R	area V
S01675	1999	6	24	RI	0	F	with feathered chick, area V
S01675	1999	6	28	RI	0	R	area D
S01698	**1990**	**11**	**5**	**RI**	**0**		
S01698	1993	10	10	BB	0	P	alive and well
S01698	1993	10	24	BB	0	P	alive and well
S01741	**1990**	**10**	**25**	**DAS**	**0**		
S01741	1992	1	4	BB	0	P	alive and well
S01741	1992	9	10	BB	0	P	alive and well
S01741	1995	4	17	DAS	0	E	incubating 2 under rock, area A
S01741	1996	2	23	DAS	0	E	incubating 2 eggs under rock, area A (west)
S01741	1996	11	14	DAS	0	L	loafing on shore, area A (west)
S01741	1996	11	22	DAS	0	M	on beach, area A
S01741	1997	1	10	DAS	0	L	on beach, area A

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S01741	1997	1	23	DAS	0	L	on beach, area A
S01741	1997	2	12	DAS	0	L	on beach, area A
S01741	1997	2	14	DAS	0	L	with mate under rock, area A
S01741	1997	10	22	DAS	0	M	on beach, area A
S01741	1997	10	26	DAS	0	L	on west shore, area A
S01741	1997	10	29	DAS	0	L	on beach, area A
S01741	1997	11	5	DAS	0	L	on beach, area A
S01741	1998	6	3	DAS	0	L	under rock, area A
S01742	**1990**	**10**	**26**	**DAS**	**0**		
S01742	1992	1	8	BB	0	P	alive and well
S01907	**1990**	**10**	**26**	**DAS**	**0**		
S01907	1992	9	1	BB	0	P	alive and well
S01907	1998	5	6	DAS	0	L	in burrow, area B
S01907	1998	10	7	DAS	0	L	on beach, area B
S02081	**1991**	**4**	**24**	**DYI**	**0**		
S02081	1995	8	18	BB	0	S	female at empty site, area H
S02119	**1990**	**10**	**5**	**DYI**	**0**		
S02119	1993	10	24	BB	0	P	alive and well
S02198	**1990**	**10**	**5**	**DYI**	**0**		
S02198	1993	9	22	BB	0	P	alive and well
S02198	1997	10	17	DYI	0	U	in colony
S02198	1998	2	21	DYI	0	L	in colony
S03140	**1991**	**5**	**16**	**DAS**	**0**		
S03140	1993	11	3	BB	0	P	alive and well
S03329	**1991**	**5**	**14**	**DAS**	**0**		
S03329	1992	10	1	BB	0	P	alive and well
S03375	**1991**	**5**	**15**	**DAS**	**0**		
S03375	1992	8	17	BB	0	P	alive and well
S03375	1996	10	13	II	0	P	
S03497	**1991**	**5**	**16**	**DAS**	**0**		
S03497	1993	10	24	BB	0	P	alive and well
S03497	1995	2	7	DAS	0	L	on beach, area D
S03497	1995	11	7	DAS	0	L	on beach, area D
S03497	1995	12	26	DAS	0	M	on beach, area D
S03498	**1991**	**5**	**16**	**DAS**	**0**		
S03498	1992	2	2	BB	0	P	alive and well
S04542	**1991**	**7**	**1**	**RI**	**0**		
S04542	1993	5	9	BB	0	P	alive and well
S04547	**1991**	**7**	**1**	**RI**	**0**		
S04547	1992	9	13	BB	0	P	alive and well
S04555	**1991**	**7**	**1**	**RI**	**0**		
S04555	1992	9	17	BB	0	P	alive and well
S04555	1995	3	16	SI	0	P	alive and well
S04563	**1991**	**7**	**4**	**SI**	**0**		
S04563	1992	10	3	BB	0	O	oiled, taken to SANCCOB
S04638	**1991**	**7**	**17**	**RI**	**0**		
S04638	1992	9	23	BB	0	P	alive and well
S04638	1998	3	26	RI	0	C	with 1 large downy chick, area B
S04638	1999	3	15	RI	0	L	under trees, area B
S04638	1999	3	28	RI	0	C	with 1 downy chick, area B
S04638	1999	6	24	RI	0	L	on shore, area D
S04655	**1991**	**7**	**17**	**RI**	**0**		
S04655	1992	10	1	BB	0	P	alive and well
S04892	**1991**	**8**	**6**	**RI**	**0**		
S04892	1998	8	2	BB	0	P	
S04892	1999	7	3	BB	0	R	
S04948	**1991**	**8**	**21**	**RI**	**0**		
S04948	1995	8	13	BB	0	L	Foxy Beach

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S05066	**1991**	**8**	**8**	**DYI**	**0**		
S05066	1991	10	11	BB	0	D	died within a month of finding
S05076	1991	8	8	DYI	0		
S05076	1993	11	3	BB	0	P	alive and well
S05076	1995	8	18	BB	0	C	with small downy(s)
S05166	**1991**	**8**	**8**	**DYI**	**0**		
S05166	1993	9	22	BB	0	P	alive and well
S05207	**1991**	**8**	**1**	**DYI**	**0**		
S05207	1993	10	24	BB	0	P	alive and well
S05289	**1991**	**8**	**19**	**DYI**	**0**		
S05289	1993	10	24	BB	0	P	alive and well
S05289	1994	10	21	YST	0	D	freshly dead
S05326	**1991**	**8**	**19**	**DYI**	**0**		
S05326	1992	4	12	BB	0	D	severely oiled, subsequently died
S05337	**1991**	**8**	**19**	**DYI**	**0**		
S05337	1993	11	7	BB	0	P	alive and well
S05337	1995	5	11	DYI	0	L	Loafing on rock
S05360	**1991**	**8**	**21**	**DYI**	**0**		
S05360	1997	9	30	BB	0	P	
S05369	**1991**	**8**	**21**	**DYI**	**0**		
S05369	1996	10	20	BB	0	L	loafing, Foxy beach
S05392	**1991**	**8**	**21**	**DYI**	**0**		
S05392	1992	4	14	BB	0	O	oiled, taken to SANCCOB
S05407	**1991**	**8**	**21**	**DYI**	**0**		
S05407	1995	6	21	BB	0	L	loafing under tree
S05407	1995	8	8	BB	0	L	loafing under bush
S05407	1998	5	23	BB	0	E	with S17058 (incubating 1) Nest 171
S05407	1999	4	13	BB	0	C	with mate (S17058 + 2 small downy chicks)
S05457	**1991**	**8**	**30**	**RI**	**0**		
S05457	1993	9	22	BB	0	P	alive and well
S05457	1995	6	12	RI	0	P	alive and well
S05457	1995	7	4	RI	0	E	incubating 2 eggs, area F
S05457	1996	5	22	RI	0	L	Loafing under trees, area F
S05470	**1991**	**8**	**30**	**RI**	**0**		
S05470	1992	4	4	BB	0	P	alive and well
S05480	**1991**	**8**	**30**	**RI**	**0**		
S05480	1993	10	18	BB	0	P	alive and well
S05480	1995	7	6	RI	0	E	incubating eggs, area U
S05480	1995	8	23	RI	0	H	caught for diet sample
S05480	1998	3	26	RI	0	L	on beach, area C
S05480	1999	3	13	RI	0	R	area C/D
S05527	**1991**	**10**	**23**	**DYI**	**0**		
S05527	1992	4	13	BB	0	I	exhausted
S05570	**1991**	**10**	**24**	**DYI**	**0**		
S05570	1991	11	11	BB	0	I	emaciated, taken to SANCCOB
S05685	**1991**	**9**	**16**	**RI**	**0**		
S05685	1992	9	9	BB	0	P	alive and well
S05728	**1991**	**10**	**6**	**DAS**	**0**		
S05728	1992	9	13	BB	0	P	alive and well
S05742	**1991**	**10**	**6**	**DAS**	**0**		
S05742	1993	11	17	RI	0	P	alive and well
S05742	1994	4	15	BB	0	P	alive and well
S05742	1994	9	20	DAS	0	P	alive and well
S05742	1995	5	16	DAS	0	L	Loafing on beach, area A
S05742	1996	7	2	DAS	0	L	on beach, area A
S05742	1997	3	23	DAS	0	L	with adults & crèche, area A (west)
S05742	1998	1	1	DAS	0	L	on beach, area A
S05742	1998	3	26	RI	0	L	on beach, area E

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S05742	1999	2	22	DAS	0	L	on beach, area A
S05751	**1991**	**10**	**6**	**DAS**	**0**		
S05751	1992	11	10	BB	0	P	alive and well
S05789	**1991**	**10**	**6**	**DAS**	**0**		
S05789	1993	10	3	BB	0	P	alive and well
S05789	1994	10	11	DAS	0	P	band removed, released
S05807	**1991**	**10**	**6**	**DAS**	**0**		
S05807	1993	7	5	BB	0	O	slightly oiled
S05869	**1991**	**10**	**24**	**DYI**	**0**		
S05869	1993	10	24	BB	0	P	alive and well
S05869	1997	3	18	DYI	0	L	in colony
S05937	**1991**	**10**	**4**	**DAS**	**0**		
S05937	1992	9	20	BB	0	I	found sick, injured or exhausted
S06154	**1991**	**7**	**7**	**II**	**0**		
S06154	1994	3	18	II	0	P	
S06154	1995	5	22	II	0	P	
S06154	1995	9	25	BB	0	P	present
S06154	1997	3	5	II	0	P	moult complete
S06614	**1992**	**12**	**12**	**II**	**0**		
S06614	1996	4	10	BB	0	L	loafing, Foxy Beach
S07002	**1988**	**10**	**31**	**DAS**	**0**		
S07002	1993	8	29	BB	0	P	alive and well
S07002	1993	9	24	BB	0	P	alive and well
S07002	1996	3	13	DAS	0	C	with 2 downy chicks on surface, area G
S07002	1996	5	7	DAS	0	L	in colony, area G
S07002	1996	7	1	DAS	0	L	in colony, area G
S07002	1996	8	12	DAS	0	M	in colony, area G
S07002	1996	8	20	DAS	0	M	on beach, area G. Near end of moult
S07002	1996	10	7	DAS	0	L	in burrow, area G
S07002	1996	12	2	DAS	0	E	incubating 2 in burrow, area G
S07002	1997	1	27	DAS	0	L	in colony, area G
S07002	1997	3	11	DAS	0	L	in colony, area G
S07002	1997	11	1	DAS	0	E	incubating 2 in burrow, area G
S07650	**1988**	**3**	**9**	**DAS**	**0**		
S07650	1994	7	15	BB	0	O	Apollo Sea victim. Cleaned & released, band removed
S08042	**1989**	**3**	**29**	**DAS**	**0**		
S08042	1999	7	7	BB	0	L	Foxy Beach
S08363	**1990**	**5**	**29**	**RI**	**0**		
S08363	1993	4	23	BB	0	P	alive and well
S08363	1993	8	5	RI	0	P	alive and well
S08542	**1989**	**8**	**10**	**II**	**0**		
S08542	1994	7	15	BB	0	O	Apollo Sea victim. Cleaned & released, band removed
S09314	**1990**	**8**	**23**	**RI**	**0**		
S09314	1992	8	23	BB	0	P	alive and well
S09314	1993	10	10	BB	0	P	alive and well
S09314	1994	5	30	RI	0	P	alive and well
S09314	1995	10	12	RI	0	L	loafing under bushes, area U.
S09314	1995	10	13	RI	0	L	loafing under bushes, area U
S09314	1998	3	25	RI	0	L	with mate, area U
S09314	1998	9	17	RI	0	L	under trees, area U
S09314	1998	12	24	RI	0	L	on beach, area C
S09314	1999	1	14	RI	0	L	on beach, area C
S09314	1999	6	24	RI	0	C	with 1+ small downy chick(s), area U
S09367	**1990**	**3**	**30**	**DAS**	**0**		
S09367	1992	8	25	BB	0	O	oiled, taken to SANCCOB
S09367	1994	7	1	DAS	1	O	Apollo Sea victim. Cleaned & released

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S09415	**1990**	**6**	**13**	**RI**	**0**		
S09415	1991	9	26	BB	0	I	very thin
S09732	**1990**	**10**	**5**	**DYI**	**0**		
S09732	1998	5	23	BB	0	S	
S09770	**1990**	**6**	**2**	**SP**	**0**		
S09770	1997	9	21	BB	0	P	Foxy Beach
S09796	**1990**	**7**	**28**	**SP**	**0**		
S09796	1995	6	21	BB	0	L	loafing
S09796	1995	8	8	BB	0	X	courted by unringed mate
S09836	**1991**	**9**	**14**	**SP**	**0**		
S09836	1991	9	23	BB	0	O	oiled, taken to SANCCOB
S10070	**1992**	**3**	**11**	**MGI**	**0**		
S10070	1993	11	12	BB	0	P	alive and well
S10158	**1992**	**3**	**19**	**DAS**	**0**		
S10158	1993	10	24	BB	0	P	alive and well
S10158	1995	8	2	DAS	0	L	on beach, area D
S10183	**1992**	**3**	**19**	**DAS**	**0**		
S10183	1995	9	7	BB	0	P	present
S10232	**1992**	**3**	**17**	**VI**	**0**		
S10232	1992	11	1	BB	0	P	alive and well
S10283	**1992**	**3**	**19**	**DAS**	**0**		
S10283	1992	11	1	BB	0	P	alive and well
S10283	1995	7	4	DAS	0	L	on beach, area G
S10283	1995	11	7	DAS	0	L	on beach, area G
S10283	1996	1	31	DAS	0	L	on beach, area G
S10283	1996	4	28	DAS	0	L	on beach, area G
S10283	1996	9	9	DAS	0	L	in colony, area G
S10283	1996	11	1	DAS	0	M	moulting on beach House Bay (area G)
S10283	1996	11	7	DAS	0	L	loafing on beach, House bay (area G)
S10283	1996	12	13	DAS	0	L	on beach, area G
S10283	1997	1	27	DAS	0	L	in burrow, area G
S10283	1997	10	28	DAS	0	L	on beach, area G
S10283	1999	5	13	DAS	0	L	on beach, area G
S10316	**1992**	**3**	**19**	**DAS**	**0**		
S10316	1992	11	1	BB	0	P	alive and well
S10395	**1992**	**3**	**19**	**DAS**	**0**		
S10395	1993	10	24	BB	0	P	alive and well
S10396	**1992**	**3**	**19**	**DAS**	**0**		
S10396	1993	10	24	BB	0	P	alive and well
S10396	1996	2	8	DAS	0	L	on beach, area D
S10396	1996	2	14	DAS	0	L	on shore, area E
S10396	1996	5	12	DAS	0	L	in burrow, area A
S10396	1996	5	20	DAS	0	L	with mate under rock, area G
S10396	1996	6	4	DAS	0	L	Loafing on shore, area G
S10396	1996	8	14	DAS	0	L	on beach, area G
S10396	1996	11	2	DAS	0	L	loafing on shore, area G
S10396	1996	11	7	DAS	0	L	loafing on shore, area G
S10396	1998	6	26	DAS	0	E	incubating 2 under rock, area G
S10396	1998	7	31	DAS	0	C	with 1 downy chick under rock, area G
S10396	1998	10	24	DAS	0	L	on shore, area G
S10396	1999	5	14	DAS	0	L	with mate under rock, area G
S10396	1999	6	8	DAS	0	E	incubating 2 under rock, area G
S10492	**1992**	**3**	**19**	**DAS**	**0**		
S10492	1993	9	19	BB	0	P	alive and well
S10492	1996	5	21	RI	0	L	on beach, area D
S10492	1996	12	19	RI	0	M	on beach, area C
S10492	1999	8	27	RI	0	L	under bushes, area C. Much chafing on right flank
S10597	**1992**	**7**	**1**	**RI**	**0**		

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S10597	1994	10	4	BB	0	P	present (V. Keller)
S10597	1997	2	14	RI	0	L	on beach, area D
S10597	1997	8	4	RI	0	L	on beach, area D
S10597	1998	3	26	RI	0	L	on beach, area D
S10597	1999	3	11	RI	0	R	on beach, area D
S10611	**1992**	**7**	**15**	**RI**	**0**		
S10611	1993	10	3	BB	0	P	alive and well
S10611	1995	7	4	RI	0	L	loafing under bush, area E
S10611	1996	4	25	RI	0	L	loafing under trees with mate. area E
S10611	1996	5	20	RI	0	L	on beach, area E
S10611	1998	6	13	RI	0	E	incubating 2, area F
S10611	1998	11	9	RI	0	M	on beach, area E
S10611	1998	12	26	RI	0	L	on shore, area E
S10611	1999	3	12	RI	0	L	on beach, area E
S10611	1999	6	28	RI	0	C	with 1+ small downy chick(s) Nest 57, area F
S10697	**1992**	**7**	**15**	**RI**	**0**		
S10697	1993	9	19	BB	0	P	alive and well
S10697	1993	9	24	BB	0	P	alive and well
S10697	1994	12	27	DAS	0	L	on beach, area G
S10697	1995	10	12	RI	0	L	on beach, area D
S10697	1996	5	20	RI	0	L	on beach, area E
S10697	1997	7	3	RI	0	C	with 1+ downy chick(s), area P
S10702	**1992**	**7**	**15**	**RI**	**0**		
S10702	1993	9	19	BB	0	P	alive and well
S10769	**1992**	**9**	**1**	**SI**	**0**		
S10769	1993	8	22	BB	0	P	alive and well
S10820	**1992**	**10**	**4**	**DYI**	**0**		
S10820	1993	11	29	BB	0	P	alive and well
S10820	1997	3	18	DYI	0	L	in colony
S10820	1997	9	2	DYI	0	L	in colony
S10820	1997	10	17	DYI	0	M	just started
S10820	1999	10	18	DYI	0	U	in colony, zone 7
S10826	**1992**	**10**	**4**	**DYI**	**0**		
S10826	1993	10	10	BB	0	P	alive and well
S10826	1993	10	24	BB	0	P	alive and well
S10826	1995	1	7	BB	0	P	alive and well
S10826	1995	9	19	BB	0	P	present
S10826	1995	9	20	BB	0	P	present
S10826	1998	7	3	BB	0	N	by degaussing station.
S10826	1998	8	15	BB	0	L	Foxy Beach
S10826	1998	10	27	BB	0	L	Foxy beach
S10900	**1992**	**10**	**4**	**DYI**	**0**		
S10900	1995	9	26	BB	0	P	present
S10900	1996	4	10	BB	0	L	loafing, Foxy Beach
S10913	**1992**	**10**	**4**	**DYI**	**0**		
S10913	1993	10	24	BB	0	P	alive and well
S10916	**1992**	**10**	**4**	**DYI**	**0**		
S10916	1993	10	24	BB	0	P	alive and well
S10916	1994	8	11	RI	0	P	alive and well
S10916	1995	12	3	DYI	0	M	
S11005	**1992**	**7**	**29**	**RI**	**0**		
S11005	1994	4	15	BB	0	P	alive and well
S11027	**1992**	**7**	**29**	**RI**	**0**		
S11027	1993	10	18	BB	0	P	alive and well
S11027	1995	5	16	DAS	0	L	loafing on beach, area A
S11027	1996	3	27	RI	0	R	returning from foraging, area Z
S11027	1997	2	11	RI	0	L	on beach, area G
S11027	1998	6	19	RI	0	S	area Z

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S11027	1999	3	12	RI	0	L	with mate, area Z
S11071	**1992**	**9**	**9**	**RI**	**0**		
S11071	1993	11	12	BB	0	P	alive and well
S11071	1993	11	13	RI	0	P	alive and well
S11071	1994	9	21	DAS	0	L	member of beach party
S11071	1994	9	27	RI	0	P	alive and well
S11071	1995	2	4	BB	0	I	exhausted and dehydrated, taken to SANCCOB
S11072	**1992**	**9**	**9**	**RI**	**0**		
S11072	1993	11	14	BB	0	P	alive and well
S11194	**1992**	**9**	**9**	**RI**	**0**		
S11194	1993	11	15	BB	0	P	alive and well
S11196	**1992**	**9**	**9**	**RI**	**0**		
S11196	1993	9	19	BB	0	P	alive and well
S11196	1994	2	3	CAM	0	I	emaciated, taken to SANCCOB
S11299	**1992**	**9**	**9**	**RI**	**0**		
S11299	1993	11	29	BB	0	P	alive and well
S11299	1998	3	25	RI	0	E	incubating 2 in burrow, area U
S11299	1998	6	18	RI	0	R	area C/D
S11317	**1992**	**9**	**24**	**RI**	**0**		
S11317	1993	9	22	BB	0	P	alive and well
S11428	**1992**	**10**	**9**	**DAS**	**0**		
S11428	1993	10	24	BB	0	P	alive and well
S11568	**1992**	**10**	**31**	**DAS**	**0**		
S11568	1995	9	26	BB	0	P	present
S11641	**1993**	**5**	**22**	**DAS**	**0**		
S11641	1994	3	18	BB	0	P	alive and well
S11666	**1993**	**5**	**21**	**RI**	**0**		
S11666	1995	10	2	BB	0	P	present
S11666	1996	5	22	RI	0	L	on beach, area D
S11666	1998	3	25	RI	0	L	on beach, area D
S11666	1999	3	11	RI	0	R	area S
S11666	1999	3	24	RI	0	L	
S11666	1999	8	30	RI	0	R	area D
S11689	**1993**	**7**	**21**	**RI**	**0**		
S11689	1995	3	9	DAS	0	L	on beach, area G
S11689	1995	9	14	BB	0	P	present
S11689	1996	5	28	RI	0	L	on beach, area D
S11689	1998	12	26	RI	0	L	on beach, area C
S11689	1999	6	30	RI	0	R	area B
S11689	1999	8	31	RI	0	R	area B
S11905	**1993**	**5**	**28**	**RI**	**0**		
S11905	1994	3	18	BB	0	P	alive and well
S11944	**1993**	**5**	**28**	**RI**	**0**		
S11944	1995	10	3	BB	0	P	present
S12255	**1994**	**5**	**26**	**BI**	**0**		
S12255	1994	8	11	BB	0	D	slightly oiled
S12378	**1994**	**6**	**20**	**BI**	**0**		
S12378	1997	10	19	BB	0	X	band found, no carcass, 723 km from ringing place
S13306	**1992**	**6**	**14**	**DAS**	**0**		
S13306	1993	11	6	BB	0	P	alive and well
S13306	1995	12	11	DAS	0	L	on beach, area F
S13306	1996	5	20	DAS	0	L	in burrow, area F
S13306	1996	7	1	DAS	0	E	incubating 2 in burrow, area F
S13306	1996	11	2	DAS	0	L	loafing on beach, Limekiln Bay
S13306	1996	11	7	DAS	0	L	loafing on beach, Limekiln Bay
S13306	1996	11	17	DAS	0	L	loafing on beach, Limekiln Bay
S13306	1996	12	21	DAS	0	L	on beach, area F
S13346	**1992**	**6**	**14**	**DAS**	**0**		

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S13346	1995	6	21	BB	0	G	walking to sea from colony
S13346	1998	1	30	BB	0	L	on beach
S13346	1998	2	25	BB	0	L	on beach
S13419	**1993**	**6**	**14**	**DAS**	**0**		
S13419	1993	11	29	BB	0	P	alive and well
S13492	**1992**	**7**	**29**	**RI**	**0**		
S13492	1995	9	20	BB	0	P	present
S13492	1995	10	10	BB	0	P	present
S13492	1998	3	13	BB	0	L	on beach (LU)
S13492	1998	4	23	BB	0	E	incubating 1
S13762	**1995**	**5**	**22**	**DAS**	**0**		
S13762	1995	7	16	BB	0	I	injured, taken to SANCCOB
S13976	**1993**	**5**	**23**	**DAS**	**0**		
S13976	1994	4	15	BB	0	P	alive and well
S14004	**1993**	**7**	**21**	**RI**	**0**		
S14004	1996	5	22	RI	0	P	alive and well
S14004	1996	5	23	RI	0	L	loafing, area Q
S14004	1998	1	19	RI	0	S	bird on empty nest
S14004	1998	3	25	RI	0	S	with mate S19768, area S
S14004	1998	3	26	RI	0	L	on beach, area D
S14004	1998	6	15	RI	0	E	incubating 2, Nest 82, area S
S14004	1998	9	16	RI	0	R	area D
S14004	1998	10	27	BB	0	M	on rocks, "hotel"
S14004	1999	3	30	RI	0	E	incubating 2, area S
S14004	1999	6	29	RI	0	F	with feathered chick, Nest 82, area S
S14004	1999	8	25	RI	0	L	under Manitoka, area S
S14004	1999	8	30	RI	0	L	with S19768 at Nest 166, area S
S14232	**1993**	**9**	**24**	**RI**	**0**		
S14232	1995	8	8	BB	0	L	loafing under trees
S14257	**1993**	**10**	**13**	**DYI**	**0**		
S14257	1998	2	13	BB	0	L	on beach
S14506	**1994**	**7**	**27**	**RI**	**0**		
S14506	1999	5	18	BB	0	S	female with unbanded mate, area B
S14777	**1996**	**3**	**15**	**SI**	**0**		
S14777	1997	1	22	DAS	0	L	juvenile on beach, area G
S14777	1998	8	2	BB	0	L	Foxy Beach
S14777	1998	10	14	BB	0	L	Foxy beach (S. Stephens)
S14777	1998	10	27	BB	0	L	Foxy beach
S14777	1999	5	18	BB	0	L	with mate, Foxy Beach
S14777	1999	5	28	BB	0	X	picking up large branches, Foxy Beach
S14960	**1995**	**3**	**16**	**SI**	**0**		
S14960	1997	9	21	BB	0	P	Foxy Beach
S14962	**1995**	**3**	**16**	**SI**	**0**		
S14962	1996	10	26	BB	0	L	loafing, Foxy beach
S14962	1998	11	12	SP	0	M	on shore
S14967	**1995**	**3**	**16**	**SI**	**0**		
S14967	1997	9	21	BB	0	P	Foxy Beach
S14968	**1995**	**3**	**16**	**SI**	**0**		
S14968	1995	4	26	BB	0	D	bird dead about one week
S17849	**1995**	**2**	**27**	**II**	**0**		
S17849	1997	9	21	BB	0	P	Foxy Beach
S17849	1997	10	31	LB	0	L	722 km from ringing place
S17849	1998	4	30	DAS	0	L	in colony, area A
S17849	1998	12	31	DAS	0	L	on beach, area A
S18139	**1996**	**2**	**28**	**II**	**0**		
S18139	1997	9	21	BB	0	P	Foxy Beach
S18470	**1994**	**4**	**12**	**BI**	**0**		
S18470	1997	9	22	BB	0	P	

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S20183	**1994**	**7**	**9**	**DAS**	**2**		
S20183	1995	9	19	BB	2	P	present
S20493	**1995**	**10**	**5**	**DYI**	**2**		
S20493	1999	4	13	BB	2	X	allo-preening with mate
S20493	1999	7	8	BB	2	P	above Foxy Beach
S20493	2000	2	8	BB	2	E	incubating 2 eggs
S20493	2000	5	6	BB	2	E	incubating 2 eggs
S20493	2000	7	13	BB	2	C	with 1 chick
S20493	2000	7	27	BB	2	L	by Willis Walk
S20493	2000	8	8	BB	2	P	Foxy Beach
S25354	**1995**	**5**	**24**	**BI**	**0**		
S25354	1997	4	23	DAS	0	M	on beach, area F
S25354	1997	4	27	DAS	0	M	on beach, area B
S25354	1998	5	6	BB	0	I	sent to SANCCOB. Re-released this day as A2380
S25406	**1995**	**5**	**24**	**BI**	**0**		
S25406	1996	10	20	BB	0	L	loafing, Foxy beach
S25406	1996	12	21	DAS	0	M	juvenile on beach, area F
S25509	**1995**	**5**	**24**	**BI**	**0**		
S25509	1996	4	10	BB	0	M	juvenile beginning moult, Foxy Beach
S25664	**1995**	**5**	**24**	**BI**	**0**		
S25664	1996	8	18	BB	0	P	juvenile (VAN)
S25671	**1995**	**5**	**24**	**BI**	**0**		
S25671	1995	8	18	BB	0	O	oiled, taken to SANCCOB. Ring removed
S25709	**1995**	**5**	**25**	**BI**	**0**		
S25709	1996	8	20	BB	0	P	juvenile (VAN)
S25709	1996	10	20	BB	0	L	juvenile loafing, Foxy beach
S25886	**1995**	**5**	**25**	**BI**	**0**		
S25886	1996	12	1	BB	0	X	per Cheryl Campbell
S25974	**1995**	**5**	**31**	**SP**	**0**		
S25974	1996	10	20	BB	0	L	loafing, Foxy beach
S25974	1998	8	14	SP	0	N	
S26026	**1996**	**6**	**21**	**SP**	**0**		
S26026	1997	9	21	BB	0	P	Foxy Beach
T2878	**1991**	**10**	**23**	**DYI**	**0**		
T2878	1991	11	5	BB	0	D	subsequently died
T2985	**1991**	**10**	**1**	**DAS**	**0**		
T2985	1993	11	5	BB	0	P	alive and well
T2985	1998	6	10	DAS	0	E	incubating 2 in burrow, area A
T2985	1998	10	25	DAS	0	L	moult complete on shore, area A
T2988	**1991**	**10**	**1**	**DAS**	**0**		
T2988	1993	10	24	BB	0	P	alive and well
T2988	1995	5	9	DAS	0	L	on beach, area B
T2988	1996	8	5	DAS	0	L	in burrow, area B
T2988	1996	9	13	DAS	0	L	on beach, West Bay
T2988	1998	3	7	DAS	0	L	in burrow, area B
V2902	**1982**	**10**	**23**	**DYI**	**0**		
V2902	1982	12	1	BB	0	D	exhausted, died at SANCCOB
V3085	**1987**	**7**	**7**	**DAS**	**0**		
V3085	1993	6	4	BB	0	D	data inconclusive, probably poisoned
V6164	**1985**	**11**	**5**	**DYI**	**0**		
V6164	1997	9	22	BB	0	P	
V6193	**1985**	**11**	**5**	**DYI**	**0**		
V6193	1998	8	7	BB	0	L	Boulders Beach

APPENDIX 3.3

African Penguins banded in juvenile plumage or of unknown age and later re-sighted at The Boulders. The first line for each bird represents the ringing date (release date for rehabilitated birds) and locality. See Appendix 3.1 for abbreviations

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
G05993	**1971**	**8**	**13**	**RI**	**1**		
G05993	1974	4	6	DYI	1	N	
G05993	1986	1	12	BB	1	D	previously re-banded as V7172
A02363	**1998**	**4**	**24**	**RI**	**2**		
A02363	1998	10	12	BB	2	L	Foxy beach (S. Stephens)
S00798	**1990**	**8**	**24**	**RI**	**1**		
S00798	1995	3	9	BB	1	P	alive and well
S02870	**1991**	**10**	**7**	**RI**	**2**		
S02870	1996	12	5	BB	2	X	moved from above Willis Walk
S02870	1997	4	20	DAS	2	E	incubating 2 in burrow, area B
S02870	1997	9	21	BB	2	P	Foxy Beach
S09962	**1990**	**11**	**15**	**RI**	**2**		
S09962	1995	6	21	BB	2	C	with 2 small downy chicks
S09969	**1990**	**11**	**27**	**RI**	**2**		
S09969	1995	10	2	BB	2	P	present
S09969	1997	10	1	BB	2	R	Foxy Beach
S09969	1998	8	2	BB	2	R	Foxy Beach
S14553	**1995**	**10**	**2**	**WB**	**1**		
S14553	1996	9	3	DAS	1	L	on beach, area G
S14553	1996	10	22	BB	1	L	loafing, Foxy beach
S14553	1996	12	7	DAS	1	L	on beach, area G
S14553	1996	12	19	DAS	1	M	on beach, area G
S16980	**1992**	**11**	**17**	**RI**	**1**		
S16980	1994	8	25	BI	1	P	
S16980	1995	3	9	BB	1	P	alive and well
S17016	**1993**	**2**	**23**	**RI**	**3**		
S17016	1995	9	22	BB	3	P	present
S21191	**1994**	**7**	**26**	**SS**	**1**		
S21191	1994	12	18	DAS	1	L	on beach, area B
S21191	1995	8	30	BB	1	O	oiled, taken to SANCCOB
S21191	1995	12	26	DAS	1	L	on beach, area A
S21191	1996	2	20	DAS	1	R	arriving from sea, West Bay
S21191	1996	3	19	DAS	1	E	incubating 1 in burrow, area A
S21191	1996	5	18	DAS	1	L	on beach, area B
S21191	1996	5	23	DAS	1	L	on beach, area B. Near end of moult
S21191	1996	6	24	DAS	1	E	incubating 2 in burrow, area B
S21191	1996	7	8	DAS	1	E	incubating 2 in burrow B719
S21191	1996	10	2	DAS	1	L	on beach, area B
S21191	1996	10	9	DAS	1	M	on beach, area B
S21191	1996	10	15	DAS	1	M	on beach, area B
S21191	1996	10	23	DAS	1	L	on beach, area B
S21191	1997	1	6	DAS	1	E	incubating 2 in burrow, area B
S21191	1997	1	20	DAS	1	E	incubating 1 in burrow, area B
S21191	1997	3	6	DAS	1	L	on beach, area B
S21191	1998	1	30	DAS	1	C	with 2 downy chicks in burrow, area B
S21191	1998	11	19	DAS	1	L	on beach, area B
S21191	1999	1	13	DAS	1	E	incubating 2 in burrow BG29
S21191	1999	2	13	DAS	1	C	with 2 downy chicks in burrow BG29
S21191	1999	2	25	DAS	1	C	with 2 downy chicks in burrow BG29
S21191	1999	6	7	DAS	1	E	incubating 2 in burrow BH16, old BG29
S22813	**1994**	**8**	**12**	**RI**	**1**		

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S22813	1995	10	13	BB	1	P	present
S22813	1996	9	11	DAS	1	L	loafing on shore, area A (West)
S22813	1996	12	12	DAS	1	M	on beach, area A
S22813	1997	10	26	DAS	1	L	under rock, area A (West)
S22813	1998	1	21	DAS	1	L	on beach, area A
S22813	1998	2	9	DAS	1	L	in burrow, area A
S23000	**1994**	**7**	**29**	**RI**	**1**		
S23000	1997	9	21	BB	1	P	Foxy Beach
S23000	1998	3	13	BB	1	L	on beach (LU)
S23000	1998	7	18	BB	1	R	Foxy Beach
S23928	**1995**	**10**	**2**	**WB**	**1**		
S23928	1996	12	1	BB	1	X	per Cheryl Campbell
S23982	**1995**	**10**	**1**	**WB**	**1**		
S23982	1995	10	10	BB	1	P	present
S23982	1995	10	13	BB	1	P	present
S23982	1998	2	22	DYI	1	L	on shore
S23982	1998	11	10	DYI	1	M	near end of moult on shore
S23982	1999	8	12	DYI	1	L	in colony
S23982	1999	9	30	DYI	1	L	near shore, zone 2
S25226	**1994**	**8**	**16**	**RI**	**1**		
S25226	1996	2	21	DAS	1	L	on beach, House Bay (area G)
S25226	1996	4	10	BB	1	L	loafing, Foxy beach
S25226	1997	8	5	RI	1	L	under trees, area Ic
S25226	1998	3	26	RI	1	L	on beach, area D
S25226	1998	11	9	RI	1	L	post moult on beach, area D
S25226	1999	3	13	RI	1	R	area C/D
S26410	**1995**	**9**	**26**	**WB**	**1**		
S26410	1995	9	30	BB	1	P	present
T1137	**1997**	**6**	**11**	**CR**	**2**		**found stranded in KwaZulu-Natal**
T1137	1998	5	6	BB	2	I	re-released on this day at The Boulders

APPENDIX 3.4

African Penguins banded in adult plumage at breeding colonies other than The Boulders and later re-sighted at The Boulders. The first line for each bird represents the ringing date and locality. See Appendix 3.1 for abbreviations

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S01317	**1991**	**2**	**13**	**RI**	**0**		
S01317	1991	4	24	RI	0	P	alive and well
S01317	1991	7	17	RI	0	P	alive and well
S01317	1992	5	6	RI	0	P	alive and well
S01317	1992	5	25	RI	0	P	alive and well
S01317	1992	6	3	RI	0	P	alive and well
S01317	1992	6	17	RI	0	P	alive and well
S01317	1992	9	9	RI	0	P	alive and well
S01317	1992	9	23	RI	0	P	alive and well
S01317	1993	2	4	RI	0	P	alive and well
S01317	1993	2	10	RI	0	P	alive and well
S01317	1993	5	26	RI	0	P	alive and well
S01317	1993	6	2	RI	0	P	alive and well
S01317	1993	6	16	RI	0	P	alive and well
S01317	1993	9	24	BB	0	P	alive and well
S06509	**1993**	**9**	**24**	**SP**	**0**		
S06509	1998	3	13	BB	0	L	on beach (LU)
S06509	1999	2	17	BB	0	L	per B.M. Dyer
S06509	1999	4	13	BB	0	L	Foxy Beach
S06514	**1993**	**9**	**17**	**SP**	**0**		
S06514	1998	4	23	BB	0	E	incubating 1+
S06514	1999	3	5	BB	0	L	beside nest?
S08357	**1990**	**2**	**14**	**RI**	**0**		
S08357	1990	4	17	RI	0	P	alive and well
S08357	1990	5	2	RI	0	P	alive and well
S08357	1992	2	9	BB	0	P	alive and well
S08357	1995	3	8	RI	0	P	alive and well
S08357	1995	5	31	RI	0	P	alive and well
S08357	1996	5	20	RI	0	E	incubating 2 eggs, area F
S08357	1996	5	22	RI	0	L	loafing under bushes, area F
S08357	1996	10	17	RI	0	L	loafing under trees with moulting mate, area F
S08357	1996	12	18	RI	0	L	on beach, area F
S08357	1997	2	15	RI	0	L	on beach, area F
S08357	1998	1	19	RI	0	E	incubating egg(s)
S08357	1998	3	24	RI	0	L	on beach, area F
S08357	1998	7	1	RI	0	C	with 2 medium downy chicks Nest 123
S08357	1998	12	24	RI	0	L	on beach, area F
S08357	1999	3	10	RI	0	L	on shore, area F
S10757	**1992**	**9**	**1**	**SI**	**0**		
S10757	1996	8	25	BB	0	L	loafing, Foxy Beach
S10757	1998	1	30	BB	0	L	on beach
S12116	**1992**	**1**	**23**	**BI**	**0**		
S12116	1997	9	19	DYI	0	M	per A. Venter
S12116	1997	9	29	BB	0	D	723 km from ringing place
S14252	**1993**	**10**	**12**	**DYI**	**0**		
S14252	1993	10	24	BB	0	P	alive and well
S14252	1997	1	31	BB	0	L	
S14252	1998	8	2	BB	0	N	
S26013	**1996**	**5**	**20**	**SP**	**0**		
S26013	1999	2	17	BB	0	L	per B.M. Dyer
S26013	1999	4	13	BB	0	L	on slipway

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
T2518	**1992**	**3**	**16**	**RI**	**0**		
T2518	1992	3	25	RI	0	P	alive and well
T2518	1994	4	5	BB	0	P	alive and well
T2518	1994	5	30	RI	0	P	alive and well
T2518	1995	3	29	RI	0	L	on Beach
T2518	1995	3	30	RI	0	S	male at empty site, area Y
T2518	1996	5	21	RI	0	L	on beach, area E
T2518	1996	5	22	RI	0	P	alive and well
T2518	1996	5	24	RI	0	C	with 2 downy chicks, area Y
T2564	**1993**	**1**	**6**	**RI**	**0**		
T2564	1993	2	18	BB	0	B	blood sampled for parasites
T2564	1996	10	22	BB	0	L	loafing, Foxy beach
T2564	1999	3	5	BB	0	L	on Foxy Beach
T2566	**1993**	**6**	**30**	**RI**	**0**		
T2566	1994	2	10	BB	0	B	blood sampled for parasites
T2566	1995	6	21	BB	0	N	on nest
T2566	1995	8	18	BB	0	C	with downy young
T2566	1996	4	10	BB	0	L	loafing
T2566	1997	1	31	BB	0	L	
T2581	**1993**	**6**	**30**	**RI**	**0**		
T2581	1994	2	10	BB	0	B	blood sampled for parasites
T2581	1998	7	3	BB	0	C	with 1 small downy chick
T2582	**1993**	**6**	**30**	**RI**	**0**		
T2582	1994	2	10	BB	0	B	blood sampled for parasites
T2585	**1993**	**6**	**30**	**RI**	**0**		
T2585	1994	2	10	BB	0	B	blood sampled for parasites
T2585	1994	8	16	BB	0	B	blood sampled for parasites
T2585	1996	4	10	BB	0	R	returning from sea, Boulders Beach
T2590	**1993**	**6**	**30**	**RI**	**0**		
T2590	1994	2	10	BB	0	B	blood sampled for parasites
T2590	1994	8	16	BB	0	B	blood sampled for parasites
V1472	**1988**	**3**	**1**	**PSI**	**0**		
V1472	1992	1	1	BB	0	P	alive and well
V1669	**1986**	**12**	**12**	**MYI**	**0**		
V1669	1992	7	22	BB	0	P	alive and well
V7472	**1986**	**11**	**26**	**SP**	**0**		
V7472	1987	3	17	BB	0	P	alive and well (Benguela Ecology Project)

APPENDIX 3.5

Birds banded in adult plumage at The Boulders and re-sighted at other breeding colonies. The first line for each bird represents the ringing date and locality. See Appendix 3.1 for abbreviations

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
T2570	**1993**	**2**	**18**	**BB**	**0**		
T2570	1999	1	14	RI	0	M	on beach, area C/D
T2578	**1993**	**2**	**18**	**BB**	**0**		
T2578	1996	9	27	DAS	0	M	on beach, area B
T2613	**1994**	**1**	**10**	**BB**	**0**		
T2613	1994	4	7	RI	0	P	alive and well
V6141	**1986**	**10**	**5**	**BB**	**0**		
V6141	1996	3	29	RI	0	L	standing by road, area Ia

APPENDIX 3.6

African Penguins released by SANCCOB and subsequently re-sighted at The Boulders. The first line for each bird represents the release date and locality. See Appendix 3.1 for abbreviations.

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
A01002	**1997**	**5**	**15**	**RI**	**2**		
A01002	1997	9	21	BB	2	P	Foxy Beach. Sent to SANCCOB from The Boulders
A01067	**1997**	**9**	**2**	**RI**	**2**		
A01067	1997	9	21	BB	2	P	Foxy Beach
A01067	1998	11	17	LB	2	P	
A01084	**1997**	**7**	**24**	**RI**	**1**		
A01084	1998	2	24	DAS	1	L	on beach, area G (oiled at The Boulders)
A01084	1998	8	26	DAS	1	L	on beach, area G
A01084	1998	10	27	BB	1	M	nearly complete, "hotel"
A01084	1998	12	9	DAS	1	L	with mate in burrow, area G
A01084	1999	4	5	DAS	1	L	in burrow, area G
A01084	1999	5	25	DAS	1	L	in burrow, area G
A01102	**1997**	**8**	**30**	**JB**	**2**		
A01102	1998	1	16	BB	2	I	injured. Taken to SANCCOB. 595 km from ringing place
A01702	**1997**	**7**	**24**	**RI**	**1**		
A01702	1998	10	27	BB	1	L	Foxy beach. (oiled at The Boulders)
A01757	**1997**	**8**	**5**	**BB**	**1**		
A01757	1999	10	10	DYI	1	L	on rocks, zone 6. (oiled at The Boulders)
A01774	**1997**	**9**	**2**	**RI**	**1**		
A01774	1997	9	21	BB	1	P	Foxy Beach
A01776	**1997**	**8**	**13**	**RI**	**2**		
A01776	1997	9	22	BB	2	P	
A01776	1997	10	15	BB	2	P	per E. Augustine. Picked up from The Boulders
A01776	1998	7	3	BB	2	L	Foxy Beach
A01776	1999	3	5	BB	2	L	on Foxy Beach
A01882	**1997**	**9**	**23**	**RI**	**2**		
A01882	1997	10	1	BB	2	L	pink dye, Foxy Beach
A01882	1998	8	2	BB	2	L	Foxy Beach
A01882	1999	3	5	BB	2	L	on beach
A01888	**1997**	**10**	**21**	**RI**	**2**		
A01888	1998	7	3	BB	2	G	Foxy Beach. Picked up at The Boulders
A01888	1998	7	18	BB	2	X	at entrance to burrow with mate A3028
A01888	1998	10	27	BB	2	L	Foxy beach
A01888	1999	5	18	BB	2	C	with 2 large downy chicks, Foxy Beach
A01888	1999	7	2	BB	2	G	
A01935	**1997**	**11**	**14**	**RI**	**2**		
A01935	1998	4	23	BB	2	E	with 3 eggs!
A01985	**1997**	**12**	**3**	**RI**	**1**		
A01985	1998	2	25	BB	1	L	on beach. Pink dye. (Found oiled at The Boulders)
A01985	1998	4	4	BB	1	E	incubating 1
A01985	1998	7	3	BB	1	N	area A
A02106	**1997**	**12**	**19**	**RI**	**1**		
A02106	1998	3	13	BB	1	L	on beach (LU). (Found oiled at The Boulders)
A02106	1998	7	3	BB	1	G	Foxy Beach
A02132	**1998**	**3**	**10**	**RI**	**2**		
A02132	1998	8	10	BB	2	L	Foxy Beach. Picked up from The Boulders
A02132	1998	10	16	BB	2	L	Foxy beach
A02132	1998	10	27	BB	2	L	Foxy beach
A02132	1999	8	27	RI	2	L	on shore, area C
A02133	**1997**	**12**	**23**	**RI**	**1**		
A02133	1998	10	27	BB	1	U	Boulders beach. (Oiled at The Boulders)
A02161	**1997**	**12**	**30**	**RI**	**1**		
A02161	1998	5	23	BB	1	E	incubating 2 Nest 424. (Found oiled at The Boulders)

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
A02161	1998	7	18	BB	1	N	
A02161	1998	8	2	BB	1	N	pink dye on neck
A02162	**1998**	**2**	**3**	**RI**	**2**		
A02162	1999	2	17	BB	2	L	B.M. Dyer (picked up at The Boulders)
A02183	**1998**	**1**	**20**	**RI**	**1**		
A02183	1998	3	13	BB	1	L	on beach (L.Upfold). (Found oiled at The Boulders)
A02302	**1998**	**2**	**3**	**RI**	**2**		
A02302	1999	3	5	BB	2	L	on Foxy Beach (picked up at The Boulders)
A02302	1999	4	13	BB	2	L	Foxy Beach
A02314	**1998**	**2**	**4**	**RI**	**2**		
A02314	1998	10	14	BB	2	L	Foxy beach (S. Stephens). (Picked up at The Boulders)
A02331	**1998**	**3**	**13**	**RI**	**2**		
A02331	1998	3	18	BB	2	P	G. Murison. (Orig. found at The Boulders)
A02331	1998	7	3	BB	2	C	with large downy chick, area B
A02331	1998	7	18	BB	2	F	beside feathered chick. Pink dye on neck
A02331	1998	8	8	BB	2	L	
A02331	1999	3	5	BB	2	L	on beach
A02331	1999	5	18	BB	2	N	
A02384	**1998**	**5**	**8**	**RI**	**2**		
A02384	1998	10	12	BB	2	L	Foxy beach (S. Stephens). (Picked up at The Boulders)
A02385	**1998**	**5**	**6**	**BB**	**2**		
A02385	1998	7	16	DAS	2	L	on beach, area G. (picked up at The Boulders)
A05069	**1998**	**6**	**13**	**M**	**1**		
A05069	1998	8	19	DAS	1	L	on beach, area G. Yellow dye on side of neck
A05069	1998	10	16	BB	1	L	Foxy beach. Yellow on neck. (Oiled at Robben Island)
A05202	**1998**	**6**	**19**	**M**	**1**		
A05202	1998	10	27	BB	1	L	Foxy beach. Yellow on neck, pink on belly
A05202	1999	4	13	BB	1	L	Boulders Beach
A06827	**1998**	**7**	**26**	**??**	**1**		
A06827	1998	10	16	BB	1	M	Foxy beach
A06827	1999	6	27	RI	1	R	area D
A06841	**1998**	**8**	**1**	**BB**	**1**		
A06841	1999	6	9	DAS	1	E	incubating 1 in burrow, area I
A06842	**1998**	**8**	**1**	**BB**	**1**		
A06842	1999	10	8	DYI	1	L	on shore, zone 6. (picked up at Pringle Bay)
A08042	**1999**	**2**	**3**	**RI**	**2**		
A08042	1999	5	28	BB	2	C	with 2 large downy chicks, Foxy Beach. Pink hue on belly
A10143	**1999**	**5**	**19**	**BB**	**2**		
A10143	1999	9	27	DYI	2	L	by mortuary. Has bad left leg
A10143	1999	9	30	DYI	2	L	in colony
A10201	**1999**	**8**	**23**	**BB**	**1**		
A10201	1999	9	4	RI	1	L	on shore, area D
A10207	**1999**	**8**	**23**	**BB**	**1**		
A10207	1999	8	27	RI	1	L	under bushes, area C
A10456	**1999**	**9**	**23**	**BB**	**1**		
A10456	1999	10	8	DYI	1	L	on "house rock". Pink spot on belly
A10456	1999	10	13	DYI	1	L	on west shore. Pink spot on belly
A10602	**1999**	**9**	**28**	**BB**	**1**		
A10602	1999	10	1	DYI	1	L	in colony, zone 2. Pink spot on breast
A10602	1999	10	13	DYI	1	L	in colony, zone 2
S02769	**1991**	**9**	**10**	**RI**	**1**		
S02769	1995	6	21	BB	1	L	on beach
S02808	**1991**	**9**	**10**	**RI**	**3**		
S02808	1991	11	10	BB	3	I	emaciated. Taken to SANCCOB
S02808	1995	8	7	BB	3	P	seen almost daily, Foxy Beach.
S02808	1995	8	8	BB	3	P	alive and well
S02808	1995	8	18	BB	3	P	has hunchback. Foxy Beach
S02882	**1991**	**10**	**8**	**RI**	**1**		

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S02882	1995	8	8	BB	1	N	at nest
S02882	1996	12	4	BB	1	X	moved from above Willis Walk
S02882	1996	12	12	BB	1	L	on rocks
S02882	1997	8	2	BB	1	L	beside sitting mate
S02882	1998	6	29	BB	1	C	with 1 small downy chick, Nest 616
S02882	1998	7	3	BB	1	R	Foxy Beach. Humpback
S02882	1999	6	7	BB	1	N	area A
S02882	1999	6	17	BB	1	N	area A, by fence
S02882	1999	7	4	BB	1	E	incubating 1, area A
S02973	**1992**	**4**	**3**	**RI**	**1**		
S02973	1999	7	3	BB	1	L	by fence
S12702	**1992**	**7**	**31**	**RI**	**1**		
S12702	1995	6	21	BB	1	C	with medium downy chick
S12702	1995	8	18	BB	1	L	loafing under bushes
S12702	1999	4	13	BB	1	R	
S12753	**1992**	**8**	**7**	**RI**	**1**		
S12753	1995	9	24	BB	1	P	present
S12753	1995	9	26	BB	1	P	present
S12756	**1992**	**8**	**7**	**RI**	**1**		
S12756	1998	10	27	BB	1	L	Foxy beach
S12785	**1992**	**8**	**11**	**RI**	**1**		
S12785	1993	5	2	BB	1	L	in colony
S12785	1997	9	22	BB	1	P	
S12785	1998	2	25	BB	1	L	on beach
S12788	**1992**	**8**	**11**	**RI**	**1**		
S12788	1994	12	30	BB	1	P	alive and well
S12788	1995	9	20	BB	1	P	present
S12789	**1992**	**8**	**11**	**RI**	**1**		
S12789	1995	5	12	DYI	1	C	with small chick *c.* 1week old
S12789	1995	10	1	BB	1	P	present
S12808	**1992**	**8**	**14**	**RI**	**1**		
S12808	1993	10	12	BB	1	P	alive and well
S12900	**1992**	**8**	**27**	**RI**	**1**		
S12900	1997	9	22	BB	1	P	
S12988	**1992**	**9**	**11**	**RI**	**1**		
S12988	1995	8	18	BB	1	R	coming in from sea, Foxy Beach
S12988	1997	9	22	BB	1	P	
S12989	**1992**	**9**	**11**	**RI**	**1**		
S12989	1997	9	22	BB	1	P	
S14713	**1995**	**9**	**26**	**WB**	**1**		
S14713	1995	10	2	BB	1	P	present
S14713	1995	10	24	DAS	1	L	on beach, area D
S14713	1996	12	27	DAS	1	M	on beach, area D
S14713	1997	1	5	DAS	1	M	on beach, area D. Near end of moult
S14713	1998	2	9	DAS	1	C	with 2 downy chicks under rock, area A
S14725	**1995**	**9**	**26**	**WB**	**1**		
S14725	1997	9	21	BB	1	P	Foxy Beach
S14725	1998	2	18	DAS	1	L	on beach, area A
S14725	1998	12	9	DAS	1	L	on beach, area A
S14844	**1995**	**9**	**20**	**WB**	**1**		
S14844	1995	10	25	BB	1	L	loafing on rock, Foxy Beach. Pink dye
S14844	1996	8	29	DAS	1	L	on beach, area D
S14844	1997	9	9	DAS	1	M	on beach, area A
S14844	1998	2	18	DAS	1	L	on beach, area A
S16957	**1992**	**3**	**6**	**RI**	**2**		
S16957	1993	5	2	BB	2	L	in colony
S16957	1999	3	5	BB	2	L	on beach
S16957	1999	3	19	BB	2	E	incubating 1+, Foxy Beach

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S16957	1999	4	13	BB	2	E	incubating 1+ on Foxy Beach
S16957	1999	5	18	BB	2	C	with 1small downy chick, Foxy Beach
S16957	1999	7	8	BB	2	C	with one chick
S16957	1999	7	22	BB	2	C	with one chick
S17014	**1993**	**2**	**23**	**RI**	**1**		
S17014	1997	1	31	BB	1	L	
S17014	1997	8	2	BB	1	C	with 2 medium downy chicks
S17014	1997	10	1	BB	1	L	by fence
S17014	1998	1	30	BB	1	L	on beach
S17058	**1993**	**7**	**13**	**RI**	**1**		
S17058	1997	4	22	RI	1	H	area U
S17058	1998	5	23	BB	1	E	incubating 1 Nest 171. Mate S5407 present
S17058	1999	3	5	BB	1	L	by Boulders entrance
S17058	1999	4	13	BB	1	C	feeding 1+ small downy chick by Boulders entrance
S17088	**1993**	**11**	**23**	**RI**	**1**		
S17088	1997	9	21	BB	1	P	Foxy Beach
S18572	**1994**	**2**	**18**	**RI**	**3**		
S18572	1996	4	10	BB	3	S	female at empty site under rock, area E. V. aggressive!
S18572	1999	5	18	BB	3	L	on rock, Foxy Beach
S18614	**1994**	**8**	**3**	**SS**	**1**		
S18614	1996	8	25	BB	1	L	loafing, Foxy Beach
S18614	1996	12	4	BB	1	X	moved from above Willis Walk
S18614	1997	1	31	BB	1	L	
S18614	1997	10	1	BB	1	L	by fence
S18733	**1994**	**7**	**30**	**SS**	**1**		
S18733	1996	12	4	BB	1	X	moved from above Willis Walk
S20745	**1994**	**8**	**16**	**SS**	**1**		
S20745	1997	9	21	BB	1	P	Foxy Beach
S20745	1998	8	19	DAS	1	E	incubating 2 in burrow, area A
S20745	1998	11	5	DAS	1	L	on beach, area A
S20974	**1994**	**7**	**26**	**SS**	**1**		
S20974	1995	8	18	BB	1	L	Foxy Beach
S20974	1998	6	29	BB	1	E	incubating 2 Nest 601
S20974	1998	8	2	BB	1	R	Foxy Beach
S21116	**1994**	**7**	**26**	**SS**	**1**		
S21116	1995	3	29	RI	1	L	on beach
S21116	1997	10	1	BB	1	R	by car park
S21253	**1994**	**7**	**26**	**SS**	**1**		
S21253	1995	4	24	DAS	1	C	with 2 under Tetragonia, area C
S21253	1995	10	10	BB	1	P	present
S21253	1996	12	4	DAS	1	L	on beach, area C
S21253	1997	9	29	DAS	1	L	on beach, area C
S21478	**1994**	**7**	**26**	**SS**	**1**		
S21478	1995	12	26	DAS	1	L	on beach, area B
S21478	1996	6	11	DAS	1	E	incubating 2 eggs under rock, area B
S21478	1996	8	5	DAS	1	C	with 2 downy chicks under rock, area B
S21478	1996	10	9	DAS	1	M	on beach, area B
S21478	1996	10	20	BB	1	L	loafing, Foxy beach
S21478	1997	1	6	DAS	1	E	incubating 2 under rock, area B
S21478	1997	3	20	DAS	1	E	incubating 1 in burrow, area B
S21478	1998	4	14	DAS	1	L	in colony, area B
S21478	1999	3	10	DAS	1	M	on beach, area B
S22324	**1994**	**7**	**26**	**SS**	**1**		
S22324	1995	8	17	BB	1	L	Foxy Beach
S22324	1995	9	25	BB	1	P	present
S22324	1996	4	10	BB	1	E	incubating 2 eggs
S22324	1997	8	2	BB	1	R	Foxy Beach
S22324	1997	9	21	BB	1	P	Foxy Beach

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S22324	1997	10	1	BB	1	R	Foxy Beach
S22358	**1994**	**7**	**26**	**SS**	**1**		
S22358	1995	6	21	BB	1	L	loafing
S22358	1995	8	13	BB	1	L	Foxy Beach
S23264	**1994**	**8**	**18**	**SS**	**1**		
S23264	1999	5	29	BB	1	D	half buried, Water's Edge
S23765	**1995**	**9**	**26**	**WB**	**1**		
S23765	1995	10	1	BB	1	P	present
S23765	1996	1	9	DAS	1	L	on beach, area G
S23765	1996	3	1	DAS	1	L	on shore, area G
S23765	1996	4	22	DAS	1	L	in burrow, area G
S23765	1996	5	7	DAS	1	L	in colony, area G
S23765	1996	6	9	DAS	1	L	loafing in colony, area G
S23765	1996	11	2	DAS	1	U	pre-moult on shore, area G
S23765	1997	1	2	DAS	1	L	on beach, area G
S23765	1997	2	20	DAS	1	L	on beach, area G
S23765	1997	6	3	DAS	1	E	incubating 1 under rock, area G. Mate present
S23765	1997	12	10	DAS	1	L	on beach, area G
S23765	1998	6	5	DAS	1	X	
S23765	1999	1	19	DAS	1	L	on beach, area G
S23821	**1994**	**9**	**2**	**RI**	**1**		
S23821	1996	4	10	BB	1	N	on nest, area G
S23850	**1994**	**9**	**2**	**SS**	**1**		
S23850	1995	10	2	BB	1	P	present
S23895	**1995**	**10**	**2**	**WB**	**1**		
S23895	1997	8	2	BB	1	R	Foxy Beach
S24462	**1994**	**7**	**30**	**SS**	**1**		
S24462	1995	9	12	DAS	1	L	on beach, area D
S24462	1995	10	31	DAS	1	L	on beach, area D
S24462	1995	11	7	DAS	1	L	on beach, area D
S24462	1996	1	9	DAS	1	L	on beach, area D
S24462	1996	1	17	DAS	1	M	on beach, area D
S24462	1996	1	18	DAS	1	M	in heavy moult on beach, area D
S24462	1996	1	24	DAS	1	L	loafing on beach, Whale Bay
S24462	1997	6	4	DAS	1	L	on beach, area B
S24462	1997	9	30	BB	1	P	
S24647	**1994**	**8**	**1**	**SS**	**1**		
S24647	1995	9	30	BB	1	P	present
S24647	1996	5	28	RI	1	F	with feathered chick, area Ic
S24689	**1994**	**8**	**18**	**SS**	**1**		
S24689	1995	9	22	BB	1	P	present
S24689	1995	10	1	BB	1	P	present
S24689	1996	1	19	DAS	1	C	with 1 live, 1 dead small downy chick in burrow
S24689	1996	2	1	DAS	1	C	with 1 medium downy chick in burrow, area G
S24689	1996	4	16	DAS	1	L	in burrow, area G
S24689	1996	4	22	DAS	1	E	incubating 1 in burrow, area G
S24689	1996	4	26	DAS	1	E	incubating 2 in burrow, area G
S24689	1996	5	6	DAS	1	E	incubating 2 in burrow, area G
S24689	1996	5	11	DAS	1	E	incubating 2 in burrow, area G
S24689	1996	5	16	DAS	1	E	incubating 2 in burrow, area G
S24689	1996	5	20	DAS	1	E	incubating 2 in burrow, area G
S24689	1996	5	26	DAS	1	E	incubating 2 in burrow G719
S24689	1996	6	5	DAS	1	C	with 2 small downy chicks in burrow, G719
S24689	1996	7	15	DAS	1	L	In burrow G719 - its burrow; previous attempt failed
S24689	1996	9	26	DAS	1	L	in burrow, area G
S24689	1996	11	10	DAS	1	R	returning from sea, House Bay (area G)
S24689	1996	11	15	DAS	1	E	incubating 2 eggs in burrow, G910
S24689	1996	11	19	DAS	1	E	incubating 2 in burrow G910

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S24689	1996	12	2	DAS	1	C	with 2 downy chicks in burrow G910
S24689	1997	2	24	DAS	1	L	with mate in burrow G910, where it nested successfully
S24689	1997	6	3	DAS	1	M	in burrow, area G
S24689	1997	9	18	DAS	1	E	incubating 2 in burrow, area G
S24689	1997	11	1	DAS	1	E	incubating 2 in burrow, area G
S24689	1997	12	13	DAS	1	L	with mate in burrow, area G
S24689	1998	5	8	DAS	1	L	in colony, area G
S24689	1998	5	12	DAS	1	L	under rock, area G
S24689	1998	7	15	DAS	1	L	with mate under rock, area G
S24689	1998	7	20	DAS	1	E	incubating 1 under rock, area G
S24689	1998	7	22	DAS	1	E	incubating 2 in burrow, area G
S24689	1998	8	4	DAS	1	E	incubating 2 in burrow, area G
S24689	1998	9	4	DAS	1	C	with 2 downy chicks under rock, area G
S24689	1998	9	6	DAS	1	C	with 2 downy chicks under rock, area G
S24689	1998	10	14	DAS	1	L	on beach, area G
S24689	1999	1	7	DAS	1	L	with mate in burrow, area G
S24689	1999	1	28	DAS	1	L	with mate in burrow, area G
S24689	1999	5	13	DAS	1	L	in burrow, area G
S24689	1999	5	25	DAS	1	E	incubating 2 in burrow, area G
S24689	1999	6	8	DAS	1	E	incubating 2 in burrow, area G
S24689	1999	6	22	DAS	1	E	incubating 2 in burrow, area G
T3761	**1992**	**5**	**8**	**RI**	**1**		
T3761	1999	2	8	BB	1	I	hit by car: taken to SANCCOB
T3764	**1992**	**5**	**8**	**RI**	**1**		
T3764	1995	6	21	BB	1	E	female incubating 2 eggs
T3829	**1992**	**6**	**4**	**RI**	**1**		
T3829	1997	2	27	BB	1	I	sent to SANCCOB. Finding date = release date
T5690	**1984**	**8**	**3**	**RI**	**1**		
T5690	1997	9	22	BB	1	P	
V2109	**1985**	**5**	**15**	**RI**	**3**		
V2109	1992	12	22	BB	3	B	blood sampled for parasites
V2109	1995	8	7	BB	3	C	with 2 chicks
V2109	1995	9	14	BB	3	C	with chicks
V2109	1995	10	25	BB	3	L	on rocks
V2109	1996	12	12	BB	3	L	on rocks
V2109	1997	9	21	BB	3	P	Foxy Beach
V2109	1998	10	27	BB	3	L	on rocks
V2109	1999	3	19	BB	3	L	Foxy Beach
V2109	1999	5	18	BB	3	E	incubating 2, area B
V2109	1999	5	28	BB	3	N	in rocks, gate 4
V2109	1999	6	7	BB	3	N	area B

CHAPTER FOUR

IMMIGRATION TO AND EMIGRATION FROM BREEDING COLONIES BY AFRICAN PENGUINS

4.1 INTRODUCTION

The African Penguin population has declined by at least 90% over the course of the 20th century (Shannon & Crawford 1999, Underhill 2000, Crawford *et al.* 2001), with current trends differing between colonies (Crawford *et al.* 2001). The rate of decline or increase of some of these colonies can only be explained by the emigration of birds from and immigration of birds to breeding colonies. The growth in colony size recorded at Dyer Island between 1956 and 1967 and at Robben Island and The Boulders between 1989 and 1995, was attributed mainly to immigration of first time breeders from other colonies (Crawford 1998a, Crawford *et al.* 1999, Crawford *et al.* 2000b). Randall *et al.* (1987) stated that settlement and breeding at colonies other than the natal one, by African Penguins banded as chicks, was found to be rare and that breeding adults are both colony and site faithful. None were known to have settled or attempted to breed at any colony other than that at which they were known to be established breeders (Randall *et al.* 1987). These statements are re-examined using the database of African Penguin re-sightings held by the Avian Demography Unit.

