forestry, fisheries
& the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

THE BIODIVERSITY MANAGEMENT PLAN FOR THE AFRICAN PENGUIN (*Spheniscus demersus*)

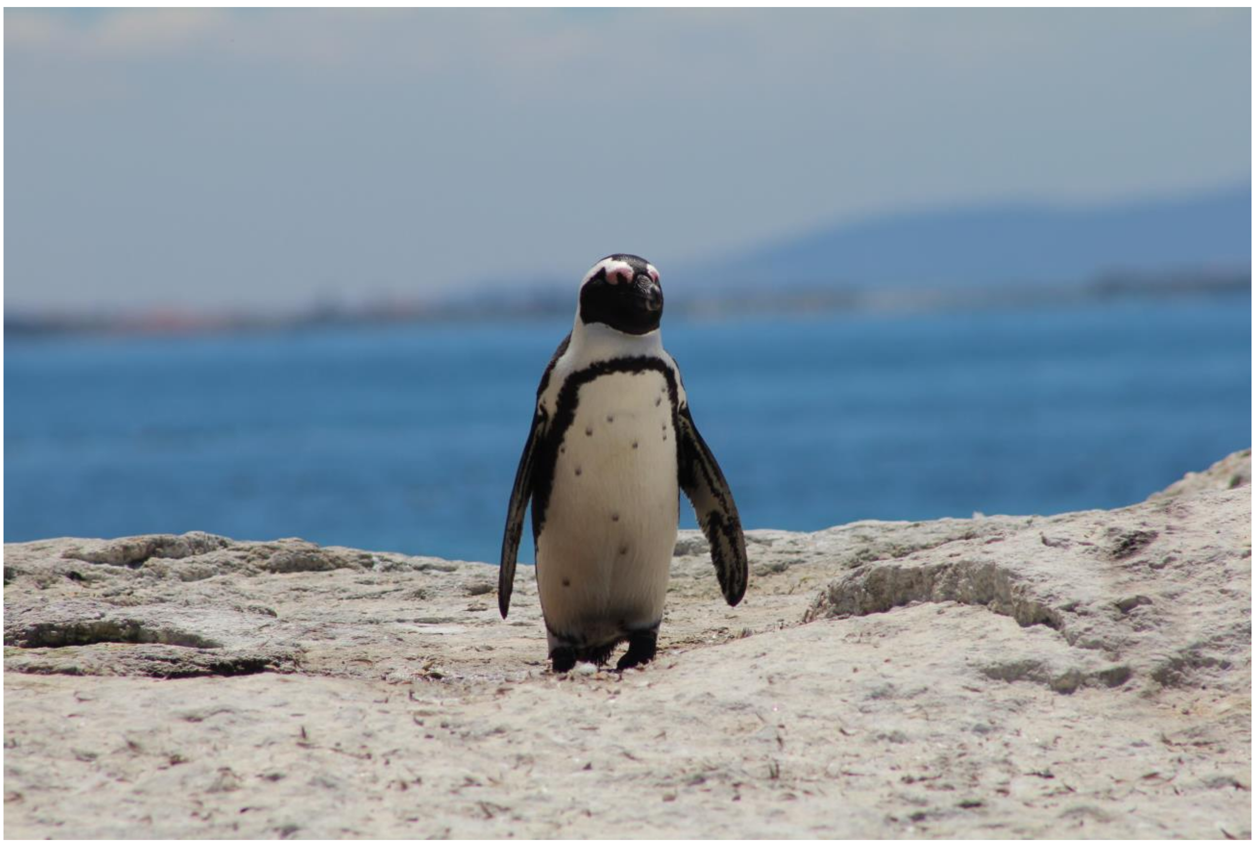

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

The African penguin *Spheniscus demersus*, Africa's only extant penguin, is endemic to Namibia and South Africa. It was formerly the most abundant seabird of the Benguela upwelling ecosystem but following a large overall decline of the species in the 20th century, and a collapse of the South African population in the present century, it is now classified as Endangered by the International Union for Conservation of Nature (IUCN) and under Threatened or Protected Marine Species Regulations (TOPMS) (NEM:BA). In addition to biodiversity concerns, African penguins (and other seabirds) are important in regional economies (e.g., through attracting tourism) and in the healthy functioning of ecosystems. A Biodiversity Management Plan for the African Penguin was first gazetted in 2013, with the aim "*To halt the decline of the African penguin population in South Africa within two years of the implementation of the management plan and thereafter achieve a population growth which will result in a downlisting of the species in terms of its status in the IUCN Red List of Threatened Species"*.

The implementation of the African Penguin BMP was a cooperative effort with management authorities that manage African penguin breeding colonies (SANParks, CapeNature, Robben Island Museum and the City of Cape Town), fisheries sector, the National Zoological Gardens (NZG) under the South African National Biodiversity Institute (SANBI) as well as various Non-Government Organisations and academic and research institutions. Despite the successful implementation of many of the actions listed in the plan, the aim of the BMP (2013) was not attained, and African penguin populations have continued to decline, albeit at a slower rate. The decline of the African penguin is attributed to various factors including reduced availability of forage fish, oil spills, breeding habitat modification, extreme weather events and disease among others. Predation by Cape Fur Seals (*Arctocephalus pusillus*) and Kelp Gulls (*Larus dominicanus*) have localised colony impacts.

Despite these challenges, strides have been made to conserve the African penguin and they include:

a) Improved cooperative management: through the establishment and implementation of interagency working groups which include DFFE, management authorities, conservation agencies, museums and zoos, NGOs, research institutions e.g. co-management of Simon's Town penguin colony by SANParks and City of Cape Town and the management of Stony Point penguin colony by Cape Nature.

b) Population reinforcement: rescuing (abandoned chicks, oiled and injured birds), rehabilitating and returning to the wild oiled and injured birds and abandoned chicks, chick and egg bolstering (via hand-rearing) and release. Increased monitoring of demographic parameters through the deployment of passive integrated transponders, beach surveys and development of guidelines to assess chick condition. There is also a project investigating and taking steps to initiate a colony for African penguins at De Hoop Nature Reserve, which is close to present distributions of its primary forage resources and where penguins formally bred.

c) Improved breeding habitat management: testing the suitability of artificial nest designs that decrease losses of eggs and chicks to aerial predators and inclement weather, e.g. heat stress). Improved predator management guidelines to reduce the losses to predation, storm and severe weather readiness interventions to temporarily move penguins at risk to areas of safety; implementing measures to monitor and curtail the spread of pathogenic viruses through the disease surveillance programme; ensuring preparedness to cope with oil spills.

d) Improved management of the captive population: development of a studbook, including DNA and BioBanking, Norms and Standards of Seabirds in Captivity; translocation guidelines for African penguins that conform to IUCN criteria and determining the genetic suitability of their offspring for release to bolster diminishing colonies (DFFE 2021).

e) Policies and guidelines: numerous policy documents and guidelines have been developed. These include the *Norms and Standards relating to the management of Seabirds in Captivity*, Translocation Guidelines for African penguins which conform with IUCN criteria, guidelines to assess chick conditions of African penguins, as well as the National Oiled Wildlife Preparedness Response and Contingency Plan. Other guidelines still require finalisation, and they include the Disturbance and Predator guidelines.

f) Research and monitoring: improved coordinated research with various stakeholders including both academic and non-academic research. Priority research has been identified, and research contributing to island closure and research on survival rates through implantation of PIT tags, foraging distribution of African penguins at various stages of their biology, trophic ecology, and various demographic parameters such as breeding success and body condition and chicks' growth rates. New research addressing new emerging threats has ready begun on ship-to-ship bunkering and increased in seismic activities and ships trafficking.

g) Education and awareness: numerous African penguin education and awareness campaigns were held by various institutions including DFFE communication and Benguela Current Commission information day (BCC), Penguin Promises Campaign, Waddle, and the celebration of African penguin Day as well as World Penguin Day. These campaigns are aimed at educating and encouraging people on the plight of the African penguin.

h) Forage Fish availability: An Island Closure Experiment was initiated by the South African Government in 2008 to determine whether fishing closure restrictions adjacent to African penguin breeding colonies had a positive impact on penguin demographics. The Minister subsequently established the Governance Forum, the Extended Task Team, and the *Consultative Advisory Forum for Marine Living Resources (CAFMLR)-Special Project: Penguin and Small Pelagic Fishery Interactions* comprising various conservation and fisheries stakeholders. They were tasked with exploring the different delineations of island closures to ameliorate resource competition around six major African penguin colonies, namely, Stony Point, Dassen-, Robben-, Dyer-, St Croix- and Bird Islands. The recommendations for which will form an integral part of this BMP. Furthermore, the Synthesis Report on the Current Scientific Information Relating to the Decline in the African Penguin Population, the Small Pelagic Fishery and Island Closures, which was developed through the Governance forum was independently reviewed by international reviewers.

This review of the APBMP will, however, improve from the already established structures and where necessary establish new working group structures to oversee the implementation of new actions. Consideration of new actions addressing emerging threats, and modified and ongoing actions from the first draft were taken into account. These new and emerging threats include at-sea threats; human-induced stresses, the mitigation intervention on management processes implemented for ship-to-ship bunkering and ensuring Disease Contingency Plans are in place at seabird colonies. Modified and on-going actions include improving where possible access to available food for African penguins, reviewing the implementation and monitoring of predation management, Strategic Research Plan for the African penguin, socio-economic and ecosystem benefits of African penguins to South Africa as well as the risk assessment on the release of captive-bred birds among others.

This Plan will ensure that a carefully considered effective monitoring programme is in place to ensure the efficacy of the actions implemented and how the action plan contributes to reducing the population decline and promoting the improvement of the African penguin species' recovery.

2. DEFINITIONS

“Biodiversity Management Plan - Species” means a species management plan in terms of section 43 of the National Environmental Management: Biodiversity Act (No 10 of 2004).

“Collaborators” mean those individuals and/or organisations that will be approached/included in the process to participate and complete the relevant actions.

“**Catastrophic event**” means any event that affects or has the potential to significantly negatively impact a colony and can include oil spills, disease outbreaks, fire and inclement weather (flooding, wind chills, heat stress, etc.).

“Conservation Authorities” mean those organisations mandated in terms of legislation with the conservation of South Africa’s biota.

“**Conservation Translocation**” means the intentional movement and release of a living organism where the primary objective is a conservation benefit: this will usually comprise improving the conservation status of the focal species locally or globally, and/or restoring natural ecosystem functions or processes.

“Ecosystem-Based Management” is an environmental management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation

“Management Authorities” in relation to a protected area, means the organ of state or other institution or person in which the authority to manage the protected area is vested.

“Permitted Rehabilitation Centres” refer to those centres that have permission from Provincial Conservation Authorities (by means of a permit) to rehabilitate animal species as specified on the permit.

“Protected Area Management Plans” mean those management plans developed for protected areas as set out in section 39 of the National Environmental Management: Protected Areas Act (No 57 of 2003).

“Rehabilitation” means the re-establishment of part of the productivity, structure, function and processes of the original ecosystem.

“Responsible Party” means the organisation or body that has the delegated authority to carry out an action either through legislation or through delegation of that authority.

“Restoration” means that all of the key ecological processes and functions are re-established, and all of the original biodiversity is re-established.

"Stakeholder" means any group or individual who can affect or is affected by any of the actions in the Biodiversity Management Plan.

"Steering Committee" means a group of individuals appointed by this Department to oversee the implementation of the management plan in accordance with the determined terms of reference for the Committee.

"Working Group" means a number of individuals invited to form a group in order to complete an action or actions set out in the Biodiversity Management Plan. The tenure of such a group may be until the completion of the action or for the duration of the Management Plan.

3. ABBREVIATIONS

AEWA:	African-Eurasian Waterbird Agreement
APBMP:	African Penguin Biodiversity Management Plan
CITES:	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DFFE:	Department of Forestry, Fisheries and the Environment
EBM:	Ecosystem Based Management
IUCN:	International Union for Conservation of Nature
NEMA:	National Environmental Management Act, 1998 (Act No. 107 of 1998)
NEM: BA:	National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)
SANBI:	South African National Biodiversity Institute
SANParks:	South African National Parks
SCTI:	Species Conservation Toolkit Initiative
TOPMS:	Threatened or Protected Marine Species as listed in terms of section 56 of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)
PAAZA:	Pan-African Association of Zoos and Aquaria
PAMP:	Protected Area Management Plan
ZIMS:	Zoological Information Management System

4. INTRODUCTION

4.1 Why the African Penguin requires a Biodiversity Management Plan?

A Biodiversity Management Plan for the African Penguin (APBMP) was gazetted in 2013 on account of a rapid decrease of the species at the start of the present century and a classification of the African penguin as Endangered in 2010 through an IUCN Red List assessment. More than 50 000 pairs of African penguins bred in South Africa in 2004 but this fell to c. 10 400 pairs in 2021. Increased intensity and effectivity of conservation efforts were required from DFFE and its stakeholders to assist in reversing this downward trend. However, despite the multifaceted approach to the conservation of the African penguin and successful implementation of several actions listed in the APBMP, numbers continued to decrease with South Africa's penguin population falling by 30% between 2013 and 2019. In 2016, the status of the African penguin was re-assessed according to the IUCN Red Listing criteria and its classification as Endangered was maintained (IUCN 2016). In 2021, a record low of c. 10 400 pairs were recorded breeding in South Africa. The rate of decline of the African penguin, has been identified and likened as one of the three species of penguins globally that are in critical need of urgent conservation action (Boersma et al. 2020).

Should no further effective management actions be implemented, it is predicted that the population along the west coast of South Africa could be functionally extinct in this region by 2035 (Sherley et al. 2018). Multiple stress factors have been identified and the most important of these need to be identified and effectively mitigated. Prey availability, affected by shifts in the distributions of prey species and competition with commercial purse-seine fisheries, is considered to be the main driver of the loss of about 35,000 breeding pairs of African penguins in South Africa between 2001 and 2009 and thereafter (Crawford et al. 2011, 2018; Crawford and Makhado 2020), and is still most likely the main cause of future declines unless addressed (Sherley et al. 2018).

Penguins are considered sentinels of ecosystem health (Boersma 2008) playing an important role in the functioning of marine ecosystems (see Section 4.6). They transfer nutrients from the sea to their colonies, which in turn act as key sources of nutrients to adjacent marine ecosystems. They facilitate healthy prey populations by selecting fish that are small and/or in poor body condition. Furthermore, they herd fish shoals to the surface making them available to other seabirds that are restricted to surface feeding. Therefore, thriving African penguin colonies will give some indication of the status of other marine top predators that target the same prey and, more broadly, to the relative condition of the marine ecosystem.

4.2 Aims of the Biodiversity Management Plan

The African Penguin BMP aims:

a) To improve the conservation status of the African penguin and ensure its long-term survival in wild populations.
b) Through addressing threats to their survival, to increase African penguin numbers in South Africa, as measured by the number of pairs breeding in the wild, by at least 5% from the population size estimated within the schedule of this APBMP.
c) To ensure that no extant colonies become extinct and that the populations in each of three regions in South Africa (Orange River to Cape Point, Cape Point to Cape Agulhas, east of Cape Agulhas) are stable or increasing.
d) To maintain (with possible expansion through building on the value-added of the current mainland colonies, Boulders, Dyer Island, De Hoop, Robben Island, Stony Point, and colonies within the Addo Elephant National Park MPA) the socio-economic benefit (jobs and revenue) that African penguins generate.
e) To support iterative improvement in the knowledge base for adaptive management.

4.3 Objectives of the Biodiversity Management Plan

The objectives of the Biodiversity Management Plan for the African Penguin are to:

a) Maintain and where possible expand a research and monitoring programme that provides information that supports adaptive management and the conservation of the African penguin population.
b) Ensure as far as possible availability of forage fish in key foraging areas throughout their annual cycle.
c) Improve Breeding Habitat, Predator Management and Population Reinforcement.
d) Minimise and/or mitigate the impact of catastrophic events and other key pressures and risks on African penguins.
e) Increase the socio-economic benefit of African penguins.

4.4 Rationale and Benefits of the Biodiversity Management Plan

The African Penguin Biodiversity Management Plan will continue to guide the various coordinated conservation initiatives of South African agencies aimed at the recovery of the species. It will also facilitate South Africa's contribution to international efforts to improve the conservation status of African penguins, e.g., through the African-Eurasian Waterbird Agreement (AEWA), a treaty to which South Africa is a signatory. It is expected that other agencies both locally and international (including non-governmental organisations and academic institutions) will continue to contribute substantially to efforts to improve the conservation status of the species through research, rehabilitation and other activities.

A major achievement in the initial implementation of the APBMP is that all the management authorities are now working together in a coordinated manner to prioritise and implement best practice across the entire population. Additionally, stakeholder involvement has been very successful through outputs from a number of coordinated working groups. Examples include harmonisation of research projects, standardisation of research and monitoring methods, a compilation of research reports, and standardisation of rehabilitation methods. The 2013 APBMP listed 65 actions, of which 41 were achieved (63%). Some actions are ongoing (routine actions that need to continue - 9%) or still in progress (finite actions still to be completed - 25%). Ongoing and incomplete actions have been included as actions in this APBMP (**Table 2**). As part of the requirements of the Norms and Standards for Biodiversity Management Plans for Species (BMP-S), annual reports under the African Penguin BMP were produced for each year that the BMP has been in effect. The progress of each action is highlighted in the Annual report.

In this APBMP, it is expected that this close cooperation will continue its function, grow and enable the manner in which the WGs and Steering Committee will work as described in Section 9. Furthermore, it is imperative to ensure that the necessary capacity and monetary requirements are in place as part of the commitment to ensuring that the actions within this BMP are adequately implemented.

4.5 Anticipated Outcomes of the Biodiversity Management Plan

The anticipated outcomes of the BMP, if fully and effectively implemented, are that:

a) The declining population trend will have at least slowed and at best reversed.
b) Implementation of spatial management in important foraging areas for African penguins.
c) A framework is in place to prioritise research and provide sound scientific information for decision support to management authorities.
d) Current detrimental human activities near breeding colonies reduced and any additional activities negatively impacting colonies minimized.
e) Increase in African penguin tourism resulting in economic and employment benefits.
f) An understanding of the cumulative impacts of threats versus mitigation intervention.

4.6 The role of seabirds in the functioning of marine ecosystems

Seabirds are “central-place” foragers when breeding (Orians and Pearson 1979), that bring large amounts of nutrients from the ocean to their colonies. This influences the functioning of island ecosystems and their adjacent marine areas, for example, through increasing algal growth and changing the structure of intertidal communities, which in turn increases the population sizes of some shorebird species (Bosman and Hockey 1988). Inputs to both the island and the adjacent inshore ecosystem by seabirds of nitrogen (N), and phosphorus (P), are of similar magnitude to other inputs of these nutrients in global N and P cycles, with concentrations per unit of surface area in seabird colonies among the highest measured on the Earth's surface. Moreover, an important fraction of the estimated total excreted N and P can be readily solubilized, hence increasing the short-term bioavailability of these nutrients in continental and coastal waters near seabird colonies (Otero *et al*. 2018). Not only do seabirds have beneficial bottom-up impacts but they can also exert top-down control of some marine biota. For example, they may select prey that is small and in poor body condition and by removing these substandard individuals ensuring the long-term survival of prey populations (Tucker *et al*. 2016). Accordingly, large decreases in seabird populations, as have been observed for African penguins and other seabird species in South Africa (e.g. Crawford *et al*. 2015), will have detrimental consequences for marine ecosystem functioning.

African penguins facilitate prey capture by flying seabird species, such as Gannets, Cape Cormorants (*Phalacrocorax capensis)*, Swift Terns (*Sterna bergii*) and Sooty Shearwaters (*Puffinus griseus*), by herding prey from depths > 33 m to the surface where they become more accessible to these species (McInnes and Pistorius 2019). This form of symbiosis is likely to play an important role in the foraging efficiency of volant seabird species whose distributions overlap those of African penguins.

Since seabirds are top predators and are sensitive to ecosystem change (Croxall 1992; Piatt *et al*. 2007; Hazen *et al.* 2019), they have the potential to provide an index of the health of marine ecosystems (Underhill and Crawford 2005). They are ocean samplers and can be used as indicators of the location and variability of marine resources, including those exploited by commercial fisheries (Berruti *et al*. 1993; Cherel and Weimerskirch 1995; Weimerskirch *et al*. 2008; Mullers and Navarro 2010), and of ecosystem changes (Crawford *et al*. 2002, 2014; Boersma 2008; Carpenter-Kling *et al.* 2019). Dietary data from top predators such as penguins are relatively inexpensive and easily obtained and can be collected more frequently and at a broader spatial scale than ship-based surveys of fish abundance (Imber and Berruti 1981; Cherel and Weimerskirch 1995). Phenological data that are relatively simple to collect can provide useful indicators of food availability (Sherley *et al.* 2018). Hence, the study of top predators such as the African penguin is a potentially useful source of information for the management of prey resources and their ecosystems (Benguela Current Large Marine Ecosystem Top Predators Project Steering Committee 2007; Roux *et al*. 2013).

