Journal for Nature Conservation 86 (2025) 126919

Contents lists available at ScienceDirect

Journal for Nature Conservation

journal homepage: www.elsevier.com/locate/jnc

A decade of implementing the Biodiversity management plan for African penguins – successes, failures and lessons learnt

Lorien Pichegru [a,*], Millicent Makoala [b], Barbara J. Barham [c], Peter J. Barham [d,e], Desiré Dalton [f], Katta Ludynia [d,g], Mandy Freeman [h], Deon Geldenhuys [i], Christina Hagen [j], Gabby Harris [k], Alison Kock [l,m], Cloverley Lawrence [a,l], Cuan McGeorge [i], Alistair M. McInnes [a,j], Azwianewi B. Makhado [b,n,o], Trudi Malan [p], Makhudu J. Masotla [b], Rob Milne [l], Heinrich Muller [b], Arne Purves [q], Richard B. Sherley [d,r], Nicky Stander [g], Pierre de Villiers [i], Johan Visagie [i], Chris Wilke [s], Lauren J. Waller [d,t]

[a] Institute for Coastal and Marine Research, Nelson Mandela University, Gqeberha, South Africa
[b] Department of Forestry, Fishery and the Environment, South Africa
[c] Penguin Datasystems, Bristol, UK
[d] Department of Biodiversity and Conservation Biology, University of the Western Cape, Bellville, South Africa
[e] School of Physics, University of Bristol, UK
[f] School of Health and Life Sciences, Teesside University, Middlesbrough, UK
[g] Southern African Foundation for the Conservation of Coastal Birds, Table View, South Africa
[h] Tenikwa Wildlife Rehabilitation Centre, Plettenberg Bay, South Africa
[i] CapeNature, South Africa
[j] Seabird Conservation Programme, BirdLife South Africa, Cape Town, South Africa
[k] South African Association for Marine Biological Research, Durban, South Africa
[l] South African National Parks, South Africa
[m] South African Institute for Aquatic Biodiversity (SAIAB), Makhanda, South Africa
[n] FitzPatrick Institute of African Ornithology, University of Cape Town, South Africa
[o] Center for Polar Research, Shanghai Ocean University, Shanghai 201306, China
[p] Dyer Island Conservation Trust, Gansbaai, South Africa
[q] City of Cape Town, Environmental Management Department, Coastal Management Branch, Cape Town, South Africa
[r] Centre for Ecology and Conservation and Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, UK
[s] Wilke's Eco Solutions Service Provider to Robben Island Museum, South Africa
[t] Endangered Wildlife Trust, South Africa

ARTICLE INFO

Keywords:
Conservation
Critically endangered species
Rehabilitation
Predator management
Stakeholder interviews
Managing authorities
NGOs

ABSTRACT

The rapid decline of the African penguin *Spheniscus demersus* in the early 2000 s triggered the drafting of the first African Penguin Biodiversity Management Plan (BMP) published in 2013, to "halt the decline of the African penguin population". Working Groups (WGs) were created with stakeholders involved in penguin conservation to facilitate the implementation of the BMP. This study reviews the execution of the plan (1) from aide memoires and reports circulated within these WGs between 2013 and 2022; (2) by interviewing (in 2023) some of the stakeholders involved to assess their perceptions of the BMP 10 years post-implementation; and (3) by assessing the effectiveness of some actions using available scientific data. Interviewees unanimously agreed that the plan improved the species's management and facilitated collaboration across institutions involved. Conservation actions identified as the most effective were 1) the rehabilitation of adults and chicks; 2) predator management and 3) habitat improvement with the provision of artificial nests. Scientific reviews of these actions validated their success. For example, rehabilitation effort may have increased the 2023 penguin breeding population by ca 7 %. Nevertheless, African penguin numbers continued decreasing and the species is now "Critically Endangered" on the IUCN Red List. Measures are still lacking in effectively increasing prey availability despite intensive engagement. Dedicated funding, trained capacity and accountability by relevant institutions undertaking their

* Corresponding author.
E-mail address: lorien.pichegru@mandela.ac.za (L. Pichegru).

https://doi.org/10.1016/j.jnc.2025.126919
Received 24 October 2024; Received in revised form 24 January 2025; Accepted 23 March 2025
Available online 27 March 2025

actions and deliverables were identified as essential for a more successful implementation of the BMP. Lessons learnt may pave the way for stronger conservation actions for African penguins and other threatened seabirds.

1. Introduction

African penguins *Spheniscus demersus* are endemic to Southern Africa (Fig. 1) and are at risk of going extinct in the wild within the next decade (Sherley et al. 2024). Their population declined by 90 % during the 20th century and, after a short period of increase in the early 21st century, numbers decreased again from 2004 to their lowest levels ever recorded in each year since (Sherley et al. 2024). In 2023, the global breeding populations of African penguins was just under 10 000 pairs, close to 90 % of them in South Africa (ca 8 750 pairs, Sherley et al. 2024). Past threats contributing to their decline in the 20th century include egg harvesting for consumption and guano harvesting, which disturbed and removed their nesting habitat. The collection of eggs ceased in 1968 and guano harvesting stopped in the 1970 s in South Africa. However, the legacy of removing guano still impacts the contemporary penguin population, due to the reduced availability of burrowing substrate for nesting penguins. Burrows are an adaptation of these birds to a hot climate, providing buffered temperatures and humidity in the nest, while sheltering the brood from predators, such as kelp gulls *Larus dominicanus* (Frost et al. 1976). The removal of guano forces the penguins to breed in open surface nests, making them vulnerable to overheating, which can lead to the temporary (or permanent) abandonment of the brood and increase predation risk. Chicks from open nests are also vulnerable to hypothermia during cold rain events or storms (Seddon & van Heezik 1991), the frequency of which is likely to increase with ongoing human-induced climate change.

African penguin population dynamics are closely linked to the availability of their small pelagic fish prey, mostly sardines *Sardinops sagax* and anchovies *Encraulis encrasicolus* (Crawford et al. 1999, Sherley et al. 2013, Robinson et al. 2015). Over-fishing of small pelagic fish resources in Namibia in the 1960 s led to the collapse of the African penguin population there by the 1970 s (Roux et al. 2013), and to this day, neither the African penguin nor sardine populations have recovered (Crawford et al. 2007, Sherley et al. 2024). In the early 2000ss there was a temporary improvement in recruitment of small pelagic fish stocks in South African waters, especially sardine stocks, which combined with the cessation of egg and guano harvesting for a few decades prior to this, saw the African penguin population increase (Crawford et al. 2011). However, since the mid-2000 s, the sardine stock has continued to decline due to a combination of climate change and fishing (Coetzee et al. 2008, Mhlongo et al. 2015). Sardine spawning biomass was below 500 000 tons in 13 of the 17 years between 2006 and 2022, and below 800 000 t in 16 of those years (Coetzee et al., 2022), a threshold at which "recruitment from significantly smaller stock biomasses will be likely to be greatly reduced, resulting in prolonged depletion of the stock with limited potential for recovery" (Punt et al. 2023).

In parallel, chronic and acute oil pollution remain a significant threat to African penguins, with many colonies located on major shipping routes or close to industrial harbours. Oiling has negatively affected population trends at some colonies (Weller et al. 2014, 2016) and the prevention of oil spills, as well as adequate preparedness to rescue and rehabilitate oiled birds, have been identified as critical (Vanstreels et al.

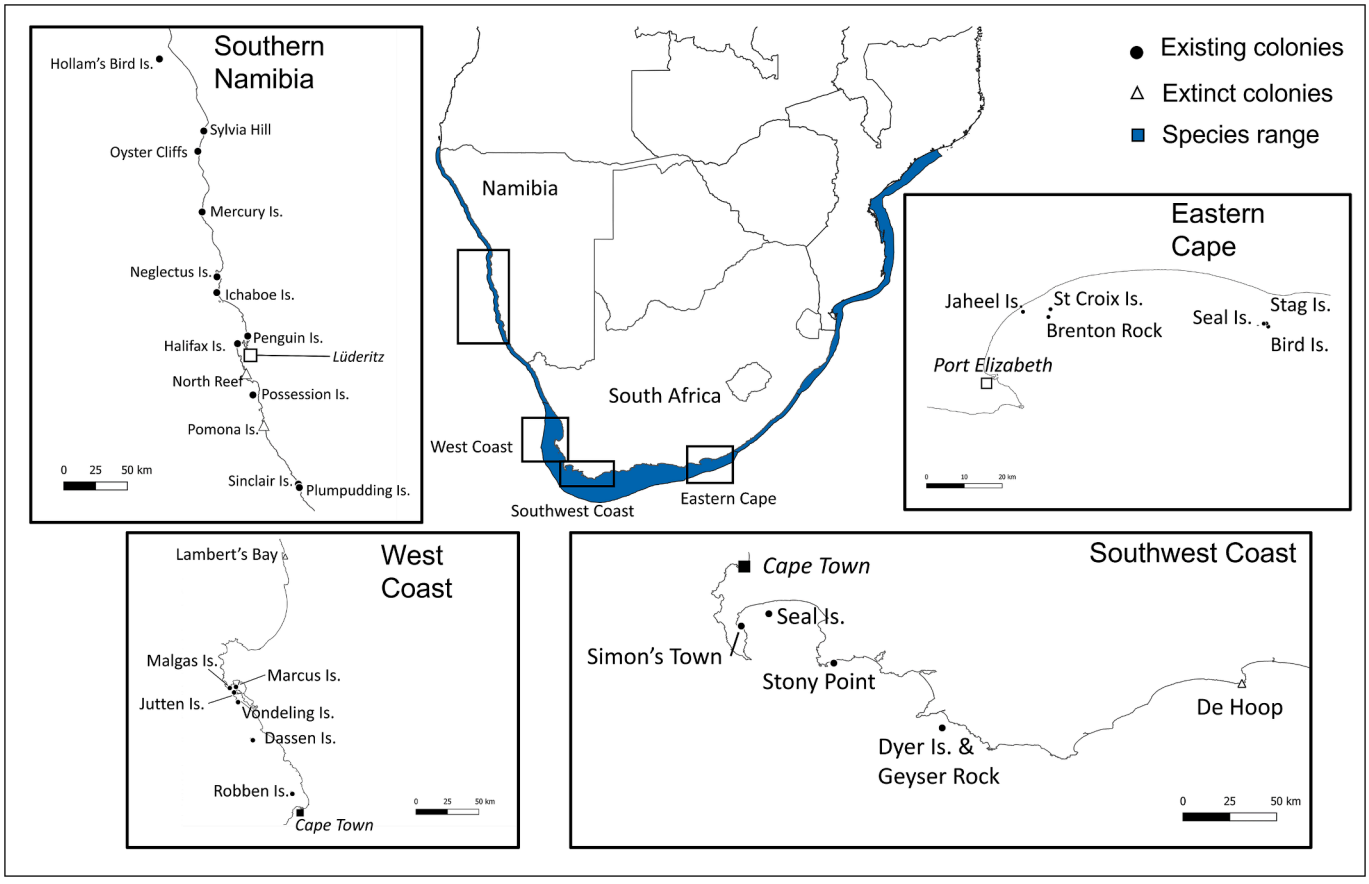

Fig. 1. Map of the African penguins *Spheniscus demersus* range in Southern Africa, showing all existing and extinct colonies in Southern Namibia, and on the West Coast, Southwest Coast and the Eastern Cape of South Africa.

2023). Finally, as penguins historically bred on islands devoid of terrestrial predators, they have not developed defence mechanisms against these. However, mainland colonies in South Africa now hold 25 % of the breeding populations (AB Makhado, unpublished data) and regular records of predators targeting African penguins in these colonies (Vanstreels et al. 2019) highlight the importance of managing both land and marine predators.

The decline of the African penguin population since 2004, and the uplisting of this species to 'Endangered' on the IUCN Red List in 2010 prompted the South African government to increase conservation efforts for this species, and to improve coordination amongst all stakeholders involved. This included management authorities, Non-Governmental Organisations (NGOs), captive facilities and academic institutions. The urgent need for science-based and coordinated conservation interventions was recognised and a Biodiversity Management Plan for African penguins (AP BMP) was identified as the appropriate tool to facilitate coordination of management interventions (Waller 2011). Biodiversity Management Plans are a legislative tool in terms of section 43 of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) ("NEMBA"). They are aimed at ensuring the long-term survival in nature of the species to which the plan relates in South Africa. BMPs can be developed for both indigenous and migratory species. In 2009, Norms and Standards on the development of Biodiversity Management Plans for Species were published in the Government Gazette providing the scope and process for BMP development. Since then, numerous BMPs have been developed, including among others, BMPs for the Black Rhinoceros *Diceros bicornis*, Bearded Vultures *Gypaetus barbatus*, Pickersgill's reed frog *Hyperolius pickersgilli* and several shark species. Once drafted the BMP is submitted to the Minister responsible for environmental affairs for approval and publication. The Minister must formally review the BMP at least every five years and assess compliance with the plan to ensure that its objectives are being met (section 46, NEMBA).

For the development of the African penguin BMP, a workshop took place in Arniston, South Africa, in 2010, with strong stakeholder engagement including from penguin colony management authorities, industries, government representatives, NGOs, scientists, rehabilitation centres and zoos/aquaria (Table 1). Threats were identified, objectives were set, actions to be taken were described, with a timeline and assignment to responsible agencies. The BMP included 22 objectives and 65 actions (summarised in Table S1) and was circulated for public comment and published in the Government Gazette on 31 October 2013. The aim of the BMP was: "*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*" (DEA 2013). The benefits envisaged with the Plan were to "*formalise much of the work that is currently being conducted and provide the mechanism whereby this effort can be coordinated, directed and implemented to the benefit of the species. Furthermore, it will also identify those areas where necessary additional interventions are required to address issues impacting on the species*" (p 14, DEA 2013). The BMP was gazetted with a timeline of five years (2013 – 2018), to be reviewed and subsequently updated. A review of the first BMP was conducted by the Department of Forestry, Fisheries and the Environment (DFFE) in 2019, and a new BMP was drafted and gazetted for public comment in 2019 and in 2022.

This study reviews the achievements of the first BMP for African penguins, comparing the planned actions against what was achieved, on one hand using documents from the BMP working group meetings, and on another hand assessing the perceptions of stakeholders involved in African penguin conservation in South Africa via interviews undertaken in 2023. When data were available, the effectiveness of specific actions was assessed. These were, 1) rehabilitation effort and chick bolstering, 2) management of predators, 3) provision of artificial nests, and 4) purse-seine fishing exclusion zones. Reflecting on the achievements and

Table 1
Description of stakeholders' institutions involved in the implementation of the BMP (i.e., attending the various WGs), their roles and the colonies they were involved in, when relevant.