4.2 METHODS

Details of the collection of data and field visits were given in Chapter Two. Three regions were considered: the Eastern Cape (Algoa Bay colonies), Western Cape and Namibia. The database was investigated for evidence of chicks settling at non-natal colonies and of adults attempting to breed at more than one colony. For birds banded as chicks, they were said to have emigrated if they were found at a nest, incubating eggs or guarding chicks at a colony other than their natal colony.

Emigrations between and within regions were investigated, along with the years when most immigration was detected. Birds banded as adults were included in the analysis if they were recorded incubating eggs or guarding chicks at more than one colony. In the case of adults, their natal colony was rarely known and their breeding status at the time of banding was not recorded on banding schedules. The data, particularly that for

birds banded as adults, were rigorously checked for the possibility of reading and transcription errors.

4.3 RESULTS

4.3.1 *Penguins banded as chicks*

A total of 3572 chicks was seen alive after banding. Of these, 85 (2%) were found to have settled to breed at non-natal colonies, whereas 514 (14%) were recorded breeding at natal colonies. Only one of the birds breeding at a non-natal colony was also recorded breeding at its natal colony. S11099 was recorded incubating one egg, when in its third year, at its natal colony, Robben Island. It was later seen incubating eggs at Dassen Island when in its fourth year (Appendix 4.2). There were 28 pairs of localities recorded amongst the birds that settled at non-natal colonies (Table 4.1). Fourteen of the birds settled in another region (Table 4.2). Colonies from which penguins banded as chicks emigrated, numbered two in the Eastern Cape, six in the Western Cape and four in Namibia. They recruited to one colony in the Eastern Cape, nine in the Western Cape and two in Namibia (Table 4.1).

Of the six birds emigrating from colonies in the Eastern Cape, four remained within the region (Table 4.2), moving 48 km from St Croix Island to Bird Island (Table 4.1). The remaining two birds moved to Western Cape colonies. Penguin S12287 was found with downy young at Dassen Island just over two years from banding on Bird Island, but there were no further sightings of this bird. Penguin V0685 was in its fourth year after banding on St Croix Island when found incubating an egg at Stony Point, but it disappeared after this sighting (Appendix 4.2).

In the Western Cape, all but two of the 65 birds that emigrated settled at other colonies within the region (Table 4.2). One bird (V7854) from Jutten Island settled at Bird Island in the Eastern Cape, while another (S02202) left Dyer Island for Ichaboe Island in Namibia. The latter bird was only sighted once, when it was incubating eggs, nearly six years after it was banded (Appendix 4.2). The majority of emigrations (29) took place from Dyer Island, on the south coast (Table 4.1), most (11) settling at Dassen Island, on the west coast. Six and five birds respectively settled at the two South African mainland colonies of Stony Point and The Boulders, and four at the

recently re-colonised Robben Island. Twenty-one birds emigrated from Dassen Island, 19 of which settled at nearby Robben Island, 51 km to the south. Seven birds emigrated from Robben Island to Dassen Island.

Of the 14 birds recorded emigrating from Namibian colonies, 10 (70%) settled in the Western Cape, the remainder settling at other Namibian colonies (Table 4.2). All but one of those that settled in the Western Cape did so at Robben or Dassen Islands (Table 4.1). The other bird, banded as V3449, settled at Dyer Island (Appendix 4.2). The four birds that settled within Namibia did so at localities to the north of their natal colonies.

Immigration of birds to Robben and Dassen Islands accounted for 64% of the total. These two colonies received the highest intensity of monitoring during the period between 1995 and 1999. The two South African mainland colonies at The Boulders and Stony Point recorded five or more immigrations, as did Bird Island in Algoa Bay.

Of the chicks that emigrated from natal colonies, most were banded between 1983 and 1993, with the years 1990–1992 accounting for 59% of them (Table 4.3). Of the total number of 21 585 chicks that were banded between 1978 and 1995 at the colonies from which at least one bird was known to emigrate, 16 590 (77%) were banded between 1983 and 1993, including 7944 (37%) in the years 1990–1992 (Table 4.4). Between 1990 and 1992, most emigrations took place from Dyer Island (44%), with Dassen Island accounting for another 22%. In the 1980s, Dyer and Dassen Islands again had the largest numbers of emigrations. Dyer Island had a smaller proportion of the total (24%) but the proportion emigrating from Dassen Island was slightly higher than in the early 1990s (28%). For colonies from which chicks were known to emigrate, the proportion of those banded that emigrated ranged from 0.2% to 8.3% (Table 4.5). Dyer Island, Stony Point, Jutten Island, Marcus Island, Possession Island and Halifax Island all had proportions of emigrants that exceeded 1% of the total banded in one or more years (Table 4.5). The arrival of most of the immigrants was recorded between 1993 and 1999, with the period 1995–1997 accounting for 58% of the total (Table 4.6). In the latter period, most of the immigrants were recorded at Robben and Dassen Islands (63%). Ten chicks banded between 1991 and 1993 left Dassen Island, recruiting to the Robben Island population between 1995 and 1999.

During the same two periods of emigration and immigration, seven chicks left Robben Island to settle at Dassen Island (Table 4.7). The mean period between banding at the natal colony and detection at the non-natal colony was 4.3 years for birds moving between Dassen and Robben Islands. Only eight immigrants were recorded in the 1980s (Table 4.6), five of which settled at Robben Island. The remaining three all settled at south coast colonies.

The ages of birds banded as chicks when first detected breeding ranged between two years and two months and nine years and six months. These breeding attempts did not form part of a closely monitored group of nests, and it is possible that earlier breeding attempts by some of these birds may have been missed. The majority of birds were first detected breeding at their new colony when aged between three years and seven years old, five to six years being the most frequently recorded age range (Table 4.8). Birds banded prior to 1990 were excluded from the table because their inclusion led to some unrealistically high ages at first breeding. This was due to the paucity of observer effort prior to the mid-1990s, causing many first breeding attempts to be missed.

Within the Western Cape, the numbers of chicks emigrating from south coast and from west coast colonies were approximately equal (Table 4.9). However, 57 of the 75 immigrations (76%) were recorded at west coast colonies. In Namibia, there were equal numbers of chicks recorded emigrating from colonies north and south of Lüderitz, but all recorded immigrants settled at colonies to the north of Lüderitz (Table 4.9).

4.3.2 *Penguins banded as adults*

There were 17 apparent instances of African Penguins that were banded as adults attempting to breed at more than one colony. Of these, nine were strongly suspected to relate to mistakes in reading or transcribing the band number. In three of the nine cases there was only a single sighting of the bird at one of the colonies where breeding had been recorded, and the original data were not available to check the validity of those sightings. In another case, the only breeding attempt at one of the colonies related to a sighting of a bird on a nest, but no eggs or chicks were seen to confirm the breeding attempt. Another bird was present at a study nest on Dassen

Island, having previously bred on Robben Island. It was only recorded on one of eight visits to the study nest and may have been a visiting bird that had taken refuge in another penguin's burrow. The remaining four cases were rejected because of the likelihood that the band numbers had been misread. In each instance, there were only one or two sightings from one of the colonies where breeding was recorded, and a bird with a similar ring number, differing by only one digit, was known to breed in the vicinity. In two of these cases the bird with the similar ring number was known to be breeding at the same time that the suspected mistaken observation was made. The possibility of further such mistakes having occurred cannot be ruled out, but there was no strong evidence to suggest that the remaining eight records did not consist of genuine observations. All of the records that were treated as genuine related to survivors of the *Apollo Sea* oil spill of June 1994. Following this incident, which caused 10 000 African Penguins to be oiled (Dehrmann 1994, Underhill *et al.* 1999), over 4000 cleaned, flipper-banded penguins were released back into the wild (Underhill *et al.* 1999). Most of the oiled penguins were transported from Dassen Island with 2 500 having come to SANCCOB from Robben Island (Erasmus 1995).

All of the eight birds concerned attempted to breed at two colonies, one of the attempts being at Dassen Island. Of the other breeding attempts, five were made at Robben Island, one at Jutten Island and two at Vondeling Island (33° 09′ S 17° 59′ E) (Appendix 4.3). All four colonies are situated on the west coast of the Western Cape Province, South Africa, and all four have shown an upward trend in the number of occupied nest sites throughout the 1990s (Crawford *et al.* 2001). Two birds (S21661 and S23183) made single breeding attempts at Robben Island and Dassen Island respectively, before settling to become regular breeders at Dassen Island (S21661) and Vondeling Island (S23183). Another two birds (S20953 and S23110) bred at Robben Island and were then recorded breeding at Dassen Island the next year. Both returned to Robben Island within two months of their breeding attempt at Dassen Island, and S23110 was recorded breeding again at Robben Island the following year (Appendix 4.3). S22044 appeared to make two breeding attempts at Dassen Island in 1995, the first of which probably failed. It then moved to Robben Island where it was found to be breeding in 1997. The other records related to single breeding attempts at each of two localities. None of the breeding attempts by any of these eight birds was

closely monitored and only S20953 was known to have successfully reared chicks to fledging age (Appendix 4.3).

4.4 DISCUSSION

Birds banded as chicks that were subsequently recorded breeding were seven times more likely to have been found breeding at natal colonies than at non-natal ones. Randall *et al* (1987) recorded three birds that were banded as chicks breeding out of 90 re-sightings at non-natal colonies (3.3%). In the current study, 85 of 1006 sightings (8%) at non-natal colonies were of immigrant birds breeding. While still a fairly rare event, the incidence is greater than that reported by Randall *et al.* (1987). The largest numbers of immigrants were recorded at the two colonies with the highest intensities of observer effort (Robben and Dassen Islands). After Dyer Island, these two colonies also had the largest number of emigrants. In most of the cases where the percentage of birds emigrating exceeded 1% of the total number of birds banded, the latter total was less than 100 birds (Tables 4.4 and 4.5). The proportion of penguins emigrating was thus exaggerated by the small totals of birds banded. However, for the years 1990 to 1992, the proportion of emigrants from Dyer Island ranged from 1.4% to 3.3% of those banded (Table 4.5), while the total numbers of birds banded in those years ranged from 150 to 901 per year (Table 4.4). This tends to suggest that relatively large numbers of young penguins were leaving Dyer Island to settle at other breeding colonies. The mean percentage of emigrants recorded from Dyer Island for the years 1984–1995 was 1.65% of those banded, whereas for both Robben and Dassen Islands it was 0.5%. This suggests that over three times as many birds were emigrating from Dyer Island than were recorded leaving from Dassen and Robben Islands, the colonies with the second and third largest number of emigrants respectively. Marcus Island also recorded proportions of emigrants exceeding 1% of the total numbers banded (Table 4.5). The number of penguins banded at this colony in 1978 was only 12 but the proportion of 1.5% of birds banded in 1986 emigrating was based on a sample of 130 (Tables 4.4 and 4.5). This colony was known to be decreasing in size during the mid-1980s (Shelton *et al.* 1984, La Cock *et al.* 1987). Most birds emigrating from Eastern Cape and Western Cape colonies settled at other colonies within the region. This was not the case with birds emigrating from Namibian colonies, most of which settled in the Western Cape.

The data available suggest a movement of some young African Penguins away from the south coast of the Western Cape Province, where Dyer Island is situated, towards the western side of the Western Cape, centred on Robben and Dassen Islands. Re-settlement of birds from Algoa Bay in the Eastern Cape seemed to be mostly on a local scale, from St Croix Island to Bird Island. There is also evidence for some relocation of birds from southern Namibia to the Western Cape of South Africa, and to colonies farther north off the Namibian coast. This pattern of emigration and immigration of young African Penguins may relate to changing patterns of dominance in the main prey species. Sardine *Sardinops sagax* and Anchovy *Engraulis capensis* are subject to shifts in abundance, termed regimes (Lluch-Belda *et al.* 1992, Crawford 1998a). These shifts in the dominance of each species over the other are probably governed by environmental factors. Changes in temperature and salinity, both of which are associated with areas of upwelling, such as the Benguela system, could influence such shifts (Skud 1982). Sardine was the dominant species in the Benguela system up to the mid-1960s off South Africa and until the early 1970s off Namibia (Crawford 1998a). Anchovy then became dominant until the early 1980s off Namibia and the late 1980s off South Africa. Sardine stocks have again become dominant off South Africa and had partially recovered by the early 1990s off Namibia (Crawford 1998a). However, the Namibian stock declined again, exacerbated by continued fishing, resulting in the lowest recorded catch in the history of the fishery in 1996 (Boyer *et al.* 2001).

During the period when Anchovy was dominant, food was probably more consistently available to African Penguins on the west Agulhas Bank. Older Anchovy remain here throughout the year with an annual migration of Sardine through the region (Crawford 1998a). For African Penguins, colonies closest to the Agulhas Bank would benefit most in periods of Anchovy dominance. Those between Lüderitz and Table Bay would have been faced with a diminished food supply, as the Sardine distribution contracted to the north off Namibia and to the south off South Africa (Lluch-Belda *et al.* 1989, Crawford 1998a). This distribution of prey resources probably explains the decreasing sizes of African Penguin colonies between Lüderitz and Table Bay, and the increasing size of those between Table Bay and Cape Agulhas between the 1950s and 1980s (Crawford 1998a). By the end of the 1970s, Dyer Island, which is close to

the Agulhas Bank, had become the largest African Penguin colony with over 22 000 breeding pairs (Crawford *et al.* 1995c). In contrast, the colony at Possession Island, off the Namibian coast south of Lüderitz, had declined by 96% between 1956 and 1995 (Cordes *et al.* 1999). That at Dassen Island decreased from an estimated 145 000 African Penguins in 1956 (Rand 1963a) to 27 000 in the early to mid-1980s (Crawford *et al.* 1995c).

A return to a system dominated by Sardine would benefit African Penguin colonies between Lüderitz and Table Bay. The pattern of emigration of birds banded as chicks from Dyer Island to settle at colonies on the west coast of South Africa, and those closer to Cape Town, would be in keeping with the change from a system where Anchovy is dominant to one where Sardine is the dominant species. The active nest counts at the African Penguin colonies at The Boulders, Robben Island, Dassen Island, Vondeling Island and Jutten Island have all shown an increase during the 1990s. In contrast, that at Dyer Island declined by 90% to just under 2000 active nests in 1998 (Crawford *et al.* 2001). However, the pattern is complicated by emigration of some birds from expanding colonies to other expanding colonies. The shift in prey dominance does not explain why 19 chicks from Dassen Island settled at nearby Robben Island, while seven chicks from Robben Island settled at Dassen Island. Ten of the Dassen Island birds left the island during the same time period as those that left Robben Island (1991–1993). They all recruited to Robben and Dassen Islands respectively between 1995 and 1999 (Table 4.7). Biomass estimates indicate that there was less food available to penguins between 1995 and 1997, when most of the immigrations were recorded, than in subsequent years (Table 4.10) when only 13 immigrations were noted (Table 4.6). The general paucity of available food resources in those years may have resulted in more penguins immigrating to colonies where prey was more readily available. Birds settling at non-natal colonies within Namibia all travelled northwards (Tables 4.1 & 4.9), presumably as a result of the northerly contraction of the sardine resource off the Namibian coast. Pelagic Goby *Sufflogobius bibarbatus*, were also readily available to penguins in the vicinity of Ichaboe and Mercury Islands (Figure 1.1), and would have provided an alternative food source to birds settling at these two localities (Crawford 1980, Crawford *et al.* 2001). In 1980, Pelagic Goby comprised 73% of the items found in stomachs of penguins at Mercury

Island, while those at Halifax and Possession Islands, farther to the south, were found to be feeding principally on cephalopods (Crawford *et al.* 1985).

As only one bird banded as a chick was recorded breeding at its natal colony prior to emigration, it is assumed that the immigrants are almost exclusively first time breeders. Most were between the ages of three and seven years old when recorded breeding for the first time (Table 4.8). Crawford *et al.* (1999) found that most birds in a study population at Robben Island bred for the first time between the ages of three and five years. Randall (1983) found ages of first breeding for nine birds at St Croix Island to vary between three years and five years old. It is thought that first time breeders may take advantage of the distribution of food resources at the time of commencement of breeding, and that they have the capacity to settle at breeding colonies that are situated close to the best food resources (Crawford 1998a).

Randall *et al.* (1987) stated that "no breeding adults were known to have settled or bred at other islands". In this study, there is evidence to suggest that eight birds banded in adult plumage did attempt to breed at more than one locality. The possibility that some of these records may relate to misread or incorrectly transposed band numbers cannot be completely excluded, but it was considered unlikely that all such occurrences were the result of human error. All eight were victims of the *Apollo Sea* oil spill of June 1994. Five of them made their first, and probably unsuccessful, breeding attempt within a year of being released after cleaning. The ages and breeding status of these eight birds, none of which were banded prior to being oiled, were unknown. It may be possible that the trauma and stress of the oiling, petro-chemical poisoning and rehabilitation experience, causes disorientation of some birds, particularly perhaps of first time breeders, leading them to attempt breeding at a colony other than the one at which they finally chose to settle. It is also possible that some birds lost their mate and formed a new partnership with a bird from a different colony. Breeding at more than one colony by African Penguins is still an extremely rare event. It is anticipated that fieldwork following the release of over 16 000 penguins that were cleaned after the *Treasure* oil spill of June 2000, may reveal further instances of birds attempting to breed at more than one locality.

TABLE 4.1

Localities involved in emigration and immigration by African Penguins banded as chicks.

			Recruited to											
		EC	Western Cape									Namibia		
		BI	DYI	SP	SI	BB	RI	DAS	JI	VI	MCI	II	MYI	TOTAL
Left from	EC: BI							1						1
	EC: SCI	4		1										5
	Western Cape: DYI			6	1	5	4	11		1		1		29
	Western Cape: SP		1											1
	Western Cape: RI					1		7	1					9
	Western Cape: DAS					1	19				1			21
	Western Cape: JI	1												1
	Western Cape: MCI		1				1	2						4
	Namibia: HI						1	3				1		5
	Namibia: PSI							1				1		2
	Namibia: II							2					2	4
	Namibia: MYI		1				1	1						3
	TOTAL	5	3	7	1	7	26	28	1	1	1	3	2	85

BB = The Boulders
BI = Bird Island (Algoa Bay)
DAS = Dassen Island
DYI = Dyer Island
EC = Eastern Cape
HI = Halifax Island
II = Ichaboe Island
JI = Jutten Island
MCI = Marcus Island
MYI = Mercury Island
PSI = Possession Island
RI = Robben Island
SCI = St Croix Island
SI = Seal Island (False Bay)
SP = Stony Point
VI =Vondeling Island

TABLE 4.2

Emigration and immigration of birds banded as chicks by region

		To		
		Eastern Cape	Western Cape	Namibia
From	Eastern Cape	4	2	0
	Western Cape	1	63	1
	Namibia	0	10	4

TABLE 4.3

Years of banding of chicks that subsequently emigrated from their natal colonies.

	Eastern Cape		Western Cape						Namibia				
Year banded	BI	SCI	DYI	SP	RI	DAS	JI	MCI	HI	PSI	II	MYI	TOTAL
1978								1					1
1979		1											1
1980													0
1981		1											1
1982		1											1
1983		1						1					2
1984		1	2			2							5
1985			1			2							3
1986				1				2			1		4
1987			1									1	2
1988			2				1						3
1989						3					1		4
1990			4			2			4				10
1991			13		2	5			1	2	1		24
1992			5		6	4					1		16
1993					1	3						2	6
1994	1												1
1995			1										1
TOTAL	1	5	29	1	9	21	1	4	5	2	4	3	85

See Table 4.1 for locality abbreviations

TABLE 4.4

Numbers of chicks that were flipper-banded between 1978 and 1995 at colonies from which at least one chick was known to emigrate.

	Eastern Cape		Western Cape						Namibia				
Year banded	BI	SCI	DYI	SP	RI	DAS	JI	MCI	HI	PSI	II	MYI	TOTAL
1978	0	173	503	0	0	74	0	12	99	453	314	106	1734
1979	0	158	0	0	0	0	0	1	0	0	0	0	159
1980	0	192	0	0	0	0	0	179	0	0	0	0	371
1981	0	174	0	0	0	0	0	115	0	0	0	0	288
1982	0	205	0	0	0	69	0	67	0	24	19	18	402
1983	0	104	5	0	0	175	0	315	0	0	0	0	599
1984	0	123	389	0	0	248	5	121	0	0	0	0	886
1985	0	112	661	20	0	484	0	159	0	0	0	0	1436
1986	0	0	0	25	0	0	24	130	0	43	150	200	572
1987	0	0	35	0	104	266	9	10	0	45	146	152	767
1988	0	0	215	0	29	276	84	33	0	96	0	0	733
1989	0	0	54	1	191	718	1	1	0	0	217	242	1184
1990	0	0	201	22	464	449	0	0	80	2	374	290	1646
1991	0	0	901	16	508	963	0	0	33	40	694	41	3156
1992	1	0	150	5	660	1062	0	0	0	104	411	785	3142
1993	1	0	48	6	394	510	0	0	37	102	537	434	2069
1994	500	0	0	6	81	399	0	0	0	0	112	111	1209
1995	575	0	50	14	0	0	0	0	0	0	207	36	832
TOTAL	1077	1241	3162	114	2431	5693	122	1142	249	831	3181	1941	21585

See Table 4.1 for locality abbreviations

TABLE 4.5

Numbers of chicks emigrating from natal colonies expressed as a percentage of the number banded for the years 1978–1995.

	Eastern Cape		Western Cape						Namibia			
Year banded	BI	SCI	DYI	SP	RI	DAS	JI	MCI	HI	PSI	II	MYI
1978								8.3				
1979		0.6										
1980												
1981		0.6										
1982		0.5										
1983		1.0						0.3				
1984		0.8	0.5			0.8						
1985			0.2			0.4						
1986				4.0				1.5			0.7	
1987			2.9									0.7
1988			0.9				1.2					
1989						0.4					0.5	
1990			2.0			0.4			5.0			
1991			1.4		0.4	0.5			3.0	5.0	0.1	
1992			3.3		0.9	0.4					0.2	
1993					0.3	0.6						0.4
1994	0.2											
1995			2.0									

TABLE 4.6

Numbers of birds banded as chicks that were recorded settling in each year between 1981 and 2000 by colony.

	EC	Western Cape									Namibia		
Year banded	BI	DYI	SP	SI	BB	RI	DAS	JI	VI	MCI	II	MYI	TOTAL
1981	1												1
1982													0
1983													0
1984													0
1985													0
1986			1										1
1987		1											1
1988													0
1989						5							5
1990						1							1
1991	1												1
1992													0
1993	2				2	2							6
1994	1					3	2					1	7
1995		1	2		2	7	7			1	2		22
1996		1	2			4	4				1	1	13
1997			1	1	1	1	8	1	1				14
1998					1	1	4						6
1999			1		1	2	2						6
2000							1						1
TOTAL	5	3	7	1	7	26	28	1	1	1	3	2	85

See Table 4.1 for locality abbreviations

TABLE 4.7

Years of banding of African Penguin chicks that emigrated from Dassen Island to Robben Island and vice versa, and the years in which they were first detected at the recruiting colony.

Year banded at Dassen or Robben Island	Year recruited at Robben Island (from Dassen Island)	Year recruited at Dassen Island (from Robben Island)
1984	1989 x 2	
1985	1989, 1993	
1986		
1987		
1988		
1989	1989 x 2, 1994	
1990	1995 x 2	
1991	1994, 1995 x 2	1995
1992	1995 x 2, 1996, 1998	1996 x 2, 1997, 1998, 1999
1993	1995, 1999 x 2	1997
1994		
1995		

TABLE 4.8

Age at first detected breeding (in years) of immigrant African Penguins banded as chicks, on or after 1st January 1990.

	Years of age								
	< 1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	> 8
Number of birds	0	0	2	12	11	15	10	7	1

TABLE 4.9

Number of chicks emigrating from and settling at colonies on the south and west coasts of the Western Cape Province, and emigrating from and settling at colonies in Namibia, south and north of Lüderitz (Halifax Island is included with those colonies south of Lüderitz).

	South coast	West coast	South of Lüderitz	North of Lüderitz
Emigrating from	30	35	7	7
Recruiting to	18	57	0	5

TABLE 4.10

Combined biomass (million tonnes) of Anchovy and Sardine off South Africa, 1995–2000. Source: Marine and Coastal Management, unpublished, updated from Barange *et al.* 1999.

Year	Biomass
1995	1.05
1996	0.64
1997	1.71
1998	2.30
1999	2.67
2000	5.35

APPENDIX 4.1

Explanation of abbreviations and codes used in Appendices 4.2–4.3

Locality Codes

BB	The Boulders
BI	Bird Island, Algoa Bay
DAS	Dassen Island
DYI	Dyer Island
HI	Halifax Island
II	Ichaboe Island
JI	Jutten Island
MCI	Marcus Island
MYI	Mercury Island
PSI	Possession Island
RI	Robben Island
ROB	Robberg Beach
SCI	St. Croix Island
SI	Seal Island, False Bay
SP	Stony Point
X	other
SS	Silwerstroomstrand
VI	Vondeling Island

Activity Codes

B	blood sampled
C	with downy chick(s)
D	found dead
E	incubating egg(s)
F	with feathered chick(s)
I	injured/sick
L	loafing
M	moulting
N	on nest
O	oiled
P	present
R	returning from sea
S	at empty site
U	pre-moult condition

Rehabilitation (Rehab.) status

0 = not rehabilitated
1 = oiled, cleaned and released
2 = rehabilitated but not oiled

APPENDIX 4.2

Re-sighting information of birds banded as chicks that bred at non-natal colonies. The first line for each bird represents the ringing date and locality. See Appendix 4.1 for list of abbreviations.

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
A01973	**1991**	**4**	**25**	**DYI**	**0**		**originally S01410**
A01973	1997	11	4	BB	0	I	released from SANCCOB on this date
A01973	1998	7	3	BB	2	F	with 1 feathered chick
A01973	1998	8	2	BB	2	R	Foxy Beach. Injured left leg
A01973	1999	5	18	BB	2	E	incubating 1+, area A
A01973	1999	6	7	BB	2	E	incubating 2, Foxy Beach
A01973	1999	6	10	BB	2	C	with 1 egg, 1 downy chick, Foxy Beach
A01973	1999	6	24	BB	2	C	with 1 downy chick, Foxy Beach
A01973	1999	7	2	BB	2	N	collecting nest material. Limping
A01973	1999	7	8	BB	2	C	with 2 downy chicks, Foxy Beach
A01973	1999	7	13	BB	2	C	feeding chick
A01973	1999	7	29	BB	2	C	with one chick
S01263	**1990**	**4**	**28**	**HI**	**0**		
S01263	1995	11	15	DAS	0	E	incubating 2 in burrow, area B
S01273	**1990**	**4**	**28**	**HI**	**0**		
S01273	1995	6	27	DAS	0	C	with 1 downy chick under rock, area A
S01282	**1990**	**4**	**28**	**HI**	**0**		
S01282	1998	3	7	DAS	0	E	incubating 2 in burrow, area G
S01282	1998	5	28	DAS	0	E	incubating 1 in burrow, area H
S01300	**1990**	**4**	**28**	**HI**	**0**		
S01300	1993	11	17	RI	0	P	alive and well
S01300	1995	8	2	RI	0	C	with 2 small downy chicks
S01419	**1991**	**4**	**25**	**DYI**	**0**		
S01419	1997	8	13	DAS	0	L	on beach, area B
S01419	1999	1	25	DAS	0	E	incubating 2 in burrow, area B
S01466	**1991**	**3**	**27**	**DAS**	**0**		
S01466	1998	5	23	BB	0	C	with 1 large downy chick, Nest 13
S01531	**1991**	**3**	**27**	**DAS**	**0**		
S01531	1994	8	10	RI	0	P	alive and well
S01531	1996	5	27	RI	0	E	with mate, latter incubating 2 eggs, Area Id
S01895	**1990**	**10**	**26**	**DAS**	**0**		
S01895	1995	3	30	RI	0	E	2 eggs,1 pipping
S01895	1998	6	18	RI	0	R	area C/D
S02089	**1991**	**4**	**24**	**DYI**	**0**		
S02089	1994	8	10	RI	0	P	alive and well
S02089	1995	5	31	RI	0	E	incubating 1 egg, area Ia
S02160	**1990**	**10**	**5**	**DYI**	**0**		
S02160	1996	5	23	RI	0	C	with 2, 1–2 day-old downy chicks, Area C
S02160	1997	7	4	RI	0	C	with 2 medium downy chicks, area C
S02196	**1990**	**10**	**5**	**DYI**	**0**		
S02196	1997	8	13	DAS	0	C	with 2 downy chicks in burrow, area F
S02202	**1990**	**10**	**5**	**DYI**	**0**		
S02202	1996	9	13	II	0	E	incubating 2
S02255	**1991**	**4**	**24**	**DYI**	**0**		
S02255	1994	12	11	DAS	0	E	incubating 2 in burrow G24
S02430	**1991**	**4**	**18**	**II**	**0**		
S02430	1997	5	28	DAS	0	C	with 1 downy chick in burrow, area B
S03321	**1991**	**5**	**14**	**DAS**	**0**		
S03321	1995	8	24	RI	0	E	incubating 1 egg, area V
S04438	**1992**	**10**	**10**	**II**	**0**		
S04438	1995	7	11	II	0	P	
S04438	1998	4	28	DAS	0	C	with 2 downy chicks in collapsed burrow, area G

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S04561	**1991**	**7**	**1**	**RI**	**0**		
S04561	1995	11	6	DAS	0	F	with 2 feathered chicks under Tetragonia, area H
S04562	**1991**	**7**	**1**	**RI**	**0**		
S04562	1997	10	21	JI	0	M	under rock
S04562	1998	2	24	JI	0	E	incubating 2 under rock
S05076	**1991**	**8**	**8**	**DYI**	**0**		
S05076	1993	11	3	BB	0	P	alive and well
S05076	1995	8	18	BB	0	C	with small downy chick(s)
S05229	**1991**	**8**	**11**	**DYI**	**0**		
S05229	1996	3	4	SP	0	E	incubating 2, nest G3.9
S05229	1996	3	11	SP	0	E	incubating 2, nest G3.9
S05229	1999	5	13	SP	0	E	with mate S25963 and one egg, nest G3.5
S05229	1999	5	21	SP	0	E	incubating 2 eggs, nest G3.10
S05229	1999	5	28	SP	0	E	incubating 2 eggs, nest G3.10
S05385	**1991**	**8**	**21**	**DYI**	**0**		
S05385	1996	1	26	DAS	0	X	skulking under Tetragonia with a.n.other, Area H
S05385	1999	6	8	DAS	0	C	with 2 downy chicks under Tetragonia, area H
S05407	**1991**	**8**	**21**	**DYI**	**0**		
S05407	1995	6	21	BB	0	L	loafing under tree
S05407	1995	8	8	BB	0	L	loafing under bush
S05407	1998	5	23	BB	0	E	with S17058 (incubating 1) Nest 171
S05407	1999	4	13	BB	0	C	with mate (S17058 + 2 small downy chick)
S05413	**1991**	**8**	**21**	**DYI**	**0**		
S05413	1995	8	7	SP	0	F	with 1 feathered chick
S05504	**1991**	**10**	**23**	**DYI**	**0**		
S05504	1997	1	22	DAS	0	L	on beach, area G
S05504	1997	2	10	DAS	0	L	under rock, area G
S05504	1997	3	6	DAS	0	L	on beach, area G
S05504	1997	10	25	DAS	0	M	on shore, area G
S05504	1998	4	15	DAS	0	L	in colony, area G
S05504	1999	2	1	DAS	0	E	incubating 2 under rock, area G
S05504	1999	6	8	DAS	0	E	incubating 2 under rock, area G
S05540	**1991**	**10**	**23**	**DYI**	**0**		
S05540	1997	6	15	DAS	0	L	in burrow, area B
S05540	1998	4	28	DAS	0	E	incubating 1 in burrow, area G
S05540	1998	9	2	DAS	0	L	on beach, area G
S05540	1998	10	13	DAS	0	M	in burrow, area G
S05794	**1991**	**10**	**6**	**DAS**	**0**		
S05794	1995	5	29	RI	0	L	sitting under log, area S
S05794	1995	7	5	RI	0	E	incubating 2 fresh eggs.
S05794	1995	8	24	RI	0	C	with 2 small downy chicks, area S.
S05794	1998	12	29	RI	0	L	on beach, area D
S05794	1999	3	13	RI	0	E	incubating 1+ under Rooikrantz, area S
S05794	1999	6	29	RI	0	F	with 2 feathered chicks, area S
S05794	1999	8	25	RI	0	S	with mate, area S
S05862	**1991**	**10**	**24**	**DYI**	**0**		
S05862	1995	5	29	SP	0	C	with 2 small chicks
S05862	1998	8	13	SP	0	P	
S05862	1998	11	12	SP	0	U	allo-preening with S26035
S05862	1999	3	13	SP	0	E	incubating 2 fresh eggs
S05862	1999	4	1	SP	0	E	incubating 2 eggs
S05862	1999	8	13	SP	0	L	on shore
S05901	**1991**	**10**	**4**	**DAS**	**0**		
S05901	1995	1	10	DAS	0	M	on beach, area G
S05901	1995	5	15	MCI	0	E	incubating 1 egg
S05901	1995	6	9	MCI	0	L	loafing under tree
S05901	1998	3	11	MCI	0	E	incubating 1+
S06229	**1991**	**10**	**15**	**HI**	**0**		

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S06229	1995	5	25	II	0	P	
S06229	1996	10	16	II	0	L	
S06229	1996	10	17	II	0	S	paired
S06229	1997	3	21	II	0	E	incubating 2
S06413	**1991**	**8**	**11**	**PSI**	**0**		
S06413	1994	9	23	MYI	0	P	
S06413	1995	3	23	DAS	0	C	with 2 in burrow, area F
S06424	**1991**	**9**	**28**	**PSI**	**0**		
S06424	1995	2	23	II	0	P	
S06424	1996	8	21	II	0	E	incubating 2
S07145	**1989**	**3**	**30**	**DAS**	**0**		
S07145	1994	8	9	RI	0	C	with chick(s)
S07180	**1989**	**3**	**29**	**DAS**	**0**		
S07180	1989	6	27	RI	0	P	alive and well
S07180	1989	7	11	RI	0	P	alive and well
S07180	1990	3	14	RI	0	P	alive and well
S07180	1990	4	2	RI	0	P	alive and well
S07180	1990	6	27	RI	0	P	alive and well
S07180	1990	7	27	RI	0	P	alive and well
S07180	1990	8	8	RI	0	P	alive and well
S07180	1991	7	17	RI	0	P	alive and well
S07180	1992	4	23	RI	0	P	alive and well
S07180	1995	3	8	RI	0	P	alive and well
S07180	1995	5	31	RI	0	P	alive and well
S07180	1995	7	6	RI	0	C	with 2 medium downy chicks
S07180	1995	8	24	RI	0	F	with feathered chick, area E
S07180	1995	9	13	RI	0	P	alive and well
S07180	1995	10	11	RI	0	L	on beach, Area E
S07180	1996	5	20	RI	0	C	with 2 large downy chicks, Area E
S07180	1998	6	13	RI	0	F	with feathered chick, Nest 189, area E
S07180	1998	6	14	RI	0	L	on beach, area E
S07180	1998	6	19	RI	0	R	area E
S07180	1998	11	9	RI	0	L	on beach, area E
S07180	1999	3	12	RI	0	L	on beach, area E
S07180	1999	6	28	RI	0	F	with 2 feathered chicks, area E
S07190	**1989**	**3**	**29**	**DAS**	**0**		
S07190	1989	5	9	RI	0	P	alive and well
S07190	1989	5	22	RI	0	P	alive and well
S07190	1989	7	11	RI	0	P	alive and well
S07190	1990	2	28	RI	0	P	alive and well
S07190	1990	3	15	RI	0	P	alive and well
S07190	1990	7	11	RI	0	P	alive and well
S07190	1991	6	13	RI	0	P	alive and well
S07190	1992	5	6	RI	0	P	alive and well
S07190	1992	5	20	RI	0	P	alive and well
S07190	1992	6	3	RI	0	P	alive and well
S07190	1992	6	17	RI	0	P	alive and well
S07190	1993	5	5	RI	0	P	alive and well
S07190	1994	4	20	RI	0	P	alive and well
S07190	1994	5	30	RI	0	P	alive and well
S07190	1994	7	15	DAS	0	O	Apollo Sea victim. Cleaned & released
S07190	1995	5	29	RI	1	L	loafing on beach
S07190	1995	7	11	RI	1	P	alive and well
S07190	1995	10	11	RI	1	L	loafing under bushes, Area E
S07190	1996	4	25	RI	1	P	alive and well
S07190	1996	5	17	RI	1	P	alive and well
S07190	1996	5	21	RI	1	L	on beach, Area E
S07190	1996	5	22	RI	1	P	alive and well

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S07190	1996	6	5	RI	1	P	alive and well
S07190	1996	6	24	RI	1	P	alive and well
S07190	1996	7	2	RI	1	P	alive and well
S07190	1997	1	27	RI	1	P	alive and well
S07190	1997	2	25	RI	1	P	alive and well
S07190	1997	7	3	RI	1	E	incubating 2, Nest 22, area Q
S07190	1998	1	19	RI	1	E	incubating egg(s)
S07190	1998	3	24	RI	1	E	incubating 2, Nest 29, area Q
S07190	1998	12	26	RI	1	L	on shore, area E
S07190	1999	3	14	RI	1	L	on beach, area D
S07190	1999	3	15	RI	1	L	on beach, area E
S07938	**1989**	**9**	**20**	**II**	**0**		
S07938	1994	7	23	MYI	0	P	
S07938	1996	2	17	MYI	0	P	
S07938	1997	1	29	MYI	0	F	with 1 feathered chick
S09393	**1990**	**3**	**30**	**DAS**	**0**		
S09393	1995	5	31	RI	0	E	female on eggs, area Ia
S10361	**1992**	**3**	**19**	**DAS**	**0**		
S10361	1996	3	28	RI	0	L	on beach, Area D
S10361	1996	5	20	RI	0	S	defending empty site, Area Q/R
S10361	1996	5	21	RI	0	S	at empty site, Area R
S10361	1996	10	17	RI	0	L	on beach, area D
S10361	1997	7	3	RI	0	E	incubating 2 (BMD/LU)
S10530	**1992**	**5**	**27**	**RI**	**0**		
S10530	1998	1	10	DAS	0	E	incubating 2 in burrow, area G
S10826	**1992**	**10**	**4**	**DYI**	**0**		
S10826	1993	10	10	BB	0	P	alive and well
S10826	1993	10	24	BB	0	P	alive and well
S10826	1995	1	7	BB	0	P	alive and well
S10826	1995	9	19	BB	0	P	present
S10826	1995	9	20	BB	0	P	present
S10826	1998	7	3	BB	0	N	by Degaussing station.
S10826	1998	8	15	BB	0	L	Foxy Beach
S10826	1998	10	27	BB	0	L	Foxy beach
S10855	**1992**	**10**	**4**	**DYI**	**0**		
S10855	1995	5	11	DYI	0	P	present at colony
S10855	1996	1	29	SP	0	E	incubating 2, nest C6.10
S10895	**1992**	**10**	**4**	**DYI**	**0**		
S10895	1995	3	21	DAS	0	L	on beach, area F
S10895	1999	4	22	SP	0	E	incubating 1 egg, nest D4.2
S10901	**1992**	**10**	**4**	**DYI**	**0**		
S10901	1996	11	28	DYI	0	L	loafing
S10901	1997	9	2	SP	0	R	
S10901	1999	5	21	SP	0	E	incubating 2 eggs, nest F5.3
S10949	**1992**	**10**	**4**	**DYI**	**0**		
S10949	1997	10	20	VI	0	L	on shore
S10949	2000	2	26	VI	0	C	with 2 small chicks
S10966	**1992**	**10**	**8**	**DAS**	**0**		
S10966	1998	6	17	RI	0	R	area C
S10966	1999	9	2	RI	0	F	with 1 feathered chick, area Ia
S11002	**1992**	**7**	**29**	**RI**	**0**		
S11002	1996	2	14	DAS	0	L	on shore, Area G
S11002	1996	4	22	DAS	0	E	incubating 2 on surface, area G
S11002	1996	5	7	DAS	0	C	with 1 egg, 1 downy chick under rock, area G
S11002	1996	5	20	DAS	0	C	with 1 downy chick under rock, area G
S11002	1996	10	29	DAS	0	M	moulting on shore, Area G
S11002	1996	11	2	DAS	0	M	moulting on shore, Area G
S11002	1996	11	7	DAS	0	M	moult just complete on shore, Area G

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S11099	**1992**	**9**	**9**	**RI**	**0**		
S11099	1995	7	4	RI	0	L	loafing under bush, area F
S11099	1995	8	2	RI	0	E	incubating 1 egg
S11099	1996	2	28	DAS	0	L	on shore, Whale bay (Area D)
S11099	1996	4	25	DAS	0	E	incubating 2 on surface, area D
S11099	1996	4	29	DAS	0	E	incubating 2 on surface, area D
S11283	**1992**	**9**	**9**	**RI**	**0**		
S11283	1997	6	30	DAS	0	C	with 2 downy chicks in burrow, area G
S11346	**1992**	**9**	**24**	**RI**	**0**		
S11346	1999	4	20	DAS	0	E	incubating 2 in burrow, area A
S11620	**1993**	**5**	**22**	**DAS**	**0**		
S11620	1999	3	27	RI	0	E	incubating 1, area C
S11767	**1993**	**5**	**22**	**DAS**	**0**		
S11767	1995	7	6	RI	0	L	on beach early p.m., area C
S11767	1996	10	9	RI	0	L	loafing under bushes, Area F
S11767	1996	10	16	RI	0	L	on beach, area E
S11767	1997	7	3	RI	0	C	with large downy chick, area F
S11767	1998	3	26	RI	0	L	on beach, area E
S11767	1999	3	12	RI	0	L	on beach, area E
S12287	**1994**	**6**	**1**	**BI**	**0**		
S12287	1996	8	27	DAS	0	C	with 2 downy chicks in burrow G810
S13374	**1992**	**6**	**14**	**DAS**	**0**		
S13374	1995	7	6	RI	0	L	on beach early p.m., area D
S13374	1996	5	28	RI	0	C	with 2 small downy chicks, Area Ic
S13410	**1992**	**6**	**14**	**DAS**	**0**		
S13410	1995	8	24	RI	0	C	with 2 downy chicks, area U
S13492	**1992**	**7**	**29**	**RI**	**0**		
S13492	1995	9	20	BB	0	P	present
S13492	1995	10	10	BB	0	P	present
S13492	1998	3	13	BB	0	L	on beach (LU)
S13492	1998	4	23	BB	0	E	incubating 1
S13883	**1993**	**5**	**23**	**DAS**	**0**		
S13883	1996	5	8	DAS	0	L	on beach
S13883	1996	6	11	DAS	0	L	loafing in colony, Area A
S13883	1999	3	16	RI	0	R	area C
S13883	1999	8	27	RI	0	C	with 1+ small downy chick under Rooikrantz, area B
S14011	**1993**	**7**	**21**	**RI**	**0**		
S14011	1997	12	3	DAS	0	C	with 2 downy chicks in burrow, area B
S16451	**1993**	**10**	**1**	**MYI**	**0**		
S16451	1994	11	18	MYI	0	P	juvenile
S16451	1998	2	5	DAS	0	C	with 2 downy chicks in burrow, area A
S17549	**1993**	**12**	**18**	**MYI**	**0**		
S17549	1995	10	31	DAS	0	L	on beach, area A
S17549	1995	12	11	DAS	0	L	on beach, area G
S17549	1996	12	18	RI	0	U	on beach, area F
S17549	1997	8	6	RI	0	C	with 2 small downy chicks, area K
S17549	1998	4	10	RI	0	C	with 1 downy chick, area K
S17549	1998	12	28	RI	0	S	with mate, area K
S20493	**1995**	**10**	**5**	**DYI**	**2**		
S20493	1999	4	13	BB	2	X	allo-preening with mate
S20493	1999	7	8	BB	2	P	above Foxy Beach
S20493	2000	5	6	BB	2	E	incubating 2 eggs
S20493	2000	7	13	BB	2	C	with 1 chick
S20493	2000	7	27	BB	2	L	by Willis Walk
S20493	2000	8	8	BB	2	P	Foxy Beach
T2806	**1991**	**10**	**23**	**DYI**	**0**		
T2806	1997	3	6	DAS	0	L	on beach, area F
T2806	1999	6	13	DAS	0	C	with 2 downy chicks under rock, area F

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T5079	**1978**	**10**	**14**	**MCI**	**0**		
T5079	1987	3	28	DYI	0	E	incubating (BEP)
V0271	**1981**	**9**	**20**	**SCI**	**0**		
V0271	1982	11	6	SCI	0	M	
V0271	1993	11	15	BI	0	P	
V0271	1994	8	9	BI	0	P	
V0271	1995	4	24	BI	0	P	
V0271	1995	6	19	BI	0	P	
V0271	1995	11	7	BI	0	C	with chick
V0271	1997	5	11	ROB	0	D	dead on beach
V0574	**1982**	**7**	**9**	**SCI**	**0**		
V0574	1983	11	6	SCI	0	L	
V0574	1991	3	11	BI	0	E	
V0574	1994	4	21	BI	0	P	
V0574	1995	11	7	BI	0	R	coming ashore in evening
V0574	1995	12	26	BI	0	P	
V0574	1996	3	12	BI	0	P	
V0574	1996	12	15	BI	0	P	
V0685	**1983**	**9**	**22**	**SCI**	**0**		
V0685	1985	10	24	SCI	0		
V0685	1986	10	21	SP	0		
V0685	1987	5	27	SP	0	E	incubating 1 egg (BEP)
V1105	**1984**	**10**	**7**	**SCI**	**0**		
V1105	1985	11	16	SCI	0		
V1105	1993	10	7	BI	0	P	
V1105	1994	11	21	BI	0	P	
V1105	1995	1	3	BI	0	P	
V1105	1996	8	27	BI	0	P	
V1105	1996	11	15	BI	0	P	
V1105	1999	3	30	BI	0	E	incubating 1+
V1860	**1986**	**11**	**29**	**II**	**0**		
V1860	1996	3	24	MYI	0	E	incubating
V1860	1996	9	30	MYI	0	N	
V3449	**1987**	**8**	**31**	**MYI**	**0**		
V3449	1995	9	30	DYI	0	C	with medium downy chick
V3871	**1983**	**7**	**4**	**MCI**	**0**		
V3871	1987	6	10	MCI	0	P	alive and well (BEP)
V3871	1995	10	31	DAS	0	L	on beach, area F
V3871	1997	10	25	DAS	0	L	on shore, area F
V3871	1998	4	30	DAS	0	L	with mate S23428 under whale bone, area F
V3871	1998	6	1	DAS	0	E	incubating 2 in whale bone, area F
V4201	**1984**	**7**	**17**	**DYI**	**0**		
V4201	1996	3	28	RI	0	C	with 2 medium downy chicks, Area R
V4538	**1984**	**7**	**20**	**DAS**	**0**		
V4538	1989	7	11	RI	0	P	alive and well
V4538	1993	6	30	RI	0	B	blood sampled for parasites
V4538	1993	7	21	RI	0	P	alive and well
V4538	1993	8	5	RI	0	P	alive and well
V4538	1994	3	23	RI	0	P	alive and well
V4538	1994	3	30	RI	0	P	alive and well
V4538	1995	4	26	RI	0	P	alive and well
V4538	1995	5	10	RI	0	E	incubating egg(s)
V4538	1995	5	29	RI	0	E	incubating egg(s)
V4538	1995	5	31	RI	0	L	loafing on beach
V4538	1995	6	28	RI	0	P	alive and well
V4538	1995	9	29	RI	0	S	at empty site, Area Q
V4538	1996	1	29	RI	0	P	alive and well
V4538	1997	1	27	RI	0	P	alive and well

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
V4538	1997	8	4	RI	0	R	area D
V4538	1998	12	24	RI	0	L	on beach, area D
V4538	1999	3	14	RI	0	L	on beach, area D
V4538	1999	6	24	RI	0	R	on shore, area D
V4657	**1984**	**7**	**23**	**DAS**	**0**		
V4657	1989	8	1	RI	0	P	alive and well
V4657	1989	9	14	RI	0	P	alive and well
V4657	1993	11	18	RI	0	P	alive and well
V4657	1995	5	29	RI	0	C	with 2 large downy chicks, area S
V4657	1995	8	24	RI	0	E	incubating 1 egg, area S
V4657	1996	3	28	RI	0	C	with 2 medium downy chicks, Area S
V4657	1997	8	4	RI	0	L	on beach, area D
V4657	1998	3	25	RI	0	C	with 2 large downy chicks, area S
V4657	1999	8	27	RI	0	R	area D
V4880	**1984**	**11**	**17**	**DYI**	**0**		
V4880	1995	6	26	DAS	0	E	incubating 2 in burrow, area A
V4880	1996	2	27	DAS	0	U	pre-moult loafing in colony, Area A
V6259	**1985**	**8**	**18**	**DAS**	**0**		
V6259	1989	4	11	RI	0	P	alive and well
V6259	1991	4	24	RI	0	P	alive and well
V6259	1994	3	30	RI	0	P	alive and well
V6259	1995	3	8	RI	0	P	alive and well
V6259	1995	5	29	RI	0	P	alive and well
V6259	1995	9	29	RI	0	M	moulting on beach, Area D
V6259	1995	10	12	RI	0	L	loafing under bush, Area Q
V6259	1996	3	27	RI	0	E	incubating 1 egg, Area D
V6259	1997	2	10	RI	0	L	on beach, area D
V6259	1997	7	30	RI	0	S	nest 104, area D
V6259	1997	8	13	RI	0	L	on beach, area D
V6259	1998	3	23	RI	0	L	under bush, area D
V6259	1998	6	10	RI	0	L	on beach, area D
V6259	1998	12	24	RI	0	L	on beach, area D
V6259	1999	3	14	RI	0	L	on beach, area D
V6259	1999	8	30	RI	0	L	near Nest 1, area Q
V6476	**1985**	**8**	**20**	**DAS**	**0**		
V6476	1993	11	17	RI	0	P	alive and well
V6476	1995	5	30	RI	0	E	incubating 2 eggs, area R
V6476	1996	3	28	RI	0	S	female with unbanded Male at empty site, Area W
V6476	1996	5	23	RI	0	C	with 2 medium downy chicks, Area W
V6476	1996	5	27	RI	0	L	on beach, Area D
V6782	**1985**	**11**	**8**	**DYI**	**0**		
V6782	1990	8	22	RI	0	P	alive and well
V6782	1991	7	17	RI	0	P	alive and well
V6782	1995	5	30	RI	0	L	loafing on beach
V6782	1995	5	31	RI	0	L	female loafing under bush, area Q
V6782	1995	5	31	RI	0	L	loafing on beach
V6782	1995	8	9	RI	0	C	with small chick(s), area Q
V6782	1995	8	17	RI	0	P	alive and well
V6782	1995	8	23	RI	0	C	with medium/large downy chick, Area Q
V6782	1995	10	13	RI	0	F	With feathered chick, Area Q
V6782	1996	5	22	RI	0	L	on beach, Area D
V6782	1996	5	27	RI	0	L	on beach, Area D
V6782	1996	10	16	RI	0	M	moulting, area Q
V6782	1997	7	4	RI	0	L	under bush, area Q
V6782	1997	7	30	RI	0	X	probably defending 2 feathered chicks, area Q
V6782	1998	6	19	RI	0	R	area D
V7311	**1986**	**7**	**9**	**MCI**	**0**		
V7311	1995	1	10	DAS	0	L	on beach, area G

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
V7311	1995	2	14	DAS	0	L	on beach, area G
V7311	1995	8	8	DAS	0	L	on beach, area G
V7311	1996	1	18	DAS	0	E	on fresh egg in burrow, Area G
V7311	1996	2	15	DAS	0	E	incubating 2 eggs in burrow, Area G
V7311	1996	3	14	DAS	0	L	with mate in burrow, area G
V7311	1996	4	6	DAS	0	E	incubating 2 in burrow, area G
V7311	1996	4	22	DAS	0	E	incubating 2 in burrow, area G
V7311	1996	5	7	DAS	0	C	with 2 downy chicks in burrow, area G
V7311	1996	5	20	DAS	0	C	with 1 downy chick in burrow, area G
V7311	1996	9	24	DAS	0	M	in burrow, area G
V7311	1996	9	29	DAS	0	M	on beach, area G. Near end of moult
V7311	1996	10	2	DAS	0	L	on beach, area G
V7311	1996	12	2	DAS	0	L	in burrow, area G
V7311	1996	12	5	DAS	0	X	intruder in burrow G838
V7311	1996	12	27	DAS	0	L	on beach, area G
V7311	1997	1	16	DAS	0	L	on beach, area G
V7311	1997	2	10	DAS	0	L	in burrow, area G
V7311	1997	5	4	DAS	0	L	with mate in burrow, area G
V7311	1997	6	3	DAS	0	E	incubating 2 in burrow, area G
V7311	1997	9	4	DAS	0	L	in burrow, area G
V7311	1997	12	27	DAS	0	L	in burrow, area G
V7311	1998	1	22	DAS	0	C	with 1 downy chick, 1 egg in burrow, area G
V7311	1998	3	7	DAS	0	L	in burrow, area G
V7311	1998	6	21	DAS	0	M	on beach, area G
V7311	1998	9	16	DAS	0	E	incubating 2 in burrow, area G
V7311	1998	10	13	DAS	0	E	incubating 2, one pipping, in burrow, area G
V7311	1998	11	8	DAS	0	L	on beach, area G
V7311	1998	11	25	DAS	0	E	incubating 2 in burrow, area G
V7311	1998	12	9	DAS	0	E	incubating 2 in burrow, area G
V7311	1998	12	24	DAS	0	E	incubating 2 in burrow, area G
V7311	1999	1	5	DAS	0	C	with 2 downy chicks in burrow, area G
V7311	1999	1	14	DAS	0	C	with 2 downy chicks in burrow, area G
V7311	1999	1	19	DAS	0	C	with 2 downy chicks in burrow, area G
V7311	1999	5	5	DAS	0	M	on beach, area G
V7444	**1986**	**7**	**11**	**MCI**	**0**		
V7444	1997	8	13	RI	0	C	with large downy chicks, area R
V7444	1998	3	23	RI	0	L	on beach, area D
V7444	1998	12	29	RI	0	L	on beach, area D
V7557	**1986**	**10**	**21**	**SP**	**0**		
V7557	1996	3	15	DYI	0	L	loafing just east of houses
V7557	1997	1	6	DYI	0	E	incubating one egg
V7557	1997	3	17	DYI	0	L	in colony
V7557	1997	10	18	DYI	0	X	possibly with 2 downy chicks, by houses
V7557	1998	2	21	DYI	0	L	in colony
V7557	1999	8	12	DYI	0	N	
V7557	1999	10	2	DYI	0	C	with 1 large downy chick on "house rock"
V7669	**1987**	**10**	**23**	**DYI**	**0**		
V7669	1997	10	16	SI	0	E	incubating 2
V7758	**1988**	**6**	**11**	**DYI**	**0**		
V7758	1994	12	18	DAS	0	L	on beach, area A
V7758	1996	2	13	DAS	0	L	on west shore, Area A
V7758	1996	11	28	DAS	0	L	on beach, area A
V7758	1997	10	4	DAS	0	L	under rock, area A
V7758	1998	9	26	DAS	0	F	with 1 feathered chick in burrow, area A
V7759	**1988**	**6**	**11**	**DYI**	**0**		
V7759	1999	6	10	DAS	0	E	incubating 2 in burrow, area A
V7854	**1988**	**6**	**12**	**JI**	**0**		
V7854	1994	3	2	BI	0	P	

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
V7854	1994	5	31	BI	0	P	
V7854	1995	11	6	BI	0	C	with large chick
V7854	1997	8	13	BI	0	P	
V7854	1997	12	9	BI	0	P	
Z1022	**1979**	**1**	**21**	**SCI**	**0**		
Z1022	1981	10	9	BI	0	L	
Z1022	1982	1	7	SCI	0	M	
Z1022	1982	9	9	BI	0	L	
Z1022	1984	3	19	BI	0	E	
Z1022	1987	4	3	BI	0	P	
Z1022	1991	3	11	BI	0	C	
Z1022	1993	12	20	BI	0	P	
Z1022	1994	3	24	BI	0	P	
Z1022	1994	8	13	BI	0	P	
Z1022	1995	2	8	BI	0	P	
Z1022	1995	8	28	BI	0	P	
Z1022	1995	10	18	BI	0	P	
Z1022	1996	1	15	BI	0	P	
Z1022	1996	2	1	BI	0	P	

APPENDIX 4.3

Re-sighting information of birds banded as adults that attempted to breed at more than one colony. The first line for each bird represents the ringing date (or release date for rehabilitated birds) and locality. See Appendix 4.1 for list of abbreviations.