5. INFORMATION PERTINENT TO THE MANAGEMENT OF AFRICAN PENGUINS

5.1 Taxonomic Description

The species is one of four in the genus *Spheniscus*. The current classification of *S. demersus* is as follows (Hockey *et al*. 2005):

Order: Sphenisciformes

Family: Spheniscidae

Genus: *Spheniscus*

Species: *demersus* (Linnaeus 1758)

No subspecies are recognised.

5.2 Distribution

The African penguin is endemic to the Benguela upwelling ecosystem off south-western Africa (Crawford *et al.* 2011). Historically, it bred at 32 colonies from Hollams Bird Island, central Namibia, to Bird Island in South Africa's Eastern Cape Province (Crawford, Kemper, & Underhill, 2013) however since 2004, 5 colonies have gone extinct in South Africa (DFFE 2021). The majority of the population occurs in South Africa, which supports c. 71% of the breeding population of this species (Sherley *et al*. 2021).

In South Africa, African penguins breed in three recognized areas, where recent trends in their numbers have been quite different (Sherley *et al.* 2020). These are north of Cape Town, between Cape Point and Cape Agulhas (both in the Western Cape) and in Algoa Bay (Eastern Cape; Crawford *et al*. 2011; Crawford *et al*. 2013). Colonies in the Western Cape Province are separated by c. 600 km from those in Namibia and Algoa Bay (Crawford *et al.* 2008). The distance between some localities increased due to extinctions of, for example, the colonies at Lambert's Bay in 2006 (Crawford *et al.* 2008) and at Mossel Bay around 1926 (Shelton *et al.* 1984). There is substantial movement of immature penguins between colonies, a trait that should enable the species to adjust to altered environmental conditions, albeit with some delay (Sherley *et al*. 2014a). Dispersing juvenile penguins from the west and southwest coasts tend to migrate up the west coast to the northern Benguela ecosystem, following intrinsic cues to historically high prey abundances (Sherley *et al*. 2017). Furthermore, population genetic studies using DNA evidence show that the three sub-populations are not genetically distinct on a broad scale (Nupen 2014). Thus, the conclusion from results obtained in the APBMP supports African penguins at different colonies as contributing to a single meta-population and to be managed as such. African penguin colonies presumed extant in 2021 are shown in Figure 1 and the authorities that manage the various colonies are indicated in Table 1.

The usual non-breeding range of the species extends along c. 3,200 km of coast, between c. 18°S on the Namibian coast and c. 29°S on the coast of KwaZulu-Natal. Vagrant birds have been recorded as far north as Sette Cama (2°32'S), Gabon on the West African coast (Malbrant and Maclatchy 1958) and up to the Limpopo River mouth (25°S), in Mozambique on the east coast (Shelton *et al*. 1984). Although the northern extent of the range of African penguins off the west coast of southern Africa is predicted to contract southwards in future with no eastward expansion expected (BirdLife International 2021). They have also been recorded up to 100 km offshore (Rand 1960). Most occur within 40 km of the coast (Wilson *et al*. 1988; Heath and Randall 1989; Petersen *et al*. 2006; Ludynia *et al.* 2012; Pichegru *et al*. 2010; Waller 2011; Grigg 2016; Robinson 2016), except on the Agulhas Bank where the distribution of their prey extends farther offshore (Shelton *et al*. 1984; Carpenter-Kling *et al.* 2021 submitted).

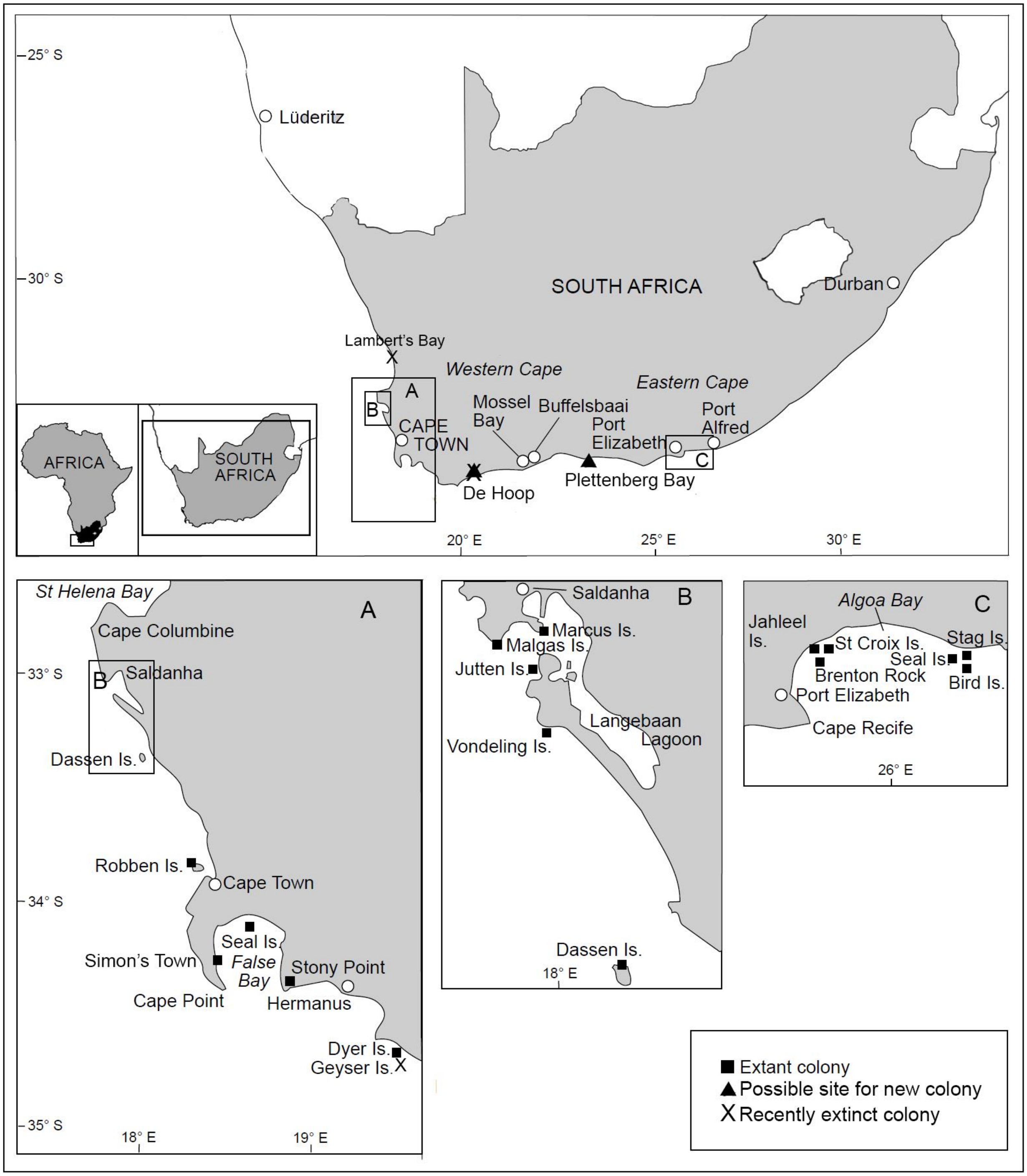

Figure 1: The localities of African penguin breeding colonies in South Africa that were extant in 2021 or recently extinct, and sites under consideration for the establishment of new colonies.

Table 1: List of management authorities responsible for extant African penguin colonies or those that became recently extinct, in South Africa.

COLONY	**MANAGEMENT AUTHORITY**	**2021 CENSUS**
Bird Island (Lambert's Bay) *	CapeNature	0
Malgas Island[X]	SANParks	7
Marcus Island*	SANParks	0
Jutten Island[X]	SANParks	49
Vondeling Island[X]	SANParks	106
Dassen Island[XX]	CapeNature	1806
Robben Island[XX]	Robben Island Museum	1007
Simon's Town (Seaforth, Windmill, Boulders, Burgher's Walk)	SANParks and City of Cape Town	975
Seal Island (False Bay)[X]	SANParks	44
Stony Point[XX]	CapeNature	1623
Dyer Island[XX]	CapeNature	1069
Geyser Island*	CapeNature	0
De Hoop Marine Reserve*	CapeNature	0
Jahleel Island[x]	SANParks	55
Brenton Island*	SANParks	0
St Croix Island[XX]	SANParks	1543
Seal Island (Algoa Bay)[x]	SANParks	83
Stag Island*	SANParks	0
Bird Island (Algoa Bay)[XX]	SANParks	1853

** became extinct in the present century*

[x] 96% chance extinction in 40 years

[xx] 67% probability of survival in next 40 years

5.3 Population Trends

The overall African penguin population (Namibian and South African) in the 1920s was probably of the order of millions, with reports of around one million pairs on Dassen Island alone (Crawford *et al*. 2007). By 1956/57 numbers had decreased to about 141,000 pairs (Kemper *et al*. 2007a). It further declined to about 69,000 pairs by 1979/80, c. 63,000 pairs in 2001, 57,000 pairs in 2004/05, 36,000 pairs in 2006/07 (Kemper *et al*. 2007a) and 25,000 pairs in 2015 (BirdLife International 2021). The global population was at a historical low of 13 600 pairs in 2019 (Sherley *et al.* 2021). Since the 2019, 3,315 breeding pairs – almost a quarter (24.2%) of what remained –

has been lost from the population in the space of two years (Sherley *et al*. 2021) The South African and Namibian populations have experienced different rates of decrease in the last 30 years (3 generations). The Namibian population has decreased by 38% over the period while the South African population decreased by 73,1% (Sherley *et al.* 2020; Sherley *et al*. 2021). Within South Africa the colonies on the west coast have declined overall by 72.2% over the last 3 generations (30 years). The rate of decline has not however been constant during this time. The population along the west coast declined by 3% over the last 30 years, 10.2% over the last 20 years, and 2.9 % in the last 10 years (Sherley *et al*. 2021). Colonies on the south-west coast (east of Cape Town) have declined overall by 39.2% in the last 30 years (Sherley *et al*. 2021. In the eastern Cape, colonies have decreased by 82.3% over the last 30 years and by 7.3% annual rate of decline over the last 10 years. The decline in the numbers breeding in South Africa this century is shown in Figure 2.

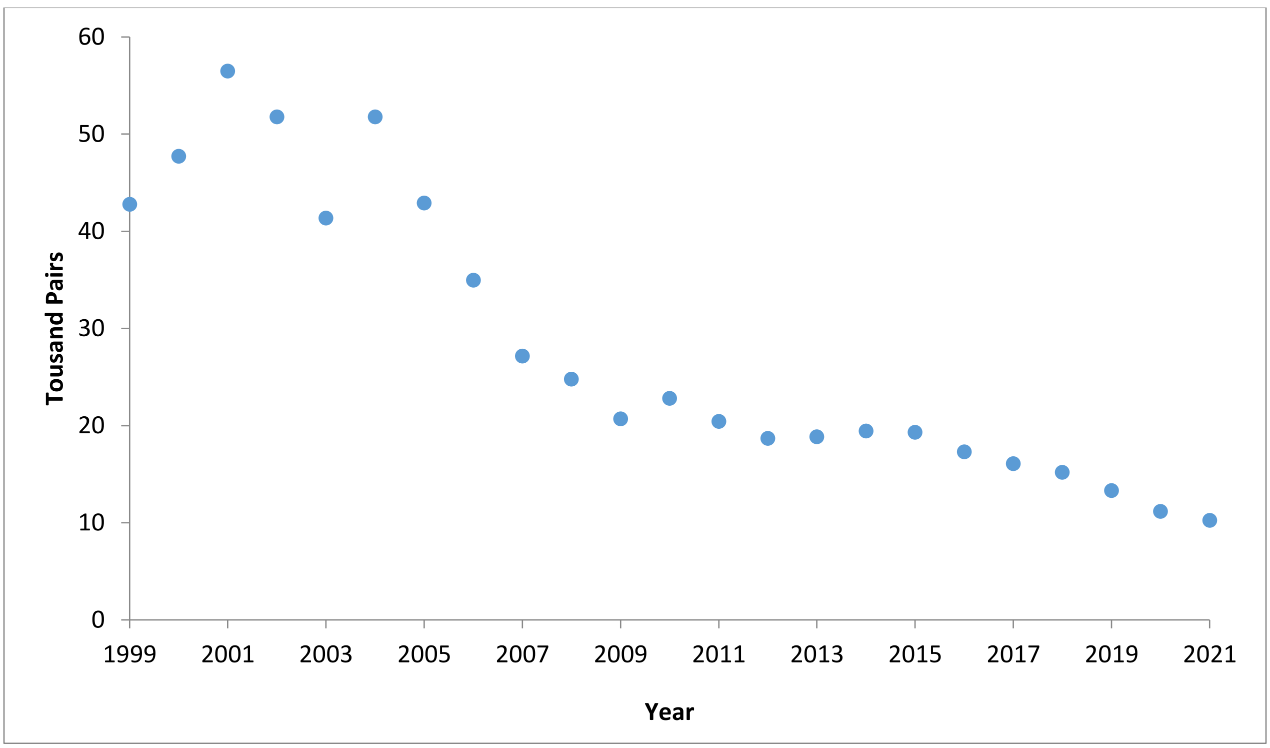

Figure 2: Trends in numbers of African penguins breeding in South Africa, 1999–2021.

The decrease of c. 35,000 pairs of African penguins breeding in South Africa between 2001 and 2009 was investigated in detail to ascertain the probable causes of mortality (Crawford et al. 2011, Crawford et al. 2018). The loss of 24,000 pairs (48,000 breeding birds) west of Cape Agulhas was mainly attributed to a decreased abundance of sardine *Sardinops sagax*, which led to an increased annual mortality of adult penguins north of Cape Town after 2004 from c. 15% when sardine was plentiful to as much as 50% when it was scarce (Crawford *et al.* 2011, 2014, Sherley *et al.* 2014a, Robinson *et al*. 2015). Additionally, in the Western Cape, estimates of nests between 1991 and 2010 were significantly correlated with the combined spawner biomass and sardine in the same year, the previous year, and the year before that (Figure 3) (Crawford *et al.* 2011). Similarly, in the Eastern Cape, nest estimates were significantly correlated with the combined spawner biomass of anchovy and sardine in the same year and these significant correlations suggest that the overall abundance of food influences the number of birds that breed (Crawford *et al.* 2011) and therefore food scarcity is considered the key driver of the rapid decline in African penguin.

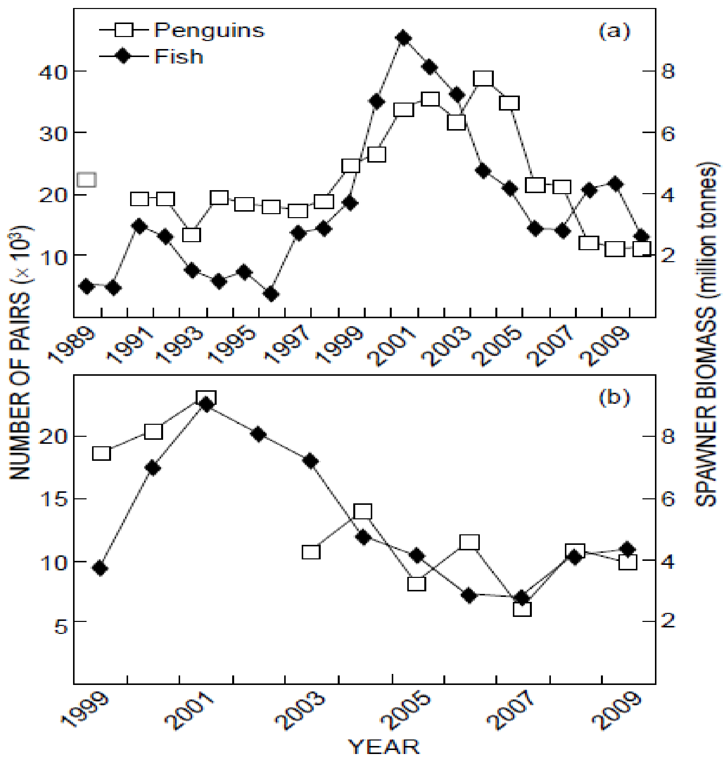

Figure 3: Comparison of trends in estimates of the combined spawner biomass of anchovy and sardine numbers of nests occupied by African penguins in (a) the Western Cape, 1989-2010 and (b) the Eastern Cape, 1999-2009.

5.4 Nesting Habitat

African penguin colonies occupy various habitats that range from islands with little or no vegetation cover to well-vegetated environments on the mainland. Originally, nests were mainly burrows in guano, but the large-scale collection of guano deposits particularly on southern African islands supporting penguin colonies since the mid-nineteenth century destroyed much of this breeding habitat. This resulted in African penguins breeding in a variety of suboptimal habitats (Frost *et al.* 1976b, Wilson and Wilson 1989, Lei *et al.* 2014). More recently, nesting is attempted in burrows and in sand, but more often in clefts between rocks, in the open, under available vegetation, in disused buildings and in artificial nests (Sherley *et al.* 2012a, Pichegru 2013, Shelton *et al.* 1984, Crawford *et al.* 1995). Nesting material includes seaweed, pieces of vegetation, rocks, shells, bones and feathers, with some nests having no lining. Burrows have a more constant microclimate than the surface and some artificial nests (Lei *et al.* 2014, Tol 2015). African penguins breed more successfully in nest sites where there is cover (e.g. under vegetation, under rocks, some types of artificial nests) rather than in the open (e.g. Frost *et al.* 1976a, Seddon and van Heezik 1991, Pichegru 2013).

Artificial nests are not universally beneficial with both the location of the nest, and the microclimate in the nest affecting its suitability. On Robben Island, breeding success was found to be higher for penguins using artificial nests made of wooden boxes and disused buildings (Sherley *et al.* 2012a). A study carried out by Espinaze *et al*. (2020) assessed the nest characteristics, parasite infestations and basic health of penguins associated with three nest types (artificial (made of fibreglass resin), natural open and natural shaded) in the Stony Point colony, South Africa. Tick and flea infestations were higher in warmer and drier nest conditions and in artificial nests, compared to the two natural nest types. The study concluded that penguin nest design should consider site-specific factors on parasite populations, in order to minimize the potential risk that ectoparasites pose to breeding African penguins.

5.5 Breeding

African penguins usually breed for the first time between four and six years of age (Whittington *et al*. 2005a). Once they have bred, adults show strong fidelity to colonies and mates, as well as some nest-sites (e.g. Randall *et al.* 1987, La Cock and Hänel 1987, La Cock and Cooper 1988, Crawford *et al.* 1995, Whittington *et al.* 2005b, Barham 2017, Traisnel and Pichegru 2018). First-time breeders have the flexibility to emigrate to non-natal colonies and hence to take advantage of long-term changes in the distribution of prey resources (Crawford 1998). Breeding is monogamous in the wild (Randall 1983, Crawford *et al.* 1995).

The clutch size is usually two eggs, sometimes one and rarely three (Crawford *et al.* 1999). Eggs are rounded oval and white, becoming stained as incubation proceeds. The laying interval is approximately 3 days (Williams 1981, Williams and Cooper 1984). Double clutching in one season is not unusual; both clutches may fail, or one or both succeed (Randall and Randall 1981, La Cock and Cooper 1988, Crawford *et al.* 1999, Barham 2017). Incubation usually starts with the first-laid egg, lasts 38–41 days (c. 37–38 d/egg) and is shared by both sexes (Rand 1960, Williams and Cooper 1984, Randall 1989).

Chicks from the same clutch generally hatch asynchronously, usually about two days apart (Williams and Cooper 1984, Seddon and van Heezik 1991). Chicks are closely attended by adults until about 26-30 days old when they are mostly left unguarded and may form crèches of up to 25 chicks (Seddon and Van Heezik, 1993; Erasmus and

Smith, 1974), although today crèches rarely exceed 12 chicks (DFFE, unpublished data). Chicks fledge between 55 and 130 days old (Seddon and Van Heezik 1993, Kemper 2006). Often both chicks will fledge from two chick broods but survival from hatching to fledging is variable and influenced by a multitude of factors such as burrow collapse, drowning, predation by Kelp Gulls *Larus dominicanus*, starvation, heat stress, parent mortality and chick abandonment due to parents having to moult (Seddon and Van Heezik 1991, Barham *et al.* 2007, Kemper *et al.* 2007b, Sherley 2010, Pichegru 2013 Sherley et al. 2014b).