Institutions	Role	Colonies
Department of Environmental Affairs (DEA 2008 – 2018); Department of Forestry, Fisheries and the Environment (DFFE, 2018 – onward)	Government. Overseeing the drafting and publishing of the BMP; overseeing its implementation by organizing/running the WG meetings bi-monthly (calling for reports, comments on documents shared, minutes of meetings, follow up on matters arising); conducting long-term monitoring on all seabird colonies; conducting fish surveys and ensuring management, regulation and the development of South Africa's fisheries sector to insure the sustainable use and access to marine living resources; overall giving effect to the right of citizens to an environment that is not harmful to their health or well-being, and to have the environment protected for the benefit of present and future generations	All
South African National Biodiversity Institute (SANBI)	Government. Managing the studbook for captive populations; conducting research on ex situ African penguin genetics	Ex situ
South African National Parks (SANParks)	Managing authority. Promotes the conservation of the country's natural and cultural heritage by managing a network of 22 national parks, including 10 Marine Protected Areas; ensuring implementation of the BMP and the WG recommendations, as well as their own Management Plans and Standard Operating Procedures on the penguin colonies they manage	Malgas Island, Marcus Island, Jutten Island, Boulders beach/Simon's Town, St Croix Island, Brenton Island, Jahleel Island, Bird Island, Stag Island, Seal Island
CapeNature	Managing authority. Ensuring biodiversity conservation in the Western Cape, including 112 nature reserves and wilderness areas and six Marine Protected Areas; ensuring the implementation the BMP and the WG recommendations, and their own Standard Operating Procedure on the penguin colonies they manage	Lambert's Bay, Dassen Island, Stony Point, Dyer Island
Robben Island Museum	Managing authority. Managing, developing and marketing Robben Island as a national estate and World Heritage Site	Robben Island
City of Cape Town	Managing authority. Ensuring the implementation of the BMP and the WG recommendations, and their own Standard Operating Procedure and monitoring programme on the penguin colony they manage	Simon's Town
BirdLife South Africa	NGO. Leading the re-establishment of the De Hoop colony; advocating for the South African penguin population as a whole;	All

(*continued on next page*)

Table 1 (*continued*)

Institutions	Role	Colonies
	conducting research on some colonies	
Southern African Foundation for the Conservation of Coastal Birds (SANCCOB)	NGO. Leading the Chick Bolstering Project; rehabilitating birds from most colonies, as well as stranded birds on the West Coast and False Bay, and in Algoa Bay from 2016; funding rangers in several colonies since 2014 to assist managing authorities and give first assistance to injured birds; advocating for the South African penguin population as a whole; assisted the development of NAMCOB for rehabilitation of the Namibian penguins; conducting research ex situ and on various colonies	Ex situ, Dassen Island, Robben Island, Boulders beach/ Simon's Town, Stony Point, St Croix Island, Bird Island
Dyer Island Conservation Trust (DICT) – African Penguin & Seabird Sanctuary (APSS)	NGO. DICT manages APSS. Rehabilitating stranded penguins and other seabirds around the area of Dyer Island; funding a ranger on Dyer Island to assist CapeNature and to manage chick intervention programme on that colony; leading the artificial nest project	Ex situ, Robben Island, Boulders Beach/ Simon's Town, Stony Point, Dyer Island, Bird Island
Seabird and African Penguin Rehabilitation Centre (SAPREC)	NGO. Rehabilitating stranded penguins and other seabirds around the area of Mossel Bay	Ex situ
Tenikwa	NGO. Rehabilitating stranded penguins and other seabirds around the area of Plettenberg Bay	Ex situ
Pan-African Association for Zoos and Aquaria (PAAZA)	NGO. Representing all captive facilities that are PAAZA members in South Africa, e.g. Two Ocean Aquarium, uShaka, East London Aquarium, Bayworld, Pretoria Zoo, etc.	Captive
South African Association for Marine Biological Research (SAAMBR)	NGO. Focusing on environmental education, hosts the Oceanographic Research Institute (ORI) focusing on fish research, and uShaka Sea World, Africa's largest aquarium holding a small captive population of African penguins	Captive
Two Oceans Aquarium Foundation	NGO. Focusing on marine science education, sea turtle conservation and research efforts of the Two Oceans Aquarium which holds a small captive population of African penguins	Captive
Academic Institutions (University of Cape Town, University of Exeter, Bristol University, Nelson Mandela University)	Scientists. Conducting research on various colonies	Dassen Island, Robben Island, Boulders beach, Stony Point, Dyer Island, St Croix Island, Bird Island

failures of the plan and understanding the perception of the role-players involved enables important lessons to be learnt maximising the success of other BMPs, as well as for future African penguin conservation in general.

2. Materials and methods

2.1. Stakeholders' perception of the BMP successes and failures

To assess the degree to which the actions listed in the BMP published in 2013 (DEA 2013) were addressed, the implementation of the plan was reviewed using the DFFE report of the BMP compiled in 2019 (DFFE 2019) and the minutes of three scientific working groups (WGs) meetings reporting to the DFFE: the Habitat WG, the Population Reinforcement WG and the Seabird Task Team of the Top Predator WG, all formed shortly after the gazetting of the BMP in 2013. Grey literature and documents circulated within these WGs were included in this analysis with facts cross-checked by WG members to ensure accuracy. Additional ad-hoc documents (emails, unpublished reports accessible to members of the WGs) were also consulted to ensure completeness of the information included here.

To assess the perception of the stakeholders involved in implementing the BMP (Table 1), a total of 28 participants were interviewed in 2023 (ethics clearance: H23-SCI-ZOO-001), following methods described in Knott et al. (2022). Invitations to participate were based on a purposive sampling method ("A sampling method where the guiding logic when deciding who to recruit is to achieve the most relevant participants for the research topic, in terms of being rich in information or insights", Knott et al. 2022). All participants were involved in African penguin conservation, with experience in this field ranging from a few years to several decades (Table 2). Most were members of the WGs cited above, being affiliated with government departments (GVT), management authorities (MA), NGOs or academic institutions involved in the various colonies (Fig. 1). To limit saturation (Small et al. 2009), no more than two people from managing authorities involved in the same colony were invited to participate. Similarly, no more than two people within the same governmental department or the same NGO were invited. Interviews took place online (via online meeting platforms or over the phone) for one to two hours. Participants were informed of the purpose of the study, ensured anonymity, and asked to provide their views on each of the objectives and/or actions of the BMP (i.e., semi-structured interviews). They were asked if they deemed an objective or action relevant, if the objective was achieved/the action taken, if it was successful, and/or what could have been improved. Within a few days following the interaction, they were presented with the notes taken during their personal interview for additional comments if needed. All people invited agreed to participate in the study. Positive and negative terms were extracted from responses for each objective/action and grouped by work institution of interviewees or profession (i.e., GVT, MA, NGOs or scientists). Scientists (SCI) were either academics or scientists within managing authorities or NGOs.

2.2. Review of specific BMP actions

In addition to interviews, the potential effectiveness of specific BMP actions was evaluated whenever data were available. These included (1) the contribution of rehabilitation effort in increasing the wild breeding population of penguins in South Africa (Section 2 Anthropogenic Impact, Objective 6: "To halt, and if possible, reverse further decline or

Table 2
Representativeness of the participants in terms of experience (time span involved in African penguin conservation) and the type of institutions they worked for during the time of their involvement.

Experience in African penguin conservation		**Institution type**	
1 – 5 years	N = 5	Managing authorities	N = 11
5 – 10 years	N = 4	Government	N = 5
10 – 15 years	N = 10	Scientists	N = 5
15 years	N = 9	NGOs	N = 7

loss of colonies and to prevent further fragmentation of the African penguin population"); (2) the management of predators to reduce negative impacts of predation (Section 4 Threats from Predators, Objective 1: "Improve survival rates of African penguins during all their life cycle stages by preventing or reducing predation impacts"); (3) the provision of artificial nests to increase breeding output (Section 2 Anthropogenic Impact, Objective 1: "To improve breeding habitat for African penguins"); and (4) the potential benefits of purse-seine fishing exclusions to reduce resource competition (Section 3 Fish and Fishing, Objective 1: "To ensure adequate abundance of prey for penguins").

For (1), records of all rehabilitation centres active in South Africa between 2012 and 2022 were obtained from SANCCOB in Table View, Cape Town (2012 – 2022), in Cape St Francis (2013 – 2018), and in Gqeberha (2016 – 2022); the South African Marine Rehabilitation and Education Centre (SAMREC) in Gqeberha (2012 – 2016); the Seabird and African Penguin Rehabilitation Centre (SAPREC) in Mossel Bay (2016 – 2022); the African Penguin and Seabird Sanctuary (APSS) in Gansbaai (2016 – 2022); and Tenikwa in Plettenberg Bay (2012 – 2022). Using these data, we developed a simple deterministic model to estimate the contribution of rehabilitation efforts in increasing the wild breeding population of South African penguins in 2023. The latest published information on African life history traits was used for adult annual survival (0.77; min: 0.62; max 0.89; Leith et al. 2022), chick annual survival (0.32; min: 0.18; max 0.49) and age at recruitment (4 years, Sherley et al., 2014b), the proportion of adults breeding each year (70 %; Leith et al. 2022), and breeding success (50 %; min: 25 %: max 75 %; Pichegru et al. 2024). For simplicity, juveniles are assumed to be individuals about to moult into adult plumage, thus they were assumed to be 1 year old at the point of release with the same survival probability as adults following their release (Sherley et al., 2014b). Adults were assumed to start breeding the year following their rehabilitation, following Wolfaardt et al. (2008) who observed an average of 11 months between the release of oiled birds and them being observed breeding. Only 70 % of individuals were considered available to breed at any one time, as 30 % are believed to skip breeding in any given year (Leith et al. 2022). The model assumed simplistically that two rehabilitated adults would form one pair. Chicks fledged from pairs formed by rehabilitated birds were then considered to recruit to the population after 4 years. Note, while the surviving offspring of these chicks would also add to the population of rehabilitated adults in the long run, the effect is marginal (< 1 additional pair) in the timeframe considered. Thus, their contribution is omitted for simplicity. This model did not account for temporal or spatial differences between years or colonies, and a more complex Integrated Population Model using mark-recapture data from a marking programme (using passive integrated transponders; e.g. Leith et al. 2022) led by SANCCOB since 2016 across most African penguin colonies is currently being developed. The present model aimed to give a broad overview of the impact of rehabilitation as a conservation action.

We estimated the total number of pairs added to the breeding population from rehabilitated individuals and their offspring (T_P) in year t as:

a) $$B_{P,t} = \frac{\left(\left[(R_{A,\ t-1}+B_{A,t-1})\times\phi_A\right]+\left[(R_{J,\ t-3}\times\phi_A^3)+(B_{J,t-1}\times\phi_A)\right]+\left[((R_{C,\ t-4}\times\phi_J)\times\phi_A^3)+(B_{C,t-1}\times\phi_A)\right]\right)\times P}{2},$$

b) $$B_{F,t} = \frac{\left(B_{P,t}\times S\times\phi_J\times\phi_A^3\times P\right)}{2},$$

c) $$T_{P,t} = B_{P,t} + B_{F,t-4}$$

(eqn. 1)

where B_P, B_A, B_J and B_C are the total number of pairs (P), adults (A), juveniles (J) and chicks (C) currently available in the breeding population from rehabilitation of each age class respectively in year t, R_A is the number of adults released from rehabilitation centres in a given year, R_J is the number of juveniles released from rehabilitation centres, R_C is the number of hand-reared chicks released from rehabilitation centres as fledglings, ϕ_A and ϕ_J are annual adult (0.77) and juvenile, or first-year, (0.32) survival respectively, S is breeding success (0.5), P is the annual probability that an individual will breed (0.7) and B_F is the number of breeding pairs subsequently formed by fledged chicks produced from pairs of rehabilitated individuals.

For (2), the records of predator culls were obtained from officials from SANParks, CapeNature, DFFE and Robben Island Museum to evaluate the level of implementation of that intervention. These were related to breeding counts of kelp gulls (DFFE unpublished data, see Whittington et al. 2016 for methods) and to counts of penguin carcasses attributed to Cape fur seal predation at Dyer Island, Stony Point and Boulders beach/Simon's Town. Penguin carcasses were recorded by staff from the relevant managing authorities (see Table 2) on an ad hoc basis, most being sent to SANCCOB for post-mortem analyses (Rhoda 2022). However, identifying the predator species from wounds or bite marks on African penguins can be challenging (Vanstreels et al. 2019), therefore the number of predation events on African penguins attributed to seals or caracals need to be interpreted with caution. In addition, predation at sea is logistically challenging to observe at various colonies and were not systematically recorded.

For (3), breeding success data were available across eight colonies over 14 years to review the efficacy of the provision of artificial nests. The results were published in Pichegru et al. (2024) and a brief overview of the conclusions of the study is included here.

Finally, for (4), information on foraging effort and chick survival has been collected at Dassen Island, Robben Island, St Croix Island and Bird Island for 12 years to evaluate the benefits of purse-seine fishing exclusions for African penguins in the context of the Island Closure Experiment (ICE). Several peer-reviewed articles emanated from this research and in 2023, an international panel of experts reviewed the scientific results of the experiment (Punt et al. 2023). A summary of the experiment, the literature and the experts' review are also included here.

3. Results

Key events that are referred to in this study that took place during the implementation of the BMP, and the actions they relate to, are shown in Fig. 2, alongside population trends of the South African penguin and of their main prey, sardines and anchovies, between 2000 and 2024, as estimated with annual bio-acoustic surveys (see Coetzee et al. 2008 for methods). The IUCN status of the species is also shown.

3.1. Legislative framework

The BMP identified the need to review the legislation applicable to African penguins. Because nature conservation and environment are concurrent competencies, provincial and national laws have been enacted and regulations passed which impact on various aspects repsonsible for the conservation measures of African Penguins. In many cases, local municipalities have passed by-laws which also impact on these measures. This causes an overlap and in some cases, different authorities have different legal interpretation of these legislative provisions. The fragmentation has thus caused confusion amongst stakeholders. Amendments were necessary to address possible shortfalls, align mandates and clarify permitting procedures, as described in the five objectives and 15 actions included in this section. Some of these shortfalls were amended in 2017 with the adoption of the Threatened or Protected Marine Species Regulations and the List of Threatened or Protected Marine Species Lists (Government Notices R477 and No. 476 of 30 May 2017) (Marine TOPS) by the Minister responsible for environmental affairs, clarifying permitting processes for rehabilitation and captive facilities, as well as managing authorities. In addition, the draft "Norms and Standards relating to the Management of Seabirds in Captivity" were developed by members of the BMP WGs, and compliance with Norms and Standards became a condition of permits in