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S20953	**1994**	**7**	**26**	**SS**	**1**		
S20953	1995	3	8	RI	1	P	alive and well
S20953	1995	5	31	RI	1	P	alive and well
S20953	1995	8	2	RI	1	F	with 2 fledged young
S20953	1995	8	24	RI	1	F	with 2 feathered chicks, Area T
S20953	1996	3	19	DAS	1	C	with 2 small chicks under rock, Area A
S20953	1996	4	25	RI	1	P	alive and well
S20953	1996	5	21	RI	1	L	loafing under tree, Area Q
S20953	1997	10	8	RI	1	R	on beach, area D
S20953	1998	3	26	RI	1	L	on beach, area D
S21565	**1994**	**7**	**26**	**SS**	**1**		
S21565	1995	3	16	DAS	1	E	incubating 2 in burrow, area G
S21565	1995	7	5	RI	1	L	loafing under trees
S21565	1995	8	10	RI	1	E	incubating 2 eggs, area J
S21661	**1994**	**7**	**26**	**SS**	**1**		
S21661	1995	5	30	RI	1	E	female incubating 1 egg, area R
S21661	1996	2	6	DAS	1	L	on west shore, Area A
S21661	1997	9	3	DAS	1	E	incubating 2 in burrow, area A
S21661	1998	2	5	DAS	1	E	incubating 2 in burrow, area A
S21661	1998	2	19	DAS	1	E	incubating 2 in burrow, area A
S21661	1998	3	7	DAS	1	E	incubating 2 in burrow, area A
S21661	1998	5	27	DAS	1	E	incubating 2 in burrow, area A
S21661	1998	8	26	DAS	1	L	in colony, area A
S21661	1998	9	18	DAS	1	L	on beach, area A
S21661	1999	2	18	DAS	1	C	with 1 downy chick, 1 egg in burrow, area A
S22044	**1994**	**7**	**26**	**SS**	**1**		
S22044	1995	3	11	DAS	1	C	with 2 in burrow, area B
S22044	1995	5	29	DAS	1	C	with 2 downy chicks in burrow, area G
S22044	1996	5	22	RI	1	L	on beach, Area D
S22044	1996	5	27	RI	1	L	on beach, Area D
S22044	1996	12	19	RI	1	L	with mate near Nest 92, area R
S22044	1997	1	10	DAS	1	L	on beach, area A
S22044	1997	2	14	RI	1	E	incubating 2, area R
S22044	1997	7	3	RI	1	C	with 2 downy chicks (BMD/LU)
S22044	1997	8	13	RI	1	L	area R
S22701	**1994**	**8**	**27**	**SS**	**1**		
S22701	1996	3	18	DAS	1	P	alive and well
S22701	1996	3	19	DAS	1	E	incubating 2 eggs under Tetragonia, Area A
S22701	1996	11	1	DAS	1	M	moulting under rock, Area A (west)
S22701	1999	2	23	JI	1	E	incubating 2, "Mt. Jutten"
S23106	**1994**	**7**	**26**	**SS**	**1**		
S23106	1995	10	17	DAS	1	L	on beach, area G
S23106	1995	12	6	DAS	1	E	incubating 2 in burrow, area G
S23106	2000	4	19	VI	1	C	with 2 small downy chicks
S23110	**1994**	**8**	**18**	**SS**	**1**		
S23110	1995	6	28	RI	1	B	blood sampled for parasites
S23110	1996	3	28	RI	1	E	with mate & 2 eggs, Area O
S23110	1997	2	13	RI	1	E	incubating 2, area O?
S23110	1998	6	11	DAS	1	E	incubating 2 in burrow, area G
S23110	1998	6	19	RI	1	R	area D
S23110	1998	9	19	RI	1	L	under shrub, area O
S23110	1999	3	12	RI	1	C	with 1 medium downy chick, area O

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S23110	1999	6	24	RI	1	R	on shore, area D
S23183	**1994**	**8**	**6**	**SS**	**1**		
S23183	1995	3	15	DAS	1	E	incubating 2 in burrow, area G
S23183	1997	3	21	VI	1	F	with 2 feathered chicks
S23183	2000	2	26	VI	1	E	incubating 2 eggs, mate present

CHAPTER FIVE

AGE AT FIRST BREEDING OF AFRICAN PENGUINS

5.1 INTRODUCTION

The reproductive potential of a species depends on several factors. These include the number of eggs laid (clutch size), number of broods raised per season, breeding frequency, annual survival, longevity and the age at which individuals begin to breed (Welty 1964). Knowledge of these parameters is important in the study of population dynamics. The age at which a species begins to breed may vary among individuals (Lack 1954) and may differ between males and females. This chapter is concerned with the age at which African Penguins begin to breed. Annual survival of adults and first year birds is discussed in Chapter Six. Previous estimates of age at first breeding in African Penguins were made by Randall (1983), at St Croix Island, and by Crawford *et al.* (1999) at Robben Island.

5.2 METHODS

Age at first breeding attempts for African Penguins were estimated from data held by the Avian Demography Unit, based on re-sightings of penguins that had been banded as chicks and were, therefore, of known age. Data were analysed from five African Penguin colonies: Bird Island, Algoa Bay in the Eastern Cape Province of South Africa, Robben and Dassen Islands in the Western Cape Province of South Africa and Ichaboe and Mercury Islands in Namibia. Most of the data from Bird Island were collected by staff of Port Elizabeth Museum and were available from 1992 until the end of May 2001. Additional sightings from annual census visits made between 1991 and 1999 were contributed by staff of Marine and Coastal Management and PAW. Sightings of banded penguins at Dassen Island, made by staff of the Western Cape Nature Conservation Board on an almost daily basis from August 1994 up to June 1999, were also incorporated into the database. Two areas of the island received intensive fieldwork during an investigation into the growth of chicks, while these areas and two further areas were part of a study where a sample of nesting burrows was checked for occupancy on a weekly basis. Staff of Marine and Coastal Management (MCM) collected additional information during annual counts of the

number of penguin nests on the island. Thorough searches of the penguin colony on Robben Island were made on a quarterly basis from 1995 to 1999. Re-sightings of African Penguins for the years 1990 to the end of June 2001 at Ichaboe Island and to February 2001 at Mercury Island, were received from staff of the Ministry of Fisheries and Marine Resources, Namibia. Re-sighting effort at these two colonies was fairly consistent throughout, with special efforts being made to record banded birds on a fortnightly basis, coupled with observations made on daily patrols of the islands (J. Kemper *in litt.*).

The number of African Penguins banded as chicks at each of the study colonies, between 1990 and 1995, varied considerably between years and between colonies (Table 5.1). The database was investigated for all records of birds banded as chicks in the above years at these colonies that were subsequently recorded at nests, incubating eggs or guarding chicks. The age of each bird on the first apparent occurrence of breeding was computed in days then divided by 365 to obtain the value in years. Trends were compared between different year cohorts for each colony and between different colonies. Mean and median ages of first breeding were computed for each year at each colony. No attempt was made to monitor the success or failure of breeding attempts. One-way ANOVA tests were performed on data for the five colonies; comparisons between means of the age of first recorded breeding were made between colonies and between years for each colony. Data from Robben and Dassen Islands and from Ichaboe and Mercury Islands were pooled to compare means between representatives of the three regions (Eastern Cape, Western Cape and Namibia). Data for birds that had been restored to the breeding population after being oiled were compared with those for non-rehabilitated birds.

An attempt was made to estimate the monitoring effort at each colony by plotting the number of days in each year when observations were made, along with the total number of re-sightings made in that year. This assessment of monitoring effort was restricted to re-sightings of birds banded as chicks in the years covered by the analysis. The number of observation days alone could result in a large number of days when relatively few birds were re-sighted inflating the monitoring effort. However, by considering re-sightings alone the same effect could result from a few days of monitoring on which many re-sightings were being made.

5.3 RESULTS

The numbers of birds banded as chicks that were subsequently recorded breeding from each of the year cohorts, varied between two and 83 (Table 5.2). Only one chick was banded at Bird Island in 1993 but it had not been recorded breeding by the end of May 2001 (Table 5.2). Estimates of between 2.07 and 10.20 years were obtained for age at first breeding at the five colonies. Mean age at first breeding varied from 3.82 to 7.73 years (Table 5.3) and median age at first breeding from 3.82 to 7.88 years (Table 5.4). If sample sizes of less than ten birds are excluded, the range of mean values is 4.59 to 7.73 years and of median values is 4.21 to 7.88 years (Tables 5.3 and 5.4).

The frequency distributions of recorded age at first breeding of African Penguins that were banded as chicks at Bird Island were different for all three cohorts (Figure 5.1). Most of those banded in 1992 were not recorded breeding until five years of age or older. All but one of those banded in 1994 were over four years old when first found breeding, most being in their fifth year. The maximum possible age at first breeding for birds banded in 1995 was six years; 47% were in their sixth year when first found breeding and all but one of the remaining birds were in their fourth or fifth year of life.

The frequency distributions of birds banded as chicks at Robben Island in the years 1990 to 1993 were uniform. In all years, the majority of first breeding attempts were detected between the fourth and sixth year after banding. For all cohorts other than that of 1992, most of the first breeding attempts were recorded at the age of four years (Figure 5.2). The frequency distributions of birds banded as chicks at Dassen Island were similar to those of birds banded at Robben Island (Figures 5.2 and 5.3). As with Robben Island, the majority of birds banded in the years 1990 to 1993 were first detected breeding in their fourth, fifth or sixth year of life.

For Ichaboe Island in Namibia, frequency distributions for birds banded in the years 1990 to 1995 were similar (Figure 5.4). With the exception of birds banded in 1993, most were first recorded breeding in their fifth or sixth years of life. Most of those banded in 1993 were not detected breeding until their sixth or seventh year.

Frequency distributions of age at first recorded breeding seemed to show most variation at Mercury Island (Figure 5.5). Diagrams were only plotted for the three years where more than ten birds were subsequently recorded breeding (Table 5.2, Figure 5.5). The distribution for 1990 differs markedly from that of other colonies in that most birds were not recorded breeding until their eighth year, and none were recorded doing so before their sixth year. Sixteen (29%) of those banded in 1992 were first recorded breeding in their sixth year, while 17 (31%) were not recorded breeding until they were over seven years old. Most of those banded in 1993 at Mercury Island were in their seventh year when first discovered breeding (Figure 5.5c).

Frequency distributions for all years combined were similar for four of the five colonies, showing a peak in first recorded breeding for birds in their fifth and sixth years (Figures 5.1d, 5.2e, 5.3e and 5.4g). Mercury Island showed a slight departure from this pattern, with more birds making their first breeding attempt in their seventh and eighth years than in their fifth (Figure 5.5d).

Mean and median ages of first recorded breeding at the two Western Cape islands (Robben and Dassen) were similar to each other for all cohorts from 1990 to 1993 (Tables 5.3 and 5.4). Values for the 1990 cohorts from the Namibian islands differed, Ichaboe Island recording a mean of 5.8 years old and Mercury Island one of 7.8 years old (Table 5.3). For the 1992 cohort, mean and median ages of first recorded breeding for birds banded at the two Namibian colonies and at Bird Island, were higher than for the two Western Cape colonies. Bird Island, Algoa Bay recorded the highest median age of first recorded breeding for that cohort. Values for the 1993 cohort were higher at the two Namibian colonies than at those in the Western Cape. Only Bird and Ichaboe Islands had sample sizes of over ten birds that were re-sighted breeding for the 1994 and 1995 cohorts (Table 5.2). Bird and Mercury Islands had the highest mean and median ages of first recorded breeding for birds banded in 1994, Robben Island having the lowest. Birds banded in 1995 at Bird and Ichaboe Islands had similar mean and median values.

With the exception of Mercury Island, overall mean ages at first recorded breeding for all cohorts combined were similar at the different colonies (Table 5.3). Mean age of first recorded breeding at the other four colonies differed by a maximum of 0.5 years.

The mean ages of first recorded breeding were five years old for Bird, Robben and Ichaboe Islands. That for Dassen Island was marginally under five and the mean for Mercury Island was over six years old (Table 5.3). If cohorts for which less than ten birds were subsequently found breeding were excluded, then all colonies except for Mercury Island recorded a mean age of first recorded breeding of five years. The median age of first recorded breeding showed a similar pattern (Table 5.4). It was found to be four years old for Robben and Dassen Islands, five years old for Bird and Ichaboe Islands and six years old for Mercury Island. Exclusion of the years where less than ten birds were subsequently found breeding made little difference to the overall result.

Only seven penguins that had been banded as chicks and then subsequently oiled and rehabilitated were found breeding (Tables 5.2 and 5.5). They comprised one bird from Bird Island, four birds from Robben Island and two from Dassen Island. Their first recorded ages of breeding ranged from 3.8 to 6.1 years old (Figure 5.6). The mean age of first recorded breeding for these seven birds was 4.9 years (Table 5.3) and the median was 4.7 years (Table 5.4).

If all years of data were combined for each colony, the mean ages of first recorded breeding were not found to differ significantly for Bird, Robben and Dassen Islands (Table 5.6). Mean ages of first recorded breeding for Ichaboe and Mercury Islands were statistically significantly different from the other three colonies and from each other (Tables 5.6 and 5.7). Using data for birds banded in 1992, which was the only banding year for which reasonable numbers of birds from all five colonies were recorded breeding, the mean ages of first recorded breeding were found to differ for all five colonies (Tables 5.6). Excluding data from Bird Island, which showed the largest variance, made little difference to the result (Table 5.8).

Differences between mean ages of first recorded breeding for different cohorts were investigated for each colony. For both Robben and Dassen Islands, the mean ages of first recorded breeding for the 1992 to 1994 cohorts did not differ significantly (Tables 5.9 and 5.10). The same was true for Ichaboe Island for the 1990 to 1994 cohorts (Table 5.11). ANOVA tests on all cohort pairings for both Bird Island and

Mercury Island showed highly significant differences between the means of age at first recorded breeding ($P < 0.01$ in all cases).

There were some regional differences between mean ages of first recorded breeding. Means of data from Bird Island and the two Western Cape islands combined did not differ significantly from each other, but were statistically significantly different from the combined data from the two Namibian islands (Table 5.6). Mean age at first recorded breeding of the rehabilitated birds did not differ significantly from that recorded at Bird, Robben and Dassen Islands, using data for all years combined (Table 5.12). All of the rehabilitated birds that were recorded breeding had been banded at one of these three colonies.

Re-sighting effort of banded African Penguins at Bird Island, Algoa Bay, intensified from about 1995 (N.T.W. Klages pers. comm.). Monitoring effort at this colony, in terms of the number of days when re-sightings were made and of the total number of re-sightings made per year, was high in 1994, 1995 and 1999 (Figure 5.7a). At Robben and Dassen Islands, monitoring effort became more regular and intensified from 1994 onwards (Figures 5.7b and c). The few re-sightings received from Dassen Island prior to 1994 were not computerised. Re-sighting effort from the Namibian islands was complicated by the fact that data were missing for certain periods. Only six months of data were available for the years 1995, 1996, 1997 and 1998 from Ichaboe Island and for 1994, 1995, 1997 and 1998 from Mercury Island. However, proportions of birds banded as chicks that were subsequently found breeding on these islands tended to be similar to the other three colonies (Table 5.13). At Ichaboe Island, there were peaks in re-sighting effort in 1991 and 1993 (Figure 5.7d). Re-sighting effort at Mercury Island peaked in 1992 and 1996 (Figure 5.7e).

5.4 DISCUSSION

The age at which African Penguins first bred varied between individuals. The youngest birds attempted breeding when two years old. Most were not recorded breeding until they were over three years old and one was not detected breeding until its eleventh year. Monitoring effort was not uniform between colonies and was more intense in some years than others. Also, breeding penguins are not equally visible at

the different colonies. It is probably hardest to find those breeding at Dassen Island, where most nest in burrows, and at Robben Island, where they are obscured by thick bush. This probably led to an overestimate of age of first breeding in some instances due to earlier breeding attempts being unobserved. At all five colonies the mean apparent age of first recorded breeding varied between cohorts. This variation may be due to differences in monitoring effort. Birds banded in the earliest years of the study returned the highest mean and median ages of first recorded breeding. This is to be expected, given that the maximum age at which a bird can be detected breeding for the first time decreases by a year with each cohort. However, it is also likely that monitoring intensity played a part in producing this distribution of first recorded breeding attempts.

Given the relatively high observer effort at Bird Island, Algoa Bay in 1994 and 1995, it might be expected that birds that were banded in 1992 would have been detected if they had attempted breeding before the end of their third year. The peak of first breeding records of 1992 birds in their seventh year and of 1994 birds in their fifth year can be explained by the large number of re-sightings made in 1999 (Figures 5.1a,b, figure 5.7 a). Another explanation for the late detection of breeding by birds banded in 1992 may be the relatively small sample size of birds banded as chicks in that year. The number banded in 1992 was only 13% of the total banded in 1994 and 11% of that banded in 1995 (Table 5.1). It may, therefore, have been more difficult to locate the relatively small number of birds from the 1992 cohort that returned to breed, even though the proportion found breeding was by far the highest for any cohort at any colony (Table 5.13). The re-sighting effort at Robben and Dassen Islands during this study suggests that if birds banded in 1990 and 1991 had attempted to breed before their fourth and third year respectively, i.e. prior to 1994, their first breeding attempts would probably have been missed. This may have led to an overestimate of age of first breeding for those cohorts and could explain why the means for those cohorts were found to differ significantly from those of the cohorts from 1992 to 1994. Crawford *et al.* (1999) found the youngest of 66 breeding birds, which had been banded as chicks at Robben Island, was one year and eight months old when it first attempted to breed. However, the nest was abandoned within two weeks of its discovery and no further breeding attempts were made by the bird that year. By the age of six, 80% of all known-age birds were breeding, most (36%)

making their first breeding attempt in their fifth year of life (Crawford *et al.* 1999). In this study, 82% of known-age birds were breeding by the age of six and 32% made their first breeding attempt in their fifth year of life.

The relatively high re-sighting rate at Ichaboe Island in 1993 suggests that any birds banded in 1990, which may have attempted breeding in their third year, should have been detected. Many of the birds banded in 1992 were first recorded breeding in 1997, which was not reflected by a particularly high monitoring effort (Figure 5.7d). In addition, only six months of data were available for that year. The peaks in ages of first recorded breeding for birds banded in 1990, 1992 and 1993 were not reflected by the high re-sighting rate at Mercury Island in 1996.

ANOVA tests suggested that mean age at first recorded breeding did not differ significantly for birds banded at Bird Island when compared to Robben and Dassen Islands in the Western Cape. However, mean ages of first recorded breeding of birds banded at the Namibian colonies (5.5 years for Ichaboe Island, 6.2 years for Mercury Island) differed significantly from those of birds banded at Bird Island, Algoa Bay (5.2 years) and at the two Western Cape islands (5.0 years for both Robben and Dassen Islands). This may be due to differences in monitoring intensity between these regions. Re-sighting effort was probably highest at Robben Island, Dassen Island and Bird Island. However, this suggestion is not fully supported by higher proportions of banded birds discovered breeding at these three colonies (Table 5.13). It is, of course, possible that there is a genuine tendency for age at first breeding to vary between regions and between years. This may reflect variations in the energy cost of reproduction and available food resources, which may influence when birds are able to breed for the first time. For example, it appears, from the data presented, that most of the 1992 cohort from Bird Island did not settle to breed until five or six years of age (Figure 5.1a).

The overall mean and median ages at first recorded breeding were similar for all colonies with the exception of Mercury Island (Tables 5.3 and 5.4), suggesting that, on average, African Penguins attempt breeding for the first time in their fifth or sixth year. These results are similar to those obtained by Crawford *et al.* (1999) at Robben Island and Randall (1983) at St Croix Island, Algoa Bay. Randall (1983), working at

St Croix Island, Algoa Bay, recorded nine African Penguins breeding that had been previously banded as fledglings on the island. The youngest was aged three years and ten months while the others laid their first clutches in their fourth, fifth and sixth years of life. All lost their first clutches with the exception of the youngest bird, which raised a chick to fledging age (Randall 1983). Five birds, banded as chicks at Stony Point, Betty's Bay between 1984 and 1991, were subsequently recorded breeding (J.H. Hofmeyr unpublished data). The youngest was in its third year, one in its fourth year, two in their fifth year and one in its sixth year. Only the oldest bird was known to have successfully raised a chick. Ages of chicks recorded breeding at The Boulders ranged from three years six months to seven years and two months. All were banded as chicks at other penguin colonies but subsequently settled to breed at The Boulders (Crawford *et al.* 2000b, Table 3.2).

At Mercury Island, mean age at first recorded breeding was found to be a year later than at the other four colonies. There is no obvious explanation for this difference because re-sighting effort, while perhaps not as intense as at Bird Island and at the Western Cape colonies, was similar to that at Ichaboe Island (J. Kemper *in litt.*). Age at first recorded breeding of penguins that had been oiled and then treated at the Southern African Foundation for Conservation of Coastal Birds (SANCCOB), did not differ significantly from that of birds which had not been oiled. This suggests that oiling, and subsequent treatment prior to release, did not offset the birds' first attempts to breed. However, it should be noted that the sample size of rehabilitated birds was small, only seven.

Average life expectancy at fledging of breeding African Penguins has been estimated to be 10–11 years (Crawford 1998b), although birds up to 27 years old have been recorded in the wild (Whittington *et al.* 2000b). If African Penguins do not usually breed until they are five years old, their average breeding lifespan is approximately 5–6 years. Mean numbers of chicks fledged per pair per year were estimated to be 0.38 at St Croix Island (Randall 1983), 0.47 at Robben Island (Crawford *et al.* 1999), 0.61 at The Boulders in 1998 (Crawford *et al.* 2000b) and 0.63 at Marcus Island, Saldanha Bay (La Cock *et al.* 1987). These estimates suggest that, on average, a pair of African Penguins may successfully fledge between a minimum of 0.38 x 5.5 = 2 and a maximum of 0.63 x 5.5 = 3.5 chicks in their lifetime. Given that between 9% and 35% of chicks may survive to breeding age (Table 7.7), the lifetime output for a pair

of African Penguins may be between 2 x 0.09 = 0.18 and 3.5 x 0.35 = 1.2 chicks, which survive to breeding age. If this is indeed the case, then clearly there are insufficient young being produced to replace the adults lost to mortality. This has important implications for the future conservation of the African Penguin.

TABLE 5.1

Numbers of African Penguins banded as chicks at each of five breeding colonies between the years 1989 and 1995. Numbers of birds that were later oiled, cleaned and released are included within parentheses. Penguins at Bird Island were banded by staff of Port Elizabeth Museum, those at Robben and Dassen Islands by staff of Marine and Coastal Management (MCM) and those in Namibia by staff of the Ministry of Fisheries and Marine Resources, Namibia and by staff of MCM.

		Breeding colony				
		Bird Island	Robben Island	Dassen Island	Ichaboe Island	Mercury Island
Year	1990	0	464 (1)	449 (6)	370 (2)	290
	1991	0	508 (1)	963 (7)	693	41
	1992	66	660 (5)	1062 (3)	411	785
	1993	1	394 (2)	510	537 (1)	422
	1994	495	53	399	112	111
	1995	574 (2)	0	0	211	36
	Total	1136	2079	3383	2551	1927

TABLE 5.2

Numbers of African Penguins, banded as chicks at five breeding colonies between the years 1989 and 1995, that were subsequently recorded breeding. Numbers of birds that were oiled, cleaned and released are included within parentheses.

		Breeding colony				
		Bird Island	Robben Island	Dassen Island	Ichaboe Island	Mercury Island
Year banded	1990	-	21	34	21	27
	1991	-	37 (1)	63 (1)	41	2
	1992	14	59 (2)	83 (1)	25	55
	1993	0	26 (1)	26	16	32
	1994	36	2	5	12	6
	1995	53 (1)	-	-	21	2
	Total	103	145	211	136	124

TABLE 5.3

Mean age at first recorded breeding (in years) for African Penguins banded as chicks at five breeding colonies. Values marked with an asterisk are based on less than ten re-sightings. These are excluded from means in parentheses.

		Breeding colony					
		Bird Island	Robben Island	Dassen Island	Ichaboe Island	Mercury Island	Rehabilitees
Year banded	1990	-	5.77	5.68	5.76	7.73	-
	1991	-	5.12	5.16	5.85	7.73*	4.26*
	1992	6.03	4.79	4.63	5.57	6.22	4.97*
	1993	-	4.90	4.73	5.56	5.16	5.64*
	1994	5.48	3.82*	4.40*	4.59	5.23*	-
	1995	4.82	-	-	4.80	3.84*	5.20*
	All years	5.21	5.02 (5.15)	4.97 (5.05)	5.48	6.21 (6.28)	4.89*

TABLE 5.4

Median age at first recorded breeding in years for African Penguins banded as chicks at five breeding colonies. Values marked with an asterisk are based on less than ten re-sightings. These are excluded from totals in parentheses.

		Breeding colony					
		Bird Island	Robben Island	Dassen Island	Ichaboe Island	Mercury Island	Rehabilitees
Year banded	1990	-	5.39	5.39	5.70	7.88	-
	1991	-	4.74	4.85	5.43	7.73*	4.26*
	1992	6.42	4.93	4.21	5.44	5.95	4.62*
	1993	-	4.83	4.82	5.44	5.26	5.64*
	1994	5.10	3.82*	4.40*	4.71	5.30*	-
	1995	4.82	-	-	4.73	3.84*	5.20*
	All years	5.18	4.85 (4.87)	4.78 (4.79)	5.24	6.23 (6.33)	4.74*

TABLE 5.5

Sample sizes, means, standard deviations and variances for all years of data combined for each colony and for rehabilitated birds

	Bird Island	Robben Island	Dassen Island	Ichaboe Island	Mercury Island	Rehabilitees
Sample size (n)	103	145	211	136	124	7
Mean ( )	5.21	5.02	4.97	5.48	6.21	4.89
Standard deviation (s)	1.18	1.18	1.15	1.27	1.62	0.83
Variance (s^2)	1.40	1.39	1.33	1.61	2.62	0.69

TABLE 5.6

Tests for homogeneity of variance of mean ages of first recorded breeding of African Penguins banded at five breeding colonies.

	"F" value	"P" value
Bird, Robben, Dassen, Ichaboe and Mercury Islands, all years combined.	1.98	<0.01
Bird, Robben and Dassen Islands, all years combined.	1.59	0.20
Robben and Dassen Islands, all years combined.	0.19	0.66
Ichaboe and Mercury Islands, all years combined.	16.66	<0.01
Bird, Robben, Dassen, Ichaboe and Mercury Islands, birds banded in 1992.	2.60	<0.01
Bird Island, Namibian islands combined, Western Cape islands combined.	1.64	<0.01
Bird Island, Western Cape islands combined.	3.00	0.08

TABLE 5.7

ANOVA test on data for Bird, Robben, Dassen and Ichaboe Islands, combining data from all years for each colony.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	24.6325	3	8.210838	5.786716	0.000666	3.814904
Within Groups	838.5768	591	1.418912			
Total	863.2093	594				

TABLE 5.8

ANOVA test on data for Robben, Dassen, Ichaboe and Mercury Islands for ages of first recorded breeding of birds banded as chicks in 1992.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	96.7346	3	32.24487	24.57472	9.76E-14	3.872685
Within Groups	286.0412	218	1.31212			
Total	382.7758	221				

TABLE 5.9

ANOVA test on age at first recorded breeding for the years 1992–1994 for Robben Island

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.17531	2	1.087653	0.964327	0.385419	4.867161
Within Groups	94.74258	84	1.127888			
Total	96.91789	86				

TABLE 5.10

ANOVA test on age at first recorded breeding for the years 1992–1994 for Dassen Island

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.5127	2	0.256348	0.246305	0.78211	3.078057
Within Groups	115.5261	111	1.040776			
Total	116.0388	113				

TABLE 5.11

ANOVA test on age at first recorded breeding for the years 1990–1994 for Ichaboe Island

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	15.3261	4	3.831513	2.261755	0.067048	3.494563
Within Groups	186.3448	110	1.694044			
Total	201.6709	114				

TABLE 5.12

ANOVA test on age at first recorded breeding, for all years combined, on data from Bird, Robben and Dassen Islands and birds that had been oiled, cleaned and released.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.4792	3	1.493051	1.103728	0.347234	3.824255
Within Groups	624.9636	462	1.352735			
Total	629.4428	465				

TABLE 5.13

Proportions (%) of birds banded as chicks that were subsequently discovered breeding at each of five colonies.

		Breeding colony				
		Bird Island	Robben Island	Dassen Island	Ichaboe Island	Mercury Island
Year	1990	-	5	8	6	9
	1991	-	7	7	6	5
	1992	21	9	8	6	7
	1993	0	7	5	3	8
	1994	7	4	1	11	5
	1995	9	-	-	10	6
	Total	9	7	6	5	6

Figure 5.1 Age at first recorded breeding for birds banded as chicks at Bird Island, Algoa Bay in a) 1992, b) 1994, c) 1995 and d) all years combined.

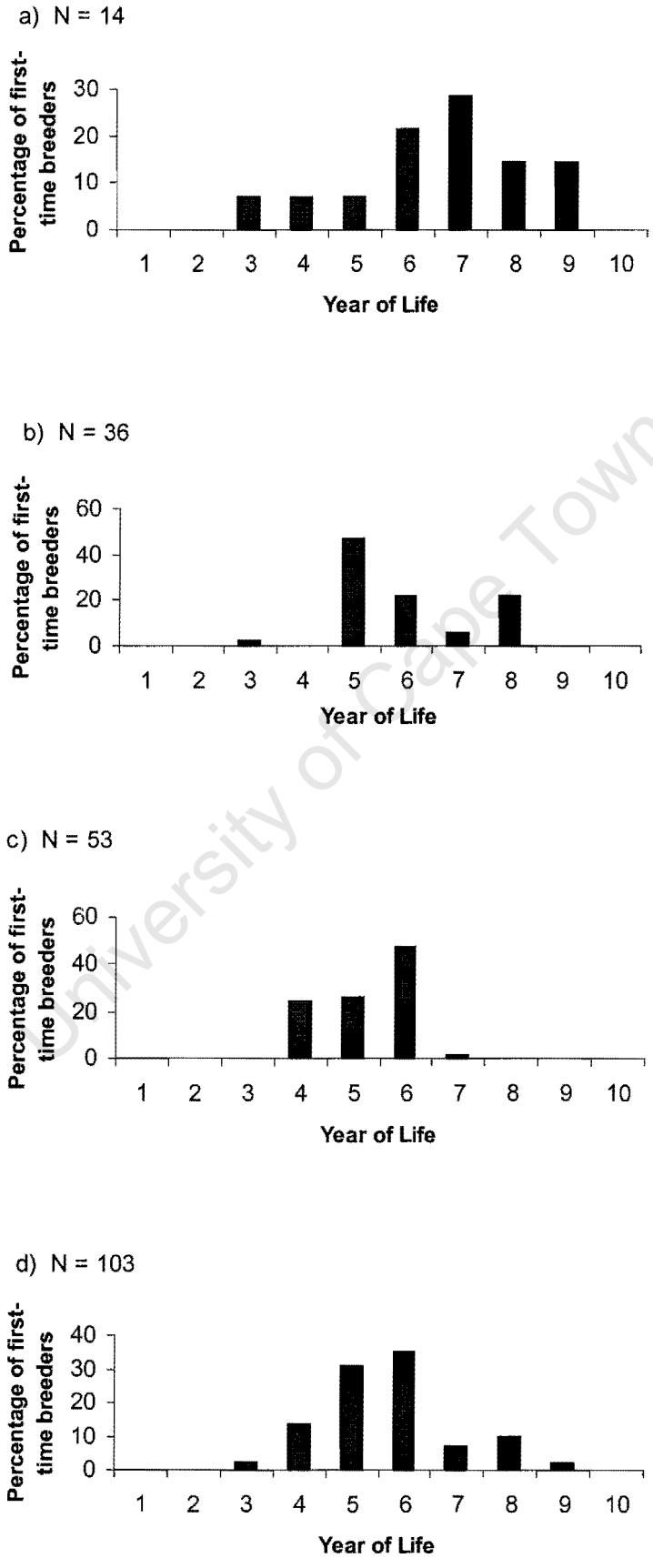


Figure 5.2 Age at first recorded breeding for birds banded as chicks at Robben Island in a) 1990, b) 1991, c) 1992, d) 1993 and e) all years combined.

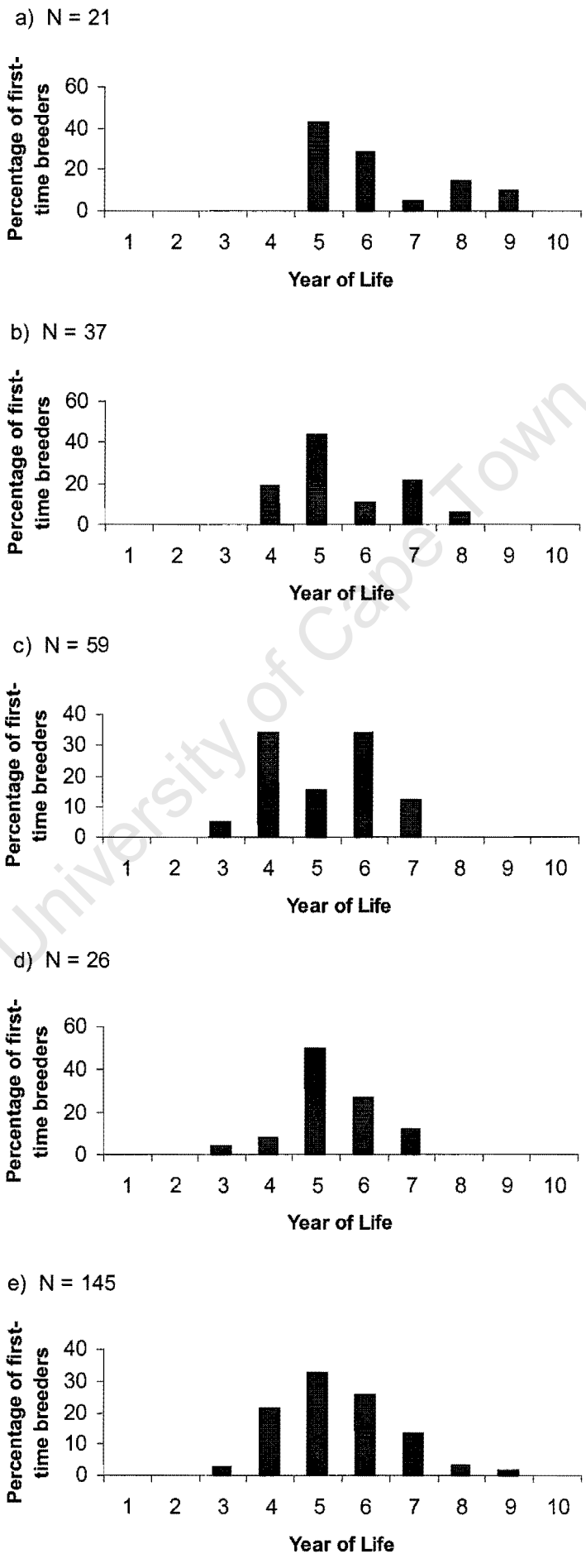


Figure 5.3 Age at first recorded breeding for birds banded as chicks at Dassen Island in a) 1990, b) 1991, c) 1992, d) 1993 and e) all years combined.

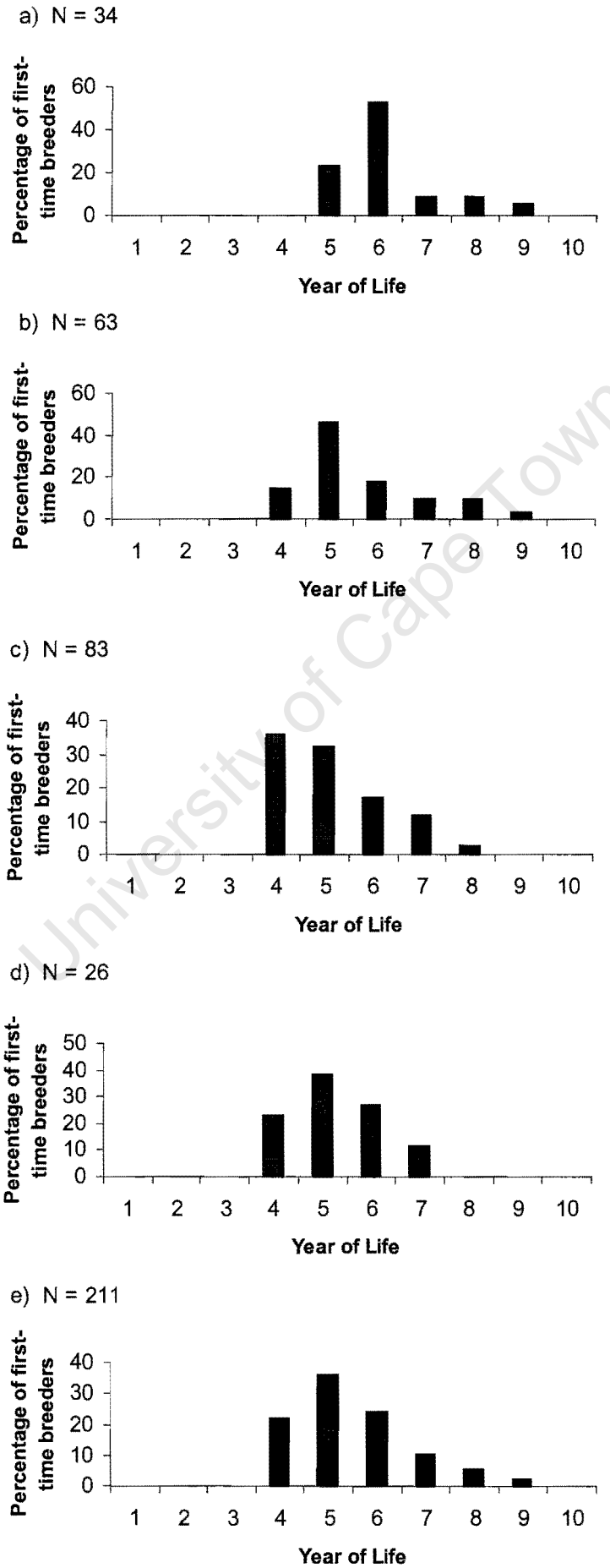
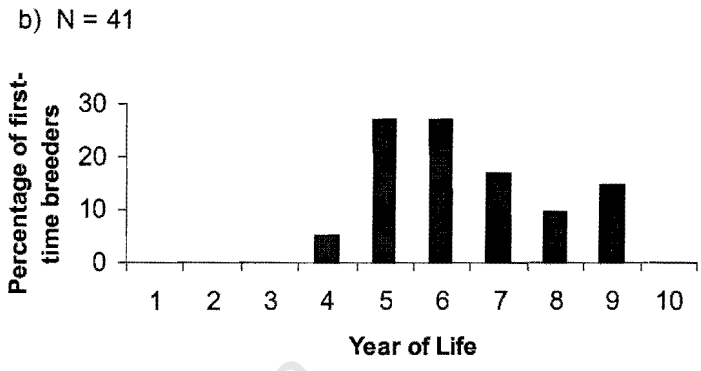
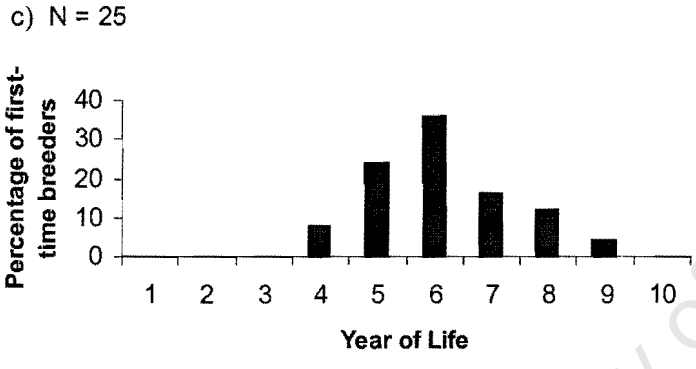
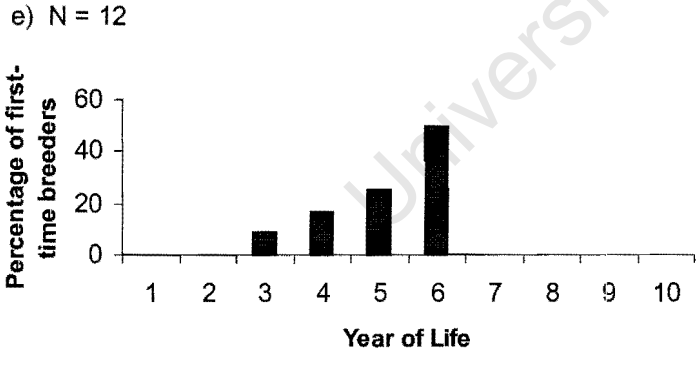
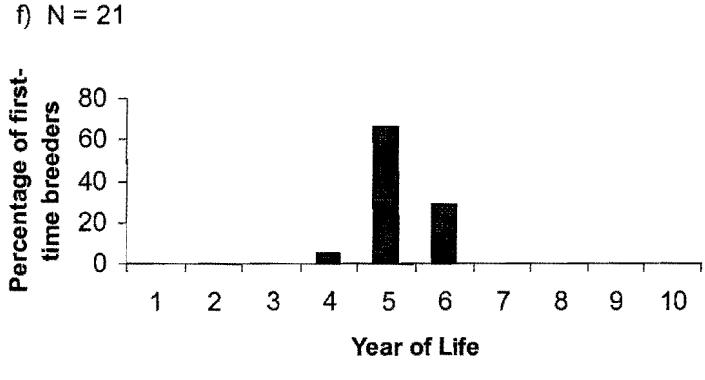


Figure 5.4 Age at first recorded breeding for birds banded as chicks at Ichaboe Island in a) 1990, b) 1991, c) 1992, d) 1993, e) 1994, f) 1995 and g) all years combined.









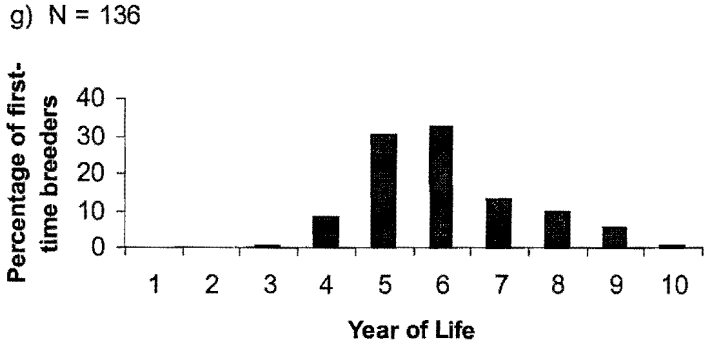


Figure 5.5 Age at first recorded breeding for birds banded as chicks at Mercury Island in a) 1990, b) 1992, c) 1993 and d) all years combined.

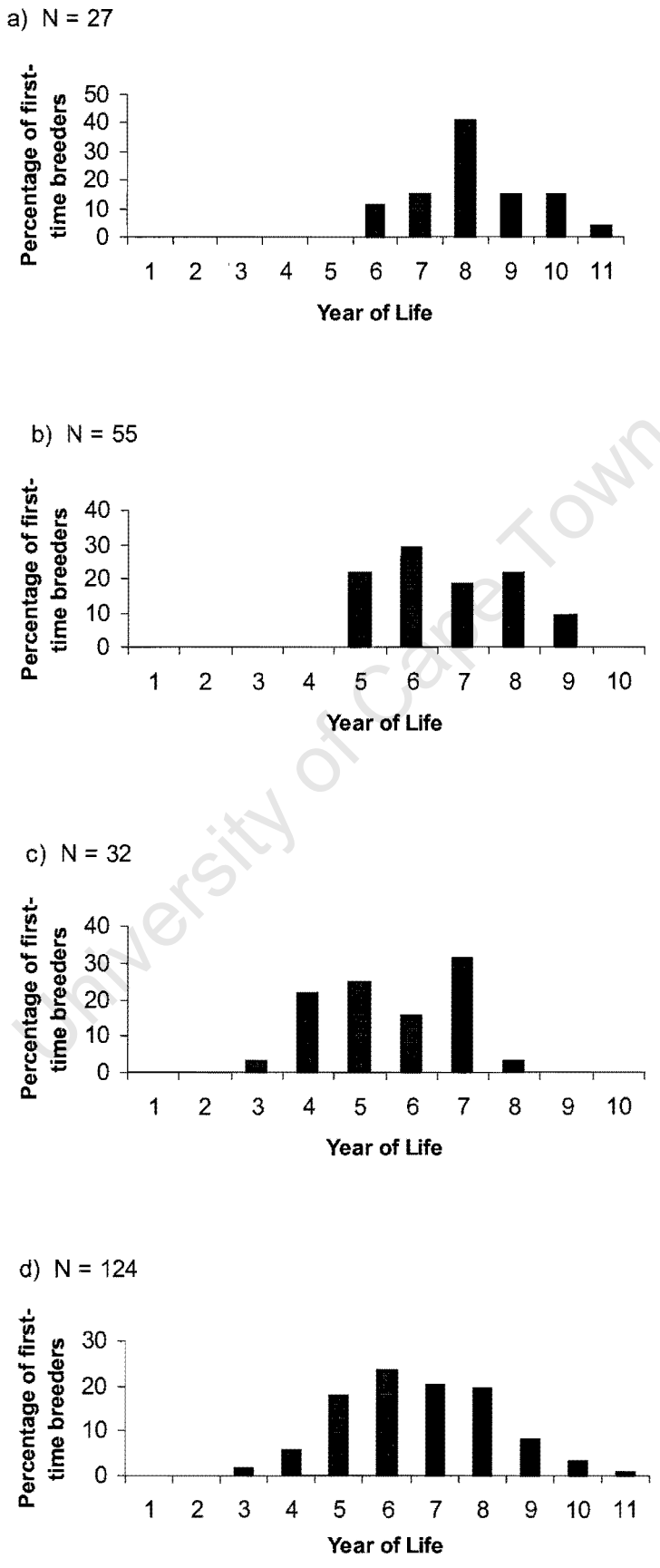
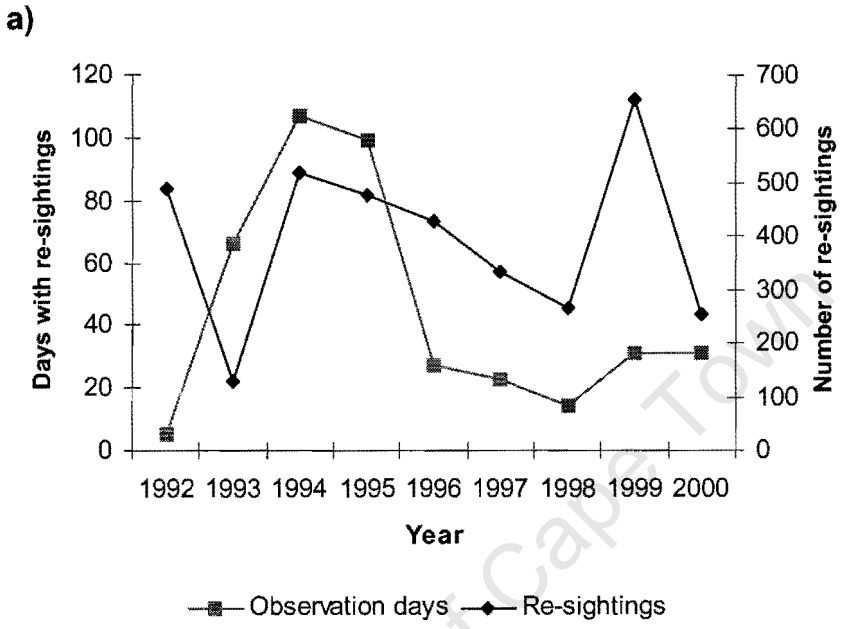
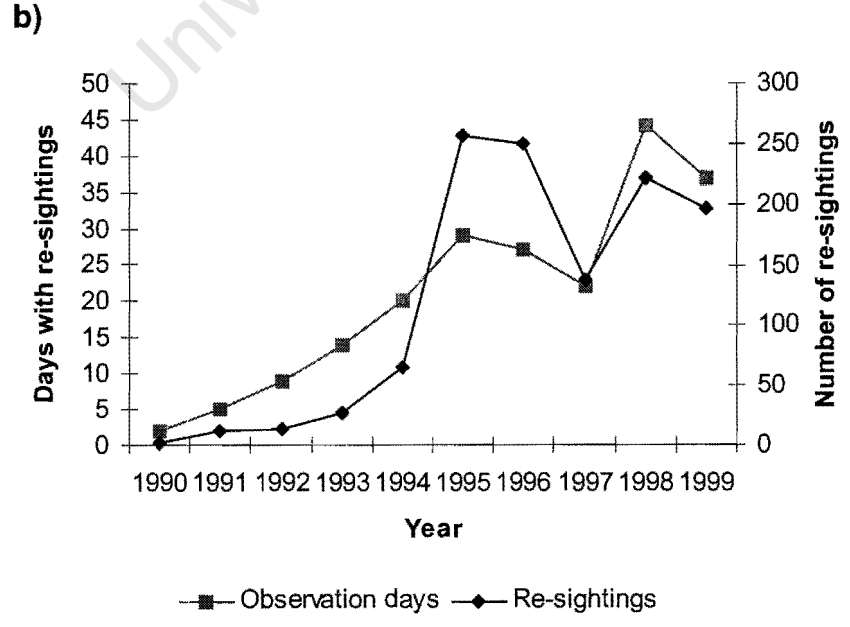


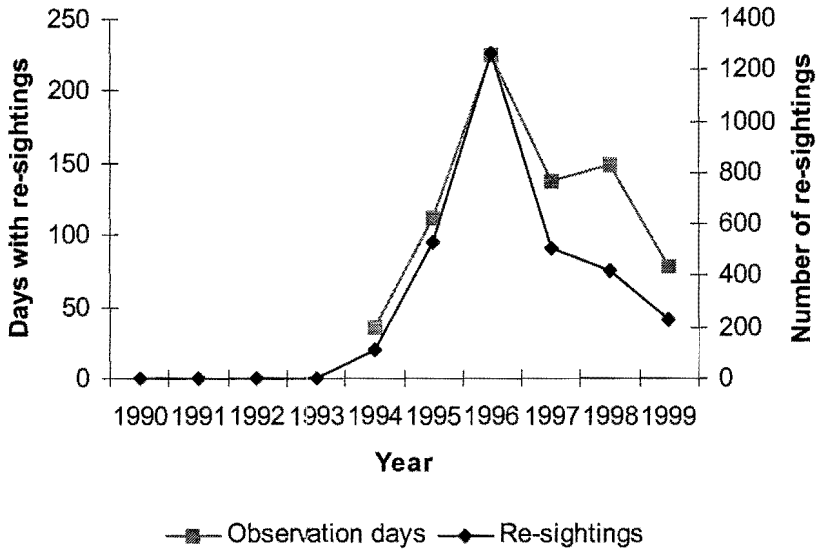
Figure 5.6 Age at first recorded breeding for birds banded as chicks and later oiled, cleaned and released. All years and colonies are combined.

Figure 5.7 Numbers of days when re-sightings were made (Observation days) and total number of re-sightings made (Re-sightings) in each year at a) Bird Island, b) Robben Island, c) Dassen Island, d) Ichaboe Island and e) Mercury Island.

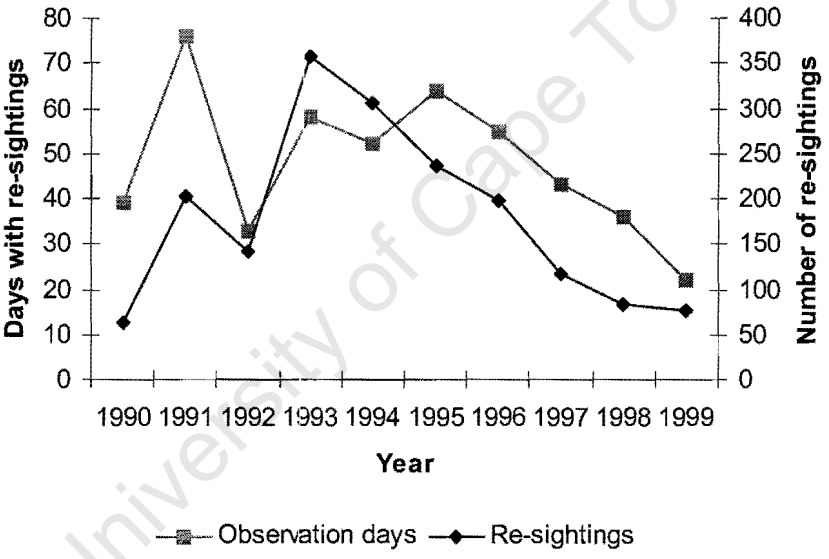




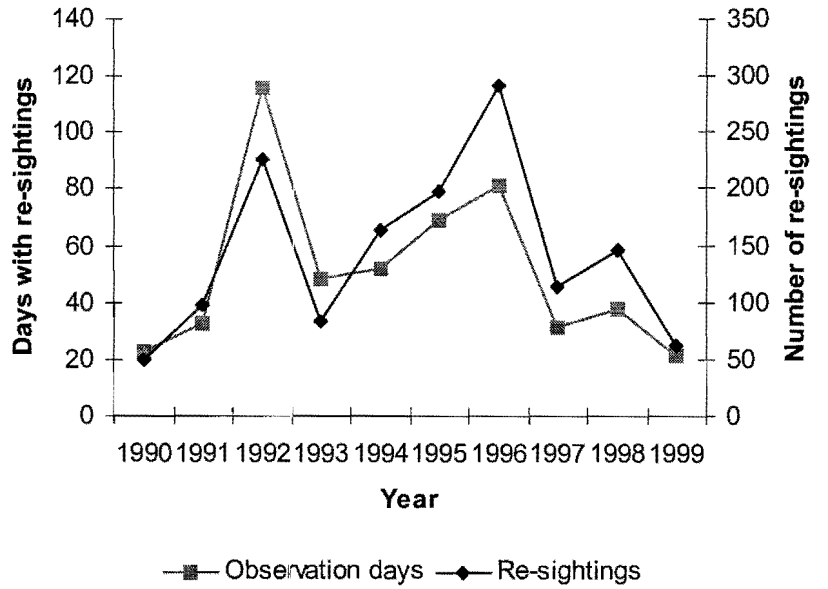
c)



d)



e)



CHAPTER SIX

ESTIMATES OF SURVIVAL OF AFRICAN PENGUINS

6.1 INTRODUCTION

Conservation measures and management plans rely on a basis of sound scientific information. An understanding of the basic parameters that impact on populations is useful in this context. Important parameters in population dynamics include how long individuals live for, what proportion of a population may be expected to survive over time and how many are likely to die. For a population to be self-sustaining, the survival of individuals over time plus the new recruits to the population must be equal to or exceed the numbers lost to mortality. If survival and recruitment are consistently greater than mortality, the population will grow. If mortality is consistently greater than survival and recruitment the population will decline. It is natural to think in terms of survival as being survival between breeding attempts, and it is therefore best quantified as annual survival. The survival parameter can be expressed as a survival rate denoted as S or φ. Survival and mortality rates are normally expressed as a number between 0 and 1, the latter representing survival of all individuals, or as a percentage. Subtracting the survival rate from 1 gives the proportion of the population that died, i.e. the mortality rate, which is expressed as 1-S or 1-φ.

These parameters are unlikely to be constant between years but vary due to environmental circumstances. They may be affected by short-term events, such as El Niño, and by more long-term consequences, e.g. global warming, increased competition for food resources, direct harvesting and changes in habitat quality. They may also vary with relation to the size of the population, in which case they are said to be density-dependent. For instance, a large population of birds in a certain area may exhibit a lower annual survival rate amongst individuals than a smaller population occupying the same area. The degree of energy investment in reproductive efforts may also affect the survival parameter (Boyce & Perrins 1987).

It is a common phenomenon in the natural world that survival rates of adult organisms are relatively high and those of youngsters, particularly those in their first year or phase of life, much lower (Lack 1954). Birds may maintain stable populations by

producing large numbers of young, thus increasing the likelihood that one at least will survive to adulthood. Most seabirds have relatively low reproductive rates but adults usually have high survival rates and are long-lived, thus able to produce many young in their lifetime (Ashmole 1971). For instance, the Wandering Albatross *Diomedea exulans* does not begin to breed until 9–11 years of age (Carrick & Ingham 1967). It may only produce one offspring every other year (Del Hoyo *et al.* 1992) but breeding adults have an annual survival rate of 96% (Tickell 1968) and have an average life span of 30–40 years, although some may live to be 80 years of age (Del Hoyo *et al.* 1992).

African Penguins produce a maximum of two chicks per brood and a pair will generally fledge between 0.38 and 0.63 chicks per year (Randall 1983, La Cock *et al.* 1987, Crawford *et al.* 1999, 2000b). Average life expectancy of birds that attain breeding age has been estimated at 10–11 years (Crawford 1998b) although birds up to 27 years old have been recorded in the wild (Whittington *et al.* 2000b).

Although a great deal of effort has been expended on banding African Penguins since 1971, there have been no serious attempts made to estimate survival rates on a large scale. Randall (1983) estimated first year, second year and subsequent adult survival of penguins at St Croix Island between 1978 and 1982. La Cock *et al.* (1987) and La Cock & Hänel (1987) estimated first year and adult survival rates at Marcus and Dyer Islands respectively. Crawford *et al.* (1999) estimated adult survival of birds at Robben Island between 1993 and 1995. These studies calculated survival from the proportions of banded penguins that were seen in the breeding colony in the years subsequent to banding. La Cock *et al.* (1987) made no allowance for birds being alive but not sighted. La Cock & Hänel (1987) stated that the limited amount of re-sighting effort at Dyer Island and the inability to re-sight some individuals each year precluded presentation of accurate survival figures. All the above studies covered periods of seven years or less, involved up to a maximum of 2700 banded birds and re-sightings were made only at the study colony, although La Cock & Hänel (1987) also used sightings from other areas, held by the South African Bird Ringing Unit (SAFRING). This study is based on a banding sample of over 20 000 penguins, uses re-sighting data from throughout the species' breeding range and spans a banding period of up to 15 years.

6.2 METHODS

About 20 000 African Penguins were banded between 1985 and 1998 at 18 different penguin colonies (Table 6.1). These years were chosen for the analysis because most (66%) penguins were banded during this period. Monitoring intensity was low prior to the 1990s and most penguins that had been banded prior to 1985 would have died before monitoring effort intensified in the 1990s. The exact age of those banded in adult plumage was unknown, although they must have been at least one year old at the time of banding because this is the minimum time taken to attain adult plumage (Randall 1989). It is likely that many of them were banded when breeding but this was rarely recorded on banding schedules, and the adult samples included non-breeding birds as well. Penguins banded when in their brown, immature plumage will have fledged from their colony and been to sea and can be aged at between about 3 and 22 months (Randall 1989). It is likely that a substantial proportion of penguins banded in such plumage were fledged from a colony other than that at which they were banded, since they undertake extensive post-fledging movements (Randall 1989, Chapter Two). For penguins banded as chicks, both the age and natal colony were known.