5.6 Moulting

In penguins, moulting is catastrophic, as they replace all their feathers in a relatively short period of time (13–40 days) in contrast to other birds that continuously replace a few feathers at a time (Stonehouse 1967). Full moult in penguins is essential to remain waterproof and thus insulated in cold waters while foraging (Stonehouse 1967; Payne 1972). While moulting, penguins are land bound, fasting and are entirely dependent on endogenous fat (Cherel *et al.* 1994), resulting in a 40–50% loss in body mass over the moult period (Brown 1986). Since penguins are unable to forage at sea while their plumage is compromised (Groscolas and Cherel 1991), if they do not commence their moult with sufficient fat reserves to complete the moult and return to sea, they are likely to starve (Brown 1985; Cherel *et al*. 1994; Green *et a*l. 2004). This makes the moulting period a key and critical life-history stage, during which penguins use up most of their body reserves placing them at an increased risk of mortality during the immediate post-moult period (Cooper 1978; Johannesen *et al*. 2002).

A fasting African penguin loses about 40% of its pre-moult mass (Cooper 1978). Should a moulting African penguin not have sufficient food reserves, it can go to sea before the moult is complete (Cooper 1978), but this drastic measure is likely to result in the bird's death. Optimal foraging success for African penguins during the pre-moult fattening period and the post-moult recovery period is thus crucial for adult survival (Wolfaardt *et al*. 2008b, 2009a, Waller 2011). It can also influence parent condition and breeding success over the next breeding season (Sherley *et al*. 2013).

In South Africa, the timing of moult is somewhat synchronous, with birds of all ages undergoing the moulting process during early summer, from September to January, although small numbers of moulting birds are common throughout the year (Crawford *et al*. 2006b; Kemper *et al*. 2008; Wolfaardt *et al*. 2009a). However, colony-specific variability in synchrony and seasonality during this period has been shown (Underhill and Crawford 1999, Crawford *et al*. 2006b, Kemper 2006, Wolfaardt *et al*. 2009a, Waller 2011), which may be attributed to variation in available prey resources around the colonies or in alternative survival strategies. For African penguins, the full moulting process, including pre- and post-moult foraging lasts about 100 days (Crawford *et al*. 2006b). Substantial variation exists in the lengths of both pre- and post-moult foraging periods (Wolfaardt *et al*. 2009a) but on average they are approximately 40 days each (Roberts 2016), while the actual land bound feather shedding phase of moult usually takes 21 days (Randall *et al*. 1986).

The at-sea distribution of the adult African penguins outside of the breeding season, particularly during the pre- and post-moult stage, is much greater compared to during the breeding season (Carpenter-Kling et al. In press). However, a recent study found that even though their foraging range expands from c. 40 km to over 600 km away from their breeding colonies during the pre- and post- moult stages, the waters within 20 and 40 km of their colonies are still used intensively and represent important foraging areas to non-breeding birds (Carpenter-Kling et al. In press). Adult African Penguins are generally thought to return to their breeding colony after their pre-moult foraging period to undergo moult, sometimes even to the same nest in which they bred (Wolfaardt *et al*. 2009a). Recent studies, however, have indicated a change in this behaviour with large numbers of west coast penguins moulting at south coast colonies, particularly at Stony Point (Wolfaardt *et al.* 2009a, Roberts 2016, de Blocq et al. 2019). This may indicate poorer foraging conditions during pre-moult periods on the west coast as the majority of pre-moult birds dispersing from Dassen Island have been shown to travel much greater distances compared to pre-moult birds from Bird Island and Stony Point (Carpenter-Kling et al. submitted). A greater understanding of the timing of moult, including when and where pre-moult fattening, moult and post-moult recovery takes place is of importance for penguin conservation management.

5.7 Population Genetics

Molecular markers including full mitochondrial genomes, microsatellites and single nucleotide polymorphisms (SNPs) have been developed and validated for the African penguin (Labuschagne *et al*., 2012; Labuschagne *et al*., 2013; Labuschagne *et al*., 2014) by the National Zoological Gardens, South African Biodiversity Institute (NZG SANBI). These markers are now used for individual identification, to determine genetic diversity, population structure, inbreeding and parentage determination to monitor African penguin captive and wild populations as well as trade (Labuschagne *et al*., 2015).

Genetic analysis of wild African penguins, which included samples from 12 of the largest breeding colonies, provided evidence of weak regional population structure and high genetic connectivity between breeding colonies. Genetic diversity was found to be moderate to high (Nupen 2014). However, low genetic diversity in the innate immune region of African penguins, similar to that observed in the New Zealand robin (*Petroica australis*) that has undergone several severe population bottlenecks, has been confirmed (Dalton *et al*., 2016). Thus, the African penguin may display lowered resistance to disease and adaptation to changing environments and stress.

Genetic analysis of captive African penguin populations showed comparable and presumably adequate, levels of genetic variability to wild populations (Labuschagne *et al*., 2016). In addition, the observed genetic diversity was found to be similar to levels reported for other penguin species. Genetic variability in terms of a number of alleles between founders in the populations and their offspring were found to be similar. However, the offspring generation displayed a marginally higher inbreeding coefficient in comparison to the founder generation, most likely due to an increase in relatedness. Currently, the captive African penguin populations are not at risk of the deleterious effects of inbreeding. However, management of these populations should be directed to maintain the low inbreeding levels. The baseline assessment of genetic diversity and population structure is an important first step for the establishment of a genetic-monitoring program for the African penguin. However, sampling and genetic analyses should be a continuous process, to measure the extent and effect of processes such as genetic drift on diversity in the captive African penguin populations. It will also be important to ensure the genetic health of captive penguins to be released into new colonies or when supplementing existing colonies.

5.8 Prey and Foraging

African penguins in the wild, feed mainly on active, free-swimming prey, usually schooling pelagic fish, which they may locate visually, through smell (Wright *et al*. 2011) or using cues from the environment (van Eeden *et al*. 2016; Sherley *et al*. 2017). Especially important are anchovy *Engraulis encrasicolus*, sardine *Sardinops sagax* and, in Namibia, bearded goby *Sufflogobius bibarbatus* (Hockey *et al.* 2005; Crawford *et al.* 2011; Ludynia *et al.* 2010). Other prey includes cephalopods, horse mackerel *Trachurus capensis* and juvenile hake *Merluccius* species. and redeye (e.g., Randall and Randall 1986, Hockey *et al.* 2005, Connan *et al.* 2016).

African penguins feed either solitarily or in small to large groups (up to 150 birds; Rand 1960; Wilson and Wilson 1990, Ryan *et al*. 2012). They may dive to 130 m but usually forage at depths < 80 m, with dives lasting 1–2 minutes on average (Pichegru *et al*. 2012). They may hunt co-operatively, corralling fish located in deep waters and driving them to the surface (Wilson 1985b; Wilson and Wilson 1990; Ryan *et al*. 2012) and this improves their catch per unit effort (McInnes *et al*. 2017). African penguins are generally diurnal foragers and rely on ambient light to catch prey, with a lull in feeding activity around midday (Wilson and Wilson 1995; Petersen *et al*. 2006; Ludynia 2007; Waller 2011). Birds seldom feed at night (Wilson 1985a) but may remain at sea resting. Adult penguins at many localities generally feed within 20 – 40 km off their colonies but there are others noted to travel farther to forage (Heath and Randall 1989; Petersen *et al*. 2006; Ludynia 2007; Pichegru *et al*. 2010; Waller 2011; Grigg 2016; Robinson 2016). Adult African penguins perform between 200 and 400 dives in a foraging trip (Ryan *et al*. 2007).
When breeding, most foraging trips last < 24 h. Foraging effort increases as chicks grow, and parents brooding large chicks can forage for 3–5 days (Ludynia 2007; Waller 2011, DEA unpubl. data). Outside the breeding season, birds may travel as far as 540 km away from their colony (Waller 2011; Roberts 2016). During pre- and post-moult foraging periods, penguins spend c. 30–50 days foraging out at sea and can travel total distances of c. 600–1000

km (Roberts 2016). Pre- and post-moult penguins from west coast colonies travelled further from their colony and spent longer out at sea than birds from south coast colonies (de Blocq *et al.* 2019). Recent evidence from non-breeding African penguin tracking data has shown that areas close to their breeding colonies are important foraging areas during the pre- and post-moult stages (Carpenter-Kling *et al.* 2021 submitted).

5.9 South African *Ex Situ* Populations and their Status

Currently, African penguin populations are being kept in registered *ex-situ* facilities throughout South Africa. These facilities include rehabilitation centres, zoos and aquariums. As part of the management plan for this species, a national studbook (as stated in TOPMS) is maintained by the Pan-African Association of Zoos and Aquaria (PAAZA). The studbook for the African penguin uses the Zoological Information Management System (ZIMS) for Studbooks developed by *Species360* and the Species Conservation Toolkit Initiative (SCTI) tools for population analysis and management. Each bird is uniquely identified through inserting of microchips. In an effort to genetically monitor captive birds and to regulate legal trade, a total of 448 African penguin biological samples were collected following a chain of custody protocol from 13 *ex-situ* facilities during the first round of sampling in 2016/2017. A bi-annual sampling and genetic analyses programme is now in place to ensure compliance within the ex-*situ* populations.

Blood on FTA paper is used to determine gender and genetic diversity (neutral and adaptive). Blood, as well as swabs and feather samples, are currently being stored in the National Zoological Gardens National Biobank for future research. In addition, phenotypic measurements and photographic evidence of each bird are taken and stored in the national African penguin database. The National Biobank and National Studbook databases are cross-referenced to form the Animal Passport which is unique to each captive penguin. A total of 469 African penguins are distributed between various facilities and these populations are managed to prevent inbreeding and to maintain a healthy level of genetic diversity.

Studbook records show that African penguins have been held in captivity since 1980 and there has been a steady increase in the numbers of birds recorded in the studbook since that time. African penguins that are deemed non-releasable but still have a good quality of life are kept at several captive institutions throughout South Africa where they are exhibited to educate and provide awareness to the public. During recent years the breeding of penguins in captivity has proved very successful and this now creates limitations with regards to space and capacity at several facilities. Several facilities actively manage their populations by pricking eggs as they have reached optimal capacity. There is an option to bolster current colonies and establish new colonies from captive-bred individuals, however, a risk assessment must first be completed to inform such a decision to ensure there is no deleterious consequences and sufficient prey for the wild population.

5.10 Conservation Translocation

Conservation translocation is defined as *the intentional movement and release of a living organism where the primary objective is a conservation benefit: this will usually comprise improving the conservation status of the focal species locally or globally, and/or restoring natural ecosystem functions or processes* (IUCN/SSC 2013). The rescue, rehabilitation, and release of oiled, diseased or injured African penguins, as well as the rescue, raising and release of orphaned chicks has been undertaken with success in South Africa for many years. These activities are considered as conservation translocations since combined they aim to improve the conservation status of African penguins in the wild (Sherley *et al.* 2014b).

The rehabilitation and release of de-oiled birds, or those translocated to prevent being oiled (e.g., after the *Treasure* oil spill in 2000), have been shown to be effective conservation interventions, with many of the birds subsequently recorded breeding at colonies (Crawford *et al.* 1995a; Whittington *et al.* 2005b; Barham *et al.* 2008; Wolfaardt *et al.* 2009b). However, long-term survival and breeding of some of the birds were impaired (Underhill *et al.* 1999 Crawford *et al.* 2000; Crawford *et al*. 2006a; Barham *et al*. 2007; Wolfaardt *et al.* 2008a, 2009b), thus necessitating efforts to reduce the frequency and scale of oiling events.

Results from hand-reared, wild-origin chicks returned to the wild have shown that post-release juvenile (0.32, SE= 0.08) and adult (0.76, SE= 0.10) survival rates were similar to those for African penguin chicks reared after oil spills and to recent survival rates recorded for naturally reared birds (Barham *et al.* 2007; Sherley at al. 2014a&b). More than 3,500 hand-reared wild-origin chicks were released in the five-year period 2013–2017, showing similar first-year survival rates to wild reared chicks (Ludynia unpubl. Data). Conservation translocation is an ongoing activity that takes place with collaboration between management authorities and rehabilitation facilities.

6. THREATS

In order to halt the decline in the population, the whole suite of conservation actions currently in place, in combination with those that could still be implemented, need to result in improvements in the population growth rate of at least 5% (Table 1). Therefore, attaining population stability may require that impact of various drivers (e.g. predation, inadequate breeding habitat, and anthropogenic factors such as oil spills and disturbance related to the Coega harbour development in Algoa Bay) on the penguin population growth rate were mitigated and gauged accordingly on how this will aid in reducing the rate of decline (see for example in table 1) and improve population growth (see examples in Table 1).

Table 1: A summary of the estimated annual percent change in population growth rate of African penguins (at the specified location) attributed to various threats or actions. Modified from Sherley et al. 2020.

Threat/ Action	Percent change in growth rate	Penguin demographic parameter affected	Location of study	References
Food abundance/ availability ▪ with fishing ▪ without fishing	 8% reduction 6.1% reduction	Adult survival	Robben Island	Robinson et al. 2015
Food abundance/ availability	6% reduction	Juvenile survival	Western Cape	Sherley et al. 2017
Chronic oiling	1.3% reduction	Reproductive output	Dassen Island	Weller et al. 2014
Catastrophic oiling^	2% reduction	Adult mortality	Dassen Island	Weller et al. 2014
Seal predation	2.7% reduction	Adult mortality	Dyer Island	Weller et al. 2016
Gull predation	0.2% reduction	Breeding success	Dyer Island	Weller et al. 2016
Disease outbreaks^	3.2% reduction	Adult mortality	Halifax Island (Namibia)	OIE 2019
Fishery closure*	3.1% increase	Adult survival	Robben Island	Robinson et al. 2015
Artificial nests	1% increase	Fledging success	South Africa	Sherley et al. 2012
Island closure†	~1% increase	Chick and juvenile survival	Robben and Dassen islands	Sherley et al. 2018

*This study considered the closure of the entire small pelagic fishery.

†This study considered island closures at Robben and Dassen Island.

^ These threats do not act on the population continuously.

6.1 Food scarcity

The recent population decline of African penguins has been attributed to food shortages caused by shifts in the distributions of prey species and competition with commercial purse-seine fisheries for food (e.g., Crawford *et al.* 2011, 2018). There was an eastward shift in the distribution of sardine and anchovy, with the mature biomass of these species near the breeding islands north of Cape Town decreasing in the early 2000s (Coetzee *et al*. 2008). It is thought that changes in sea surface temperatures, atmospheric surface pressure and winds have affected spawning conditions for sardine and anchovy stocks and resulted in a shift in the distribution of these species towards the east of the Agulhas Bank (Roy *et al*. 2007; Coetzee *et al*. 2008). This may have been exacerbated by intensive fishing of sardine along the west coast (Coetzee *et al*. 2008). This shift in distribution has created a mismatch in African penguin breeding colonies and their prey, resulting in a localised shortage of food, particularly for breeding adults and their chicks, as well as for non-breeders recovering from their moult fast in the western breeding colonies (Crawford et al. 2011). In addition to this distribution change, the status of the sardine stock is currently considered depleted along the west coast (DFFE 2021), further reducing access to sufficient food for African penguins.

The abundance of forage fish species is known to influence the breeding success (Crawford *et al.* 2006a; Sherley *et al.* 2013), adult survival (Sherley *et al.* 2013; Robinson *et al*. 2015) and juvenile survival (Weller *et al.* 2016) of African penguins. Off South Africa's west coast, fish abundance is often too low to maintain population equilibrium (Weller *et al.* 2014, 2016). Competition between fisheries and penguins may especially be felt at low biomass levels. It has been shown that penguin adult mortality increases when the sardine and anchovy biomass fall below 25% of the maximum recorded value (Robinson *et al.* 2015). In Namibia, where sardine and anchovy are virtually absent from the foraging ranges of breeding penguins (due to overfishing), breeding birds feed predominantly on the relatively abundant though energy-poor bearded goby S*ufflogobius bibarbatus,* thus the lack of energy-rich prey is contributing to the declining penguin numbers rather than a lack of prey entirely (Ludynia *et al.* 2010). One mitigation measure is to create breeding sites in regions where prey is relatively abundant such as re-establish the colony at De Hoop Nature Reserve (https://www.birdlife.org.za/what-we-do/seabird-conservation/what-we-do/coastal-seabird-conservation/creating-penguin-colonies/).

Recent studies on foraging behaviour have further important implications for African penguin management. A long-running experiment, over a decade, investigating the effect of fishing on penguin demographic and foraging parameters has involved 20 km no-take zones around four island colonies which have been alternately opened and closed during three-year experimental cycles. Analyses of results from the experiment and interpretations thereof have differed (Pichegru *et al*. 2010; Sherley *et al*. 2018, 2019; Ross-Gillespie & Butterworth 2020). Significantly, the two sets of analyses (Ross-Gillespie & Butterworth 2016; Sherley *et al.* 2019) have converged to the point that these results indicate biologically meaningful effects of fishing closures around African penguin breeding colonies and that importantly, some of those effects are on variables (chick survival, fledging success) that affect the demography of the species. Further, fishing exclusion around St Croix Island, the once largest remaining colony, has been shown to effectively reduce foraging effort of breeding African penguins when fishing pressure was not increased at the border of the exclusion zone (Pichegru *et al*. 2010; 2012). The reduction in energy spent foraging while breeding was also consistently associated with fishing exclusion around that colony (Pichegru *et al*. 2012).

These results are significant, and any future decision relating to this work needs to be appropriately matched to the penguin biology (DFFE 2021). Furthermore, with updated analyses, Sydeman *et al*. 2021 note the following:

"While other interventions also are required to increase the penguin's population growth rate, these (chick survival) analyses clearly demonstrate (i) the impact of local exploitation of forage fish in proximity to breeding colonies compete with penguins for food and (ii) fisheries closures could offset ∼20% of the penguin population decline which has averaged ∼5% per annum (Sherley *et al.* 2020). Given the high temporal and spatial variability in forage fish abundance (DFFE, 2021) and recent poor accessibility of some prey, notably anchovies (e.g. Crawford *et al.* 2019), the finding of robust local-scale changes in offspring survival related to fisheries closures is remarkable. This result suggests that even quite small (<1100km^2) fisheries time–area closures near breeding colonies are likely to positively affect breeding success in seabirds (Free *et al.* 2021), and that larger fisheries exclusion zones may confer even greater conservation benefits for ecosystems and marine wildlife."

In a study that tracked dispersing African penguin fledglings from eight sites, it was found that these birds travelled hundreds of kilometres to areas of low sea surface temperatures and high chlorophyll-a concentrations on the northern west coast of South Africa and northern Namibia (Sherley *et al.* 2017). Climate change and industrial fishing have however depleted forage fish stocks in these regions so that these cues are no longer a reliable indicator of fish availability (Sherley *et al.* 2017). This study further reported that juvenile penguin survival is low in populations selecting areas of low fish abundance and estimated that breeding numbers are ~50% lower than if the juveniles had foraged in non-impacted regions. This marine ecological trap is of significant concern to an endangered species that continues to decline especially as juvenile recruitment is an important demographic aspect that contributes to population recovery and growth. The results of this study support suspending fishing when prey drops below critical thresholds and suggest that mitigating these ecological traps requires matching conservation action to the scale of these ecological processes (Sherley *et al.* 2017), and thus needs to be addressed in this BMP.

There is thus substantial scientific evidence to support the closures of important penguin foraging areas to fishing. An international review of the impact of forage fish abundance on marine predators suggests that closures around breeding sites could be more effective than more broad-scale interventions for range restricted species (e.g. overall quota reductions) (Free *et al.* 2021). While fishing closures around penguin colonies alone will not prevent this species from going extinct, and fishing closures will have an economic impact on the purse-seine industry, the critical state of this species requires all contributing conservation measures to be implemented urgently.

Options for island closures at the six major penguin colonies (Stony Point, Dassen, Robben, Dyer, St Croix and Bird islands) have been the subject of recent targeted discussions and stakeholder engagements. Recent published science has argued and supported the rationale of positive return for penguins from fishing closures to reduce food competition. Interventions must be biologically meaningful for African penguins (taking into account their generation length). In addition, investigating the protection of important foraging areas away from the colonies, used during the non-breeding season for fattening before and after moult must be prioritized

The scarcity of food for African penguins makes it likely that the attainment of several of the APBMP's objectives will necessitate the effective management of local competition with the purse-seine fishing industry for sardine and anchovy, through exclusion of fishing in areas that surround South Africa's important penguin colonies and any proposed new breeding locality for the species.

