IN THE HIGH COURT OF SOUTH AFRICA
GAUTENG DIVISION, PRETORIA

Case No: 2024-029857

In the matter between:

BIRDLIFE SOUTH AFRICA	First Applicant
SOUTH AFRICAN FOUNDATION FOR THE CONSERVATION OF COASTAL BIRDS	Second Applicant
and	
THE MINISTER OF FORESTRY, FISHERIES AND THE ENVIRONMENT	First Respondent
THE DEPUTY DIRECTOR-GENERAL: FISHERIES MANAGEMENT, DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT	Second Respondent
THE DEPUTY DIRECTOR-GENERAL: OCEANS AND COASTS, DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT	Third Respondent
THE SOUTH AFRICAN PELAGIC FISHING INDUSTRY ASSOCIATION	Fourth Respondent
EASTERN CAPE PELAGIC ASSOCIATION	Fifth Respondent

REPLYING AFFIDAVIT
(IN RESPONSE TO THE FOURTH AND FIFTH RESPONDENTS)

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I, the undersigned,

ALISTAIR MC INTYRE MC INNES

do hereby make oath and state that:

1. I am a marine ecologist and the Seabird Conservation Programme Manager at BirdLife South Africa, the first applicant. I am the deponent to the founding affidavit from which my particulars and capacity appear as well as deponent to the supplementary founding affidavit.

2. This affidavit responds to the answering affidavit filed on behalf of the fourth and fifth respondents (**the Industry Respondents**). To date, no answering affidavit has been filed on behalf of the first to third respondents (**the State parties**).

3. A supporting affidavit deposed to by Dr Katrin Ludynia on behalf of the second applicant will be filed in parallel as will a confirmatory affidavit from Ms Eleanor Weideman and expert affidavits from Dr Murray Christian and Ms Jennifer Grigg. I note that as Ms Grigg is outside South Africa, an unsigned affidavit will be filed with this replying affidavit. Her signed affidavit will be available at the hearing of this matter.

4. The facts contained herein are within my personal knowledge, unless otherwise stated or as appears from the context, and are to the best of my belief both true and correct.

5. Insofar as I make legal submissions, I rely on the advice of the applicants' legal representatives, which advice I accept to be true and correct.

6. In what follows, I use the same abbreviations and definitions as are used in the founding and supplementary founding affidavits, save as otherwise indicated.

INTRODUCTION

7. This review concerns whether the Minister acted rationally and lawfully in taking the decision announced on 4 August 2023[1] which followed Ministerial approvals signed-off on 23 July 2023.[2]

8. The Minister's decision concerns the implementation of the island closures. It is material to the merits of this review that the purpose of the island closures is to serve as a conservation measure to intervene in the rapid decline of the African Penguin population which has seen its conservation status steadily worsen from "Vulnerable" to "Endangered" in 2010,[3] and to the point of being recommended for uplisting as "Critically Endangered" in 2024 – just one step away from being extinct in the wild, which is feared to occur as soon as 2035.[4]

9. It is similarly material that the obligations to prevent such degradation falls on the Minister and the department, the DFFE. Both are bound by the domestic and international environmental and biodiversity framework as well as the requirements of just administrative action and the rule of law. It is the conduct and decision-making of the Minister (and – to the extent, relied upon – DFFE officials) that are the subject of this review. The Court is called upon to consider

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1 "**AM15**" to the founding affidavit (hereinafter the founding affidavit is referred to as "**FA**". Annexures "**AM1**" to "**AM76**" are annexures to the FA and will simply be referred to by annexure label).
2 "**SFA9**" to the supplementary founding affidavit (hereinafter the supplementary founding affidavit is referred to as "**SFA**". Annexures "**SFA1**" to "**SFA32**" are annexures to the SFA and will simply be referred to by annexure label).
3 FA, para 40.
4 "**SFA1**" p 12 (all page numbers to annexures are internal to those documents).

whether such decision-making meets the legal requirements of rationality and lawfulness. It is not called upon to consider the merits or otherwise of various scientific disagreements. To the extent that the Industry Respondents suggest this is the case, they are mistaken.

10. This error, however, infects the Industry Respondents' entire answer and the affidavit of their expert, Dr Bergh. Rather than assist in the resolution of pertinent disputes raised in this matter, Dr Bergh's arguments and analysis serve to reopen scientific debates settled by the panel of international experts (**Panel**) convened by the Minister precisely to settle these debates and to provide recommendations to inform her decision-making regarding closures. Where the Industry Respondents do not seek to litigate now-settled scientific debates, they simply deny that the Panel drew the conclusions and made the recommendations it did – alternatively claim that the Panel did not meet its Terms of Reference.[5] Significantly, however, the Industry Respondents do not deny the conservation purpose of island closures, nor that a trade-off between conservation benefits and the costs they claim will be borne by Industry, was to be struck by the Minister. This leaves the Industry Respondents in a vulnerable position: if their claims regarding the Panel's conclusions and recommendations do not withstand scrutiny, their opposition necessarily falls away.

11. The Industry Respondents have made a second critical error: while they have opposed both the merits of this review and the relief sought, they have conflated the two. This is readily apparent from their insistence on the "policy" nature of

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5 The Terms of Reference appears as "**AM13**".

the Minister's decision[6] which, they argue, both prevents a court from granting the relief claimed by the applicants and "infects" the merits. As I explain below, this is simply not the case.

12. This confusion is symptomatic of the generally contradictory nature of the Industry Respondents' claims which, variously, contain a series of bald denials; seek to impugn the *bona fides* of the applicants and other conservation sector stakeholders; rely selectively on the Panel's Report while otherwise ignoring or denying its findings; both defending the rationality of the Minister's decision, and claiming that it was based on nothing at all; and claiming that agreement was necessary and possible between themselves and the conservation sector, while denying all possible bases on which such agreement might rest. In fact, the entire content and tenor of the Industry Respondents' answer highlights the irrationality of the Minister subordinating her decision regarding island closure delineations to "agreement" between Industry and the conservation sector.