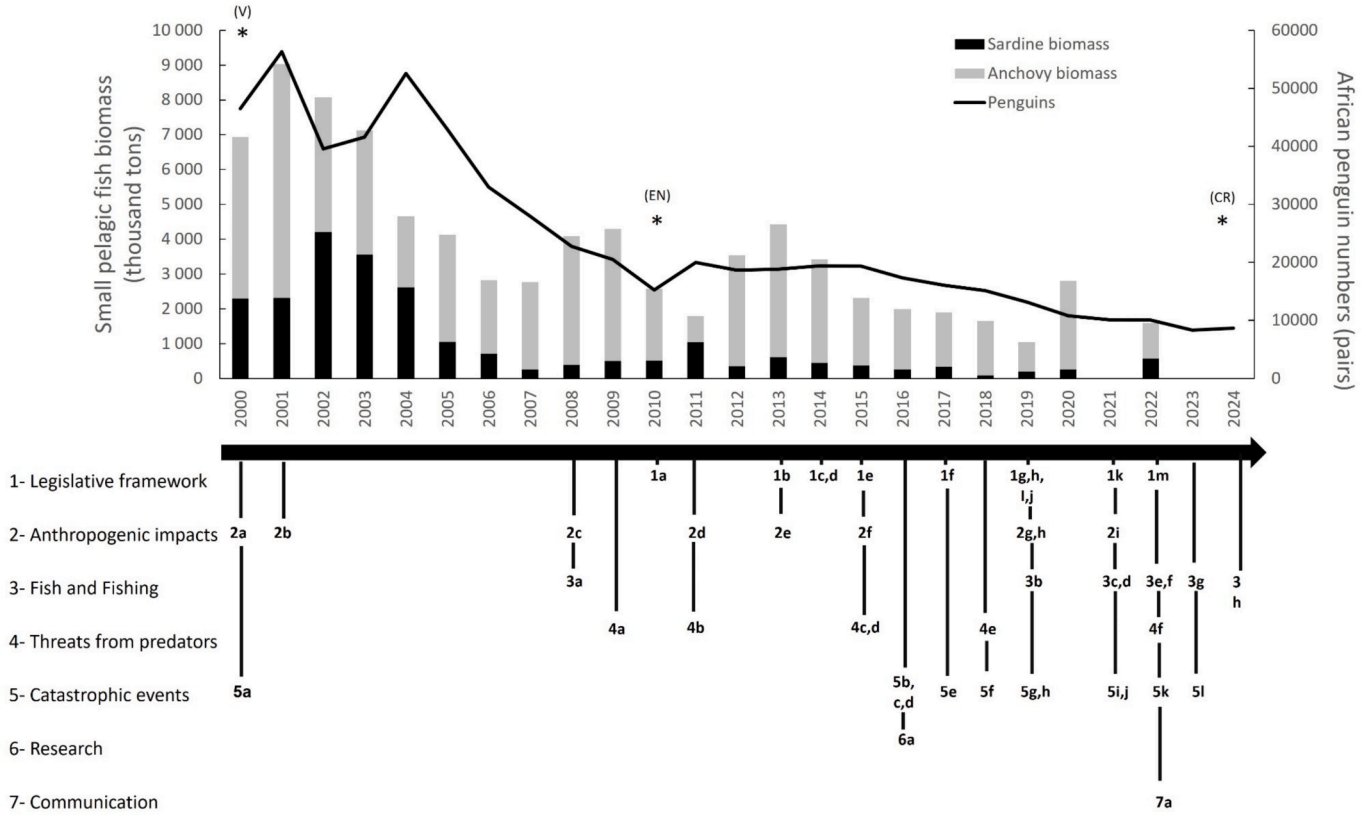

Fig. 2. Timeline of African penguin population trends (breeding pairs) in South Africa in relation with small pelagic fish biomass (sardines and anchovies, thousand tons) between 2000 and 2024, showing changes in IUCN classification (*) and major events arranged per the sections of the Biodiversity Management Plan (see Table S1 for details). **1 Legislative framework.** 1a Workshop to initiate the drafting of the BMP (2010). 1b Publication of the African Biodiversity Management Plan (2013). 1c Establishment of the BMP Steering committee, the Habitat Working Group and the Population Reinforcement Working Group (2014). 1d Stony Point colony's management handed to CapeNature (2014). 1e Draft of an International Multi-species Action Plan for the Conservation of Benguela Current Upwelling System Coastal Seabirds, under the auspices of the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) (2015). 1f Publication of the Marine TOPS regulations (2017). 1 g Publication of the "Norms and Standards relating to the management of seabird in captivity (2019). 1 h Regional Marine Top Predator Working Group established by the Benguela Current Convention (2019). 1i Review of the first BMP (2019). 1 k Declaration of 22 new Marine Protected Areas (2019). 1 l Publication of the revised National Oil Spill Contingency Plan, including the National Oiled Wildlife Contingency Plan (2021). 1 m Circulation of the 2nd BMP for public comments (2022). **2 Anthropogenic impacts.** 2a Largest penguin chick rescue and hand-rearing operation (N = 3,350 chicks) after the Treasure oil spill (2000). 2b First artificial nests in South Africa − wooden boxes on Robben (2001). 2c Fibreglass nests placed on most major colonies (2008). 2d Chick-rearing unit established at SANCCOB (2011). 2e Formalisation of the Chick Bolstering Project (2013). 2f First draft of the Human Disturbance guideline (2015). 2 g Conservation Translocation guidelines finalised (2019). 2 h Chick-rearing guidelines finalised (2019). 2i Double-layered ceramic nests placed on most colonies (2021). **3 Fish and Fishing.** 3a Start of the Island Closure Experiment (2008). 3b End of the Island Closure Experiment (2019). 3c Governance Forum Extended Task Team formed and proposal produced (2021). 3d Consultative Advisory Forum on Marine Living Resources formed and proposal produced (2021, 2022). 3e International Panel of Experts appointed (2022). 3f Temporary closures in place (2022). 3 g Panel's report publication; temporary closures maintained (2023). 3 h Similar closures maintained for 10 years (2024). **4 Threats from predators.** 4a Start of culling of Kelp gulls on Bird Island (2009). 4b Start of culling of Kelp gulls on Dyer Island (2011). 4c Start of culling of Cape fur seals on Dyer Island (2015). 4d First draft of the Predator Management Plan (2015). 4e Start of culling of Cape fur seals at Stony Point (2018). 4f CapeNature removes official weapons from reserves (2022). **5 Catastrophic events.** 5a Treasure oil spill (2000). 5b Southern African Seabird Colony Risk Assessment published (2016). 5c Initiation of offshore ship to ship bunkering in Algoa Bay (2016). 5d Oil spill in Algoa bay (2016). 5e Disease Surveillance guidelines published (2017). 5f Avian Influenza outbreak (2018). 5 g Oil spill in Algoa Bay (2019). 5 h Moratorium on new offshore bunkering licenses until the completion of an Environmental Risk Assessment study (ERA) (2019). 5i Avian Influenza outbreak (2021). 5j Publication of bunkering codes of practise; oil spill in Algoa Bay (2021). 5 k Oil spill in Algoa Bay (2022). 5 l Temporary halt of offshore bunkering in Algoa Bay due to irregular tax issues (2023). **6 Research.** 6a Creation of the Seabird Task Team (2016). **7 Education.** 7a NOOW campaign (2022).

accordance with the Marine TOPS. Other guidelines were drafted (Table S2) but only the "Norms and Standards" and the "Conservation Translocation Guidelines" have been incorporated into legislation and published to date. This delay in the finalisation of some of these guidelines was highlighted as a concern by ~ 20 % of the study participants (N = 6), who felt that it prevented more effective and streamlined implementation of predator management, even though predation levels were managed (see 3.4). Four participants acknowledged the benefits of the marine TOPS ("at higher levels a lot was achieved", "TOPS regulations [helped] clarify mandates"), and notably the Norms and Standards of Rehabilitation Centres, which "was really good" (NGO); "Regulated rehabilitation centres, with clear objectives, and best standard operation practices made a massive difference, allowed to scale operations up and improve their efficiency" (SCI).

The BMP also aimed to secure a protected status for all extant African penguin colonies, with colony management plans that would include actions from the BMP. An agreement was also to be explored to facilitate cooperative management of the species with Namibia. In 2014, Stony Point, which initially was managed by the Overstrand Municipality, was proclaimed a Nature Reserve and management was subsequently transferred to CapeNature, the Western Cape's provincial conservation agency. Thus, all colonies in South Africa then obtained protected status, except for part of the Simon's Town colony, which extended outside the limits of the area managed by South African National Parks (SANParks)

and is currently managed by the City of Cape Town with an informal agreement with SANParks. All colonies have management plans that are reviewed and updated every ten years, although actions from the BMP have not been systematically included in all of those plans ~~pending the plans' revision~~. Several colonies have penguin-specific Standard Operation Procedures (SOPs), and participants expressed their wish that these be shared among the WG to "learn from one another" (N = 3). Twenty new Marine Protected Areas (MPAs) were declared in 2019 designed to protect marine ecosystems at large, thus protecting only some areas of the African penguins' foraging habitat (see 3.3 below).

An International Multi-species Action Plan for the Conservation of Benguela Current Upwelling System Coastal Seabirds was drafted in 2015 under the auspices of the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) (Hagen and Wanless 2015). In 2019, Benguela Current Convention with representatives from Angola, Namibia and South Africa established a Regional Marine Top Predator Working Group to cooperatively manage the species across its distributional and breeding range and oversee the implementation of this AEWA action plan, even though Namibia and Angola are not party members to AEWA. However, the action plan has not yet been fully implemented due to a lack of funding, although a further AEWA workshop was held in 2020, which produced a set of recommendations pertaining to forage fish management and seabird conservation (https://www.unep-aewa.org/en/meeting/benguela-current-forage-fish-workshop), which all three countries participated in. In parallel, the NGO NAMCOB (https://namcob.org.na/) has been established between partner organisations including SANCCOB based in Cape Town, the Namibia Nature Foundation, and the Namibia Chamber of Environment, among others, to improve disaster responses and align conservation methods across countries. Few participants were aware of this agreement (N = 4 of 19 that commented on that section).

The last objective of this section included the investigation of the feasibility of establishing new colonies or re-establishing old colonies of African penguins. BirdLife South Africa took the lead on this initiative, starting with extensive engagement with stakeholders and experts in the field between 2013 and 2015. They first undertook a site-based feasibility assessment, which included dedicated acoustic fish surveys in 2016 to estimate prey availability around potential sites to ensure adequate foraging conditions. The feasibility of predator proofing the area and limiting predation at sea were also considered at two sites until administrative complications (legal ownership of the land) prevented further consideration of one site. Thus, effort shifted towards the site in De Hoop Nature Reserve, managed by CapeNature, and a Risk Assessment study and a Colony Management Plan were developed. In 2019, decoys and speakers playing African penguin calls were deployed for passive attraction. From 2021 onward, abandoned chicks and eggs from other colonies, which were incubated and/or hand reared at SANCCOB to fledging were released at the site. By the end of 2022 one pair of African penguins successfully bred on site. Four pairs raised chicks in 2023. All stakeholders that mentioned this action praised BirdLife's achievement, highlighting that "this action (…) followed due procedure and was transparent, with regular reports, Risk Assessment, Standard Operating Procedures, Management Plan, etc." (GVT), although some had reservations in terms of impact on the population: "it was a good action that needed to be tried, worth attempting and good work was done, but not sure if it would work long-term" (NGO), as someone else highlighted: "even though predator-proofing was included in the risk assessment, predation by mainland predators could not be prevented" (GVT).

3.2. Anthropogenic impacts

Anthropogenic threats have the strongest impact on African penguin population trends (Ropert-Coudert et al. 2022, Gimenez et al. 2024). These threats extend from guano removal which reduced the birds' breeding habitat and forced birds to breed in surface nests vulnerable to extreme weather events and predators, to human disturbance at colonies, competition over prey or oil spills. In this section, which included six objectives and 15 actions, the BMP focused on habitat improvement and population reinforcement. Habitat improvement was led by the Habitat WG and included the provision of artificial nests, habitat restoration, reducing disturbance on land and at sea, and reducing road mortality. The Population Reinforcement WG was formed to advise on the rehabilitation and release of individuals and hand rearing of chicks, with standardized protocols, as well as the regulation of the trade of the species, and the possibility of captive breeding to bolster wild populations.

3.2.1. Artificial nests and habitat restoration

By the time of the publication of the BMP, several types of artificial nests were already deployed at various colonies which produced varying results in terms of breeding success (Sherley et al. 2012, Pichegru 2013). Subsequently, through stakeholder engagement, research and field testing between 2016 and 2018, a new artificial nest design was developed by the Dyer Island Conservation Trust (https://dict.org.za/) using two ceramic layers to ensure adequate insulation (Welman and Pichegru 2022). These nest types were rolled out in eight colonies between 2018 and 2020 and monitored for breeding success. A recent study compared performance of four types of artificial nests (wooden boxes, cement nests, fibreglass nests and ceramic nests) to natural nests (natural burrows, bush nests and open surface nests) over 14 years. They demonstrated that overall artificial nests successfully increased penguin productivity by 16.5 % (95 % CI: 6.7–26.2 %) compared to natural nests (Pichegru et al. 2024), although no single design was consistently most effective across all locations. Ceramic nests generally performed better than other types of artificial nests, but the best performing nest designs were colony specific due to the variety of habitats in the different colonies (Pichegru et al. 2024). The deployment of artificial nests thus proved to be a successful conservation measure for African penguins, although further modelling is required to translate this increase in breeding success in population growth.

Habitat restoration included alien vegetation clearing programmes on Robben Island, installation of irrigation systems to help increase vegetation cover to reduce erosion at Stony Point, and 'brush-packing' supplementing vegetation removal by other breeding seabird species, like Cape cormorants (*Phalacrocorax capensis*). 'Brushpacking' used vegetative material harvested off site (*Acacia cyclops*) and carried into the colony to be placed in locations where viable breeding habitat was either absent, and/or compromised by wind erosion; or to target very exposed locations where signs of 'open' nest site exploration was evident. The branches were woven, placed in feathered rows along contour thus grounding a terracing effect along the declining aspect of Stony Points colony landscape. The material was also purposefully placed to provide a support structure to isolated vegetative growth points of *Tetragonia fruticosa*, to allow this rambling ground cover to grow and provide a sheltered nest site, rather than pairings digging burrows which would ultimately collapse during heavy rain events or become engulfed by wind blown sands. The action of 'brushpacking' was initiated seasonally prior to each Cape cormorant breeding season, with the objective to cover any active and established African penguins nesting sites that were well established under the canopies created of *Tetragonia* to limit Cape cormorant demand and activity. Finally 'brushpacking' was also initiated when severe weather warnings were broadcast and active nest sites were hastily covered with additional material. More recently, habitat restoration was initiated at Boulders/Simon's Town to remove alien plants and restore indigenous vegetation, as well as sand management to prevent soil erosion.

Participants generally valued the Habitat WG: "we could share views on issues and how to improve management. (…), better at managing and improving research, and management on the ground in the colonies" (MA, GVT, N = 3). While there was general support for artificial nests that were seen as effective (see discussion), lack of communication and

accountability around the development of ceramic nests were voiced by participants across all institutions (N = 6). It is worth noting that the interviews took place before the recent study by Pichegru et al. (2024) demonstrated the benefits of artificial nests. There were mentions of a "lack of communication etiquette with the people already working on the colonies" (NGO), "a lack of cooperation, (…) there should have been a smaller committee dedicated to ensure nests were tested, monitored etc.," (SCI); that "not enough research was done before deploying thousands of artificial nests" (MA) and "managing authorities took over by accepting nests, without going through the Habitat WG" (GVT). These statements highlight the importance of transparent and regular communication within the WG, from managing authorities making decisions to scientists analysing the data, for a smooth implementation of actions. There was, nevertheless, general support for artificial nests, seen as "effective, (…) can help penguins", particularly on "islands without vegetation" or "where [natural] burrows get flooded in sand, [but the] nests need to be covered by vegetation".

3.2.2. Human disturbance and road mortality

One action of the BMP included the establishment of Disturbance Guidelines, to manage human disturbance at colonies, including road mortality. This document was drafted and circulated for comments in 2015, but the large demand from the group for these guidelines to be as inclusive as possible (disturbance at sea, from Unmanned Aerial Vehicles, film crew, researchers, etc.), in parallel with limited input in terms of drafting, led to these guidelines not being finalised in 2024. Nevertheless, actively minimising disturbance was part of all permits issued to conduct work on the species. Road mortality was reduced on Robben Island following an education campaign that intensified in 2017, as acknowledged by all but two participants that mentioned Robben Island (N = 7), stating "increase of signage", and "an effective education campaign (…) with regular training sessions (…) that dropped mortality from five a month to one every five months" (NGO, SCI). Similarly, at Simon's Town "a few campaigns were initiated by [SANParks] honorary rangers, who placed signage in parking areas, [which] contributed a lot to reduce road mortality" (NGO), but several participants still had concerns around that colony where "more awareness needs to be done, with car guards, guest houses, etc.", as "there are too many unnecessary deaths" (NGO). However, most people that mentioned this issue shared the opinion that "road mortality can probably never be stopped as (…) penguins roam around" and "it is all accidental, (…) penguins on a tar road are virtually invisible".

3.2.3. Rehabilitation efforts and chick bolstering

Rehabilitation of African penguins has a long history and includes the largest oiled wildlife rescue operation in the world, when over 40 000 birds were handled during the response to the Treasure oil spill in 2000 (Wolfaardt et al. 2009). The first official rehabilitation centre, the Southern African Foundation for the Conservation of Coastal Birds (SANCCOB), was formally launched in 1968 in order to respond to oiling events and rehabilitate oiled birds. Over the course of the rescue events during oil spills, a substantial number of individuals were marked with flipper bands, which allowed an assessment of the survival rate and recruitment to the wild breeding population of the rescued birds, that were either oiled, evacuated to prevent being oiled or orphaned. Studies showed high rehabilitation success of de-oiled birds (Wolfaardt et al. 2008a), with 90 % of the oiled birds being released (Crawford et al. 2000), of which 73 % successfully recruited into the wild population to breed, albeit with lower breeding success than non-oiled birds (Barham et al. 2007).

African penguin chick bolstering (hand rearing and release of chicks prematurely abandoned by their parents) had been taking place after oil spills since at least 1994 and a large cohort of around 3,350 were collected after the Treasure oil spill in 2000 (see Barham et al. 2008). Research showed similar survival and breeding success of hand-reared chicks following the Treasure oil spill to that of wild reared birds (Underhill et al. 1999, Barham et al. 2008). Based on the apparent success of this intervention, between 2001 and 2005 small numbers (24–99 per year) of chicks abandoned by their parents that started their moulting process were rescued and reared by SANCCOB (Sherley et al., 2014b). In 2006 and 2007, two relatively large cohorts (841 and 481 chicks respectively) were abandoned, leading to the formalization of the Chick Bolstering Project to hand-rear these chicks and release them wearing flipper bands so their fates could be followed (Schwitzer et al. 2013). It is worth noting that flipper bands are no longer used instead since ca. 2010 and all released birds have been fitted with passive integrated transponder chips – PIT tags from 2015 onward). A Chick Rearing Unit was established in November 2011 at SANCCOB in Cape Town. Subsequently, the survival and recruitment of the hand-reared chicks removed in 2006 and 2007 were confirmed to be similar to that of wild chicks (Sherley et al., 2014a), validating this action as a conservation policy. The BMP streamlined this action by generalizing it to other colonies and establishing a suite of guidelines. For example, the "Conservation Translocation Guidelines" published in 2019 deals with egg and chick removal and their release into the wild, while the "Chick Rearing Guidelines" provides information on care and management of rescued chicks.

Over the years, rescuing, rehabilitation and hand-rearing techniques continuously improved, partly thanks to the engagement of most rehabilitation stakeholders in the drafting of these various guidelines. This continuous improvement in population bolstering techniques led to high release rates of individuals raised from both chicks and eggs (Klusener et al. 2018). A Body Condition Index for African penguin chicks was developed (Lubbe et al. 2008) as a tool to assist decisions on when to admit chicks from the wild for rehabilitation. Chicks rescued in poorer condition were shown to have a lower chance of survival and successful release than chicks caught before their condition deteriorated (Morten et al. 2017), suggesting proactive interventions and frequent colony monitoring to assess nest abandonment at early stages to maximise the success of rehabilitation.