It is thus that in February 2021, the Minister of Forestry, Fisheries and the Environment initiated a joint Governance Forum, comprising of officials from the Branches: Oceans and Coasts and Fisheries Management as well as the South African National Parks (SANParks). The aim of the Governance Forum was to prepare a comprehensive Synthesis Report of the current state of knowledge relating to African penguins, island closures, fisheries management relevant to African penguins and the socioeconomics of island closures and penguin-related tourism. The Governance Forum was guided by the National Environmental Management Act (No. 107 of 1998) ("NEMA"), an overarching legislation applicable to Oceans and Coasts, Fisheries Management and SANParks. The Synthesis Report needed to include the NEMA principles, amongst others, of conservation, sustainable use and the precautionary approach. The report titled "*A Synthesis of Current Scientific Information Relating to the Decline in the African Penguin Population, the Small Pelagic Fishery and Island Closures*" was compiled (DFFE 2021) and submitted to be reviewed by two independent international reviewers. An Extended Task Team (ETT) within the Governance Forum was formed that included representatives from the conservation and small pelagic fishing industry sectors. The primary role of the ETT was to explore different delineations of island closures to ameliorate resource competition around six major African penguin colonies, namely, Stony Point, Dassen-, Robben-, Dyer-, St Croix- and Bird Islands as well as to inform management decisions to mitigate resource competition around African penguin colonies and to prevent further decline. Following the Extended Task Team's recommendations, the *Consultative Advisory Forum for Marine Living Resources (CAFMLR)* was engaged to consider and advise on the recommendations. Recommendations emanating from this process will play a role in the implementation of the African Penguin Biodiversity Management Plan, and as such, will form part of the APBMP.

6.2 Breeding habitat modification

Penguins have in the past been exploited through harvesting of adults and eggs for food and by the removal of guano from their colonies for use as fertiliser. Egg-collecting, now no longer legal, was probably the primary driver of the decrease of the species in the early 20th century (Frost *et al.* 1976b, Shannon and Crawford 1999). Guano collection was historically a major cause of disturbance at many colonies as the removal of guano deprived penguins of nest-burrowing sites. This led to birds nesting on open ground where they are more vulnerable to heat stress (often resulting in the abandonment of nests), flooding of nests by rain, and predation by gulls, seals, and other terrestrial predators (Frost *et al.* 1976b, Shannon and Crawford 1999, Pichegru 2013, Kemper 2015). Habitat management through revegetation and the provision of artificial nests is being implemented at colonies where a lack of nesting habitat is a concern. Artificial nests constructed using a new design and different materials are currently being tested at several colonies (African Penguin and Seabird Sanctuary unpubl. data, Sherley *et al.* 2012a, Pichegru 2013).

In the longer term, climate change may decrease the extent of nesting habitat suitable for the species at the northern extent of its historical range (BirdLife International 2021). As is the case for Bank Cormorants *Phalacrocorax neglectus* (Sherley *et al.* 2012b), an increase in the frequency and intensity of storms and in ambient temperatures may reduce the breeding success of birds at low-elevation or unshaded nest sites. Recent observations from the Simon's Town, Stony Point and Robben Island colonies suggest that the increase in the frequency of long periods of high temperatures early in the breeding season may have resulted in an increase in the rate of nest abandonment, which is also likely to affect other colonies. Management authorities improve breeding habitat for penguins through habitat restoration and artificial nests in order to protect them from the impacts of adverse, and in some instances, extreme weather events.

6.3 Human disturbance in colonies

Humans and penguins often come into direct contact at some colonies. Tourists visiting Stony Point and Simon's Town colonies frequently interact with African penguins, and some fail to observe rules, often leaning over or even crossing barriers to photograph penguins or attempting to touch them. Penguins have also been killed by cars, especially at parking lots close to these colonies (SANParks, CapeNature, City of Cape Town unpubl. data). Researchers and management staff at most colonies also interact with African penguins to gather necessary data to monitor the status of the birds, and to implement conservation actions.

The impact of the potential disturbance caused by these penguin-human interactions is not yet fully understood. It is known that impacts of human disturbance vary widely across species. For example, Humboldt *Spheniscus humboldtii* and Yellow-eyed *Megadyptes antipodes* penguins appear to be particularly sensitive to disturbance (Ellenberg *et al*. 2006, 2007), while other species, e.g. Gentoo *Pygoscelis papua* (Holmes *et al*. 2006), Adélie *P. adeliae* (Carlini *et al*. 2007) and Magellanic Penguins *S. magellanicus* (Villanueva *et al*. 2012), show no detrimental effects caused by human presence. However, research that has been carried out on African penguins suggests that they can and do habituate to regular human approaches to nests (Barham and Sherley 2013; Pichegru *et al*. 2016) and penguins on beaches (van Heezik and Seddon 1990). Chicks of birds that are disturbed at erratic intervals appear to show reduced body condition (Barham and Sherley 2013). Recent research suggests that exposure to frequent human activity may induce habituation/desensitisation in African penguin chicks, while unhabituated chicks showed significantly elevated of Glucose Cortisoid (GCM) levels to infrequent anthropogenic presence (Miller 2019; Scheun et al. In Review). Here authors suggest managers and legislation should attempt to minimise all forms of activity around important breeding colonies that are already exposed to regular tourism. However, humans may deter some predators in some cases e.g. it is believed that the two land-based colonies of Stony Point and Simon's Town might benefit from the urban edge created by residential houses and human presence in deterring land based predators like caracal and leopard.

6.4 Catastrophic events

6.4.1 Oil Spills

Past mortality from oil spills has been substantial (Wolfaardt *et al*. 2009b) and may increase if the proposed harbour expansions close to colonies proceeds and high-risk oil and gas exploration ramps up, particularly along the Southern coast and north of Algoa Bay. Most of the African penguin population occur largely in areas that are near existing or planned major shipping routes or ports. South Africa experienced two major oil spills in 1994 and 2000, affecting approximately 30 000 seabirds, and an unquantified number that was never recovered. Long-term survival and breeding of these individuals have been impaired despite rehabilitation programmes (Underhill *et al.* 1999; Crawford *et al.* 2000; Wolfaardt *et al.* 2008a, 2009b). For example, breeding success on Robben Island fell to 0.23 chicks per pair following the spill in 2000, compared with an average of 0.62 ± 0.19 over the other 15 years from 1989 to 2004 (Crawford *et al.* 2006a). Additionally, rehabilitation of oiled birds does not necessarily ensure good future reproduction by affected individuals. During 2001–2005, pairs involving at least one bird rehabilitated from the oil spill in 2000 showed a reduced breeding success of 0.66 chicks per year compared to 1.02 chicks per year in unaffected pairs. This was largely attributable to lower fledging success (43%), mostly owing to higher mortality in older chicks, compared to unaffected pairs (61%) and those involving at least one bird affected by a previous oil spill (71%) (Barham *et al.* 2007). This may indicate physiological or behavioural problems that reduce the parents' ability to meet the food requirements of older chicks, perhaps on account of the toxicity of the heavy oil in the 2000 spill or prolonged captivity and time between oiling and washing of birds in that spill (Barham *et al.* 2007).

A new and growing threat is the expansion of harbours and an increase in ship traffic. Another emerging threat for the African penguin, is ship-to-ship bunkering. This is the process of transferring fuel from one ship to another out at sea. Algoa Bay has been identified as a marine transport hub, and a permanent ship-to-ship bunkering operation was established in 2016, 5km from St Croix Island, increasing the likelihood and risk of oil spills and disturbance (e.g. noise, traffic) with resulting negative effects on penguins. Ship-to-ship bunkering also occurs in Cape Town and Saldanha harbours on an ad hoc basis. Applications for routine ship-to-ship bunkering in Saldanha Bay and St Helena Bay have been submitted. There have been two reported oil spills in Algoa Bay since the commencement of ship-to-ship bunkering, once in 2016 and again in 2019, resulting in the oiling of at least 220 penguins, and other seabirds (SANCCOB unpubl. Data). Addressing and mitigating the threat that ship-to-ship bunkering has to African penguins (and other marine life) requires more focussed attention.

6.4.2 Disease Outbreaks

African penguins are naturally infected by variety of diseases. While many can be of a serious nature for stressed and captive birds (including those in rehabilitation centres), most of these diseases are not known to negatively affect the wild population, except for small chicks and otherwise compromised birds. Highly pathogenic Avian Influenza (H5N8) was diagnosed as the cause of deaths of at least 100 adult African penguins in South Africa in 2018 and over 350 adult African penguins in Namibia in 2019 (Khomenko *et al*. 2018; Molini *et al.* 2019; SANCCOB unpubl. data). A separate outbreak of highly pathogenic Avian Influenza (H5N1) affected over 200 African penguins in 2021. Globig *et al*. 2009 also concluded that outbreaks may be sparked by food shortages amongst others in wild bird.

Avian cholera or pasteurellosis (*Pasteurella multocida*) has been recorded as a cause of death of African penguins (Crawford *et al*. 1992; SANCCOB, unpubl. data). Aspergillosis (*Aspergillus fumigatus* and less frequently, *A. flavus*) is a common and potentially lethal respiratory disease of penguins (Wallace 2014), including African penguins in the wild and undergoing rehabilitation (SANCCOB, unpubl. data). Environmental conditions such as excessive moisture and poor ventilation can also be risk factors (Burco *et al.* 2014; Silva-Filho *et al.* 2015). African penguins are also susceptible to infection by soft ticks (*Ornithodoros capensis*), fleas (*Parapsyllus longicornis humboldti*) and lice (*Austrogoniodes demersus*) (Brandão *et al.* 2014; Snyman *et al.* 2020). Babesiosis (*Babesia peircei*) is a relatively common tick-borne disease in African penguins (Parsons *et al.* 2016). Although most infections are relatively mild and do not have significant health effects (Parsons et al. 2017; SANCCOB, unpubl. data) babesiosis can cause severe disease in penguin chicks. This can lead to reduced breeding success in suboptimal colony environments that have higher than normal tick burdens.

Avian malaria (*Plasmodium sp.*) is a mosquito-borne disease to which penguins are particularly susceptible (Vanstreels *et al*. 2016). Two species are known to infect African penguins in South Africa: *P. relictum*

(Fantham & Porter 1944) and *P. elongatum* (SANCCOB, unpubl. data). The prevalence is low in wild individuals (<1%) (Brossy 1992; Brossy *et al*. 1999; Parsons *et al.* 2016), however it can be as high as 20% at rehabilitation centres unless preventative methods are employed (Parsons & Underhill 2005; Botes *et al*. 2017). Avian pox (*Avipoxvirus*), also transmitted by biting insects, occasionally infects African penguin chicks, especially those which are otherwise compromised and can lead to blindness, deformity and ultimately to death (Kow 1992; Kane *et al.* 2012; SANCCOB, unpubl. data). Changes in tick or mosquito numbers due to changes in climate or colony habitat could lead to higher penguin mortalities due to malaria and babesiosis. The risk of infectious disease negatively affecting African penguin populations may be due to reduced breeding success or through the death of adult birds. This risk increases when penguins are under stress from other factors such as poor nutrition and when they breed in suboptimal colony environments.

6.4.3 Extreme weather events

Extreme weather events such as heat waves and severe storms can decrease breeding success at some colonies where penguins nest on the surface. If adults leave a nest unattended due to extreme heat, young chicks are vulnerable to predation or overheating (Cooper 1974; Frost *et al.* 1976; Yorio and Boersma 1994). Large storms can also cause flooding (from rain and storm surges), as was the case on Dyer Island in June 2017 (CapeNature unpubl. data). Climate change predictions for South Africa are for increased temperatures and more intense storms (New *et al.* 2006; Turasie 2021). Habitat management at colonies is ongoing by management authorities, including preparations prior to predicted storms and the installation of artificial nests (SANParks and CapeNature unpubl. data). More extreme weather events also increase the likelihood of wildfires. Although fires have not affected any colonies to date, Stony Point and Boulders are potentially vulnerable.

6.5 Predation

Predation on penguins by other predators is a natural occurrence, but in some cases, it can result in a large number of mortalities (Makhado et al 2013). It occurs on land on eggs and individuals, and at sea on individuals. At-sea predation includes that by Cape fur seals *Arctocephalus pusillus*, which impose significant mortality at some colonies (Makhado 2009; Makhado *et al*. 2013; Weller *et al*. 2016), and occasionally by sharks (Randall *et al*. 1988). On land, kelp Gulls *Larus dominicanus* scavenge deserted and unguarded clutches and small chicks especially in surface nests (Cooper 1974). Culling of Kelp Gulls at Bird Island in Algoa Bay led to improved penguin breeding success (Pichegru 2013). Feral cats' prey on eggs and chicks at some colonies (Weller *et al.* 2014, 2016). At mainland colonies, predation by domestic animals (including feral dogs) remains a problem. Predation by natural predators including mongooses, leopards *Panthera pardus* and caracal may also severely affect mainland colonies (e.g., Underhill *et al.* 2006; Vanstreels *et al*. unpublished data; CCT; SANParks and CN, unpublished data). Attempts to establish penguin colonies on the mainland should incorporate predator management measures, as the project to re-establish the colony at the De Hoop Nature Reserve does (BirdLife South Africa, unpublished). The feasibility of creating artificial islands as breeding colonies should be considered as this will reduce the risks from terrestrial predators. Occasional predation of eggs and small chicks by mole snakes *Pseudaspis cana* at Robben Island (Dyer 1996) is not considered a major threat at present. Draft predation management guidelines were written as part of the first AP-BMP. Protected Area Management Plans (PAMPs) also include aspects of predation management.

6.6 Maritime industries

There are a number of other threats stemming from maritime industries African penguins that affect penguins at sea, away from breeding colonies. Large portions of South Africa's Exclusive Economic Zone (EEZ) are under exploration or mining rights for oil and gas as well as seabed mining. The full impacts of these activities on African penguins, their prey and other marine life are not known and should be investigated and managed if marine mining is to go ahead. Exploration for oil and gas reserves under the ocean floor often make use of seismic surveys, which uses reflected sound waves to generate a map of geologic structures. Seismic surveys taking place within < 100 km of African penguin breeding colonies have been shown to induce a behavioural response so that the penguins use foraging areas further away from the location of the seismic activities (Pichegru *et al*. 2017). As a result, energy expenditure while foraging significantly increases. Due to rapidly increasing seismic activities planned by the government, this disturbance of and possible detrimental effects on penguins at sea should be managed.

The impacts of shipping activities (e.g., noise generation, disturbance to penguins and/or fish) on African penguins are unknown. However, an increase in shipping activity in Algoa Bay since the advent of ship-to-ship bunkering in the bay has coincided with a rapid decrease in penguin numbers at the St Croix Island colony (L. Pichegru, pers. comm.) which suggests there could be an impact. Two Aquaculture Development Zones (ADZ) have been declared in recent years, one in Saldanha Bay and the other in Algoa Bay. Both are close to penguin breeding colonies, particularly the zone in Algoa Bay which is close to St Croix Island. Both ADZs allow for bivalve and finfish farming and it is likely the latter will affect African penguins both directly and indirectly. Direct effects include displacement from foraging areas and potential entanglement in nets. Indirect effects include impacts of therapeutic chemicals to treat the farmed fish and the farms attracting increased numbers of predators such as sharks and seals.

7. SOCIO-ECONOMIC CONSIDERATIONS

Ecotourism can be viewed as an important tool for conservation, raising much needed funds through the non-consumptive use of wildlife (Pegas *et al.*, 2014; Shannon *et al.*, 2017; Steven *et al.*, 2013) as well as creating public awareness of environmental issues (Emerton *et al.*, 2006). In South Africa, Simon's Town (which includes the areas of Boulders, Seaforth, Burgher's Walk and Windmill Beach), Stony Point and Robben Island, provide opportunities for the public to observe African penguins in their natural habitat and have become popular tourist destinations (e.g. Lewis *et al*. 2012). The economic benefits of these colonies include income generated through entrance fees, provision of jobs and associated tourism benefits to the surrounding areas (Lewis *et al*. 2012). For example, the colony at Boulders is one of the world's most-visited penguin colonies with 885 jobs associated with it (van Zyl and Kinghorn 2018). In 2018, the likely income generation directly associated with this colony over the next 30 years was estimated at approximately ZAR 6.87 billion (van Zyl and Kinghorn 2018).

It is important, however, to ensure that potential negative impacts of ecotourism are understood and carefully mitigated (see Section 6.2). Species that are exposed to human presence through ecotourism (as well as additional human activities such as research, monitoring and management) respond, either behaviourally or physically, to unpredictable human activities within their surroundings in addition to more predictable stressors such as seasonal changes and resource availability (Gaynor *et al*. 2018). It is the activation of anti-predator behaviours in response to these human activities that can have a fitness cost to a population (Amo *et al.* 2006), through physiological and behavioural changes such as immune and reproductive suppression, metabolic alteration as well as an increased susceptibility to future stressors (Auperin *et al*. 2008; Kaufman *et al*. 2007; Teicher *et al*. 2003; Webster Marketon *et al.* 2008). Given that people can see African penguins at these sites and the present poor conservation status of the species, any expansion of tourism to other island colonies would need to be carefully considered before implementation. Furthermore, any plans to grow the African penguin ecotourism industry, should be considered only once the population has sufficiently recovered, and in line with the National Development Goals, must take into account and mitigate against causing additional stress to this species (Scheun *et al*. 2020).

<u>Economic costs to the small pelagic industry</u>

While the closures of colonies to fishing (see section 6.1) have benefit for African penguins, and these closures would not affect allowable catches, it has been argued that they would have a cost to the purse-seine fishery (Berg *et al.* 2016, DFFE 2021). However, it should be borne in mind that other predators of epipelagic forage resources (e.g. gannets, cormorants, seals, cetaceans, predatory fish) also support marine ecotourism or alternative fisheries, and failure to apply an ecosystem approach to fisheries (EAF) may result in severe losses in ecosystem services (e.g. Roux *et al.* 2013, section 5.10 above). In order to effectively implement an EAF, it is important to understand exactly what the costs to industry are and how they are impacted by conservation measures aimed at benefitting penguins. As such, a detailed socio-economic study is required that looks at the small pelagic industry, at a company scale, to understand the costs of fishing restrictions around colonies. DFFE (2021) states that the decline in the sardine population and its current depleted state have had substantial impacts on the small pelagic fishery. It is thus critically important to distinguish between costs to industry that are attributable to island closures alone, and those costs that are as a result of the poor biomass.

Management of the South African small pelagic fishery is primarily through the setting of annual total allowable catches (TAC)s, total allowable bycatches (TABs) and precautionary upper catch limits (PUCLs) (DFFE 2021). Given research that shows how local food availability impacts seabirds, spatial management of the small pelagic fishery needs to be looked at, to reduce high fishing intensity in close proximity to African penguin (seabird) breeding colonies. The area between Stony Point and Dyer Island for example has high concentrated intensity of sardine fishing compared to the rest of the coastline west of Agulhas (DFFE 2021). Furthermore, in order to be considered a truly sustainable fishery, it is necessary to ensure that pricing of the products reflects the true cost of catches and so an evaluation of the pricing structures of sardine and anchovy is needed. The South African anchovy fishery is largely an export fishery and used exclusively for fishmeal and fish oil (DFFE 2021). A number of marine predators rely on these forage fish, many of which have threatened conservation status, and investigations looking into more efficient uses for anchovy should be considered as far as possible (AEWA 2020, Shannon & Waller 2021). This would include investigating and supporting using anchovy for human consumption (van der Lingen 2021) and alternative sources of protein for animal feed other than anchovies, such as insect protein like black soldier fly larvae (Shannon & Waller 2021). The latter can also be a source of job creation and economic development as well as food waste reduction.

8. ENVIRONMENTAL EDUCATION AND PUBLIC AWARENESS

Penguins are highly charismatic; many zoos and aquaria note that the penguins they keep are one of their most popular attractions (Mann, Ballantyne, and Packer, 2017). Mann *et al*., (2018) discovered that over a year after a visit to an aquarium approximately 50% of adult visitors, who made a promise to penguins to become more environmentally responsible, were still carrying out their intended actions, such as not littering. Pro- conservation related behaviour change after a zoo visit may be related to personal connections to animals and conservation ideas developed during the zoo visit (Mann, Ballantyne, and Packer 2017).