13. The Industry Respondents present an answer which is in material respects contradictory and the high watermark of which is that they "disagree" with the applicants' interpretation of the Report. Critically, the Industry Respondents appear to have missed the point of the decision; the role of the Panel in the Minister's decision-making; and the legal and factual context in which the Minister took her decision. Moreover, the Industry Respondents appear to entirely disregard the legal obligations and conduct of the State and persist in framing the matter as one between "Industry" and "conservation" – in which they, not the State, are the final arbiters of the State's legal obligations. In the result,

[6] Industry Respondents' answering affidavit (hereinafter "**AA**") paras 12.3and 17.1.

they fail to disturb the merits of the applicants' claims. In effect, they in fact support the necessity for the Court granting the relief sought in the amended notice of motion.

14. In what follows, I:

14.1 explain that the Industry Respondents have failed to defend the rationality of the Minister's decision;

14.2 explain that the Industry Respondents have failed to defend the unlawfulness of the Minister's decision;

14.3 address (and counter) the Industry Respondents' resistance to the trade-off mechanism; misunderstanding key recommendations made by the Panel in respect of African Penguin "benefits"; and fail to appreciate the import and basis of the irrationality of the Interim Closures;

14.4 address the Industry Respondents' refusal to accept the Panel's findings regarding their own data and methods;

14.5 counter specific criticisms levelled by the Industry Respondents aimed at the relief sought by the applicants to show these criticisms have no merit;

14.6 provide an *ad seriatim* response to the Industry Respondents' answer; and

14.7 conclude by confirming that the applicants persist in their review and pray for the relief set out in the amended notice of motion.

NO DEFENCE ON RATIONALITY

Ex post facto rationalisation

15. Despite filing a notice to oppose this application, the Minister has not filed an answering affidavit. There is accordingly no attempt by the Minister to defend the rationality of the impugned decision by explaining what the Minister had in mind when taking it.

16. That, however, has not deterred the Industry Respondents. They have taken it upon themselves to attempt to explain the decision on the Minister's behalf. According to them, what the Minister intended by the decision was:

16.1 to defer the implementation of the trade-off mechanism because it required further research before it could be implemented;[7]

16.2 to provide for a "review" period of six years to enable this research (but not a monitoring period)[8] to be undertaken,[9] as only after the completion of that research would it be possible to implement the trade-off mechanism to determine alternative closures to the Interim Closures (or remove closures completely);[10]

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7 AA para 121.
8 AA paras 39; 312.
9 AA paras 34; 52.5.
10 AA paras 39; 121; 181; 327; 373.

16.3 to allow, in the meantime, for the possibility of Industry and the conservation sector agreeing to different closure delineations (without putting any parameters in place) within a period of six months, failing which the Interim Closures would persist.[11] In doing this, the Industry Respondents say the Minister "*allowed for consensus not in abdication of her responsibility, but in recognition that the Panel's report did not equip her to finally determine new closure areas*;[12] and

16.4 to extend the Interim Closures to ensure something was in place to protect African Penguins and to enable more research to be undertaken.[13]

17. The Industry Respondents' attempt to obscure the obvious flaws in the Minister's decision-making through inventive interpretation that is unsupported by the documents on record is unavailing. I am advised that our law precludes after-the-fact attempts to put a gloss on decisions of this nature. The preclusion applies primarily to the decision-makers themselves, but it operates with even greater force when it comes to attempts by third parties (such as the Industry Respondents) to do so on a decision-maker's behalf. The explanation for the decision can only be that of the Minister: and it can only be that explanation which operated at the time the Minister took her decision.

18. The Industry Respondents fall foul on both counts: they attempt to explain and justify the decision on the Minister's behalf and they do so having regard to

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[11] AA paras 52.6; 186.
[12] AA para 187.
[13] AA paras 52.1; 52.3; 184-185.

factors which they speculate formed part of the Minister's thought process. The difficulty however is that there is no evidence before this Court that the Minister in fact considered these factors. Indeed, some of the factors predate the Minister's decision (and had already been discounted as relevant considerations). Others postdate it. All are irrelevant. For example, the Industry Respondents rely:

18.1 on the one hand, on the contents of the Panel's Report to explain what the Minister's decision must have intended. However, the Report presents a pretext to the Minister's decision. While it offers insight into what the Minister ought to have taken into consideration when taking her decision (which is precisely the concern of the applicants), it can never offer an indication of what the Minister actually took into consideration when taking her decision. This is especially so when it is not apparent from the record that the Minister even had regard to the relevant aspects of the Panel's recommendations; and

18.2 on the other hand, on the contents of communications occurring after the Minister's decision. For instance, the Industry Respondents argue that the Minister's letter of 18 January 2024[14] and the DFFE's e-mail of February 2024[15] "*both reveal that the Minister understood the work of the Panel to require further important research and data collection to be done before new closure areas could be determined*".[16] Not only is

[14] "**MC7**" to the AA (Annexures "**MC1**" to "**MC11**" are annexures to the AA and will simply be referred to by annexure label).
[15] Attached as "**RA1**".
[16] AA para 104.

this incorrect as a matter of fact, but I am advised that it is impermissible as a matter of law. Communications exchanged five and six months after the decision can never explain what the Minister "*understood the work of the Panel to require*" at the time the decision was taken.

19. Critically, the Industry Respondents do not adduce a shred of evidence to show that this is what the Minister actually had in mind when taking her decision. Nor are they able to point to any evidence in the record which supports their contention.

20. It is simply not for the Industry Respondents to endeavour to explain what the Minister meant by the decision – and it is certainly not for them to do so through the lens of their own hindsight, interests and consequent bias.