From the rehabilitation records obtained from SANCCOB, SAMREC, SAPREC, APSS and Tenikwa between 2012 and 2022, more than 11 100 individual African penguins were released into the wild after rehabilitation over a decade (Table S3). We estimated that by 2023, the contribution of rehabilitation efforts from 2012 onwards amounted to approximately 4.5 % of the wild breeding population (min. 2 %, max. 12 %, Table 3, Table S4, corroborating previous findings justifying the value of rehabilitation for African penguins (Barham et al. 2008, Wolfaardt et al. 2009, Sherley et al., 2014a, Vanstreels et al. 2023). One caveat of the model is assuming that all individuals that have been rehabilitated would have not survived in the wild without intervention. This assumption is true for most oiled birds, as even lightly oiled birds released without being cleaned had lower survival than de-oiled birds (Wolfaardt et al. 2008). It is also true for the majority of chicks (Morten et al. 2017), which form the bulk of the rehabilitated individuals (75 %, Table 3, Table S3). For adults, however, it is likely that some individuals, that were rescued with wounds for example, could have survived without rescue, although their proportion is difficult to estimate. Assuming that up to half of the adults admitted for rehabilitation did not need intervention, the minimum model still estimates that the South African penguin population is at least 1.1 % larger in 2023 with rehabilitation effort than it would have been without (3.4 % using the average model, Table S4). While a more comprehensive Integrated Population Model is currently being developed to quantify rehabilitation input in terms of population growth rate, the present results show that rehabilitation clearly contributed to slowing the rate of decline of the species and to reducing the risks of the species going extinct in the near future (Sherley et al. 2024).

Most participants mentioned Chick Bolstering as successful and contributing positively to the conservation of African penguins (see discussion Table 6). Out of the twenty-one participants that commented on this action, all but four had positive words on this objective, from

Table 3
Estimates (min – max) of the contribution of rehabilitation efforts between 2012 and 2022 to the total number of adult African penguins in the breeding population ($B_{A,t}$) from 2013 to 2023, the number of pairs formed ($B_{P,t}$) by these rehabilitated individuals and the number of pairs formed by their chicks that successfully fledged that would subsequently recruit into the breeding population in 4 year's time ($B_{F,t}$). The estimated total number of pairs ($T_{P,t}$) formed by rehabilitated individuals and their offspring is shown, in relation to the total breeding pairs in South Africa (DFFE, unpublished data), and the percentage the former contributed to the latter. $R_{A,t}$ released adults at year t, $R_{J,t}$ released juveniles at year t, and $R_{C,t}$ released chicks at year t.

Year	$R_{A,t}$	$R_{J,t}$	$R_{C,t}$	$B_{A,t}$	$B_{P,t}$	$B_{F,t}$	$T_{P,t}$	Breeding pairs in South Africa	Percentage from rehabilitation
2012	354	53	411	–	–	–	–	18 683	–
2013	248	48	816	272.6 (219.5 – 315.1)	95.4 (76.8 – 110.3)	2.4 (0.3 – 10.0)	95.4 (76.8 – 110.3)	18 835	0.5 (0.4 – 0.6)
2014	130	50	1074	400.8 (289.8 – 501.1)	140.3 (101.4 – 175.4)	3.6 (0.4 – 15.9)	140.3 (101.4 – 175.4)	19 412	0.7 (0.5 – 0.9)
2015	170	89	651	432.9 (272.9 – 599.1)	151.5 (95.5 – 209.7)	3.9 (0.4 – 19.0)	151.5 (95.5 – 209.7)	19 338	0.8 (0.5 – 1.1)
2016	287	115	996	546.2 (303.7 – 860.3)	191.2 (106.3 – 301.1)	4.9 (0.4 – 27.3)	191.2 (106.3 – 301.1)	17 304	1.1 (0.6 – 1.7)
2017	148	56	717	783.6 (413.1 – 1338.2)	274.3 (144.9 – 468.4)	7.0 (0.5 – 42.5)	276.7 (144.9 – 478.4)	16 038	1.7 (0.9 – 3.0)
2018	83	61	634	914.9 (415.2 – 1756.5)	320.2 (145.7 – 614.8)	8.2 (0.5 – 55.7)	323.8 (145.7 – 630.7)	15 133	2.1 (1.0 – 4.2)
2019	161	163	562	916.0 (364.2 – 1943.1)	320.6 (127.8 – 680.1)	8.2 (0.5 – 61.7)	324.5 (127.8 – 699.1)	13 176	2.5 (1.0 – 5.3)
2020	83	88	495	1000.3 (381.7 – 2256.2)	350.1 (134.0 – 789.7)	9.0 (0.5 – 71.6)	355.0 (134.0 – 817.0)	10 822	3.3 (1.2 – 7.5)
2021	92	26	954	966.8 (333.4 – 2372.5)	338.4 (117.2 – 830.4)	8.7 (0.4 – 75.3)	345.4 (117.2 – 872.9)	10 102	3.4 (1.2 – 8.6)
2022	207	73	1059	982.3 (329.8 – 2527.3)	343.8 (116.0 – 884.6)	8.8 (0.4 – 80.2)	352.0 (116.0 – 940.3)	10 042	3.5 (1.2 – 9.4)
2023	–	–	–	1038.0 (377.9 – 2689.7)	363.3 (132.7 – 941.4)	9.3 (0.5 – 85.4)	371.5 (132.7 – 1003.1)	8324	4.5 (1.6 – 12.1)

Note: $T_{P,t} = B_{P,t} + B_{F,t-4}$ (see eqn. 1). Thus, where $t = 2023$, $T_{P,t} = 363.3 + 8.2 = 371.5$ and prior to 2017, B_F does not contribute to .$T_{P,t}$

Table 4
Number of individual kelp gulls culled in relation to the size of their breeding colonies in the Bird Island group (Bird, Seal and Stag islands) and Dyer Island (DFFE, unpublished data) between 2009 and 2022.

	Bird Island		Dyer Island	
	Culled	Breeding pairs	Culled	Breeding pairs
2009	0	222		
2010	318	169		
2011	94	98		603
2012	220	no data	150	610
2013	234	122	0	213
2014	127	81	60	172
2015	130	118	22	443
2016	81	104	32	297
2017	90	90	85	209
2018	80	26	24	196
2019	150	75	131	340
2020	36	no data	106	176
2021	5	126	0	no data
2022	0	147	150	no data

"very important" and "successful, to "done well" or "very well", or even "the most important objective and actions on the whole BMP". The majority (N = 12) had both positive and negative comments, and praises and criticisms were voiced equally among all groups interviewed (GVT, MA, NGO and scientists). People commended the bolstering towards the re-establishment of the colony at De Hoop (N = 2), and SANCCOB's capacity to successfully hatch eggs and raise chicks (N = 2). Many saw the "value", "importance", and "usefulness" of bolstering chicks: "we saved a good number", "we do need to rescue abandoned chicks to boost the population (…) all these factors should assist in keeping the numbers out there", "it's very important to bolster as penguins are going extinct" (3 MAs). The negative comments were around two main aspects: the methods used for chick removal (N = 7), as "en mass removal prior to a storm doesn't seem right" and "breaking the pair bond may have unintentional long-term consequence" (N = 2); and the release of birds in "an environment without enough fish" (N = 5).

3.2.4. *Studbook, trade and captive-breeding*

The African penguin was already listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2013, but the BMP highlighted a lack of knowledge on the species level of trade and impact on wild populations, and on the status of unmanaged captive populations. There was a need to assess the genetic diversity of the captive population to explore the suitability of captive birds for release into the wild (those that have been in rehabilitation for long periods or those that have been bred in captivity) (DEA 2013). All non-releasable captive birds needed to be genetically identified and recorded in the African penguin studbook. This studbook (collated and managed under the auspices of the African Conservation Programme (ACP) of PAAZA®) was already in existence in 2014 (the first record of a publication was in 2004) but it became compulsory for all captive facilities to participate in the studbook program once the Marine TOPS Regulations came into effect in 2017. All (but one) rehabilitation facilities contributed samples to biobanks following the "Procedure of Biological Sampling for African Penguins" (Table S2) drafted by the South African National Biodiversity Institute (SANBI). Permits for rehabilitation centres were also updated following the Marine TOPS regulations. A Non-Detrimental Finding was issued in 2015 by the Scientific Authority of South Africa (the authority responsible for advising the Minister as regards the trade in endangered species under the CITES regime) to advise on the trade of penguins, although not published for implementation yet. The draft stated that: "Considering the poor conservation status of the African penguin, trade in healthy wild specimens would have a detrimental impact on the wild population. It is therefore recommended that exports of *S. demersus* be confined to captive-bred specimens and rehabilitated wild specimens that have been deemed unfit for release into the wild.".

One BMP action included consideration of "the suitability of bolstering existing colonies (…) with (…) possible captive-bred penguins". This question generated strong divisions within the Population

Table 5
Number of African Penguins (adults and juveniles) killed or injured presumably by Cape fur seals at Simon's Town, Stony Point and Dyer Island between 2012 and 2022, with number of individual Cape fur seals culled over the same period.

	Simon's Town			**Stony Point**			**Dyer Island**		
	African penguins		*Seals culled*	*African penguins*		*Seals culled*	*African penguins*		*Seals culled*
	dead	*injured*		*dead*	*injured*		*dead*	*injured*	
2012	1	1	0	no data		0	no data		0
2013	1	5	0	2	0	0			0
2014	6	5	0	1	15	0			0
2015	2	7	0	15	0	0			1
2016	1	7	1	78	9	0	3	0	29
2017	0	1	0	158	7	0	7	0	28
2018	0	0	0	0	0	4	4	0	17
2019	9	0	0	no data		2	7	0	21
2020	2	0	0			0	no data		2
2021	0	0	0			2			no data
2022	0	0	1			no data			16

Table 6
Stakeholder's perception of the conservation actions for African penguins in place in 2023 that were **seen as** the most successful, and the actions most urgently needed in future.

Successful				Needed			
Actions	N	Institutions	N	Actions	N	Institutions	N
Rehabilitation of adults, chicks and eggs	12	MA	5	Fishery closures/spatial management of fishery/ecosystem approach to fishery management	16	MA	5
		GVT	2			GVT	3
		NGO	3			NGO	4
		SCI	2			SCI	4
Predator Management	10	MA	3	Increased capacity/funding	6	MA	3
		GVT	2			GVT	2
		NGO	3			NGO	1
		SCI	2			SCI	2
Artificial nests	8	MA	3	Limiting risks of oil spill and underwater noise pollution from ship-to-ship bunkering	5	MA	2
		GVT	1			GVT	1
		NGO	3			NGO	1
		SCI	1			SCI	1

Reinforcement WG due to opposing views between stakeholders regarding the risks these would represent to the wild population, which generated lengthy debates around Risk Assessments that remained unresolved. Ten years after the publication of the BMP, the general sentiment of the WG was that due to poor environmental conditions in the wild, this action was a low priority. Nevertheless, two Risk Assessment studies, one for the removal, rearing and releasing of wild eggs and chicks, and one for the release of captive-bred birds were initiated in 2023.

Stakeholders were unanimous in praising the regulations on the trade and of rehabilitation and captive facilities (N = 17 that commented on that objective). "Studbook was a must, the only responsible way for captive breeding" (MA); "well achieved" (MA); "Regulation of rehabilitation was necessary (…), formalising protocols was important" (NGO). While the topic of the release of captive-bred birds and the need for Risk Assessments were hotly debated during the meetings of the WGs, participants were less expressive during the interviews, although one person shared that these meetings were "very stressful, with lots of tension and people angry at each other". The "misunderstanding and disagreement around the Risk Assessments" (GVT) prevented their completion, which was voiced as a concern and a frustration by several (N = 6). Some had "ethical concerns" about the release of birds in an environment with poor food availability (N = 2, SCI, NGO), although two people viewed the need to start discussions around "a threshold as to when to start implementing captive breeding and consider the release of captive bred birds" (NGO), or even around considering "taking all the freshly laid eggs in the wild and let them breed again and have a factory" (MA), although "adequate food must be ensured for these released birds" (N = 2).

3.3. Fish and fishing

In this section, the only objective of the BMP was "to ensure an adequate abundance of prey for penguins" (a) in areas close to their breeding localities and (b) during non-breeding periods of their life cycle, acknowledging that the small pelagic industry targeting the same prey as penguins may reduce the total food available for the birds, resulting in possible competition around breeding colonies. The seven actions included monitoring the possible impact on the biology of African penguins of fishing near their colonies, while monitoring prey distribution and abundance at both small (colony) and large (national) scales. Research findings were to be incorporated in the management of small pelagic fish stocks.

None of these objectives and actions were discussed in the African Penguin BMP WG meetings. Rather, these actions were conducted under the Island Closure Experiment (ICE, see Sherley et al. 2018, McInnes et al. 2024), which was initiated prior to the BMP in 2008 and coordinated through the Small Pelagic Scientific Working Group (PEL-SWG), within the then Department of Agriculture, Forestry and Fisheries (DAFF) (2008–2018). In 2018, the function of Forestry and Fisheries was transferred to the Department of Environmental Affairs, which was renamed the Department of Forestry, Fisheries and the Environment (DFFE). The PEL-SWG then reported to the Fisheries Management branch of the DFFE. The BMP was convened by the Department of Environmental Affairs (DEA) (2008–2018) and subsequently by the Ocean & Coasts branch of DFFE after 2018. These two government branches (Fisheries and Ocean and Coast) have different but overlapping mandates, with Oceans & Coasts implementing the BMP through NEMBA, while Fisheries Management implements and is governed by the Marine Living Resources Act, 1998 (Act No 18 of 1998).

The ICE constituted two sets of paired islands, Dassen and Robben islands on the west coast of South Africa, and St Croix and Bird islands in Algoa Bay, where at any time one colony in each pair had a 20 km radius purse-seine fishing exclusion zone in place for three years, while the other remained open to fishing. The scenario was alternated every three years between 2008 and 2020. Foraging effort of chick-rearing adults, chick growth, chick condition and breeding success were monitored at all four colonies for the full duration of the experiment (see Pichegru et al. 2010, Sherley et al. 2015).

Substantial academic research took place during the ICE to reveal the at-sea habitat use of African penguins during the breeding (e.g., Pichegru et al. 2009), and non-breeding seasons (Carpenter-Kling et al. 2022), and the biology of penguins in relation to fishing catches and fishing exclusions (Pichegru et al. 2010, 2012, Sherley et al. 2013, 2015, 2018, Grigg 2016, McInnes 2016, Campbell et al. 2019, Sydeman et al. 2021). Bio-acoustic surveys to monitor the distribution and abundance of small pelagic fish stocks have been conducted bi-annually by government scientists since 1984 (e.g., Coetzee et al. 2008) with additional small-scale acoustic surveys initiated on the West Coast from 2009 until 2016 (Campbell et al. 2019), and in Algoa Bay between 2011 and 2018 (McInnes et al. 2015, 2017). Several models were developed linking African penguin demographics and their prey availability, including fishery catches and exclusion zones (Sherley et al. 2013, 2015, 2018, Robinson et al. 2015). However, contradicting interpretation of the results from the various models prevented the findings from being incorporated in the management of small pelagic fish stocks. In the meantime, the discovery in the mid-2010 s that the sardine stock should be considered two stocks (De Moor & Butterworth 2015, McGrath et al. 2020) promoted the implementation of split allocations of sardine catches at a large scale, east and west of Cape Agulhas, which alleviated some fishing pressure on the West Coast.

When the ICE came to an end in 2020, small pelagic fishery exclusion zones around key colonies were to be considered. However, members and observers of the PEL-SWG could not agree on the outcome of the ICE, as different statistical approaches led to opposing conclusions (see Sydeman et al. 2021, 2022, Butterworth and Ross-Gillespie 2022). Subsequently, several governmental processes followed to discuss the configuration of fishery closures (see McInnes et al. 2024 for details). These included a Governance Forum Extended Task Team in 2021 and a Consultative Advisory Forum on Marine Living Resources in 2022, but none succeeded in reaching a decision on the extent of future closures deemed mutually acceptable by both the fishery and conservation sectors. Thus, in September 2022, interim fishery closures were implemented around six penguin colonies based on a mix of previously proposed no-take zones, while an international panel of experts was appointed to provide an independent review of the scientific results of the ICE. The panel concluded that excluding fishing around penguin colonies was likely to reduce the rate of decline in the population to a small extent, through improved breeding success (Punt et al. 2023). The panel noted that due to limitations in the design and implementation of the ICE, longer-term fishing exclusions would likely have positive benefits on adult and juvenile survival which were not assessed during the ICE (Punt et al. 2013). The panel also provided recommendations on the design and implementation of no-take zones including a trade-off mechanism to balance the competing interests of fisheries and conservation stakeholders in the selection of no-take zone extents (Punt et al. 2023). Following the publication of their review, the temporary closures were maintained for ten years from January 2024 due to a lack of agreement on alternative boundaries between the fishery and the conservation sectors. The designs of these closures were deemed inadequate to provide sufficient protection to African penguins (McInnes et al. 2024).