By engaging members of the public using penguins as a primary attraction or crowd-puller, it is possible to raise their individual awareness of environmental and conservation issues and even modify their future behaviour, assists with fund raising research and conservation action among others. Most, if not all, institutions that keep African penguins both within and outside South Africa, offer regular talks at penguin exhibits and provide plenty of signage all of which draw the attention of the many visitors to a range of environmental and conservation issues. Such regular talks to visitors are supplemented at most zoos and rehabilitation centres with a range of educational projects both inhouse and as outreach to schools, etc. Furthermore, researchers and conservationists working in the field with wild penguins also regularly provide talks about their work and conservation of these birds to local interest groups including schools and at public events. Each organisation involved with the AP-BMP conducts environmental education and awareness linked to penguins. Overall, it is notable that very large audiences whose environmental behaviour can be influenced are reached every year, through the medium of the African penguin. One example of a successful awareness campaign is ‘Penguin Promises’ which encourages people to make pledges to change their own behaviour in ways that will improve the overall environment, for example by reducing their use of plastics or by changing their diets, etc. The campaign, which originated at uShaka Sea World in 2011, now has partners throughout South Africa and has started work in South America.

9. IMPLEMENTATION, MONITORING AND EVALUATION

The implementation of the first African Penguin BMP (AP-BMP) was initially overseen by a Steering Committee. The Steering Committee comprised of officials from organs of state and management authorities i.e., DFFE, SANParks, CapeNature, City of Cape Town and Robben Island Museum. While most of the actions form part of the day-to-day responsibilities of Management Authorities as part of their mandated protected area management, care must be taken to ensure to ensure that sufficient resources are allocated to ensure their effective implementation. Furthermore, the Department and other implementing agents need to ensure that adequate budget and resources are available to implement the actions required of them. The APBMP actions were guided by two functioning working groups (WGs), namely, the Population Reinforcement WG and the Habitat WG. The purpose of the Population Reinforcement WG was to enhance population viability, by increasing population size, increasing genetic diversity and improving demographic representation to inform conservation interventions. The Habitat WG was established to advise on improvement and maintenance of breeding habitats and oversaw the research into artificial nest suitability as well as to provide guidance for the management of breeding habitats, and identification of sites suitable for restorative or rehabilitative actions. These working groups met on a quarterly basis each year. These WGs comprised members from management authorities, nongovernmental organisations management authorities, non-governmental organisations (NGOs) and academic institutions.

The Seabird Technical Team, under the Top Predators Scientific Working Group provide scientific advice on matters relating to the African penguin and other seabirds. Other working groups that were involved in the implementation of the first APBMP include the Small Pelagic Scientific and Management Working Groups that advise on and implemented matters relating to prey and prey availability. The Department of Transport and the South African Maritime Safety Authority (SAMSA) established the National Incident Management Organisation (IMOrg) which played a role in the review of the National Oil Spill Contingency Plan, under which the National Oiled Wildlife Contingency Plan is drafted.

The National Oiled Wildlife Preparedness, Response and Contingency Plan was drafted to ensure that species such as the African penguin, which are highly susceptible to oiling, formed part of the overall oil spill response. Some members of the African Penguin WGs are standing members under the IMOrg.

In addition to the above-mentioned Management Authorities, the South African National Biodiversity Institute (SANBI), particularly the National Zoological Gardens (NZG) component, advised on the genetic diversity of African penguins both in the wild and in captivity. Furthermore, NZG's Biobank Information System, which is a repository of biological material (sperm, tissue, blood products and DNA), increased the efficiency of captive breeding of penguins and complementary conservation strategies. The collection of DNA supports the Department in issuing export permits for African penguins under CITES.

The first APBMP was implemented for the past five years through various initiatives and established working groups and task teams structures, and this will be adopted in this APBMP. Following these initiatives, the APBMP will use the already established structures and where necessary a need to establish new working group structures to oversee the implementation of the new actions.

However, in order to assess the efficacy of the actions implemented in the first BMP draft and how these actions contributed to reducing the population decline and promoting the improvement in African penguin species' recovery, it is essential to have an effective monitoring and evaluation programme in place that is able to provide data appropriate for a variety of information needs. Furthermore, comprehensive quantitative assessment on the efficacy of implementation of actions or management interventions conducted under the first AP-BMP should also be reviewed as the assessment will be essential for informing adaptive management measures which can be continued to be implemented in this APBMP draft that can improve the population status to penguins. This will be used to further analyse and review any actions taken forward in this Plan for its effective and efficient implementation.

Although, linking changes to the African penguin population to specific management actions is difficult and requires a carefully considered modelling approach that could include the identification of functional relationships. Key to this, is the collection of data on population size, as well as appropriate demographic data that are important in driving population change, which include survival, fecundity, condition, recruitment and (natal and breeding) dispersal. The monitoring of individual birds is essential, and South Africa has an effective programme in place that involves the sub-cutaneous insertion of passive integrated transponders (PITs) into adult, and chicks that are about to fledge. Monitoring data on variables such as food availability, predation, oiling, disease, and other threats impacting the African penguin population as well as data on foraging behaviour, breeding habitat type, extent and cause of mortality, and emigration also needs to be collected.

It is important to have a programme that will assess the efficacy of BMPs, in which the African Penguin BMP will be a part of. Additionally, DFFEs Top Predators Scientific Working Group and Seabird Technical Team (STT) together with the already established working groups guide the specifics of the development of a monitoring and evaluation programme to scientifically assess the efficacy of the African Penguin BMP.

10. ACTIONS

Table 2: A summary of the actions in the APBMP listed against the objectives to which they apply. An indication is given as to whether they are new or from the 2013 APBMP.

Threats and Objectives	Actions	BMP version
RESEARCH, MONITORING AND EVALUATION		
Objective 1: Maintain and where possible expand a research and monitoring programme that provides information that supports adaptive management and conservation of the African penguin population.	1.1 Continue long-term monitoring of colony sizes, demographic parameters, and efficacy of management interventions for African penguins.	APBMP (2022)
	1.2 Further develop system-wide population models of African penguins to assess multiple threats, counterfactual analysis to evaluate cause and effect between interventions and outcome, as well as to inform and benefit current and future conservation interventions.	APBMP (2022)
	1.3 Develop a strategic Research Plan for African penguins based on the experience from the 2013 APBMP gazette.	APBMP (2022)
	1.4 Identify, prioritise and mitigate new emerging at-sea threats to African penguins (e.g. maritime activities, anthropogenic pollutants).	APBMP (2022)
	1.5 Investigate the effects of anthropogenic pollutants such as microplastics, microfibres and persistent organic pollutants and heavy metals such as mercury, etc., on African penguin survival and breeding success.	APBMP (2022)

FORAGE FISH AVAILABILITY		
Objective 2: Ensure availability of forage fish for African penguins in key forage areas throughout their annual cycle.	2.1 Implement and review the effect of the recommendations from the Consultative Advisory Forum for Marine Living Resources (CAFMLR) - Special Project: Penguin and Small Pelagic Fishery Interactions. Review to be considered on a colony-by-colony basis.	APBMP (2022)
	2.2 Identify potential fisheries-penguins foraging overlap and fishery management strategies (including Operational Management Procedures) impacting African penguins and advise appropriate mitigation interventions.	APBMP (2022)
	2.3 Determine the impacts of environmental/climate–driven shifts in forage fish availability on penguins and investigate options for mitigating such impacts.	APBMP (2022)
	2.4 Identify the costs and benefits of additional fishing restrictions in the identified areas of overlap between small pelagic fisheries and African penguins throughout their lifecycle.	APBMP (2022)
	2.5 Update and expand on the inclusion of African penguin related information into the small pelagic Operational Management Procedure (OMP) and investigate the development of an ecosystem threshold for African penguins	APBMP (2022)
IMPROVE BREEDING HABITAT, PREDATOR MANAGEMENT AND POPULATION REINFORCEMENT		
Objective 3: Improve Breeding Habitat, Predator Management and Population Reinforcement.	3.1 a) Continue the evaluation of breeding effectiveness for different nest types and the design and construction of artificial nests (Modified from action 4.2.1.2 from AP-BMP 1) b) Applying the results from a), identifying suitable artificial nest types and providing them on colony-by-colony basis where necessary.	Action 4.2.1.2. in progress from APBMP (2013)

	3.2 Review and improve the implementation and monitoring of predator management at all African penguin colonies	Combination and modification of APBMP (2013) actions 4.4.1.1, 4.4.1.2, 4.4.1.3, 4.4.2.1
	3.3 Draft a risk assessment on the release of captive-bred penguins into the wild.	APBMP (2022)
	3.4 Develop and implement guidelines to minimise disturbance and prevention of road mortality (Continuation of action 4.2.2.1 from AP-BMP).	Continuation of action 4.2.2.1 from AP-BMP (2013).
CATASTROPHIC EVENTS		
Objective 4: Minimise and/or mitigate the impact of catastrophic events on African penguins: Oil spills**.**	4.1 Advise on zonation of shipping lanes, bunkering operations, and shipping activities to minimize the risk of oil spills and other forms of pollution (including underwater noise) near seabird colonies.	Action 4.2.3.1 in progress from APBMP (2022)
	4.2 Finalise the National Oiled Wildlife Preparedness, Response and Contingency Plan and ensure that all colonies have specific Oiled Wildlife Response Plan.	APBMP (2022)
Objective 4: Minimise and/or mitigate the impact of catastrophic events on African penguins: Disease Outbreaks.	4.3 Assess the efficacy of the implementation of the African Penguin Disease Surveillance and Diagnosis Programme.	Modified action 4.5.4.2 in progress from APBMP (2013)
	4.4 Ensure all colonies have Disease Contingency Plans with associated accessible resources for rapid management action	Modified action 4.5.4.4 in progress from APBMP (2013)
Objective 4: Minimise and/or mitigate the impact of catastrophic events on African	4.5 Investigate the impacts of extreme weather and other natural disasters on the African penguin population.	Action 4.5.5.1 ongoing from APBMP (2022)

penguins: Extreme weather and Climate Change.		
SOCIO-ECONOMIC AND ECOSYSTEM BENEFITS		
Objective 5: Increase the socio-economic benefit of African penguins.	5.1 Management Authority WG to consider scientific advice in decision making and matters relating to education and awareness programme including school outreach, and relevant public fora.	APBMP (2022)
	5.2 Facilitate a dedicated study on the socio-economic value of each colony locally and regionally and their ecosystem benefit.	APBMP (2022)
	5.3 Establish a repository for communication between stakeholders involved in the Biodiversity Management Plan.	APBMP (2022)
	5.4 Encourage new initiative to pilot approaches for increased benefit (incl. Guides, monitors and supplementary livelihood)	APBMP (2022)

Objective 1: Maintain and where possible expand a research and monitoring programme that provides information that supports adaptive management and conservation of the African penguin population

1.1 CONTINUE LONG-TERM MONITORING OF COLONY SIZES, DEMOGRAPHIC PARAMETERS AND EFFICACY OF MANAGEMENT INTERVENTIONS FOR AFRICAN PENGUINS	
Responsible Party	DFFE (Oceans and Coasts), Management authorities
Collaborators	SANBI, Academia, NGOs, Fisheries Management Branch
Timeline	As stipulated below
Resources Needed	Funding for population analyst; database management; colony monitoring by both remote (electronic) and manual (ranger) means
Indicators	a) Standardised monitoring protocols developed. b) Annual standardized reporting including a summary of demographic data for all life stages: - Breeding census, survival rates, emigration/immigration rates, breeding success (including per nest type), chick condition, mortality in the wild (Academia, DFFE, Management Authorities). c) Standardised annual reports of management interventions undertaken at different localities and measures implemented to gauge their success (Management Authorities). d) Annual Studbook report (Rehabilitation and Captive facilities). e) Assess protection level (consider a spatial plan to manage multiple threats).

1.2 FURTHER DEVELOP SYSTEM WIDE POPULATION MODELS OF AFRICAN PENGUINS TO ASSESS MULTIPLE THREATS, COUNTERFACTUAL ANALYSIS TO EVALUATE CAUSE AND EFFECT BETWEEN INTERVENTIONS AND OUTCOME, AS WELL AS TO INFORM AND BENEFIT CURRENT AND FUTURE CONSERVATION INTERVENTIONS (MICE AND/OR ECOSYSTEM MODELS).	
Responsible Party	DFFE (Oceans and Coasts & Fisheries Management), Management Authorities
Collaborators	SANBI, Academia, NGOs
Timeline	As stipulated below
Resources Needed	Funding for population analyst and spatial analysis support
Indicator	a) A preliminary report based on demographic information required by the end of Year 1 (DFFE based on 5.2 (Indicators b-d)). b) A final report based on updated demographic information by the end of Year 2. c) An assessment of synergistic effects of multiple threats to African penguins, quantify impacts of multiple drivers and protection level analysis. d) Counterfactual analysis to evaluate or attribute cause and effect between conservation interventions and outcomes.

1.3 DEVELOP A STRATEGIC RESEARCH PLAN FOR AFRICAN PENGUINS BASED ON THE EXPERIENCE FROM THE 2013 APBMP GAZETTE	
Responsible Party	DFFE (Oceans and Coasts)
Collaborators	Fisheries Management, SANBI, Management Authorities, NGOs, Academia
Timeline	As stipulated below.
Resources Needed	Experts to serve on the Seabird Technical Team
Indicator	a) African Penguin Research Plan.

	b) Report identifying and prioritising research gaps submitted to DFFE's Top Predator Scientific Working Group (TPSWG) with six months of the gazetting of the APBMP[1]. c) The report reviewed by TPWG and submitted to funders and universities within six months following achievement of Indicator b). d) Annual assessment of achievement of research priorities by APBMP Steering Committee.

1.4 IDENTIFY, PRIORITISE, IMPLEMENT AND RECOMMEND ALL MITIGATION MEASURES ON AT-SEA THREATS.	
Responsible Party	BirdLife-South Africa, Academia
Collaborators	DFFE, NGOs, Academic Institutions, management authorities
Timeline	Within 1 year of gazetting of the APBMP
Resources Needed	Internal and external
Indicator	a) Report on the status of At-Sea Threats (BirdLife-South Africa). b) A report on maritime traffic and marine noise pollution (Academia).

[1] This should include (but not be limited to) consideration of the impacts of seismic operations, marine pollution and climate change on African penguins, an updated assessment of the efficacy of rehabilitation of oiled African penguins and assessments of the economic, employment and ecosystem benefits of African penguins.

1.5 INVESTIGATE THE EFFECTS OF ANTHROPOGENIC POLLUTANTS SUCH AS MICROPLASTICS, MICROFIBRES AND PERSISTENT ORGANIC POLLUTANTS AND HEAVY METALS SUCH AS MERCURY, ETC., ON AFRICAN PENGUIN SURVIVAL AND BREEDING SUCCESS.	
Responsible Party	DFFE (Oceans and Coasts Branch)
Collaborators	Academics, NGOs, Management Authorities
Timeline	Ongoing
Resources Needed	Research budget, specialised skills, monitoring equipment/capacity
Indicator	a) Working Group Reports b) Research publications

Objective 2: To ensure availability of forage fish for African penguins in key forage areas throughout their annual cycle

2.1 IMPLEMENT AND REVIEW THE EFFECT OF THE RECOMMENDATIONS FROM CONSULTATIVE ADVISORY FORUM FOR MARINE LIVING RESOURCES (CAFMLR) - SPECIAL PROJECT: PENGUIN AND SMALL PELAGIC FISHERY INTERACTIONS.	
Responsible Party	DFFE (Oceans and Coasts- and Fisheries Management)
Collaborators	Other relevant authorities; NGOs, Academic Institutions
Timeline	a) A review to take place after 4 years of implementing the closure recommendations from the Consultative Advisory Forum for Marine Living Resources (CAFMLR) - Special Project: Penguin and Small Pelagic Fishery Interactions. Review to be considered on a colony-by-colony basis.
Resources Needed	Internal and external funding (actual cost estimate)
Indicator	a) Report on the review of the CAFMLR Recommendations highlighting each colony. b) Implementation of approved management recommendations colony by colony.

2.2 IDENTIFY POTENTIAL FISHERIES-PENGUINS FORAGING OVERLAP AND FISHERY MANAGEMENT STRATEGIES (INCLUDING OPERATIONAL MANAGEMENT PROCEDURES) IMPACTING AFRICAN PENGUINS AND ADVISE APPROPRIATE MITIGATION INTERVENTIONS	
Responsible Party	DFFE (Oceans and Coasts; Fisheries Management)
Collaborators	Researchers, Fishery Organisations, NGOs
Timeline	a) Within a year of the gazetting of the APBMP (see below)- b-d) Within three years of the gazetting of the APBMP (see below)
Resources Needed	Internal and external
Indicator	a) key foraging locations during the non-breeding stages (juvenile, pre and post moult etc identified b) Overlaps with potential fisheries identified c) Mitigation interventions aimed to limit interaction between the fishery and penguins identified and reported to DFFE d) Consider management strategies that limit interaction between the fishery and penguins during the non-breeding stages

2.3 DETERMINE THE IMPACTS OF ENVIRONMENTAL/CLIMATE–DRIVEN SHIFTS IN FORAGE FISH AVAILABILITY ON PENGUINS AND INVESTIGATE OPTIONS FOR MITIGATING SUCH IMPACTS.	
Responsible Party	DFFE (Oceans and Coasts, and Fisheries Management Branches)
Collaborators	NGOs, Academic Institutions, Fishing Industry, and other relevant authorities

Timeline	Within two years
Resources Needed	Funding for the analyses and reporting
Indicator	a) Report on the impacts of environmental/climate-driven shifts in forage fish availability and recommendation for mitigating impacts.

2.3 IDENTIFY THE COSTS AND BENEFITS OF ADDITIONAL FISHING RESTRICTIONS IN THE IDENTIFIED AREAS OF OVERLAP BETWEEN SMALL PELAGIC FISHERIES AND AFRICAN PENGUINS THROUGHOUT THEIR LIFECYCLE.	
Responsible Party	BirdLife-SA; DFFE (Oceans and Coasts, and Fisheries Management Branches)
Collaborators	NGOs, Academic Institutions, Fishing Industry, and other relevant authorities
Timeline	Within two years of completing fishing overlap analysis
Resources Needed	Funding for analyses and reporting
Indicator	b) Estimates of penguin survival rate and pre-breeding conditions (and others) c) Quantify cost to the fishing industry of closures d) Quantify cost to fishing industry of low biomass e) Recommendations for possible additional fishing management tools

2.4 UPDATE AND EXPAND ON THE INCLUSION OF AFRICAN PENGUIN RELATED INFORMATION INTO THE SMALL PELAGIC OPERATIONAL MANAGEMENT PROCEDURE (OMP) AND INVESTIGATE THE DEVELOPMENT OF AN ECOSYSTEM THRESHOLD FOR AFRICAN PENGUINS	
Responsible Party	DFFE (Oceans and Coasts and Fisheries Management)
Collaborators	Researchers, Fishery Organisations, NGOs, Management Authorities
Timeline	a) Within a three-year timeframe of the gazetted APBMP b) When the Operational Management Procedure (OMP) for the Small Pelagic Fishery is revised.
Resources Needed	a) Personnel, historical banded and PIT data, fish biomass indices and reproductive success. b) Internal and external
Indicator	a) Updated and spatially expanded functional relationships that link penguin population size to forage fish biomass levels (e.g. Robinson et al. 2015): I. Terms of Reference of the Study. II. Report on the functional relationships that link penguin population size to forage fish biomass levels for all colonies. III. Implement the outcomes of the study. b) Incorporate the results from a) into the OMP- for the Small Pelagic Fishery. c) Report on the implementation of an ecosystem threshold for African penguins (if applicable).

Objective 3: To improve breeding habitat, predator management and population reinforcement.

3.1 a) CONTINUE THE EVALUATION OF BREEDING EFFECTIVENESS FOR DIFFERENT NEST TYPES AND THE DESIGN AND CONSTRUCTION OF ARTIFICIAL NESTS (Modified from action 4.2.1.2 from AP-BMP 1) **b) APPLYING THE RESULTS FROM A), IDENTIFYING SUITABLE ARTIFICIAL NEST TYPES AND PROVIDING THEM ON COLONY-BY-COLONY BASIS WHERE NECESSARY**.	
Responsible Party	Management Authorities
Collaborators	DFFE (Oceans and Coasts Branch), NGOs, Academic Institutions
Timeline	a) Within 2 years of gazetting of the APBMP b) Within 2 years of gazetting of the APBMP c) 2.5 years of gazetting of the APBMP
Resources Needed	Data from all breeding colonies, production of most effective nest type or types
Indicators	a) Synthesis report on the effectiveness of different nest types (natural and artificial nests) including recommendations for improvements. b) Report on a detailed evaluation of design, construction and success of artificial nest (taking into account extreme weather and other natural disasters). c) Identify preferred nest types and introduce them in appropriate numbers to all colonies where breeding habitat is considered to be a constraint to colony breeding success.