21. The difficulties faced by the Industry Respondents go further. Not only is their attempted explanation of the Minister's decision unavailing, if accepted, it serves only to prove – and not disprove – the irrationality of the decision. The urgency of addressing the rate of African Penguin population decline was recognised in the Terms of Reference.[17] Data has been collected and analysed since 2008. To defer a trade-off decision for a further six years (or more) of data-collection is simply inexplicable. Moreover, to defer the trade-off decision to conduct an analysis into the "real reasons" for population decline (i.e. the MICE[18] analysis for which the Industry Respondents advocate) is patently irrational in the context of the role of prey availability (and competition with fisheries) which was

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[17] FA para 104.2.
[18] "MICE" stands for "Model of Intermediate Complexity for Ecosystem".

expressly acknowledged by the Minister in the announcement of her decision.[19] This is without considering that the Industry Respondents are simply incorrect in their reading of the Panel's recommendations (as explained in detail below).

22. In what follows, I address the primary components of the Industry Respondents' defence to the applicants' irrationality ground of review, namely (1) that the applicants have misinterpreted the Minister's decision and (2) that the closures proposed by the applicants somehow prove the rationality of the Minister's decision.

First argument: the alleged misinterpretation

23. The Industry Respondents contend that the applicants have misinterpreted the Minister's decision. They are wrong. However, even if they were right, it would not get them anywhere – the Minister's decision would remain irrational even on their interpretation.

24. The Industry Respondents' attack on the applicants' interpretation of the Minister's decision suffers from three errors. I address them in turn.

First error: the need for closures

25. The Industry Respondents claim that the Panel "*did not recommend that island closures must be imposed*"[20] (original emphasis). But that is not what the applicants contend. We did not say that the Panel recommended that there "*must*" be island closures. We simply noted that the Panel had found that island

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[19] "**AM15**".
[20] AA para 15.1.

closures were an appropriate conservation intervention and that the Minister had accepted that by deciding to impose closures.

26. Proceeding from their false premise, the Industry Respondents then seize upon the text of the Report which, in addressing the findings of the ICE, states that it demonstrated a "small impact" (relative to the estimated relative reductions in penguin abundance).[21] They then suggest that, because the ICE demonstrated a "small impact", African Penguins will only receive a marginal benefit from island closures and, accordingly island closures should not be implemented. Their argument misses the mark in a number of important respects and reflects a limited understanding of the science behind slowing the rate of African Penguin decline.

26.1 First, the Industry Respondents make the simplistic error of assuming that a small reduction cannot be a significant reduction.

26.1.1 The IUCN Red List criteria for defining the conservation status of a species uses rates of population decline as an important measure. This is evident from the analysis carried out in relation to the uplisting of the African Penguin from "Endangered" to "Critically Endangered" outlined in Dr Sherley's affidavit.[22]

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21 "**AM14**" p 23 para 2.3.2.
22 "**AM4**".

26.1.2 It is also evident from BirdLife International's uplisting recommendation[23], which:

(a) indicates that "*[a]n updated analysis of all nest count data from 1979 and 2023 has shown that the already very rapid rate of population reduction has accelerated extremely rapidly*";[24] and

(b) justifies the accelerating rate of decline by stating: "*If rates of decline persist at the recent rates, the projected reduction over the next three generations will also exceed 80%. If the rate of population reduction since 1993 (5.4% annually) is used the projected reduction is 81% (53-93%), whereas the rate since 2013 (7.9% annually) results in a projected reduction of 92% (70-98%)*"[25]

(emphasis added).

26.1.3 What this means is that any intervention to slow the rate of population decline (currently measured as an annual rate of 5.4% or 7.9%, depending on whether the rate per annum is measured against population numbers commencing in 1993

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23 "**SFA1**"
24 "**SFA1**" p 2 ("Rationale for proposed change").
25 "**SFA1**" p 3 ("Justification").

or 2013) is an intervention which may change the conditions which are leading towards projected extinction in the wild.

26.1.4 In this context, where the African Penguin is already listed as Endangered, and likely will be uplisted to Critically Endangered in October 2024, an intervention to slow or reverse the rate of decline is an important conservation intervention.

26.1.5 The "small" impact of closures demonstrated by the ICE around Dassen and Robben islands is in fact very significant in this context. To demonstrate just how significant, I have filed an affidavit of Ms Jennifer Grigg who has modelled the potential for population growth rates in the period until 2033 focusing on Robben Island and Stony Point. Her findings demonstrate that 20km fishing closures around Robben Island will likely reverse the current trends in population decline if implemented on a long-term basis. Her projections indicate that the threshold of 1% would have been surpassed if a 20km Robben Island closure had been retained until 2023; that by 2025 the population growth rate will become positive; and if such closure is in place by 2033, that the population will be approximately 30% larger than under open fisheries (i.e. compared to a scenario with no closures). Her projections in respect of Stony Point reflect a still more meaningful improvement.

26.2 Second, the Industry Respondents seem to have forgotten that there is a pre-agreed threshold of what would be "meaningful" in terms of population growth rate which reflects the fact that numerically "small" shifts can be significant. In 2016, fisheries and seabird scientists who were members of the Penguin Island Closure Technical Team, which worked on analysing the ICE results, agreed that a 1% population increase was the threshold for a meaningful population growth rate that would meet a "*management objective*". This agreement followed recommendations of the 2015 International Stock Assessment Workshop. This agreement is in fact referenced at page 21 of the Report which states "*larger negative impacts of fishing, close to the -1% value used as a reference, were estimated for Dassen and Robben islands based on chick survival data…*". The Industry Respondents were part of the deliberations that determined this threshold and should be well aware of its significance. I attach a recordal of this decision as "**RA2**".[26]

26.3 Third, the Panel's conclusions are context specific. They address what the ICE was able to show (and designed to show) in relation to reduction of the rate of African Penguin decline when measured through improvements related to "*reproductive success*". While the experiment used a series of years of "open" and "closed" fishing areas of three years, this did not match the age at which African Penguins hatched during the "closed" period would themselves begin to breed

[26] See the recordal at 2(c) "Identification of Effects sizes".