The majority of the interviewees that commented on this section (N = 17 of 21) used negative terms, and of the four people who had neutral comments or did not feel that they knew enough to respond, three were involved in African penguin conservation for less than 5 years. One person felt that the colony where they worked had adequate protection from competition with fisheries. There was general agreement that these "actions around fishing [were] important" and "lots of effort has been put in to collect the data and conduct the science" (MA), but many stated that the objective was not fully achieved (N = 8). The key barrier identified in the achievement of this objective was the "split between fisheries and environment at government" (NGO), which "did not allow for communication" (MA). In essence, "these actions should not have been left to the Small Pelagic Scientific Working Group to be dealt with alone, as there was some biodiversity component that Oceans and Coast should have been responsible for" (GVT). It was felt by many participants that "there was no will from the fishing industry to negotiate **[in good faith]"** (MA), that "fisheries always had the power" (NGO), "fisheries always had it easy, (…) there was dishonesty and no willingness to participate" (MA). Several were concerned about recent revelations that fishing vessels were operating illegally inside the exclusion zones around Dassen and St Croix islands when they were closed to fishing (N = 6), that Robben Island MPA was "a paper park" (MA), and it "seems there was a lot of fishing around Dyer anyway" (NGO). Some also shared their disappointment at the BMP working groups that "did not help" (GVT), that "no BMP WG was created to undertake these actions" (SCI), as "the BMP group should be [involved], we would be more effective if we were working as a group" (NGO).

3.4. Threats from predators

Due to concerning levels of predation on African penguins at some colonies (e.g., Weller et al. 2016), the BMP recommended preventing or reducing predation impacts on penguins during their full life cycle, with the development of predation guidelines and implementation of management programs where needed, to be monitored scientifically. Draft Predator Guidelines were circulated for comments to the WGs from 2015 onward and stakeholder engagement took place with workshops on a regular basis, but to date, no standardised guidelines for predation management have been finalised.

Predation by kelp gulls and the effectiveness of their culling was monitored on Bird Island in 2009 and 2010, demonstrating the benefits of gull removal on African penguins' breeding success (Pichegru 2013). Kelp gulls were subsequently managed on Bird Island from 2010 onward and on Dyer Island from 2012, significantly reducing their initial breeding numbers (Table 4). Gull-culling experiments throughout the world confirm that in order to be effective culling should be continued over multiple years (Guillemette and Brousseau 2001, Sanz-Aguilar et al. 2009), as gull predation can return to pre-culling levels the following year (Guillemette and Brousseau 2001). While predation levels are no longer monitored on Bird Island, gull breeding numbers increased rapidly in 2021–2022 once culling ceased, prompting the re-initiation of culling in 2023 (R. Milne pers. obs.). Kelp gulls have been impacted by predation from great white pelicans *Pelecanus onocrotalus* on the west coast of South Africa in recent years, which displaced colonies and reduced their overall breeding numbers in South Africa (De Ponte Machado, 2010). However, kelp gulls are adaptive and resilient (Reusch et al. 2024) and are distributed widely in the southern hemisphere. Their populations in South Africa are presumably above historical limits (Steele and Hockey 1990), benefiting from human-induced food subsidies and landfill sites (Crawford et al. 2009). In such disturbed systems, human intervention is justified to assist endangered species. However, CapeNature has now removed all official weapons from their reserves and culling is no longer being implemented since 2022 in the colonies under their management. Gull eggs on Dyer Island have been oiled from 2022 in an attempt to decrease breeding success and keep breeding numbers low.

Cape fur seals *Arctocephalus pusillus pusillus* are one of the main predators of seabirds at sea (Makhado et al. 2006, 2013) and represent a severe threat to penguins at some colonies, like Dyer Island, but also to a lesser extent at Robben Island (Weller et al. 2016). Problematic

individual seals have been regularly culled over the years by the DFFE and CapeNature (Makhado et al. 2009, Table 5). Between 2016 and 2022, 17 to 29 individual seals were culled annually around Dyer Island (Table 5) and few predations on penguins were recorded concomitantly, possibly as a direct result of seal management but also from lower observation effort due to logistical challenges (D. Geldenhuys, pers. obs). However, this action stopped in 2022 as CapeNature has now removed all official weapons from reserves under their management. At Stony Point, high levels of predation by Cape fur seals on penguins were recorded in 2016 and 2017, with 78 to 158 adult and juvenile penguins killed in the respective years. These high levels of fatal events prompted the culling of four individual seals in 2018 and no predation was recorded on penguins that year (Table 5). Another two seals were removed from Stony Point in 2019 and 2021, but no further records of seal predation on penguins were available beyond 2018 to assess the efficiency of the regular culling of problematic individual seals in reducing predation levels on penguins. At Simon's Town, presumed seal predation levels on penguins have been low to negligible with only one seal removed from the area before 2020. In 2022, another individual seal was culled following increased observations of predation at sea even if no injured penguin or carcasses was found on land. However, recent changes in the distribution and number of white sharks in False Bay (Bowlby et al., 2023) are suspected to have reduced predation risk from sharks on seals, leading to shifts in Cape fur seal habitat use over time and space. This may have contributed to an increase in seal numbers in the area, potentially resulting in a spike in penguin predation by seals at Simon's Town in 2023 (City of Cape Town, South Africa, unpublished data). It is likely that regular monitoring of predation events and rapid mobilisation to remove culprit individual seals at that colony will be required from now on. No seals were culled around Robben or Dassen islands during the timespan of the BMP.

Penguins being naïve to mammalian predators on land and with little protection, fall prey to leopards *Panthera pardus*, caracals, mongooses, Cape clawless otters *Aonyx capensis* or domesticated cats and dogs (Vanstreels et al. 2019), which can have disproportionally large impacts on their colonies. Of the terrestrial predators, caracals are the most destructive and have had significant impacts on the African penguin colonies in Simon's Town and at Stony Point (Rhoda 2022). The management of their impact is, however, challenging. Clear Standard Operating Procedures in place at Simon's Town including early detection and management of caracals have been effective recently in limiting the impact of predation on African penguins in this mainland colony (Rhoda 2022). Predation on land by leopards (*Panthera pardus*) is occasional (Hockey et al. 2005) but can have significant impact on African penguins as they can kill a relatively large number of adult penguins in a few hours (e.g., 33 adult penguins in one night in 2016 at Stony Point). However, no incident has been recorded since 2016 and the leopard responsible for the predation at Stony Point was hazed out of the area and did not return.

At Simon's Town, fatal dog attacks on African penguins averaged one or two per year between 2012 and 2022, except in 2015 and in 2022 when 44 and 17 birds were killed, respectively (Rhoda 2022). At Stony Point, predation by dogs between 2013 and 2018 occurred in three years where one bird was killed each year (one chick was killed by a cat in 2014). But there are limited actions that can be undertaken to further reduce dog related mortalities at these two mainland colonies other than the existing patrols by rangers, the fining of contraveners and the education of visitors. Feral cats are some of the most damaging introduced predators on islands and have contributed to a minimum of 14 % of all bird, mammal, and reptile extinctions and the decline of at least 8 % of critically endangered birds, mammals, and reptiles on islands globally (Medina et al. 2011). Their impact on vertebrates have been reported from at least 120 different islands, including Robben Island. In South Africa, a professional hunter was contracted by the Robben Island Museum to actively remove cats from Robben Island since October 2009. A total of 118 cats have been eradicated and for the past 3 years fewer than 5 adult cats have been located on the Island (C. Wilke, pers. obs.). Baited cat traps were trialled but with no success. Current annual breeding and recruitment is likely retaining a total population that is less than double digits, and the contractor reported that he usually encounters and collects some of the recruits as they are somewhat naïve when they first become independent from their mother (C. Wilke, pers. obs.).

Participants in the interviews all recognized the challenging nature of predation and its management, due *inter alia* to internal institutional rules and the need for cross-department collaboration. "Different colonies have different managing authorities with different rules, regarding firearms, culling, relocating etc." (NGO) and the "need to have [Business Firearm Competency Certificate] weapon licenses to be able to cull [represents] challenges within the entity to regulate and train rangers to cull" (MA), which is an "issue from change-over of staff, [when] people that used to shoot the gulls [leave]" (SCI). In addition, some colonies are "scrutinized by the public, tourists, NGO, conservation authorities" (MA, NGO). As such, it is "difficult to shoot seals in front of the public, even if the animal was killing penguins" (NGO). Several participants concorded in saying that little was achievable: "nothing can be done to stop predation by mole snakes (…) [and] the erratic nature [of seal predation] makes it difficult to manage" (SCI); "[regarding] land mammal predation, once they know there is food, they will come back, they won't be able to be kept away" (NGO). It was also deemed "almost impossible to measure the impacts of our actions" (GVT), echoed by an NGO "it's very difficult to do research on predation". Nevertheless, most stakeholders regretted the lack of finalized Guidelines for Predator Management by DFFE (N = 6 voiced it, two were not sure if they were in place), as "[we] need a uniform approach across all colonies, [actual] Standard Operating Procedures", and "predation management needs to be consistent" (N = 4 used the word "consistent" or "consistency"). DFFE has however advised that work on the finalisation of the guidelines is ongoing and the Department is confident that draft guidelines are near finalisation.

3.5. Catastrophic events

3.5.1. Oil spills

Following large oil spills in the 20th century along the South African coast, the African penguin is considered to have suffered more from oiling than any other seabird species globally (Wolfaardt et al. 2009). Risks of oiling remain one of the highest threats to this species (Nel et al. 2003, Sherley et al. 2020a, Vanstreels et al. 2023). Thus, the prevention of oil spills and preparedness for appropriate responses to spills for penguins were major objectives of the BMP, with a suite of 13 detailed actions provided to achieve this objective. Local Oil Spill Contingency Plans were revised from 2015 by DFFE and the South African Maritime Authority (SAMSA) and three colony oil spill contingency plans were developed through the Benguela Current Convention, for Dassen, Robben and Boulders Beach/Simon's Town. Plans for the other colonies have not been completed to date due to various circumstances. Nevertheless, a National Oil Spill Contingency Plan was published by the DoT in 2021, and a National Oiled Wildlife Preparedness, Response and Contingency Plan has been drafted by DFFE who has workshopped the draft plan with conservation stakeholders and partners in 2024. In parallel, offshore ship-to-ship bunkering, the refuelling at sea of one ship by another, was initiated in 2016 in Algoa Bay in close vicinity of St Croix Island, authorised by the DoT with limited engagement with other departments or institutions. It was rapidly followed by the collapse of the St Croix colony, which was then the world largest African penguin colony, largely contributing to the uplisting of the species to Critically Endangered by the IUCN (Sherley et al. 2024). This collapse coincided with a significant increase in vessel-derived underwater noise associated with bunkering (Pichegru et al. 2022). Algoa Bay experienced a ten-fold increase in the number of bulk carriers and of vessel activity in shipping lanes and anchorage areas, temporally linked with the initiation and expansion of STS bunkering activities. Estimated underwater noise

levels doubled, making Algoa Bay one of the noisiest bays in the world (Pichegru et al. 2022). Noise pollution was not identified as a significant threat to African penguins in the first BMP, which recommended to "develop protocols to mitigate impacts of pollutants on the African penguins", including "hazardous and noxious substances, marine litter, physical, air, noise and thermal pollution (other than oil)" (Section 5 Catastrophic events, Objective 5.3). Noise pollution has since been identified as an emerging threat to be minimised and included in the draft of the second BMP.

Four oil spills occurred between 2016 and 2022 from bunkering operations, affecting 279 individual seabirds, 92 % of which being African penguins (SANCCOB, 2015). These oil spills triggered the formation of stakeholder working groups facilitated by SAMSA in 2018 involving participation by several environmental organisations (e.g., SANParks, SANCCOB, BirdLife South Africa, the Wildlife and Environment Society for South Africa). These WGs were to discuss *inter alia* bunkering codes of practice, processes behind licensing of operators, a moratorium on new licenses, and the socio-economic benefits of bunkering versus the environmental risks the activity represents (see Ryan et al., 2019). The issues around bunkering were discussed between DFFE, SAMSA, DoT and at MinTECH's Working Group 7 (MinTECH is the cooperative governance body established under the auspices of the Intergovernmental Relations Framework Act, 2005 that consists of the heads of provincial departments responsible for environmental affairs and the Director General of DFFE). They were reported at BMP WGs by some stakeholders involved, but in essence most members of the African Penguin BMP WGs had limited direct involvement on the issue.

Several participants felt despondent in the face of the bunkering issue, that while "some actions were achieved, [they] did not make a change in the bigger objective [as they] did not prevent four oil spills in Algoa Bay" (MA), an opinion shared by another: "a lot has been done, not sure if it makes a difference" (NGO). But the majority of participants that commented on that objective (11 out of 19) expressed their concern about "colony-specific oiled wildlife contingency plans [that] are still not available", a process which is "taking too long" (N = 5), although some criticized the limited contribution of MAs on the documents (N = 2). Additional training was called for by several participants, e.g., "Training of stakeholders does not represent real scenarios (i.e., strong winds, etc.). Practice needs to be fine-tuned, across SAMSA, DFFE" (MA). Particularly as "some regions are more prepared than others", with two people highlighting the experience gained in the Eastern Cape from the four bunkering-related oil spills.

3.5.2. Disease outbreak

The BMP also aimed to control disease outbreaks, by conducting a risk assessment for seabird colonies and developing guidelines for African penguin disease surveillance and diagnosis, as well as colony contingency plans. These were led by SANCCOB, and the Risk Assessment was finalized in December 2016 (Parsons et al. 2016), while the Disease Surveillance Guidelines were published in 2017. In the context of that work, Parsons and colleagues achieved significant advances in the science of disease in South African seabirds (Parsons et al. 2015a,b, 2016, Botes et al. 2017, Vanstreels et al. 2018, Hurtado et al. 2020, Snyman et al. 2020). A South African Seabird Disease Outbreak Contingency Plan is currently being drafted and the colony-specific Disease Contingency Plans are still to be finalized. However, when an avian influenza (AI) outbreak started towards the end of 2017, affecting African penguins in 2018, and again in 2021, the existing structure of the WGs and of guidelines enabled prompt and adequate communication across all organisations involved. All (100 % of the people that commented on that objective) had positive words, from "been done very well", or "that area has been really good" to "one of the few objectives where a lot was done" (N = 19). Parsons' Guidelines were deemed "good and very clear" (1 MA), and the existing "protocol [not specific to AI] to wash shoes, equipment, limit research etc., (…) was immediately put in place. Letters went out to everyone, (…) [there was an] effective collaboration" (2 MAs) during the 2018 AI outbreak. "MAs worked well together and shared their experience together (…), a very good example of how things worked well" (NGO). MAs and DFFE then drafted AI specific protocols, with expertise from the Western Cape Department of Agriculture and coordination through the Western Cape Disaster Management. Since, "regular engagements are happening and [are] positive" (GVT). But a significant concern over the high risk and potentially devastating consequence of a disease outbreak was voiced by several, highlighting the importance of training (N = 3). The "disease risk is very significant, and since 2018 the risk has increased, so surveillance is absolutely important, (…) training is fundamental for the MA to recognize symptoms and protocols to carry carcasses as they are biohazards, [but there is an] issue of funding, as each MA must have budget available for disease surveillance" (NGO), a concern shared by MA: "we need monitors that know what to look for. There is a real issue of capacity, there are not enough monitors, not enough funding to cover them". In the end, several observed that "not much can be done to prevent an outbreak", "we can only react as quickly as possible and limit the spread" (N = 3), hence the importance of adequate training.