3.2 REVIEW AND IMPROVE THE IMPLEMENTATION AND MONITORING OF PREDATOR MANAGEMENT AT ALL AFRICAN PENGUIN COLONIES (Combination and modification of 2013 APBMP actions 4.4.1.1, 4.4.1.2, 4.4.1.3, 4.4.2.1)	
Responsible Party	Management Authorities, DFFE (Oceans and Coasts).
Collaborators	Academia, NGOs
Timeline	Ongoing
Resources Needed	Internal & External
Indicator	a) Colony-specific annual reports on predation and mitigation from Management Authorities on the different life stages of penguins b) Mechanism established to advise on additional mitigation

3.3 IMPLEMENT A PILOT PROJECT ON THE RELEASE OF CAPTIVE-BRED[2] PENGUINS INTO THE WILD	
Responsible Party	NGOs
Collaborators	DFFE (Oceans and Coasts), Management Authorities, SANBI, Academia
Timeline	a) Initiate the pilot project as soon as possible following the approval of the Risk Assessment: - Within 3 years of gazetting of the APBMP. - Within 3 years of gazetting of the APBMP. b) Ongoing c) Ongoing d) At the end of the APBMP period.
Resources Needed	Operational budget, specialised skills
Indicator	a) Implement a pilot project on the release of captive-bred penguins:

[2] Provided Risk Assessment approved by Management Authority.

	- Draft Risk Assessment on the release of captive-bred penguins approved. - Draft Risk assessment for the release of chicks from non-releasable birds that are currently in home-pens of rehabilitation centres approved. b) Monitor and evaluate the success of the project (survival, recruitment and breeding). c) Monitor stress-related responses in captive birds pre- and post-release d) Report at the end of the APBMP period

3.4 DEVELOP AND IMPLEMENT GUIDELINES TO MINIMISE DISTURBANCE AND PREVENTION OF ROAD MORTALITY. (Continuation of action 4.2.2.1 from AP-BMP 1)	
Responsible Party	Management authorities
Collaborators	DFFE (Oceans and Coasts Branch), NGOs, Academic Institutions, and relevant municipalities
Timeline	Within 2 years of gazetting of the APBMP
Resources Needed	Internal and external
Indicator	Guideline document on minimizing disturbance (including human disturbances) and road mortality

Objective 4: To minimise the impact of catastrophic events on African penguins.

4.1 ADVISE ON THE ZONATION OF SHIPPING LANES, BUNKERING OPERATIONS AND SHIPPING ACTIVITIES TO MINIMIZE THE RISK OF OIL SPILLS AND OTHER FORMS OF POLLUTION (INCLUDING UNDERWATER NOISE) NEAR SEABIRD COLONIES.	
Responsible Party	DFFE (Oceans and Coasts), Department of Transport, SAMSA

Collaborators	DoT, SAMSA, Management authorities, Stakeholders
Timeline	a) Within 2 years of the gazetting of the APBMP.
Resources Needed	Internal
Indicator	a) Develop a sensitivity map (i.e. ecosystem models e.g. MICE) taking into account noise generation, physical movement of ships, disturbance of foraging environment and pollution from emissions with recommendations).

4.2 FINALISE THE NATIONAL OILED WILDLIFE PREPAREDNESS, RESPONSE AND CONTINGENCY PLAN AND ENSURE THAL ALL COLONIES HAVE SPECIFIC OILED WILDLIFE RESPONSE PLANS.	
Responsible Party	DFFE
Collaborators	NGOs, Academia, Management Authorities, SAMSA, DoT, Transnet, Industry
Timeline	a) Within two years of the gazetting of the APBMP. b) Within three years of the gazetting of the APBMP.
Resources Needed	Internal and External
Indicator	a) National Oiled Wildlife Preparedness, Response and Contingency Plan (by DFFE) b) Oiled Wildlife Plans for African penguin colonies (by Management Authorities).

4.3 ASSES THE EFFICACY OF THE IMPLEMENTATION OF THE AFRICAN PENGUIN DISEASE SURVEILLANCE AND DIAGNOSIS PROGRAMME. (Modified from actions 4.5.4.2 and 4.5.4.4 from APBMP 1)	
Responsible Party	Management Authorities
Collaborators	DFFE (Oceans and Coasts), NGOs, State Veterinary Service

Timeline	Ongoing
Resources Needed	Internal and External
Indicator	Disease contingency plans available and implemented.

4.4 ENSURE ALL COLONIES HAVE DISEASE CONTINGENCY PLANS WITH ASSOCIATED ACCESSIBLE RESOURCES FOR RAPID MANAGEMENT ACTION (Modified from actions 4.5.4.2 and 4.5.4.4 from APBMP 1)	
Responsible Party	Management Authorities
Collaborators	DFFE (Oceans and Coasts), NGOs, State Veterinary Service
Timeline	Ongoing
Resources Needed	Internal and External
Indicator	a) Disease contingency plans available and implemented. b) Resources identified and procured.

4.5 INVESTIGATE THE IMPACTS OF EXTREME AND OTHER NATURAL DISASTERS ON THE AFRICAN PENGUIN POPULATION. (Ongoing action 4.5.5.1 from APBMP 1)	
Responsible Party	Management Authorities
Collaborators	DFFE (Oceans and Coasts), NGOs
Timeline	Ongoing
Resources Needed	Internal
Indicator	Report on the number of birds impacted and interventions.

Objective 5: To increase the socio-economic benefit of African penguins

5.1 MANAGEMENT AUTHORITIES TO CONSIDER SCIENTIFIC ADVICE IN DECISION MAKING AND MATTERS RELATING TO EDUCATION AND AWARENESS PROGRAMME INCLUDING SCHOOL OUTREACH, AND RELEVANT PUBLIC FORA.	
Responsible Party	DFFE
Collaborators	Management Authorities; NGOs
Timeline	Within a year of the gazetting of the APBMP
Resources Needed	Internal
Indicator	a) Regular meetings and minutes. b) Environmental days on African penguins celebrated.

5.2 FACILITATE A DEDICATED STUDY ON THE SOCIO-ECONOMIC AND ECOSYSTEM BENEFITS OF AFRICAN PENGUINS TO SOUTH AFRICA	
Responsible Party	DFFE (Oceans and Coasts), Academia
Collaborators	Management Authorities, Department of Tourism
Timeline	Within one years of the gazetting of the BMP
Resources Needed	Finances, data collected (e.g. numbers of visitors to each colony and entrance fees paid)
Indicator	a) Report on the socio-economic and ecosystem value of the African penguin completed,

5.3 ESTABLISH A REPOSITORY FOR COMMUNICATION BETWEEN STAKEHOLDERS INVOLVED IN THE BIODIVERSITY MANAGEMENT PLAN.	
Responsible Party	DFFE
Collaborators	All APBMP stakeholders
Timeline	Within a year of the gazetting of the APBMP
Resources Needed	Internal
Indicator	a) A drive to house Communication platform such as meeting minutes, agendas, scientific papers etc. b) Including marketing and public awareness material for inclusion in the repository and to share among the different stakeholders. c) Review a Communication Plan, taking into account, clear communication goals and audiences.

5.4 ENCOURAGE NEW INITIATIVE TO PILOT APPROACHES FOR INCREASED BENEFIT (INCL. GUIDES, MONITORS AND SUPPLEMENTARY LIVELIHOOD)	
Responsible Party	SANBI in partnership with DFFE
Collaborators	Management Authorities, NGOs, Academia
Timeline	Within 3 years of gazetting the APBMP (following the Study under 5.2)
Resources Needed	Internal and External
Indicator	a) Terms of Reference for the pilot project b) Pilot on the approaches for increased benefit established

11. REFERENCES

AEWA (African Eurasian Migratory Waterbird Agreement). 2020. Recommendations – Benguela Current Forage Fish Workshop, Online via GoToMeeting, 2–4 November 2020.

Aldhoun JA, Horne EC. 2015. Schistosomes in South African penguins. *Parasitology Research* 114: 237–246.

Amo L, López P, Martı J (2006) Nature-based tourism as a form of predation risk affects body condition and health state of *Podarcis muralis* lizards. *Biol Conserv* 131: 402-409.

Auperin B, Geslin M (2008) Plasma cortisol response to stress in juvenile rainbow trout is influenced by their life history during early development and by egg cortisol content. *Gen Comp Endocrinol* 158: 234-239.

Barham B. 2017. Nest site fidelity of the African penguin (*Spheniscus demersus*) on Robben Island. MSc(R) thesis, University of Bristol.

Barham PJ, Barham B, Underhill LGU, Crawford RJM, Leshoro TM. 2007. Differences in breeding success between African Penguins (*Spheniscus demersus*) that were and were not oiled in the *Treasure* oil spill in 2000. *Emu* 107: 1–7.

Barham PJ, Underhill LG, Crawford RJM, Altwegg R, Leshoro TM, Bolton DA, Dyer BM, Upfold L. 2008. The efficacy of hand-rearing penguin chicks: evidence from African Penguins (*Spheniscus demersus*) orphaned in the *Treasure* oil spill in 2000. *Bird Conservation International* 18: 144–152.

Barham PJ, Sherley RB. 2013. Does research harm African penguins? In: Abstracts: 8th International Penguin Conference (IPC8), Bristol, UK, 2–6 September 2013.

Barriga GP, Boric-Bargetto D, Martin MCS, Neira V, van Bakel H, Thompsom M, Tapia R, Toro-Ascuy D, Moreno L, Vasquez Y, Sallaberry M, Torres-Pérez F, González-Acuña D, Medina RA. 2016. Avian Influenza virus H5 strain with North American and Eurasian lineage genes in an Antarctic penguin *Emerging Infectious Diseases* 22: 2221–2223.

Benguela Current Large Marine Ecosystem Top Predators Project Steering Committee. 2007. Introduction. In: Kirkman SP (ed) Final report of BCLME (Benguela Current Large Marine Ecosystem) project on Top Predators as Biological Indicators of Ecosystem Change in the BCLME. Avian Demography Unit, Cape Town, p 15.

Berg M, Lallemand P, Donaldson T, Leach K. 2016. The economic impact of penguin island closures on the pelagic fishing industry. FISHERIES/2016/MAY/SWG-PEL/01: 91 pp.

Berruti A, Underhill LG, Shelton PA, Moloney C, Crawford RJM. 1993. Seasonal and interannual variation in the diet of two colonies of the Cape Gannet (*Morus capensis*) between 1977–78 and 1989. *Colonial Waterbirds* 16: 158–175.

Beaucournu JC, Rodhain F. 1990. *Parapsyllus senellarti* n. sp. (Siphonaptera, Rhopalopsyllidae) parasite d'Albatros à l'ile Nouvelle-Amsterdam. *Annales de Parasitologie humaine et comparée* 65: 279–281.

BirdLife International. 2021. Spheniscus demersus. The IUCN Red List of Threatened Species 2020: e.T22697810A157423361. https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T22697810A157423361.en. Downloaded on 23 July 2021.

Boersma PD. 2008. Penguins as marine sentinels. *Bioscience* 58: 597–607.

Boersma PD, Borboroglu PG, Gownaris NJ, Bost CA, Chiaradia A, Ellis S, Schneider T, Seddon P, Simeone A, Trathan P, Waller LJ, Wienecke B (2020) Applying science to pressing conservation needs for penguins. *Conservation Biology*.

Borges JN, Santos HLC, Brandao ML, dos Santos EGN, de Miranda DF, Balthazar DD *et al.* 2014. Molecular and morphological characterization of *Contracaecum pelagicum* (Nematoda) parasitizing *Spheniscus magellanicus* (Chordata) from Brazilian waters. *Revista Brasileira De Parasitologia Veterinaria* 23: 74–79.

Bosman AL, Hockey PAR. 1988. The influence of seabird guano on the biological structure of rocky intertidal communities on islands off the west coast of southern Africa. *South African Journal of Marine Science* 7: 61–68.

Botes A. 2004. Immunological and epidemiological investigations in South African ostriches and penguins. PhD thesis (Biochemistry), University of Stellenbosch, 237 pp.

Brandão, M., Moreira, J., & Luque, J. L. (2014). Checklist of Platyhelminthes, Acanthocephala, Nematoda and Arthropoda parasitizing penguins of the world. Check list, 10:562.

Brault AC, Powers AM, Chavez CLV, Lopez RN, Cachon MF, Gutierrez LFL *et al*. 1999. Genetic and antigenic diversity among eastern equine encephalitis viruses from North, Central, and South America. *American Journal of Tropical Medicine and Hygiene* 61: 579–586.

Brossy J-J. 1992. Malaria in wild and captive Jackass penguins *Spheniscus demersus* along the southern African coast. *Ostrich* 63: 10–12.

Brossy J-J 1993. Haemoparasites in the African (jackass) penguin (*Spheniscus demersus*). *Penguin Conservation* 6: 20–21.

Brossy J-J, Plös AL, Blackbeard JM, Kline A. 1999. Diseases acquired by captive penguins: what happens when they are released into the wild? *Marine Ornithology* 27: 185–186.

Brown C (1986) Feather growth, mass loss and duration of moult in macaroni and rockhopper penguins. Ostrich 57:180–184.

Brown CR (1985) Energetic cost of moult in macaroni penguins (*Eudyptes chrysolophus*) and rockhopper penguins (*E. chrysocome*). *Journal of Comparative Physiology B* 155:515–520.

Burco JD, Massey JG, Byrne BA, Tell, L, Clemons KV, Ziccardi MH. 2014. Monitoring of fungal loads in seabird rehabilitation centers with comparisons to natural seabird environments in northern California. *Journal of Zoo and Wildlife Medicine* 45: 29–40.

Carpenter-Kling T, Harding C, Roberts J, de Blocq A, Morris T, Hagen C, Wanless RM, Ryan PG, Pichegru L, van der Lingen C, Coetzee J, McInnes A. Submitted. Important marine areas of African penguins during two critical history stages outside of the breeding season.

Carpenter-Kling T, Handley JM, Connan M, Crawford RJM, Makhado AB, Dyer BM, Froneman W, Lamont T, Wolfaardt AC, Landman M, Sigqala M. 2019. Pistorius, P.A. Gentoo penguins as sentinels of climate change at the sub-Antarctic Prince Edward Archipelago, Southern Ocean. *Ecological Indicators* 101: 163 – 172.

Carlini AR, Coria NR, Santos MM, Libertelli MM, Donini G. 2007. Breeding success and population trends in Adélie penguins in areas with low and high levels of human disturbance. *Polar Biology* 30: 917–924.

Chahota R, Ogawa H, Mitsuhashi Y, Ohya K, Yamaguchi T, Fukushi H. 2006. Genetic diversity and epizootiology of *Chlamydophila psittaci* prevalent among the captive and feral avian species based on VD2 region of ompA gene. *Microbiology and Immunology* 50: 663–678.

Cherel Y, Charrassin J, Challet E (1994) Energy and protein requirements for molt in the king penguin Aptenodytes patagonicus. *American Journal of Physiology* 266:R1182–R1188.

Cherel Y, Weimerskirch H. 1995. Seabirds as indicators of marine resources: black-browed albatrosses feeding on ommastrephid squids in Kerguelen waters. *Marine Ecology Progress Series* 129: 295–300.

Coetzee JC, van der Lingen CD, Hutchings L, Fairweather TP. 2008. Has the fishery contributed to a major shift in the distribution of South African sardine? *ICES Journal of Marine Science* 65: 1676–1688.

Coles AC. 1941. The size and visibility of the filterable or virus bodies. *British Medical Journal* 1941: 507–509.

Connan M, Hofmeyr GJG, Pistorius PA. 2016. Reappraisal of the trophic ecology of one of the World's most threatened Spheniscids, the African penguin. *Plos One* 11(7): e0159402.

Cooper J. 1974. The predators of the jackass penguin *Spheniscus demersus*. *Bulletin British Ornithologist's Club* 94: 21−24.

Cooper J. 1978. Moult of the black-footed penguin. *International Zoo Yearbook* 18: 22–27.

Crawford R, Ellenberg U, Frere E, Hagen C, Baird K, Brewin P, Crofts S, Glass J, Mattern T, Pompert J, Ross K, Kemper J, Ludynia K, Richard B, Mangel JC, Bugoni L, Uzcátegui GJ, Simeone A, Luna-Jorquera G. Gandini P, Woehler, EJ, Pütz K, Dann P, Chiaradia A, Small C. 2017. Tangled and drowned: a global review of penguin bycatch in fisheries. *Endangered Species Research* 34: 373–396.

Crawford RJM. 1998. Responses of African penguins to regime changes of sardine and anchovy in the Benguela system. *South African Journal of Marine Science* 19: 355–364.

Crawford RJM, Allwright DM, Heÿl CW. 1992. High mortality of Cape cormorants (*Phalacrocorax capensis*) off western South Africa in 1991 caused by *Pasteurella multocida*. *Colonial Waterbirds* 15: 236–238.

Crawford RJM, David JHM, Williams AJ, Dyer BM. 1989. Competition for space: recolonising seals displace endangered, endemic seabirds off Namibia. *Biological Conservation* 48: 59–72.

Crawford RJM, Boonstra HGvD, Dyer BM, Upfold L. 1995. Recolonization of Robben Island by African Penguins, 1983–1992. In: Dann P, Norman I, Reilly P (eds). *The Penguins: Ecology and Management*. Surrey Beatty & Sons, Chipping Norton, NSW, pp 333–363.

Crawford RM, Shannon LJ, Whittington PA. 1999. Population dynamics of the African Penguin *Spheniscus demersus* at Robben Island, South Africa. *Marine Ornithology* 27: 139–147.

Crawford RJM, Davis SA, Harding RT, Jackson LF, Leshoro TM, Meÿer MA, Randall RM, Underhill LG, Upfold L, van Dalsen AP, van der Merwe E, Whittington PA, Williams AJ, Wolfaardt AC. 2000. Initial impact of the *Treasure* oil spill on seabirds off western South Africa. *South African Journal of Marine Science* 22: 157–176.

Crawford RJM, Cooper J, Dyer BM, Upfold L, Venter AD, Whittington PA. 2002. Longevity, inter-colony movements and breeding of crested in terns in South Africa. *Emu* 102: 1–9.

Crawford RJM, Barham PJ, Underhill LG, Shannon LJ, Coetzee JC, Dyer BM, Leshoro TM, Upfold L. 2006a. The influence of food availability on breeding success of African penguins *Spheniscus demersus* at Robben Island, South Africa. *Biological Conservation* 132: 119–125.

Crawford RJM, Hemming M, Kemper J, Klages NTW, Randall RM, Underhill LG, Venter AD, Ward VL, Wolfaardt AC. 2006b. Molt of the African penguin, *Spheniscus demersus*, in relation to its breeding season and food availability. *Acta Zoologica Sinica* 52: 444–447.

Crawford RJM, Underhill LG, Upfold L, Dyer BM. 2007. An altered carrying capacity of the Benguela upwelling ecosystem for African penguins (*Spheniscus demersus*). *ICES Journal of Marine Science* 64: 570–576.

Crawford RJM, Underhill LG, Coetzee JC, Fairweather T, Shannon LJ, Wolfaardt AC. 2008. Influences of the abundance and distribution of prey on African penguins *Spheniscus demersus* off western South Africa. *African Journal of Marine Science* 30: 167–175.

Crawford RJM, Whittington PA, Martin AP, Tree AJ, Makhado AB. 2009. Population trends of seabirds breeding in South Africa's Eastern Cape, and the possible influence of anthropogenic and environmental change. *Marine Ornithology* 37: 159–174.

Crawford RJM, David JHM, Williams AJ, Dyer BM. 1989. Competition for space: recolonising seals displace endangered, endemic seabirds off Namibia. *Biological Conservation* 48: 59–72.

Crawford RJM, Altwegg R, Barham BJ, Barham PJ, Durant JM, Dyer BM, Geldenhuys D, Makhado AB, Pichegru L, Ryan PG, Underhill LG, Upfold L, Visagie J, Waller LJ, Whittington PA. 2011. Collapse of South Africa's penguins in the early 21st century: a consideration of the possible influence of food and fishing. *African Journal of Marine Science.* 33: 139–156.

Crawford RJM, Kemper J, Underhill LG. 2013. African penguin *Spheniscus demersus*. In: Garcia-Borboroglu P, Boersma PD (eds) *Penguins: Natural History and Conservation*. University of Washington Press, Seattle, WA, pp 211–231.