In addition to birds banded at colonies, variable numbers of penguins were banded at rehabilitation centres, principally by the Southern African Foundation for Conservation of Coastal Birds (SANCCOB), following cleaning after being oiled or, for some birds, treatment for ailments and injuries (Table 6.1). Numbers banded by SANCCOB varied from year to year, depending on the frequency and severity of oiling incidents. These birds were either in adult or in immature plumage when taken to rehabilitation centres. Additionally, attempts were made to hand-rear small numbers of chicks (see Chapter Seven). Ages were not always recorded on banding schedules and for 383 of the 5590 birds re-sighted (7%), it is not known whether they were in juvenile or in adult plumage when released. Because birds banded as adults were essentially of unknown age, penguins whose ages were not recorded on banding schedules were included in the adult sample for analysis purposes. Of over 15 000 penguins that were banded and released by SANCCOB, 77% were known to be in adult plumage.

Details of the degree of coverage and intensity of field observations of flipper-banded penguins are described in Chapter Two. Because the re-sighting effort was most regular and intensive on Dassen and Robben Islands during the period 1994–1999, analyses of survival of non-rehabilitated birds were performed on penguins banded at these two colonies. A total of 151 African Penguins in adult plumage was banded at Dassen Island between 1987 and 1998 (Table 6.2). However, over 5000 penguins were banded there as chicks. In order to boost the sample sizes for analysis of adult survival rate, re-sightings of chicks were used if made three years after the banding date. Many birds have begun to breed by their fourth year (Crawford *et al.* 1999, Chapter Five) and could therefore be considered as adults. The first re-sighting three years or more after the true banding date as a chick was treated as the banding date for this analysis. Lebreton *et al.* (1992) also used this technique to concentrate on adult survival of Greater Flamingos *Phoenicopterus ruber*, for a population where all the marked birds had been initially ringed as chicks.

All re-sightings of birds banded at Robben and Dassen Islands were used in the analyses, including those made at other localities. Re-sighting effort was nearly continuous at Dassen Island throughout the year. At Robben Island re-sighting efforts were concentrated in periods of 10–12 days each quarter, with additional sightings made by staff of Marine and Coastal Management on a fortnightly basis. Re-sightings of flipper-banded penguins were made in the field with the aid of binoculars and a telescope. They were rarely captured, unless found injured or oiled. Because it was not usually known which colonies rehabilitated penguins had come from, survival rates were estimated using all the data available, i.e. treating all rehabilitees as if they were from the same colony. Over the study period, most re-sightings of oiled birds (65%) were from the *Apollo Sea* spill, which mainly involved penguins from Robben and Dassen Islands (Underhill *et al.* 1999). No attempt was made to calculate separate survival parameters for males and females because the sexes of African Penguins are not readily separable in the field. Randall (1983), using a sample of 154 penguins in a study colony on St Croix Island, found average annual survival rates of males and females to be similar. The condition of flipper-bands was noted in the field, particularly if they showed signs of opening up or causing injury to the bird. Whenever possible, penguins with problem bands were caught and the bands were then either refitted, removed or replaced.

Live re-sighting data were analysed using the software package MARK, which takes capture-mark-recapture data and computes estimates of model parameters using maximum likelihood techniques (Lebreton *et al.* 1992, White & Burnham 1999). This program differentiates re-sighting and survival rates to a greater extent than previous studies involving survival estimates of African Penguins have done. Re-sighting data were initially transformed into individual capture histories for each bird. These consisted of a series of "1"s and "0"s, one digit for each time period, indicating whether the bird was re-sighted (1) or not recorded (0). The software computes estimates for survival rate (φ) between each time period and for recapture or re-sighting rate (P) at each "capture" period. It allows a range of models to be tested on the data. The initial model used for each data set, with the exception of birds banded as chicks or as juveniles, was the Cormack-Jolly-Seber (CJS) model (Cormack 1964, Jolly 1965, Seber 1965), where both survival and re-sighting rates are set to be time dependent. The notation used for this was $\varphi(t)$,P(t) where "t" denotes time dependency. This model makes four basic assumptions (Pollock *et al.* 1990):

1. Each animal in the population has an equal probability of capture (or re-sighting).
2. Each animal in the population has an equal probability of survival between capture periods i and $i + 1$.
3. Marks (flipper-bands) are not lost or overlooked.
4. Samples are instantaneous, i.e. all the observations for a year are made simultaneously.

Data were initially run through the program RELEASE (Burnham *et al.* 1987) to test the goodness of fit to the CJS model. This program uses two tests (known as Tests 2 and 3) utilising pooled chi-square test statistics (Lebreton *et al.* 1992). They test principally for violations of assumptions 1 and 2 above (Cooch *et al.* 1997). Test 2 examines whether the probability of an animal being seen at occasion ($i + 1$) is a function or not of whether it was seen on occasion (i). If assumption 1 above is met, then all animals should be equally visible at occasion ($i + 1$) regardless of whether or not they were seen at occasion (i). Test 3 is more concerned with violations of assumption 2 above. When an animal is known to be alive at occasion (i), it tests whether the probability of it being seen again is dependent on whether or not it was

marked (banded) at or before occasion (*i*) (Cooch *et al.* 1997). A non-significant value for the tests indicates that the model shows a reasonable fit to the data. Test 3 is split into two components: Test 3.SR and Test 3.Sm. The former tests whether the probability of an individual known to be alive at occasion (*i*) being seen again, is dependent on whether it was marked at or before occasion (*i*). Test 3.Sm considers for those birds that were seen again, whether when they were seen depended on whether they were marked at or before occasion (*i*) (Cooch *et al.* 1997). Each test has an associated chi-square value, degrees of freedom and P-value. The chi-square values and degrees of freedom for the Test 2 and Test 3 components are summed to produce the overall result of the goodness of fit test. By subtracting the chi-square value and associated degrees of freedom obtained by the Test 3 SR results from the overall chi-square value and summed degrees of freedom, the goodness of fit to a model with two, time-dependent age classes is obtained (Cooch *et al.* 1997). This was done for the analyses on Robben and Dassen Island chicks and for rehabilitated birds that were banded as juveniles.

MARK provides a goodness of fit test using a parametric bootstrap procedure and this was performed on the initial model, usually the CJS model. In this technique, the parameter estimates from the model are used to simulate data, which exactly fit the assumptions of the model. The model is then fitted to the simulated data and a model deviance and measure of the lack of fit produced. A "variance inflation factor", *c*, can be computed to indicate the degree of extra-binomial variation in the data. Where a model fits the data perfectly the value of *c* is equal to 1 (Cooch *et al.* 1997). The larger the value of *c*, the greater the amount of "extra" variation that is present in the data (Cooch *et al.* 1997). The value of *c* is usually estimated by dividing the model deviance by the model degrees of freedom (Cooch & White 2001). MARK calculates this value for each simulation and records it as a measure of the lack of fit to the model, using the notation "c-hat" (Cooch & White 2001). An estimate of model deviance and of "c-hat" is made for each of the number of simulations that is requested by the user (Cooch & White 2001). Initially, 100 simulations were requested.

Where the CJS model was found to be a poor fit to data collected throughout the year, a sampling period was imposed upon the data. The data used were then restricted to a

period of between three and seven months. Only data for birds banded and re-sighted in those months were used in the analysis, and a goodness of fit test was performed on the reduced data set. In cases where it was not possible to achieve a good fit to the data, an adjustment was made using the estimated inflation factor "c-hat". This adjusts the test statistics used for comparing the fit of different models to the data (Cooch *et al.* 1997) and also adjusts the standard errors of the estimates. The value of "c-hat" used was derived from the bootstrap simulations. Two values of "c-hat" were computed: one obtained by dividing the observed model deviation by the mean deviation derived from the bootstrap simulations, and the other by dividing the observed value for "c-hat" by the mean "c-hat" derived from the bootstrap simulations. These values provide a measure of the amount of over-dispersion in the original data (Cooch & White 2001). The greater of these two values was used to make the adjustment.

Other models derived from the CJS model were fitted to the data. These involved making survival constant i.e. not time dependent ($\varphi(.),P(t)$), removing the time dependency from re-sighting rate ($\varphi(t),P(.)$) and making both parameters have a constant rate ($\varphi(.),P(.)$). In addition, other models introduced an age effect, whereby the year following banding (the first year in the case of birds banded as chicks) exhibited a different survival rate to subsequent years. A sub-adult stage was also introduced by making the second year rates differ from those of the first year and from subsequent years. In some models, the first rate was allowed to span two or three periods and the "sub-adult" rate allowed to span two periods. Other models investigated the effects of making the rates different for each cohort of birds banded. In each case, models where survival and re-sighting rates were time dependent and models where they were held constant over time were fitted. In most cases, the "capture" period was set as a calendar year.

The most suitable model was chosen using the criteria of biological significance and Akaike's Information Criterion (AIC). MARK computes the latter value as

$$AIC = -2\ln(L) + 2(\text{number of estimable parameters})$$

where L is equal to the model likelihood. The model with the most parameters exhibits the lowest model deviance and will generally fit the data best (Cooch *et al.* 1997) and there is less risk of bias in the estimators (Lebreton *et al.* 1992). However, as the number of parameters increases so does the sampling variance (Lebreton *et al.* 1992) and the precision of the parameter estimates is lowered (Cooch *et al.* 1997). There is, therefore, a need to find a compromise between model fit and precision of estimates. The principle of parsimony states that only those parameters justified by the data should be retained in the model supported by the data (Lebreton *et al.* 1992). The AIC values were used to select the most parsimonious model fitted to the data. The lower the value of the AIC, the better the "trade-off" between bias and precision of the parameter estimates (Lebreton *et al.* 1992, Cooch *et al.* 1997). In cases where the AIC of models differed by less than 3 and where there was no obvious biological preference for one model over another, the model with fewest parameters was selected as the most parsimonious model. Adjustments made for lack of model fit using the variation inflation factor "c-hat" changes the value of the AIC, and therefore may alter model choice. The calculation of AIC then becomes:

$$\text{AIC} = \frac{\text{model deviance}}{\text{c-hat}} + 2(\text{number of estimable parameters})$$

AIC tends to favour reduced parameter models with increasing value of "c-hat" (Cooch & White 2001).

6.3 RESULTS

6.3.1 *Penguins banded in adult plumage at Robben and Dassen Islands.*

A total of 564 penguins banded as adults at Robben Island was re-sighted and used in the initial analysis, which utilised all sightings throughout the years 1989–1999. The result of fitting the CJS model to these data with RELEASE gave a significant result ($\chi^2_{50} = 257.3$, $P < 0.0001$), indicating a poor fit. Consequently, the data were restricted to those birds banded and re-sighted in the months February to July, which gave the largest sample of birds banded and re-sighted within a six-month period. The fit of the CJS model was still found to be significant ($\chi^2_{50} = 180.8$, $P < 0.0001$) but was slightly better than that obtained using data from all months of the year. Using the parametric

bootstrap procedure in MARK, a value of 1.19 was obtained for "c-hat". This value was used to adjust the AIC values used in model choice.

Using the AIC criterion, the preferred model was one that mirrored an age structure to survival and where re-sighting rate varied with time (Table 6.3). As all the penguins were banded in adult plumage, an age-dependent structure was not expected. The fourth model in the list in Table 6.3 shows a constant survival rate throughout and a re-sighting rate that varied with time. The AIC value is only 2.45 greater than the preferred model and the number of parameters 11 compared to 21 in the preferred model. This model, $\varphi(.),P(t)$, was selected as the most parsimonious model. Model notation is given in Appendix 6.1.

This model predicts an annual survival rate (φ) of 0.81 $\pm$ 0.02 (81%) for penguins banded as adults at Robben Island between 1989 and 1998 (Table 6.4). Re-sighting rates varied between 0.33 in 1992 and 0.80 in 1999. They showed a marked increase from 1994, when monitoring became more intensive following the release of birds from the *Apollo Sea* oil spill.

Using all re-sightings in all months of birds banded as adults at Dassen Island (n = 116), and for those banded as chicks that were re-sighted when adults (n = 398, see Methods), for the years 1989–1999, a poor fit was obtained to the CJS model (χ^2_{28} = 111.7, $P < 0.0001$). The fit for the 465 birds banded and re-sighted between January and June 1989–1999 was $\chi^2_{26} = 64.4$, $P< 0.0001$. Due to the paucity of birds banded or re-sighted when adult between March and August, the analysis was restricted to the 330 birds seen in the years 1994–1999. The goodness of fit to the CJS model was, again, significant ($\chi^2_{12} = 38.6$, $P = 0.0001$). Using the parametric bootstrap procedure in MARK, values of 1.73, 1.60 and 1.88 were obtained for the value of "c-hat" for the data for all months, January to June and March to August respectively. The January to June period for the years 1989–1999 was taken as the best compromise. The sample size of birds was reasonable, the result of Test 2 in RELEASE was non-significant (both Tests 2 and 3 gave significant results with the other two samples) and the lowest value of "c-hat" was obtained, indicating that there was slightly less extra-binomial variation in the data. The "c-hat" value of 1.60 was used to adjust the AIC values used in model choice.

As with the Robben Island adults, the adjusted AIC values (QAIC in Table 6.5) support an "age-structured" model, where the survival rate in the year after banding differs from that of subsequent years. The model where both rates were constant over time was the preferred option (Table 6.5). The model accepted for the Robben Island adults (φ(.),P(t)) appeared third on the list for the Dassen Island adults (Table 6.5), but this time the QAIC value differed by 9.24 from the preferred model. Consequently, the model φ(a2-c/c),P(t) was accepted as the most parsimonious solution.

This model provides two survival rates: one for the year following banding (φ 1 in Table 6.6) and another for all subsequent years (φ 2 in Table 6.6). The rate in the year following banding (φ 1) was 0.2 or 20% less than that for all subsequent years (φ 2). Although the 95% confidence levels were fairly wide for both rates (Table 6.6) they did not overlap. At 0.80 ± 0.07, φ 2 is nearly identical to the value obtained for adult survival at Robben Island for the same span of years. Re-sighting rates ranged from 0.03 in 1992 to 0.81 in 1996. There was a marked increase in these rates from 1995 onwards.

MARK was used to compare the parameter estimates for African Penguins banded as adults at the above two colonies, by treating the data from each of the colonies as a different group (see Cooch *et al.* 1997, Cooch & White 2001). The comparison was made between Robben Island adults, banded and re-sighted between February and July, and Dassen Island adults, banded and re-sighted between January and June, i.e. the two data sets described above. The initial model tested was the CJS model but with a group effect. This model assumes that survival and re-sighting rates are time dependent and are different for the two different groups, i.e. there is a difference in the rates for those birds banded at Robben Island from those banded at Dassen Island. The model was termed φ(c*t),P(c*t), where the lower case "c" indicates a colony effect. The parametric bootstrap procedure was run for 100 iterations and the deviance computed was, in each case, less than the observed deviance of the model when run on the two data sets. Due to the large number of parameters (38), it was not possible to do more than 100 iterations, because this would have been too time consuming. Consequently, the result was taken to be significant ($P < 0.01$) and the model assumed to be a poor fit to the data. Using the mean deviance and mean value of "c-hat" derived from the bootstrap simulations, a "c-hat" value of 1.23 was computed and

used to adjust the AIC values during model selection. As with the previous analyses on individual colonies, several models, with and without a colony effect, were fitted to the data. Those without a colony effect set the parameters to be the same value for both data sets, whereas those with a colony effect allowed the parameters to have different values for the two different data sets.

The preferred model was the same as that accepted to explain the Dassen Island adult data, except that this model (φ(c*a2-c/c),P(c*t)) suggested that the rates for the two colonies are different (Table 6.7). The third model in the list was identical to the preferred model, except that the age structure was only applied to the Dassen Island data. There was clear preference given to models that allowed the survival rates for each colony to be different (Table 6.7), although the starting model φ(c*t),P(c*t) was the least preferred of these. It was also apparent from the models tested that the data were best explained when re-sighting rates were different for each colony and were time dependent. The first model in Table 6.7 was accepted as the most parsimonious model. A likelihood ratio test (LRT) was used to compare this model with the fourth model in the Table (φ(a2-c/c),P(c*t)), which differed from the first model in that the survival rates were the same for both colonies. The difference between these models was found to be significant ($\chi^2_2 = 12.2$, $P = 0.002$).

The main difference between the survival rates for the two colonies, as described by the preferred model, was in the rate for the year after banding. This was found to be 0.75 ± 0.06 for Robben Island adults and 0.60 ± 0.07 for Dassen Island adults (Table 6.8). There was an overlap in the 95% confidence intervals for the two rates for subsequent years, which were 0.82 ± 0.03 for Robben Island and 0.80 ± 0.06 for Dassen Island. Re-sighting rates for Robben Island ranged from 0.35 to 0.80, whereas those for Dassen Island ranged between 0.03 and 0.81. The proportion of re-sightings made at Robben Island in 1990 was higher than that in each of the subsequent three years. Re-sighting rate increased again from 1994. There were few re-sightings from Dassen Island prior to 1995. As shown in Table 6.6, 1996 provided the highest proportion of re-sightings at Dassen Island.

6.3.2 *Penguins banded as chicks at Robben and Dassen Islands.*

Re-sightings were made of 483 of the 2429 African Penguins banded as chicks at Robben Island between 1987 and 1998. As with the data for penguins banded as adults, the CJS model was initially fitted and tested for goodness of fit. However, on this occasion, an age related model was expected to explain the data distribution and the model φ(a2-t/t),P(t) was taken as the starting model. Using all banding and re-sighting data for all months in the above year span, the starting model did not show a good fit to the data ($\chi^2_{52} = 103.5$, $P < 0.01$). Two six monthly periods were selected that included a high proportion of the banding and re-sighting data. The goodness of fit for data for May to November 1987–1999, comprising re-sightings of 481 penguins, was still a poor fit ($\chi^2_{49} = 91.7$, $P < 0.01$), while that for March to September from the same year span (n = 445 birds) was slightly better ($\chi^2_{47} = 66.5$, $P < 0.05$). Using the parametric bootstrap procedure on the latter data, a non-significant result was obtained ($P = 0.17$), indicating an acceptable fit to the model. Consequently, the data for the months March to September was tested with a variety of other models (Table 6.9). Although the model was a reasonable fit with "c-hat" set at 1 (the value of "c-hat" when the model fits the data perfectly), the model choice was adjusted using a correction factor derived as previously. This made little difference, except that the starting model slipped from the second favoured to third favoured model, and a model with a three-tiered age structure became second favourite.

Although the AIC values of the first two models in Table 6.9 differed by less than 2.0, the top model (φ(a2-t/c),P(t)) was preferred because it has fewer parameters and the lower AIC value. This model indicates that a two-age structure for survival was preferred, one rate applicable to the year after banding, i.e. the first year of the penguin's life, and the other to all subsequent years. The survival of first year birds was time dependent but the survival rate over subsequent years was constant across time.

According to the selected model, survival rates for the first year of Robben Island penguins banded as chicks varied between 0.13 from 1994 to 1995 to 0.64 from 1989 to 1990 (Table 6.10). However, the standard errors of the first three survival estimates

were all above 10% and the confidence intervals were all greater than 50% (Table 6.10). After the first year, survival was estimated to be constant at 0.75 ± 0.04 (Table 6.10). The program was unable to compute realistic survival rates for the period 1995 to 1998. There were no chicks banded at the island during the years 1995–1997 (Table 6.2) and no birds were re-sighted in 1988. Other re-sighting rates ranged from 0.02 in 1989 and 1990 to 0.90 in 1999 (Table 6.10). As with the re-sightings of adult birds, rates increased markedly from 1995 onwards.

The total number of re-sightings made of the 5722 chicks banded at Dassen Island between 1985 and 1999 was 919. As with the Robben Island data, there was a poor fit to the initial model φ(a2-t/t),P(t) ($\chi^2_{62} = 173.2$, $P < 0.01$), when all re-sightings in all months were used. The largest sample of re-sightings of banded penguins was obtained using the period March to October (n = 857), and the span of years was reduced to 1987–1999, in keeping with those used for the Robben Island analysis. Although better than the previous example (Tests 3Sm and 2Cm of RELEASE were non-significant), the model was still a poor fit to the data ($\chi^2_{57} = 92.2$, $P < 0.01$). The parametric bootstrap procedure also signified a poor fit ($P < 0.01$) and model choice was adjusted using a computed "c-hat" value of 1.35.

The preferred models were similar to those best fitted to the Robben Island data (Table 6.11) and the same model (φ(a2-t/c),P(t)) was chosen as the most parsimonious model. Ignoring the survival rate for 1987–1988, which seems to be estimated from sparse data, survival in the first year ranged from 0.03 in 1998–1999 to 0.80 between 1990 and 1991 (Table 6.12). As noted with the Robben Island data, the survival rates for years 1988 to 1991 all had large associated standard errors and confidence intervals covering over 40% (Table 6.12). As at Robben Island, no chicks were banded at Dassen Island during the years 1995–1997 and survival rates for the period 1995 to 1998 were not computed with accuracy. Survival after the first year was estimated as 0.70 ± 0.03. No re-sightings were made in either 1988 or 1989, after which re-sighting rates remained below 10% until 1995. As with the re-sightings of adults at this colony, the largest proportion of re-sightings (61%) was made in 1996.

The two samples used above to calculate survival and re-sighting rates for Robben and Dassen Islands were compared by treating them as different groups, as was done

for birds banded as adults. Using RELEASE to fit the model φ(c*a2-t/t),P(c*t), a significant result was obtained, indicating a poor fit to the model ($\chi^2_{105} = 164.4$, $P < 0.01$). The parametric bootstrap procedure was run for only 50 iterations: 100 iterations would have taken over an hour to complete! The goodness of fit was again poor ($P < 0.02$). The correction factor value for "c-hat" was computed as 1.41 from the observed value of "c-hat" divided by the mean expected value of "c-hat" from the bootstrap simulations.

From the nine models tested on the two data sets it was clear that the preferred model allowed for a first year survival rate, varying over time, and a subsequent "adult" survival rate for all remaining years that was constant over time (Table 6.13). This was the same model that was preferred for each of the analyses run separately on the two colonies (Tables 6.9 & 6.11). In this case, the preferred model φ(c*a2-t/c),P(c*t) indicated a difference in the survival and re-sighting rates between the two colonies, as had been the case with the adult data. The difference in QAIC value between this model and the corresponding model, which did not allow for a difference in survival rates between the two colonies, was 2.96 (Table 6.13). A likelihood ratio test comparing these two models was significant at the 5% level ($\chi^2_{10} = 23.1$, $P = 0.01$). In all instances, models with a difference in re-sighting rates between the two colonies were preferred to those where the rates were set to be the same (Table 6.13). Only one model was tested with re-sighting rate constant across time and this model was the least preferred of the nine.

It was not possible to compute an accurate first-year survival rate for Dassen Island between 1987 and 1988 because there were no re-sightings in the latter year of birds banded at that colony. First-year survival estimates for the years 1987–1990 for both colonies had associated standard errors of over 10% and confidence intervals with length in excess of 45% (Table 6.14). The survival estimates for 1990–1991 for the two colonies differed by 0.57, but the Dassen Island estimate had a standard error of 0.14 and the upper and lower confidence limits differed by 0.51. As previously noted, first-year survival rates were not computed for the year span 1995–1998 at either colony. The survival estimates for 1998–1999 are also inaccurate and while the estimate for Robben Island is 0.19 greater than that for Dassen Island, the confidence intervals of the two estimates overlap by 0.25 (25%). Of the remaining first-year

estimates, which had standard errors of less than 0.08, the survival estimates were higher for Dassen Island birds, with the exception of 1994–1995, where the rate was higher for Robben Island birds. The latter period showed the lowest rate for first-year survival if the value of 0.03 for Dassen Island chicks in 1998–99 is ignored. Survival for the second and subsequent years differed by 0.06 and was higher for birds banded at Robben Island (Table 6.14). Re-sighting rates were below 4% for both colonies for the years 1988–1993. They were similar for both colonies in 1994 and 1998 and increased markedly in 1995. Re-sighting rate was higher for Dassen Island in both 1996 and 1997 but was higher for Robben Island in 1999 (Table 6.14).

6.3.3 *Penguins treated at rehabilitation centres and returned to the wild.*

The CJS model was the initial one used for computation of survival and re-sighting estimates of adults and of birds of unrecorded age that had been rehabilitated. Using all re-sightings of 4209 penguins from all months of the years 1990–1999, a poor fit was obtained to the model ($\chi^2_{46} = 1310.4$, $P < 0.0001$). Most of the major oil spills, which gave rise to the majority of rehabilitated penguins, occurred between the months of May and November, with most of the penguins being released between June and February. However, most re-sightings of rehabilitated birds were made between January and June. Two periods were tested with the CJS model: all birds banded, released and re-sighted between the months of June and November (n = 3905) and those banded, released and re-sighted between January and June (n = 433). For the former period, the fit was again poor ($\chi^2_{41} = 689.4$, $P < 0.0001$) as was that to the latter period ($\chi^2_{22} = 62.9$, $P < 0.0001$), although for the January to June period, Test 2 of program RELEASE gave a non-significant result ($P = 0.11$). The former period was then reduced to all birds banded, released and re-sighted between July and September (n = 3498), but still did not show a fit to the CJS model ($\chi^2_{30} = 217.7$, $P < 0.0001$). While the least poor fit was obtained for observations between January and June, this involved throwing away most of the data and was considered inappropriate for further analysis. The parametric bootstrap technique confirmed the poor fit of all alternatives and the values computed for the correction factor, "c-hat" were all greater than 4.0, with the exception of the January to June sample. The poorest fit seemed to be to the sample using all data for all months ("c-hat" = 6.13) and the June to November sample was used for further analysis.

A number of models were fitted using a correction factor of 4.97. The preferred model was the same as that used to describe the data of birds banded as chicks at Robben and Dassen Islands (φ(a2-t/c), P(t)) (Table 6.15). The next preferred model differed by a QAIC value of 6.94 and the first model without an "age-structure", the CJS model, had a QAIC value that was 50.72 greater than the preferred model. A LRT between the preferred model and the CJS model was significant ($\chi^2_2 = 54.7$, $P < 0.0001$). The chosen model implied that there was a difference in the survival rate in the year following banding, which varied across time, to the survival rate in all subsequent years, which was not time dependent.

Survival rates for the year following release ranged from 0.16 to 0.66 (Table 6.16). However, the associated standard errors were greater than 10% for all but three of the nine estimates and the difference between the upper and lower confidence intervals was 0.38 or greater. The three most accurate estimates ranged from 0.29 from 1992–1993 to 0.66 from 1994–1995. For all subsequent years, the annual estimate of survival was 0.79 ± 0.04 (Table 6.16). None of the birds banded in 1990 were re-sighted in either 1991 or 1992, nor were any of the birds banded in 1991 reported in 1992. Re-sighting rates otherwise followed the pattern of previous analyses, showing a sharp increase from 1995. The peak rate of 0.59 (59%) was recorded in 1998 (Table 6.16).

To further investigate the differences between survival rates in the year after banding and those in subsequent years, the data set was modified, such that birds did not enter the data until one year or more after their release. This meant that the first re-sighting made a year or more after the release date became the new, artificial release date, i.e. a bird with the original capture history of 1001101001 would now have the new capture history of 0001101001. This was done for the same period as above, i.e. June to November 1990–1999 and resulted in the first "new" year of release becoming 1993. The goodness of fit test was again significant ($\chi^2_{15} = 181.0$, $P < 0.0001$) and the derived value for the correction factor "c-hat" was 6.32.

Using the latter correction factor, there were four models separated by a QAIC value of less than 2 (Table 6.17). Three of these retained the differences between survival rates in the year after banding and subsequent years, while the fourth suggested a

difference in survival rate between each cohort. The most parsimonious model, φ(a2-c/c),P(t), suggested a difference between survival rate in the year following the first re-sighting (now treated as the new banding date) and all subsequent years. However, the rate for this first year was no longer time dependent. The model was compared to the sixth model on the list (φ(.),P(t)), which set the survival rate equal for all years and constant across time, using a LRT. The result of this was significant at the 5% level ($\chi^2_1 = 5.4$, $P = 0.02$).

Using the preferred model, survival rates of 0.70 ± 0.07 and 0.83 ± 0.09 were obtained for the year following first re-sighting and subsequent years respectively (Table 6.18). The model φ(.),P(t) predicted a survival estimate of 0.76 ± 0.05.

It was also possible to estimate survival rates for rehabilitated juvenile birds. The starting model was the same as that initially used with birds banded as chicks (φ(a2-t/t),P(t)), because it seemed likely that juvenile birds in their first year would show a different survival rate to adults. Using all re-sightings of 358 penguins from all months for the years 1990 to 1999, a reasonable fit was achieved ($\chi^2_{28} = 41.4$, $P < 0.05$). To improve the fit, a sample was taken of 276 penguins that were banded and re-sighted between July and December for the same span of years. Using RELEASE, the test gave a non-significant result ($\chi^2_{18} = 16.8$, $P > 0.05$). The parametric bootstrap procedure over 100 iterations also indicated a reasonable fit of the model to the data ($P = 0.74$). Thirteen different models were subsequently compared (Table 6.19).

All models with an age-related component were preferred to those where ages had similar survival rates. The preferred model, φ(a2-c/c),P(t), set one survival rate for the first year from release and another rate for all subsequent years. Both rates remained constant over time. A re-sighting rate that varied across time was preferred but without any difference between ages.

The preferred model gives an estimate of 0.2 ± 0.04 for survival of rehabilitated juvenile penguins in their first year following release. For all subsequent years, the estimated survival rate was 0.79 ± 0.06 (Table 6.20). The program was unable to compute re-sighting rates for the years 1991–1993 inclusive, because there were no re-sightings made in any of these years that related to birds banded in a previous year.

For the remaining years, the rates ranged from 0.16 in 1994 to 0.57 in 1998 (Table 6.20).

A comparison was made between the survival parameters of rehabilitated adults, together with birds of unrecorded age, and those of adults banded at breeding colonies. The sample used for rehabilitated birds included all those banded and re-sighted between the months of June and November, 1990–1999 (n = 3905). For non-rehabilitated penguins, all birds banded as adults and re-sighted at breeding colonies over the same time period were used in the comparison (n = 472). As before, the starting model, φ(g*t),P(g*t) assumed that survival and re-sighting rates varied over time and were different for the two different groups. A lower case "g" was used this time to indicate a group effect rather than a colony effect. A poor fit to the data was obtained using this model ($\chi^2_{65} = 713.8$, $P < 0.0001$). A parametric bootstrap procedure was run for 100 iterations and again indicated a poor fit ($P < 0.01$). Dividing the observed value of "c-hat" by the mean of the expected values from 100 simulations, gave a correction factor of 3.40. This was used to adjust the AIC values used for model choice.

The model with the lowest QAIC value was φ(g*a2-t/c),P(g*t), which described the data by setting the survival rate for the year after banding to vary across time and to be different from survival for all subsequent years, which was constant over time. The rates also differed for each of the groups. Re-sighting rates varied with time and were different for the two different groups. However, the second model in the list in Table 6.21 had a QAIC value within two of the first model and had fewer parameters. It was, therefore, accepted as the most parsimonious model. This model, φ(a2-t/c),P(c*t), was the same as that described above except that the survival rates were identical for each of the two groups, i.e. birds banded at breeding colonies had the same survival rates as those that had been rehabilitated. Re-sighting rates were, however, different for the two groups. A LRT comparing these two models was found to be significant at the 5% level ($\chi^2_{10} = 22.0$, $P = 0.015$).

Survival rates for the two groups in the year following banding, or release in the case of rehabilitated penguins, ranged from 0.23 ± 0.06 in 1992–1993 to 0.67 ± 0.05 in 1994–1995 (Table 6.22). The survival rate over subsequent years for the two groups

was 0.78 ± 0.03. For both groups, re-sighting rates showed a marked increase from 1995 onwards. As previously noted, there were no re-sightings of rehabilitated penguins released in previous years in either 1991 or 1992, and a smaller proportion was seen in 1993 than was the case with non-rehabilitated birds. The proportion of birds banded at colonies that was re-sighted was low in 1996 while that of rehabilitated birds was nearly three times as high. Otherwise, the re-sighting rates for the two groups were fairly similar (Table 6.22).

Few penguins were banded as juveniles at breeding colonies and it was consequently not possible to make a meaningful comparison between these and rehabilitated juveniles. Estimates were computed for the subset of penguins that had been oiled. The samples used were all oiled adults or birds of unrecorded age that were cleaned, released and re-sighted between May and October 1990–1999 (n = 3828), and all oiled juvenile birds that were cleaned, released and re-sighted between June and December of the same period (n = 232). These formed 98% and 80% respectively of the numbers of rehabilitated penguins used in the previous analyses. The models that best described the data were the same in both cases to the corresponding analyses with all rehabilitated birds. For adult birds and those of unrecorded age, survival rates in the year following banding ranged from 0.11 to 0.72 (0.28 to 0.72 for the most accurate estimates) and for all subsequent years the survival rate was estimated as 0.76 ± 0.04. For birds oiled when juveniles, the rate of survival in the year following banding was 0.23 ± 0.05 and was 0.79 ± 0.06 for all subsequent years.

There were 389 recorded sightings of flipper-bands that had turned round on the flipper, such that the band number was no longer visible to the observer. In addition, 313 bands were considered to be open or opening and eight were in the process of falling off or causing injury to the penguin. It was also found that the design of some flipper-bands, particularly those with the prefix "T", made them difficult to read in the field, the last number frequently being obscured behind the flipper. There were 68 occasions when a number could not be read due to poor band design.

For each field visit to five selected breeding colonies, the proportion of the total number of bands recorded that could not be read for one of the above reasons was calculated. These proportions ranged from 0.4% to 8.7% (Table 6.23). The

proportions of opening bands seen on each visit was also calculated and means ranged from 0.8% to 5% (Table 6.23). If opening bands were not closed or replaced they could potentially be lost or may cause injury to the bird. Dyer Island seemed to have the largest proportions of bands that had turned round, opened or were illegible due to their design and on six field visits, proportions of turned bands exceeded 10% of the total number of flipper-bands recorded.

6.4 DISCUSSION

The Cormack-Jolly-Seber model did not adequately explain the distribution of re-sighting data for flipper-banded African Penguins used in this study. Cormack (1979) stated that by including a separate parameter for each survival and each capture probability, the model was too general and lacked parsimony. The more parameters there are, the more likely it is that they may have too large a variance to be practically useful (Cormack 1979). It is likely that some of the basic assumptions of the model were violated. The first assumption, requiring that each animal has an equal probability of capture (or equal chance of being re-sighted), is unlikely to be met in practice. Although every effort was made at Robben Island to search evenly through the study area for flipper-banded birds, some areas were passed through more frequently than others, particularly along the shoreline, and the birds regularly present in those areas would thus have a greater probability of being re-sighted. Staff of Marine and Coastal Management undertook regular monitoring of a number of nest sites at Robben Island on a fortnightly basis, while Western Cape Nature Conservation Board set up four areas on Dassen Island for breeding studies, which were visited at least once each week throughout the period 1994–1999. Flipper-banded birds in these closely monitored areas would certainly have been recorded with greater frequency than banded penguins in less regularly monitored parts of the islands. However, estimation of survival rates by the CJS model is thought to be fairly robust to heterogeneous capture or re-sighting probabilities (Pollock *et al.* 1990) and the bias introduced into the estimates may be relatively small, probably less than 5% as determined by simulation studies (Carothers 1973). Any bias that did affect the survival rates would tend to make them too low.

The problem of band-loss has not been rigorously addressed by this study. Stainless steel flipper-bands have been used on African Penguins since 1971 and were considered to be able to last the lifetime of the penguin without loss of legibility (Cooper & Morant 1980). The design of the flipper-bands has remained the same throughout the period 1971–2001, but there have been changes made to the mass and thickness of metal used during this period (Klages & Spencer 1996). The series of bands in common use between 1989 and 1997, which were given the prefix "S", had a mass of 8–9 grams. Bands in use prior to this and those used from 1997 onwards had a mass of between 12 and 17 grams (Klages & Spencer 1996). The thickness of metal used in the "S" series bands was 1mm compared to a thickness of 1.6–1.9 mm used with other bands. This made the "S" series bands, which formed the bulk of those in use during this analysis, prone to eventually opening (pers. obs). Klages & Spencer (1996) found that these bands could be opened by applying 25% of the force that was required to open the other types of stainless steel flipper-bands in use. Opening of bands could eventually result in loss of the band and could also cause injury to the bird and thus detrimentally affect the bird's survival probability. The most commonly observed effect, at least initially, was that the opening band rotated on the flipper, so that the band number became hidden from the observer on the inside of the flipper. If the penguin could not be caught and the band re-fitted this would essentially have the same negative effect on survival estimates as band-loss. At Robben and Dassen Islands, up to 4% and 2% respectively of flipper-bands could have been "lost" in this way (Table 6.23). Of 2490 flipper-banded Little Blue Penguins *Eudyptula minor* observed between 1994 and 2000 at Phillip Island (38° 31′ S 145° 08′ E), Victoria, Australia, 0.6% were found to have lost their flipper-bands and 0.04% had injuries directly attributable to their being banded (Dann *et al.* 2000). The re-trap rate of banded birds was found to be low in the first year, then rose and remained stable. First year survival may, therefore, be adversely affected by banding (Dann *et al.* 2000). Klages & Spencer (1996) concluded that the subsequent loss of bands or injury caused to penguins by bands opening could bias calculations of survival rates, as was noted by Pollock *et al.* (1990). Consequently, the survival rates reported in this study may represent underestimates of the true survival parameters.

Assumption four of the CJS model indicates that all samples must be taken and animals released instantaneously. This may be of more relevance to short-lived species, such as some European passerines, but is unlikely to have anything other than a trivial effect on long-lived species, such as the African Penguin (L.G. Underhill *in litt.*). The model ideally fits a regime where sampling periods are short and there are long periods between when the mortality takes place (W.J. Peach *in. litt.*). Monitoring of African Penguins, however, was fairly constant throughout the year, especially at Dassen Island. Model fit appeared to improve by shortening the banding and re-sighting periods to six months, although this necessitated losing some of the data. In practice, this apparent improvement was more likely due to a reduction in sample size than to a genuinely better fit to the model. The CJS model also assumes that any emigration from the population is permanent (Pollock *et al.* 1990). This could result in bias in the estimates of first year survival, because African Penguins banded as chicks will make temporary emigrations away from their natal colony for a year or more (Randall *et al.* 1987, Randall 1989, Chapter Two).

During the study period, African Penguins were affected by a number of oiling incidents (Chapter Eight). The worst of these, in 1994, resulted in the oiling of 10 000 penguins, 54% of which perished (Williams, A.J. 1995, Underhill *et al.* 1999). Penguins from Robben and Dassen Islands were affected by at least three of these oil spills and survival rates may, therefore, have been depressed due to the mortality associated with these incidents.

In all the analyses made in this study, the models that best explained the data demonstrated a difference in the survival rate in the period immediately following banding to that estimated for all subsequent periods (i.e. an "age-structured" model). This situation was expected for penguins that were banded as chicks or juveniles but not for those that were banded in adult plumage. The possibility that this effect was a direct consequence of banding, a circumstance that could result in an initially reduced survival rate (Cormack 1972) should be considered. By eliminating the period (a year in most instances) immediately following banding, this difference in initial and subsequent survival rates should be lost, if the banding of the birds caused it. This was done with rehabilitated adult penguins, where the banding date was substituted by the date of the first re-sighting made a year or more after release. This, in effect, became

the "new" banding date. However, the models with differences between survival rates for the period immediately following the new "banding date" and those of all subsequent periods were still preferred (Table 6.17). This was also the case with the analysis of adults from Dassen Island, where birds banded as chicks were used but they did not enter the data set until three years old or older (Table 6.5). It was therefore considered unlikely that banding caused the lower initial survival rates. It is possible that some birds banded in adult plumage, especially those that were rehabilitated, were actually visiting the breeding colonies at which they were either banded or collected from when oiled. They may have dispersed after banding or release and visited, settled at or returned to more remote and infrequently monitored colonies, resulting in their not being recorded again. First re-sightings of rehabilitated penguins were often of birds moving away from their release point before returning to settle at their chosen breeding colony (see Chapter Two). Consequently, it was considered that the initial survival rates for the period immediately following banding or release of adult African Penguins may be biased, and that the survival estimates for all subsequent periods were a more accurate reflection of the true adult survival rate.

A comparison of the annual adult survival rates of birds banded at Robben Island with those banded at Dassen Island suggested that survival of birds from the two colonies differed significantly. However, the main differences were found to be in the year after banding, Robben Island birds having a survival estimate of 0.75 and Dassen Island birds of 0.60 (Table 6.8). Assuming that the estimates relating to all subsequent years are more accurate, the survival rates for the two colonies were very similar: 0.82 ± 0.03 for Robben Island and 0.80 ± 0.06 for Dassen Island (Table 6.8). The mean estimate of annual adult survival for the two colonies of 0.81 is probably an underestimate of the true value, due to the heterogeneity of re-sighting probabilities. It is likely that observers missed some banded birds and that others were present at colonies which received little or no monitoring effort. This would tend to make the survival estimates lower. The estimates obtained for Robben and Dassen Islands in this study are, however, greater than those reported by La Cock & Hänel (1987), who estimated a survival rate of 68.6% for African Penguins banded as adults at Dyer Island. La Cock *et al.* (1987) estimated annual adult survival to be between 33.3% and 70.4% with an overall rate of 61.7% at Marcus Island. However, this latter study did not account for birds that were alive but not re-sighted. The colonies at both Dyer and

Marcus Islands were in decline at the time that the observations of banded birds were being made (Crawford *et al.* 1995c). However, at the time when the penguins used in the study by La Cock and Hänel were being banded, Dyer Island was the largest African Penguin colony and was just reaching its peak. The annual adult survival rates from this study were below the estimates of 87% for the Saldanha Bay Islands (Furness & Cooper 1982) and the average of 91.1%, recorded for adults banded at St Croix Island by Randall (1983). However, they were very close to those obtained by Crawford *et al.* (1999) for adults banded at Robben Island. In fact, the estimate of 82% for the year 1993 (Crawford *et al.* 1999) is the same as the annual estimate for birds banded at Robben Island derived for the years 1990–1999 in this study. The rates are also similar to estimates of annual adult survival for other penguin species e.g. 86% for Adelie Penguin *Pygoscelis adeliae* (Reid 1968, Ashmole 1971), 87% for Yellow-eyed Penguin *Megadyptes antipodes* (Richdale 1957, Ashmole 1971), 66%–79% for Little Blue Penguins at Phillip Island (Dann & Cullen 1990), over 85% for Magellanic Penguin *Spheniscus magellanicus* (P.D. Boersma unpublished data, Williams, T.D. 1995) and 86.7% for male and 82.1% for female Galapagos Penguin *Spheniscus mendiculus* (Williams, T.D. 1995).

First year survival of penguins banded as chicks at Robben and Dassen islands varied across time for the years 1987–1999. This may be an indication that survival of first year birds is more dependent than adult survival on temporal changes in environmental variables, such as the distribution and abundance of food resources. First year survival estimates from Robben and Dassen Islands showed a close correlation with the available biomass of Anchovy (Figure 6.1). When there was relatively little Anchovy available in 1990, 1993 and 1994, first year survival rates of the penguins banded in those years were low. An exception to this is the 1990 cohort from Dassen Island, which had the highest rate of first year survival recorded in this study. It should be noted, however, that the standard error of this estimate was 13% and that the 95% confidence limits covered over 50% (Table 6.12). Of the chicks banded at Dassen Island in 1990, 399 (89%) were banded in October. These birds may have benefited from the recovery in the Anchovy biomass that had taken place by the austral autumn of 1991 (Crawford & Dyer 1995). Most of the 1990 cohort from Robben Island (71%) was banded before the end of August.

Using the more accurate estimates where standard errors were less than 0.1 and the differences between upper and lower 95% confidence intervals were less than or equal to 0.25, first year survival of penguins banded as chicks at Robben Island ranged from 0.13 to 0.44 (Table 6.10), while for birds banded as chicks at Dassen Island the range was from 0.10 to 0.53 (Table 6.12). The mean estimates for first year survival were 0.31 for Robben Island and 0.38 for Dassen Island. The survival estimates of 0.21 and 0.03, obtained for chicks banded in 1998 at Robben and Dassen Islands respectively, are comparatively low because relatively few of the birds had returned to their colonies by the end of the study period. Although a significant difference was found between the survival rates of birds banded as chicks at the two colonies, the more accurately estimated survival parameters and ranges of first year survival were similar for the two colonies. Randall (1983), working at St Croix Island, recorded annual survival rates ranging from 3.9% to 34.9% for birds in their first year. The latter figure was considered to be more typical and is similar to the mean estimates for first year survival obtained in this study. The lower one represented a particularly poor year (Randall 1983). The minimum annual survival of 69.1% for penguins banded as fledglings at Dyer Island (La Cock & Hänel 1987) exceeded all but one of the estimates of first year survival in this study, while the minimum first-year survival rate of 12.5%, obtained by La Cock *et al.* (1987) at Marcus Island, was close to the minimum value estimated in this study. First year survival rates of 0.33 were estimated for both Little Blue Penguins at Phillip Island (Dann & Cullen 1990) and Galapagos Penguins (Williams, T.D. 1995). These estimates fall between the mean values estimated in this study for first year survival of African Penguins at Robben and Dassen Islands.

Randall (1983) found African Penguins in their second year at St Croix Island to have an annual survival rate (90.5%) that was almost identical to that of adults (91.1%). There was no firm evidence from this study to suggest that survival in the second year differed from that of subsequent years. Survival rates for the second year onwards, derived from penguins banded as chicks, were less than those obtained from penguins banded as adults (0.75 compared to 0.82 at Robben Island, 0.70 compared to 0.80 for Dassen Island). This could be explained by the possibility that some of the birds banded as chicks emigrated, which would lower the subsequent survival rates. Birds from three cohorts banded at Robben Island and seven cohorts banded at Dassen

Island were found to have emigrated to other breeding colonies (Chapter Four). The proportions of birds banded as chicks that were found to have emigrated ranged from 0.3–0.9% at Robben Island, and 0.4–0.8% at Dassen Island. These small proportions of emigrants are unlikely to have much effect on survival rates. However, it should be borne in mind that searches for flipper-banded birds were less intensive at localities other than Robben and Dassen Islands, and the above figures should, therefore, be regarded as the minimum proportions of birds that emigrated. It is extremely rare for a breeding adult to settle and breed at another colony (Randall *et al.* 1987), but first time breeders seem to have the flexibility to settle at non-natal colonies if environmental conditions favour this (Crawford 1998a).

As was found with adult penguins banded at Robben and Dassen Islands, the preferred model for rehabilitated adult penguins exhibited a different survival rate in the year after banding to that of subsequent years. Taking the latter rate as the most reliable estimate of annual adult survival, a figure of 0.79 ± 0.04 was obtained (Table 6.16). This was virtually identical to the estimates of adult survival for birds banded at Robben and Dassen Islands, and the 95% confidence intervals of all three estimates overlapped. When the data for rehabilitated adult penguins were compared to penguins banded as adults at all breeding colonies, the most parsimonious model suggested that there was no difference in survival rates between the two groups. This further supports the evidence of Whittington (1999) and Chapter Nine, showing that once an African Penguin that has been successfully cleaned or treated after being oiled, sick or injured has been released, it has as good a chance of survival in the wild as a penguin that has never been oiled or treated. First year survival of rehabilitated juveniles was found to be 0.2 ± 0.04, which falls within the range of first year survival of birds banded as chicks. However, it was less than the mean first-year survival rates estimated for penguins banded as chicks at Robben and Dassen Islands. This may suggest that juvenile rehabilitees do not fare so well in the wild in their first year after release. However, proportions of hand-reared orphaned chicks that survived to breeding age were found to be approximately equal to those of naturally reared chicks (see Chapter Seven). It may be that the low estimate for first year survival of rehabilitated juveniles was due to recording of transient birds, which returned to infrequently monitored colonies after release. Survival of these birds after the first year was found to be the same as the estimate derived from rehabilitated adults. There

was little or no difference between survival rates of oiled penguins and those of all rehabilitated birds, because over 80% of all rehabilitees had been oiled and cleaned.

Re-sighting rates in all analyses showed a marked increase after 1994. This can be attributed to the intensification of re-sighting efforts following the release of over 4000 cleaned African Penguins, after the *Apollo Sea* oil spill of June 1994 (Underhill *et al.* 1999). In all analyses, models where re-sighting rates varied over time were clearly preferred to models where they were constant. Re-sighting effort was particularly high at Dassen Island in 1996 and this is reflected in the re-sighting rates. Comparisons of data from Robben and Dassen Islands indicated that re-sighting rates were different at the two colonies. This is a fair reflection, as monitoring at Dassen Island was generally continuous throughout the year, whereas this was not the case at Robben Island.

TABLE 6.1

Totals of African Penguins banded between 1985 and 1998.

	Banded at breeding colonies		Treated at rehabilitation centres	
Year	Adult plumage	Chicks	Adult plumage	Immatures
1985	50	1439	860	63
1986	280	695	159	48
1987	111	504	153	59
1988	49	779	42	106
1989	290	1228	135	73
1990	92	1891	299	131
1991	259	2476	264	219
1992	927	3175	881	168
1993	244	2046	176	55
1994	485	747	3997	385
1995	139	828	515	93
1996	80	140	58	49
1997	146	377	547	152
1998	233	340	722	245
Total	3385	16665	8808	1846

TABLE 6.2

Numbers of African Penguins banded at Robben and Dassen Islands, 1987–1998

	Banded at Robben Island		Banded at Dassen Island	
Year	Adult plumage	Chicks	Adult plumage	Chicks
1987	21	104	0	266
1988	0	29	0	276
1989	137	191	95	718
1990	29	464	0	449
1991	217	508	0	963
1992	59	660	0	1062
1993	102	394	10	510
1994	46	63	0	399
1995	15	0	0	0
1996	30	0	0	0
1997	60	0	0	0
1998	50	16	46	155
Total	766	2429	151	5238

TABLE 6.3

Models tested on annual survival of African Penguins, banded in adult plumage at Robben Island and re-sighted at all localities between February and July, 1989–99. Model selection based on c-hat = 1.19. See Appendix 6.1 for model notation. The "Q" prefix to column headings indicates that values were adjusted for a "c-hat" value greater than 1.

Model	QAICc	Delta QAICc	Number of parameters	QDeviance
{φ(a2-t/c),P(t)}	2869.609	0.00	21	602.784
{φ(a2-c/c),P(t)}	2869.686	0.08	12	621.311
{φ(a2-t/c),P(a2-t/t)}	2871.556	1.95	29	588.123
{φ(.) P(t)}	2872.061	2.45	11	625.722
{φ(a2-t/t),P(t)}	2872.283	2.67	28	590.937
{φ(t),P(t)}	2872.619	3.01	19	609.915
{φ(C),P(t)}	2877.234	7.62	20	612.471
{φ(a2-t/c,C),P(t)}	2879.380	9.77	29	595.948
{φ(t),P(.)}	2922.047	52.44	11	675.708
{φ(a2-t/c),P(a2-t/c)}	2923.465	53.86	21	656.640
{φ(.),P(.)}	2951.577	81.97	2	723.422

TABLE 6.4

Annual survival and re-sighting rates of African Penguins banded in adult plumage at Robben Island and re-sighted at all localities between February and July, 1989–99, based on model φ(.),P(t). Model selection based on c-hat = 1.19. N = 483.

Parameter	Estimate	Standard Error	95% Confidence Interval	
			Lower	Upper
φ	0.807278	0.010604	0.785637	0.827214
P (1990)	0.637766	0.054686	0.525408	0.736847
P (1991)	0.383857	0.051616	0.288854	0.488636
P (1992)	0.332573	0.038586	0.261674	0.411964
P (1993)	0.378570	0.038431	0.306655	0.456252
P (1994)	0.515742	0.039798	0.437988	0.592741
P (1995)	0.565963	0.040963	0.484646	0.643878
P (1996)	0.688833	0.042272	0.600637	0.765166
P (1997)	0.500618	0.045578	0.412203	0.588993
P (1998)	0.704106	0.044079	0.611175	0.782723
P (1999)	0.797508	0.050073	0.682015	0.878525

TABLE 6.5

Models tested on annual survival of African Penguins, banded in adult plumage (or banded as chicks and re-sighted three or more years later) at Dassen Island and re-sighted at all localities between January and June, 1989–99. Model selection based on c-hat = 1.60. See Appendix 6.1 for model notation. The "Q" prefix to column headings indicates that values were adjusted for a "c-hat" value greater than 1.

Model	QAICc	Delta QAICc	Number of parameters	QDeviance
{φ(a2-c/c),P(t)}	974.718	0.00	12	77.073
{φ(a2-t/c),P(t)}	978.472	3.75	19	66.245
{φ(.),P(t)}	983.960	9.24	11	88.377
{φ(C),P(t)}	985.087	10.37	18	74.959
{φ(a2-t/c,C),P(t)}	985.348	10.63	23	64.669
{φ(a2-t/c),P(a2-t/t)}	985.858	11.14	23	65.179
{φ(a2-t/t),P(t)}	991.107	16.39	26	64.031
{φ(t),P(t)}	998.097	23.38	19	85.870
{φ(t),P(.)}	1042.681	67.96	11	147.099
{φ(.),P(.)}	1075.345	100.63	2	198.085

TABLE 6.6

Annual survival and re-sighting rates of African Penguins, banded in adult plumage (or banded as chicks and re-sighted three or more years later) at Dassen Island, and re-sighted at all localities between January and June, 1989–99, based on model φ(a2-c/c),P(t). Model selection based on c-hat = 1.60. N = 465.

Parameter	Estimate	Standard Error	95% Confidence Interval	
			Lower	Upper
φ 1	0.602015	0.041947	0.517672	0.680705
φ 2	0.804544	0.032254	0.733592	0.860200
P (1990)	0.036678	0.032593	0.006205	0.188439
P (1991)	0.070265	0.050539	0.016320	0.256099
P (1992)	0.029840	0.037497	0.002423	0.280317
P (1993)	0.037437	0.046886	0.003027	0.332537
P (1994)	0.092871	0.080455	0.015506	0.399566
P (1995)	0.577377	0.151449	0.288132	0.821788
P (1996)	0.809108	0.056088	0.675346	0.896226
P (1997)	0.588618	0.051715	0.484920	0.685001
P (1998)	0.519153	0.056928	0.408463	0.627995
P (1999)	0.500946	0.068558	0.369651	0.632110

TABLE 6.7

Models tested on a comparison of annual survival of African Penguins banded in adult plumage at Robben Island, with those banded in adult plumage (or banded as chicks and re-sighted three or more years later) at Dassen Island, and re-sighted at all localities between January and July, 1989–99. Model selection based on c-hat = 1.23. See Appendix 6.1 for model notation. The "Q" prefix to column headings indicates that values were adjusted for a "c-hat" value greater than 1.

Model	QAICc	Delta QAICc	Number of parameters	QDeviance
{φ(c*a2-c/c),P(c*t)}	4028.886	0.00	24	699.404
{φ(c*a2-t/c),P(c*t)}	4029.908	1.02	40	667.449
{φ(c*a2-c/cDAS),P(c*t)}	4031.094	2.21	23	703.657
{φ(a2-c/c),P(c*t)}	4037.002	8.12	22	711.608
{φ(c),P(c*t)}	4043.760	14.87	22	718.366
{φ(.),P(c*t)}	4052.864	23.98	21	729.511
{φ(c*t),P(c*t)}	4058.172	29.29	38	699.862
{φ(c),P(t)}	4137.481	108.59	13	830.389
{φ(.),P(t)}	4185.095	156.21	11	882.050
{φ(c),P(c)}	4244.262	215.38	4	955.320

TABLE 6.8

Annual survival and re-sighting rates of African Penguins banded in adult plumage at Robben Island as compared with those banded in adult plumage (or banded as chicks and re-sighted three or more years later) at Dassen Island, and re-sighted at all localities between January and July, 1989–99. Based on model φ(c*a2-c/c),P(c*t). Model selection based on c-hat = 1.23. See Appendix 6.1 for model notation. N = 948.

Parameter	Estimate	Standard Error	95% Confidence Interval Lower	Upper
φ Robben Island first year	0.753110	0.028313	0.693558	0.804353
φ Robben Island other years	0.824787	0.013440	0.796869	0.849593
φ Dassen Island first year	0.602015	0.036774	0.528229	0.671438
φ Dassen Island other years	0.804543	0.028276	0.743168	0.854131
P Robben Island 1990	0.664962	0.056873	0.546152	0.765996
P Robben Island 1991	0.394235	0.053568	0.295424	0.502524
P Robben Island 1992	0.347671	0.041225	0.271789	0.432166
P Robben Island 1993	0.388808	0.040021	0.313800	0.469479
P Robben Island 1994	0.524775	0.040858	0.444743	0.603555
P Robben Island 1995	0.574386	0.041894	0.490973	0.653769
P Robben Island 1996	0.691929	0.042874	0.602271	0.769123
P Robben Island 1997	0.500827	0.046431	0.410788	0.590813
P Robben Island 1998	0.703569	0.045149	0.608272	0.783918
P Robben Island 1999	0.796705	0.051605	0.677288	0.879777
P Dassen Island 1990	0.036678	0.028573	0.007742	0.156676
P Dassen Island 1991	0.070265	0.044306	0.019610	0.222123
P Dassen Island 1992	0.029840	0.032873	0.003311	0.221667
P Dassen Island 1993	0.037437	0.041104	0.004141	0.266739
P Dassen Island 1994	0.092871	0.070533	0.019454	0.345674
P Dassen Island 1995	0.577378	0.132771	0.319853	0.798747
P Dassen Island 1996	0.809108	0.049171	0.694288	0.887774
P Dassen Island 1997	0.588618	0.045337	0.497821	0.673757
P Dassen Island 1998	0.519154	0.049908	0.421847	0.615029
P Dassen Island 1999	0.500946	0.060103	0.385226	0.616565

TABLE 6.9

Models tested on annual survival of African Penguins, banded as chicks at Robben Island and re-sighted at all localities between March and September, 1987–99. Model selection based on c-hat = 1.12. See Appendix 6.1 for model notation. The "Q" prefix to column headings indicates that values were adjusted for a "c-hat" value greater than 1.

Model	QAICc	Delta QAICc	Number of parameters	QDeviance
{φ(a2-t/c),P(t)}	3721.783	0.00	22	336.645
{φ(a3-t/c/c),P(t)}	3723.752	1.97	23	336.580
{φ(a2-t/t),P(t)}	3725.266	3.48	30	323.813
{φ(a2-t/c,C),P(t)}	3729.898	8.12	29	330.490
{φ(a3-t/t/c),P(t)}	3732.932	11.15	29	333.524
{φ(a2[2,11]-t/c),P(t)}	3735.791	14.01	23	348.619
{φ(a2-c/c),P(t)}	3738.460	16.68	14	369.541
{φ(a3-c/c/c),P(t)}	3740.040	18.26	15	369.099
{φ(a2[3,10]-t/c),P(t)}	3754.000	32.22	24	364.792
{φ(a2[2,11]-c/c),P(t)}	3754.227	32.44	14	385.307
{φ(a2-t/c),P(C,t)}	3764.841	43.06	78	263.436
{φ(a2-t/c),P(a2-t/c)}	4007.145	285.36	19	628.100
{φ(a2-t/c),P(.)}	4102.664	380.88	11	739.802

TABLE 6.10

Survival and re-sighting rates of African Penguins banded as chicks at Robben Island and re-sighted at all localities between March and September, 1987–99, based on model φ(a2-t/c),P(t). Model selection based on c-hat = 1.12. N = 445.