3.5.3. Extreme weather events

Catastrophic events such as heat waves, storms or flooding are likely to increase in intensity and frequency in future due to human-induced climate change (Otto 2020), and African penguins are increasingly vulnerable to these (Russo et al. 2024). The BMP only vaguely stated that "provision [was] to be made to mitigate effects of extreme weather", but concrete actions took place on the ground, partly due to the rapidly increasing need and awareness of the risks of extreme weather events. For example, from 2017 onward, proactive removal of nests at risk of flooding or during storms was implemented by many management authorities. The presence of SANCCOB monitors from the mid to late 2010 s at several colonies increased capacity to respond to extreme weather events, either in a proactive or reactive manner. All participants (100 %) mentioned various interventions that are taking place in colonies to minimize the potential impacts of extreme weather events, heat waves or storms. These include warnings of extreme weather events being sent on WhatsApp groups, with rehabilitation centres on stand-by; brush packing of vegetation on top of existing nests (MA); digging of trenches for drainage (N = 2); or installation of sandbags (N = 2). Some rangers remove chicks in areas with high risks of flooding and put them back after the storm. No data is formally collected when monitoring the survival of these nests after the chicks have been put back, but no nest abandonments have been noticed by the rangers. In some places, "penguins are discouraged to breed in areas prone to flooding, by fencing off the area" (SCI). "Guidelines for extreme events were drafted, colony specific, with types of interventions, etc. (…). Having regular BMP meetings including colony managers helped, to check weather warnings for example" (GVT). It was mentioned that "having more rangers on the colonies helped rescuing chicks, sheltering them momentarily and putting them back after" (NGO). "Impact of extreme weather (flooding, and heat) seems [to be] getting worse, with more and more birds, especially chicks, being admitted at SANCCOB. Maybe it is because we remove more chicks and eggs now, as we are much better at incubating eggs" (NGO). But several participants agreed that "preventing catastrophic events is difficult, mostly we can help after the damage is done", "rangers try the best they can, (…) get weather warnings, but very little can be done [at some colonies] (…), apart from asking rehab centres to be on stand-by" (2 MAs).

3.6. Research

The BMP identified the need for an overall research strategy to inform conservation management of the African penguin, including standardised data collection and curation (Table S1). To this end, the Seabird Task Team was created in 2016 and provided scientific input on various research projects and/or management issues around African

penguins and other seabirds.

Substantial research took place on African penguins during the timeframe of the BMP, with 137 peer-reviewed papers published between 2013 and 2023, and 26 post-graduate theses completed. A research plan was drawn up by SANBI around the genetics of African penguins, particularly in captivity, and research was conducted following this plan (Dalton et al. 2016, Labuschagne et al., 2012, Labuschagne et al., 2013, Labuschagne et al., 2014, Labuschagne et al., 2015, Labuschagne et al., 2016), although not discussed in depth at the working groups. The need for a gap analysis to identify research projects to be prioritised was mentioned several times, but the analysis has not yet commenced. Nevertheless, many academics conducted research following the needs identified in Appendix 2 of the BMP (e.g., on artificial nests or on the ICE). Permits issued by government and managing authorities also streamlined the research by becoming more restricted towards projects of relevance to the species conservation with minimally invasive methods, and by encouraging collaboration across institutions to minimise sample size of birds handled and disturbance at the colonies. A SOP is currently being drafted with strong engagement from the group to be as complete and thorough as possible to accommodate the requirements of MA and academics, as well as minimising disturbance in colonies. Currently a draft research and science plan is being finalised, and research and monitoring recommendations for island closures currently in place also cover many of the actions highlighted in the BMP (Punt et al. 2023).

The necessity of a government-owned database was first mentioned in 2017 and several options were considered, but the systems opted, such as the Marine Information Management System (MIMS) or OCIMS, are not currently used in the context of the BMP, due *inter alia*, to the complexity of the various data collected with different storage requirements and the lack of capacity from government to manage the database. Rehabilitation centres have, however, adopted the WRMD – Wildlife Rehabilitation Management Database solely for reporting rehabilitation statistics to government, **and** a mark-recapture database is in place and being used for, for example, long-term survival analyses (see Leith et al. 2022).

A participant mentioned that "African penguin is the most researched [penguin species] in the world". But interviewees' opinions contrasted sharply on this objective, with some feeling that it was "fully achieved" (N = 8 from all institutions) or "partially achieved" (N = 3 MA), while others felt that it was "not done at all" (N = 1 GVT), with "no standardized data collection implemented, no data available" (N = 2, NGO, MA). The document on "Monitoring and Standardisation of data" was recognised as a work in progress by several (N = 5), but they also censured its delay (MA).

Importantly, the issue around data availability for management purposes was a source of tension for many (N = 7). Some mentioned the issue of "data being collected by [some] but belonging to [others]" (MA) or "data being protected by data collectors and not available to [others]" (NGO). But the main issue was the "delays between data collection and results, as [scientific] publications take a lot of time to be out", whereas if "data [were] stored [where we can] get access to it (…) we can start implementing what is needed for practical management" (MA). Thus, "better curation of the data would improve feed-back to management" (SCI) and "would have helped taking managing authorities to task, to explain why some data were not collected" (NGO).

Finally, it was suggested that better coordination would have helped "pulling our resources together, [as] the lack of government subsidization, even though the research is with government's mandate, [was] draining NGO budgets that could have been used for salaries. [There is a need for] more concerted research programmes across government and non-government" (NGO). One participant confirmed that the "lack of funding" prevented this objective from being fully achieved, even though "government is doing everything it can to support the implementation of the BMP. [Among other,] government has WGs that define research priorities and support stakeholders in exploiting these priorities to obtain funds for certain actions" (GVT).

3.7. Education

A communication, awareness and education strategy was to be developed by the BMP WG to facilitate collaboration and information sharing to improve the understanding by stakeholder groups and the broader public of African penguin conservation. While the BMP WG decided in 2015 there was no need to create a WG dedicated to developing this strategy, education material was shared among members. There have been several awareness campaigns, the 'Penguin Promises Campaign', aiming to change behaviour and using the African penguin as an icon; the 'Penguin Waddle', an awareness campaign on the plight of the African penguin; and the various Penguin Days that organisations around the country are participating in. Research showed that there was a behaviour change with respect to what people are doing after they made their Penguin Promise (Mann et al. 2018). In 2022, the #NotOnOurWatch (#NOOW) campaign was launched, with large stakeholder involvement hosted by the Two Ocean Aquarium.

This objective also had contrasting perceptions from the participants, with two people mentioning that "it never materialised", "nobody is driving this action" to N = 6 saying that "the message is out there", "it is good", "lots happened", "communication strategy happened and had been really good", "we developed the WG, the strategy and we got the (…) campaign", "[there is] regular media cover". Five participants were not aware of this section of the BMP or of communication campaigns, regardless of the length of their involvement in the BMP (< 5 years to > 10 years).

Two participants felt that a governmental WG was in fact not needed, "it was the right call (…) it would have been hard for government (…) without resources"; "it takes too long (…). Usually when there is a need, things just happen mostly driven by NGOs". Five people mentioned that campaigns were led by many organisations simultaneously although some regretted the lack of coordination. Along these lines, some thought that "more could be done", but also that "we missed the bus with the fishermen, they were not aware that penguins are endangered". One person insisted, though, that "channelling the public action is important, as lobbying gets attention of politicians. (…) we need public support behind Marine Protected Areas and fishing closures for penguins" (NGO).

4. Conclusions

4.1. The successes of the BMP

Overall, all participants recognised the value of the BMP, all using positive words at some point in the interview, either towards the BMP as a whole or about specific objectives or actions that they viewed had a positive impact. First, it was felt by many participants that the BMP brought the various stakeholders and organisations together as "we were fractured before" (MA). "The BMP opened a lot to work together, a lot of knowledge got shared. We learnt a lot of lessons. Processes have improved and have been refined. Now we need to utilise that knowledge to help the species to recover" (GVT). "The (…) BMP brought everyone together, CapeNature, SANParks, City of Cape Town, DFFE, with some type of standardisation across colonies" (MA), "it helped communication between government, MA and NGOs" (NGO), and "people are working much better since 2010, moving forward together" (NGO).

The BMP brought recognition among stakeholders of a common goal. "We all want to save penguins" (GVT), "we are a group of stakeholders with diverse interests who are hopeful something can be done" (NGO). Some participants also acknowledged that "[several organisations] are dedicated and working hard" (GVT), "lots of effort was put by many people, (…) lots of good will and passion (and emotion)" (NGO). One person commented that the AP BMP "was one of the best working BMPs [they have] been working in. One of the few BMPs with good

stakeholder engagement" (GVT). Notably, that person highlighted that "usually other BMPs are driven by one person or organisation; thus, if that person leaves, the whole BMP would fall apart. In the AP BMP, many people are involved". This level of stakeholder engagement was therefore key in ensuring the continuity of the BMP, a significant practical lesson for the development and achievement of a sustained implementation of a BMP, and conservation actions in general.

Improved communication and collaboration across stakeholders involved in the WGs contributed towards science-based conservation. As a result, many of the BMP actions were achieved, and some large-scale conservation measures were set in place across most colonies over the past decade with significant positive outcomes on the species, as perceived by the participants interviewed (Table 6). New designs of artificial nests were researched and deployed, and the monitoring of their success in the field was largely collaborative, involving MA, NGOs and academics (Pichegru et al. 2024). The best designs were colony-specific, but overall, artificial nests successfully increased African penguins' breeding productivity by 16.5 % across the majority of colonies (Pichegru et al. 2024). The rehabilitation of adult and juvenile penguins, from emaciation, injuries or oiling, and the bolstering of eggs and chicks at several colonies boosted the current breeding population by ca 4.5 %, at least 2 % but up to 12 % (Table 3). It significantly slowed down the current species' rate of decline (Sherley et al. 2024). Such large-scale actions required cohesion across managing authorities and rehabilitation centres, facilitated by the collaborative drafting of guidelines, such as "Conservation Translocation guidelines", or the "Chick rescuing guidelines" among others (Table S3). Similarly, the management of predation and removal of problematic predators (Tables 4 and 5) required implementation across managing authorities, and improved breeding success of African penguins (Pichegru 2013). Although data were not available, the culling of seals around Dyer Island and Stony Point probably increased adult survival locally (Table 5). Breeding habitat was also improved by brush packing, revegetating some colonies or increasing the drainage of some areas to avoid flooding, which improved brood survival even if the impact of these actions could not be monitored. Finally, various awareness campaigns contributed to limit disturbance in colonies and likely reduced road kills.

4.2. Hindrances

Communication remains an area that can always be enhanced, as seen from comments from most participants. At times some WG members may have taken decisions or collected data without the input from the WGs, or did not communicate timely progress, which created misunderstandings and weariness within the groups. Regular written reports on all activities pertaining to African penguin conservation, from management on the ground to scientific research or legal challenges, would clarify the role and responsibility of all parties involved. They would also ensure accountability on the deliverables of the BMP. Importantly, such reports should be stored on a relevant platform accessible to all role players involved, under relevant confidentiality agreements, to allow for transparency and improve conservation benefits (Graham et al. 2021). Their availability would allow all stakeholders to be informed of the relevant legislation, Standard of Practise or biology of the species managed. In addition, a lack of understanding was apparent from stakeholders from various institutions of how state-owned entities work together in relation to environmental management and processes. Further communication within the WGs regarding how issues are discussed between and within government departments and institutions may iron out misunderstandings and possibly facilitate support from NGOs and academics.

The plan did not "halt the current decline in the population" and reasons for the current continued decline are multiple and cumulative, including catastrophic events such as oil spills and disease outbreaks that took place during the time span of the plan. But the main hindrance identified by several participants across all institutions was the division between Fisheries Management and Ocean & Coast branches during most of the BMP (2010——2019), which had different mandates: "the government structure failed the BMP" (GVT). This division made "dealing with fisheries a challenge" (MA) and allowed that "no one took responsibility for what was reported" (NGO) and that "there was no accountability" (MA). It was suggested (from MA) that the lack of engagement with the stakeholders of the AP BMP and the Small Pelagic Scientific WG led by Fisheries Management resulted in "polarisation and confusion between DFFE mandates" (i.e., Total Allowable Catch quotas and island closures). Some said that "the BMP group should be [involved], we would be more effective if we were working as a group" (NGO). In the end, the BMP failed to ensure adequate prey for penguins near their breeding sites and during non-breeding periods of their life cycle, and, as a participant said, "if prey abundance is not adequate, it makes all other actions [of the BMP] null and void" (MA). Someone suggested that an "Ecosystem Approach to Fisheries Working Group [should] be revived within the Department, [to improve] governance of the management of the small pelagic fish stocks (…) and consider spatial management of the fishery" (SCI).

It was also perceived that engagement with other Departments, such as the DoT or Department of Energy, may have been insufficient on issues like "ship-to-ship bunkering, seismic explorations, or Karpowership" (SCI), including "strengthening legislation around oil spills" (NGO). Strong leadership within the BMP WG would have been necessary to ensure essential cross-departmental discussions to take place to maximise conservation benefits. It was suggested that "a DFFE person with scientific background should [act as] a bridge between science and management (…) and sits [on various relevant] WGs" (MA), to facilitate reporting and engagement. Such strong leadership would also ensure focused discussions during meetings, avoiding lengthened debates leading to contradictory conclusions at times. Similarly, accountability needed to be requested on matters arising between meetings, such as contribution from the relevant stakeholders on various guidelines and management documents to allow their final publication.

4.3. Future actions

In the end, actions perceived as successful by the participants, i.e., rehabilitation, predator management and artificial nests (Table 6), are actions that are relatively well monitored, where data are recorded and (to some extent) results have been published showing their positive impacts. There is, thus, large support for conservation actions that are evidence-based. Similarly, fisheries closures, effects of oil spills and underwater noise are also relatively well studied and papers on their impacts have been published, hence interventions against these threats were highlighted as needed by the participants (Table 6). These actions, however, require the participation of sectors involved in other maritime activities and have social and political aspects beyond the control of the BMP actors, including DFFE. The BMP therefore worked well for actions that the directly involved stakeholders had control over but failed for actions that required additional political will and more far-reaching changes in management of maritime activities.

Consequently, one of the main objectives of the plan, "to ensure adequate prey abundance for penguins", failed. Increasing prey abundance within the foraging range of the birds during their life cycle with adequate fishing exclusion zones ("fishery closures", "marine protected areas", "spatial management of fishery") was identified by the majority of the participants as the most urgent conservation action to be put in place (Table 6). Current spatial management of the fishery remains inadequate (McInnes et al. 2024). Food availability is, however, the most important driver of the species population trend (Crawford et al. 1999, 2007, 2022), directly impacting adult and juvenile survival (Sherley et al., 2014b, Robinson et al. 2015), the most important demographic parameter influencing the population trajectory, but also breeding success (Sherley at al. 2013, 2020b). Importantly, this driver affects the entire population. By contrast, localised predator

management impacts few colonies. For example, gull predation only significantly impacted penguins on Bird and Dyer Island together representing ca. 12 % of the South African population in 2022. Similarly seals mostly significantly impact the Dyer Island colony (10 % of the population, Weller et al. 2016). Oil spills and disease outbreaks that affect relatively large proportions of the population are usually sporadic, allowing some capacity for recovery (Weller et al. 2014, 2016). Our model estimating the contribution of rehabilitation to the wild breeding population of African penguins further highlights that, should annual adult survival increase to 0.89, a value recorded in the 1990 s and early 2000 s (Sherley et al., 2014b), the contribution of chick bolstering and rehabilitation in general to the wild population would approximately double. The availability of small pelagic fish to seabirds has decreased particularly on the West Coast of South Africa over recent years (Crawford et al. 2022) and improving access to prey sources is the most urgent conservation measure to implement for African penguins.

In parallel, ship-to-ship bunkering activities initiated in Algoa Bay in 2016 (Ryan et al. 2019) generated four oil spills with significant ecological damage. Associated increase in underwater noise pollution due to increased maritime traffic in the bay is believed to have largely contributed to the collapse of the largest African penguin colony, St Croix Island (Pichegru et al. 2022), a collapse which played a significant part in the consideration for uplisting the species to Critically Endangered on the IUCN Red List (Sherley et al. 2024, IUCN 2024). Actively limiting risks of oil spills and reducing noise pollution associated to bunkering activities were also called for urgent attention by interviewees (Table 4). Some of these have been included in the revised BMP currently being finalised by DFFE.