Crawford RJM, Makhado AB, Waller LJ, Whittington PA. 2014. Winners and losers – responses to recent environmental change by South African seabirds that compete with purse-seine fisheries for food. *Ostrich* 85: 111–117.

Crawford RJM, Makhado AB, Whittington PA, Randall RM, Oosthuizen WH, Waller LJ. 2015. A changing distribution of seabirds in South Africa – the possible impact of climate and its consequences. *Frontiers in Ecology and Evolution* 3: 10, 1–10.

Crawford RJM, Makhado AB, Oosthuizen WH. 2018. Bottom-up and top-down control of the Benguela ecosystem's seabirds. *Journal of Marine Systems* 188: 133–141.

Crawford RJM, Sydeman WJ, Thompson SA, Sherley RB, and Makhado AB. 2019. Food habits of an endangered seabird indicate recent poor forage fish availability off western South Africa. ICES Journal of Marine Science, 76: 1344–1352.

Crawford RJM, Makhado AB. 2020. On the role of food scarcity in the collapse of African penguins off South Africa in the early 21st century. Department of Environment, Forestry and Fisheries Report: FISHERIES/2020/AUG/SWG-PEL/78. Pp 1-2

Croxall JP. 1992. Southern Ocean environmental changes: effects on seabird, seal and whale populations. *Philosophical Transactions of the Royal Society of London* B 338: 319–328.

Dalton DL, Vermaak E, Roelofse M, Kotze A. 2016. Diversity in the toll-like receptor genes of the African penguin (*Spheniscus demersus*). *Plos One* 11

David JHM, Cury P, Crawford RJM, Randall RM, Underhill LG, Meyer MA. 2003. Assessing conservation priorities in the Benguela ecosystem, South Africa: analysing predation by seals on threatened seabirds. *Biological Conservation* 114: 289–292.

de Blocq A, Morris T, Roberts J, Harding C, McInnes A, Hagen C, Pichegru L, Wanless R, Ryan P. (2019). Tracking African penguins in their sensitive pre- and post-moult life stages: conservation implications for a species threatened by a lack of food. Poster presentation at the 10th International Penguin Conference, 23-28 August 2019, Dunedin University, New Zealand.

Department of Forestry, Fisheries and the Environment (DFFE). 2021. A synthesis of current scientific information relating to the decline in the African penguin population, the small pelagic fishery and island closures. Unpublished report. Cape Town, South Africa: DFFE.

Doherty RL, Carley JG, Murray MD, Main AJ Jr, Kay BH, Domrow R. 1975. Isolation of arboviruses (Kemerovo group, Sakhalin group) from Ixodes uriae collected at Macquarie Island, Southern Ocean. *American Journal of Tropical Medicine and Hygiene* 24: 521–526.

Dyer BM. 1996. Predation by snakes on seabirds at three South African islands. *South African Journal of Marine Science* 17: 309–313.

Earle RA, Bennett GF, Brossy JJ 1992. 1st African record of leucocytozoon Tawaki (Apicomplexa, Leucocytozoidae) from the jackass penguin *Spheniscus demersus*. *South African Journal of Zoology* 27: 89–90.

Earlé RA, Huchzermeyer FW, Bennett GF, Brossy J-J. 1993. *Babesia peircei* sp. nov. from the jackass penguin. *South African Journal of Zoology* 28: 88–90.

Ellenberg U, Mattern T, Seddon PJ, Luna Jorquera G. 2006. Physiological and reproductive consequences of human disturbance in Humboldt penguins: the need for species-specific visitor management. *Biological Conservation* 133: 95–106.

Ellenberg U, Setiawan AN, Cree A, Houston DM, Seddon PJ. 2007. Elevated hormonal stress response and reduced reproductive output in yellow-eyed penguins exposed to unregulated tourism. *General Comparative Endocrinology* 152: 54–63.

Ellis S, Croxall JP, Cooper J. 1998. Penguin Conservation Assessment and Management Plan. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, USA.

Emerton L, Bishop J, Thomas L (2006) Sustainable Financing of Protected Areas: A global review of challenges and options. IUCN, Geneva, Switzerland.

Erasmus T, Smith D. 1974. Temperature regulation of young jackass penguins, *Spheniscus demersus*. *Zoologica Africana* 9: 195–203.

Erlacher-Reid C, Dunn JL, Camp T, Macha L, Mazzaro L, Tuttle AD. 2012. Evaluation of potential variables contributing to the development and duration of plantar lesions in a population of aquarium-maintained African penguins (*Spheniscus demersus*). *Zoo Biology* 31: 291–305. doi:10.1002/zoo.20395.

Espinaze MPA, Hui C, Waller L, Matthee S. 2020. Nest-type associated microclimatic conditions as potential drivers of ectoparasite infestations in African penguin nests. Parasitology Research: 119: 3603-3616.

Fantham HB, Porter A. 1944. On a plasmodium (*Plasmodium relictum* var. spheniscid ae, n. var.), observed in four species of penguins. *Proceedings of the Zoological Society of London* 114: 279–292.

Free CM, Jensen OP, Hilborn R. 2021. Evaluating impacts of forage fish abundance on marine predators. *Conservation Biology.* https://doi.org/10.1111/cobi.13709.

Frost PGH, Siegfried WR, Burger AE. 1976a. Behavioural adaptations of the jackass penguin *Spheniscus demersus* to a hot, arid environment. *Journal of Zoology* 179: 165–187.

Frost PGH, Siegfried WR, Cooper J. 1976b. Conservation of the jackass penguin (*Spheniscus demersus* (L.)). *Biological Conservation* 9: 79–99.

Gaynor KM, Hojnowski CE, Carter NH, Brashares JS (2018) The influence of human disturbance on wildlife nocturnality. *Science* 360: 1232-1235.

Globig A, Staubach C, Beer M, Koppen U, Fiedler W, Nieburg M, Wilking H, Starick E, Teifke JP, Werner O, Unger F, Grund C, Wolf C, Roost H, Feldhusen F, Conraths FJ, Mettenleiter, Harder TC. 2019. Epidemiological and ornithological aspects of outbreaks of highly pathogenic avian influenza virus H5N1 of Asian lineage in wild birds in Germany, 2006 and 2007. *Transboundary and emerging Disease* 56(3): 57 – 72.

Green JA, Butler PJ, Woakes AJ, Boyd IL (2004) Energetics of the moult fast in female macaroni penguins *Eudyptes chrysolophus*. *Journal of Avian Biology* 35:153–161.

Grigg J. 2016. Monitoring the African penguin (*Spheniscus demersus*) for conservation: evaluating the effectiveness of spatial fisheries management and investigating relationships between foraging behaviour and reproductive success. MSc thesis, University of Bristol.

Groscolas R, Cherel Y. 1991. How to molt while fasting in the cold: the metabolic and hormonal adaptations of Emperor and King penguins. *Ornis Scandinavica* (*Scandinavian Journal of Ornithology*) 23: 328–334

Hazen EL, Abrahms B, Brodie S, Carroll G, Jacox MG, Savoca MS, Scales KL, Sydeman WJ, Bograd SJ (2019) Marine top predators as climate and ecosystem sentinels*. Frontiers in Ecology and the Environment* 17:565–574.

Heath RGM, Randall RM. 1989. Foraging ranges and movements of jackass penguins (*Spheniscus demersus*) established through radio telemetry. *Journal of Zoology* 217: 367–379.

Hockey PAR, Dean WRJ, Ryan PG (eds). 2005. *Roberts' Birds of Southern Africa, 7th ed*. John Voelcker Bird Book Fund, Cape Town.

Holmes ND, Giese M, Achurch H, Robinson S and Kriwoken LK. 2006. Behaviour and breeding success of gentoo penguins *Pygoscelis papua* in areas of low and high human activity. *Polar Biology* 29: 399–412.

Hurt AC, Vijaykrishna D, Butler J, Baas C, Maurer-Stroh S, Silva-de-la-Fuente MC *et al.* 2014. Detection of evolutionarily distinct Avian Influenza A viruses in Antarctica. *Mbio* 5.

Imber MJ, Berruti A. 1981. Procellariiform seabirds as squid predators. In: Cooper J (ed.) *Proceedings of the symposium on birds of the sea and shore*. African Seabird Group, Cape Town, pp 43–61.

IUCN/SSC. 2013. *Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0*. IUCN Species Survival Commission, Gland, Switzerland, viiii + 57 pp. ISBN: 978-2-8317-1609-1.

IUCN. 2016. IUCN Red List of Threatened Species. Version 2011.1. www.iunredlist.org. Downloaded on 24 October 2016.

Jencek JE, Beaufrere H, Tully TN, Garner, MM, Dunker FH, Baszler TV. 2012. An outbreak of *Chlamydophila psittaci* in an outdoor colony of Magellanic penguins (*Spheniscus magellanicus*). *Journal of Avian Medicine and Surgery* 26: 225–231.

Johannesen E, Steen H, Perriman L. 2002. Seasonal variation in survival, weights, and population counts of blue penguins (*Eudyptula minor*) in Otago, New Zealand. *New Zealand Journal of Zoology* 29: 213–219.

Johnson RL, Venter A, Bester MN, Oosthuizen WH. 2006. Seabird predation by white shark and Cape fur seal at Dyer Island. *South African Journal of Wildlife Research* 36: 1–10.

Kane OJ, Uhart MM, Rago V, Pereda AJ, Smith JR, Van Buren A. *et al.* 2012. Avian pox in Magellanic penguins (*Spheniscus magellanicus*). *Journal of Wildlife Diseases* 48: 790–794.

Kaufman D, Banerji MA, Shorman I, Smith ELP, Coplan JD, Rosenblum LA, Kral JG (2007) Early-life stress and the development of obesity and insulin resistance in juvenile bonnet macaques. *Diabetes* 56: 1382-1386.

Kemper J. 2006. Heading towards extinction? Demography of the African Penguin in Namibia. PhD dissertation, University of Cape Town.

Kemper J, Roux, JP, Underhill LG. 2008. Effect of age and breeding status on molt phenology of adult African Penguins (*Spheniscus demersus*) in Namibia. *Auk* 125: 809–819.

Kemper J. 2015. African penguin *Spheniscus demersus*. In: Simmons RE, Brown CJ and Kemper J (eds) *Birds to watch in Namibia: red, rare and endemic species*. Ministry of Environment and Tourism and Namibia Nature Foundation, Windhoek, pp 183–185.

Kemper J, Underhill LG, Crawford RJM, Roux J-P. 2007a. Revision of the conservation status of seabirds and seals in the Benguela ecosystem. In: Kirkman SP (ed.) *Final Report of the BCLME (Benguela Current Large Marine Ecosystem) Project on Top Predators as Biological Indicators of Ecosystem Change in the BCLME*. Avian Demography Unit, Cape Town, pp 325–342.

Kemper J, Underhill LG, Roux J-P, Bartlett PA, Chesselet YJ, James JAC, Jones R, Uhongora N-N, Wepener S. 2007b. Breeding patterns and factors influencing breeding success of African Penguins *Spheniscus demersus* in Namibia. In: Kirkman SP (ed.) *Final Report of the BCLME (Benguela Current Large Marine Ecosystem) Project on Top Predators as Biological Indicators of Ecosystem Change in the BCLME*. Avian Demography Unit, Cape Town, pp 89–99.

Kirkman S.P. 2009. Evaluating seal-seabird interactions in southern Africa: a critical review. *African Journal of Marine Science* 31: 1–18.

Khomenko S, Abolnik C, Roberts L, Waller L, Shaw K, Monne I, Taylor J, Dhingra M, Pittiglio C, Mugyeom M, Roche X, Fredrick K, Kamata A, Okuthe S, Kone P, Wiersma L, Von Dobschuetz S, Soumare B, Makonnen Y, Morzaria S, Lubroth J. 2018. 2016–2018 spread of H5N8 highly pathogenic avian influenza (HPAI) in sub-Saharan Africa: epidemiological and ecological observations. FOCUS ON, No. 12, Aug 2018. Rome.

Kow, D. K. (1992). Characterization of avipoxviruses for use in recombinant vaccines (Master's thesis, University of Cape Town).

La Cock GD, Hänel C. 1987. Survival of African Penguins *Spheniscus demersus* at Dyer Island, southern Cape, South Africa. *Journal of Field Ornithology* 58: 284–287.

La Cock GD, Cooper J. 1988. The breeding frequency of jackass penguins on the west coast of South Africa. *Journal of Field Ornithology* 59: 155–156.

Labuschagne C, Dalton DL, Kotze A. 2012. Isolation and characterization of SNP markers for African penguin (*Spheniscus demersus*). *Conservation Genetics Resources* 4: 1067–1069.

Labuschagne C, van Wyk AM, Kotze A, Grobler P, Dalton DL. 2013. Isolation and characterization of species-specific microsatellite loci in African penguin (*Spheniscus demersus*). *Conservation Genetics Resources* 5: 169–171.

Labuschagne C, Kotze A, Grobler JP, Dalton DL. 2014. The complete sequence of the mitochondrial genome of the African penguin (*Spheniscus demersus*). *Gene* 534: 113–118.

Labuschagne C, Nupen L, Kotze A, Grobler PJ, Dalton DL. 2015. Assessment of microsatellite and SNP markers for parentage assignment in ex situ African penguin (*Spheniscus demersus*) populations. *Ecology and Evolution* 5: 4389–4399.

Labuschagne C, Nupen L, Kotze A, Grobler JP, Dalton DL. 2016. Genetic monitoring of ex situ African penguin (*Spheniscus demersus*) populations in South Africa. *African Zoology* 51: 83–90.

Lei BR, Green JA, Pichegru L. 2014 Extreme microclimate conditions in artificial nests for endangered African penguins. *Bird Conservation International* 24: 201–213.

Lewis SEF, Turpie JK, Ryan PG. 2012. Are African penguins worth saving? The ecotourism value of the Boulders Beach colony. *African Journal of Marine Science*: 34: 497–504.

Ludynia K. 2007. Identification and characterisation of foraging areas of seabirds in upwelling systems: biological and hydrological implications for foraging at sea. PhD thesis, University of Kiel, Germany.

Ludynia K, Roux J-P, Jones R, Kemper J, Underhill LG. 2010. Surviving off junk: low-energy prey dominates the diet of African Penguins *Spheniscus demersus* at Mercury Island, Namibia, between 1996–2009. *African Journal of Marine Science* 32: 563–572.

Ludynia K, Kemper J, Roux J-P. 2012. The Namibian Islands' Marine Protected Area: using seabird tracking data to define boundaries and assess their adequacy. *Biological Conservation* 156: 136–145.

Malbrant R, Maclatchy A. 1958. A propos de l'occurrence de deux oiseaux d'Afrique austral au Gabon: le manchot du Cap, *Spheniscus demersus* Linné et la grue couronnée, *Balearica regulorum* Bennett. *L'Oiseau et la Revue Française d'Ornithologie* 28: 84–86.

Majo L, La Linn M, Slade RW, Schroder WA, Hyatt AD, Gardner J, *et al.* 2009. Ticks associated with Macquarie Island penguins carry arboviruses from four genera. *Plos One*: 4(2), p.e4375

Makhado AB. 2009. Investigation of the impact of fur seals on the conservation status of seabirds at islands off South Africa and at the Prince Edward Islands. PhD thesis, University of Cape Town.

Makhado AB, Crawford RJM, Waller LJ, Underhill LG. 2013. An assessment of the impact of predation by Cape fur seals *Arctocephalus pusillus pusillus* on seabirds at Dyer Island, South Africa. *Ostrich* 84: 191–198.

McInnes AM, McGeorge C, Ginsberg S, Pichegru L, Pistorius PA. 2017. Group foraging increases foraging efficiency in a piscivorous diver, the African penguin. *Royal Society open science* 4: 170918.

McInnes AM, Pistorius PA. In press. Up for grabs – prey herding by penguins facilitates shallow foraging by volant seabirds. *Royal Society open science*.

Miller R. 2019. The effects of anthropogenic disturbance upon African penguin colonies. MSC Thesis, University of the Western Cape.

Mullers RHE, Navarro RA. 2010. Foraging behaviour of Cape gannets as an indicator of colony health status. *Endangered Species Research* 12: 193–202.

Molini, U., Aikukutu, G., Roux, J. P., Kemper, J., Ntahonshikira, C., Marruchella, G., ... & Dundon, W. G. (2020). Avian influenza H5N8 outbreak in African penguins (Spheniscus demersus), Namibia, 2019. Journal of Wildlife Diseases, 56(1), 214-218.

New M, Hewitson B, Stephenson DB, Tsiga A, Kruger A, Manhique A, Gomez B, Coelho CAS, Masisi DN, Kululanga E, Mbambalala E, Adesina F, Saleh H, Kanyanga J, Adosi J, Bulane L, Fortunata L, Mdoka ML, Lajoie R 2006. Evidence of trends in daily climate extremes over Southern and West Africa. Journal of Geophysical Research 111:D14102

Nupen L. 2014. A conservation genetic study of threatened endemic southern African seabirds. PhD thesis, University of Cape Town.

Orians GH, Pearson NE. 1979. On the theory of central place foraging. In: Horn DJ, Mitchell RD, Stairs GR (eds) *Analysis of ecological systems*. Ohio State University Press, Colombus, USA, pp 154–177.

Osorio LG, Xavier MO, Ladeira SRL, Silva RP, Faria RO, Vargas GD *et al.* (2013). Study of bacteria isolated from the foot pad of *Spheniscus magellanicus* with and without bumblefoot. *Arquivo Brasileiro De Medicina Veterinaria E Zootecnia* 65: 47–54.

Otero LX, de la Peña-Lastra S, Augusto Pérez-Alberti A, Ferreira TO, Huerta-Diaz MA. 2018. Seabird colonies as important global drivers in the nitrogen and phosphorus cycles. *Nature Communications* 9: 246.

Parsons NJ, Underhill LG. 2005. Oiled and injured African penguins *Spheniscus demersus* and other seabirds admitted for rehabilitation in the Western Cape, South Africa, 2001 and 2002. *African Journal of Marine Science* 27: 289–296

Parsons NJ, Gous TA, van Wilpe E, Strauss V, Vanstreels RET. 2015. Herpesvirus-like respiratory infection in African penguins *Spheniscus demersus* admitted to a rehabilitation centre. *Diseases of Aquatic Organisms* 116: 149–155.

Parsons NJ, Gous TA, Schaefer AM, Vanstreels RET. 2016. Health evaluation of African penguins (*Spheniscus demersus*) in southern Africa. *Onderstepoort Journal of Veterinary Research* 83(1).

Parsons NJ, Voogt NM, Schaefer AM, Peirce MA, Vanstreels RET. 2017. Occurrence of blood parasites in seabirds admitted for rehabilitation in the Western Cape, South Africa, 2001-2013. *Veterinary Parasitology* 233: 52–61.

Payne RB. 1972. Mechanisms and control of moult. In: Farner DS, King JR (eds), *Avian Biology Vol. 2*. Academic Press, New York, pp 103–155.

Pegas FdV, Castley JG (2014) Ecotourism as a conservation tool and its adoption by private protected areas in Brazil. *J Sustain Tour* 22: 604-625.

Petersen SL, Ryan PG, Gremillet D (2006) Is food availability limiting African Penguins *Spheniscus demersus* at Boulders? A comparison of foraging effort at mainland and island colonies. *Ibis* 148: 14–26.

Piatt JF, Sydeman WJ, Wiese F. 2007. Introduction: A modern role for seabirds as indicators. *Marine Ecological Progress Series* 352:199–204

Pfaff F, Schulze C, Konig P, Franzke, K, Bock S, Hlinak A, Kämmerling J, Ochs A, Schüle A, Mettenleiter TC. Höper D. 2017. A novel alphaherpesvirus associated with fatal diseases in banded penguins. *Journal of General Virology* 98: 89–95.

Pierson GP, Pfow CJ. 1975. Newcastle-disease surveillance in United States. *Journal of the American Veterinary Medical Association* 167: 801–803.

Pichegru L, Ryan PG, van Eeden R, Reid T, Grémillet D, Wanless R. 2012. Industrial fishing, no-take zones and endangered penguins. *Biology Conservation.* 156: 117–125.

Pichegru L, Grémillet D, Crawford RJM, Ryan PG. 2010. Marine no-take zone rapidly benefits endangered penguin. *Biology Letters*: doi:10.1098/rsbl.2009.0913.

Pichegru L. 2013. Increasing breeding success of an endangered penguin: artificial nests or culling predatory gulls? *Bird Conservation International* 23: 296–308.