Parameter	Estimate	Standard Error	95% Confidence Interval Lower	Upper
φ first year 1987–88	0.537619	0.224808	0.164962	0.872505
φ first year 1988–89	0.529125	0.322593	0.081578	0.934280
φ first year 1989–90	0.637201	0.151731	0.326689	0.864088
φ first year 1990–91	0.238697	0.056171	0.146080	0.364940
φ first year 1991–92	0.415070	0.065862	0.294269	0.547024
φ first year 1992–93	0.439779	0.048172	0.348580	0.535234
φ first year 1993–94	0.261703	0.034953	0.199136	0.335690
φ first year 1994–95	0.131953	0.046961	0.063723	0.253464
φ first year 1995–96	0.450083	0.0	0.450083	0.450083
φ first year 1996–97	0.450083	0.0	0.450083	0.450083
φ first year 1997–98	0.450083	0.0	0.450083	0.450083
φ first year 1998–99	0.209431	0.116640	0.062437	0.513100
φ for birds aged > 1 year	0.753580	0.019892	0.712559	0.790469
P 1988	0.0	0.0	0.0	7.9E-06
P 1989	0.017774	0.019635	0.001992	0.140928
P 1990	0.018874	0.012111	0.005310	0.064822
P 1991	0.029070	0.013291	0.011757	0.070070
P 1992	0.024981	0.009734	0.011571	0.053096
P 1993	0.028219	0.007994	0.016136	0.048901
P 1994	0.085437	0.014214	0.061388	0.117727
P 1995	0.421463	0.032172	0.359997	0.485462
P 1996	0.415517	0.033942	0.350889	0.483188
P 1997	0.308817	0.034955	0.244784	0.381147
P 1998	0.586666	0.045933	0.494734	0.672930
P 1999	0.895281	0.071069	0.659280	0.974209

TABLE 6.11

Models tested on annual survival of African Penguins, banded as chicks at Dassen Island and re-sighted at all localities between March and October, 1987–99. Model selection based on c-hat = 1.35. See Appendix 6.1 for model notation. The "Q" prefix to column headings indicates that values were adjusted for a "c-hat" value greater than 1.

Model	QAICc	Delta QAICc	Number of parameters	QDeviance
{φ(a2-t/c),P(t)}	5827.512	0.00	22	376.373
{φ(a3[1,2,9]-t/c/c),P(t)}	5829.379	1.87	23	376.224
{φ(a3-t/c/c),P(t)}	5829.528	2.02	23	376.373
{φ(a2-t/c,C),P(t)}	5834.927	7.41	29	369.661
{φ(a2-t/c),P(a2-t/t)}	5836.222	8.71	29	370.956
{φ(a2-t/t),P(t)}	5836.832	9.32	29	371.566
{φ(a3-t/t/c),P(t)}	5838.096	10.58	28	374.850
{φ(a2[2,10]-t/c),P(t)}	5855.694	28.18	23	402.539
{φ(a2-t/c),P(C,t)}	5893.394	65.88	78	328.271
{φ(t) P(t)}	5908.424	80.91	23	455.269
{φ(a2-c/c),P(t)}	5918.031	90.52	14	482.994
{φ(.) P(t)}	6087.807	260.3	13	654.781
{φ(a2-t/c),P(C)}	6622.137	794.62	18	1179.055
{φ(a2-t/c),P(.)}	6625.963	798.45	11	1196.953
{φ(t) P(.)}	7244.068	1416.50	13	1811.041
{φ(.) P(.)}	7466.654	1639.10	2	2055.688

TABLE 6.12

Survival and re-sighting rates of African Penguins banded as chicks at Dassen Island and re-sighted at all localities between March and October, 1987–99, based on model φ(a2-t/c),P(t). Model selection based on c-hat = 1.35. N = 857.

Parameter	Estimate	Standard Error	95% Confidence Interval Lower	Upper
φ first year 1987–88	1.0	4.5E-06	0.999991	1.000009
φ first year 1988–89	0.452075	0.162772	0.185389	0.749449
φ first year 1989–90	0.674983	0.124603	0.405542	0.863427
φ first year 1990–91	0.804554	0.132337	0.441641	0.955405
φ first year 1991–92	0.522394	0.064192	0.397799	0.644263
φ first year 1992–93	0.530771	0.049473	0.433864	0.625411
φ first year 1993–94	0.358845	0.040619	0.283653	0.441680
φ first year 1994–95	0.101424	0.021249	0.066702	0.151290
φ first year 1995–96	0.450083	0.0	0.450083	0.450083
φ first year 1996–97	0.450083	0.0	0.450083	0.450083
φ first year 1997–98	0.450083	0.0	0.450083	0.450083
φ first year 1998–99	0.033682	0.039012	0.003316	0.267516
φ for birds aged > 1 year	0.700750	0.015680	0.669144	0.730552
P 1988	0.0	0.0	0.0	1E-07
P 1989	0.0	0.0	0.0	0.000002
P 1990	0.002847	0.002372	0.000555	0.014473
P 1991	0.001171	0.001369	0.000118	0.011487
P 1992	0.009092	0.003435	0.004327	0.019002
P 1993	0.012733	0.003677	0.007217	0.022371
P 1994	0.066934	0.009292	0.050864	0.087611
P 1995	0.339783	0.022231	0.297653	0.384611
P 1996	0.610337	0.028569	0.553119	0.664671
P 1997	0.477243	0.033440	0.412459	0.542801
P 1998	0.574352	0.046489	0.481737	0.662029
P 1999	0.549811	0.061709	0.428313	0.665645

TABLE 6.13

Models tested on a comparison of annual survival of African Penguins banded as chicks at Robben Island, with those banded as chicks at Dassen Island, and re-sighted at all localities between March and October, 1987–99. Model selection based on c-hat = 1.41. See Appendix 6.1 for model notation. The "Q" prefix to column headings indicates that values were adjusted for a "c-hat" value greater than 1. N = 1338.

Model	QAICc	Delta QAICc	Number of parameters	QDeviance
{φ(c*A2-t/c),P(c*t)}	7726.536	0.00	44	570.192
{φ(A2-t/c),P(c*t)}	7729.493	2.96	34	593.336
{φ(c*A2-t/t),P(c*t)}	7743.396	16.86	59	556.682
{φ(c*A2-t/c),P(t)}	7767.763	41.23	32	635.637
{φ(t),P(c*t)}	7807.416	80.88	35	669.242
{φ(c*t),P(c*t)}	7814.112	87.58	46	653.725
{φ(c*t),P(t)}	7825.995	99.46	35	687.822
{φ(c),P(c*t)}	8016.035	289.50	26	895.993
{φ(c*t),P(c)}	9453.503	1726.90	26	2333.461

TABLE 6.14

Annual survival and re-sighting rates of African Penguins banded as chicks at Robben Island as compared with those banded in as chicks at Dassen Island, and re-sighted at all localities between March and October, 1987–99. Based on model φ(c*a2-t/c),P(t). Model selection based on "c-hat" = 1.41. See Appendix 6.1 for model notation. N = 1338.

Parameter	Estimate	Standard Error	95% Confidence Interval	
			Lower	Upper
φ Robben Is. first year. 1987–88	0.529588	0.261257	0.125982	0.897885
φ Robben Is. first year. 1988–89	0.523480	0.376752	0.053846	0.954966
φ Robben Is. first year. 1989–90	0.689532	0.186855	0.286421	0.924749
φ Robben Is. first year. 1990–91	0.236989	0.065809	0.132093	0.387949
φ Robben Is. first year. 1991–92	0.412315	0.077250	0.273038	0.567205
φ Robben Is. first year. 1992–93	0.438168	0.056708	0.331791	0.550549
φ Robben Is. first year. 1993–94	0.261737	0.041305	0.189091	0.350238
φ Robben Is. first year. 1994–95	0.132447	0.053066	0.058159	0.274021
φ Robben Is. first year. 1995–96	0.450083	0.0	0.450083	0.450083
φ Robben Is. first year. 1996–97	0.450083	0.0	0.450083	0.450083
φ Robben Is. first year. 1997–98	0.450083	0.0	0.450083	0.450083
φ Robben Is. first year. 1998–99	0.216044	0.142166	0.050495	0.588149
φ Robben Is. other years	0.756847	0.023502	0.707892	0.799917
φ Dassen Is. first year. 1987–88	1.0	4.73E-05	0.999907	1.000093
φ Dassen Is. first year. 1988–89	0.457079	0.177024	0.172177	0.773128
φ Dassen Is. first year. 1989–90	0.652998	0.131549	0.376216	0.854474
φ Dassen Is. first year. 1990–91	0.809929	0.143375	0.407119	0.963561
φ Dassen Is. first year. 1991–92	0.524626	0.069377	0.390157	0.655617
φ Dassen Is. first year. 1992–93	0.531871	0.053332	0.427472	0.633552
φ Dassen Is. first year. 1993–94	0.358749	0.043658	0.278330	0.447980
φ Dassen Is. first year. 1994–95	0.101180	0.022789	0.064445	0.155376
φ Dassen Is. first year. 1995–96	0.450083	0.0	0.450083	0.450083
φ Dassen Is. first year. 1996–97	0.450083	0.0	0.450083	0.450083
φ Dassen Is. first year. 1997–98	0.450083	0.0	0.450083	0.450083
φ Dassen Is. first year. 1998–99	0.033033	0.041132	0.002730	0.298864
φ Dassen Is. other years	0.699000	0.016880	0.664918	0.731017
P Robben Island 1988	0.0	0.0	0.0	1.17E-05
P Robben Island 1989	0.017965	0.023433	0.001352	0.198148
P Robben Island 1990	0.017613	0.013324	0.003948	0.075019
P Robben Island 1991	0.027919	0.015058	0.009588	0.078520
P Robben Island 1992	0.024521	0.011280	0.009876	0.059573
P Robben Island 1993	0.027981	0.009361	0.014452	0.053490
P Robben Island 1994	0.084574	0.016624	0.057182	0.123368
P Robben Island 1995	0.415403	0.037612	0.344062	0.490476
P Robben Island 1996	0.407892	0.039574	0.333178	0.487121
P Robben Island 1997	0.301836	0.040547	0.228695	0.386643
P Robben Island 1998	0.588308	0.053974	0.480060	0.688637
P Robben Island 1999	0.867875	0.083052	0.613656	0.964494
P Dassen Island 1988	0.0	0.0	0.0	3.4E-06
P Dassen Island 1989	0.0	0.0	0.0	1.56E-05
P Dassen Island 1990	0.002920	0.002616	0.000503	0.016754
P Dassen Island 1991	0.001187	0.001491	0.000101	0.013793
P Dassen Island 1992	0.009149	0.003717	0.004117	0.020207
P Dassen Island 1993	0.012786	0.003970	0.006943	0.023430
P Dassen Island 1994	0.067303	0.010045	0.050092	0.089868
P Dassen Island 1995	0.342394	0.024037	0.296945	0.390931
P Dassen Island 1996	0.616649	0.030809	0.554754	0.674980
P Dassen Island 1997	0.483717	0.036268	0.413431	0.554653
P Dassen Island 1998	0.573288	0.050253	0.473187	0.667724
P Dassen Island 1999	0.560612	0.067493	0.427173	0.685828

TABLE 6.15

Models tested on annual survival of adult and unknown aged African Penguins that were cleaned and/or treated at SANCCOB and released, then re-sighted between June and November, 1990–99. Model selection based on "c-hat" = 4.97. See Appendix 6.1 for model notation.

Model	QAICc	Delta QAICc	Number of parameters	QDeviance
{φ(A2-t/c),P(t)}	4680.412	0.00	19	162.426
{φ(A2-t/c),P(A2-t/t)}	4687.356	6.94	26	155.313
{φ(A2-c/c),P(t)}	4717.524	37.11	11	215.583
{φ(t),P(t)}	4731.137	50.72	17	217.165
{φ(.) P(t)}	4742.539	62.13	10	242.602
{φ(t) P(.)}	4870.027	189.61	10	370.090
{φ(.) P(.)}	5002.573	322.16	2	518.655

TABLE 6.16

Annual survival and re-sighting rates of adult and unknown aged African Penguins that were cleaned and/or treated at SANCCOB and released, then re-sighted at all localities between June and November, 1990–99, based on model φ(a2-t/c),P(t). Model selection based on "c-hat" = 4.97. N = 1338.

Parameter	Estimate	Standard Error	95% Confidence Interval	
			Lower	Upper
φ first year 1990–91	0.301493	0.131572	0.112572	0.594918
φ first year 1991–92	0.362280	0.127494	0.161502	0.626243
φ first year 1992–93	0.293057	0.063672	0.184981	0.430893
φ first year 1993–94	0.438713	0.135758	0.209662	0.697241
φ first year 1994–95	0.664707	0.025117	0.613833	0.712023
φ first year 1995–96	0.365003	0.055509	0.264420	0.478935
φ first year 1996–97	0.161540	0.194511	0.011413	0.762771
φ first year 1997–98	0.452351	0.106743	0.261979	0.657766
φ first year 1998–99	0.461086	0.101884	0.276957	0.656484
φ other years	0.789071	0.019378	0.748596	0.824556
P 1991	0.0	0.0	0.0	4.7E-06
P 1992	0.0	0.0	0.0	1.13E-05
P 1993	0.035268	0.024879	0.008645	0.132887
P 1994	0.101064	0.041596	0.043821	0.216179
P 1995	0.496654	0.024950	0.447939	0.545433
P 1996	0.549639	0.025518	0.499290	0.598991
P 1997	0.481727	0.029421	0.424556	0.539380
P 1998	0.594707	0.039863	0.514822	0.669873
P 1999	0.373700	0.041113	0.297199	0.457085

TABLE 6.17

Models tested on annual survival of adult and unknown-aged African Penguins that were released and rehabilitated, then re-sighted between June and November, 1990–99. The new release date is taken as the first re-sighting made one year or more after the true date of release. Model selection based on "c-hat" = 6.32. See Appendix 6.1 for model notation.

Model	QAICc	Delta QAICc	Number of parameters	QDeviance
{φ(A2-c/c),P(t)}	1298.860	0.00	8	36.863
{φ(A2-t/c),P(t)}	1299.455	0.60	13	27.407
{φ(A2-c/c),P(A2-t/t)}	1299.718	0.86	13	27.670
{φ(C),P(t)}	1300.431	1.57	12	30.395
{φ(A2-t/t),P(t)}	1302.145	3.29	15	26.070
{φ(.) P(t)}	1302.210	3.35	7	42.221
{φ(A2-c/c,C),P(t)}	1306.922	8.06	17	26.816
{φ(t) P(.)}	1307.001	8.14	7	47.011
{φ(t),P(t)}	1308.944	10.08	11	40.919
{φ(.) P(.)}	1324.263	25.40	2	74.297

TABLE 6.18

Annual survival and re-sighting rates of adult and unknown-aged African Penguins that were released and rehabilitated, then re-sighted between June and November, 1990–99. The new release date is taken as the first re-sighting made one year or more after the true date of release. Model selection based on "c-hat" = 6.32. See Appendix 6.1 for model notation. N = 2460.

Parameter	Estimate	Standard Error	95% Confidence Interval	
			Lower	Upper
φ first year	0.702273	0.033875	0.631951	0.764172
φ other years	0.826599	0.037985	0.739291	0.889057
P 1994	0.0	0.000001	0.0	0.000121
P 1995	0.594628	0.368305	0.068393	0.967007
P 1996	0.741312	0.044510	0.645170	0.818723
P 1997	0.566996	0.041845	0.483892	0.646494
P 1998	0.644682	0.052920	0.535673	0.740497
P 1999	0.349447	0.048527	0.261179	0.449402

TABLE 6.19

Models tested on annual survival of juvenile African Penguins that were released and rehabilitated, then re-sighted between July and December, 1990–99. See Appendix 6.1 for model notation.

Model	AICc	Delta AICc	Number of parameters	Deviance
{φ(A2-c/c),P(t)}	1523.412	0.00	11	143.373
{φ(A2-t/c),P(t)}	1528.831	5.42	19	132.433
{φ(A2-c/c),P(A2-t/t)}	1532.200	8.79	19	135.802
{φ(A2-c/t),P(t)}	1532.888	9.48	18	138.545
{φ(A2-t/t),P(t)}	1533.836	10.42	22	131.254
{φ(A2[2,7]-c/c),P(t)}	1540.218	16.81	11	160.179
{φ(A2-c/c,C),P(t)}	1541.493	18.08	26	130.625
{φ(A2[3,7]-c/c),P(t)}	1574.722	51.31	11	194.683
{φ(A2-c/c),P(A2-t/c)}	1595.358	71.95	12	213.284
{φ(t),P(t)}	1617.154	93.74	17	224.863
{φ(.) P(t)}	1631.836	108.42	10	253.829
{φ(t) P(.)}	1758.275	234.86	10	380.268
{φ(.) P(.)}	1790.859	267.45	2	429.001

TABLE 6.20

Annual survival and re-sighting rates of juvenile African Penguins that were released and rehabilitated, then re-sighted at all localities between July and December, 1990–99, based on model φ(a2-c/c),P(t). N = 276.

Parameter	Estimate	Standard Error	95% Confidence Interval	
			Lower	Upper
φ first year	0.201092	0.019863	0.164954	0.242844
φ other years	0.792473	0.031054	0.725081	0.846834
P 1991	4.77E-15	1.95E-08	-3.82E-08	3.82E-08
P 1992	2.17E-16	2.73E-09	-5.35E-09	5.35E-09
P 1993	3.37E-16	3.04E-09	-5.95E-09	5.95E-09
P 1994	0.156769	0.047610	0.084064	0.273573
P 1995	0.427001	0.052319	0.328889	0.531214
P 1996	0.426648	0.054014	0.325562	0.534258
P 1997	0.413077	0.060030	0.302259	0.533461
P 1998	0.567205	0.071105	0.426227	0.698080
P 1999	0.194905	0.043380	0.123436	0.293883

TABLE 6.21

Models tested on a comparison of annual survival of African Penguins banded in adult plumage at breeding colonies, with adults that were rehabilitated, released and re-sighted at all localities between June and November, 1990–99. Model selection based on c-hat = 3.40. See Appendix 6.1 for model notation. The "Q" prefix to column headings indicates that values were adjusted for a "c-hat" value greater than 1.

Model	QAICc	Delta QAICc	Number of parameters	QDeviance
{φ(g*A2-t/c),P(g*t)}	7515.596	0.00	38	297.729
{φ(A2-t/c),P(g*t)}	7517.451	1.86	28	319.690
{φ(A2-t/t),P(g*t)}	7527.486	11.89	34	317.665
{φ(A2-c/c),P(g*t)}	7599.277	83.68	20	417.579
{φ(t),P(g*t)}	7603.191	87.60	27	407.439
{φ(t),P(t)}	7608.435	92.84	17	432.754
{φ(g*t),P(g*t)}	7612.807	97.21	34	402.986
{φ(g),P(g*t)}	7637.286	121.69	20	455.588
{φ(.),P(g*t)}	7639.030	123.43	19	459.338
{φ(t),P(g)}	7864.612	349.02	11	700.959

TABLE 6.22

Annual survival and re-sighting rates of African Penguins banded in adult plumage at breeding colonies as compared with those rehabilitated, banded and released in adult plumage and re-sighted at all localities between June and November, 1990–99. Based on model φ(a2-t/c),P(g*t). Model selection based on c-hat = 3.40. See Appendix 6.1 for model notation. N = 4377.

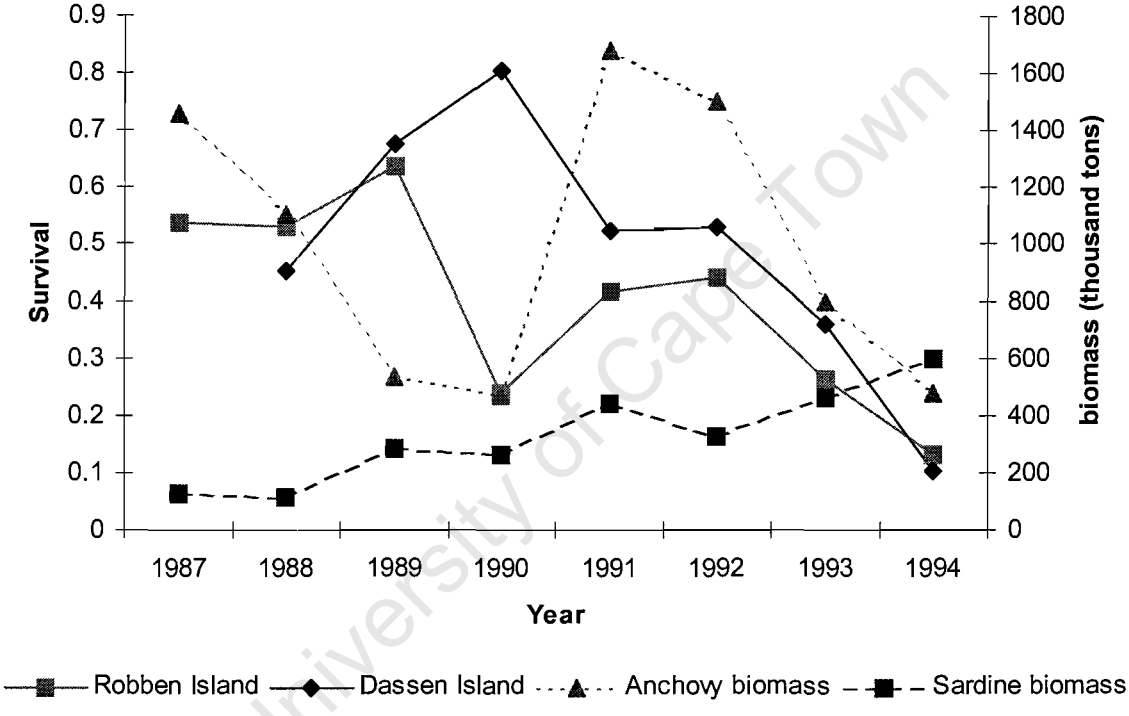
Parameter	Estimate	Standard Error	95% Confidence Interval Lower	Upper
φ first year 1990–91	0.307201	0.103221	0.146311	0.534285
φ first year 1991–92	0.511620	0.096646	0.329240	0.690958
φ first year 1992–93	0.227578	0.038633	0.160733	0.311892
φ first year 1993–94	0.443175	0.078791	0.298577	0.598091
φ first year 1994–95	0.666894	0.020783	0.624994	0.706312
φ first year 1995–96	0.398690	0.045329	0.313992	0.489918
φ first year 1996–97	0.477956	0.122682	0.258854	0.705882
φ first year 1997–98	0.443684	0.066815	0.319346	0.575502
φ first year 1998–99	0.434170	0.071933	0.301797	0.576651
φ other years	0.784137	0.015327	0.752589	0.812664
P 1991 banded at colony	0.0	4E-07	0.0	0.000117
P 1992 banded at colony	0.030141	0.031935	0.003639	0.209152
P 1993 banded at colony	0.132586	0.056693	0.054968	0.286571
P 1994 banded at colony	0.118373	0.046451	0.053134	0.243142
P 1995 banded at colony	0.427061	0.086002	0.272342	0.597502
P 1996 banded at colony	0.200223	0.064772	0.101772	0.356151
P 1997 banded at colony	0.456337	0.085382	0.299510	0.622328
P 1998 banded at colony	0.662472	0.090747	0.469758	0.813023
P 1999 banded at colony	0.461635	0.084564	0.305621	0.625545
P 1991 rehabilitated	0.0	1E-07	0.0	0.000029
P 1992 rehabilitated	0.0	1E-07	0.0	3.49E-05
P 1993 rehabilitated	0.035644	0.020739	0.011202	0.107614
P 1994 rehabilitated	0.101603	0.034448	0.051212	0.191567
P 1995 rehabilitated	0.495076	0.020567	0.454885	0.535331
P 1996 rehabilitated	0.548769	0.021118	0.507136	0.589731
P 1997 rehabilitated	0.482469	0.024226	0.435285	0.529967
P 1998 rehabilitated	0.599277	0.032403	0.534443	0.660813
P 1999 rehabilitated	0.381786	0.033462	0.318680	0.449151

TABLE 6.23

Mean proportions (%) of total flipper-bands recorded that were turned round, open or illegible due to poor design at each of five different African Penguin colonies, visited between March 1995 and October 1999.

	Bird Island (Algoa Bay)	St Croix Island	Dyer Island	Robben Island	Dassen Island
Number of visits	2	3	13	20	8
Band turned round	2.8	3.5	8.7	3.7	1.4
Band opening	2.9	0.8	5.0	3.0	2.9
Band illegible	0.0	1.6	2.1	0.5	0.4

Figure 6.1 First year survival rates of African Penguins, banded as chicks at Robben and Dassen Islands between 1987 and 1994, plotted with biomass of Anchovy and Sardine (biomass data courtesy of Marine and Coastal Management).



APPENDIX 6.1

Explanation of the notation used for model names.

Model name	Explanation of terms
φ or P(a2-t/c)	Survival and/or re-sighting rates separate for two age groups. Rates are time dependent for age 1, constant over time for age 2.
φ or P(a2-c/c)	Survival and/or re-sighting rates separate for two age groups. Rates constant over time for both groups.
φ or P(a2-t/t)	Survival and/or re-sighting rates separate for two age groups. Rates are time dependent for both groups.
φ(.),P(t)	Survival rate constant for all ages and cohorts, re-sighting rate time dependent.
φ(t),P(.)	Survival rate time dependent, re-sighting rate constant for all ages and cohorts.
φ(t),P(t)	Survival and re-sighting rates time dependent and similar for all age groups and cohorts. This is the Cormack-Jolly-Seber (CJS) model.
φ(C),P(t)	Survival rates different for each cohort but constant over time, re-sighting rate time dependent.
φ or P(a2-t/c,C)	Survival and/or re-sighting rates separate for two age groups and different for each cohort. Rates are time dependent for age 1, constant over time for age 2.
φ or P(c*t)	Survival and/or re-sighting rates differ for two or more colonies and are time dependent.
φ or P(c)	Survival and/or re-sighting rates differ for two or more colonies but are constant over time.
φ or P(a3-t/c/c)	Survival and/or re-sighting rates separate for three age groups. Rates are time dependent for age 1, constant over time for ages 2 and 3.
φ(a2[2,11]-c/c)	Survival rates separate for two age groups. The first age group spans 2 time units and the second spans 11 time units. Both rates are constant over time.
φ or P(g*t)	Survival and/or re-sighting rates differ for two or more groups (e.g. those banded at breeding colonies and those that were rehabilitated) and are time dependent.

CHAPTER SEVEN

AN ASSESSMENT OF THE SUCCESS OF RETURNING HAND-REARED AFRICAN PENGUIN CHICKS BACK INTO THE WILD

7.1 INTRODUCTION

Hand rearing of chicks to fledging age is a difficult, demanding and time-consuming process. There have been relatively few attempts made to hand rear penguin chicks and release them back into the wild.

Hand-reared Magellanic Penguins *Spheniscus magellanicus* were released into a breeding colony at Punta Tombo (44° 02′ S 65° 11′ W), Argentina, and went to sea with other chicks and adults (P.D. Boersma *in litt.*). Whether these birds returned to the colony is unknown (P.D. Boersma *in litt.*). The proportion of chicks banded at nests that subsequently get recorded again is low; less than 1% of 40 000 chicks banded over a period of twenty years were re-sighted again at the colony (P.D. Boersma *in litt.*).

In the summer of 1989/1990, *c.* 150 adult Yellow-eyed Penguins *Megadyptes antipodes* were found dead on the Otago Peninsula, New Zealand (Gill & Darby 1993). The total mainland population consisted of *c.* 240 breeding pairs. As a result of the adult mortality, a number of nests were left with orphaned chicks. A total of 130 Yellow-eyed Penguin chicks were hand-raised and released in late February. By this time, the number of dead birds being found had declined and those surviving were in good condition (Gill & Darby 1993). However, only one of these chicks was subsequently recovered and that had spent only a few days in captivity (J.T. Darby *in litt.*).

The Netherlands Institute for Sea Research (NIOZ) at Texel (53° 00′ N 04° 47′ E), conducted experiments on keeping seabirds in captivity for biological observation. Guillemot *Uria aalge* chicks, aged between 3 and 12 days old, were taken from a breeding colony in Aberdeenshire, Scotland, in June 1972 and were kept in purpose-built aviaries, containing a seawater basin, at Texel, The Netherlands (Swennen 1977). Twenty-seven of these chicks that had been hand-reared were later ringed and

released (C.J. Camphuysen *in litt.*). Two of these were subsequently recovered dead, one after 3.4 years in Fife, Scotland, 605 km from the release point, and the other after 1.6 years in Ireland, 974 km from the release point (Camphuysen *et al.* 1997).

In South Africa, oil spills occurring during the breeding season of African Penguins *Spheniscus demersus* have, on two occasions, resulted in large numbers of chicks being orphaned (Gildenhuys 1995, Crawford *et al.* 2000a). This paper assesses the degree of success with which chicks have been hand-reared and their subsequent occurrence in the wild following their release.

7.2 METHODS

The first attempt to hand-rear African Penguin chicks, with a view to returning them to the wild, was made in 1994 (Gildenhuys 1995). On 20 June 1994, the bulk ore carrier *Apollo Sea* sank near Dassen Island (Erasmus 1995). The resulting spillage from the wreck caused approximately 10 000 African Penguins to be oiled, mostly from Dassen and Robben Islands (Underhill *et al.* 1999). A total of 9600 oiled penguins was collected and taken to rehabilitation centres in Cape Town, run by the Southern African Foundation for Conservation of Coastal Birds (SANCCOB) (Williams, A.J. 1995). This resulted in large numbers of nests being effectively abandoned because the parents had either died or were at the rehabilitation centres. A total of 507 orphaned chicks was collected and hand-reared at Dassen Island (Gildenhuys 1995). Chicks were collected from nests where there had been no sign of adult birds visiting for 3–4 days. They were collected regardless of condition and most were at the large, down-covered stage (30–50 days old) or had their first full plumage, known as the "blue" or "baby blue" stage (50–90 days old) (Gildenhuys 1995). This was considered a pilot project to establish the feasibility or rearing abandoned chicks. Details of how the chicks were cared for can be found in Gildenhuys (1995). Staff of Marine and Coastal Management banded 399 chicks at nests on Dassen Island in 1994 (SAFRING unpublished). This cohort serves as a control to the "treatment" group. Three chicks from Bird Island, Algoa Bay were also hand-reared and released in 1994 (N.T.W. Klages *in litt.*).

Fifty orphaned chicks from Dyer Island were hand-reared by A. Gildenhuys and released in 1995. These chicks were orphaned as a result of a "chronic" oiling incident near the island in August 1995 (see Chapter Eight). No other chicks were banded at Dyer Island in 1995 but 856 were banded at nests at other penguin colonies in that year (Table 7.1). Staff members of the Percy FitzPatrick Institute of African Ornithology banded a cohort of 512 fledglings at the nest on Dyer Island in October/November 1978. Monitoring visits totalling 1–3 weeks per year were spent on the island between 1979 and 1985, usually in February, June/July and November, during which banded birds were recorded. The proportion of these birds that were re-sighted was compared to that of the Dyer Island orphans.

Ten fledged chicks, found stranded on the coast near Port Elizabeth, were hand-reared and released from Cape Recife in 1995 (N.T.W. Klages *in litt.*). Their colony of origin was not known.

Following the releases of hand-raised chicks and cleaned birds, which had survived the *Apollo Sea* oil spill in 1994, a period of intensive fieldwork began in order to search for these and other flipper-banded penguins at breeding colonies. Re-sighting effort at Dassen Island was made on an almost daily basis from August 1994 until the end of the study period in June 1999. Thorough searches were made at Robben Island on a quarterly basis and at other localities opportunistically. For Dyer Island, 3–4 visits were made each year, comprising an average total of six days annually, between March 1995 and August 1999. In addition, an extended stay of four weeks was made in September/October 1999. Comparisons were made between the numbers of orphaned and naturally fledged chicks that were re-sighted alive, recovered dead and recorded breeding. A Mann-Whitney test was applied to the ages of orphaned and naturally fledged chicks from Dassen Island that were recorded breeding. Chicks were banded at nests on Dassen Island, by staff of Marine and Coastal Management, in all years from 1990 to 1993 and at Bird Island, Algoa Bay, by staff of Port Elizabeth Museum, in 1994. Survival of chicks was compared between years and between the two localities. Distances travelled by chicks that were re-sighted alive or recovered dead were calculated by the method described in Chapter Two.

7.3 RESULTS

Of 507 orphaned chicks collected at Dassen Island in 1994, 33 died while still in care. The remaining 474 (93%) fledged successfully (Gildenhuys 1995), 437 of which were flipper-banded with the band sequence S20001–S20437. Between August 1994 and June 1999, 137 re-sightings of the hand-reared orphans were made involving 47 different birds, 10.8% of the total of hand-reared orphans that was released with flipper-bands. All but eight of the birds were re-sighted at Dassen Island (Appendix 7.2). The majority (64%) was first re-sighted within two years of release (Table 7.2). If first re-sightings at the natal colony only are considered, this proportion drops to 54% (Table 7.3). Of the eight birds not re-sighted at Dassen Island, five (S20019, S20320, S20335, S20338 and S20375) were seen at Robben Island, one (S20183) at The Boulders and the other (S20166) at Ichaboe Island, Namibia (Appendix 7.2). Of the orphaned chicks that were recorded back at Dassen Island, one (S20079) was previously seen at Ichaboe Island, Namibia, while both S20032 and S20068 were later seen at Robben Island. S20032 then turned north again and was later seen at Jutten Island, Saldanha Bay (Figure 1.1, Appendix 7.2).

Eight (1.8%) were recovered dead within a period of four years (Table 7.4). Five of these were found well to the north of Dassen Island, three being found between 1197 km and 1312 km away in Namibia (Table 7.4, Appendix 7.2). S20213 was found near Port Nolloth (29° 16′ S 16° 52′ E), 475 km north of Dassen Island, in the Northern Cape and S20021 at the Olifants River mouth, 191 km north of Dassen Island. Of the eight birds found dead, six died within four months of release, including all of those that travelled over 100 km from Dassen Island (Table 7.4). The other two birds (S20091 and S20292) survived into their second and fourth year after release respectively (Table 7.4). S20091 was found dead 85 km north of Dassen Island, while S20292 returned to Dassen Island but was later predated by a Cape Fur Seal *Arctocephalus pusillus pusillus* or a shark. Six of the birds that returned to Dassen Island (15.4% of those re-sighted there) attempted to breed, at least one of them being successful (A.C. Wolfaardt pers. comm.). The ages of those birds when first seen back at Dassen Island ranged between 1 year 2 months and 4 years 6 months with a mean of 2 years 6 months. Their ages when first recorded breeding ranged between 2 years 9 months and 4 years 10 months with a mean of 4 years 1 month (Table 7.5).

Of the 399 chicks banded at nests on Dassen Island in 1994 that subsequently fledged naturally, 36 (9.0%) were seen alive between August 1994 and June 1999. All but three were seen back at Dassen Island. As with the orphaned chicks, most (64%) were first re-sighted within two years of banding (Table 7.2). This proportion drops to 52% when first re-sightings at Dassen Island only are considered (Table 7.3). Of the three birds that had not yet returned to Dassen Island, S18989 was seen moulting at Ichaboe Island 11 months and four days after banding, S18862 was seen at Robben Island and S18957 was oiled and taken to SANCCOB, probably from Dyer Island, 17 months after banding (Appendix 7.3). It was later released at Walker Bay after cleaning. Some of the birds that did return to Dassen Island were also seen at other localities. Three (S14392, S14498 and S18862) arrived via Robben Island (Appendix 7.3). S14444 and S14500 subsequently visited Robben Island and S18799 was seen at Dyer Island (Appendix 7.3).

Four birds (1.0%) were found dead, all in Namibia. S18907 was found dead at Mercury Island, 912 km from Dassen Island, while the farthest distance travelled was 1574 km by S18963, found dead at Terrace Bay (Table 7.4, Appendix 7.3). Only the latter bird, which was nearly 18 months old when found, had survived for more than three months after banding. Five of the birds that returned to Dassen Island (15.2%) had attempted to breed. One (S18764) was probably successful (A.C. Wolfaardt pers. comm.), having large downy young in June 1999 (Appendix 7.3). The ages of those five birds when first seen back at Dassen Island ranged between 9 months and 4 years 3 months with a mean of 2 years 3 months. Their ages when first recorded breeding ranged between 3 years and 5 years 2 months with a mean of 4 years 4 months (Table 7.5). Mann-Whitney tests compared the ages when orphans and naturally fledged birds that attempted breeding were first seen back at Dassen Island ($Z = 0.37$, n.s.), and when they were first recorded breeding ($Z = -0.73$, n.s.). There was no significant difference recorded between the orphaned chicks and naturally fledged birds in either age of first re-sighting or age of first breeding records.

Of the three hand-reared chicks from Bird Island, Algoa Bay, one (33.3%) was subsequently seen alive back at Bird Island, 3 years 6 months after it was banded.

Of the 50 orphaned chicks that were hand-reared on Dyer Island in 1995 and released with the band sequence S20451–S20500, nine (18.0%) were subsequently re-sighted alive at breeding colonies between October 1996 and October 1999. Six of them (S20465, S20474, S20478, S20487, S20491 and S20492) had returned to Dyer Island (Appendix 7.4). Most (56%) were first re-sighted between one year and two years after their release, the remainder being seen between three and four years (Table 7.2). Most of those (67%) that returned to Dyer Island were first re-sighted there between three and four years after release (Table 7.3). S20455 was seen on two occasions, as a juvenile, at Dassen Island, 211 km west and north of Dyer Island, just over a year after its release. It has not been seen subsequently (Appendix 7.4). S20470 was seen at Stony Point, 59 km west of Dyer Island, over three years after its release. S20493 settled and later bred at The Boulders in its fourth year after release and was not recorded again at its natal colony (Crawford *et al.* 2000b, Appendix 7.4). Of the six that returned to Dyer Island, three (S20465, S20478 and S20487) were first seen at Dassen Island, S20487 also visiting Robben Island before being sighted back at its natal colony (Appendix 7.4). None of the 50 birds was recovered dead. Only S20493, the bird that emigrated to The Boulders, was recorded breeding. None of the 10 hand-reared chicks that were released from Cape Recife were subsequently seen alive during the study period, although one bird was subsequently seen at Bird Island in August 2000 (N.T.W. Klages *in litt.*). One was found dead at Sedgefield (34° 02′ S 22° 49′ E), 264 km west of the release point, nine months after its release.

Of the 856 chicks banded at the nest at localities other than Dyer Island in 1995, 268 (31.3%) were re-sighted alive. The proportion seen within the first two years of banding was 56%, although 37% were not re-sighted until after three years from banding (Table 7.2). Fifty-eight percent of chicks were over three years old when first re-sighted at their natal colonies (Table 7.3). Fourteen (1.6% of those banded) were recovered dead, seven of them (50%) within one year of banding (Table 7.4). A total of 17 (8.5%) of the birds re-sighted alive at their natal colonies had attempted to breed (Table 7.6). All but one of these birds were banded as chicks at Bird Island, Algoa Bay, the other having been banded at Stony Point. The orphaned chick from Dyer Island that bred was first seen at its new colony at The Boulders 3 years and 6 months after banding, and was recorded breeding when 4 years and 4 months old (Table 7.6).

For naturally fledged chicks that returned to breed the mean first re-sighting at the natal colony was after 3 years 2 months and the mean age when first recorded breeding was 3 years 8 months. Sixty-five of the 512 fledglings banded in 1978 (12.7%) were subsequently re-sighted at Dyer Island between 1979 and 1985 (La Cock & Hänel 1987).

The proportions of chicks from Dassen Island that were banded at nests in years prior to 1994 and subsequently re-sighted alive were greater than that of birds banded in 1994 (Table 7.7). Proportions of birds from Bird Island that were banded at nests in 1994 and 1995 and subsequently re-sighted alive, were greater than those recorded from all years at Dassen Island (Table 7.7). For birds banded in the earlier years, most were not re-sighted until after three years from banding and the largest number of re-sightings were usually made in 1995 and 1996 (Table 7.8). Proportions of birds banded as chicks at Dassen Island that were re-sighted alive were compared to the available biomass of Sardine *Sardinops sagax* and Anchovy *Engraulis capensis*, as measured by acoustic surveys off South Africa by Marine and Coastal Management, in each year from 1990–1994 (Figure 7.1). Biomass of Sardine increased steadily from 1986 to 1999, while that of Anchovy showed peaks in 1986, 1991 and 1999. The proportions of Dassen Island chicks banded in 1991 and 1992, when Anchovy was plentiful, that were re-sighted were large. The proportion re-sighted of those banded in 1994, when the Anchovy biomass had decreased, was small. The proportion of Anchovy recruits (6–7 month old fish) on the recruiting grounds was large from 1990 to 1992 but small in 1993 and 1994 (Barange *et al.* 1999, Figure 7.2). The proportion of the total Anchovy biomass found north of Doring Bay (31° 49′ S 18° 14′ E) (178 km north of Dassen Island) was also large in 1990 (43.4%) but small in 1994 (5.2%) (Barange *et al.* 1999).

7.4 DISCUSSION

The proportions of hand-reared orphans and of naturally fledged chicks from Dassen Island that were banded in 1994 and later re-sighted alive were 10.8% and 9.0% respectively. The difference of 1.8%, which is not statistically significant, is in the opposite direction to what would be expected. The majority of those re-sighted (83% and 92% respectively) returned to Dassen Island. The return rates of the Dassen Island

chicks fall within the ranges obtained for naturally reared chicks of other penguin species. Fifteen percent of Snare's Crested Penguins *Eudyptes robustus* survived their first year, survivorship being 57% in each of the following two years (Williams, T.D. 1995). This gives a proportion of 0.15 x 0.57 x 0.57 = 0.049 (4.9%) of birds surviving to their fourth year. The survival of fledged Yellow-eyed Penguin *Megadyptes antipodes* chicks to breeding age (2–3 years) ranged between 10% and 45% annually for birds banded between 1936–37 and 1949–50, and averaged 26%. A mean proportion of 15% of the eggs laid annually during this period resulted in breeding adults recruiting to the population (Richdale 1957, Gill & Darby 1993, Williams, T.D. 1995). Reilly & Balmford (1975) banded 14 Little Blue Penguin *Eudyptula minor* chicks at Phillip Island, Victoria, Australia in 1967–68, only one of which (7.1%) was recorded alive back at Phillip Island up to November 1972. Of the 81 chicks banded there in 1968–69, eight (9.9%) had been re-sighted alive by November 1972. Dann & Cullen (1990), from a 20-year study at Phillip Island, estimated that 31% of Little Blue Penguin chicks survived to their breeding age of 2–3 years.

The proportion of hand-reared orphans from Dyer Island that was subsequently re-sighted alive was greater than that of orphans from Dassen Island. This might seem surprising considering that the intensity of observer effort was much greater at Dassen Island. However, Dyer Island occupies less than 10% of the area of Dassen Island and supported less than 20% of the number of penguins found at Dassen Island throughout the study period. In addition, all of the penguins breeding at Dyer Island nest on the surface, whereas about 80% of the penguins breeding at Dassen Island nest under rocks or in burrows (Western Cape Nature Conservation Board and Marine and Coastal Management, unpublished data). This makes banded birds at Dassen Island potentially more difficult to detect. The proportion of hand-reared orphans from Dyer Island that were re-sighted alive (18%) was less than that of naturally fledged chicks that were banded at other colonies in 1995 (31%) (Table 7.1). This difference may have been exaggerated by the more regular monitoring done at Bird Island, Algoa Bay, by staff of Port Elizabeth Museum. This colony accounted for 67% of the chicks banded at nests in 1995 (Table 7.1). If re-sightings made by staff of Port Elizabeth Museum are excluded, the total number of chicks re-sighted is reduced to 175 (21%), which is much closer to the proportion of 18% of the orphaned chicks from Dyer Island that were re-sighted. However, the proportion of the 1995 orphans that was re-

sighted was higher than that of naturally fledged chicks that were banded at Dyer Island in 1978, 12.7% of which were re-sighted over the six years following banding (La Cock & Hänel 1987). The observer effort was similar to that made in this study. Most of the orphaned and naturally reared chicks banded in both 1994 and 1995 were first re-sighted within two years of banding or release (Table 7.2). Many of these re-sightings were of post-fledged chicks at non-natal colonies. Most of the chicks banded at Dassen Island in 1994 were first seen back there between one and three years after banding or release. Most of the chicks banded in 1995, however, were not recorded back at their natal colonies until three years after banding or release (Table 7.3). The same pattern was found at Dyer Island by La Cock & Hänel (1987), where 65% of banded fledglings were first re-sighted between three and five years after banding. The earlier return of chicks to Dassen Island may relate to the high intensity of observer effort there when compared to other breeding colonies, where it may take longer for returning individuals to be detected.

The proportions of orphaned and naturally fledged chicks from both years that were found dead within five years of banding or release, varied between 0% and 1.8%. This was below the estimated reporting rate of 2.33% for African Penguins (Underhill *et al.* 1999). Using this reporting rate, we would anticipate that 11 of the 474 banded orphan chicks, released from Dassen Island in 1994, would be recovered dead and reported. Seven of these 11 anticipated recoveries (64%) were made within 24 months, suggesting that approximately 302 of the 474 fledglings had died by this age. There was no indication that mortality rates of hand-reared orphans differed from those of naturally reared birds. Seventy-five percent of both orphaned and naturally fledged chicks banded at Dassen Island in 1994 that died, were found within four months of banding (Table 7.4), suggesting that peak mortality probably occurs soon after fledging. None of the Dyer Island orphans from 1995 was recovered dead, although one of the hand-reared chicks released at Cape Recife was (Table 7.4). The latter bird was recovered within 10 months of banding. Of the naturally reared chicks banded in 1995 that were found dead, seven (50%) were found within a year from banding and 13 (93%) within two years (Table 7.4). These birds seemed to have survived for longer than those banded at Dassen Island in 1994, but peak mortality again seemed to occur fairly soon after fledging and before birds could return to their breeding colonies.

Post-fledging movements of the hand-reared orphan chicks from Dassen Island was markedly similar to those of naturally fledged birds. In both groups there was a northerly dispersal of fledged chicks, five birds in each of the groups reaching Namibia. Birds in both groups were known to have travelled over 1000 km. The Dyer Island orphans appeared to undertake shorter post-fledging movements than those from Dassen Island. While they also travelled west and north, none were recorded further north than Dassen Island, 211 km from Dyer Island.

The proportion of the Dassen Island orphans that attempted to breed (15.4%) was almost identical to that of the naturally fledged chicks (15.2%). None of the nesting attempts were regularly monitored so no comparison of breeding success was possible. The mean age at which the naturally fledged chicks were first recorded back at Dassen Island was slightly less than that of the hand-reared orphans, while their mean age when first recorded breeding was slightly greater (Table 7.5). However, these differences were of less than four months and were not statistically significant.

Only one Dyer Island orphan (11.1%) was recorded breeding but had settled at another colony, The Boulders (Tables 7.6 & 3.2). This mirrors the behaviour of many naturally fledged chicks from Dyer Island, which have been discovered breeding at other penguin colonies, mostly to the west of Dyer Island (see Chapter Four). This emigration of first time breeders from Dyer Island may explain why the proportion of the orphaned birds that were found breeding is lower than that of the Dassen Island orphans. The proportion of birds banded at other penguin colonies in 1995 that were subsequently recorded breeding (8.5%) is even lower than the proportion of orphans from Dyer Island. This may be due to the fact that several different breeding colonies are included in this sample, some of which do not have regular and intensive monitoring, leading to under-recording of breeding attempts.

Most of the chicks banded in 1995 were from Bird Island, Algoa Bay, including 16 of the 17 birds that were recorded breeding. This colony does have a regular monitoring effort but even if the analysis is restricted to chicks banded at Bird Island, the proportion found breeding is still small at 9.6%. The mean time at which Bird Island chicks that returned to breed at their natal colony were first recorded back there, was

39 months after banding. This was later than the chicks banded at Dassen Island in 1994, which returned to their natal colony in an average of 27 months after banding. However, the average time that elapsed between banding and the first record of breeding was 45 months for the Bird Island chicks and 52 months for the Dassen Island chicks. It is likely that some of the chicks banded at Bird Island in 1995 had not yet returned there, thus lowering the proportion found breeding and the age at which breeding was recorded. The latter statement is born out by data collected by staff of Port Elizabeth Museum subsequent to October 1999. By the end of May 2000 (five years after banding), the proportion of Bird Island chicks that had returned to breed was 14.5%, which is within 1% of the proportions of Dassen Island chicks from 1994 that returned to breed. The latter birds also had five years in which to be recorded. By the end of May 2001, 29.6% of the Bird Island chicks had attempted to breed.

It would seem that 1994 was a poor year in terms of the numbers of chicks from Dassen Island that were subsequently re-sighted alive. The proportions of chicks that were banded in the years 1990–1993 and later seen alive, were all more than double that of 1994 (Table 7.7). It could be argued that there has been a greater time span for chicks from the earlier years to be recorded, and that most chicks banded in 1990 and 1991 were not seen alive until after four years from banding (Table 7.8). However, this pattern is almost certainly due to the increased intensity of re-sighting effort from 1994 onwards. Relatively few birds were being re-sighted prior to 1994 and this explains why chicks from the earlier years were not recorded until several years after banding. It is thought that the majority of the chicks from 1994, which had survived, will have been re-sighted within five years from banding. Survival of African Penguins in their first year is known to be lower than in subsequent years (Randall 1983, La Cock *et al.* 1987). It was assumed, therefore, that the biomass of prey available to birds during their first year would have the greatest effect on their survival. Proportions of chicks banded at Dassen Island that were subsequently re-sighted alive did not appear to have any correlation to the available biomass of Sardine (Figure 7.1). Proportions of birds re-sighted showed some correlation to Anchovy biomass, although this did not seem to be the case in 1990 and 1993, when survival of chicks appeared to be relatively good even though the Anchovy biomass had decreased. However, there was a clearer relationship when the proportion of recruits in the Anchovy biomass and the distribution of the biomass were taken into

account. Recoveries and re-sightings of chicks from Dassen Island indicated that many move northward, some reaching the coast of Namibia. If the proportion of the Anchovy biomass between Doring Bay and the Orange River are plotted against the proportion of re-sightings of chicks banded at Dassen Island, a similar pattern emerges (Figure 7.2). If the proportion of Anchovy recruits, i.e. fish of about 6–7 months of age, on the recruiting grounds are considered, the pattern is again similar. Wilson (1985) was of the opinion that fledgling African Penguins are too slow to catch prey that adults feed on. They may therefore rely on catching larval and juvenile fish (Wilson 1985) or slow moving prey (Rand 1960, La Cock *et al.* 1987). The high proportion of young Anchovy on the recruiting grounds in 1990, coupled with the high proportion of the biomass found to the north of Doring Bay, may explain why chick survival was much greater than in 1994. In the latter year, the proportions of recruits on the recruiting grounds and of Anchovy biomass north of Doring Bay were both small.

The proportion of chicks banded at Bird Island, Algoa Bay, in 1994 that was subsequently re-sighted is over three times greater than the corresponding number from Dassen Island (Table 7.7). It was also greater than the proportions re-sighted from Dassen Island in all years from 1990–1993, and the proportion of chicks banded in 1995 at Bird Island that were re-sighted was greater still, even though there were fewer years of monitoring during which to record them. While the intensity of penguin monitoring effort was higher at Dassen Island during the years 1994–1999, locating flipper-banded birds at Bird Island would have been less difficult. Bird Island is similar in size to Dyer Island and supported approximately 25% of the number of African Penguins present at Dassen Island during the study period.

As at Dyer Island, most of the penguins at Bird Island nest on the surface (pers. obs) and would therefore be easier to find than those at Dassen Island. Numbers of chicks that were banded at St Croix Island in Algoa Bay between 1976 and 1981 that returned after their first year, was found to vary between 3.9% and 34.9% (Randall, 1983). The years 1976 and 1977, which gave the two lowest survival rates, were considered to be atypical and a rate between 31.9% and 34.9% was considered to be more "normal". Randall (1983) estimated a mean second year survival of 90.5% and an adult survival of 91.1%. If these are applied to chicks banded at St Croix in 1978

and 1979 it would give respective proportions of 26% and 29% of birds surviving to their fourth year. These estimates both exceed the figures obtained for Dassen Island for all years between 1990 and 1994.

La Cock *et al.* (1987), in a study made at Marcus Island, Saldanha Bay (44 km north of Dassen Island) between 1979 and 1985, re-sighted only 11 (4.7%) of 232 fledglings banded at the colony prior to 1985. These results therefore suggest that survival of birds banded as chicks in the Eastern Cape may be higher than that of those banded at some Western Cape colonies. Of 23 African Penguins known to have survived for over 20 years, 20 (87%) were from colonies in Algoa Bay (Whittington *et al.* 2000b). Of 10 253 African Penguins, banded at Western or Eastern Cape breeding colonies between 1972 and 1979, only 1557 (15%) were banded at Eastern Cape colonies. This clearly indicates that the higher percentage of older birds recorded from Algoa Bay is not directly proportional to the number that were banded.

Why survival of Eastern Cape birds should be higher than that of Western Cape birds is open to question. Birds in the Western Cape are competing for Anchovy and Sardine with an active, commercial purse-seine fishery. Between 1970 and 1989, 5.7 million tons of sardine were harvested off the coasts of South Africa and Namibia, compared to 13.5 million tons between 1950 and 1969 (Crawford 1998a). However, no purse-seine fishery existed in the Algoa Bay region of the Eastern Cape until 1989. The average annual catch made by this fishery, over a 10-year period, was 4000 tons (J.v.d. Westhuizen pers. comm.).

In addition, Western Cape birds forage in the vicinity of several Cape Fur Seal populations. Cape Fur Seals not only compete with penguins for food but are also predators of African Penguins (Shelton *et al.* 1984, Crawford *et al.* 1989, Randall 1989). There are seven breeding and two non-breeding colonies of Cape Fur Seals between Cape Agulhas and Lambert's Bay, whereas there is only one, small colony in Algoa Bay and one other colony, that at Seal Island (34° 09′ S 22° 07′ E), Mossel Bay, between Port Elizabeth and Cape Agulhas (David 1989). More than 90% of the Cape Fur Seal population lives on the West Coast (David 1989). Penguins that move northwards from the Western Cape to Namibia have to pass the seal colony at

Kleinsee (29° 40′ S 17° 03′ E), which supports 350 000 – 400 000 seals (Whittington 2001), making it one of the largest mainland seal colonies in the world (David 1989). Increased competition for food and higher predation levels from Cape Fur Seals may be factors that reduce the survival of young African Penguins from the Western Cape, relative to their counterparts from the Eastern Cape.

Hand rearing of orphaned African Penguin chicks appears to be successful. The proportions that return to breeding colonies are similar to those of naturally fledged chicks and there is no evidence of a higher mortality rate for hand-reared birds. Post-fledging movements are similar to those of naturally fledged chicks and similar proportions were recorded attempting to breed. An assessment of a larger sample of over 2000 hand reared chicks, orphaned by the *Treasure* oil spill of June 2000, will be possible by 2005. However, given that adult annual survival is much higher than that of first year birds, adults must be given priority in cases in which resources are severely limited.

TABLE 7.1

Number of chicks banded at the nest at various localities in 1995 and the number and proportions subsequently re-sighted alive.

Banding locality	Number banded	Number seen alive	Proportion seen alive (%)
Bird Island, Algoa Bay	574	203	35
Stony Point	14	1	7
Seal Island, False Bay	21	7	33
Ichaboe Island	211	46	22
Mercury Island	36	10	28
Total banded	856	268	31

TABLE 7.2

Number of first re-sightings of both orphaned and naturally reared chicks at breeding colonies in annual periods after banding (or release in the case of orphans).

	Years from banding/release				
	< 1	1–2	2–3	3–4	> 4
Orphans, Dassen Island, 1994	14	16	8	2	7
Naturally reared, Dassen Island 1994	10	13	10	3	0
Orphans, Dyer Island, 1995	0	5	0	4	-
Naturally reared, all colonies, 1995	70	81	19	77	21

TABLE 7.3

Number of first re-sightings of both orphaned and naturally reared chicks at their natal colony in annual periods after banding (or release in the case of orphans).

	Years from banding/release				
	< 1	1–2	2–3	3–4	> 4
Orphans, Dassen Island, 1994	9	12	9	2	7
Naturally reared, Dassen Island 1994	6	11	11	4	1
Orphans, Dyer Island, 1995	0	2	0	4	-
Naturally reared, all colonies, 1995	15	55	14	92	23

TABLE 7.4

Orphaned and naturally fledged chicks banded in 1994 and 1995 that were recovered dead.

Band number	Date banded or released	Banding locality	Date recovered	Age at recovery	Distance travelled (km)	O = orphan N = naturally fledged
S14452	12/04/1994	Dassen Island	03/07/1994	2 months 21 days	1257.6	N
S18771	26/03/1994	Dassen Island	20/05/1994	1 month 24 days	1193.1	N
S18907	27/03/1994	Dassen Island	26/06/1994	2 months 30 days	911.5	N
S18963	27/03/1994	Dassen Island	21/09/1995	1 year 5 months 25 days	1574.3	N
S20021	02/07/1994	Dassen Island	24/09/1994	2 months 22 days	191.1	O
S20023	02/07/1994	Dassen Island	21/10/1994	3 months 19 days	1197.2	O
S20054	07/07/1994	Dassen Island	04/09/1994	1 month 28 days	1312.7	O
S20091	07/07/1994	Dassen Island	22/03/1996	1 year 8 months 15 days	84.8	O
S20213	13/07/1994	Dassen Island	20/10/1994	3 months 7 days	475.5	O
S20292	15/07/1994	Dassen Island	31/05/1998	3 years 10 months 16 days	0	O
S20308	16/07/1994	Dassen Island	05/11/1994	3 months 20 days	1225.6	O
S20378	17/07/1994	Dassen Island	17/09/1994	2 months 0 days	22.1	O
S14968	16/03/1995	Seal Island, False Bay	26/04/1995	1 month 10 days	13.4	N
S17910	11/03/1995	Ichaboe Island	03/12/1995	8 months 22 days	369.2	N
S25379	24/05/1995	Bird Island, Algoa Bay	07/09/1995	3 months 14 days	8.1	N
S25467	24/05/1995	Bird Island, Algoa Bay	03/10/1999	4 years 4 months 9 days	663.1	N
S25477	24/05/1995	Bird Island, Algoa Bay	12/03/1996	9 months 16 days	0	N
S25498	24/05/1995	Bird Island, Algoa Bay	16/07/1995	1 month 22 days	150.4	N
S25577	24/05/1995	Bird Island, Algoa Bay	20/08/1995	2 months 27 days	700.0	N
S25653	24/05/1995	Bird Island, Algoa Bay	04/01/1997	1 year 7 months 11 days	98.5	N
S25683	24/05/1995	Bird Island, Algoa Bay	12/02/1997	1 year 8 months 19 days	663.1	N
S25755	25/05/1995	Bird Island, Algoa Bay	03/01/1997	1 year 7 months 9 days	676.6	N
S25811	25/05/1995	Bird Island, Algoa Bay	05/09/1995	3 months 11 days	813.9	N
S25812	25/05/1995	Bird Island, Algoa Bay	21/09/1996	1 year 3 months 27 days	958.6	N
S25845	25/05/1995	Bird Island, Algoa Bay	22/02/1997	1 year 8 months 28 days	340.1	N
S25879	25/05/1995	Bird Island, Algoa Bay	07/05/1997	1 year 11 months 12 days	801.6	N
S25325	15/03/1995	Cape Recife	20/12/1995	9 months 5 days	264.1	O

TABLE 7.5

Ages of orphaned and naturally fledged chicks banded at Dassen Island in 1994 when first seen and when first recorded breeding at Dassen Island.

Band number	Date banded or released	Date when first seen	Date when first breeding	Age when first seen	Age when first breeding	Status O = orphan N = naturally fledged
S14361	12/04/1994	29/04/1997	29/04/1997	3 years 0 months	3 years 0 months	N
S14420	12/04/1994	18/07/1998	18/07/1998	4 years 3 months	4 years, 3 months	N
S14500	12/04/1994	08/11/1996	04/09/1998	2 years 6 months	4 years 4 months	N
S18764	26/03/1994	23/01/1995	03/06/1999	0 years 9 months	5 years 2 months	N
S18932	27/03/1994	10/01/1995	10/05/1999	0 years 9 months	5 years 1 month	N
S20006	02/07/1994	18/09/1996	13/02/1998	2 years 2 months	3 years 7 months	O
S20124	08/07/1994	12/09/1995	02/06/1998	1 year 2 months	3 years 10 months	O
S20196	09/07/1994	01/02/1999	01/02/1999	4 years 6 months	4 years 6 months	O
S20310	16/07/1994	26/06/1996	09/06/1999	1 year 11 months	4 years 10 months	O
S20371	17/07/1994	22/10/1997	12/06/1999	3 years 3 months	4 years 10 months	O
S20405	19/07/1994	09/10/1996	04/05/1997	2 years 2 months	2 years 9 months	O

TABLE 7.6

Ages of orphaned and naturally fledged chicks banded in 1995 when first seen and when first recorded breeding.