(at four to six years old). This meant that the experiment could not measure whether closures assisted with a "second generation" or any exponential benefit in terms of the slowing of rates of decline. For this reason, the Panel expressly noted "*Potential but not studied benefits to adult and immature African penguins from the ICE*" at paragraph 2.5.[27] The Industry Respondents ignore this statement.

26.4 Fourth, the benefit of the island closures is not limited to the small reduction in the rate of decline resulting from improved reproductive success. Chapter 1 of the Panel report expressly indicates that the benefit of the island closures may well include *additional* benefits that the ICE was not designed or able to measure. Bullet 3 of the Executive Summary (on which the Industry Respondents rely) in fact qualifies what is meant by a "small extent" stating:

> *[The ICE] is now complete, and notwithstanding the difficulties implementing the experiment, has been successful in demonstrating for the west colonies of Dassen and Robben islands (those more intensively studied within the ICE), that excluding fishing around island breeding colonies is likely to reduce the rate of decline in the population to a small extent, mediated through improvements in reproductive success. Excluding purse-seine fishing around island breeding colonies is also likely to have other positive benefits for penguin conservation, such as facilitating higher adult survival, but the ICE was not designed to estimate such effects."*[28]

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[27] "**AM14**" p 25.
[28] "**AM14**" p 8.

26.5 Fifth, the Industry Respondents' own evidence demonstrates the significance of the "small" reduction achieved through island closures. Dr Bergh notes that the Interim Closures are preventing the death of between 29 to 62 breeding pairs of African Penguins per annum and that the applicants proposed closures would increase the benefit to 50 to 106 pairs per annum.[29] Compared to the "absolute rate of decline" of 800 breeding pairs per annum observed by the Industry Respondents,[30] that is significant. It is transparently self-serving of the Industry Respondents to then conclude that the benefits are small. They clearly are not.

26.6 Sixth, this case is not about whether island closures should be implemented. That question has been answered by the Minister. It is about whether the Minister acted properly in her delineation of those closures. The Industry Respondents' attempt to suggest otherwise is a classic straw man manoeuvre. Even if there were merit in the argument, it is not clear to what end the Industry Respondents advance it, as the very decision they seek to defend is one which purports to impose island closures. Ironically, by arguing against island closures, they are supporting the review and setting aside of the Minister's decision, albeit on different grounds to those advanced by the applicants.

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[29] AA paras 140-142; Dr Bergh's affidavit para 15; 53.
[30] AA paras 140-142; Dr Bergh's affidavit para 53.

27. In any event, the argument does not take the Industry Respondents anywhere because the applicants' case for review does not turn on this aspect of the Panel's recommendation.

Second error: the application of mIBA-ARS

28. The second manner in which the Industry Respondents claim the applicants have misinterpreted the Minister's decision is the applicants' statement that the Panel recommended the use of mIBA-ARS as the best scientific basis for delineating preferred foraging habits during breeding "without qualification".[31] Instead, the Industry Respondents contend that the Panel found that further research must be carried out to "validate" the mIBA-ARS areas using dive data to provide so-called "objective" data of foraging locations, rather than commuting or travelling locations.[32] Their contention is misplaced for two important reasons.

28.1 First, it conflates the Panel's recommendations regarding (a) the best available scientific method for delineating preferred foraging habitats; and (b) how the data used in such analysis may be improved in the future. The relevant conclusions and recommendations read as follows:

> *"The Panel **recommended** that analyses delineating mIBAs using ARS methods represent the best scientific basis for delineating the preferred foraging habitats during breeding. In the future, additional analyses would further improve understanding, especially with respect to how the spatial scale of any given mIBA might vary by year. The Panel **concluded** that such between-year variation is likely to be important, as the years of the*

[31] AA para 116.
[32] AA para 116.

ICE, during which most telemetry data have been collected, have been years of relatively low prey resource abundance. Further, evidence related to the prolonged African penguin breeding season (e.g., Crawford et al., 2013), also highlights the need to ensure adequate resource availability is maintained within a given mIBA around the year, as the demand is not simply seasonal.

The Panel ***recommended*** *that further validation of mIBAs should occur, in particular using dive data that provide objective identification of foraging locations, rather than commuting (or travelling) locations (see also section 5.9). Such analyses could be included in species distribution models (e.g., Warwick-Evans et al., 2018) that could be used to identify areas of key importance. However, important uncertainties remain, particularly if mIBAs are determined (as they have been) using telemetry data predominantly limited to early chick rearing when breeding adults are most constrained; further, that mIBAs may differ in the future, should prey resource abundance increase.*[33]

(underlining my emphasis)

28.2 The Panel clearly indicated that the "ARS" method was the best available scientific method for delineating preferred foraging area based on the data available (i.e. the telemetry data collected by the applicants). It did so without equivocation or qualification. This method can be applied now to delineate the preferred foraging area.

28.3 The Panel's parallel recommendations regarding identification of between-year variation (to be conducted within a one-to-two year period)[34] and verification through analysis of dive data (to be achieved within a two-to-five-year period)[35] do not displace the validity of the

[33] This is clear from the text of the Report ("**AM14**" at pp 34-35).
[34] See "**AM14**", p 45, Table 7.1.
[35] As above.

ARS method, nor the status of the telemetry data as the best available scientific data for purposes of calculating mIBA-ARS at present. It is simply not the case that the mIBA-ARS delineations had to "*first be validated by dive data before being used in trade-off analyses to provide objective identification of foraging locations of penguins, rather than travelling locations*".[36] The Industry Respondents' attempt to tie the application of the trade-off mechanism to the completion of "*future research*" is self-serving.

28.4 Second, in the case of "dive data", Table 7.1 of the Report provides the time-horizons for future research. Task 2(a) ("*Validate the mIBAs given information on foraging locations*") is indicated as having a two-to-five-year time horizon. The Panel could not possibly have contemplated deferring the implementation of the trade-off mechanism for up to five years to "*validate*" mIBAs which, in any event, are closure delineation options to be assessed using the trade-off – and not part of the workings of the "mechanism" itself.[37] To do so would, for reasons I explain immediately below, in itself be irrational.