Pichegru L, Edwards TB, Dilley BJ, Flower TP and Ryan PG. 2016. African Penguin tolerance to humans depends on historical exposure at colony level. *Bird Conservation International* 26: 307–322.

Pichegru L, Nyengera R, McInnes AM, Pistorius P. 2017. Avoidance of seismic survey activities by penguins *Scientific Reports* 7: 16305.

Ploeg M, Ultee T, Kik M. 2011. Disseminated toxoplasmosis in black-footed penguins (*Spheniscus demersus*). *Avian Diseases* 55: 701–703.

Rand RW. 1960. The biology of guano-producing seabirds. 2. The distribution, abundance and feeding habits of the Cape penguin, *Spheniscus demersus*, off the south-western coast of the Cape Province. *Investigational Report Sea Fisheries Research Institute South Africa* 41: 1–28.

Randall RM. 1983. Biology of the jackass penguin *Spheniscus demersus* (L.) at St. Croix Island, South Africa. PhD dissertation, University Port Elizabeth.

Randall RM. 1989. Jackass penguins. In: Payne AIL, Crawford RJM (eds) *Oceans of Life off Southern Africa*. Vlaeberg Publishers, Cape Town, pp 244–256.

Randall RM, Bray RA. 1983. Mortalities of jackass penguin *Spheniscus demersus* chicks caused by trematode worms *Cardiocoephaloides physalis*. *South African Journal of Zoology* 18: 45–46.

Randall RM, Randall BM. 1981. The annual cycle of the jackass penguin *Spheniscus demersus* at St Croix Island, South Africa. In: Cooper J (ed.) *Proceedings of the Symposium of Birds of the Sea & Shore*. African Seabird Group, Cape Town, pp 427–450.

Randall RM, Randall BM. 1986. The diet of jackass penguins *Spheniscus demersus* in Algoa Bay, South Africa, and its bearing on population declines elsewhere. *Biological Conservation* 37: 119–134.

Randall RM, Randall BM, Cooper J, Frost PGH. 1986. A new census method for penguins tested on Jackass Penguins *Spheniscus demersus*. *Ostrich* 57: 211–215.

Randall RM, Randall BM, Cooper J, la Cock GD, Ross GJB. 1987. Jackass penguin *Spheniscus demersus* movements, inter-island visits, and settlement. *Journal of Field Ornithology* 58: 445–455.

Randall BM, Randall RM, Compagno LJV. 1988. Injuries to jackass penguins (*Spheniscus demersus*): evidence for shark involvement. *Journal of Zoology* 214: 589–599.

Roberts J. 2016. African Penguin (*Spheniscus demersus*) distribution during the non-breeding season: preparation for, and recovery from a moulting fast. MSc thesis, University of Cape Town.

Robinson KJ. 2016. Factors influencing the foraging behaviour of African Penguins (*Spheniscus demersus*) provisioning chicks at Robben Island, South Africa. PhD thesis, University of Cape Town.

Robinson WML, Butterworth DS, Plaganyi EE. 2015. Quantifying the projected impact of the South African sardine fishery on the Robben Island penguin colony. *ICES Journal of Marine Science.*

Ross-Gillespie A and Butterworth DS. 2020. Updated implementation of the Algorithm recommended by the Panel for the 2016 International Stock Assessment Workshop for assessing whether or not to continue with the penguin island closure experiment. Department of Environment, Forestry and Fisheries Report: FISHERIES/2020/JAN/SWGPEI/09. Pp. 1–17.

Ross-Gillespie A, Butterworth DS. 2016. Penguin power analyses using the approach recommended by the international panel: methods and results. FISHERIES/2016/NOV/SWG-PEL/Peng/01. 31 pp.

Roux J-P, van der Lingen CD, Gibbons MJ, Moroff NE, Shannon LJ, Smith ADM, Cury PM. 2013. Jellyfication of marine ecosystems as a likely consequence of overfishing small pelagic fishes: lessons from the Benguela. *Bulletin of Marine Science* 89: 249–284.

Roy C, van der Lingen CD, Coetzee JC, Lutjeharms JRE. 2007. Abrupt environmental shift associated with changes in the distribution of Cape anchovy *Engraulis encrasicolus* spawners in the southern Benguela. *African Journal of Marine Science* 29: 309–319.

Ryan PG, Petersen SL, Simeone A, Grémillet D. 2007. Diving behaviour of African penguins: do they differ from other *Spheniscus* penguins? *African Journal of Marine Science* 29: 153–160.

Ryan PG, Edwards L, Pichegru L. 2012. African Penguins *Spheniscus demersus*, bait balls and the Allee effect. *Ardea* 100: 89–94.

Scheun, J., Gulson, J., & Ganswindt, A. (2020). Monitoring glucocorticoid metabolite concentrations as a proxy of environmental stress across important life-history stages in captive African penguins. General and Comparative Endocrinology, 296, 113539.

Scheun J, Miller RJ, Ganswindt A, Waller LJ, Pichegru L, Sherley RB, Maneveldt GW (In Review). Implementing non-invasive endocrine monitoring to assess the physiological response of African penguin chicks to human disturbance.

Seddon PJ, van Heezik YM. 1991. Hatching asynchrony and brood reduction in the jackass penguin: an experimental study. *Animal Behaviour* 42: 347–356.

Seddon PJ, van Heezik YM. 1993. Behaviour of the jackass penguin chick. *Ostrich* 64: 8–12.

Shannon G, Larson CL, Reed SE, Crooks KR, Angeloni LM (2017) Ecological consequences of ecotourism for wildlife populations and communities. In Blumstein DT, Geffroy B, Samia DSM, Bessa E eds, Ecotourism's Promise and Peril: a Biological Evaluation, Cham: Springer International Publishing, pp 29-46.

Shannon L and Waller L (2021) A Cursory Look at the Fishmeal/Oil Industry from an Ecosystem Perspective. Front. Ecol. Evol. 9:645023. doi: 10.3389/fevo.2021.645023

Shannon LJ, Crawford RJM. 1999. Management of the African Penguin *Spheniscus demersus* – insights from modelling. *Marine Ornithology* 27: 119–128.

Shelton PA, Crawford RJM, Cooper J, Brooke RK. 1984. Distribution, population size and conservation of the jackass penguin *Spheniscus demersus*. *South African Journal of Marine Science* 2: 217–257.

Sherley RB. 2010. Factors influencing the demography of endangered seabirds at Robben Island, South Africa: implications and approaches for management and conservation. PhD thesis, University of Bristol.

Sherley RB. 2020. Revisiting the key results in MARAM/IWS/2019/PENG/P4 in light of the 2019 Panel recommendations. FISHERIES/2020/JUL/SWG-PEL/53REV

Sherley RB, Barham BJ, Barham PJ, Leshoro TM, Underhill LG (2012a). Artificial nests enhance the breeding productivity of African Penguins (*Spheniscus demersus*) on Robben Island, South Africa. *Emu* 112: 97–106.

Sherley RB, Crawford RJM, Dyer BM, Hagen C, Upfold L, McInnes A, Masotla MJ, Shannon LJ, Waller LJ, Makhado AB. 2021. Updated population trajectories and conservation status of the African penguin in South Africa following the 2021 census. FISHERIES/2021/JUL/SWG-PEL/46

Sherley RB, Ludynia K, Underhill LG, Jones R, Kemper J. 2012b. Storms and heat limit the nest success of bank cormorants: implications of future climate change for a surface-nesting seabird in southern Africa. *Journal of Ornithology* 153: 441–455.

Sherley RB, Underhill LG, Barham BJ, Barham PJ, Coetzee JC, Crawford RJM, Dyer BM, Leshoro TM, Upfold L. 2013. Influence of local and regional prey availability on breeding performance of African penguins *Spheniscus demersus*. *Marine Ecology Progress Series* 473: 291–301.

Sherley RB, Abadi F, Ludynia K, Barham BJ, Clark AE, Altwegg R. 2014a. Age-specific survival and movement among major African penguin *Spheniscus demersus* colonies. *Ibis* 156: 716–728.

Sherley RB, Winker H, Altwegg R, van der Lingen CD, Votier SC, Crawford RJM. 2015. Bottom-up effects of a no-take zone on endangered penguin demographics. *Biology Letters* 11: 20150237: 1–4.

Sherley RB, Barham BJ, Barham PJ, Campbell KJ, Crawford RJM, Grigg J, Horswill C, McInnes A. Morris TL, Pichegru L, Steinfurth A, Weller F, Winker H, Votier SC. 2018. Bayesian inference reveals positive but subtle effects of experimental fishery closures on marine predator demographics. *Proceedings of the Royal Society* B: 285: 20172443.

Sherley RB, Barham BJ, Barham PJ, Campbell KJ, Crawford RJM, de Blocq A, Grigg J, Le Guen C, Hagen C, Ludynia K, Makhado AB, McInnes A, Meyer A, Morris T, Pichegru L, Steinfurth A, Upfold L, van Onselen M, Visagie J, Weller F and Winker H. 2019. A Bayesian approach to understand the overall effect of purse-seine fishing closures around African penguin colonies. Department of Environment, Forestry and Fisheries Report:MARAM/IWS/2019/PENG/P4. pp. 1–25.

Sherley RB, Ludynia K, Dyer BM, Lamont T, Makhado AB, Roux J-P, Scales KL, Underhill LG. Votier SC. 2017. Metapopulation tracking juvenile penguins reveals an ecosystem-wide ecological trap. *Current Biology* 27: 563–568.

Sherley RB, Waller LJ, Strauss V, Geldenhuys D, Underhill LG and Parsons NJ. 2014b. Hand-rearing, release and survival of African penguin chicks abandoned before independence by moulting parents. *PLoS ONE* 9(10): e110794.

Silva-Filho RP, Xavier MO, Martins AM, Ruoppolo V, Mendoza-Sassi RA, Adornes AC, Cabana ÂL, Meireles MC. 2015. Incidence density, proportionate mortality, and risk factors of aspergillosis in Magellanic penguins in a rehabilitation center from Brazil. *Journal of Zoology Wildlife Medicine* 46: 667–674.

Snyman A, Vanstreels RET, Nell C, Schaefer AM, Stracke T, Parsons NJ., ... & Pistorius PA. (2020). Determinants of external and blood parasite load in African penguins (Spheniscus demersus) admitted for rehabilitation. Parasitology, 147(5), 577-583.

St. George TD, Doherty RL, Carley, JG *et al.* 1985. Isolation of arboviruses including a new flavivirus and a new bunyavirus from *Ixodes* (*Ceratixodes*) uriae (Ixodoidea: Ixodidae) collected at Macquarie Island, Australia, 1975–1979. *American Journal of Tropical Medicine and Hygiene* 34: 406–412.

Steven R, Castley JG, Buckley R (2013) Tourism revenue as a conservation tool for threatened birds in protected areas. *PLOS ONE* 8: e62598.

Stannard LM, Marais D, Kow D, Dumbell KR. 1998. Evidence for incomplete replication of a penguin poxvirus in cells of mammalian origin. *Journal of General Virology* 79: 1637–1646.

Stonehouse B. 1967. The general biology and thermal balance of penguins. In: Cragg JB (ed.) *Advances in Ecological Research IV*. Academic Press, London, pp 131–196.

Sydeman WJ, Hunt GL, Pikitch EK, Parrish JK, Piatt JF, Boersma PD, Kaufman L, Anderson DW, Thompson SA, and Sherley RB. 2021. South Africa's experimental fisheries closures and recovery of the endangered African penguin. *ICES Journal of Marine Science* 78: 3538 - 3543.

Teicher MH, Andersen SL, Polcari A, Anderson CM, Navalta CP, Kim DM (2003) The neurobiological consequences of early stress and childhood maltreatment. *Neurosci Biobehav Rev* 27: 33-44.

Tol L. 2015. Factors impacting the breeding success of African penguins *Spheniscus demersus* on Robben Island. MSc thesis, University of Cape Town.

Traisnel G, Pichegru L. 2018. Possible drivers and consequences of nest and mate fidelity in a long-lived seabird. *Marine Ornithology* 45: 85–88.

Tucker S, Hipfner JM, Trudel M. 2016. Size-and condition-dependent predation: a seabird disproportionately targets substandard individual juvenile salmon. *Ecology* 97: 461–471.

Turasie AA. 2021. Exceedance and Return Period of High Temperature in the African Region. Climate 9: 53.

Tuttle AD, Andreadis TG, Frasca S, Dunn JL. 2005. Eastern equine encephalitis in a flock of African penguins maintained at an aquarium. *Javma-Journal of the American Veterinary Medical Association* 226(12) 2059.

Underhill LG, Crawford RJM. 1999. Season of moult of African penguins at Robben Island, South Africa, and its variation, 1988–1998. *South African Journal of Marine Science* 21: 437–441.

Underhill LG, Crawford RJM. 2005. Indexing the health of the environment for breeding seabirds in the Benguela ecosystem. *ICES Journal of Marine Science* 62: 360–365.

Underhill LG, Bartlett PA, Baumann L, Crawford RJM, Dyer BM, Gildenhuys A, Nel DC, Oatley TB, Thornton M, Upfold L, Williams AJ, Whittington PA, Wolfaardt AC. 1999. Mortality and survival of African Penguins *Spheniscus demersus* involved in the *Apollo Sea* oil spill: an evaluation of rehabilitation efforts. *Ibis* 141: 29–37.

Underhill LG, Crawford RJM, Wolfaardt AC, Whittington PA, Dyer BM, Leshoro TM, Ruthenberg M, Upfold L, Visagie J. 2006. Regionally coherent trends in colonies of African penguins *Spheniscus demersus* in the Western Cape, South Africa, 1987–2005. *African Journal of Marine Science* 28: 697–704.

van der Lingen CD. 2021. Adapting to climate change in the South African small pelagic fishery. In: Bahri T, Vasconcellos M, Welch DJ, Johnson J, Perry RI, Ma X, Sharma R (eds.), *Adaptive management of fisheries in response to climate change*. *FAO Fisheries and Aquaculture Technical Paper* No. 667. Rome: Food and Agriculture Organization of the United Nations.

van Eeden RB, Reid T, Ryan PG, Pichegru L. 2016. Fine-scale foraging cues for African Penguins in a highly variable marine environment. *Marine Ecology Progress Series* 543: 257–271.

van Heezik Y, Seddon PJ. 1990. Effect of human disturbance on beach groups of jackass penguins. *South African Journal of Wildlife Research* 20: 89–93.

Vanstreels RET, Capellino F, Silveira P, Braga EM, Rodriguez-Heredia SA, Loureiro J, Catao-Dias JL. 2016. Avian malaria (*Plasmodium* spp.) in captive Magellanic penguins (*Spheniscus magellanicus*) from Northern Argentina, 2010. *Journal of Wildlife Diseases* 52: 734–737.

Van Zyl H, Kinghorn J. 2018. The economic value and contribution of the Simon’s Town penguin colony. Report to the City of Cape Town. Independent Economic Researchers, Cape Town, 23 pp.

Varsani A, Kraberger S, Jennings S, Porzig EL, Julian L, Massaro M. *et al.* 2014. A novel papillomavirus in Adelie penguin (*Pygoscelis adeliae*) faeces sampled at the Cape Crozier colony, Antarctica. *Journal of General Virology* 95: 1352–1365.

Varsani A, Porzig EL, Jennings S, Kraberger S, Farkas K, Julian L. *et al.* 2015. Identification of an avian polyomavirus associated with Adelie penguins (*Pygoscelis adeliae*). *Journal of General Virology*: 96: 851–857.

Villanueva C, Walker BG. Bertellotti M. 2012. A matter of history: effects of tourism on physiology, behaviour and breeding parameters in Magellanic Penguins (*Spheniscus magellanicus*) at two colonies in Argentina. *Journal of Ornithology* 153: 219–228.

Von Keler S. 1952. On some Mallophaga of seabirds from the Tristan da Cunha Group and the Dyer Island. *Journal of the Entomological Society of Southern Africa* 15: 204–238.

Wallace RS. 2014. Sphenisciformes (penguins). *Fowler's Zoo and Wild Animal Medicine* 8: 82–88.

Waller LJ. 2011. The African Penguin *Spheniscus demersus*: conservation and management issues. PhD, University of Cape Town.

Webster Marketon JI, Glaser R (2008) Stress hormones and immune function. *Cell Immunol* 252: 16-26.

Weimerskirch H, Le Corre M, Bost CA. 2008. Foraging strategy of masked boobies from the largest colony on the world: relationship to environmental conditions and fisheries. *Marine Ecology Progress Series* 362: 291–302.

Weller F, Cecchini L-A, Shannon LJ, Sherley RB, Crawford RJM, Altwegg R, Scott L, Stewart T, Jarre A. 2014. A system dynamics approach to modelling multiple drivers of the African penguin population on Robben Island, South Africa*. Ecological Modelling* 277: 38–56.

Weller F, Sherley RB, Waller LJ, Ludynia K, Geldenhuys D, Shannon LJ, Jarre A. 2016. System dynamics modelling of the endangered African penguin populations on Dyer and Robben islands, South Africa. *Ecological Modelling* 327: 44–56.

Whittington PA, Klages NTW, Crawford RJM, Wolfaardt AC, Kemper J. 2005a. Age at first breeding of the African Penguin. *Ostrich* 76: 14–20.

Whittington PA, Randall RM, Crawford RJM, Wolfaardt AC, Klages NTW, Randall BM, Bartlett PA, Chesselet YJ, Jones R. 2005b. Patterns of immigration to and emigration from breeding colonies by African Penguins. *African Journal of Marine Science* 27: 205–213.

Williams AJ. 1981. Why do penguins have long laying intervals? *Ibis* 123: 202–204.

Williams AJ, Cooper J. 1984. Aspects of the breeding biology of the jackass penguin *Spheniscus demersus*. In: Ledger JA (ed.) *Proceedings of the 5th Pan-African Ornithological Congress.* Southern African Ornithological Society, Johannesburg, pp 841–853.

Wilson RP. 1985a. Diurnal foraging patterns of the jackass penguin. *Ostrich* 56: 212–214.

Wilson RP. 1985b. The jackass penguin (*Spheniscus demersus*) as a pelagic predator. *Marine Ecology Progress Series* 25: 219–227.

Wilson RP, Wilson M-PT. 1989. Substitute burrows for penguins on guano-free islands. *Gerfaut* 79: 125–131.

Wilson RP, Wilson M-PT (1990) Foraging ecology of breeding *Spheniscus* penguins. In: Davis LS, Darby JT (eds) *Penguin Biology*. Academic Press, San Diego, pp 181–206.

Wilson RP, Wilson M-PT. 1995. The foraging behaviour of the African Penguin *Spheniscus demersus*. In: Dann P, Norman I, Reilly P (eds) *The Penguins: Ecology and Management*. Surrey Beatty & Sons, Chipping Norton, NSW, pp 244–265.

Wilson RP, Wilson M-PT, Duffy DC. 1988. Contemporary and historical patterns of African penguin *Spheniscus demersus* distribution at sea. *Estuarine Coastal Shelf Science* 26: 447–458.

Wolfaardt AC, Underhill LG, Altwegg R, Visagie J. 2008a. Restoration of oiled African Penguins *Spheniscus demersus* a decade after the *Apollo Sea* oil spill. *African Journal of Marine Science* 30: 421–436.

Wolfaardt AC, Underhill LG, Nel DC, Williams AJ, Visagie J. 2008b. Breeding success of African Penguins *Spheniscus demersus* at Dassen Island, especially after oiling following the *Apollo Sea* spill. *African Journal of Marine Science* 30: 565–580.

Wolfaardt AC, Underhill LG, Crawford RJM. 2009a. Comparison of moult phenology of African Penguins *Spheniscus demersus* at Robben and Dassen islands. *African Journal of Marine Science* 31: 19–29.

Wolfaardt AC, Williams AJ, Underhill LG, Crawford RJM, Whittington PA. 2009b. Review of the rescue, rehabilitation and restoration of oiled seabirds in South Africa, especially African Penguins *Spheniscus demersus* and Cape gannets *Morus capensis*, 1983–2005. *African Journal of Marine Science* 31: 31–54.

Wright KLB, Pichegru L, Ryan PG. 2011. Penguins are attracted to dimethyl sulphide at sea. *Journal of Experimental Biology*. 214: 2509–2511.

Yabsley MJ, Parsons, NJ, Horne EC, Shock BC, Purdee M. 2012. Novel relapsing fever Borrelia detected in African penguins (*Spheniscus demersus*) admitted to two rehabilitation centers in South Africa. *Parasitology Research* 110: 1125–1130.

Zumpt F. 1959. Arthorpods parasitizing birds in Africa south of the Sahara. *Ostrich* 30(S1): 346–352.