Band number	Date banded or released	Date when first seen	Date when first breeding	Age when first seen	Age when first breeding	Status O = orphan N = naturally fledged
S20493	05/10/1995	13/04/1999	08/02/2000	3 years 6 months	4 years 4 months	O
S25341	23/05/1995	29/03/1999	29/03/1999	3 years 8 months	3 years 8 months	N
S25350	24/05/1995	15/12/1996	22/07/1998	1 year 6 months	3 years 1 month	N
S25399	24/05/1995	16/11/1998	23/06/1999	3 years 5 months	4 years 0 months	N
S25423	24/05/1995	23/06/1999	23/06/1999	4 years 0 months	4 years 0 months	N
S25425	24/05/1995	23/06/1999	23/06/1999	4 years 0 months	4 years 0 months	N
S25466	24/05/1995	21/07/1998	23/06/1999	3 years 1 month	4 years 0 months	N
S25484	24/05/1995	09/12/1997	21/07/1998	2 years 6 months	3 years 1 month	N
S25537	24/05/1995	21/07/1998	15/02/1999	3 years 1 month	3 years 8 months	N
S25563	24/05/1995	04/06/1998	30/03/1999	3 years 0 months	3 years 10 months	N
S25700	24/05/1995	30/03/1999	23/06/1999	3 years 10 months	4 years 0 months	N
S25734	25/05/1995	04/06/1998	30/03/1999	3 years 0 months	3 years 10 months	N
S25759	25/05/1995	09/12/1997	21/07/1998	2 years 6 months	3 years 1 month	N
S25769	25/05/1995	05/10/1998	30/03/1999	3 years 4 months	3 years 10 months	N
S25796	25/05/1995	29/03/1999	29/03/1999	3 years 10 months	3 years 10 months	N
S25841	25/05/1995	29/03/1999	29/03/1999	3 years 10 months	3 years 10 months	N
S25899	25/05/1995	30/03/1999	30/03/1999	3 years 10 months	3 years 10 months	N
S25974	31/05/1995	20/10/1996	14/08/1998	1 year 4 months	3 years 2 months	N

TABLE 7.7

Proportions of chicks banded at the nest at Dassen Island and at Bird Island Algoa Bay between 1990 and 1995, that were subsequently re-sighted alive.

Year	Banding locality	Number banded	Number re-sighted	Proportion re-sighted (%)
1990	Dassen Island	449	92	20.5
1991	Dassen Island	963	179	18.6
1992	Dassen Island	1062	250	23.5
1993	Dassen Island	510	107	21.0
1994	Dassen Island	399	36	9.0
1994	Bird Island	495	140	28.3
1995	Bird Island	574	203	35.4

TABLE 7.8

Number of first re-sightings of naturally reared chicks from Dassen Island in annual periods after banding for the years 1990–1994.

	Years from banding				
Year banded	<1	1–2	2–3	3–4	>4
1990	0	5	3	23	62
1991	5	8	12	61	93
1992	3	15	76	112	43
1993	4	16	66	13	7
1994	10	13	10	3	0

Figure 7.1 Proportions of African Penguins banded as chicks at Dassen Island between 1990 and 1994 that were subsequently re-sighted alive, plotted against biomass, in thousands of tons, of Anchovy and Sardine for the years 1984–1999 (biomass data courtesy of Marine and Coastal Management).

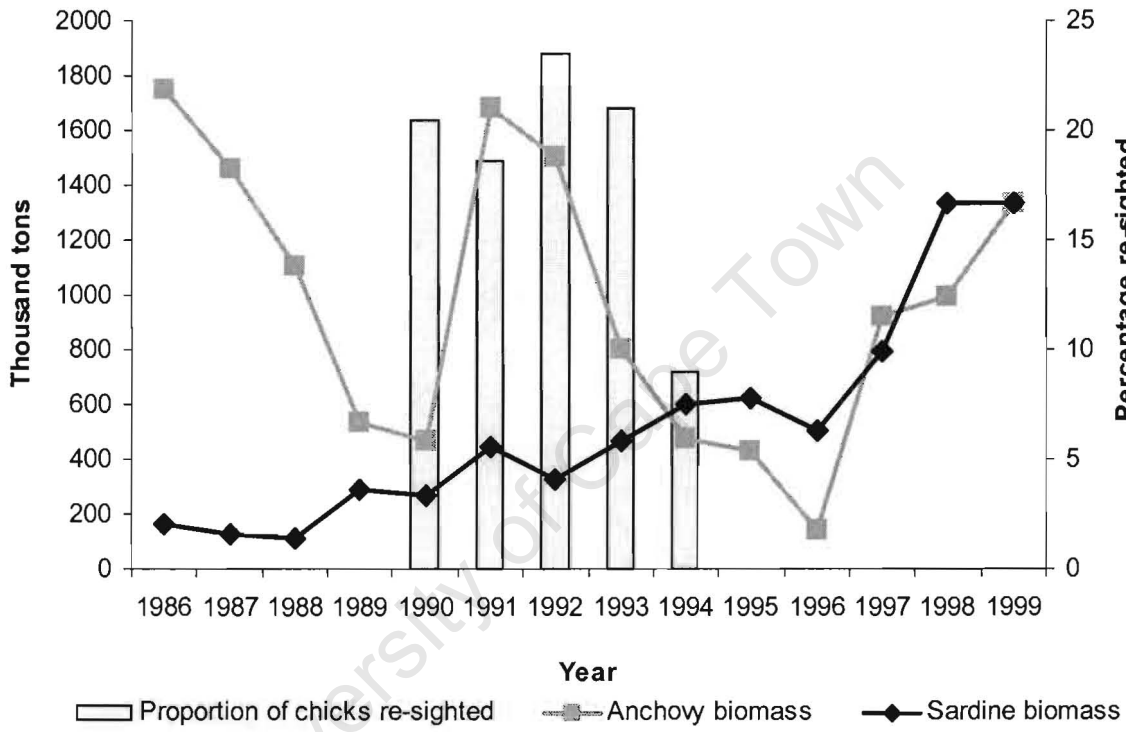
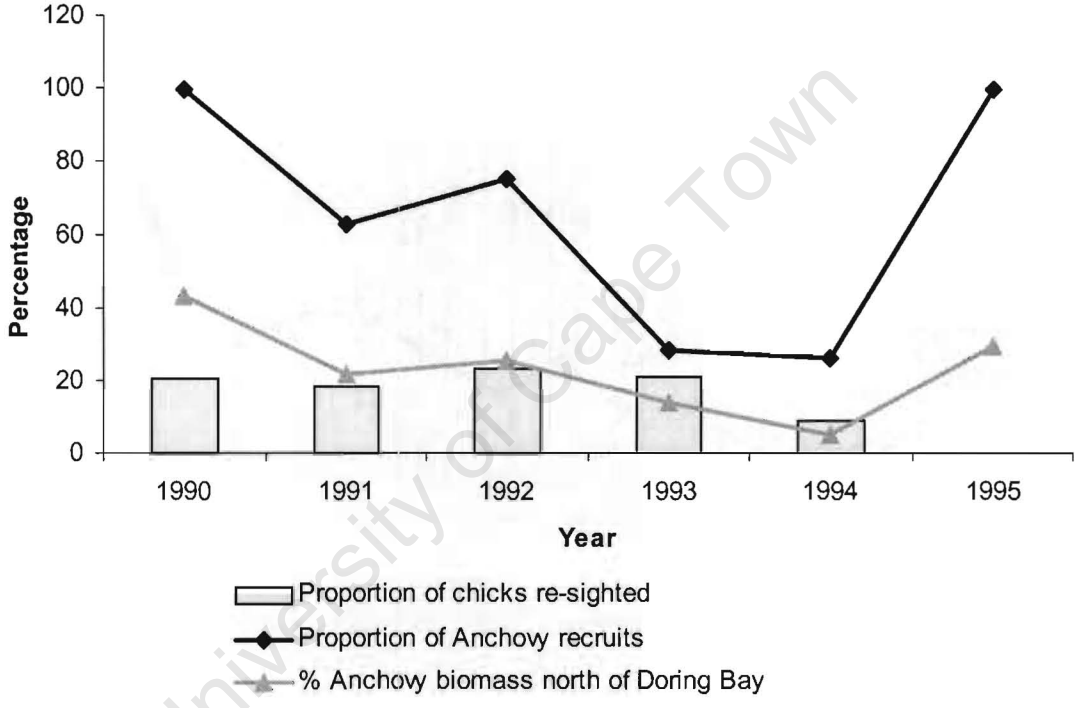


Figure 7.2 Proportion of African Penguins banded as chicks at Dassen Island, between 1990 and 1994, that were subsequently re-sighted alive, plotted alongside the proportion of recruits in the Anchovy biomass on the recruiting grounds and the percentage of total biomass found north of Doring Bay. (Anchovy data from Barange *et al.* 1999).



APPENDIX 7.1

Explanation of abbreviations and codes used in Appendices 7.2–7.4.

Locality Codes

AGU	Agulhas
BB	The Boulders
DAS	Dassen Island
DWA	Dwarskersbos
DYI	Dyer Island
GRO	Grotto Bay
II	Ichaboe Island
JI	Jutten Island
MCD	McDugal's Bay
MYI	Mercury Island
OLI	Olifants River mouth
OMA	Omaruru River mouth
PEL	Pelican Point
RI	Robben Island
SAN	SANCCOB
S O	South of Walvis Bay
SP	Stony Point
SWP	Swakopmund Pier
TER	Terrace Bay

Activity Codes

C	with downy chick(s)
D	found dead
E	incubating egg(s)
I	injured/sick
L	loafing
M	moulting
O	oiled
P	present
R	returning from sea
S	at empty nest site
U	pre-moult condition
X	other

Rehabilitation (Rehab.) status

0 = not rehabilitated
1 = oiled, cleaned and released
2 = rehabilitated but not oiled
3 = rehabilitated, no further details

The area codes, e.g. area A, area B, referred to under the "Comments" column in Appendices 7.2–7.4, represent names assigned to discreet areas of penguin colonies by Marine and Coastal Management, and are used principally for monitoring and census purposes. For those relating to Dassen Island see Crawford *et al.* (1997).

APPENDIX 7.2

Re-sightings of hand reared orphan chicks from Dassen Island released in 1994. The first line for each bird, in bold, represents the ringing date and locality. Codes are explained in Appendix 7.1.

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S20006	**1994**	**7**	**2**	**DAS**	**2**		
S20006	1996	9	18	DAS	2	L	on beach, area B
S20006	1996	9	27	DAS	2	L	on beach, area B
S20006	1996	10	31	DAS	2	L	loafing on shore, Area B
S20006	1996	11	3	DAS	2	L	loafing on beach, House Bay (Area A)
S20006	1997	3	6	DAS	2	L	on beach, area B
S20006	1997	6	10	DAS	2	L	with mate in burrow, area B
S20006	1997	9	24	DAS	2	L	on beach, area B
S20006	1997	11	26	DAS	2	L	on beach, area G
S20006	1998	1	6	DAS	2	L	on beach, area B
S20006	1998	1	7	DAS	2	L	on beach, area B
S20006	1998	2	13	DAS	2	E	incubating 1 in nestbox, area B
S20006	1998	7	27	DAS	2	L	on beach, area B
S20006	1998	8	31	DAS	2	L	on beach, area B
S20006	1999	1	25	DAS	2	L	with mate in nestbox, area B
S20006	1999	2	13	DAS	2	L	with mate in nestbox, area B
S20006	1999	2	25	DAS	2	E	incubating 2 in nestbox, area B
S20006	1999	5	3	DAS	2	E	incubating 2 in nestbox, area B
S20006	1999	5	12	DAS	2	C	with 2 downy young in nestbox BH14
S20006	1999	5	31	DAS	2	C	with 2 downy young in nestbox BH14
S20019	**1994**	**7**	**2**	**DAS**	**2**		
S20019	1995	10	12	RI	2	L	juvenile on beach, Area C.
S20021	**1994**	**7**	**2**	**DAS**	**2**		
S20021	1994	9	24	OLI	2	D	found dead
S20023	**1994**	**7**	**2**	**DAS**	**2**		
S20023	1994	10	21	S O	2	D	skeleton/dried out corpse
S20032	**1994**	**7**	**2**	**DAS**	**2**		
S20032	1997	2	27	DAS	2	L	on beach, area C
S20032	1997	7	30	RI	2	S	under bushes, area E
S20032	1997	10	21	JI	2	M	on shore
S20042	**1994**	**7**	**2**	**DAS**	**2**		
S20042	1994	10	21	DAS	2	P	alive and well
S20043	**1994**	**7**	**2**	**DAS**	**2**		
S20043	1995	10	10	DAS	2	L	juvenile on beach, area F
S20048	**1994**	**7**	**2**	**DAS**	**2**		
S20048	1995	4	11	DAS	2	L	juvenile on beach, area G
S20053	**1994**	**7**	**7**	**DAS**	**2**		
S20053	1995	6	13	DAS	2	L	juvenile on beach, area G
S20054	**1994**	**7**	**7**	**DAS**	**2**		
S20054	1994	9	4	OMA	2	D	found dead. Partly eaten.
S20056	**1994**	**7**	**7**	**DAS**	**2**		
S20056	1995	7	18	DAS	2	L	juvenile on beach, area G
S20056	1995	7	25	DAS	2	L	juvenile on beach, area G
S20056	1998	9	25	DAS	2	L	on beach, area D
S20068	**1994**	**7**	**7**	**DAS**	**2**		
S20068	1995	7	18	DAS	2	L	juvenile on beach, area D
S20068	1996	3	29	RI	2	L	on beach, Area D
S20068	1996	4	25	RI	2	L	on beach, Area E
S20079	**1994**	**7**	**7**	**DAS**	**2**		
S20079	1995	5	26	II	2	P	juvenile
S20079	1996	10	15	DAS	2	L	on beach, area G
S20091	**1994**	**7**	**7**	**DAS**	**2**		

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S20091	1995	9	19	DAS	2	L	juvenile on beach, area F
S20091	1996	3	22	DWA	2	D	freshly dead
S20093	**1994**	**7**	**7**	**DAS**	**2**		
S20093	1995	6	20	DAS	2	L	juvenile on beach, area G
S20093	1995	7	18	DAS	2	L	juvenile on beach, area A
S20093	1995	8	29	DAS	2	L	juvenile on beach, area A
S20093	1996	2	14	DAS	2	L	on beach, House Bay (Area G)
S20093	1996	5	8	DAS	2	L	on beach, area D
S20093	1996	5	8	DAS	2	L	on beach, area G
S20093	1996	5	10	DAS	2	L	on beach, area D
S20093	1996	10	15	DAS	2	L	on beach, area D
S20093	1997	1	11	DAS	2	L	on beach, area D
S20093	1997	1	23	DAS	2	M	on beach, area D
S20093	1997	11	12	DAS	2	L	on beach, area E
S20093	1998	4	14	DAS	2	L	on beach, area F
S20098	**1994**	**7**	**7**	**DAS**	**2**		
S20098	1999	6	1	DAS	2	M	in burrow, area B
S20106	**1994**	**7**	**8**	**DAS**	**2**		
S20106	1996	1	26	DAS	2	L	on beach, Area G
S20113	**1994**	**7**	**8**	**DAS**	**2**		
S20113	1996	7	30	DAS	2	L	on beach, area D
S20113	1996	8	7	DAS	2	L	on beach, area D
S20116	1994	7	8	DAS	2		
S20116	1999	4	27	DAS	2	L	on beach, area B
S20124	**1994**	**7**	**8**	**DAS**	**2**		
S20124	1995	9	12	DAS	2	L	juvenile on beach, area D
S20124	1996	6	19	DAS	2	L	on beach, Limekiln
S20124	1997	10	13	DAS	2	L	on beach, area E
S20124	1997	11	12	DAS	2	L	on beach, area E
S20124	1997	12	17	DAS	2	L	on beach, area E
S20124	1998	6	2	DAS	2	E	incubating 2 in burrow, area F
S20124	1999	6	13	DAS	2	E	incubating 2 in burrow, area F
S20131	**1994**	**7**	**8**	**DAS**	**2**		
S20131	1999	3	5	DAS	2	L	on beach, area G
S20142	**1994**	**7**	**8**	**DAS**	**2**		
S20142	1995	8	8	DAS	2	L	juvenile on beach, area G
S20155	**1994**	**7**	**9**	**DAS**	**2**		
S20155	1995	9	8	AGU	2	O	oiled. Taken to SANCCOB
S20166	**1994**	**7**	**9**	**DAS**	**2**		
S20166	1995	5	1	II	2	P	juvenile
S20172	**1994**	**7**	**9**	**DAS**	**2**		
S20172	1996	10	2	DAS	2	L	on beach, area A
S20172	1996	12	18	DAS	2	U	on beach, area A
S20172	1996	12	27	DAS	2	M	on beach, area A
S20172	1997	1	2	DAS	2	L	on beach, area A
S20172	1997	5	17	DAS	2	L	on beach, area F
S20173	**1994**	**7**	**9**	**DAS**	**2**		
S20173	1995	9	12	DAS	2	L	juvenile on beach, area G
S20173	1995	9	19	DAS	2	L	juvenile on beach, area A
S20173	1996	3	20	DAS	2	L	on beach, area G
S20173	1996	4	17	DAS	2	L	on beach, area G
S20173	1996	5	8	DAS	2	L	on beach, area G
S20173	1996	9	18	DAS	2	L	on beach, area G
S20173	1997	1	2	DAS	2	M	on beach, area G
S20173	1997	5	1	DAS	2	L	on beach, area G
S20173	1998	1	29	DAS	2	L	on beach, area C
S20173	1998	2	10	DAS	2	L	on beach, area C
S20175	**1994**	**7**	**9**	**DAS**	**2**		

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S20175	1998	2	21	DAS	2	L	in burrow, area G
S20183	**1994**	**7**	**9**	**DAS**	**2**		
S20183	1995	9	19	BB	2	P	present
S20196	**1994**	**7**	**9**	**DAS**	**2**		
S20196	1999	2	1	DAS	2	E	incubating 1 in burrow, area G
S20213	**1994**	**7**	**13**	**DAS**	**2**		
S20213	1994	10	20	MCD	2	D	dead about a week
S20251	**1994**	**7**	**15**	**DAS**	**2**		
S20251	1999	4	22	DAS	2	L	on beach, area B
S20269	**1994**	**7**	**15**	**DAS**	**2**		
S20269	1999	3	22	DAS	2	L	on beach, area G
S20292	**1994**	**7**	**15**	**DAS**	**2**		
S20292	1997	1	10	DAS	2	L	on beach, area B
S20292	1997	1	23	DAS	2	M	on beach, area B. Near end of moult
S20292	1998	5	29	DAS	2	I	on beach, area D. Seal bite wound on abdomen
S20292	1998	5	31	DAS	2	D	euthanased at SANCCOB. Deep shark? wound
S20308	**1994**	**7**	**16**	**DAS**	**2**		
S20308	1994	11	5	PEL	2	D	freshly dead. Very thin
S20310	**1994**	**7**	**16**	**DAS**	**2**		
S20310	1996	6	26	DAS	2	L	on beach, area A
S20310	1996	9	12	DAS	2	L	on shore, Area G
S20310	1996	12	13	DAS	2	M	on beach, area G
S20310	1996	12	21	DAS	2	L	on beach, area F
S20310	1999	6	9	DAS	2	E	incubating 2 under rock, area A
S20320	**1994**	**7**	**16**	**DAS**	**2**		
S20320	1995	9	29	RI	2	L	subadult, on beach, Area C
S20330	**1994**	**7**	**16**	**DAS**	**2**		
S20330	1995	6	13	DAS	2	L	juvenile on beach, area D. Moulting on head
S20335	**1994**	**7**	**16**	**DAS**	**2**		
S20335	1995	5	31	RI	2	P	alive and well
S20338	**1994**	**7**	**16**	**DAS**	**2**		
S20338	1996	3	28	RI	2	L	on beach, Area D
S20338	1996	5	21	RI	2	L	on beach, Area D
S20339	**1994**	**7**	**16**	**DAS**	**2**		
S20339	1995	9	5	DAS	2	L	juvenile on beach, area G
S20339	1996	9	18	DAS	2	L	on beach, area D
S20339	1996	10	31	DAS	2	L	loafing on beach, Whale Bay
S20339	1998	6	26	DAS	2	L	on beach, area D
S20354	**1994**	**7**	**17**	**DAS**	**2**		
S20354	1999	3	31	DAS	2	L	on beach, area G
S20371	**1994**	**7**	**17**	**DAS**	**2**		
S20371	1997	10	22	DAS	2	L	on beach, area B
S20371	1999	6	12	DAS	2	E	incubating 1 on surface, area D
S20375	**1994**	**7**	**17**	**DAS**	**2**		
S20375	1996	10	9	RI	2	L	on beach, Area C
S20378	**1994**	**7**	**17**	**DAS**	**2**		
S20378	1994	9	17	GRO	2	D	freshly dead.
S20381	**1994**	**7**	**17**	**DAS**	**2**		
S20381	1996	8	7	DAS	2	L	on beach, area A
S20381	1996	8	14	DAS	2	L	on beach, area A
S20392	**1994**	**7**	**17**	**DAS**	**2**		
S20392	1996	8	14	DAS	2	L	on beach, area G
S20392	1996	10	2	DAS	2	L	on beach, area G
S20392	1997	5	1	DAS	2	L	on beach, area G
S20405	**1994**	**7**	**19**	**DAS**	**2**		
S20405	1996	10	9	DAS	2	L	on beach, area G
S20405	1997	5	4	DAS	2	E	incubating 2 in burrow, area G
S20406	**1994**	**7**	**19**	**DAS**	**2**		

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S20406	1996	3	20	DAS	2	L	on beach, area G
S20406	1996	8	20	DAS	2	L	on beach, area G
S20410	**1994**	**7**	**19**	**DAS**	**2**		
S20410	1995	9	6	DAS	2	L	juvenile on beach, area D
S20428	**1994**	**7**	**19**	**DAS**	**2**		
S20428	1995	7	18	DAS	2	L	juvenile on beach, area D
S20428	1995	8	1	DAS	2	L	juvenile on beach, area D
S20432	**1994**	**7**	**19**	**DAS**	**2**		
S20432	1995	5	16	DAS	2	L	juvenile Area G
S20432	1995	5	17	DAS	2	L	juvenile loafing on rocks, area G
S20432	1995	9	29	RI	2	L	on beach, Area E
S20435	**1994**	**7**	**19**	**DAS**	**2**		
S20435	1995	3	28	DAS	2	L	juvenile on beach, area A
S20435	1995	8	1	DAS	2	L	juvenile on beach, area A
S20437	**1994**	**7**	**19**	**DAS**	**2**		
S20437	1994	10	15	DAS	2	P	released alive. (ring removed)

APPENDIX 7.3

Re-sightings of naturally fledged chicks that were banded at nests on Dassen Island in 1994. The first line for each bird, in bold, represents the ringing date and locality. Codes are explained in Appendix 7.1.

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S14361	**1994**	**4**	**12**	**DAS**	**0**		
S14361	1997	4	29	DAS	0	C	with 1 downy young in burrow, area B
S14378	**1994**	**4**	**12**	**DAS**	**0**		
S14378	1995	3	8	DAS	0	L	juvenile on beach, area F
S14378	1996	1	31	DAS	0	U	pre-moult on beach, Area G
S14378	1996	2	14	DAS	0	L	on beach, House Bay (Area G)
S14392	**1994**	**4**	**12**	**DAS**	**0**		
S14392	1995	10	11	RI	0	L	on beach, Area E
S14392	1996	1	25	DAS	0	L	on beach, House Bay (Area G)
S14392	1996	5	23	DAS	0	L	on beach, area D
S14398	**1994**	**4**	**12**	**DAS**	**0**		
S14398	1996	1	28	DAS	0	L	loafing in colony, Area D
S14399	**1994**	**4**	**12**	**DAS**	**0**		
S14399	1994	12	12	DAS	0	L	juvenile on beach, area F
S14400	**1994**	**4**	**12**	**DAS**	**0**		
S14400	1994	12	26	DAS	0	L	juvenile on beach, area A
S14406	**1994**	**4**	**12**	**DAS**	**0**		
S14406	1996	10	23	DAS	0	L	on beach, area A
S14406	1996	11	22	DAS	0	L	on beach, area B
S14406	1997	1	10	DAS	0	M	on beach, area A
S14418	**1994**	**4**	**12**	**DAS**	**0**		
S14418	1996	1	30	DAS	0	L	on west beach, Area A
S14418	1996	7	10	DAS	0	L	on beach, area A
S14418	1996	11	28	DAS	0	L	on beach, area A
S14418	1997	1	16	DAS	0	L	on beach, area A
S14418	1997	1	30	DAS	0	M	on beach, area A. Near end of moult
S14418	1998	11	19	DAS	0	L	on beach, area A
S14420	**1994**	**4**	**12**	**DAS**	**0**		
S14420	1998	7	18	DAS	0	C	with 2 downy young under piece of wood, area A (east)
S14420	1998	9	3	DAS	0	L	on beach, area A
S14420	1998	10	23	DAS	0	R	House Bay, area A
S14420	1999	3	11	DAS	0	L	in colony, area I
S14420	1999	6	1	DAS	0	C	with 2 downy young under wood in front of jetty, area A
S14430	**1994**	**4**	**12**	**DAS**	**0**		
S14430	1996	1	28	DAS	0	M	moulting on beach, Whale Bay
S14430	1996	8	20	DAS	0	L	on beach, area D
S14444	**1994**	**4**	**12**	**DAS**	**0**		
S14444	1995	4	18	DAS	0	M	juvenile on beach, area A
S14444	1996	2	27	DAS	0	M	moulting on west shore, Area A
S14444	1996	5	27	RI	0	L	on beach, Area D
S14444	1996	10	3	DAS	0	L	on beach, area A
S14444	1996	10	9	DAS	0	L	on beach, area A
S14444	1997	2	12	DAS	0	M	on beach, area A
S14444	1998	6	22	DAS	0	L	on beach, area B
S14444	1999	3	15	DAS	0	L	on beach, area B. Clear cut on back of neck, fresh
S14444	1999	3	22	DAS	0	L	on beach, area B. Wound healed well.
S14450	**1994**	**4**	**12**	**DAS**	**0**		
S14450	1997	12	2	DAS	0	L	on beach, area A
S14450	1998	4	14	DAS	0	L	on beach, area B
S14452	**1994**	**4**	**12**	**DAS**	**0**		
S14452	1994	7	3	SWP	0	D	freshly dead

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S14489	**1994**	**4**	**12**	**DAS**	**0**		
S14489	1997	11	12	DAS	0	L	on beach, area G
S14492	**1994**	**4**	**12**	**DAS**	**0**		
S14492	1996	10	3	DAS	0	L	on beach, area D
S14492	1997	4	27	DAS	0	L	on beach, area B
S14498	**1994**	**4**	**12**	**DAS**	**0**		
S14498	1995	10	13	RI	0	L	on beach, Area C
S14498	1996	11	13	DAS	0	L	loafing on beach, West bay
S14498	1996	11	14	DAS	0	L	loafing on shore, area A (west)
S14498	1997	12	25	DAS	0	L	on beach, area B
S14500	**1994**	**4**	**12**	**DAS**	**0**		
S14500	1996	11	8	DAS	0	X	allo-preening with mate on rock, Whale Bay
S14500	1997	2	10	RI	0	M	near end of moult, on beach area C
S14500	1998	9	4	DAS	0	C	with 1 downy young under rock, area G
S14500	1999	2	1	DAS	0	E	incubating 2 under rock, area G
S14500	1999	4	8	DAS	0	L	on beach, area G
S14500	1999	4	16	DAS	0	L	on beach, area G
S14500	1999	5	25	DAS	0	E	incubating 2 under rock, area G
S14500	1999	6	8	DAS	0	E	incubating 2 under rock, area G
S18756	**1994**	**3**	**26**	**DAS**	**0**		
S18756	1997	1	30	DAS	0	L	on beach, area E
S18764	**1994**	**3**	**26**	**DAS**	**0**		
S18764	1995	1	23	DAS	0	L	juvenile on beach, area B
S18764	1995	1	30	DAS	0	M	juvenile on beach, area B
S18764	1996	1	17	DAS	0	L	on beach, Area B
S18764	1996	11	9	DAS	0	L	loafing on beach, House Bay (Area A)
S18764	1996	12	12	DAS	0	L	on beach, area A
S18764	1997	1	30	DAS	0	M	on beach, area B
S18764	1997	12	10	DAS	0	L	on beach, area A
S18764	1998	5	21	DAS	0	L	with mate under jetty, area G
S18764	1998	8	28	DAS	0	L	on beach, area A
S18764	1998	9	3	DAS	0	L	on beach, area A
S18764	1998	10	14	DAS	0	M	on beach, area B
S18764	1998	10	21	DAS	0	L	under jetty area A/G
S18764	1999	6	3	DAS	0	C	with 2 downy young under jetty
S18764	1999	6	4	DAS	0	C	with 2 large downy young under jetty
S18771	**1994**	**3**	**26**	**DAS**	**0**		
S18771	1994	5	20	N.S	0	D	red tide poisoning?
S18776	**1994**	**3**	**26**	**DAS**	**0**		
S18776	1996	5	15	DAS	0	L	on beach, area A
S18776	1996	10	3	DAS	0	L	on beach, area A
S18776	1996	11	9	DAS	0	L	loafing on shore, area A (west)
S18776	1997	3	23	DAS	0	L	in colony, area A (west)
S18776	1997	10	26	DAS	0	U	on west shore, area A
S18776	1997	11	12	DAS	0	L	on beach, area A
S18776	1998	12	9	DAS	0	L	on beach, area A
S18776	1999	4	27	DAS	0	L	on beach, area A
S18799	**1994**	**3**	**26**	**DAS**	**0**		
S18799	1996	11	13	DAS	0	L	loafing on beach, West bay
S18799	1997	10	17	DYI	0	L	in colony
S18799	1998	2	4	DAS	0	L	on beach, area A
S18799	1998	8	26	DAS	0	L	on beach, area A
S18799	1999	4	27	DAS	0	L	on beach, area A
S18808	**1994**	**3**	**26**	**DAS**	**0**		
S18808	1996	5	15	DAS	0	L	on beach, area G
S18808	1996	6	4	DAS	0	L	loafing on shore, Area G
S18808	1996	6	13	DAS	0	L	loafing on shore, Area G
S18808	1996	9	15	DAS	0	L	on shore, area G

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S18816	**1994**	**3**	**26**	**DAS**	**0**		
S18816	1996	6	4	DAS	0	L	loafing on shore, Area G
S18826	**1994**	**3**	**26**	**DAS**	**0**		
S18826	1996	9	3	DAS	0	L	on beach, area A
S18834	**1994**	**3**	**26**	**DAS**	**0**		
S18834	1995	3	28	DAS	0	M	on beach, area G
S18851	**1994**	**3**	**26**	**DAS**	**0**		
S18851	1996	9	27	DAS	0	L	on beach, area A
S18862	**1994**	**3**	**26**	**DAS**	**0**		
S18862	1996	10	9	RI	0	L	on beach, Area D
S18865	**1994**	**3**	**26**	**DAS**	**0**		
S18865	1995	10	24	DAS	0	L	on beach, area D
S18865	1996	9	18	DAS	0	L	on beach, area D
S18865	1997	1	5	DAS	0	M	on beach, area D
S18865	1998	1	21	DAS	0	L	on beach, area B
S18865	1998	6	22	DAS	0	L	on beach, area B
S18865	1998	10	25	DAS	0	L	on shore, area B
S18870	**1994**	**3**	**26**	**DAS**	**0**		
S18870	1996	1	30	DAS	0	M	moulting on beach, House Bay (Area A)
S18870	1996	6	18	DAS	0	L	on beach, House Bay (Area G)
S18871	**1994**	**3**	**26**	**DAS**	**0**		
S18871	1996	1	17	DAS	0	L	on beach, Area A
S18879	**1994**	**3**	**26**	**DAS**	**0**		
S18879	1997	6	4	DAS	0	L	on beach, area A
S18907	**1994**	**3**	**27**	**DAS**	**0**		
S18907	1994	6	26	MYI	0	D	very thin
S18932	**1994**	**3**	**27**	**DAS**	**0**		
S18932	1995	1	10	DAS	0	L	juvenile on beach, area F
S18932	1995	11	22	DAS	0	L	on beach, area F
S18932	1996	8	14	DAS	0	L	on beach, area D
S18932	1996	12	27	DAS	0	M	on beach, area D
S18932	1997	7	8	DAS	0	L	on beach, area G
S18932	1998	2	6	DAS	0	L	in burrow, area G
S18932	1998	4	28	DAS	0	L	in burrow, area G
S18932	1998	9	28	DAS	0	L	in burrow, area G
S18932	1998	11	3	DAS	0	M	on beach, area G
S18932	1998	11	8	DAS	0	M	on beach, area G
S18932	1999	5	10	DAS	0	C	With 1+ downy young in burrow, area G
S18957	**1994**	**3**	**27**	**DAS**	**0**		
S18957	1995	8	30	SAN	0	O	released 13/10/95, Walker Bay
S18963	**1994**	**3**	**27**	**DAS**	**0**		
S18963	1995	9	21	TER	0	D	skeleton/dried out corpse
S18981	**1994**	**3**	**27**	**DAS**	**0**		
S18981	1995	3	28	DAS	0	M	on beach, area B
S18989	**1994**	**3**	**27**	**DAS**	**0**		
S18989	1995	3	3	II	0	M	juvenile
S18995	**1994**	**3**	**27**	**DAS**	**0**		
S18995	1996	5	23	DAS	0	L	on beach, area E
S18995	1996	10	10	DAS	0	L	on beach, area D
S18995	1996	12	21	DAS	0	M	on beach, area D
S18995	1997	4	27	DAS	0	L	on beach, area F
S18995	1997	6	4	DAS	0	L	on beach, area D
S18995	1998	10	21	DAS	0	L	on beach, area G
S18995	1999	2	20	DAS	0	L	on beach, area G
S18999	**1994**	**3**	**27**	**DAS**	**0**		
S18999	1995	2	7	DAS	0	M	on beach, area D

APPENDIX 7.4

Re-sightings of hand reared orphan chicks from Dyer Island released in 1995. The first line for each bird, in bold, represents the ringing date and locality. Codes are explained in Appendix 7.1.

Band number	Year	Month	Day	Locality	Rehab. Status	Activity	Comments
S20455	**1995**	**8**	**18**	**DYI**	**2**		
S20455	1996	10	15	DAS	2	L	juvenile on beach, area G
S20455	1996	10	29	DAS	2	L	juvenile loafing on shore, Area G
S20465	**1995**	**8**	**25**	**DYI**	**2**		
S20465	1996	12	12	DAS	2	M	juvenile on beach, area A
S20465	1996	12	19	DAS	2	L	on beach, area A
S20465	1997	10	25	DAS	2	L	on beach, House Bay, area G
S20465	1997	12	10	DAS	2	M	on beach, area A
S20465	1999	2	16	DYI	2	L	in colony
S20465	1999	9	28	DYI	2	L	in colony
S20465	1999	10	1	DYI	2	L	in colony
S20470	**1995**	**8**	**25**	**DYI**	**2**		
S20470	1999	4	2	SP	2	L	on edge of colony (LGU)
S20474	**1995**	**8**	**25**	**DYI**	**2**		
S20474	1996	11	27	DYI	2	M	juvenile starting to moult on shore
S20474	1997	9	11	DYI	2	L	per A.Venter
S20474	1998	11	11	DYI	2	L	in colony
S20478	**1995**	**9**	**25**	**DYI**	**2**		
S20478	1997	5	20	DAS	2	L	in burrow, area A
S20478	1997	7	25	DYI	2	O	re-released at Robben Island, 25/09/95
S20487	**1995**	**10**	**5**	**DYI**	**2**		
S20487	1996	11	23	DAS	2	M	juvenile on beach, area G
S20487	1997	7	30	RI	2	L	on beach, area D
S20487	1999	9	28	DYI	2	U	by mortuary.
S20487	1999	9	29	DYI	2	M	in heavy moult by mortuary
S20487	1999	10	2	DYI	2	M	on shore, by mortuary
S20487	1999	10	8	DYI	2	M	moult nearly complete on shore, zone 8
S20487	1999	10	10	DYI	2	L	moult complete on shore, zone 7/8
S20491	**1995**	**10**	**5**	**DYI**	**2**		
S20491	1999	9	27	DYI	2	L	in colony
S20491	1999	10	4	DYI	2	L	in colony, zone 3
S20492	**1995**	**10**	**5**	**DYI**	**2**		
S20492	1999	9	27	DYI	2	L	in colony
S20493	**1995**	**10**	**5**	**DYI**	**2**		
S20493	1999	4	13	BB	2	X	allo-preening with mate
S20493	1999	7	8	BB	2	P	above Foxy Beach
S20493	2000	2	8	BB	2	E	incubating 2 eggs
S20493	2000	5	6	BB	2	E	incubating 2 eggs
S20493	2000	7	13	BB	2	C	with 1 chick
S20493	2000	7	27	BB	2	L	by Willis Walk
S20493	2000	8	8	BB	2	P	Foxy Beach

CHAPTER EIGHT

REHABILITATION OF OILED AFRICAN PENGUINS

8.1 INTRODUCTION

The first documented oiling incident to affect seabirds in southern Africa occurred in November 1948 when the American tanker *Esso Wheeling* was wrecked thirty miles from Dyer Island (Green 1950). The closure of the Suez Canal in 1967 forced oil tankers en route to Europe from the Persian Gulf to take the route around the southern tip of Africa (Westphal & Rowan 1970, Frost *et al.* 1976, Underhill *et al.* 1999). The subsequent increase in shipping traffic off the coast of southern Africa inevitably led to an increase in oiling incidents. South Africa has experienced more catastrophic oiling events than any other country in the Southern Hemisphere (Williams *et al.* in prep.). The estimated loss of oil by shipping in South African waters during the period 1968 to 1978 alone was 200 000 tonnes (Cloete 1979). Catastrophic oiling occurs as the result of accidents, e.g. ships sinking, colliding or running aground. In addition to this, there is a persistent chronic oiling (Crawford 1998b), due mainly to vessels discharging waste oil and cleaning out their tanks at sea (Westphal & Rowan 1970, Morant *et al.* 1981). A list of some of the oiling incidents that have affected African Penguins in South Africa is presented in Table 8.1.

Oil has a severely detrimental effect on seabirds, causing the breakdown of water repellent and insulative properties of the plumage (Moldan & Westphal 1994, Crawford *et al.* 2000a). As a result, the birds are unable to remain at sea to forage and will eventually die of hypothermia or starvation if not rescued and treated (Moldan & Westphal 1994). Oil ingested during preening can cause ulceration of various tissues and lead to anaemia if it is absorbed into the blood stream (Birrel 1995, Crawford *et al.* 2000a). It is therefore important to treat oiled birds as soon as possible if they are to have a reasonable chance of survival.

An enhanced degree of chronic oil pollution and four major crises in 1968 (Westphal & Rowan 1970) resulted in the establishment of the Southern African Foundation for Conservation of Coastal Birds (SANCCOB) in Cape Town (Morant *et al.* 1981, Underhill *et al.* 1999). SANCCOB's work of rescuing, treating and releasing sick,

injured and oiled seabirds began at the Newlands home of its founder, Mrs Althea Westphal, before moving to premises in Wetton (Moldan & Westphal 1994). In 1983, SANCCOB moved to its present premises beside Rietvlei lagoon, Milnerton, where it has facilities to treat about 3000 birds (E. Augustyn pers. comm.).

Since its inception in 1968, SANCCOB has treated more than 45 000 oiled African Penguins (Whittington 2001). Details of the cleaning procedures for oiled birds are given by Randall *et al.* (1980). At least 13 600 African Penguins that had been oiled and cleaned were flipper-banded and released by SANCCOB between 1 January 1970 and 31 December 1998. By fitting penguins with purpose-designed stainless steel flipper bands (Jarvis 1970, Cooper & Morant 1980) it has been possible to follow the fortunes of those birds after release, and to assess the degree of success with which oiled birds can be rehabilitated and restored to the wild population. In this context, a rehabilitated bird is one that has been cleaned, released and that has survived in the wild for a month or more. When the bird has been recorded breeding it is said to have been restored to the wild population (Underhill *et al.* 1999, Williams *et al.* in prep.).

Frost *et al.* (1976) expressed doubt as to whether cleaning oiled African Penguins contributed to their conservation in real terms and considered that the dangers posed to the African Penguin population by oil spills had been exaggerated. Randall *et al.* (1980) pointed out that the numbers of penguins that had been cleaned, released and potentially rehabilitated by SANCCOB prior to 1980, exceeded the number found on 10 of the 27 island breeding colonies. They considered that large-scale cleaning of oiled African Penguins did serve a conservation function. Morant *et al.* (1981) stated that SANCCOB's success with rehabilitation of oiled African Penguins was without precedent anywhere in the world.

Proportions of oiled birds treated by SANCCOB that have been released back to the wild have varied between 38% and 97% (Morant *et al.* 1981, Whittington 2000b). The average release rate, based on eight oiling incidents between 1968 and 1974, was 65% of birds treated (Frost *et al.* 1976, Randall *et al.* 1980), and for the period 1970 to 1980 the overall release rate was 54% (Morant *et al.* 1981). Proportions of released birds that were subsequently re-sighted in the wild varied between 15% and 84%, for eight major oiling incidents between 1970 and 1979 (Morant *et al.* 1981). This

variation was due to differences in both the area and nature of the breeding localities and in the intensity of search efforts. The sinking of the *Apollo Sea* in 1994 caused the worst oiling incident in South Africa up to that time, in terms of numbers of African Penguins that were oiled, and presented a major opportunity to carry out a systematic post-release follow-up of cleaned African Penguins on a large scale; this opportunity was grasped (Underhill *et al.* 1999). This study documents the follow-up of the *Apollo Sea* survivors over a period of five years, from August 1994 up to the end of July 1999. The rehabilitation success of victims of a chronic oil spill near Dyer Island in 1995 (Table 8.1) is also considered, along with that of the 547 penguins released after the Cape Town Harbour spill in 1998. Observations of flipper-banded African Penguins oiled in incidents prior to 1994 allowed an assessment of longevity of cleaned, oil spill victims to be made.

Five years and three days after the *Apollo Sea* sank, the MV *Treasure*, another bulk ore carrier, broke free while being towed out to sea from Cape Town and sank about 16 km to the north of Robben Island (Cheney 2000, Crawford *et al.* 2000a). Although spilling less fuel than the *Apollo Sea* had done, the position of the wreck, between Dassen and Robben Islands, by then the largest and third largest African Penguin colonies, and the uncharacteristically calm weather, which failed to break up the resulting oil slick, caused the oiling of over 19 000 African Penguins, the worst incident to affect southern Africa to date. Approximately 14 825 oiled penguins were collected from Robben Island, 3516 from Dassen Island and about 500 from other localities, mostly in the Saldanha Bay area (Crawford *et al.* 2000a).

8.2 METHODS

Details of the *Apollo Sea* incident and the subsequent rescue and treatment of oiled African Penguins can be found in Dehrmann (1994), Erasmus (1995), Underhill *et al.* (1999) and Williams, A.J. (1995). Of the 10 000 penguins oiled and taken to SANCCOB's rescue centre, about 8000 were caught at Dassen Island and approximately 1500 at Robben Island (Dehrmann 1994). A total of 4076 cleaned, flipper-banded African Penguins comprising 3488 birds in adult plumage and 348 juveniles, was released between 26 July and 11 September 1994, following the *Apollo Sea* disaster (Underhill *et al.* 1999). No age was recorded on the banding schedules of

the remaining 240 birds. A total of 3562 penguins was released at Silwerstroomstrand, but the majority of the juvenile birds was released at Robben Island. A further 88 penguins were released at Langebaan. The numbers of released birds that were originally transported from Dassen and from Robben Islands are not known.

Of the 1332 penguins oiled at Dyer Island in 1995 (Underhill *et al.* 1999), 578 were fitted with flipper-bands prior to release (the remainder being released without bands). These comprised 313 in adult plumage, 81 juveniles and 184 of unrecorded age. Most were released from Walker Bay, Hermanus, although at least 26 were released on Robben Island, in September and October 1995.

A total of 563 African Penguins was affected by an oil spill created when a pipeline fractured in Cape Town Harbour in May 1998 (Whittington 2000b). They were taken to SANCCOB's rescue station from Robben Island (477), Dassen Island (71), Jutten Island (4) and The Boulders (8) along with single birds from each of three mainland sites. A total of 535 was released, 534 with flipper-bands, mostly at Melkbosstrand (33° 43′ S 18° 26′ E) (Whittington 2000b), opposite Robben Island, in June and July 1998. Of these, 473 were in adult plumage, 58 were juveniles and the age was not recorded for the remaining three birds.

A number of penguins already fitted with flipper-bands were oiled in each of the above incidents. These birds are treated separately in this paper and are not included in the above totals. The death or removal of oiled adults for rehabilitation during the *Apollo Sea* and Dyer Island oil spills caused the abandonment of nests and many chicks were effectively orphaned. Attempts were made to hand raise over 500 of these chicks and 487 were later released back to the wild (Gildenhuys 1995). These orphaned chicks are not included in this analysis but form the subject of Chapter Seven.

Four searches were made for penguins coming ashore on the beaches from 10 km south of Silwerstroomstrand to Yzerfontein (33° 21′ S 18° 09′ E), during and shortly after the period in which penguins were being released (Underhill *et al.* 1999). Most of the data used in this analysis was collected between August 1994, when intensive

searches for flipper-banded penguins began at both Dassen and Robben Islands, and October 1999. At Robben Island, a thorough search throughout the breeding area was made on an approximately quarterly basis and was supplemented with evening searches on the shore for banded birds. Staff of Marine and Coastal Management recorded all flipper-banded birds seen during fortnightly moult counts and during monitoring visits to long term nest study sites (Underhill *et al.* 1999). Staff of Western Cape Nature Conservation Board collected sightings of flipper-banded African Penguins at Dassen Island on an almost daily basis throughout the study period. These were supplemented by researchers from Marine and Coastal Management and the Avian Demography Unit and volunteers, who undertook thorough searches for flipper-banded penguins during short visits to the island. Searches for banded penguins were made at Dyer Island and at the islands around Saldanha Bay on an average of three to four times a year, usually in February, May and October, and to The Boulders on an approximately quarterly basis. Searches for banded birds were also made at Stony Point, Bird and St Croix Islands in Algoa Bay, and at Ichaboe Island, Namibia. Of the 27 African Penguins colonies, at least two (Hollams Bird Island and Sylvia Hill, both in Namibia), were not visited during the study period. Other colonies, such as the four small islands in Algoa Bay and the other unmanned islands in Namibia, were visited infrequently. Occasional sightings of flipper-banded birds and details of banded birds that were found dead by members of the public were reported to the South African Bird Ringing Unit (SAFRING).

The number of oil spill survivors and the proportion of those released that were re-sighted alive in subsequent years after each spill were plotted for the three oiling incidents. The numbers of birds recovered dead were compared with the expected mortality, based on estimated annual survival and reporting rates. Expected numbers of penguins that would be found dead and reported to SAFRING by members of the public were calculated assuming a reporting rate of 2.33% and an annual mortality rate of 15% (see Underhill *et al.* 1999). The number of dead penguins that we would expect to be reported by the public a year after release would thus be N x 0.15 x 0.0233, where N is the number of penguins released. For the second year after release it would be N x 0.85 x 0.15 x 0.0233 and so on for subsequent years. Numbers of oiled penguins that had been cleaned, released and re-sighted were compared with the numbers banded and released in each year between 1970 and 1998. Mean and median

ages at last live re-sighting or when recovered dead were computed and compared with those of non-oiled penguins that had been banded as adults.

Using the estimated annual mortality rate of 15% for adults and one of 65% for first year birds (see Chapter Six), an estimate was made of the number of survivors from the three oil spills that were still alive in each year from 1994 to 1999. The mortality rate for birds in their second and subsequent years was assumed to be the same as that of adults (Randall 1983, see Chapter Six). The numbers of survivors from the three spills were summed to give an estimate of the total number of birds alive in each year. By dividing the number of oil spill survivors that were actually re-sighted in each of those years by the total of birds that were estimated to be alive, a rough estimate of the intensity of follow-up was made.

8.3 RESULTS

There was no correlation between the amount of oil entering the sea during an oil spill incident and the numbers of penguins that were oiled as a result (Table 8.1, Figure 8.1). A major problem resulting from both the *Apollo Sea* and *Treasure* oil spills was that oil covered the landing beaches used by penguins on both Robben and Dassen Islands. These two spills resulted in the largest numbers of oiled birds ever recorded in South Africa.

8.3.1 *African Penguins involved in the Apollo Sea oil spill, June 1994.*

Searches of mainland beaches during and shortly after the release period of *Apollo Sea* victims failed to find any penguins, either dead or alive (Underhill *et al.* 1999). By July 1999, the Avian Demography Unit's database contained 22 429 sightings of 2962 survivors of the *Apollo Sea* oil spill, 73% of the 4076 that were released with flipper-bands (Table 8.2). Re-sightings were made at 14 of the 27 extant penguin colonies between Mercury Island in Namibia and Bird Island in Algoa Bay, South Africa (Table 8.3). The majority of re-sightings were made at Dassen Island (90%) and Robben Island (9%). If the number of birds re-sighted is taken into account, the result is similar: 83% of the birds re-sighted were seen at Dassen Island and 20% were re-sighted at Robben Island (Table 8.4). The sum of these proportions exceeds 100% because many of the penguins were seen at more than one locality. In addition, 115

penguins (4% of the total re-sighted) were seen at colonies other than Robben and Dassen Islands. Breeding was recorded at seven of these localities, six within the Western Cape, and one at Bird Island, Algoa Bay, in the Eastern Cape (Table 8.4). The latter bird was a juvenile when oiled and almost certainly a chick from Bird Island that was undertaking post-fledging dispersal (see Chapter Two). Seven colonies between St Croix and Ichaboe Islands were visited by penguins that were breeding or resident at other colonies (Table 8.5). S21288 visited Dyer Island at a time when it was known to be breeding at Dassen Island, and was presumably foraging in the area. Sixteen penguins were found oiled again, within a year of their release after the *Apollo Sea* incident, at colonies other than Robben and Dassen Islands (Table 8.5). Fourteen of these were found at Dyer Island, five of which were known to be breeding birds from Dassen Island, and a further four had been recorded at Dassen Island on several previous occasions. The bird oiled at The Boulders was also known to have bred at Dassen Island (Table 8.5).

Sixty-two percent of the total number of birds that were re-sighted, equivalent to 45% of all flipper-banded birds released, were first seen within a year of their release (Table 8.6, Figure 8.2). At least 1097 penguins (27% of those released and 37% of those re-sighted) were known to have survived into their fifth year following release (Figure 8.2). These numbers and proportions represent the minima known to have survived. It is certain that other banded birds, which are still alive, have evaded detection by researchers. To illustrate this point, five birds that were first re-sighted at Dassen Island in 1995 were not recorded there again until after 31 July 1998, two of them at nests. It is possible that these birds had been wandering between colonies and then returned to Dassen Island to breed, or they may simply have been overlooked. Also, a juvenile bird that was oiled in the *Apollo Sea* spill and banded as S23236 was seen at Mercury Island, in Namibia, in November 1995 (Y. Chesselet *in litt.*). It then went unrecorded until 2 April 1999 when it was seen at Stony Point, Betty's Bay, South Africa (L.G. Underhill *in litt.*). On 28 May 1999 it was incubating two eggs at the latter locality (J.H. Hofmeyr *in litt.*) After five years of intensive monitoring work, previously unrecorded *Apollo Sea* survivors were still being found; a further six banded penguins were seen for the first time, between 1 August and 20 October 1999, at Robben and Dyer Islands (pers. obs).

Of the 4076 flipper-banded penguins released, 67 (1.6%) had been found dead and reported to SAFRING by the end of June 1999. Thirty-seven of these were found within one year of release (Underhill *et al.* 1999). Thirty of the birds were re-sighted alive in the first instance and subsequently found dead. Out of the total of 67 penguins that were found dead, 36 were reported by researchers who were doing follow-up work on the oil spill. The remaining 31 penguins were found by members of the public or nature reserve staff. The expected numbers of reported recoveries were similar to the actual numbers reported in the first two years and greater than those reported in the latter three years (Table 8.7). If the birds found dead by research teams are also included the number found in the first year exceeds the expected value. In the second year the total of recoveries is just above the expected number but matches it in the third year. The numbers of recoveries in the fourth and fifth years following release are below the expected values. Nine penguins were found dead during the first moult after release due to gangrene poisoning, caused by flipper-bands having been fitted too tightly. They did not allow for expansion of the flipper during moult and caused wounds to develop, which became gangrenous. This increased the total number of deaths found by research teams in the first year after the spill but was not a direct consequence of the birds dying as a result of oiling. Consequently, careful searches were made for other penguins with bands that were too tight and the total of nine that was found dead is believed to reflect the entire extent of this problem. However, as a precaution, 61 poorly fitted bands were removed and the penguins re-released. Subsequent monitoring of those 61 individuals was thus no longer possible but the number involved is 1.5% of the total banded and is considered too small to make complex adjustments for.

By the end of July 1999, a total of 1629 *Apollo Sea* survivors (40% of those released) had been recorded breeding. The breeding productivity of these birds at Dassen Island has been the subject of research carried out by staff of the Western Cape Nature Conservation Board (Wolfaardt & Williams 2000). All but 24 of the birds were recorded breeding at Dassen (80%) and Robben (19%) Islands (Table 8.4).

The 10 000 penguins oiled in the *Apollo Sea* incident included 240 that had been flipper-banded prior to the oil spill. Ninety-one of the 240 birds (38%) died as a result of being oiled. Table 3 of Underhill *et al.* (1999) gives summarised banding details for

215 of these birds. Banding localities indicated that some penguins from almost the entire range of the species had been affected by the oil spill and included ten breeding colonies between Bird Island, Algoa Bay, South Africa in the east and Ichaboe Island, Namibia in the north (Table 8.8). The total included seven penguins that had been previously treated, although not oiled, by SANCCOB and 29 survivors from previous oil spills. However, 61% had been banded on either Robben Island or on Dassen Island, the two colonies worst affected by the spill. Of the 126 penguins whose breeding or natal colony was known, 106 (84%) were from Dassen or Robben Islands (Table 8.8). Of the 149 penguins that did not die during treatment, twelve were known to have had their bands removed before release. Subsequent to the presumed release of the remaining 137 penguins, 68 (50%) were seen at breeding colonies, 32 (23%) of them breeding. Of those birds that were re-sighted, 60 (88%) were at either Robben or Dassen Islands, including all but one of the breeding birds (Table 8.9). One penguin that had been released at Robben Island after being oiled in a previous spill, and was oiled for the second time in the *Apollo Sea* incident, was found breeding at Vondeling Island. Two of the five birds banded as chicks at Ichaboe Island returned there. One bird that was banded as a chick at Robben Island was found dead in West Coast National Park, just over a year after its release.

8.3.2 *African Penguins involved in the chronic oiling incident at Dyer Island, August 1995.*

A total of 979 re-sightings of 233 penguins, 40% of those released, had been made by October 1999, four years after the release of the flipper-banded survivors. These related to 160 adults, 15 juveniles and 58 birds of unrecorded age (Table 8.2). Re-sightings were made at eight breeding colonies from Algoa Bay in the east to Saldanha Bay in the north (Table 8.10). The majority of re-sightings (83%) were made at Dassen Island with 8% coming from Dyer Island and 7% from Robben Island. In terms of numbers of individual birds re-sighted, 72% were seen at Dassen Island, 15% at Dyer Island and 12% at Robben Island (Table 8.11) It would appear from subsequent re-sightings that three of the six birds recorded at Jutten Island settled there and were probably birds from that colony. The same is true of the bird seen at Vondeling Island. Penguin S14607 showed an interesting pattern of movements, appearing at Dyer Island 20 days after its release from Walker Bay on 1 October 1995 and then at Bird Island, Algoa Bay, 19 days later. It was present at Bird

Island in January 1996 before returning to Dyer Island, where it was loafing in the breeding colony in 1997 and 1999. Another of the three penguins to be recorded at Bird Island, Algoa Bay, probably originated from that colony because it was seen allopreening with a mate in the fourth year following its release (Table 8.11).

Sixty-six percent of the total number of birds re-sighted up until 20 October 1999, equivalent to 26% of those released, were first seen within a year of their release (Table 8.6, Figure 8.3). The pattern of re-sightings over time was similar to that of re-sightings of birds from the *Apollo Sea* oil spill (Figure 8.2), but the proportion of those released that were seen again was considerably less. Eighty-two birds (14% of those released and 35% of the total re-sighted) were known to have survived into their fourth year after release (Figure 8.3). One bird, which was taken back to SANCCOB from The Boulders over a year after its release, had its flipper-band removed and could not be further monitored.

Of the 578 flipper-banded penguins released, four (0.7%) had been recovered dead by October 1999, two within a year of their release. Three were re-sighted alive prior to their being recovered dead. Two of the four penguins were reported by researchers and the other two by members of the public. Using reporting and survival rates of 2.33% and 85% respectively, the expected number of recoveries of dead birds was close to that actually observed (Table 8.7).

A total of 69 of the re-sighted individuals were recorded breeding, 12% of the flipper-banded birds that were released. No attempt was made to assess the breeding productivity of these penguins. Breeding was recorded at four different penguin colonies (Table 8.11). Most of the birds recorded breeding (75%) were at Dassen Island, with 17% recorded at Robben Island and 4% at Dyer Island.

An additional 67 penguins that were already fitted with flipper-bands were oiled in this incident. Fifteen of these penguins were found oiled at localities other than Dyer Island. Two were found at Robben Island, seven at Dassen Island, two at The Boulders and one each at Cape Town (33° 54′ S 18° 25′ E), Stony Point, Blombosstrand (34° 24′ S 21° 12′ E) and Cape Columbine (32° 51′ S 17° 53′ E).

Attempts to catch five of these were unsuccessful so they did not get sent to SANCCOB. Four of those five birds, all victims of the *Apollo Sea* oil spill, were seen oiled at Dassen Island, ranging from 20% to 60% covered by oil (A.C. Wolfaardt pers. comm.). Two of these four bred later in the same year and in each of the following three years. One bred the following year and was present until at least December 1998 and the fourth bird was seen alive in each year following the oil spill.

The 62 flipper-banded penguins that were caught and sent to SANCCOB came from a variety of breeding colonies between Mercury Island, Namibia, and Bird Island, Algoa Bay (Table 8.12). The "home" colony was determined as that at which the penguin bred, was observed at on a number of occasions or, in the case of birds banded as chicks, the natal colony. Twenty-nine of the 62 birds (47%) were from Dassen Island. All eleven of the penguins from Bird Island, Algoa Bay were post-fledged chicks, banded in May 1995. Thirty-three of the penguins had been oiled before, 31 of them in the *Apollo Sea* incident. Twelve of the 62 penguins had their flipper-bands removed before being re-released, including four of the *Apollo Sea* survivors, which prevented further monitoring of those birds. Of the 50 penguins assumed to have been re-released with their flipper-bands, 19 (38%) were subsequently re-sighted, seven of them breeding. They included 14 birds previously oiled in the *Apollo Sea* incident, six of which were subsequently found breeding. Penguin S0575 was originally rehabilitated when a juvenile, although it had not been oiled, and was released on Robben Island on 26 September 1989. It was seen at Dassen Island in March 1994 and was then oiled at Robben Island in the *Apollo Sea* spill. Following release, it returned to Dassen Island where it was found oiled again in August 1995. After its third period of treatment by SANCCOB, it was again seen at Dassen Island, breeding successfully in 1996 and attempting breeding the following year.

8.3.3 *African Penguins involved in the Cape Town Harbour oil spill.*

A total of 270 survivors from this oil spill (50% of those released) had been re-sighted alive by June 1999, one year after their release. This had increased to 311 (58%) by 20 October 1999 (Table 8.2, Figure 8.4). Re-sightings were made at six breeding colonies between Jutten Island, Saldanha Bay, in the north and Dyer Island in the east (Table 8.13). Most re-sightings were made at Dassen Island (51%) and Robben Island

(44%), the two colonies most severely affected by the oil spill. Fifty-three percent of the number of birds re-sighted was seen at Dassen Island and 55% at Robben Island (Table 8.14). Sums of proportions exceed 100% because 40 penguins were observed at more than one locality.