Third error: the application of the trade-off mechanism

29. By far the most fundamental error at the heart of the Industry Respondents' opposition is their contention that "*it was not possible for the Minister to have made a quantitative trade-off decision based on the outcomes from the Panel*".[38]

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[36] AA para 15.4.1.
[37] I note that BLSA is currently engaged in analysis of data according to the medium-term timeline provided by the Panel.
[38] AA para 121.

This, they say, is because certain research tasks were necessary before the trade-off mechanism could be employed to select closure options.[39] Not only is this interpretation incorrect but it carries the perversion of enabling Industry to permanently delay implementation of the trade-off mechanism by simply failing to improve the Opportunity Based Model (OBM) (and socio-economic) data, for which they themselves are responsible.

30. The Industry Respondents' error is immediately apparent from the Panel's Terms of Reference,[40] which required it to address a distinct set of objectives, coupled to a corresponding set of outcomes and recommendations, namely:

30.1 whether island closures were of benefit as a conservation measure;[41]

30.2 if island closures were shown to be beneficial, a trade-off mechanism to maximise penguin benefit while minimising Industry costs;[42]

30.3 future monitoring;[43] and

30.4 future research.[44]

31. The structure of the Panel's Report and its recommendations correspond with these discrete elements of its Terms of Reference.

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[39] See AA paras 15.2; 15.4.1; 15.4.3; 34; 39; 44; 46; 50; 52.5; 75; 79; 81-90; 101.1-101.2; 104; 116; 121; 124; 126.1, 158; 209; 213.2; 243; 244; 248; 256; 257; 387.

[40] "**AM13**".

[41] See the objective in paragraph 2(b) read with outcome and recommendation in paragraph 5(a).

[42] See the objective in paragraph 2(c) read with outcome and recommendation in paragraph 5(d).

[43] See the objective in paragraph 2(d) read with outcome and recommendation in paragraph 5(f).

[44] See the objective in paragraph 2(e) read with outcome and recommendation in paragraph 5(g).

31.1 The Panel assessed the data relevant to the ICE and whether it showed that closures were of benefit to African Penguins in Chapter 1 (concluding that a benefit was indicated).

31.2 The trade-off mechanism (which was only required if a benefit was identified) was addressed in Chapter 4.

31.3 Considerations for monitoring were addressed in Chapter 5.

31.4 And future research was addressed in Chapter 6.

32. Consideration of "reasons for decline in the penguin population"[45] – which is the focus of the "future research" – was clearly dealt with as a separate issue to that of whether closures are of benefit to African Penguins and, if so, the trade-off mechanism to be applied in delineating those closures. The need for an urgent intervention was not contingent on a deepening of the understanding of the relative impacts of different threats to African Penguins.

33. The language of the Panel's report itself places this beyond doubt. At paragraph 7.3 of the Report, the Panel notes the following in relation to fishing closures:

> *"If designated, closed areas to protect penguins should be reviewed at a time when results are available to investigate life-history processes such as juvenile recruitment, and adult survival, and hence population growth rates. This may be a time between 6 and 10 years after designation. Analyses needed to determine juvenile recruitment, and survival, and adult survival, will require closures of between 6 and 10 years after*

[45] "AM13" para 5(g).

closure designation, if adequate responses are to be determined". (my emphasis)

34. The Panel is saying two things here. The first is that if closures are designated, they should be reviewed once further data is available. The second is that this review may take place six to ten years after closures have been designated.

34.1 Quite clearly, this recommendation is predicated on closures being designated. Moreover, this recommendation is predicated on it being uncertain, at the time the Report was published, whether closures would be designated.

34.2 What this makes patently clear is that, when the Panel refers to a review six to ten years "after designation", it is not speaking about the Interim Closures (which predated the Panel process and were implemented as temporary measures to facilitate such process). It is speaking about a designation to be made pursuant to the Panel's Report.

34.3 If that were not the case, there would have been no need to predicate their comment as only applying "*if [closures were] designated*". Once it is accepted that the Panel is referring to a set of designations selected by the Minister, and not the Interim Closures implemented to enable the Panel process, it must be accepted that the Panel contemplated imposing closures which were to be determined – without more – in the manner which was identified in the Report as being the best scientific approach for taking a closure decision in the circumstances.

35. Conversely, what the Panel is not saying is that the best scientific approach to determining closures should be ignored for the next six to ten years while the arbitrarily determined and suboptimal Interim Closures are retained for purposes of gathering further data. It is common cause that the Panel has recommended what it considered to be the best scientific trade-off mechanism for determining closures. That approach can be followed using the data that is presently available. The mere fact that the recommended mechanism would be better applied with the benefit of further research and enhanced data in no way means that it cannot and should not be applied at the moment.

36. In effect, the Industry Respondents are arguing that the Panel recommendations should be interpreted to mean that, until we have optimal input data, we should follow a suboptimal approach to closure delineation. Not only is their proposed interpretation wrong, for the reasons I have mentioned above, but it is also entirely irrational for at least the following reasons:

36.1 First, it is inconsistent with the purpose of the Report, which was procured "*[w]ithin the context of an urgent need to implement timeous conservation actions for the African Penguin*" to enable the Minister immediately to put in place closures based on the Panel's recommendations.[46] Indeed, as the Industry Respondents themselves point out, the Terms of Reference went so far as to state that "*[i]n addition to recommendations on trade-off mechanisms, the panel must preferably advise on biologically meaningful penguin habitat extents for fishery limitations per island, recommendations must be spatially and*

[46] "**AM13**" para 2(b).

temporally explicit, and provided on a map".[47] The mere fact that the Panel did not present specific map closures does not make the purpose of its Report any less about enabling the Minister immediately to put in place biologically meaningful closures, which is what the Terms of Reference contemplated.