Finally, several participants noted that the ambition of the BMP set it up to fail. “Penguins have been decreasing for a hundred years, so expecting the BMP to work within 5 years was set to fail” (GVT), “[it] was unrealistic, aiming to stop the decline in 5 years was wishful thinking” (MA). The lack of capacity and resourcing was bound to prevent its adequate implementation (Table 6). “Colony managers are inundated with responsibilities to be able to know what is happening with penguins at colony level. State entities have extreme capacity challenges, with other priorities” (GVT). Most participants from managing authorities repeatedly voiced being spread thin, with many responsibilities other than penguin conservation, including involvement in several protected areas. One person mentioned not having taken leave for six consecutive years. The deployment of SANCCOB rangers on various colonies in recent years has been essential in terms of increased capacity and short-term decision for management at colony level, the primary level of protection. Government facilitated public–private collaborations to unlock funding, but some participants still felt that a lot of the “actions boiled down to NGOs or researchers”, “draining the NGOs budget” (N = 2 NGO, 1 SCI), using their own resources, research grants or calling on external funders. Capacity and funding issues are systematically the most limiting factors in conservation globally (Martin et al. 2018). Section 24 of the Constitution of South Africa states that everyone has “the right to have the environment protected for the benefit of present and future generations”. While there have been tremendous work and effort towards African penguin conservation from stakeholders across all institutions involved, the drastic and rapid decline of the species (Sherley et al. 2024) and its recent further uplisting to Critically Endangered (IUCN 2024) calls for urgent unlocking of political will, increased capacity and funding to prevent its extinction in the wild.

5. Institutional review Board Statement

All research reported here was conducted under permits approved by the Department of Forestry, Fisheries, and the Environment, SANParks, and/or CapeNature. Methods were approved by the Ethics Review Bodies at the University of Cape Town, the University of Bristol, the University of Exeter, Nelson Mandela University and BirdLife South Africa at different times during the lifetime of the project. Ethic clearance was obtained for the interviews in 2023from Nelson Mandela University (Ethic clearance: H23-SCI-ZOO-001).

CRediT authorship contribution statement

Lorien Pichegru: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation, Conceptualization. **Millicent Makoala:** Investigation. **Barbara J. Barham:** Writing – review & editing, Investigation, Formal analysis, Data curation. **Peter J. Barham:** Writing – review & editing, Investigation, Formal analysis. **Desiré Dalton:** Writing – review & editing, Investigation. **Katta Ludynia:** Writing – review & editing, Investigation, Formal analysis, Data curation. **Mandy Freeman:** Writing – review & editing, Investigation. **Deon Geldenhuys:** Writing – review & editing, Investigation. **Christina Hagen:** Writing – review & editing, Investigation, Formal analysis. **Gabby Harris:** Writing – review & editing, Investigation. **Alison Kock:** Writing – review & editing, Investigation. **Cloverley Lawrence:** Writing – review & editing, Investigation. **Cuan McGeorge:** Writing – review & editing, Investigation. **Alistair M. McInnes:** Writing – review & editing, Investigation, Formal analysis, Data curation. **Azwianewi B. Makhado:** Writing – review & editing, Investigation. **Trudi Malan:** Writing – review & editing, Investigation. **Makhudu J. Masotla:** Investigation. **Rob Milne:** Writing – review & editing, Investigation. **Heinrich Muller:** Investigation, Writing – review & editing. **Arne Purves:** Writing – review & editing, Investigation. **Richard B. Sherley:** Writing – review & editing, Investigation, Formal analysis. **Nicky Stander:** Writing – review & editing, Investigation. **Pierre de Villiers:** Writing – review & editing, Investigation. **Johan Visagie:** Writing – review & editing, Investigation. **Chris Wilke:** Writing – review & editing, Investigation. **Lauren J. Waller:** Writing – review & editing, Project administration, Investigation, Conceptualization.

Funding

The Association of Zoos and Aquariums (through their SAFE programme), the Bristol Zoological Society, the Charl van der Merwe Trust, the Earthwatch Institute, the Isdell Family Foundation, the Leiden Conservation Foundation (through fellowship awards to R.B.S. and L.J. W.), the National Research Foundation through various grants, the Centre of Excellence at the Percy FitzPatrick Institute of African Ornithology, a Pew Fellows Program in Marine Conservation (awarded to R. B.S.) and the San Diego Zoo Wildlife Alliance are thanked for providing funding. SANCCOB receives funding from a variety of donors which are thanked. Logistical support was provided by the City of Cape Town, South African National Parks, CapeNature and the Robben Island Museum.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Many contributed towards the drafting and implementation of the Biodiversity Management Plan, without whom effort this work would not have been possible. A special thanks to the staff and rangers of the managing authorities and NGOs, as well as all the students and volunteers, involved in the field and in rehabilitation centres. **We warmly thank three anonymous reviewers to have substantially improved a previous version of the manuscript.**

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jnc.2025.126919.

Data availability

Data will be made available on request.

This article is based on interviews that required non-disclosure of the participants' identities; all other data used are included in Tables in the article.

References

Barham, P. J., Underhill, L. G., Crawford, R. J. M., Altwegg, R., Leshoro, T. M., Bolton, D. A., Dyer, B. M., & 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. https://doi.org/10.1017/s0959270908000142

Botes, A., Parsons, N. J., & Bellstedt, D. U. (2017). Conservation implications of avian malaria exposure for African penguins during rehabilitation. #2016-0244 *South African Journal of Science, 113*. https://doi.org/10.17159/sajs.2017/20160244.

Bowlby, H. D., Dicken, M. L., Towner, A. V., Waries, S., Rogers, T., & Kock, A. (2023). Decline or shifting distribution? A first regional trend assessment for white sharks (Carcharodon carcharias) in South Africa. *Ecological Indicators, 154*, Article doi: 10.1016/j.ecolind.2023.110720.

Butterworth, D. S., & Ross-Gillespie, A. (2022). Comment on "south africa's experimental fisheries closures and recovery of the endangered african penguin" by Sydeman et al. (2021). *Ices Journal of Marine Science, 79*, 1965–1971. https://doi.org/10.1093/icesjms/fsac113

Campbell, K. J., Steinfurth, A., Underhill, L. G., Coetzee, J. C., Dyer, B. M., Ludynia, K., Makhado, A. B., Merkle, D., Rademan, J., Upfold, L., et al. (2019). Local forage fish abundance influences foraging effort and offspring condition in an endangered marine predator. *Journal of Applied Ecology, 56*, 1751–1760. https://doi.org/10.1111/1365-2664.13409

Carpenter-Kling, T., de Blocq, A., Hagen, C., Harding, C., Morris, T., Pichegru, L., Roberts, J., Ryan, P. G., Wanless, R. M., & McInnes, A. (2022). Important marine areas for endangered African penguins before and after the crucial stage of moulting. *Scientific Reports, 12*. https://doi.org/10.1038/s41598-022-12969-w

Coetzee, J. C., van der Lingen, C. D., Hutchings, L., & Fairweather, T. P. (2008). Has the fishery contributed to a major shift in the distribution of South African sardine? *Ices Journal of Marine Science, 65*, 1676–1688. https://doi.org/10.1093/icesjms/fsn184

Coetzee, J.C.; de Moor, C.; van der Lingen, C.D.; Butterworth, D.G. A summary of the South African Sardine (and anchovy) Fishery. Fisheries and the Environment report MARAM/IWS/**2022**/Sardine/BG1 , 19 pp. https://zivahub.uct.ac.za/articles/standard/A_summary_of_the_South_African_sardine_and_anchovy_fishery/21586812/1?file=38257809.

Crawford, R. J. M., Shannon, L. J., Whittington, P. A., & Murison, G. (1999). Population dynamics of the African Penguin *Spheniscus demersus* at Robben Island. *South Africa. Marine Ornithology, 27*, 139–147.

Crawford, R. J. M., Underhill, L. G., Upfold, L., & Dyer, B. M. (2007). An altered carrying capacity of the Benguela upwelling ecosystem for African penguins (*Spheniscus demersus*). *Ices Journal of Marine Science, 64*, 570–576. https://doi.org/10.1093/icesjms/fsm009

Crawford, R. J. M., Altwegg, R., Barham, B. J., Barham, P. J., Durant, J. M., Dyer, B. M., Geldenhuys, D., Makhado, A. B., Pichegru, L., Ryan, P. G., et al. (2011). Collapse of South Africa's penguins in the early 21st century. *African Journal of Marine Science, 33*, 139–156. https://doi.org/10.2989/1814232x.2011.572377

Crawford, R. J. M., Sydeman, W. J., Tom, D. B., Thayer, J. A., Sherley, R. B., Shannon, L. J., McInnes, A. M., Makhado, A. B., Hagen, C., Furness, R. W., Carpenter-Kling, T., & Saraux, C. (2022). Food limitation of seabirds in the Benguela ecosystem and management of their prey base. *Namibian Journal of the Environment, 6*, 1–13.

Dalton, D. L., Vermaak, E., Roelofse, M., & Kotze, A. (2016). Diversity in the Toll-Like Receptor Genes of the African Penguin (*Spheniscus demersus*). *PLoS One, 11*, Article doi:10.1371/journal.pone.0163331.

DEA. The African Penguin *Spheniscus demersus*: Conservation and Management Issues. **2013**, *Government Gazette no. 36966*.

de Moor, C. L., & Butterworth, D. S. (2015). Assessing the South African sardine resource: Two stocks rather than one? *African Journal of Marine Science, 37*, 41–51. https://doi.org/10.2989/1814232x.2015.1009166

De Ponte Machado, M. (2010). *Food supplementation, population growth and impacts of Great White Pelicans on breeding seabirds*. South Africa: University of Cape Town. PhD thesis.

DFFE. Draft African Penguin Biodiversity Management Plan. **2019**, *Government Gazette, No 1328*.

Gimeno, M., Giménez, J., Chiaradia, A., Davis, L. S., Seddon, P. J., Ropert-Coudert, Y., Reisinger, R. R., Coll, M., & Ramírez, F. (2024). Climate and human stressors on global penguin hotspots: Current assessments for future conservation. *Global Change Biology, 30*, Article doi:10.1111/gcb.17143.

Guillemette, M., & Brousseau, P. (2001). Does culling predatory gulls enhance the productivity of breeding common terns? *Journal of Applied Ecology, 38*, 1–8.

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*. UK: University of Bristol. MSc thesis.

Frost, P. G. H., Siegfried, W. R., & Burger, A. E. (1976). Behavioral adapatations of Jacass penguin, Spheniscus demersus to a hot, arid environment. *Journal of Zoology, 179*, 165–187. https://doi.org/10.1111/j.1469-7998.1976.tb02289.x

Graham, V., Geldmann, J., Adams, V. M., Grech, A., Deinet, S., & Chang, H. C. (2021). Management resourcing and government transparency are key drivers of biodiversity outcomes in Southeast Asian protected areas. *Biological Conservation, 253*. https://doi.org/10.1016/j.biocon.2020.108875

Hagen, C.W.; Wanless, R. . *International Multi-species Action Plan for the Conservation of Benguela Upwelling System Coastal Seabirds. AEWA Technical Series No. 60*; Bonn, Germany, 2015.

Hockey, P. A. R., Dean, W. R. J., & Ryan, P. G. (2005). *Roberts birds of southern africa* (7th edn). Cape Town: John Voelcker Bird Book Fund.

Hurtado, R., Parsons, N. J., Gous, T. A., van der Spuy, S., Klusener, R., Stander, N., van Wilpe, E., & Vanstreels, R. E. T. (2020). Outbreak of cryptosporidiosis in African penguins *Spheniscus demersus*. *Diseases of Aquatic Organisms, 140*, 143–149. https://doi.org/10.3354/dao03504

IUCN. **2024**. IUCN Red List of Threatened Species. https://www.iucnredlist.org/species/22697810/256021744 . Downloaded on 13 November 2024.

Knott, E., Rao, A. H., Summers, K., & Teeger, C. (2022). Interviews in the social sciences. *Nature Reviews Methods Primers, 2*. https://doi.org/10.1038/s43586-022-00150-6

Klusener, R., Hurtado, R., Parsons, N. J., Vanstreels, R. E. T., Stander, N., van der Spuy, S., & Ludynia, K. (2018). From incubation to release: Hand-rearing as a tool for the conservation of the endangered African penguin. *PLoS One, 13*. https://doi.org/10.1371/journal.pone.0205126

Labuschagne, C., Dalton, D. L., & Kotzé, A. (2012). Isolation and characterization of SNP markers for African Penguin (*Spheniscus demersus*). *Conservation Genetics Resources, 4*, 1067–1069. https://doi.org/10.1007/s12686-012-9708-4

Labuschagne, C., van Wyk, A. M., Kotzé, A., Grobler, P., & Dalton, D. L. (2013). Isolation and characterization of species-specific microsatellite loci in African penguin (*Spheniscus demersus*). *Conservation Genetics Resources, 5*, 169–171. https://doi.org/10.1007/s12686-012-9760-0

Labuschagne, C., Kotzé, A., Grobler, J. P., & Dalton, D. L. (2014). The complete sequence of the mitochondrial genome of the African Penguin (*Spheniscus demersus*). *Gene, 534*, 113–118. https://doi.org/10.1016/j.gene.2013.09.057

Labuschagne, C., Nupen, L., Kotzé, A., Grobler, P. J., & Dalton, D. L. (2015). Assessment of microsatellite and SNP markers for parentage assignment in ex situ African Penguin (*Spheniscus demersus*) populations. *Ecology and Evolution, 5*, 4389–4399. https://doi.org/10.1002/ece3.1600

Labuschagne, C., Nupen, L., Kotzé, A., Grobler, J. P., & Dalton, D. L. (2016). Genetic monitoring of *ex situ* African Penguin (*Spheniscus demersus*) populations in South Africa. *African Zoology, 51*, 83–90. https://doi.org/10.1080/15627020.2016.1186499

Leith, F. W., Grigg, J. L., Barham, B. J., Barham, P. J., Ludynia, K., McGeorge, C., Mdluli, A., Parsons, N. J., Waller, L. J., & Sherley, R. B. (2022). Intercolony variation in reproductive skipping in the African penguin. *Ecology and Evolution, 12*, e9255.

Lubbe, A., Underhill, L. G., Waller, L. J., & Veen, J. (2014). A condition index for African penguin *Spheniscus demersus* chicks. *African Journal of Marine Science, 36*, 143–154. https://doi.org/10.2989/1814232x.2014.915232

Makhado, A. B., Crawford, R. J. M., & Underhill, L. G. (2006). Impact of predation by cape fur seals *Arctocephalus pusillus pusillus* on Cape gannets *Morus capensis* at Malgas Island, Western Cape, South Africa. *African Journal of Marine Science, 28*, 681–687. https://doi.org/10.2989/18142320609504216

Makhado, A. B., Meÿer, M. A., Crawford, R. J. M., Underhill, L. G., & Wilke, C. (2009). The efficacy of culling seals seen preying on seabirds as a means of reducing seabird mortality. *African Journal of Ecology, 47*, 335–340. https://doi.org/10.1111/j.1365-2028.2008.00966.x

Makhado, A. B., Crawford, R. J. M., Waller, L. J., & Underhill, L. G. (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. https://doi.org/10.2989/00306525.2013.863234

McGrath, A. M., Hermes, J. C., Moloney, C. L., Roy, C., Cambon, G., Herbette, S., & van der Lingen, C. D. (2020). Investigating connectivity between two sardine stocks off South Africa using a high-resolution IBM: Retention and transport success of sardine eggs. *Fisheries Oceanography, 29*, 137–151. https://doi.org/10.1111/fog.12460

McInnes, A. M., Khoosal, A., Murrell, B., Merkle, D., Lacerda, M., Nyengera, R., Coetzee, J. C., Edwards, L. C., Ryan, P. G., Rademan, J., et al. (2015). Recreational fish-finders-an inexpensive alternative to scientific echo-sounders for unravelling the links between marine top predators and their prey. *PLoS One, 10*. https://doi.org/10.1371/journal.pone.0140936

McInnes, A. M. (2016). *Fine-scale drivers of African Penguin prey dynamics in Algoa Bay, South Africa, and their impacts on penguin foraging ecology*. South Africa: University of Cape Town. PhD thesis.