The pattern of cumulative re-sightings over time was similar to that of both the *Apollo Sea* and Dyer Island oil spills (Figures 8.2 to 8.4, Table 8.6). At this stage it is unclear whether penguins re-sighted at colonies other than Robben and Dassen Islands were visiting or were breeders from those colonies. One bird, originally re-sighted at Dassen Island, moulted at Jutten Island before returning to Dassen Island again, where it was seen in a burrow with its mate.

Two of the 535 penguins released (0.4%) were found dead, one at Dassen Island and the other at Robben Island. Both were found within six months of their release during routine monitoring by researchers. The expected number of recoveries that would be reported to SAFRING by members of the public within a year of release was 535 x 0.15 x 0.0233 = 2 (Table 8.7).

A total of 23 of the released penguins (4%) had been recorded breeding after 16 months had elapsed following their release. Sixteen of these birds (70%) were breeding at Robben Island, six (26%) at Dassen Island and one at The Boulders (Table 8.14). The latter bird was one of eight penguins found oiled at that locality.

An additional 13 penguins that already bore flipper-bands were oiled in the Cape Town Harbour incident. All were found oiled at Robben Island and, after cleaning, were subsequently released. Nine had been banded at Robben Island, four of them as chicks and five in adult plumage. One bird had previously been oiled at The Boulders and, after cleaning, was released at Robben Island in January 1998. The remaining four birds had also been victims of the *Apollo Sea* oil spill. Two of the latter four were known to have bred at Robben Island and one had last been seen at Dassen Island. The fourth bird (S24611) was breeding at Robben Island when oiled. It was seen with its two chicks, which its mate had continued to raise in its absence, the day after its release (R.J.M. Crawford *in litt.*). A similar instance took place after the *Apollo Sea* oil spill in 1994 (Underhill *et al.* 1999, Whittington 2000b). Six of the 13 penguins

were re-sighted after being released, all at Robben Island. Three were recorded breeding and one seen with its mate. One of the breeding birds had been flipper-banded as a chick at Robben Island in July 1993 (Whittington 2000b), and was recorded breeding for the first time at the age of 5 years and 7 months.

8.3.4 *Intensity of re-sighting effort*

The combined totals of survivors of the three oil spills that were re-sighted reached a peak in 1995–96 then decreased until 1998–99 (Table 8.15). The proportions of those birds estimated to be alive that were re-sighted in each year ranged between 45% and 56% and peaked in the years 1995–1997 (Table 8.15). The mean and median proportion of birds that were re-sighted annually was 51%.

8.3.5 *African Penguins involved in the Treasure oil spill.*

An unprecedented number of over 19 000 African Penguins was oiled in the *Treasure* spill in June 2000 (Crawford *et al.* 2000a), including 496 birds that were already flipper-banded prior to being oiled. Of these, the breeding or natal colony was known for 306 birds. Penguins from 13 different colonies were affected (Table 8.16, Figure 8.5). A total of 247 penguins (81%) was known to be from Robben Island and 30 (10%) from Dassen Island. Of the 496 flipper-banded birds oiled, 231 (47%) had been treated by SANCCOB before, 189 (38%) of them having been oiled. The latter group included 87 victims of the *Apollo Sea* spill, seven that were also oiled at Dyer Island in 1995 and 46 survivors of the Cape Town Harbour spill. Four penguins oiled in the *Treasure* spill had already been oiled earlier in the same year and had been released just three days before the *Treasure* sank (Whittington 2000a). The oldest penguin of known age to be affected was at least 17 years old and had been oiled, cleaned and released in 1984. It had been seen at a nest site with its mate on Robben Island 16 days prior to the sinking of the *Treasure.* Its mate was a survivor of the *Apollo Sea* spill (Whittington 2000a).

8.3.6 *Longevity of oiled African Penguins released after cleaning.*

In addition to the survivors of the three oil spills detailed in this chapter, a number of flipper-banded survivors from other oil spills were also seen alive at breeding colonies or eventually recovered dead. This provides some information on the longevity of

these birds after cleaning and release. Between 1970 and 1998, a total of 13 600 penguins was oiled, cleaned and released with flipper-bands. In addition, 71 penguins that had been flipper-banded at breeding colonies were oiled, cleaned, released and subsequently re-sighted in the wild or recovered dead. Information on live re-sightings and dead recoveries for 5151 of these birds (38%) was found in the Avian Demography Unit database (Table 8.17). There were also sightings of 41 penguins cleaned and released in 1999. Excluding the 88 penguins whose bands were known to have been removed, the mean age of the remaining 5104 birds at the most recent sighting or date of recovery was 1134 days (3.1 years) and the median age was 1005 days (2.8 years). A total of 545 birds (11%) was known to have survived for five years or more after release and 121 (2%) survived for ten years or more (Table 8.18). The oldest oil spill survivor was re-sighted alive 23 years after release (Table 8.19). It was banded as an adult. As African Penguins take from 12–22 months to attain adult plumage (Randall 1989), it would have been at least 24 years old when last seen and is the longest lived oiled bird that has been rehabilitated back into the wild to date (A.J. Williams pers. comm., Whittington *et al.* 2000b).

Of the total of 36 850 African Penguins that was banded at breeding colonies between 1970 and 1998, 5812 (16%) were seen alive at breeding colonies or eventually recovered dead. There were also sightings of 152 penguins banded in 1999. Excluding 22 penguins whose bands were removed, 71 that were oiled and subsequently seen again in the wild and 51 birds for which no banding data were available, a total of 5820 penguins was obtained (5812 + 152 – 144). The 71 birds that were oiled were excluded because they had undergone the rehabilitation procedure at some point in their life, and could not, therefore, be considered as part of the "control" group. The mean age of the remaining 5820 birds at the most recent sighting or date of recovery was 1552 days (4.25 years), and the median age was 1367 days (3.74 years). A total of 2051 penguins (35%) was recorded over five years and 358 (6%) over 10 years from banding (Table 8.18). Because all of the penguins that had been oiled and cleaned were banded as adults or as juveniles, the comparison is more meaningful if the "control" group is limited to birds banded as adults or juveniles at breeding colonies and excludes those banded as chicks. This changes the mean age at the most recent sighting or date of recovery to 1447 days (3.97 years) and the median age to

1111 days (3.04 years). The number of penguins recorded over five years from banding was 644 (34%) and over 10 years from banding was 131 (7%) (Table 8.18).

8.4 DISCUSSION

The degree of damage to African Penguins that is caused by marine oil pollution is influenced more by where the oil is spilt, rather than the quantity that escapes (Morant *et al.* 1981, Table 8.1, Figure 8.1). Although the collision between the two oil tankers *Venpet* and *Venoil* resulted in 31 000 tonnes of oil entering the sea, its effect on African Penguins was less severe than the 2 400 tonnes spilt by the bulk ore carrier, *Apollo Sea*, or the 1400 tonnes spilt by the *Treasure*. This was probably because the site of the collision was over 100 km from the nearest penguin colonies in Algoa Bay and 520 km from Dyer Island, the nearest colony to the west. The site was also some distance from the main foraging grounds of penguins from Algoa Bay, which seems to be in the waters around Cape Recife (Heath & Randall 1989). In contrast, the *Apollo Sea* sank about 25 km southwest of Dassen Island, which was then the second largest African Penguin colony (Crawford *et al.* 1995c), and 60 km north-west of Robben Island. Oil washed ashore on both islands (Dehrmann 1994, Underhill *et al.* 1999) and would therefore have entered the foraging grounds of birds from both colonies.

Underhill *et al.* (1999) considered that few penguins oiled in the *Apollo Sea* spill of 1994 died at sea, on mainland beaches or at breeding colonies, but that most came ashore alive and were taken to SANCCOB's cleaning facilities in Cape Town. There are no records of penguin casualties at Dyer Island resulting from the chronic oil spill there in 1995, and no dead, oiled penguins were found after the Cape Town Harbour oil spill in 1998 (Whittington 2000b). About 150 of over 19000 African Penguins, oiled as a consequence of the sinking of the *Treasure* in June 2000, were thought to have died in the wild (Crawford *et al.* 2000a). This evidence indicates that oiled penguins do come ashore alive and that the numbers collected and taken to the rehabilitation centres are a fair reflection on the numbers of birds involved in each spill. Oiled penguins do not usually attempt to return to natal or to breeding colonies but go ashore at the nearest colony to the point of oiling (Tables 8.8, 8.12 and 8.16).

The large proportion of penguins re-sighted alive over the five years following the *Apollo Sea* oil spill suggests that the majority of birds were successfully rehabilitated to the wild. The proportion of birds released that had been re-sighted alive a year after the Cape Town Harbour oil spill, was slightly above that at a similar stage following the *Apollo Sea* incident (Table 8.6). There is reason, therefore, to assume that the penguins released from this spill will probably rehabilitate equally successfully.

The proportion of birds re-sighted following the chronic oil spill around Dyer Island was, however, considerably lower. Dyer Island receives less monitoring than either Robben or Dassen Islands, the two colonies worst affected by the *Apollo Sea* and Cape Town Harbour spills. This would reduce the number of penguins that were subsequently likely to be re-sighted. However, Dyer Island is a relatively small and open island when compared with Robben and Dassen Islands, and has considerably fewer penguins to search through than either of those colonies. Even with relatively infrequent monitoring, it might be expected that most of the cleaned birds returning to the colony would have been recorded at some stage within the four years following their release. Another factor to consider is the fact that most of the penguins involved in the Dyer Island spill were from Dassen Island, the colony receiving the highest intensity of monitoring work during the period following the spill. The Dyer Island spill actually occurred within the period of most intensive follow-up work after the *Apollo Sea* spill. It may be that the birds from the Dyer Island spill returned to areas of Dassen Island that received less regular monitoring, therefore reducing the number of birds that were re-sighted. Another factor that may have contributed to the lower numbers of penguins re-sighted from this incident is the relatively high predation pressure from Cape Fur Seals *Arctocephalus pusillus pusillus* around Dyer Island (pers. obs, A.Venter pers. comm.). Seals were estimated to be killing 8.7% of the Dyer Island penguin population in 1995 and 1996 (Marks *et al.* 1997). However, the most likely explanation is that fewer birds made the transition back to living in the wild after release. The difference in the proportions of birds re-sighted in these incidents highlights the need to continue flipper-banding birds prior to their release from rehabilitation centres and to continue post-spill monitoring work.

In each of the three oiling incidents described, the majority of cleaned birds that was subsequently re-sighted was seen for the first time within a year of the birds' release,

although in the case of the Cape Town Harbour spill, data for only one whole year were available for analysis. The pattern of re-sightings was much the same in each case, showing a rapid rise in the numbers of birds seen during the first year after release, then a gradual levelling off (Figures 8.2 to 8.4). Monitoring was at its most intensive during 1995 and 1996, which is reflected in the steepness of the curves for birds seen in those years (Figures 8.2 and 8.3, Table 8.15). In 1997, there were periods when there were gaps in the monitoring schedules. This will have reduced the rate of re-sightings during that year and explains the reduced slope for birds observed after July and September 1997 in Figures 8.2 and 8.3 respectively. Although monitoring appeared to reach a peak of intensity in 1995 and 1996, the proportions of penguins estimated to be alive that were re-sighted in each year were similar and differed by a maximum of 11% (Table 8.15). On average, 50% of the penguins estimated to be alive in each year were re-sighted by observers.

A minimum of 37% of the penguins re-sighted after the *Apollo Sea* and 35% of those re-sighted after the Dyer Island oil spills were known to have survived into their fifth and fourth years respectively, following their release. This confirms that the oil spill survivors did not just appear at breeding colonies and die soon afterwards, but that they survived for some considerable time after their release. Penguins from the *Apollo Sea* oil spill were still being recorded for the first time at breeding colonies in the sixth year after their release. It is certain that some penguins from this and other spills, especially those at colonies where monitoring intensity is low, have yet to be seen and the figures presented here are an underestimate of the rehabilitation success.

Proportions re-sighted of penguins banded in adult plumage and those of unknown aged birds (most of which were probably adults) were greater than the proportions of juveniles that were seen. This is not unexpected, because the annual mortality rate of African Penguins in their initial year of life is greater than that of adults (Randall 1983, 1989, Chapter Six). Many were likely to have been undertaking post-fledging movements so may have spent much of their time at sea or may have returned to breeding colonies that did not receive intensive monitoring, thus reducing the chances of their being re-sighted. The relatively large proportion of juveniles seen after the Cape Town Harbour oil spill may have been due to the fact that a period of intensive monitoring began immediately after the first birds were released (Whittington 2000b).

Although eight of the juvenile penguins from this spill were seen within a week of release, the mean time that elapsed between release and re-sighting of the 26 birds was 135 days. Proportions of birds that were found dead showed little difference between the age groups (Table 8.2).

The database provides some information on the colonies of origin of the penguins involved in each of the three oil spills. The *Apollo Sea* spill, which oiled the largest number of penguins in southern Africa up until June 2000, affected birds from the largest number of breeding colonies. These colonies spanned most of the breeding range of the species and constituted 52% of all known breeding colonies. Between 1970 and 1999, flipper-bands were placed on African Penguins at 19 (70%) of the 28 extant colonies. Life histories of the birds already banded at the time of oiling and subsequent sightings of penguins banded prior to their release were investigated. They revealed that most of the penguins affected by the spill were from Robben and Dassen Islands, the two colonies where the oil was known to have washed ashore. The Cape Town Harbour spill impacted on a much smaller number of penguins and re-sightings after release suggested that only birds from within the southwestern Cape had been affected by it. As in the *Apollo Sea* oil spill, most of the birds seemed to be from Robben and Dassen Islands, the two localities from which 97% of the oiled birds were collected. The chronic oil spill around Dyer Island in 1995 shows a different pattern. Penguins from a similar range of colonies to those in the *Apollo Sea* spill were affected (Tables 8.4, 8.8, 8.11 and 8.12). The penguins from the Algoa Bay colonies that were oiled were known to have been largely wandering birds in their first year, but the majority of birds affected were from colonies within the Western Cape. Unlike the other two incidents, most of the penguins that were oiled were not from the island where they were found oiled (Dyer Island), but were from Dassen Island. This is a strong indication that penguins from Dassen Island may forage in the waters around Dyer Island, 211 km to the south and east, even during breeding attempts at Dassen Island.

The findings from post-release monitoring of penguins affected by the Dyer Island oil spill have important implications when it comes to the release of cleaned African Penguins. Most of the penguins oiled by this spill were released from Walker Bay, which is about 35 km from Dyer Island. It was assumed that most of the penguins

would return to Dyer Island where they had been found oiled. Because most of these birds returned to Dassen Island, they were effectively transferred to a point 175 km from their colony. Releases of birds oiled in the Cape Town Harbour spill were made from Melkbosstrand on the mainland, about 25 km from SANCCOB's seabird rescue centre. This had no adverse impact on the time taken by the penguins to return to breeding colonies, some reaching nearby Robben Island within two and a half hours of release (Whittington 1998, 2000b). In the interest of reducing transportation of penguins to a minimum, thus reducing stress placed upon the birds and keeping costs down, it seems preferable to release birds as close to the rehabilitation centre as possible. Although a penguin is found oiled at a particular breeding colony it may be from another colony (e.g. Tables 8.8, 8.12 and 8.16), and many will not return to the locality at which they were found oiled after release. This means that long road journeys to a release point close to the point of collection are unnecessary and undesirable. Following the *Treasure* oil spill in July 2000, all releases, barring the first one, were made from Woodbridge Island (33° 52′ S 18° 29′ E), about 9 km from SANCCOB's rescue centre at Rietvlei and about 7 km from the satellite station at Salt River, where most of the birds were housed.

The numbers of flipper-banded penguins that were reported dead following release were similar or less than the numbers that would be expected from an equivalent number of non-oiled African Penguins. If rehabilitation had been unsuccessful, a larger number of flipper-banded penguins than the expected totals would have been recovered after release, with a large proportion being found soon after release. The localities where oiled penguins were released and returned to were nearly all close to centres with a high density of human habitation, and the chances of large numbers of dead, flipper-banded penguins going unreported are slim. This is a further indication that the rehabilitation of cleaned penguins was successful (Underhill *et al.* 1999). In contrast, Sharp (1996) found that for three species of North American seabirds the time that elapsed between ringing and death was 5–100 times less for birds that had been oiled, cleaned and released than for non-oiled birds. The median time between banding and death for the oiled, cleaned and released birds was less than 10 days, indicating that the birds had not made the transition back to the wild.

Proportions of cleaned African Penguins that were recorded breeding and thus restored to the wild population (Underhill *et al.* 1999, Williams *et al.* in prep.), varied between 4% in the Cape Town Harbour spill and 40% of those released after the *Apollo Sea* spill. These are minimum figures because some of the breeding birds were missed by observers. The small proportion recorded in the first mentioned incident was based on only one year's data but compares with a proportion of 14% of *Apollo Sea* survivors recorded breeding in the first year after release. The difference may be due to the fact that breeding study areas at Dassen Island were sited in areas where large numbers of oiled birds were collected during the *Apollo Sea* oil spill (A.C. Wolfaardt pers. comm.). The Cape Town Harbour spill birds that returned to Dassen Island may have bred in areas of the island that received less intensive monitoring. The majority of penguins (99%) recorded breeding after release from the *Apollo Sea* oil spill was found at Robben and Dassen Islands, whereas only 4% of those oiled in the Dyer Island spill in 1995 were subsequently found breeding at that locality. Most of the penguins oiled in the latter spill (92%) were found breeding at Dassen and Robben Islands, the two colonies receiving the most intensive monitoring effort. All of the penguins oiled in the Cape Town Harbour oil spill that were subsequently recorded breeding were at colonies from which penguins affected by the spill had been collected. Breeding studies at Dassen Island in the two years following the *Apollo Sea* oil spill showed that during the spring and summer months, the oil spill victims bred equally successfully as penguins that had not been oiled. However, in autumn and winter there were some instances of cleaned birds having a lower breeding success and producing chicks that fledged at lower masses than those of birds that had not been affected by the oil spill (Nel 1996, Williams *et al.* in prep., A.C. Wolfaardt pers. comm.). These instances were restricted to times when feeding conditions were assumed to be poor (Nel 1996, Williams *et al.* in prep.). At other times there was no discernible difference between the breeding performances of the two groups of penguins. Subsequent studies over the following three years did not reveal any difference in breeding success between de-oiled penguins and those that had not been oiled (A.C. Wolfaardt *in litt.*)

Re-sightings of released African Penguins provided evidence of the resilience of these birds to handling and treatment. Fourteen penguins, oiled in both the *Apollo Sea* and Dyer Island oil spills, were subsequently re-sighted, six of them breeding. The

African Penguin with flipper-band S0575 was a veteran of three visits to SANCCOB's seabird rescue centre, two as a result of oiling, and was known to have bred successfully after its third release. There are two documented instances of cleaned penguins returning to nests with chicks within a day of their release (Underhill *et al.* 1999, Whittington 2000b). In both cases, one adult had continued to raise the chicks alone, in the absence of its oiled partner.

Evidence provided by penguins involved in oil spills prior to 1994 shows that African Penguins can survive for long periods after release, over 20 years in one case. Four cleaned penguins aged 15 years or older were recorded breeding, the oldest being at least 17.5 years old (Table 8.19). The large proportion of oiled birds, when compared to that of non-oiled penguins, that were re-sighted or recovered dead was probably due to the intensity of monitoring following the *Apollo Sea* oil spill. This spill accounted for 58% of the total number of oiled birds that had been re-sighted or recovered dead. Proportions of released penguins that were re-sighted were largest in the years 1992–1998 (Table 8.17). This was almost certainly due to the intensity of searches for flipper-banded penguins, which began in August 1994. Mean and median ages at last recorded re-sighting or recovery were approximately one year greater for non-oiled penguins than for birds that had been oiled and cleaned. The discrepancies were reduced if birds banded as chicks were excluded but remained higher than the mean and median ages recorded for oiled penguins. Larger proportions of non-oiled penguins than cleaned birds were reported both over five and over ten years from banding. These proportions were unaffected when birds banded as chicks were excluded. This apparent difference in survival is probably explained by the fact that the majority of oiled penguins (53%) were released after January 1992 and relatively few could therefore be recorded over five years or more after release. In contrast, 72% of non-oiled penguins were banded prior to 1992, increasing the likelihood of these penguins being recorded at older ages. More detailed comparisons of the survival of non-oiled and cleaned penguins are made in Chapters Six and Nine.

The *Treasure* oil spill represents another opportunity to assess the success of rehabilitation procedures but with a much larger sample of flipper-banded birds. Over 16 000 cleaned, flipper-banded penguins were released between July and October 2000. At least 8800 of these had been re-sighted alive by the first anniversary of the

oil spill, 55% of those released (D. Oschadleus *in litt.*). This proportion compares favourably with the proportions seen at the same stage after the *Apollo Sea* and Cape Town Harbour oil spills (Table 8.6). The large sample of 496 birds that were flipper-banded prior to their being oiled in this spill provided initial information on the breeding colonies affected by the spill. Detailed life histories of many of these birds are available, resulting from the previous six years of intensive penguin monitoring, and present the first real opportunity to date to assess changes in behaviour and breeding performance of penguins before and after an oil spill.

TABLE 8.1

Selected oiling incidents affecting African Penguins between 1971 and 2000.

Name of vessel/incident	Type of incident	Locality	Year	Oil spilt (tonnes) and type	Number of penguins oiled
Esso Essen (tanker)[1]	Struck submerged object	Cape Point	1968	15 000 crude	3000
Kazimah[2]	Ran aground	Robben Island	1970	1 000	559
Wafra (tanker)[2]	Ran aground	Cape Agulhas	1971	6–10 000 crude	1 216+
Oswego Guardian/ Texanita (tankers)[1,2]	Collided	Ystervark Point	1972	10 000 crude + fuel	1600
Oriental Pioneer[2]	Ran aground	Struisbaai	1974	200 fuel	488+
Venpet/Venoil (tankers)[2]	Collided	Cape St Francis	1977	31 000 crude + fuel	47+
Pantelis A. Lemos[2]	Ran aground	Near Vondeling Island	1978	300 fuel	27
Kapodistrias (bulk carrier)[3]	Ran aground	Cape Recife	1985	1011 fuel	1180
Apollo Sea (bulk ore carrier)[4]	Sank	South-west of Dassen Island	1994	up to 2 400 fuel	*c* 10 000
Cape Town Harbour spill[5]	Burst pipeline	Cape Town Harbour	1998	150 in harbour + 5 in Table Bay	563
Unknown	Chronic	Dyer Island	1995	Unknown	1 332
Treasure (bulk ore carrier)[6]	Sank	north of Robben Island	2000	1 400 fuel	*c* 19 000

Source: [1] Moldan & Westphal 1994; [2] Morant *et al.* 1981; [3] Randall & Randall 1986b; [4] Erasmus 1995; [5] Whittington 2000b; [6] Crawford *et al.* 2000a

TABLE 8.2

Numbers of cleaned African Penguins released, re-sighted alive and recovered dead up until October 1999, following three oiling incidents.

	Adults	Juveniles	Age unrecorded	Total
Apollo Sea, 1994				
Number released	3488	348	240	4076
Number of re-sightings	21306	347	776	22429
Number of birds re-sighted alive	2754	81	127	2962
Proportion re-sighted alive (%)	79	23	53	73
Number recovered dead	62	3	2	67
Proportion recovered dead (%)	2	1	1	2
Dyer Island, 1995				
Number released	313	81	184	578
Number of re-sightings	716	46	217	979
Number of birds re-sighted alive	160	15	58	233
Proportion re-sighted alive (%)	51	19	32	40
Number recovered dead	2	0	2	4
Proportion recovered dead (%)	<1	0	<1	1
Cape Town Harbour, 1998				
Number released	473	59	3	535
Number of re-sightings	552	50	4	606
Number of birds re-sighted alive	283	26	2	311
Proportion re-sighted alive (%)	60	44	67	58
Number recovered dead	2	0	0	2
Proportion recovered dead (%)	<1	0	0	<1

TABLE 8.3

Numbers of re-sightings made at penguin breeding colonies of cleaned African Penguins that were released after the *Apollo Sea* oil spill.

Colony	Adults	Juveniles	Age unrecorded	Total
Bird Island, Algoa Bay	0	2	0	2
St Croix Island	6	1	0	7
Dyer Island	59	1	2	62
Stony Point	1	1	0	2
The Boulders	26	6	1	33
Robben Island	1778	74	76	1928
Dassen Island	19351	253	691	20295
Vondeling Island	10	0	0	10
Jutten Island	26	2	1	29
Malgas Island	1	0	0	1
Marcus Island	8	0	0	8
Possession Island	2	0	0	2
Ichaboe Island	5	1	0	6
Mercury Island	1	6	2	9
Total	21274	347	773	22394

TABLE 8.4

Numbers of cleaned African Penguins re-sighted at penguin breeding colonies and recorded breeding after the *Apollo Sea* oil spill.

	Adults		Juveniles		Age unrecorded		Total	
Colony	Seen	Breeding	Seen	Breeding	Seen	Breeding	Seen	Breeding
Bird Island, Algoa Bay	0	0	2	1	0	0	2	1
St Croix Island	4	0	1	0	0	0	5	0
Dyer Island	29	1	1	0	2	0	32	1
Stony Point	1	0	1	1	0	0	2	1
The Boulders	14	3	4	0	1	0	19	3
Robben Island	544	287	34	7	28	13	606	307
Dassen Island	2305	1233	48	15	97	49	2450	1297
Vondeling Island	9	6	0	0	0	0	9	6
Jutten Island	23	8	1	1	1	1	25	10
Malgas Island	1	0	0	0	0	0	1	0
Marcus Island	6	2	0	0	0	0	6	2
Possession Island	1	0	0	0	0	0	1	0
Ichaboe Island	5	0	1	0	0	0	6	0
Mercury Island	1	0	4	0	2	0	7	0

TABLE 8.5

Re-sightings of African Penguins oiled in the *Apollo Sea* spill at breeding colonies other than Robben and Dassen Islands. "Visiting" birds were known to be resident or to have bred elsewhere. "Probable residents" were not recorded breeding but were either observed with a mate at a potential nest site or were recorded on three or more occasions over a period of more than one year. "Status inconclusive" indicates birds that were observed once or twice only.

Colony	Visiting	Oiled	Probable resident	Confirmed breeding	Status inconclusive
Bird Island, Algoa Bay	0	0	0	1	1
St Croix Island	1	0	1	0	3
Dyer Island	1	14	6	1	10
Stony Point	0	1	0	1	0
The Boulders	7	1	2	3	6
Vondeling Island	1	0	1	6	1
Jutten Island	0	0	4	10	11
Malgas Island	0	0	0	0	1
Marcus Island	1	0	2	2	1
Possession Island	0	0	0	0	1
Ichaboe Island	2	0	0	0	4
Mercury Island	4	0	1	0	2

TABLE 8.6

Cumulative numbers of African Penguins re-sighted with time following release.

	Number released with bands	Time elapsed from release 1 year	2 years	3 years	4 years	5 years
Apollo Sea						
Number of birds	4076	1819	2608	2794	2906	2962
Proportion of those released (%)		45	64	69	71	73
Dyer Island spill						
Number of birds	578	153	198	224	233	
Proportion of those released (%)		26	34	39	40	
Cape Town Harbour spill						
Number of birds	534	270	*311			
Proportion of those released (%)		50	*58			

*Number and proportion recorded after 16 months from release

TABLE 8.7

Numbers of cleaned and released birds found dead and reported to SAFRING compared to expected numbers of reported recoveries.

	Time elapsed after release 0–1 year	1–2 years	2–3 years	3–4 years	4–5 years	Total
Apollo Sea						
Observed recoveries by members of the public	13	10	4	2	2	31
All observed recoveries (includes research teams)	33	14	10	4	6	67
Expected recoveries	14	12	10	9	7	52
Dyer Island chronic spill						
Observed recoveries by members of the public	1	0	1	0		2
All observed recoveries (includes research teams)	2	0	1	1		4
Expected recoveries	2	2	2	1		7
Cape Town Harbour spill						
Observed recoveries by members of the public	0					0
All observed recoveries (includes research teams)	2					2
Expected recoveries	2					2

TABLE 8.8

Breeding or natal colony of flipper-banded birds that were oiled in the *Apollo Sea* oil spill, June 1994.

Home colony	Number of birds
Bird Island, Algoa Bay	3
Dyer Island	5
The Boulders	1
Robben Island	42
Dassen Island	64
Vondeling Island	1
Malgas Island	1
Marcus Island	1
Possession Island	1
Ichaboe Island	7
Total	126

TABLE 8.9

Post-release sightings at penguin colonies of African Penguins that were already flipper-banded when oiled in the *Apollo Sea* spill.

Colony	Number seen	Number breeding
Robben Island	28	17
Dassen Island	37	17
Vondeling Island	1	1
Ichaboe Island	2	0

TABLE 8.10

Numbers of re-sightings made at penguin breeding colonies of cleaned African Penguins released after the Dyer Island chronic oil spill.

Colony	Adults	Juveniles	Age unrecorded	Total
Bird Island, Algoa Bay	1	0	3	4
St Croix Island	0	1	0	1
Dyer Island	42	4	28	74
The Boulders	5	5	2	12
Robben Island	54	4	14	72
Dassen Island	609	30	169	808
Vondeling Island	1	0	0	1
Jutten Island	4	2	1	7
Total	716	46	217	979

TABLE 8.11

Numbers of cleaned African Penguins re-sighted and recorded breeding after the Dyer Island chronic oil spill.

	Adults		Juveniles		Age unrecorded		Total	
Colony	Seen	Breeding	Seen	Breeding	Seen	Breeding	Seen	Breeding
Bird Island, Algoa Bay	1	0	0	0	2	0	3	0
St Croix Island	0	0	1	0	0	0	1	0
Dyer Island	20	2	1	0	13	1	34	3
The Boulders	5	0	4	0	2	0	11	0
Robben Island	19	7	2	0	6	5	27	12
Dassen Island	118	37	10	2	40	13	168	52
Vondeling Island	1	0	0	0	0	0	1	0
Jutten Island	4	2	1	0	1	0	6	2

TABLE 8.12

Colony of origin of flipper-banded birds oiled in the chronic spill around Dyer Island in August 1995.

Home colony	Number of birds
Bird Island, Algoa Bay	11
Dyer Island	4
Seal Island, False Bay	2
Robben Island	2
Dassen Island	29
Marcus Island	1
Ichaboe Island	1
Mercury Island	1
Not known	11
Total	62

TABLE 8.13

Numbers of re-sightings made at penguin breeding colonies up until October 1999, of cleaned African Penguins released after the Cape Town Harbour oil spill.

Colony	Adults	Juveniles	Age unrecorded	Total
Dyer Island	12	1	2	15
The Boulders	5	0	0	5
Robben Island	243	24	0	267
Dassen Island	285	25	2	312
Vondeling Island	2	0	0	2
Jutten Island	5	0	0	5
Total	552	50	4	606

TABLE 8.14

Numbers of cleaned African Penguins from the Cape Town Harbour oil spill that were re-sighted and recorded breeding up until October 1999.

	Adults		Juveniles		Age unrecorded		Total	
Colony	Seen	Breeding	Seen	Breeding	Seen	Breeding	Seen	Breeding
Dyer Island	9	0	1	0	1	0	11	0
The Boulders	4	1	0	0	0	0	4	1
Robben Island	156	16	16	0	0	0	172	16
Dassen Island	148	6	16	0	1	0	165	6
Vondeling Island	2	0	0	0	0	0	2	0
Jutten Island	5	0	0	0	0	0	5	0

TABLE 8.15

Intensity of re-sighting effort, expressed as the proportion of survivors from the *Apollo Sea*, Dyer Island and Cape Town Harbour spills estimated to be alive that were re-sighted in each year after their release. For *Apollo Sea* birds, a year was taken as 1 August to 31 July, for Dyer Island birds 26 September to 25 September and for Cape Town Harbour birds 10 June to 9 June.

	Annual period				
	1994–95	1995–96	1996–97	1997–98	1998–99
Estimated number of birds alive	4076	3869	3247	2760	2880
Number of birds re-sighted	1821	2177	1833	1242	1475
Proportion (%) re-sighted	45	56	56	45	51

TABLE 8.16

Colonies of origin of flipper-banded birds oiled in the *Treasure* oil spill, 2000.

Home colony	Number of birds
Bird Island, Algoa Bay	2
Dyer Island	3
Stony Point	11
The Boulders	3
Robben Island	247
Dassen Island	30
Marcus Island	1
Malgas Island	1
Jutten Island	2
Bird Island, Lambert's Bay	2
Possession Island	1
Ichaboe Island	2
Mercury Island	1
Total	306

TABLE 8.17

Numbers of oiled African Penguins that were cleaned, released and flipper-banded by SANCCOB and that were subsequently re-sighted alive or recovered dead.

Year	Number banded	Number re-sighted or found dead	Proportion re-sighted or found dead (%)	Bands subsequently removed
1970	274	5	2	
1971	811	199	25	5
1972	1229	133	11	
1973	27	4	15	
1974	368	41	11	
1975	54	3	6	
1976	0	0	0	
1977	88	14	16	
1978	47	3	6	
1979	218	7	3	
1980	50	3	6	
1981	55	5	9	
1982	278	21	8	
1983	123	6	5	
1984	555	76	14	
1985	912	129	14	1
1986	178	38	21	
1987	160	29	18	1
1988	58	11	19	1
1989	148	32	22	
1990	368	77	21	1
1991	351	82	23	1
1992	956	259	27	1
1993	158	70	44	
1994	4143	3063	74	76
1995	589	250	42	1
1996	27	9	33	
1997	552	218	39	
1998	821	364	44	
Total	13598	5151	38	88

TABLE 8.18

Numbers of oiled African Penguins cleaned by SANCCOB and penguins banded at breeding colonies that survived for various time periods after release or banding.

	Age at last re-sighting or when found dead (years)								
	0–1	1–2	2–3	3–4	4–5	5–10	10–15	15–20	>20
Number oiled and cleaned	1029	799	955	558	1218	424	113	7	1
Number banded at breeding colonies	1071	686	617	802	593	1693	248	92	18
Number banded at breeding colonies (excluding chicks)	467	279	199	201	115	513	102	21	8

TABLE 8.19

Details of the twenty oldest African Penguins that were cleaned and successfully returned to the wild. One year was added to the elapsed time after banding for birds banded as adults, as it takes at least one year for birds to attain adult plumage. Juveniles were assumed to be 6 months old when released.

Band number	Date released	Age at release	Date last reported	Age (years) when last reported	Locality	Details when last reported
P3741	26 Sep 1972	Adult	03 Oct 1995	24.0	Dyer Island	Loafing
P4055	15 Mar 1972	Adult	31 Dec 1991	20.8	Tsitsitkamma River mouth	Died within a month of finding date
G00638	13 Aug 1971	?	06 Apr 1990	>18.7	Cape Hangklip	Freshly dead
T5188	18 Jun 1982	Adult	29 Sep 1999	18.3	Dyer Island	Sitting
T4411	13 Apr 1971	Adult	23 Oct 1987	17.5	Dyer Island	With one large, downy chick
P3078	27 Jun 1972	Adult	05 Sep 1988	17.2	Dassen Island	Ring found. No carcass.
P4291	20 Sep 1972	Juvenile	11 Dec 1988	16.7	Plettenberg Bay	Found dead
T5677	07 Jul 1984	Adult	28 Aug 1999	16.1	Robben Island	Beside 3 large, downy chicks
T9316	02 Jul 1982	Adult	18 Mar 1997	15.7	Dyer Island	With mate at nest site
T6050	11 Dec 1981	Juvenile	10 Sep 1996	15.3	Marcus Island	On a nest (A. Westphal)
T9234	17 Sep 1982	Adult	26 Nov 1996	15.2	Dyer Island	Pre-moult condition, on shore
V6064	05 Oct 1984	Adult	10 Nov 1998	15.1	Dyer Island	Moulting on shore
T5584	09 Oct 1984	Juvenile	27 Mar 1999	15.0	St Croix Island	Incubating at least one egg
V6096	05 Oct 1984	Adult	25 Aug 1998	14.9	Dassen Island	With 2 downy chicks in burrow
Z2007	10 May 1985	Adult	27 Mar 1999	14.9	St Croix Island	Loafing
T9394	23 Jul 1982	Juvenile	26 Nov 1996	14.8	St Croix Island	Skeleton or dried out carcass
Z2014	14 Jun 1985	Adult	27 Mar 1999	14.8	St Croix Island	At empty nest site
G00557	07 May 1971	?	02 Jan 1986	>14.7	Struisbaai	Ring found. No carcass.
G05993	13 Aug 1971	?	12 Jan 1986	>14.4	The Boulders	Found dead
T4201	06 Apr 1971	?	28 Mar 1985	>14.0	Dyer Island	Oiled, taken to SANCCOB

Figure 8.1 Numbers of African Penguins oiled in relation to amount of oil spilt (tonnes) for 11 incidents between 1968 and 2000 in which more than 20 penguins were recorded oiled.

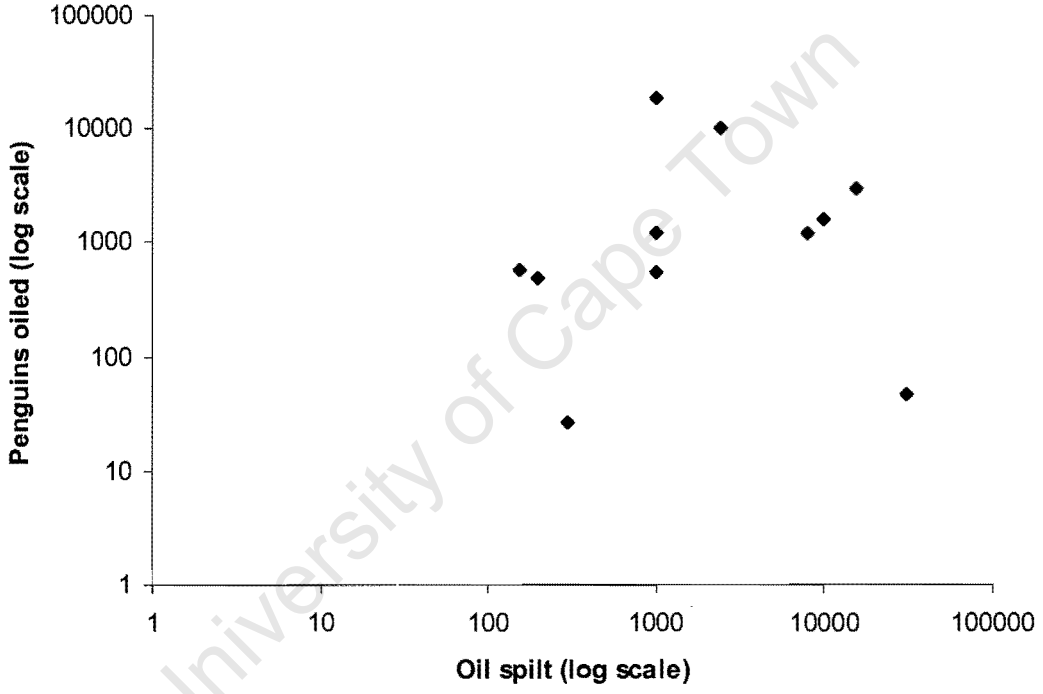


Figure 8.2 Cumulative re-sightings of banded African Penguins from the *Apollo Sea* oil spill after release (31 July 1994), after 31 July 1995, after 31 July 1996, after 31 July 1997 and after 31 July 1998. The left most line provides the overall cumulative re-sighting totals commencing from the time of release. The line labelled "after 31 July 1995" shows birds that survived for at least one year after release.

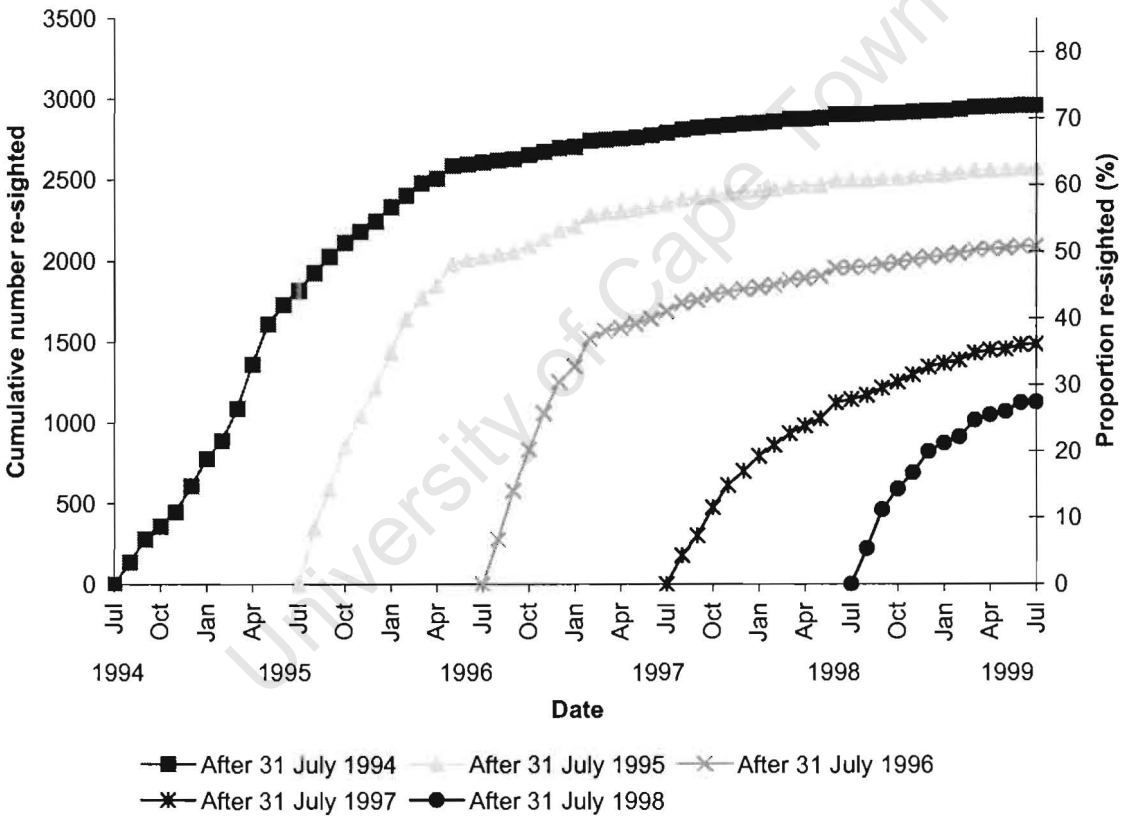


Figure 8.3 Cumulative re-sightings of banded African Penguins from the Dyer Island chronic oil spill after release (20 September 1995), after 20 September 1996, after 20 September 1997 and after 20 September 1998.

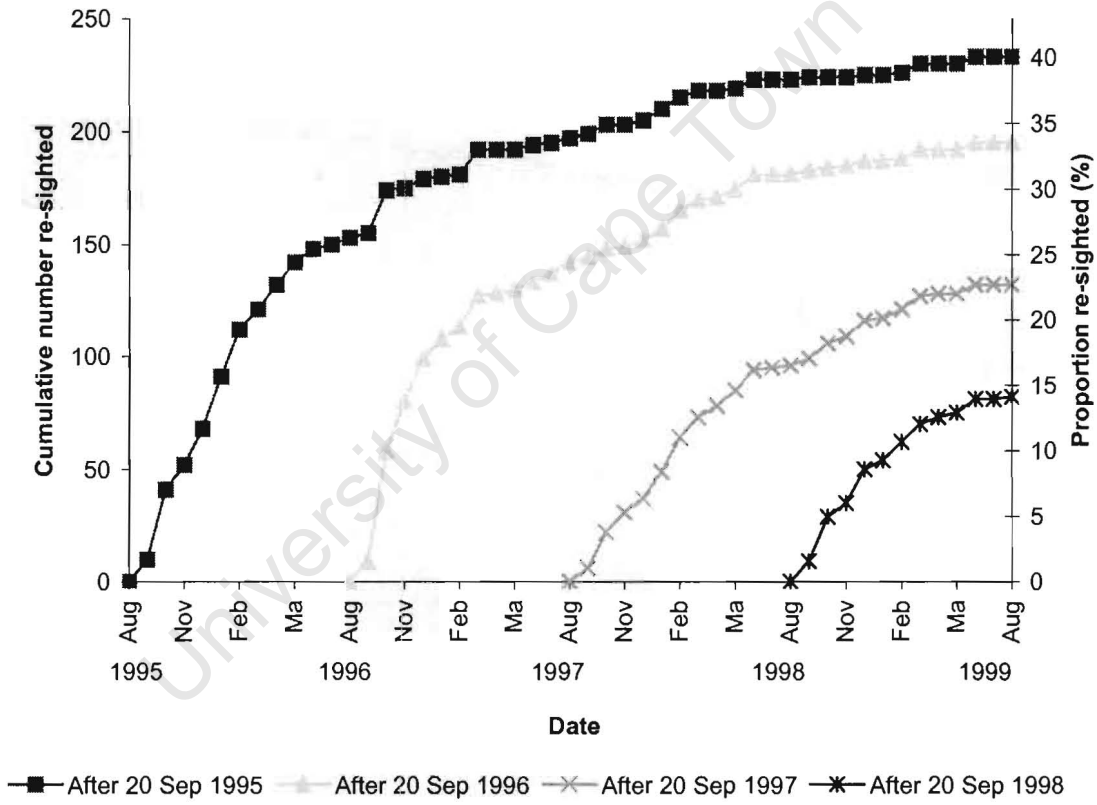


Figure 8.4 Cumulative re-sightings of banded African Penguins from the Cape Town Harbour oil spill after release on 10 June 1998.

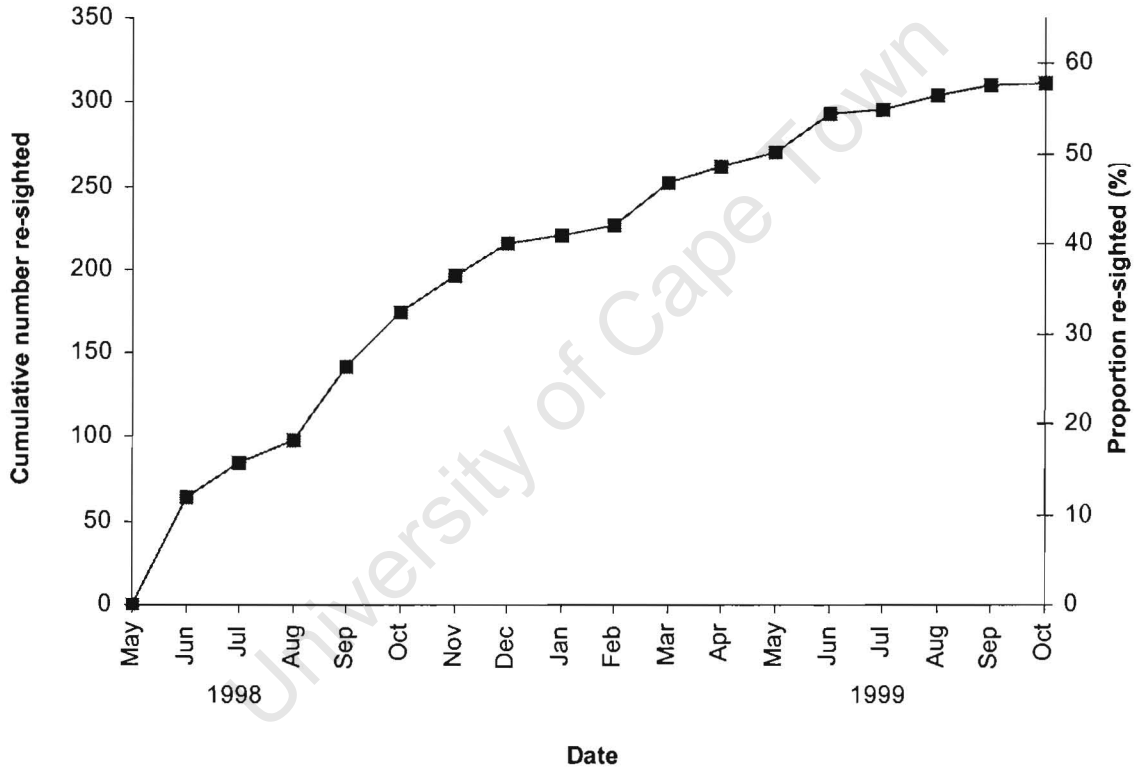
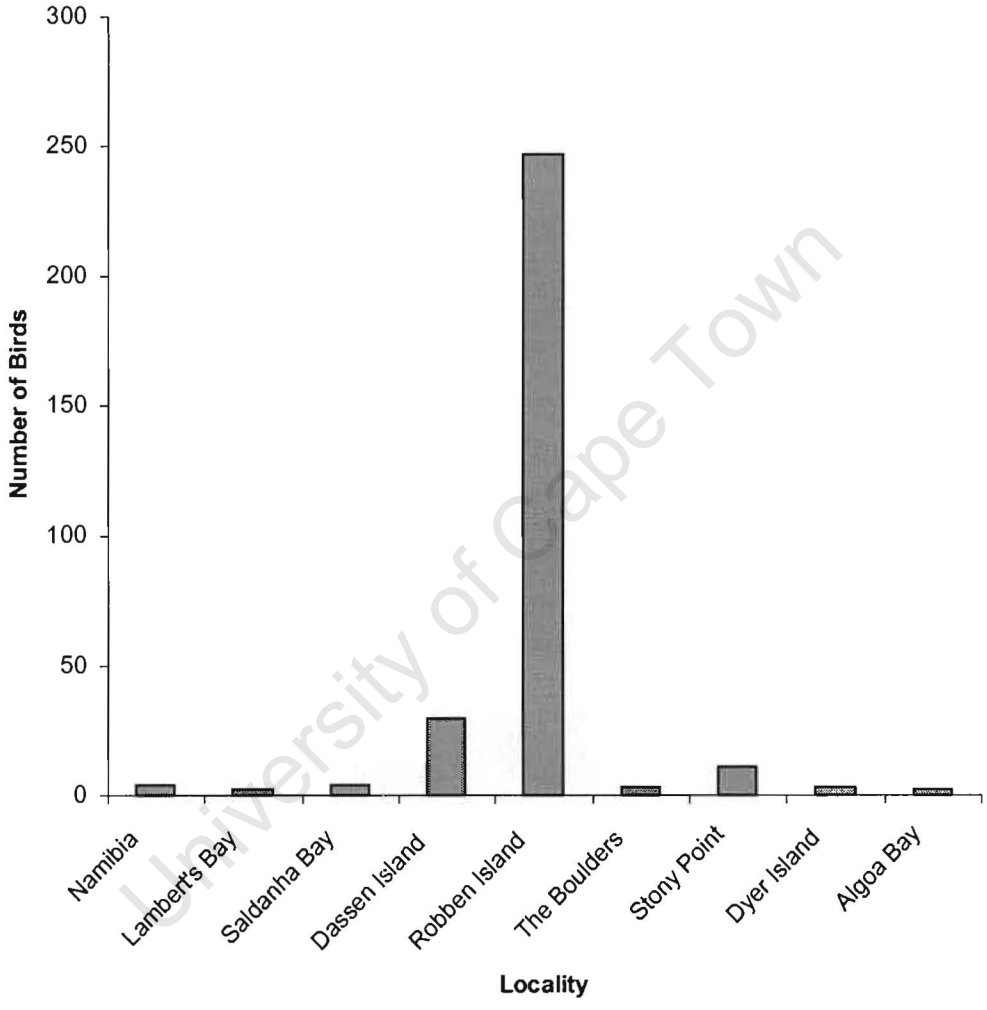


Figure 8.5 Breeding or natal colonies of flipper-banded African Penguins oiled in the *Treasure* spill, June 2000. Possession, Ichaboe and Mercury Islands are combined as Namibia. Marcus, Malgas and Jutten Islands are combined as Saldanha Bay.



CHAPTER NINE

A COMPARISON OF LONG-TERM SURVIVAL OF REHABILITATED AFRICAN PENGUINS WITH THAT OF NON-OILED PENGUINS AND OTHER SPECIES OF SEABIRDS

9.1 INTRODUCTION

Pollution of the marine environment by oil is an ever-present threat to coastal and marine flora and fauna. Of the bird species affected by such pollution in southern Africa, the African Penguin *Spheniscus demersus* is particularly vulnerable, being flightless and foraging within a relatively short distance of its inshore and coastal breeding localities.

Since 1968, attempts have been made to clean and rehabilitate oiled seabirds, particularly penguins, at the Southern African Foundation for Conservation of Coastal Birds (SANCCOB), a voluntary organisation supported by public donations, in Cape Town. Large-scale spills in 1968, 1971, 1972 and 1994 resulted in 1700, 1216, 4000 and 10 000 oiled penguins being picked up respectively (Underhill *et al.* 1999). The 1994 spill was the result of the sinking, near Dassen Island, of a bulk ore carrier, the *Apollo Sea,* which had left Saldanha (33° 02′ S 17° 55′ E) en route to Hong Kong (Erasmus 1995). The 10 000 African Penguins oiled represented about 5% of the world population at that time. A total of 5213 was released after cleaning and successful treatment by SANCCOB. Between 1970 and 1991, at least 11 300 African Penguins are known to have been victims of oil spills (Morant *et al.* 1981, Adams 1994). While this is an underestimate of the actual numbers involved, it illustrates the impact that a single spill, such as the *Apollo Sea* incident, can have when it happens close to a large penguin colony. In June 2000, another bulk ore carrier, the MV *Treasure,* sank between Dassen and Robben Islands, causing 19 000 African Penguins to be oiled, the worst incident to date in southern Africa.

Oiled penguins received at SANCCOB were washed with Light Duty Concentrate detergent and warm water. When all traces of oil had been removed, the birds were rinsed with a jet of warm water under high pressure. Cleaned birds were fed twice a day, usually with Sardine *Sardinops sagax* (Hodges 1995). When the plumage had regained its waterproofing qualities and the penguins were fit and well they were released, usually at Robben Island in Table Bay, 11 km to the north of Cape Town (Randall *et al.* 1980). Most were fitted with metal flipper bands bearing

a unique number, allowing the success of the cleaning operation to be monitored (Adams 1994). A programme of banding "wild", i.e. non-oiled birds, at breeding colonies began in the early 1970s.

In contrast to many other attempts to rescue oiled seabirds around the world (Sharp 1996), SANCCOB has attained a high degree of success in rehabilitating African Penguins into the wild (Randall *et al.* 1980). This chapter shows that flipper banding of cleaned birds has provided an insight into the survival of these birds after release, allowing us to assess the contribution made by cleaning of oiled African Penguins to the population dynamics and conservation of this vulnerable species.

9.2 METHODS

Survival of cleaned, released penguins and non-oiled ones was compared using elapsed times between banding or release and recovery of the ring at the time of death. Banding and recovery details are kept by SAFRING at the Avian Demography Unit, University of Cape Town. African Penguins attain adult plumage between 12 and 22 months of age (Randall 1989). Only birds banded as "full grown" birds, i.e. birds in adult or juvenile plumage, which had completed their first moult and gone to sea, were included in the analysis. Nestlings were excluded because they are not directly at risk from oil contamination at sea and, therefore, none were treated at SANCCOB. There were also very few nestlings banded in the early years and the ratios of nestlings banded: adults banded differed markedly from year to year. A separate analysis was performed on adult birds, excluding those that were still in immature plumage at banding.

The analysis included recoveries within a period of ten years from the banding date of each penguin. This simulated a situation where all the birds were banded on day one and the situation reviewed ten years later. Birds banded after 1985 were excluded because 10 years had not elapsed by the time of this analysis. A period of 15 years was also investigated but sample sizes were reduced. A randomisation test was performed on the data to test the null hypothesis that time elapsed from ringing to death was the same for both cleaned and non-oiled penguins. A randomisation test involves no assumptions about a parametric model for the data involving survival rates, and allows various percentiles of time elapsed between ringing and death to be tested. The 95% confidence limits for each percentile were computed by bootstrapping. For

details of the randomisation tests and their applicability to this kind of data see Manly (1991) and Oatley & Underhill (2001).

9.3 RESULTS

Totals of 147 cleaned and 163 non-oiled African Penguins were recovered dead within a 10-year period from banding, between 1971 and 1996. The totals banded that could have potentially been recovered were 5620 for cleaned penguins and 8470 for non-oiled penguins. The median elapsed time between release of a cleaned, full grown penguin and it being recovered dead was found to be 18 months and for a non-oiled bird 21 months (Table 9.1). The median time elapsed for a bird banded in adult plumage was 23 months for both data sets (Table 9.2). Rehabilitated adults lived for eight months longer at the 90th percentile, but all other comparisons differed by a maximum of three months. There was no significant difference between the times elapsed at each percentile for cleaned and non-oiled birds.

9.4 DISCUSSION

The results imply that oiled African Penguins that were cleaned and released had as good a chance of long-term survival as those that had not been oiled. This result is different to that experienced in the Northern Hemisphere. North American banding data indicate that post-release survival of oiled seabirds is low (Sharp 1996). Cleaning and release of oiled birds in the United Kingdom has also met with little success, with probably "less than 10%" of released birds surviving beyond one month (C.J. Mead as quoted by Sharp 1996). Survival rates of rehabilitated Guillemots *Uria aalge* in the U.K. were found to be only 0.7–1.3% of natural survival rates (Wernham *et al.* 1997). In the Southern Hemisphere, rehabilitation of Magellanic Penguins *Spheniscus magellanicus* has been stated to be of "little use" (Sharp 1996). Of 360 Magellanic Penguins washed in 1991, under 60 were released. None of these were seen alive more than a couple of days after release, although several were found dead in bushes near to the release point. Washing was made difficult due to lack of water and water pressure in an area of desert (P. D. Boersma *in litt.*).

Sharp (1996) considered the results of banding recovery data for three species of marine birds in North America, Western Grebe *Aechmophorus occidentalis*, Velvet Scoter *Melanitta fusca* and

Guillemot (Table 9.3). The median period elapsed between banding and recovery of cleaned individuals of these species, ranged from 0.2 to 0.4 months. Elapsed times of non-oiled birds exceeded those of cleaned birds by ratios of between 36:1 and 52:1 (Table 9.3). In comparison, elapsed times for full grown and adult African Penguins that had not been oiled were 21 and 23 months respectively, while those for rehabilitated birds were 18 and 23 months. This gives ratios of 1:1.2 and 1:1 for full grown and adult penguins respectively (Table 9.3). This indicates that rehabilitation of African Penguins has been a successful exercise, not just in the short-term survival of birds, but also over the period of a decade.

Of 26 banded penguins known to be at least 20 years old, five were rehabilitated, including two of the oldest three (Table 9.4). The latter two were both recovered dead at about 26 years old. P3741 is the oldest known oil spill survivor, having been re-sighted alive 23 years after banding. As it was banded as an adult, its true age is not known, but the minimum time taken for birds to reach adult plumage is one year, making this individual at least 24 years old (Whittington *et al.* 2000b, Table 9.4). Twenty-three of these penguins, including the five rehabilitated birds, were banded with "P" series bands, which were used between 1972 and 1979. SAFRING schedules show that 9865 of these bands were fitted on African Penguins, of which 2209 (22.4%) were birds cleaned by SANCCOB. If survival of these birds were similar, we would expect approximately one in five birds older than 20 years to be rehabilitated. The fact that five birds out of the 23 oldest (21.7%) were cleaned at SANCCOB is in keeping with this proportion and lends further weight to the evidence that rehabilitation was successful.

The evidence presented suggests that cleaning of oiled African Penguins is more than a humane exercise. Cleaned birds are likely to survive as long as non-oiled birds and thus reduce the number lost in oiling incidents. At least 65 African Penguins have now been oiled twice and were subsequently cleaned and released by SANCCOB. Of these, 27 have been re-sighted alive following their second release, 12 of them breeding. Unfortunately, four birds had their bands removed prior to their second release, preventing further monitoring of those individuals.