36.2 Second, the Industry Respondents' proposed interpretation is entirely at odds with the very purpose of the closures, which is to slow (or if possible, reverse) the rate of decline of the African Penguin. As indicated, the purpose of the closures is to address "*an urgent need to implement timeous conservation action for the African Penguin*". Considered in that context, it would be utterly nonsensical to propose an approach to determining closures which undermines that purpose. Yet that is precisely what the Industry Respondents say the Report should be determined to mean.

37. The Industry Respondents' *ex post facto* attempt to explain why the trade-off mechanism was incapable of, and not intended to have, immediate application simply cannot be countenanced. However, even if that was what the Minister had in mind when taking the decision, that does not help the Industry Respondents' case. Quite the opposite: it destroys it. This is because, in the face of the purpose for which the Panel was appointed and the purpose for which closures were imposed, it would have been both entirely irrational and an abject dereliction of duty for the Minister to have taken the decision on the

[47] AA para 31 with reference to "**AM13**" para 5(d).

understanding that the trade-off mechanism could only be applied, and optimal closures could only be determined, six to ten years from now.

38. This is especially so in circumstances where the Minister is enjoined, by statute, to ensure that "a risk averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and action".[48] On the Industry Respondents' interpretation, the Minister's decision was anything but that. It therefore stands to be reviewed and set aside on the strength of their own argument.

Second argument: the alleged rationality of the interim closures

39. The applicants contend that the irrationality of the Minister's decision is manifest not merely from the failure to follow the Panel's recommendations in adopting scientifically informed closures, but equally from the senseless continuation of the Interim Closures. The Industry Respondents' answer is one of conflation, concession and confusion.

<u>The conflation</u>

40. The Industry Respondents' answer to this part of the applicants' case is that "*[t]he Interim Closures are not Meaningless*" and, by implication, their retention was not irrational.[49] The argument is another straw man. The applicants' argument is not that the Minister's decision is irrational <u>because</u> the Interim Closures are meaningless (we do not even contend that they are all meaningless). Our

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[48] NEMA, s2(4)(a)(vii).
[49] AA paras 131 to 136.

argument is that the decision to retain the Interim Closures is irrational and that it does not adequately protect the declining African Penguin population.

40.1 The irrationality of the Minister's decision to retain the Interim Closures arises from the fact that there was no consideration of whether the Interim Closures were appropriate.[50]

40.2 The inadequacy arises from the fact that the Interim Closures are arbitrary and do not necessarily correspond with African Penguins' preferred foraging areas.

41. The Industry Respondents have employed an argument concerning adequacy of the Interim Closures to defend the rationality of the decision to retain them. In doing so, they have conflated the questions of irrationality and inadequacy. However, it does not address the irrationality of the decision to retain the Interim Closures to argue that they are "not inadequate". The irrationality of the decision is therefore left unanswered.

The concession

42. The Industry Respondents devote a significant part of their opposition towards criticising the adequacy of the applicants' Proposed Closures, to which end they rely on the affidavit of Dr Bergh. However, in relying on Dr Bergh's affidavit to prove the rationality of the retention of the Interim Closures, the Industry Respondents inadvertently prove the opposite. They do so in two respects:

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[50] SFA para 50.

42.1 First, in highlighting the alleged deficiencies in the applicants' application of the trade-off mechanism they highlight just how much more deficient the Interim Closures are, in that they make no attempt to apply the trade-off mechanism at all (and instead apply a comparative method considered and rejected by the Panel).

42.2 Second, at paragraph 98 of his affidavit, Dr Bergh notes that "in assessing the rationality of the Minister's decision it is important to quantify the benefit of the Interim Closures to penguins". That again conflates the question of rationality with that of adequacy. More fundamentally, however, it concedes the irrationality of the Minister's decision: if the rationality of the Minister's decision cannot be assessed without quantifying the benefit of the Interim Closures to African Penguins, the Minister's decision to retain the Interim Closures could never be rational when the Minister herself failed to quantify that very benefit.

The confusion

43. The Industry Respondents' attempt to prove the adequacy of the Interim Closures rests exclusively on Dr Bergh's comparison of the areal extent (or size) of the Interim Closures to the Proposed Closures. Their reasoning is that that:

> *"131…the Applicants' case and yet does not appear anywhere in their founding papers. The reason this is critical to the Applicants' case is because their case is ultimately about why the Interim Closures are not good enough and why their proposed closures are a foregone conclusion. In other words, their case is that the law requires the closures to be as*

large as their proposed closures and that the Interim Closures are unlawful because they are inadequate. But, in order for this to be their case, they needed to have provided this Court with some understanding of the difference between the impact on penguin decline of maintaining the Interim Closures {while the necessary further research is done and data is collected), as compared with imposing their proposed closures.

132 Unless the Court knows what the difference is between these two alternatives, it has no way of establishing what the relative benefit of the proposed closures is to penguins, as compared with their cost to the small pelagic fishing industry. But the Applicants have not even explained to the Court what the extent of that alleged benefit to penguins is."

44. However, the Industry Respondents fundamentally misconstrue the applicants' case, the Panel's recommendations regarding closures, and the underlying science.

45. First, it is not the applicants' case that "*the law requires the closures to be as large as their proposed closures*" – or that area *per se* is the reason why the Interim Closures fail to achieve the conservation purposes for which they have been imposed since 4 August 2023.[51]

45.1 The applicants' case is that any conservation management intervention, including closures, must be based on a sound, rational and consistent basis for making such a decision which, as a matter of law, must be linked to the purpose for which it is taken, the information

[51] I note that the Interim Closures were imposed in September 2022. However, the purpose at that point was to facilitate the work of the Panel – not to serve as conservation measures subsequent to the Panel's advice and Ministerial decision-making.

before the decision-maker and the purpose of the powers granted to the decision-maker which enable such a decision to be taken.

45.2 As explained in paragraphs 164 to 183 of the founding affidavit, the Interim Closures do not meet this standard. Nothing in Dr Bergh's affidavit, nor Mr Copeland's affidavit has displaced the fundamental irrationality and unlawfulness of the Minister's decision to impose these Interim Closures in the circumstances of the decision which is subject to this review.