McInnes, A. M., McGeorge, C., Ginsberg, S., Pichegru, L., & Pistorius, P. A. (2017). Group foraging increases foraging efficiency in a piscivorous diver the African penguin. *Royal Society Open Science, 4*. https://doi.org/10.1098/rsos.170918

McInnes, A. M., Weideman, E. A., Carpenter-Kling, T., Barham, P., Christian, M., Day, K., Glencross, J. S., Hagen, C., Kock, A., Lawrence, C., et al. (2024). Commercial fishery no-take zones for African penguins minimize fisheries losses at the expense of conservation gains. *Ices Journal of Marine Science, 81*, 1632–1646. https://doi.org/10.1093/icesjms/fsae109

Mann, J. B., Ballantyne, R., & Packer, J. (2018). Penguin Promises: Encouraging aquarium visitors to take conservation action. *Environmental Education Research, 24*, 859–874. https://doi.org/10.1080/13504622.2017.1365355

Martin, T. G., Kehoe, L., Mantyka-Pringle, C., Chades, I., Wilson, S., Bloom, R. G., Davis, S. K., Fisher, R., Keith, J., Mehl, K., et al. (2018). Prioritizing recovery funding to maximize conservation of endangered species. *Conservation Letters, 11*. https://doi.org/10.1111/conl.12604

Medina, F. M., Bonnaud, E., Vidal, E., Tershy, B. R., Zavaleta, E. S., Donlan, C. J., Keitt, B. S., Le Corre, M., Horwath, S. V., & Nogales, M. (2011). A global review of the impacts of invasive cats on island endangered vertebrates. *Global Change Biology, 17*, 3503–3510. https://doi.org/10.1111/j.1365-2486.2011.02464.x

Mhlongo, N., Yemane, D., Hendricks, M., & van der Lingen, C. D. (2015). Have the spawning habitat preferences of anchovy (*Engraulis encrasicolus*) and sardine (*Sardinops sagax*) in the southern Benguela changed in recent years? *Fisheries Oceanography, 24*, 1–14. https://doi.org/10.1111/fog.12061

Morten, J. M., Parsons, N. J., Schwitzer, C., Holderied, M. W., & Sherley, R. B. (2017). Body condition as a quantitative tool to guide hand-rearing decisions in an endangered seabird. *Animal Conservation, 20*, 471–479. https://doi.org/10.1111/acv.12338

Nel, D. C., Crawford, R. J. M., & Parsons, N. J. (2003). The conservation status and impact of oiling on the African penguin. In D. C. Nel, & P. A. Whittington (Eds.), *Rehabilitation of oiled African penguins: a conservation success story* (pp. 1–7). Cape Town, South Africa: BirdLife South Africa and the Avian Demography Unit.

Otto, F. (2020). *Angry weather: Heat waves, floods, storms, and the new science of climate change*. Canada: Greystone Books Ltd.

Parsons, N. J., Gous, T. A., van Wilpe, E., Strauss, V., & Vanstreels, R. E. T. (2015). Herpesvirus-like respiratory infection in African penguins *Spheniscus demersus* admitted to a rehabilitation centre. *Diseases of Aquatic Organisms, 116*, 149–155. https://doi.org/10.3354/dao02907

Parsons, N. J., Schaefer, A. M., van der Spuy, S. D., & Gous, T. A. (2015). Establishment of baseline haematology and biochemistry parameters in wild adult African penguins (*Spheniscus demersus*). *Journal of the South African Veterinary Association, 86*, Article doi:10.4102/jsava.v86i1.1198.

Parsons, N. J., Gous, T. A., Schaefer, A. M., & Vanstreels, R. E. T. (2016). Health evaluation of African penguins (*Spheniscus demersus*) in southern Africa. *Onderstepoort Journal of Veterinary Research, 83*. https://doi.org/10.4102/ojvr.v83i1.1147

Parsons, N.J.; Vanstreels, R.E.T.V. Southern African Seabird Colony Disease Risk Assessment – December **2016**. Southern African Foundation for the Conservation of Coastal Birds, Cape Town, South Africa.

Pichegru, L., Ryan, P. G., Le Bohec, C., van der Lingen, C. D., Navarro, R., Petersen, S., Lewis, S., van der Westhuizen, J., & Grémillet, D. (2009). Overlap between vulnerable top predators and fisheries in the Benguela upwelling system: Implications for marine protected areas. *Marine Ecology Progress Series, 391*, 199–208. https://doi.org/10.3354/meps08283

Pichegru, L., Grémillet, D., Crawford, R. J. M., & Ryan, P. G. (2010). Marine no-take zone rapidly benefits endangered penguin. *Biology Letters, 6*, 498–501. https://doi.org/10.1098/rsbl.2009.0913

Pichegru, L., Ryan, P. G., van Eeden, R., Reid, T., Grémillet, D., & Wanless, R. (2012). Industrial fishing, no-take zones and endangered penguins. *Biological Conservation, 156*, 117–125. https://doi.org/10.1016/j.biocon.2011.12.013

Pichegru, L. (2013). Increasing breeding success of an Endangered penguin: Artificial nests or culling predatory gulls? *Bird Conservation International, 23*, 296–308. https://doi.org/10.1017/s0959270912000135

Pichegru, L., Vibert, L., Thiebault, A., Charrier, I., Stander, N., Ludynia, K., Lewis, M., Carpenter-Kling, T., & McInnes, A. (2022). Maritime traffic trends around the southern tip of Africa - Did marine noise pollution contribute to the local penguins' collapse? *Science of the Total Environment, 849*. https://doi.org/10.1016/j.scitotenv.2022.157878

Pichegru, L., Sherley, R. B., Malan, T., Barham, B. J., Ludynia, K., Geldenhuys, D., Amos, K., Barham, P. J., Drost, E., Hahndiek, V., Hufke, A., Hugo, C., Lawrence, C., McGeorge, C., McInnes, A. M., Makhado, A. B., Mashau, M., Milne, R., Purves, A., Slier, M., van der Merwe, C., van Wilgen, N. J., & Waller, L. J. (2024). Decades of artificial nests for African Penguins – have we made a difference? *Ecological Evidences and Solutions, 5*. https://doi.org/10.1002/2688-8319.12388

Punt, A.; Furness, R.; Parma, A.; Plaganyi-Lloyd, E.; Sanchirico, J.; Trathan, P. Report of the international review panel regarding fishing closures adjacent to South Africa's African penguin breeding colonies and declines in the penguin population. Prepared for the Department of Forestry, Fisheries and the Environment 2023. https://www.dffe.gov.za/sites/default/files/Reports/penguinbreeding_coloniesreport.pdf.

Reusch, K., Connan, M., Ryan, P. G., Butler, M., & Pichegru, L. (2024). Spatio-temporal differences in the diet and trophic ecology of Kelp Gulls (*Larus dominicanus*) in South Africa. *Ibis*. https://doi.org/10.1111/ibi.13344

Rhoda, L. K. (2022). *The threat of terrestrial predators to mainland penguin colonies: Searching for sustainable solutions*. South Africa: University of Cape Town. MSc thesis.

Robinson, W. M. L., Butterworth, D. S., & Plagányi, E. E. (2015). Quantifying the projected impact of the South African sardine fishery on the Robben Island penguin colony. *Ices Journal of Marine Science, 72*, 1822–1833. https://doi.org/10.1093/icesjms/fsv035

Ropert-Coudert, Y., Chiaradia, A., Ainley, D., Barbosa, A., Boersma, P. D., Brasso, R., Dewar, M., Ellenberg, U., Garcia-Borboroglu, P., Emmerson, L., et al. (2019). Happy feet in a hostile world? the future of penguins depends on proactive management of current and expected threats. *Frontiers in Marine Science, 6*, 248. https://doi.org/10.3389/fmars.2019.00248

Roux, J. P., van der Lingen, C. D., Gibbons, M. J., Moroff, N. E., Shannon, L. J., Smith, A. D. M., & Cury, P. M. (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. https://doi.org/10.5343/bms.2011.1145

Russo, C.S.; Kuczyk, A.; Soares, B.; Lamont, T.; Ludynia, K.; van Wilgen, N.; Kock, A.; Daniels, T.; Ramjukadh, C.; Turner, K.; Morris, T. Extreme rainfall events orphan African penguin chicks *Oceans and Coasts Annual Science Report* **2024**.

Ryan, P.G.; Ludynia; K.; Pichegru, L. Ships' risky fuel transfers are threatening African Penguins (2019). The Conversation. Available online: https://theconversation.com/ships-risky-fuel-transfers-are-threatening-african-penguins-121575 (accessed on 25 August 2024).

SANCCOB. *Summary of oil spills in Algoa Bay since 2015*; Unpublished report. 1 page. 2022.

Sanz-Aguilar, A., Martínez-Abraín, A., Tavecchia, G., Mínguez, E., & Oro, D. (2009). Evidence-based culling of a facultative predator: Efficacy and efficiency components. *Biological Conservation, 142*, 424–431. https://doi.org/10.1016/j.biocon.2008.11.004

Schwitzer, C., Simpson, N., Roestorf, M., & Sherley, R. B. (2013). The African Penguin Chick Bolstering Project: A one plan approach to integrated species conservation. *WAZA Magazine, 14*, 23–26.

Seddon, P. J., & van Heezik, Y. M. (1991). Effects of hatching order, sibling asymmetries, and nest site on survival analysis of jackass penguin chicks. *Auk, 108*, 548–555. https://doi.org/10.2307/4088094

Sherley, R. B., Barham, B. J., Barham, P. J., Leshoro, T. M., & Underhill, L. G. (2012). Artificial nests enhance the breeding productivity of African Penguins (*Spheniscus demersus*) on Robben Island. *South Africa. Emu, 112*, 97–106. https://doi.org/10.1071/mu11055

Sherley, R. B., Underhill, L. G., Barham, B. J., Barham, P. J., Coetzee, J. C., Crawford, R. J. M., Dyer, B. M., Leshoro, T. M., & 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. https://doi.org/10.3354/meps10070

Sherley, R. B., Abadi, F., Ludynia, K., Barham, B. J., Clark, A. E., & Altwegg, R. (2014). Age-specific survival and movement among major African Penguin *Spheniscus demersus* colonies. *Ibis, 156*, 716–728. https://doi.org/10.1111/ibi.12189

Sherley, R. B., Waller, L. J., Strauss, V., Geldenhuys, D., Underhill, L. G., & Parsons, N. J. (2014). Hand-rearing, release and survival of african penguin chicks abandoned before independence by moulting parents. *PLoS One, 9*, Article e110794. https://doi.org/10.1371/journal.pone.0110794

Sherley, R. B., Winker, H., Altwegg, R., van der Lingen, C. D., Votier, S. C., & Crawford, R. J. M. (2015). Bottom-up effects of a no-take zone on endangered penguin demographics. *Biology Letters, 11*. https://doi.org/10.1098/rsbl.2015.0237

Sherley, R. B., Barham, B. J., Barham, P. J., Campbell, K. J., Crawford, R. J. M., Grigg, J., Horswill, C., McInnes, A., Morris, T. L., Pichegru, L., et al. (2018). Bayesian inference reveals positive but subtle effects of experimental fishery closures on marine predator demographics. *Proceedings of the Royal Society B-Biological Sciences, 285*, Article 20172443. https://doi.org/10.1098/rspb.2017.2443

Sherley, R. B., Crawford, R. J. M., de Blocq, A. D., Dyer, B. M., Geldenhuys, D., Hagen, C., Kemper, J., Makhado, A. B., Pichegru, L., Tom, D., Upfold, L., Visagie, J., Waller, L. J., & Winker, H. (2020). The conservation status and population decline of the African penguin deconstructed in space and time. *Ecology and Evolution, 10*, 8506–8516. https://doi.org/10.1002/ece3.6554

Sherley, R.B.; Hagen, C.; Ludynia, K.; McInnes, A.M.; Shannon, L.; Stassen, M.; Waller, L. J. Some observations on the relative impacts of different drives on change in the African penguin population growth rate. FISHERIES/2020/SEP/SWG-PEL/92. **2020b.** https://drive.google.com/file/d/12HVlw1moEYbUPNNvRCDkhlr_YwgXGpYU/view.

Sherley, R. B., Makhado, A. B., Crawford, R. J. M., Hagen, C., Kemper, J., Ludynia, K., Masotla, M., McInnes, A. M., Pichegru, L., Tom, D., Upfold, L., & Waller, L. J. (2024). The african penguin should be considered critically endangered. *Ostrich, 95*, 181–187. https://doi.org/10.2989/00306525.2024.2355618

Small, M. L. (2009). 'How many cases do I need?' On science and the logic of case selection in field-based research. *Ethnography, 10*, 5–38. https://doi.org/10.1177/1466138108099586

Snyman, A., Vanstreels, R. E. T., Nell, C., Schaefer, A. M., Stracke, T., Parsons, N. J., Ludynia, K., & Pistorius, P. A. (2020). Determinants of external and blood parasite load in African penguins (*Spheniscus demersus*) admitted for rehabilitation. *Parasitology, 147*, 577–583. https://doi.org/10.1017/s0031182020000141

Steele, W. K., & Hockey, P. A. R. (1990). Population size, distribution and dispersal of kelp gulls in the Southwestern Cape. *South Africa. Ostrich, 61*, 97–106. https://doi.org/10.1080/00306525.1990.9634153

Sydeman, W. J., Hunt, G. L., Pikitch, E. K., Parrish, J. K., Piatt, J. F., Boersma, P. D., Kaufman, L., Anderson, D. W., Thompson, S. A., & Sherley, R. B. (2021). South Africa's experimental fisheries closures and recovery of the endangered African penguin. *Ices Journal of Marine Science, 78*, 3538–3543. https://doi.org/10.1093/icesjms/fsab231

Sydeman, W. J., Hunt, G. L., Pikitch, E. K., Parrish, J. K., Piatt, J. F., Boersma, P. D., Kaufman, L., Anderson, D. W., Thompson, S. A., & Sherley, R. B. (2022). African penguins and localized fisheries management: response to butterworth and ross-gillespie. *Ices Journal of Marine Science, 79*, 1972–1978. https://doi.org/10.1093/icesjms/fsac116

Underhill, L. G., Crawford, R. J. M., Wolfaardt, A. C., Whittington, P. A., Dyer, B. M., Leshoro, T. M., 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. https://doi.org/10.2989/18142320609504218

Vanstreels, R. E. T., Parsons, N. J., Pistorius, P. A., & Schaefer, A. M. (2018). Prognostic indicators of rehabilitation outcomes for immature African penguins (*Spheniscus demersus*). *Journal of Wildlife Diseases, 55*, 758–769.

Vanstreels, R. E. T., Parsons, N. J., McGeorge, C., Hurtado, R., Ludynia, K., Waller, L., Ruthenberg, M., Purves, A., Pichegru, L., & Pistorius, P. A. (2019). Identification of land predators of African Penguins *Spheniscus demersus* through post-mortem examination. *Ostrich, 90*, 359–372. https://doi.org/10.2989/00306525.2019.1697971

Vanstreels, R. E. T., Parsons, N. J., Sherley, R. B., Stander, N., Strauss, V., Kemper, J., Waller, L., Barham, B. J., & Ludynia, K. (2023). Factors determining the number of seabirds impacted by oil spills and the success of their rehabilitation: Lessons learned from Namibia and South Africa. *Marine Pollution Bulletin, 188*, Article 114708. https://doi.org/10.1016/j.marpolbul.2023.114708

Waller, L. J. (2011). *The african penguin spheniscus demersus: conservation and management issues*. South Africa: University of Cape Town. PhD thesis.

Weller, F., Cecchini, L. A., Shannon, L., Sherley, R. B., Crawford, R. J. M., 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. https://doi.org/10.1016/j.ecolmodel.2014.01.013

Weller, F., Sherley, R. B., Waller, L. J., Ludynia, K., Geldenhuys, D., Shannon, L. J., & Jarre, A. (2016). System dynamics modelling of the Endangered African penguin populations on Dyer and Robben islands. *South Africa. Ecological Modelling, 327*, 44–56. https://doi.org/10.1016/j.ecolmodel.2016.01.011

Welman, S., & Pichegru, L. (2022). Nest micro-climate and heat stress in African penguins breeding on Bird Island, South Africa. *Bird Conservation International, e34*, 1–9. https://doi.org/10.1017/S0959270922000351

Whittington, P. A., Crawford, R. J. M., Martin, A. P., Randall, R. M., Brown, M., Ryan, P. G., Dyer, B. M., Harrison, K. H. B., Huisamen, J., Makhado, A. B., Upfold, L., Waller, L. J., & Witteveen, M. (2016). Recent trends of the Kelp Gull (*Larus dominicanus*) in South Africa. *Waterbirds, 39*, 99–113. https://doi.org/10.1675/063.039.sp102

Wolfaardt, A. C., Underhill, L. G., Nel, D. C., Williams, A. J., & Visagie, J. (2008). 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. https://doi.org/10.2989/ajms.2008.30.3.10.644

Wolfaardt, A. C., Williams, A. J., Underhill, L. G., Crawford, R. J. M., & Whittington, P. A. (2009). 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. https://doi.org/10.2989/ajms.2009.31.1.3.774