Cleaned penguins are known to have bred successfully and can thus be fully restored to the breeding population (pers. obs, Morant *et al.* 1981). In 1995, at a study site on Dassen Island off the west coast of South Africa, the fledging success of African Penguins cleaned and released

after the *Apollo Sea* oiling incident in 1994, was 55.2% as compared to 53.7% for non-oiled penguins (Williams *et al.* in prep.). However, there were seasonal differences between the two groups, the oiled birds being less successful during times of low food availability. Disruption of pair bonds as a result of oiling may lead to a reduction in breeding success of oiled birds. Familiarity with a particular partner has been found to enhance the reproductive performance of other long-lived seabirds, while changing mates may result in a temporary drop in breeding success (Ollason & Dunnet 1978, Coulson & Thomas 1985, Wooller *et al.* 1989). There is also evidence that the moult cycle of African Penguins can be disrupted as a result of oiling (Underhill & Crawford 1999, Williams *et al.* in prep.). Further studies are needed to compare the frequency of breeding attempts by penguins restored to the wild population with those of non-rehabilitated birds.

As far as African Penguins are concerned, cleaning of oiled individuals can make an important contribution to the conservation of this declining species. However, it should be stressed that measures preventing marine pollution, accidental or by negligence, are still urgently required, and are more cost effective than trying to clean up the mess afterwards.

TABLE 9.1

Time elapsed (months) between banding and death of African Penguins that were banded when "full-grown", truncated to ten years. The null hypothesis of equal elapsed periods until death is rejected if $P < 0.05$.

	Non-oiled (n = 163)		Cleaned (n = 147)		
Percentile	Months elapsed	Confidence intervals	Months elapsed	Confidence intervals	Test for difference
50	21	(15,25)	18	(7, 24)	$P = 0.45$
75	53	(36,65)	50	(40,62)	$P = 0.86$
90	89	(76,99)	91	(70,100)	$P = 0.83$
95	108	(92,113)	106	(93,112)	$P = 0.89$

TABLE 9.2

Time elapsed (months) between banding and death of African Penguins that were banded in adult plumage, truncated to ten years. The null hypothesis of equal elapsed periods until death is rejected if $P < 0.05$.

	Non-oiled (n = 137)		Cleaned (n = 124)		
Percentile	Months elapsed	Confidence intervals	Months elapsed	Confidence intervals	Test for difference
50	23	(17,28)	23	(11,30)	$P = 0.93$
75	55	(37,67)	57	(43,69)	$P = 0.84$
90	88	(75,102)	96	(78,104)	$P = 0.57$
95	111	(91,117)	109	(96,114)	$P = 0.79$

TABLE 9.3

Median months survived by oiled and non-oiled seabirds in North America, based on banding recoveries (after Sharp 1996), as compared with African Penguins (this study).

	Oiled		Non-oiled		
Species	Sample size	Months elapsed	Sample size	Months elapsed	Non-oiled:oiled ratio
Western Grebe	10	0.4	37	20.8	52
Velvet Scoter	10	0.3	22	15.5	51.7
Guillemot	78	0.2	641	7.2	36
African Penguin (full grown)	147	18	163	21	1.2
African Penguin (adult)	124	23	137	23	1

TABLE 9.4

African penguins aged twenty years or more (after Whittington *et al.* 2000)

Band number	Age at banding	Treated at SANCCOB	Date banded	Date re-sighted	Age at re-sighting (years)
P6593	Adult		30 Nov 1972	28 Mar 1999	27+ (dead)
P4240	Immature	✔	13 Sep 1972	25 Sep 1998	26–27 (dead)
P4364	Immature	✔	10 Aug 1973	04 Jan 1999	*c.* 26 (dead)
P3265	Adult		06 Oct 1974	13 Mar 1999	>25 (alive)
P3399	Immature		12 Dec 1976	30 May 2000	25 (alive)
P3741	Adult	✔	26 Sep 1972	03 Oct 1995	>24 (alive)
P4234	Immature	✔	13 Sep 1972	01 Jan 1996	>24 (dead)
P7347	Immature		02 Dec 1972	17Aug 1995	*c.* 23 (nest)
P3351	Immature		11 Dec 1976	27 Mar 1999	*c.* 23 (alive)
P6101	Immature		16 Mar1977	27 Mar 1999	22–23 (+chicks)
P9631	Immature		23 Apr1977	27 Mar 1999	22–23 (+chick)
P9759	Adult		18 Aug1977	27 Mar 1999	>22 (alive)
P4302	Immature	✔	08 Dec 1972	06 Jun 1994	*c.* 22 (alive)
P3254	Adult		06 Oct 1974	13 Nov 1995	>22 (alive)
P9482	Immature		17 Dec1977	27 Mar 1999	c. 22 (alive)
P9772	Chick		15 Apr 1978	30 May 2000	22.1 (alive)
P3222	Adult		03 Oct 1974	18 Aug 1994	>21 (alive)
P8778	Adult		01 Jul 1976	27 Aug 1996	>21 (alive)
P9447	Chick		06 Mar 1978	27 Mar 1999	21 (+ chicks)
P9449	Chick		06 Mar 1978	27 Mar 1999	21 (on eggs)
Z1172	Chick		20 May 1979	30 May 2000	21 (alive)
T1050	Chick		24 May 1978	27 Mar 1999	20.8 (alive)
P4470	Chick		29 Apr 1975	13 Nov 1995	20.5 (alive)
P4432	Chick		24 Sep 1975	10 Feb 1996	20.3 (dead)
P4777	Chick		10 Nov 1977	05 Feb 1998	20.25 (dead)
Z1028	Chick		21 Jan 1979	27 Mar 1999	20 (alive)

CHAPTER TEN

ESTABLISHMENT, GROWTH AND CONSERVATION OF A MAINLAND COLONY OF AFRICAN PENGUINS AT STONY POINT, BETTY'S BAY, SOUTH AFRICA

10.1 INTRODUCTION

Breeding colonies of the African Penguin have been almost exclusively on islands, free from mammalian predators, except where cats *Felis catus* have been introduced (Cooper & Brooke 1986). The first confirmed breeding of penguins on the African mainland was in June 1980, when six nests with eggs were found in caves below coastal cliffs at Sylvia Hill (25° 10′ S 14° 50′ E), Namibia (Finkeldey 1984, Loutit & Boyer 1985). In June 1981, an egg was found in a rock outcrop, with three adult penguins close by, at Cape Recife (34° 02′ S 25° 42′ E), Eastern Cape Province, South Africa. The outcome of this nesting attempt is unknown (Every 1983). An unsuccessful breeding attempt was made on the landward side of the harbour at Lambert's Bay between April and June 1982, but the nest was abandoned before the eggs could hatch (Shelton *et al.* 1984). The first reliable evidence for successful breeding of the species on the South African mainland was at Stony Point in 1982 (Broni 1982). Three years later, another mainland colony was founded at The Boulders (34° 11′ S 18° 27′ E), near Cape Town (Cooper 1985). The total of mainland sites increased to four when two caves with breeding penguins were found at Easter Cliffs (25° 22' S 14° 48' E), near to Sylvia Hill, Namibia, in February 2002 (J. Kemper pers. comm.).

This chapter provides an account of the development of the mainland African Penguin colony at Stony Point over the period 1982–1996.

10.2 STUDY AREA AND METHODS

Stony Point is a small, rocky peninsula lying within the holiday village of Betty's Bay on the southern coast of Western Cape Province, South Africa, about 75 km south-east of Cape Town (Figure 10.1). The penguins nest among the rocks of the peninsula and under thick, low vegetation growing on adjacent sandy areas. After the first nest was found in 1982, the colony was monitored during irregular visits until 1986. Counts were made of occupied nest sites, all

breeding activity was recorded, and over 100 adults and large young were fitted with flipper bands (Cooper 1986). No regular monitoring was undertaken during 1987 and 1988 and few data are available for these years.

Between January 1989 and May 1995, monthly visits were made by J.H. Hofmeyr on behalf of the Cape Bird Club. The colony was mapped and each nest site numbered. On each visit, a count was made of active nests and numbers of adults present, nest contents were examined whenever possible and band numbers of any adults present at nest sites recorded. From May 1995, members of the Stony Point Advisory Committee conducted monitoring visits. Many birds are feeding at sea from early morning until late afternoon and are, therefore, not present in the colony (Randall 1983). Counts of adults are best made in the late afternoon as birds return to the colony. This was not possible on all visits and some counts were made at times of day when fewer penguins were likely to have been present. Flipper banding of adults and large young has continued and all sightings of banded birds have been recorded. From the end of February 1995 until October 1995 (except between 4th and 13th of March), a trap was set to catch potential mammalian predators within the colony (Hofmeyr 1995).

Numbers of chicks reared per nest for the years 1989 to 1996 were calculated by dividing the total number of chicks fledged by the number of different occupied nests in each year. A chick was considered to have fledged if it survived to the "baby blue" stage (this describes the stage at which chicks develop their first true feathers, which have a bluish tint, and lose their down). The maximum possible number of chicks produced included the number of chicks fledged, plus the number of eggs and unfledged chicks in nests where the outcome was indeterminate. As the colony is small, it was possible to monitor the majority of nesting attempts. For banded individuals, the numbers of possible breeding attempts in consecutive pairs of years between 1982 and 1986 and between 1989 and 1996 were counted, along with the number of years in which breeding did not appear to take place. The proportion of pairs successful in raising a chick to the "baby blue" stage was also calculated for the period 1989–96. The data were checked to see whether there was a tendency for pairs, which bred successfully, to be successful in the following year and for those that failed to fail again. Birds banded in 1995 were excluded from this analysis because banding was conducted late in the breeding season and consisted

mostly of successful breeders. The extent to which penguins skipped a potential breeding year was also measured.

10.3 RESULTS

10.3.1 *Trends in colony size*

Since 1984, with the exceptions of 1987 and 1988, the annual number of monitoring visits to the colony varied between nine and 21. Counts of nests and of adult birds present at the colony each showed a pattern of growth and subsequent decrease, followed by a recovery in colony size (Figure 10.2). The highest monthly nest count was usually recorded in July but it occurred in March in one year.

During the first five years the colony grew steadily in size but, in December 1986, was severely reduced following an attack by a Leopard *Panthera pardus*. Following the Leopard attack, a chain-link fence, with access through a gate (locked when not in use), was erected around most of the breeding area and was in place by 15 July 1987. The size of the colony fell to a low in 1987 (although there are few data for this year or for 1988) but recovered rapidly thereafter, reaching a total nest count of nearly 140 in 1990. Subsequently, the colony decreased in size then recovered again to a nest count of 132 in 1996 (Figure 10.2).

10.3.2 *Seasonal patterns of breeding*

Active nests were recorded at Stony Point in all months of the year, but the main concentration of breeding activity occurred in June and July (Figure 10.3). At least three years of the study show an earlier peak of activity around February to March and, in the case of 1994, May. The March nest count in 1990 was the highest of that year. Breeding activity decreased rapidly after August.

10.3.3 *Frequency and success of breeding*

Despite the establishment and growth of the Stony Point colony, the numbers of chicks fledged have been low. Observed numbers of chicks reared per nest ranged from 0.11 to 0.39 between 1989 and 1996 (Table 10.1). The proportion of pairs that bred successfully, along with those

where the final nest outcome was unknown, is presented in Table 10.2.

Banding data suggest that individual adult penguins bred at Stony Point in almost every year, although there were gaps of one or two years between recorded breeding attempts for a few birds. For banded birds that bred in more than one year, there were 205 possible breeding attempts in consecutive pairs of years. Some banded birds apparently did not attempt to breed in 40 of these instances. Therefore, banded birds skipped 19.5% of possible breeding attempts. Of the skipped 40 breeding attempts, 28 were in years when the colony numbered less than 100 monitored nests.

Of the 73 cases where nest outcomes were known in consecutive pairs of years, six were of successful breeding in successive years, 19 had the pattern success-failure and 13 failure-success, while 35 failed to produce fledglings in successive years. For 145 birds for which outcomes of nesting attempts were known, 45 were successful and 100 failed to produce fledglings, suggesting estimated probabilities of success and failure of 0.31 and 0.69 respectively. If success or failure are statistically independent, then out of 73 birds, the expected number breeding successfully in successive years is $73 * 0.31^2 = 7.0$. Similar calculations give expected values of 15.6 for success-failure and for failure-success and 34.8 for failure in successive years. The differences between observed and expected values were not significant ($\chi^2_2 = 1.3$, n.s.).

10.3.4 *Origins and movements of birds in the colony*

Ten birds banded at other colonies have subsequently been found breeding at Stony Point (Table 10.3). These birds were banded both to the east (Dyer Island, St Croix Island (33° 48′ S 25° 46′ E)) and to the north and west (Robben Island (33° 48’ S 18° 23′ E) and Ichaboe Island, Namibia) of the Stony Point colony. Seven of these birds are known to have been banded at their natal colonies (five at Dyer Island, one at St Croix Island and one at Ichaboe Island). At least 19 birds banded at Stony Point have been recorded at other colonies in the Western Cape Province (Table 10.4). None has been recorded breeding at more than one locality.

10.3.5 *Predators*

The best documented predation of penguins at Stony Point relates to a Leopard, which killed 50 birds on the night of 18 December 1986 and a further 15 on the night of 19 December, including one bird of the original pair that founded the colony. With a total of 35 nests recorded in the colony that year, this represented a considerable proportion of the penguins present. In order to prevent extinction of the colony, the Leopard was trapped on 20 December by an officer of the Department of Nature Conservation, and translocated to the Kogelberg Nature Reserve 15 km away (Hofmeyr 1987a). However, it had returned to the Cape Hangklip area, *c.* 7 km from Stony Point, by 30 January 1987 and a freshly eaten penguin was found in the colony on 22 February 1987. Many large, Leopard-like tracks on a nearby sandy path left little doubt that a Leopard had again visited the penguin colony (Hofmeyr 1987b). The Leopard was subsequently shot on 11 March 1987 by the owner of a smallholding at Pringle Bay (34° 20′ S 18° 50′ E), 8 km from Stony Point, after it had killed a few of his sheep (Anderson 1987).

In spite of the presence of the fence, a second Leopard killed 50 penguins during August and September 1990, and an unknown predator killed 15–20 birds in September 1991. Following these occurrences, it was noticed that many nests failed at the egg stage and broken shells were found in the nest or nearby. One or two adults were also found dead on most visits, often with the neck and chest or sometimes most of the bird eaten away (Hofmeyr 1995).

Other potential predators recorded near the breeding colony include the Large-spotted Genet *Genetta tigrina*, Small Grey Mongoose *Galerella pulverulenta*, Water Mongoose *Atilax paludinosus*, Cape Clawless Otter *Aonyx capensis* and Caracal *Felis caracal*. Between late February and early May 1995, eight Water Mongooses, two Small Grey Mongooses and two Large-spotted Genets were caught in the penguin colony and translocated to a site adjacent to the Palmiet River within the Kogelberg Nature Reserve, 13 km from the colony (Hofmeyr 1995). With the exception of the first two Water Mongooses caught, the animals were individually marked with yellow picric acid dye. Only one marked animal, a genet, was subsequently recaptured at the colony, suggesting that the number of potential predators in the area is high. This individual was re-released at Kogel Bay (34° 15′ S 18° 50′ E), 23 km

from the penguin colony. It should be noted that during the period between 4 and 13 March when the trap was not in operation, seven penguin nests were found to contain broken eggshells (Hofmeyr 1995). No animals were caught between the end of May and beginning of October, although the trap was set during this period.

10.4 DISCUSSION

The reason for the establishment of a mainland colony of African Penguins at Stony Point is a matter for speculation. Island colonies have the advantage of being inaccessible to terrestrial, mammalian predators (unless introduced there by man). The small mainland colonies at Sylvia Hill and Easter Cliffs, Namibia, are situated in caves, of which the entrances are below sea level (Loutit & Boyer 1985, J. Kemper *in litt.*). These are virtually inaccessible to terrestrial mammalian predators (Loutit & Boyer 1985, J. Kemper *in litt.*). It is possible that the small peninsula of Stony Point could appear as an "island", isolated by a barrier of houses and roads (Macdonald & Cooper 1995). A similar situation exists at the African Penguin colony at The Boulders, Simon's Town. There is also the question of why birds initially left other colonies and settled at Stony Point. Young birds wander after fledging but usually return to breed at their natal colonies (Randall *et al.* 1987). They may, however, emigrate from these colonies to those where food is more readily available at the time when they are ready to commence breeding (Crawford 1998a, Chapter Four). It is possible that birds were forced to move by overcrowding or by food shortages at other colonies. It is considered that most of the immigrant penguins that settled at Stony Point came from Dyer Island, which underwent a decrease of 90% in its breeding penguin population between 1979 and 1997 (Crawford *et al.* 1995c, 2000b). The most likely explanation for this movement is the shift in the 1980s from a regime where Anchovy was dominant to one where Sardine is the dominant species (Crawford 1998a). Stony Point, although small, offers suitable nest sites for penguins, shaded by rocks and vegetation.

The decrease in the size of the Stony Point African Penguin colony is thought to be mainly due to mammalian predation. A fence surrounding the colony (erected in 1987) kept disturbance from humans and domestic animals, especially dogs, to a minimum after the access gate was kept locked, but it is unlikely that all potential predators were successfully excluded. The Small

Grey Mongoose is small enough to be able to pass through the mesh fence (J.H. Hofmeyr pers. obs), whereas the Water Mongoose is probably capable of climbing the fence and can also approach the colony from the sea, as could otters. Caracals are good tree climbers (Skinner & Smithers 1990) so the fence is unlikely to present a major obstacle to them. Also, at low tide, it would be possible for a predator to walk around the fence (J.H. Hofmeyr pers. obs).

The diet of the Cape Clawless Otter at Betty's Bay was found to consist largely of fish, along with Octopus *Octopus granulatus*, Red Rock Crabs *Plagusia chabrus* and Rock Lobster *Jasus lalandii* (Verwoerd 1987, Skinner & Smithers 1990). Analysis of Caracal scats from two areas of karoo in the Western Cape Province, revealed a diet consisting of *c.* 95% mammals, ranging from medium sized bucks to rodents, and 5% birds, including sandgrouse and guineafowl (Skinner 1979, Skinner & Smithers 1990). Data from Botswana and Zimbabwe suggest that the Large-spotted Genet feeds mainly on mice and insects, with reptiles, other invertebrates and wild fruits making up the bulk of its remaining diet (Skinner & Smithers 1990). However, the stomachs of two animals from the Jonkershoek Valley (33° 57′ S 18° 55′ E), Stellenbosch, Western Cape Province both contained Egyptian Geese *Alopochen aegyptiacus* (Stuart 1977). The closely related Small-spotted Genet *Genetta genetta* was considered, from circumstantial evidence, to be responsible for most of the African Penguin mortality on Marcus Island (33° 02′ S 17° 58′ E), Western Cape Province. It was assumed that the genets were able to climb over a two-metre-high reinforced concrete wall, built to prevent mammalian predators gaining access to the island from a causeway, which links the former island to the mainland (Cooper *et al.* 1985). Skinner and Smithers (1990) state that the Small Grey Mongoose is mainly insectivorous but will also take vertebrate prey, including birds, their eggs and young. However, of 11 stomachs examined that contained food, Stuart (1977) found three containing bird remains constituting the second most important food source, by volume, after rodents. Cavallini and Nel (1990), working in the Postberg Nature Reserve (33° 05′ S 18° 00′ E) on the west coast of Western Cape Province, carried out an analysis of 234 scats of the Small Grey Mongoose between April 1988 and February 1989. Small mammals constituted 90% of the diet by volume, insects forming 5%, birds (mostly passerines) 1% and eggs (mostly of reptiles) 0.7%. Birds occurred in only 5.6% of scats examined and then only in small quantities (Cavallini & Nel 1990). The only observation of a Small Grey Mongoose feeding on birds was of an animal

scavenging from a carcass, probably a road kill (Stuart 1977). The diet of the Water Mongoose consists mostly of isopods, crustacea, molluscs, insects and fruit, but includes birds and their eggs (Skinner and Smithers 1990). Bird remains, identified as belonging to Cape Cormorant *Phalacrocorax capensis*, made up 3.6% by occurrence in an analysis of dried scats from Betty's Bay between February and August 1995. Further inland, in the Highlands State Forest, the occurrence of bird remains in scats went up to 25.0% (Louw & Nel 1986). This evidence suggests that the Water Mongoose and the Large-spotted Genet, both of which have been trapped within the penguin colony in 1995, are likely candidates for the predation of adult penguins, chicks and eggs. The possibility of predation by Caracal should not, perhaps, be ignored, whilst the Small Grey Mongoose is probably too small to take anything bigger than a small downy chick.

The proportion of pairs that successfully fledged chicks fell steadily between 1989 and 1994, barring a peak in 1993, when the number of birds present in the colony was at its lowest during this period (Table 10.2). During the early years of the colony, when relatively few birds were present, nesting success was also higher (J.H. Hofmeyr pers. obs). There was a marked increase in the proportion of birds breeding successfully in 1995, the year in which trapping and translocation of mammals from the colony began. The proportion of birds failing to raise chicks in 1995 is probably too low. This is due to the high number of indeterminate nests resulting from a large gap in visits between early August and mid October. Although there was an increase in the number of nests in the colony in 1996 (Table 10.1, Figure 10.2), the proportion of pairs breeding successfully decreased (Table 10.2). The proportion of successful birds between 1989 and 1994 did not exceed 27%. Between 63% and 87% of pairs failed to rear chicks between 1989 and 1994 (Table 10.2). By comparison, at Marcus Island between 1979 and 1985, the proportion of clutches fledging young varied between *c.* 15% and *c.* 44% with 30.4% of breeding attempts being successful during the study (La Cock *et al.* 1987). The proportion of pairs raising fledglings from a monitored population at St Croix Island, Algoa Bay, Eastern Cape Province, between 1978 and 1982, varied between 19.3% and 47.1% with a weighted average of 33.6% (Randall 1983). At both localities, a higher proportion of clutches or pairs successfully fledging young was recorded than at Stony Point, other than in 1995 (Table 10.2).

The proportion of breeding attempts skipped by banded birds at Stony Point was 19.5%. Of the skipped attempts, 70% were between 1991 and 1995, the years in which the colony was decreasing and the highest proportions of nest failures occurred. The relatively small proportion of skipped breeding attempts suggest that once African Penguins reach breeding age they nest annually, so the number of breeding birds provides a satisfactory estimate of population size. For the Stony Point colony, the pattern of success and failure of breeding attempts was apparently random, due perhaps to the assumed high level of predation cancelling out the effects of experience.

The productivity of the Stony Point colony, with a mean observed number of 0.20 chicks per nest and a mean maximum of 0.34 (Table 10.1), was low. This compares with a mean figure of 0.38 fledglings per pair at St Croix Island, Algoa Bay, between 1976 and 1982 (Randall 1983), and 0.63 fledglings per pair per year at Marcus Island between 1979 and 1985 (La Cock *et al.* 1987). Even if all nests of unknown outcome had been successful at Stony Point, the figure of 0.38 could have only been achieved in two of the eight years from 1989 to 1996. Randall (1983) considered that if the fledglings produced were to balance the losses due to annual mortality at St Croix Island, a figure of 0.67 fledglings per pair would have to be attained. Other than in 1995, the most optimistic estimates of fledgling production per pair per year at Stony Point were well below that figure. Clearly, if the colony is to make a contribution to the total population of African Penguins, the fledging success must increase to recoup the natural losses due to mortality. The present situation seems to represent a "population sink", where adults must be drawn from outside to replace the losses due to mortality within the colony.

TABLE 10.1

Productivity of the Stony Point African Penguin colony in terms of chicks reared per nest

Year	1989	1990	1991	1992	1993	1994	1995	1996	Mean
Total number of nests	88	139	120	95	57	84	112	132	103
Number of chicks reared (observed)	20	20	14	10	16	13	44	27	20.5
Maximum number of chicks reared	43	42	28	14	20	16	74	48	35.6
Chicks reared per nest (observed)	0.23	0.14	0.12	0.11	0.28	0.16	0.39	0.20	0.20
Maximum chicks reared per nest	0.49	0.30	0.23	0.15	0.35	0.19	0.66	0.36	0.34

TABLE 10.2

Proportion of African Penguin pairs successfully fledging young at Stony Point, 1989–1996

Year	Number of pairs	Number of successful pairs	Pairs with unknown outcome	Proportion successful (%)	Proportion indeterminate (%)	Proportion failing (%)
1989	71	16	10	23	14	63
1990	96	19	11	20	12	69
1991	94	11	11	12	12	77
1992	69	8	1	12	1	87
1993	44	12	3	27	7	66
1994	69	7	3	10	4	87
1995	100	34	20	34	20	46
1996	112	25	12	22	11	67
Total	655	132	71	20	11	69

TABLE 10.3

African Penguins sighted at Stony Point that were banded at other localities

Band Number	Date Banded	Age	Status	Locality	Date found at Stony Point	Circumstance
T5367	24 Aug 1984	Adult	Rehab.[1]	Robben Island	12 Nov 1985	Nest prospecting (at nest 15/5/86)
V4012	20 July 1985	Chick	----	Marcus Island	19 Dec 1985	Alive
V4439	10 Feb 1985	Chick	----	Dassen Island	30 Jan 1987	Found dead (oiled)
V7338	11 June 1986	Chick	----	Marcus Island	19 Feb 1987	Present
V0685	22 Sep 1983	Chick	----	St Croix Island	27 May 1987	At nest with 1 egg
V3070	07 July 1987	Juvenile	----	Marcus Island	26 Nov 1988	Moulting
V4814	16 Nov 1984	Chick	----	Dyer Island	27 May 1989	At nest
V7570	29 Jan 1987	Adult	Unknown	Dyer Island	24 June 1990	At nest. Bred each year up to 1996
S7308	27 July 1987	Juvenile	----	Robben Island	14 March 1991	Killed by mammal
V3239	11 July 1987	Juvenile	----	Dassen Island	15 Nov 1992	Found dead
S5132	08 Aug 1991	Chick	----	Dyer Island	31 May 1993	Oiled. Sent to SANCCOB
S4008	20 Jan 1991	Chick	----	Ichaboe Island	27 Feb 1994	At nest with 2 eggs
S12757	07 Aug 1992	Unknown	Rehab.	Robben Island	25 May 1994	At nest with 2 eggs
S14009	21 July 1993	Chick	----	Robben Island	30 Sep 1994	Skeleton found
S20743	22 Aug 1994	Unknown	Rehab.	Silwerstroom	30 Sep 1994	Skeleton found
S5296	19 Aug 1991	Chick	----	Dyer Island	*c.* 1994	Found dead
S11124	09 Sep 1992	Chick	----	Robben Island	*c.* 1994	Found dead
S13087	13 June 1992	Chick	----	Dassen Island	*c.* 1994	Found dead
S5862	24 Oct 1991	Chick	----	Dyer Island	29 May 1995	At nest with 2 small chicks
S5413	21 Aug 1991	Chick	----	Dyer Island	07 Aug 1995	Successfully reared chick
S24693	25 Aug 1994	Adult	Rehab.	Silverstroom	23 Aug 1995	Oiled. Sent to SANCCOB
S10855	04 Oct 1992	Chick	----	Dyer Island	29 Jan 1996	Incubating
S5229	11 Aug 1991	Chick	----	Dyer Island	04 March 1996	Incubating

[1] Rehab. = oiled bird cleaned at SANCCOB Rehabilitation Centre and released at Robben Island.

TABLE 10.4

African Penguins banded at Stony Point and re-sighted at other localities

Band Number	Date Banded	Age	Banding Status	Date Re-sighted	Locality	Status
V4071	20 Nov 1984	Adult	Moulting	14 Feb 1985	Dassen Island	On beach
V4057	01 June 1984	Adult	Not breeding	04 Nov 1985	Dyer Island	Alive
V4061	15 July 1984	Adult	Unknown	30 Dec 1986	Dyer Island	Ring found
V7472	26 Nov 1986	Adult	Unknown	17 March 1987	The Boulders	Alive
V4389	09 Jan 1984	Adult	Unknown	24 Oct 1987	Dyer Island	Alive
V7558	21 Oct 1986	Chick	----	24 Oct 1987	Dyer Island	Alive
V4400	18 March 1984	Adult	Unknown	30 May 1988	Robben Island	Brooding chick
V7482	26 Nov 1986	Adult	Unknown	03 June 1988	Dyer Island	Brooding chick
V7468	26 Nov 1986	Adult	Unknown	28 Jan 1989	Vondeling Island	Long dead
V7467	26 Nov 1986	Adult	Unknown	30 April 1989	Dyer Island	Present
S9836	14 Sep 1991	Chick	----	23 Sep 1991	Simon's Town	Oiled
S9777	02 June 1990	Adult	Not breeding	27 March 1992	The Boulders	Alive
S9796	28 July 1990	Chick	----	25 Oct 1992	The Boulders	Alive
S9817	14 July 1991	Adult	Not breeding	27 March 1992	The Boulders	Alive
S9831	17 Aug 1991	Chick	----	28 April 1994	The Boulders	Alive
S6540	30 Oct 1994	Adult	Breeding	16 Jan 1995	Dassen Island	Loafing
V7455	21 Oct 1986	Chick	----	16 March 1995	Dyer Island	Paired at nest site
S0020	04 Jan 1989	Adult	Not breeding	16 March 1995	Dyer Island	At nest site
S6544	30 Oct 1994	Chick	----	17 Jan 1996	Vishoek	Found dead
S0030	12 Jan 1990	Juvenile	----	02 Feb 1996	Dassen Island	With small chick
V7557	21 Oct 1986	Chick	----	15 March 1996	Dyer Island	Loafing

Figure 10.1 Penguin colonies in the south-west of Western Cape Province, South Africa

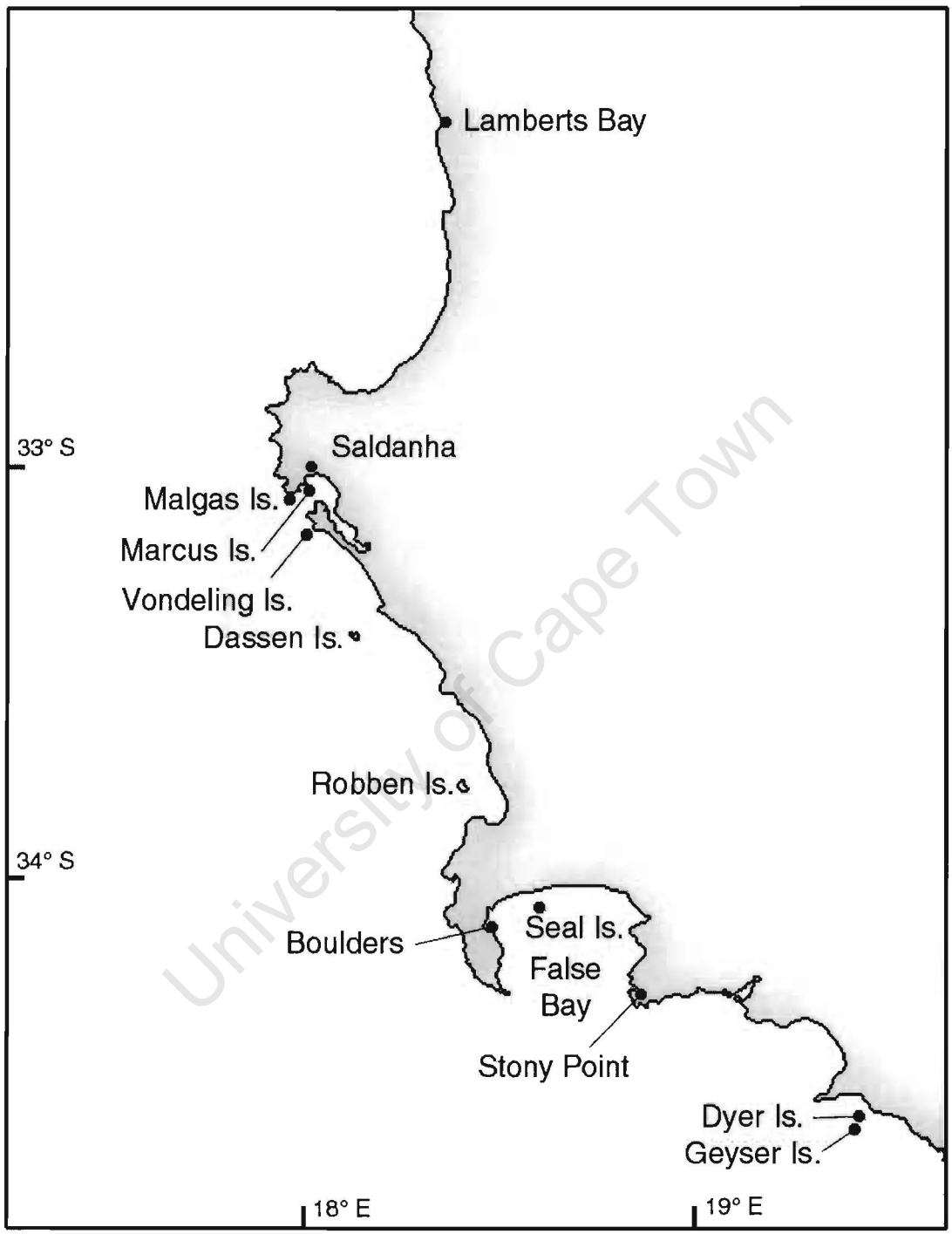


Figure 10.2 Total nest counts (solid line) and numbers of adult penguins (dashed line) at Stony Point, 1982–1996

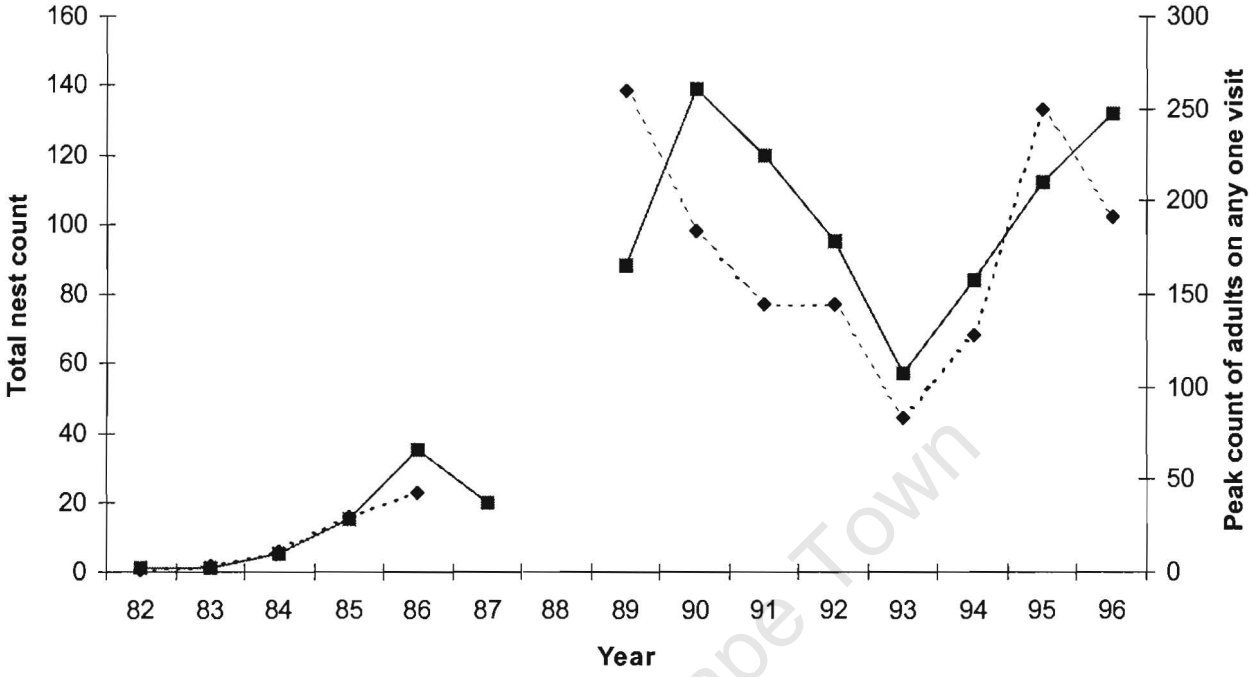
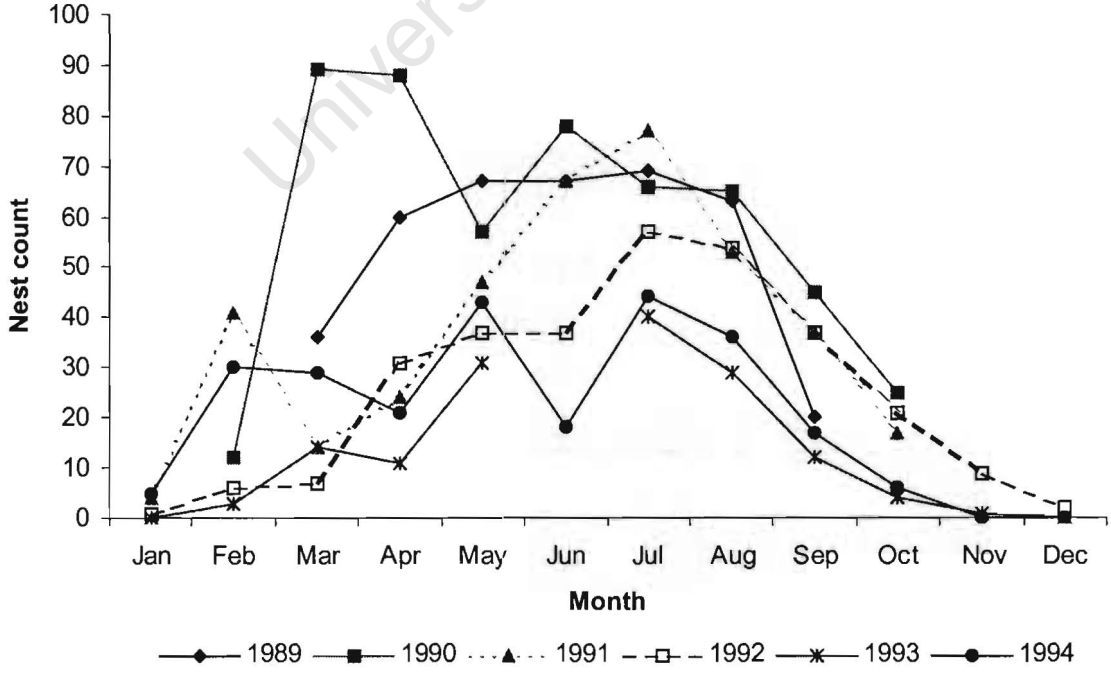


Figure 10.3 Seasonal pattern of breeding of African Penguins at Stony Point shown by monthly nest counts for the years 1989–1994



CHAPTER ELEVEN

SUMMARY AND RECOMMENDATIONS

Of the world's 17 species of penguins, 11 are more numerous than the African Penguin *Spheniscus demersus,* and of the four *Spheniscus* penguins, only the Magellanic Penguin *S. magellanicus* is more abundant (Table 11.1). Of the four species in the genus *Spheniscus*, three are found amongst the six least numerous penguin species, all with estimated populations below 200 000 birds. The remaining three of the six scarcest species are found in or close to New Zealand.

The African Penguin underwent a 90% decline in numbers in the 20th century (Underhill 2000). Causes of this decline are outlined in Chapter One. An insight into the population dynamics of the species may provide information on why the population continues to decline and help identify where measures are needed to arrest the fall in numbers. The average annual adult survival rate calculated from re-sightings of flipper-banded African Penguins in this study was 0.81 (Chapter Six). Mean first-year survival was found to be 0.35 but survival rates varied between years. Published figures of mean breeding productivity vary between 0.38 and 0.63 chicks fledged per pair per year (Randall 1983, La Cock *et al.* 1987, Crawford *et al.* 1999, 2000b). The mean age at first recorded breeding was found to be 4–5 years (Crawford *et al.* 1999, Chapter Five) and is similar to that of the Northern Gannet *Sula bassana* (Nelson 1966) and the closely-related Magellanic Penguin, which also has a clutch size of two and a similar annual adult survival of 85% (P.D. Boersma unpublished data, Williams, T.D. 1995). This deferment of breeding is typical among long-lived seabirds with high annual adult survival and small clutch size (Ashmole 1971).

Using the parameters described above, a simple model was constructed with a constant annual adult survival of 0.81 and constant first year survival of 0.35. All surviving young birds were added to the breeding population when four years old. The model assumed that all adults of breeding age bred in each year and that there were no catastrophic occurrences that would decrease the survival rates. A value of 0.52 chicks per pair per

year was used for breeding productivity. An initial population of 200 breeding adults was used, i.e.100 breeding pairs. In addition, totals of 47 three-year-olds, 58 two-year-olds and 72 one-year-old birds were included to keep the population in equilibrium. It was calculated that 47 x 0.81 = 38 of the three year olds would survive to replace the 38 breeding adults that would die after a year. By dividing 47 by 0.81 the number of two-year-old birds was derived and a further division by 0.81 produced the number of 72 one-year-olds. The model was allowed to run for ten years, after which the population consisted of 95 birds in adult plumage, including 37 breeding pairs, and 19 chicks. This represented a decrease in the adult population of 75% over a decade, which is considerably greater than that observed in the African Penguin population during the late 20th century. For instance, between the late 1970s and late 1980s the population declined from 222 000 to 194 000, a decrease of 13%. This suggests that annual survival estimates used in the model were too low, the age at first recorded breeding was too high and/or the breeding productivity has been underestimated. After experimenting with the parameters, a combination was found that came close to the observed decline in the wild. Using annual adult survival of 0.9, first-year survival of 0.41 and fledging success of 0.58, an initial population of 274 adults (100 breeding pairs) stood at 236 adults (89 breeding pairs) and 51 chicks after 10 years, a decrease of 14% in the adult population. Although this model is too simplistic to be an accurate reflection of what is happening in the wild population, it does allow a crude measure of the reliability of the parameter estimates. Both the fledging success and first-year survival rates are within the range of those recorded in this study and in others. It is therefore suspected that adult survival was probably underestimated in this study. This may be due to observers failing to find birds that were present at breeding colonies and to some birds being resident at poorly monitored colonies, even though they may have been banded at more intensely monitored ones. Small differences in adult survival can have a large impact on the population. In the above model, changing adult survival from 0.88 to 0.9 when first year survival was set to 0.41 and breeding success to 0.55 chicks per pair per year converted a 33% decrease in the adult population into a 10% decrease. For the population to remain stable, it is therefore important that adult survival remains at a high level.

Chapter Two demonstrates that African Penguins, particularly young birds, frequently travel within the breeding range and may cover distances of up to 2000 km. The database demonstrates that both juvenile and adult penguins may moult at colonies other than the one at which they breed or were fledged from. Sixteen adults out of the 220 (7%) that were recorded visiting another colony were moulting, while 92 of the 1116 birds (8%) banded as chicks that were recorded alive at a non-natal colony were in moult. These observations suggest that caution should be exercised if using counts of moulting birds as an indication of the recruitment of juvenile birds into the breeding population of a colony, or as an estimate of the breeding population. Moult counts are probably more indicative of the number of penguins that use a particular colony.

Breeding African Penguins are faithful to breeding locality (Randall 1989), although eight that were oiled, cleaned and released in 1994 attempted to breed at more than one colony. There is no evidence to suggest that breeding adults emigrate to other breeding colonies, even when environmental conditions at their colony undergo long-term deterioration and would seem to favour a move to another colony. While most juvenile African Penguins will return to their natal colony to breed, 2% of those re-sighted alive after fledging had settled to breed at non-natal colonies. It is thought that first-time breeders have the flexibility to settle at colonies where food resources, or other environmental factors, are more favourable (Crawford 1998a). Emigrating penguins must have formed the nucleus of the two South African mainland colonies at Stony Point and The Boulders in 1982 and 1985, and brought about the resettlement of Robben Island in 1983. These emigrants are believed to have been first-time breeders (Crawford *et al.* 1995a, 2000b). The rate of growth of the penguin colonies at Robben Island and at The Boulders in the early 1990s exceeded that possible from breeding productivity alone, and must have been primarily due to immigration (Ryan 1998, Crawford *et al.* 1999, 2000b). The numbers of immature birds estimated to have settled at Robben Island during this period were significantly related to the spawner biomass of Anchovy (Crawford *et al.* 1999). Immigration of penguins to other South African west coast colonies has also been observed. Flipper banding of chicks showed that most of the immigrants came from the

declining colony at Dyer Island. Of the 1252 chicks banded at Dyer Island between 1990 and 1992, 22 (2%) were found to have settled to breed at other colonies (Chapter Four).

Although numbers of breeding African Penguins at South African colonies showed an apparent increase between 1996 and 2001, probably due to the steady increase in the South African Sardine resource and recent good year-classes of Anchovy (Wolfaardt *et al.* submitted, Marine and Coastal Management unpublished data), those in Namibia have continued to decline (Kemper *et al.* 2001), and the probability of the species surviving through the 21st century is tenuous (Crawford *et al.* 2001). Randall (1983) considered that the African Penguin population at St Croix Island, at the time of his study, was in decline, due to low mean annual fledgling production (0.38 chicks per pair) and low first year survival (30%–40%). Furness & Cooper (1982) considered that a first year survival rate of 0.68 was necessary to balance an adult mortality rate of 0.13 for penguins at the Saldanha Bay islands, assuming age of first breeding to be three years and fledging success to be 40%. Breeding productivity, estimated to be 0.63 chicks per pair per year at Marcus Island in Saldanha Bay, exceeded the latter figure. However, mean annual adult survival ranged from 0.33 to 0.70, while first year survival was estimated to be 0.13 (La Cock *et al.* 1987). Both estimates were considerably lower than those assumed by Furness & Cooper (1982). Low post-fledging survival was thought to be the main reason for the decrease in size of the Marcus Island colony between 1979 and 1985 (La Cock *et al.* 1987). Randall (1983) estimated that a breeding productivity of 0.67 fledglings per pair per year was necessary to balance the losses from annual mortality at St Croix Island. From estimates of breeding success made at St Croix Island (Randall 1983), Marcus Island (La Cock *et al.* 1987), Robben Island (Crawford *et al.* 1999) and The Boulders (Crawford *et al.* 2000b), it would appear that this level of productivity is seldom achieved, although a mean chick production of about 0.8 chicks per pair, per breeding attempt, per year has been recorded at Dassen Island (Whittington *et al.* 2000a). It is therefore likely that the continued decline in the African Penguin population has been driven by a combination of low breeding productivity and poor first-year survival, factors which are probably related to insufficient food availability.

The poor conservation status of the species was recognised at the Conservation and Management Plan Meeting following the Third International Penguin Conference in Cape Town in 1996. Accordingly, the African Penguin was given the IUCN red data classification of "vulnerable" on account of a 10% or greater probability of extinction within 100 years. In April 1999, a Population and Habitat Viability Assessment (PHVA) was carried out in Cape Town, facilitated by the Conservation Breeding Specialist Group of the IUCN/SSC. The aim of this workshop was to develop a conservation action plan to improve the conservation status of the African Penguin (Whittington *et al.* 2000a).

Of the factors affecting the African Penguin in the 21st century, the most serious was thought to be the sustainability of a viable food source. Sardine and Anchovy, the two main prey items of African Penguins, naturally alternate in abundance (Skud 1982). Populations of seabirds that prey on these species may change in response to the relative abundance of the two fish species (Crawford 1987, 1998a). In addition, commercial purse-seine fisheries, which began operating in the 1940s, have reduced the available stock of both species. Reduction and changes in distribution of the prey resource is thought to be responsible for the continued decline in the African Penguin population in the mid to late 20th century, along with local declines, extinctions and increases at different colonies (Crawford & Shelton 1981, Shelton *et al.* 1984, Randall & Randall 1986a, Crawford *et al.* 1990, Best *et al.* 1997, Crawford 1998a, Cordes *et al.* 1999, Crawford *et al.* 1999, Crawford *et al.* 2001). While regime changes are a natural phenomenon, management of the pelagic fishery should ensure that enough fish remain to support populations of natural predators, including the African Penguin. It is also necessary to ensure that there is sufficient food available within the foraging ranges of breeding colonies at the time when most birds are breeding. The PHVA workshop established that in order to achieve this aim, it would be necessary to ascertain the functional relationship between breeding productivity of the penguins and biomass of available prey over a number of years. This would allow the calculation of the necessary escapement of fish required to maintain a stable or growing African Penguin population. It would also be important to establish what impact a change in Total Allowable Catch (TAC) would have on the commercial fishery (Whittington *et al.* 2000a). Crawford *et al.*

(2001) considered that the minimum viable population of African Penguins should be regarded as 50 000 pairs.

Human activity has not caused large-scale reduction in the habitat available to African Penguins but it has affected habitat quality. Guano scraping has resulted in penguins at some colonies having to nest on the surface, as there is no longer sufficient guano for them to burrow into. Surface nesters are generally less successful than burrow nesters (Frost *et al.* 1976), as they are prone to heat stress and more vulnerable to predation (pers. obs). Provision of artificial nests may help to alleviate these problems. A small number of artificial designs using concrete piping, fibre glass and wood have been utilised by penguins at Dyer Island, The Boulders, Seal Island (False Bay), Robben Island and Dassen Island. A fibre glass design used at Dyer Island in 2000 was occupied within two hours of being sited and the occupants successfully reared two chicks (A.D. Venter pers. comm.).

Cape Fur Seals *Arctocephalus pusillus pusillus* are natural predators of African Penguins but recent observations suggest that this predation may have increased in the latter part of the 20th century (Crawford *et al.* 2001). This may be a result of the increase in the seal population (Whittington *et al.* 2000a), or it may be due to an increase in reporting of the behaviour (M. du Toit pers. comm.). Interaction between Cape Fur Seals and seabirds is considered to be unsustainable at some colonies (Crawford *et al.* 2001) and management measures are therefore necessary. Current measures involve selected shooting of "problem seals". Examination of these animals at Ichaboe Island, Namibia, and at Malgas Island (33° 03′ S 17° 55′ E), South Africa, has shown that it is sub-adult male seals that are responsible for the predation of seabirds (Du Toit 2001, R.M. Randall pers. comm.). Predation of penguin eggs and small chicks by Kelp Gulls is also natural predation but may have been increased by human activities. The Kelp Gull *Larus (dominicanus) vetula* population has benefited from increased foraging opportunities provided by open refuse tips and the disposal of fisheries by-catch (A.J. Williams pers. comm.). They have also learnt to follow humans in seabird colonies in order to capitalise on feeding opportunities that may result from accidental nest disturbance (pers. obs). To address these problems, it

is desirable to keep human disturbance at seabird colonies to a minimum, to improve upon the techniques of refuse disposal and to minimise fisheries by-catch (Whittington *et al.* 2000a). Introduction of cats *Felis catus* to islands where seabirds breed has led to feral populations becoming established at Dassen and Robben Islands. There were incidences of a feral cat killing a large penguin chick at Robben Island in 1989 (Crawford *et al.* 1995a) and feral cats were thought to be preying on 9% of penguin chicks at Dassen Island in 1984 and 1985 (Berruti 1986). Of 44 cat stomachs examined in March-April 1985, 55% contained penguin chicks, which formed the major prey component by mass (Berruti 1986). Between November 1998 and February 1999, 107 feral cats were shot or removed from Robben Island (Crawford & Kroese 2000). At Dassen Island, 47 feral cats were shot and an additional three trapped, out of an estimated population of 80 cats, between March and May 1985 (Berruti 1986). Since then, cats have been controlled at Dassen Island on an opportunistic basis. It was recommended at the PHVA meeting that feral cats should be eliminated from offshore islands.

Not all human activity has been detrimental to the African Penguin population. The dense stands of exotic vegetation, such as *Acacia cyclops* and *Myoporum serratum*, and plantations of *Pinus pinaster* and *Eucalyptus* species introduced to Robben Island, provide cover for nesting penguins and are utilised by 97% of the breeding population there (Crawford *et al.* 1995a). However, the large volume of dry wood, particularly in the pine plantations, represents a severe fire hazard at this locality.

The problem presented by marine pollution is important to address but difficult to solve. While fossil fuels are in use there is always going to be a threat posed by marine oil pollution. Chapter Eight shows the effect that relatively small amounts of fuel oil can have when spilt close to large penguin colonies. It would be desirable to keep shipping to a minimum in the vicinity of seabird colonies, but in practice this is difficult to achieve. Three major ports at Saldanha, Cape Town and Port Elizabeth are close to large African Penguin colonies, as is the proposed deep-water facility at the Coega River mouth (33° 48′ S 25° 40′ E) (Figure 1.1). While oil pollution is not considered to have been a major factor in the decline of the African Penguin population, a spill occurring close to a large

penguin colony has the potential to quickly eradicate a significant proportion of the population. This situation happened in June 2000 when the MV *Treasure* sank between Dassen and Robben Islands, the largest and third largest colonies of African Penguins respectively (Crawford *et al.* 2000a). The potentially catastrophic effects of this spill, which threatened 40% of the overall African Penguin population, were mitigated by the efforts of SANCCOB, many other organisations and about 12 000 volunteers. Consequently, mortality resulting from the spill was about 10%, and over 16 000 of the 19 000 penguins oiled were cleaned and released back to the wild.

Results from North America and Europe suggest that most seabirds that have been cleaned after oiling incidents do not successfully make the transition back to the wild (Sharp 1996, Wernham *et al.* 1997). Evidence from this study suggests, however, that African Penguins do successfully rehabilitate back into the wild population after oiling, cleaning and treatment. Cleaned penguins did seem to undergo some sort of disorientation after release and often travelled in the opposite direction to their breeding colony. However, these movements in the wrong direction were relatively short. None of the birds that were banded at breeding colonies were recorded breeding at more than one colony, but eight cleaned birds attempted breeding at two colonies. Since the birds were only flipper-banded after they had been oiled, it is not known whether or where they had attempted to breed prior to oiling. Age at first recorded breeding did not seem to be affected by oiling in the sample of seven birds recorded in this study (Chapter Five). Penguins that were cleaned and released after three oiling incidents in the 1990s were known to have survived up to six years from release (Chapter Eight). The proportion of 73% of released birds re-sighted after the *Apollo Sea* incident suggests that the rescue and rehabilitation procedure was successful. Survival rates based on live re-sightings (Chapter Six) and dead recoveries (Chapter Nine) showed that cleaned penguins had as good a chance of survival in the wild as birds that had never been oiled. Work at Dassen Island by the Western Cape Nature Conservation Board has shown that rehabilitated penguins can be successfully restored back into the breeding population and that the long-term breeding success of those that are restored, is apparently unaffected by oiling (A.C. Wolfaardt in prep.). Survival of hand-reared chicks that had been orphaned as a

result of oil spills was found to be equal to that of naturally reared chicks (Chapter Seven).

In view of the low reproductive rate and continued decline of the African Penguin, it would take a long time to recover the losses resulting from a major oil spill. Modelling a colony of 100 000 penguins, Shannon and Crawford (1999) estimated that it could take more than fifty years for the colony to recover, following a spill that caused the death of one third of the birds aged between three and six years old. It is clear that rehabilitation of oiled birds has played an important role in the conservation of African Penguins. In the absence of SANCCOB, mortality of birds in oil spills would have been much higher and marine pollution would assume a far more prominent position in the list of threats to the species. It is essential that annual adult survival rates of African Penguins are kept as high as possible to prevent further declines in the population, so the mitigation of losses to pollution incidents by rehabilitation of oiled birds, especially adults, is of great importance. Consequently, the work that SANCCOB carries out deserves both national and international recognition and support.

The success of rehabilitation efforts should not, however, undermine the importance of minimising the risks associated with transporting oil at sea. Prevention of oil pollution, especially in the vicinity of seabird colonies, must be the primary aim. A major step in this direction would result from more vigorous enforcement of maritime laws concerning the safety and maintenance of shipping. Failure of ship owners and flag countries to fulfil supervisory and regulatory duties are associated with higher accident rates (Cheney 2000). The sort of circumstances that may lead to accidents include poor maintenance of ships and equipment, inadequate training of officers and crew, poor working conditions, language difficulties and economic factors over-riding safety interests (Cheney 2000). Attention to structural flaws in the design of ships, especially bulk carriers, would also serve to reduce the risk of accidents. A strong incentive is needed to deter ships from cleaning their tanks illegally at sea, thus causing an almost constant level of "chronic oiling". This could be by way of substantial financial penalties for offenders but would necessitate effective policing and enforcement of legislation. Public support for such

measures is important and one of the recommendations made at the PHVA workshop was to increase public awareness of the implications of oiling.

Further research on the effects of oil on penguins and on the rehabilitation procedure is still to be done. The sinking of the MV *Treasure* in 2000 and the subsequent large-scale rescue operation provides opportunities to continue monitoring of rehabilitation success and for new work to be done. The assessment of the success in hand-rearing and releasing orphan chicks that has been reported on in this study (Chapter Seven), can be repeated with a much larger sample size of over 2000 birds following the *Treasure* spill. Due to the intensity of re-sighting efforts since 1994, the database maintained by the Avian Demography Unit now contains over 42 000 re-sightings of banded penguins. There is detailed information on over 300 banded penguins that were oiled in the *Treasure* spill. This provides an opportunity to compare various factors, such as breeding success, movements and site fidelity before and after the spill. While breeding success of rehabilitated birds has been under study, the breeding frequency of rehabilitated adults has still to be assessed and compared with that of non-oiled penguins. The physiological effects of oiling on African Penguins would make another important addition to our knowledge of the success of the rehabilitation procedure. For instance, are cleaned penguins more susceptible to disease than non-oiled birds? Do they exhibit higher or lower stress levels when approached by humans?

Ecotourism is a growth industry and South Africa is fortunate in having a rich and diverse natural heritage. While large mammals form the main attraction for visitors, a growing number of people come to see the birds, and tourism to seabird colonies has grown considerably in recent years (R.J.M.Crawford *in litt.*). Penguins seem to be viewed as a charismatic group of species and are a major attraction to visitors. The Little Blue Penguin colony at Phillip Island, Australia, receives 520 000 visitors annually and was said to be the second most popular natural tourist attraction on the continent, after the Great Barrier Reef (P. Dann *in litt.*). Penguin colonies in South Africa have an advantage over their Australian counterpart in that the penguins are present during the daytime, whereas the Little Blue Penguins only come ashore after dark. Between September 1995

and August 1996, 218 795 tourists visited the African Penguin colony at The Boulders, paying a total of R584 000 in entrance fees (Ruse *et al.* 1995). The impact of the colony on the regional economy is estimated to have been approximately R15 million for the year (Ruse *et al.* 1995). Visitor numbers rose to 376 316 between January 2001 and January 2002, with entrance fees totalling R3 135 860 (Q. Vaughan, South African National Parks *in litt.*). African Penguin colonies at Robben Island, Stony Point and Bird Island, Lambert's Bay are also accessible to the public and it is likely that Dassen Island may become so in the near future. As well as being an important component of southern Africa's natural heritage, the African Penguin, along with other seabird species, is also a valuable economic asset. State organisations, private enterprise and conservation agencies should therefore be fully committed towards improving the conservation status of this and other seabird species in the region. The future of the African Penguin is still far from secure; should it fail to survive the 21st century the world will be much the poorer for it.

TABLE 11.1

Penguin species in descending order of estimated population size (after Ellis *et al.* 1998, R.J.M. Crawford *in litt*).

Species	Population size	Category
Macaroni Penguin *Eudyptes chrysolophus*	9 000 000	pairs
Chinstrap Penguin *Pygoscelis antarctica*	*c.* 7 500 000	pairs
Adelie Penguin *Pygoscelis adeliae*	*c.* 2 500 000	pairs
Rockhopper Penguin *Eudyptes chrysocome*	1 660 000	pairs
King Penguin *Aptenodytes patagonicus*	1 640 000	pairs
Magellanic Penguin *Spheniscus magellanicus*	1 300 000	pairs
Royal Penguin *Eudyptes schlegeli*	850 000	pairs
Little Blue Penguin *Eudyptula minor*	602 000	pairs
Gentoo Penguin *Pygoscelis papua*	317 000	pairs
Emperor Penguin *Aptenodytes forsteri*	218 000	pairs
Erect-crested Penguin *Eudyptes sclateri*	170 000	pairs
African Penguin *Spheniscus demersus*	173 000	birds
Snares Crested Penguin *Eudyptes robustus*	23 250	pairs
Humboldt Penguin *Spheniscus humboldti*	13 000	birds
Yellow-eyed Penguin *Megadyptes antipodes*	5100–6200	birds
Galapagos Penguin *Spheniscus mendiculus*	1500–4000	pairs
Fiordland Crested Penguin *Eudyptes pachyrhynchus*	2500–3000	nests

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