46. Second, I deny the relevance of Dr Bergh's analysis using the "*areal extent of the closure areas to compare the Interim Closures and the Applicants' proposed closures.*" It is not clear why Dr Bergh has conducted this comparison – despite his explanations. A comparison of area (or size) is simply not relevant to the basis for decision-making which the Panel recommended and which the Minister sought. The materiality threshold for rational closures is the extent to which they correspond with preferred foraging areas of African Penguins and the area of most value to African Penguins in terms of their foraging behaviours. This is a matter of location and shape rather than area (or extent or size).

47. Third, whether a simple spatial comparison is even appropriate is doubtful given the Panel's conclusion that "[a]n optimal solution (or acceptable "balance") between competing objectives is not simply obtained by closing 50 percent of any given area".[52] By the same token, simply extrapolating benefits and costs from one spatial area to another is unlikely to capture the suitability of a particular

[52] Report p 46.

closure zone in balancing "interests" let alone achieving a balance which optimises benefits to African Penguins while minimising costs to Industry.

48. Fourth, it appears from an examination of Dr Bergh's affidavit, that the averments in paragraph 131 of the Industry Respondents' answering affidavit are based – at least in part – on calculations in which Dr Bergh seeks to compare the total area covered by Interim Closures and the Proposed Closures to demonstrate that the Interim Closures are not, in fact, insignificant. He does so in each case by adding together the area of all the island closures imposed as "Interim Closures" and the area of all the island closures proposed as "applicants' Proposed Closures". In doing so, he concludes that the sum of the area of all Interim Closures is 70% of the sum of all the applicants' Proposed Closures. Dr Bergh's analysis is oversimplistic and flawed, given what I have said above regarding the importance of location and shape rather than area. It is, moreover, in direct opposition to the Panel's express statement that:

> *"The trade-offs between costs to the fishery and benefits to penguins in terms of the proportion of the foraging area closed will differ among islands and among sectors within the fishery. Consequently, the benefits to penguins and costs to industry should be considered by island (or region) and not simply at the national level…".*[53]

49. Fifth, the Industry Respondents (and Dr Bergh) simply ignore African Penguin behaviour.

    49.1 African Penguins have particular areas within their foraging habitats where they prefer to hunt / forage. This is precisely why it is relevant

[53] "**AM14**" p 36.

to consider preferred foraging areas for African Penguins when addressing prey availability.

49.2 Moreover, African Penguins show preferences for particular foraging areas – and this can be monitored using the tracking data that seabird scientists (including Ms Weideman and I) analyse as part of our core expertise. As I have explained in paragraph 21 of the founding affidavit and as is explained by Dr Christian, we have used a "penguin utility index" (or "penguin utility score") to measure benefits to African Penguins in the design of the trade-off mechanism.

49.3 At paragraph 21.1, I explain that the Penguin utility index is "a measure of the estimated number of individual penguins that regularly forage in a particular cell on a grid which we overlay onto penguin foraging tracks". In other words, the Penguin utility index deals with much more than "area" but also with how frequently that area is used by individual birds. Put differently, this is the measure of how much a particular location is "valued" by African Penguins. This measure is based on verifiable, observational data, collected through a recognised scientific method – and is a method which has been scrutinised by peer reviewers in relation to the measures in this case.[54]

[54] See the article published in the ICES Journal of Marine Science which I attach as "**RA3**".

49.4 Dr Bergh's analysis has consequently failed to cure the irrationality of the Interim Closures, which bear little relation to the areas where African Penguins prefer to forage.

NO DEFENCE ON UNLAWFULNESS

50. The Industry Respondents do not appear to address the applicants' argument that the decision was unlawful and unconstitutional, save to contend that (1) "*none of the legal provisions to which the Applicants' refer entitles the African penguin to be conserved at all costs"* (original emphasis);[55] (2) the claim that the applicants have questioned "*the source of the Minister's power to impose closures at all";*[56] and to maintain that (3) the applicants' grounds of unlawfulness are that the "Minister has not done enough" which is answerable by the rationality of her conduct.[57] These complaints are entirely misplaced.

51. First, the notion that conservation measures should be taken "*at all costs*" is another invention by Industry. This is not contended for by the applicants – nor has it ever been the case that seabird scientists, conservationists and officials within the Minister's own department have sought to intervene "at all costs" in respect of the conservation threat posed by industrial fishing for sardine and anchovy in relatively small marine areas which are of high value to African Penguins in terms of their foraging needs. The alarmist language of Industry does nothing to displace the unlawfulness of the Minister's inaction in the face of the current circumstances, knowledge before her and the legal principles and

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[55] AA para 194.
[56] AA para 196.
[57] AA para 198.

obligations by which the Minister entrusted with preserving the country's biodiversity and the environment is bound.

52. Second, the Industry Respondents' claims of contradiction are based on a mischaracterisation of the applicants' papers. They provide no evidence that the applicants *"regularly question the source of the Minister's powers to impose closures, all"*. The example cited (paragraph 31.4 of the founding affidavit) says exactly what it means i.e. there is no clarity regarding what powers the Minister invoked when imposing the Interim Closures and taking the decision. The Interim Closures were initially imposed in September 2022 through a curious set of negotiations, conversations, discussions and exchanges of e-mail without ever having been clearly tied to a particular statutory provision or power. Similarly, the impugned decision was made without any specific statutory provision or power being invoked. This is spelled out when the applicants state, in paragraph 31.4 that *"[the Minister] has not indicated in the announcement of her decision what the relevant empowering statute or provision is which provides the legal basis for the decision taken"*. This is categorically not a statement that there are no powers or statutory provisions available for this purpose. It is raised merely insofar as it is relevant to determining the appropriate standard against which the Minister's decision must be reviewed.

53. Third, it is simply no answer to the applicants' grounds of unlawfulness and unconstitutionality to state that the Minister need only act rationally and has done so.

53.1 This conflates the legal distinction between rationality and lawfulness both under PAJA and as applicable to legality review. The mere fact that a decision may have been rational does not mean it was lawful. Similarly, it would be no answer to the irrationality of a decision to argue that it was lawful.

53.2 In any event, this contention fails on the basis that the Minister's decision was entirely irrational.

54. Finally, the Industry Respondents offer nothing in response to the applicants' explanation of the relevant grounds of review set out in paragraphs 210 to 216 of the founding affidavit, nor do they contest the legal framework applicable to the issue before the Court. Further, in dealing with these grounds as expressed in the supplementary founding affidavit at paragraphs 414 to 418 of their answer, the Industry Respondents offer only a set of bald denials.

THE INDUSTRY RESPONDENTS' RESISTENCE TO THE TRADE-OFF MECHANISM

55. In what follows, I address the Industry Respondents' resistance to the trade-off mechanism.

The Industry Respondents' "plug and play" fallacy

56. It is perhaps unfortunate that the Terms of Reference referred to a "trade-off mechanism". This language has enabled a curious word-play by the Industry Respondents who seem to have expected such mechanism to be "mechanistic" or machine-like.

57. Their argument goes as follows: the applicants' substitution relief is untenable as "*[t]he Panel's report cannot just be plugged into a map drawing programme to generate new closure areas because the report, itself, recognised that much more work needs to be done to verify data and to analyse the impact of closures on the fishing industries and local communities*".[58] This "mechanical application" of the Panel's recommendations is, the Industry Respondents say, the premise of the applicants' case (presumably then, the premise of the review) – and for this reason, the relief sought should fail.[59]

58. This fallacious construction and the related argument are fundamentally flawed.

59. The applicants do not claim that they have mechanically implemented the Panel's recommendations. Far from it, the applicants have considerable expertise which they have, together with other scientific experts, employed to analyse the Panel's recommendations and the Minister's decision.

60. Having analysed the Report, the applicants were able to apply the trade-off mechanism recommended by the Panel and provided their analysis to the Minister and the DFFE on 17 October 2023 – a little over two months after receiving the Panel's recommendations.[60] Inexplicably, the DFFE did not undertake this exercise. Neither were they directed to do so by the Minister, whose decision excluded the trade-off mechanism entirely. The Minister did not omit the application of the trade-off mechanism because it was complex or

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[58] AA para 17.2 (Record p 1176). See also AA para 50 (Record p 1188) which reads "…far from identifying a method that could simply be plugged into a map-drawing programme to produce closure areas for each island that met the trade-off objectives…."

[59] AA para 200-201.

[60] "**AM62**" and "**AM63**" to the founding affidavit.

incomplete or insufficient or could not be mechanically applied. She simply did not consider it at all.[61]

61. Moreover, the very construction of a "map drawing programme" fundamentally misconstrues the point of the "trade-off mechanism". The Panel was tasked with recommending a mechanism which would enable the Minister to select between a number of previously delineated closure options (for which cost/benefit data was available). Each of these options had previously been expressed on a map – there was no need for "map-drawing" or a "programme" to do so.

62. What was required was a systematic and quantifiable means for the Minister to select between these options. This requirement arose from the submissions by both the conservation sector and the Industry Respondents in respect of terms of reference for an international panel of experts in 2022.

63. The Terms of Reference stipulated that the basis for such selection should be: to maximise benefits to African Penguins while minimising costs to Industry. The Panel accordingly recommended a mechanism which could compare the cost/benefit trade-off for each of the various closure options on a colony-by-colony basis. It also required that each previously-prepared closure option had to be analysed in terms of "penguin benefit" and "industry cost" i.e. the pre-determined factors to be "traded off" against one another.

64. This was clearly an analysis that could be carried out. The applicants did so. And this allowed the applicants to construct the graphs presented in Ms

[61] See the recommendations and approvals sought (and granted) at "**SFA9**".

Weideman's affidavit for each island, representing each closure option against the x-axis representing "penguin benefit" and the y-axis representing "Industry cost".

65. The proxies used on the axes of these graphs were not invented by the applicants. The Panel indicated what could be used: areas of value in terms of preferred foraging range for penguin benefit; and OBM data, despite its limitations, as a proxy for Industry cost. As with all models that attempt to quantify real-world behaviour, it was necessary to make certain assumptions. As explained in Ms Weideman's affidavit, and again in Dr Christian's affidavit, the assumptions made were reasonable based on the available data and Panel recommendations.

66. None of this required additional research. None of this required "verification" of mIBAs using dive-data, nor more accurate cost data from Industry. And it most certainly did not require a MICE analysis to determine the "real reason" for African Penguin population decline. However, it did require an appreciation for what the trade-off was in fact required to do as a decision-making framework for the Minister and the very purpose of island closures as a conservation measure.

The Industry Respondents misunderstand the purpose of the trade-off mechanism

67. The Industry Respondents appear to entirely misunderstand the purpose and parameters of the trade-off mechanism. This is reflected in the analysis provided by Dr Bergh in his affidavit and which is relied upon by the Industry Respondents

both to oppose the applicants' relief and to defend the rationality of the Interim Closures.

68. At paragraphs 12.6 and 12.7 of his affidavit, Dr Bergh explains that he will address:

> *"12.6 The specific set of closure options selected for weighing-up costs and benefits, and for providing the basis for the trade-off relationship between costs and benefits.*
>
> *12.7 The appropriate way to draw the trade-off curve describing the trade-off relationship between costs and benefits".*

69. The parameters that Dr Bergh sets for himself, however, do not appreciate that the "trade-off" is not a simple weighing exercise between "costs" and "benefits". It is a decision that is weighted in favour of benefits to African Penguins – in other words, any outcome must achieve benefits within a range that will achieve the conservation objective of imposing closures. The Industry Respondents appear to lose sight of the role of closures as conservation interventions (and the Panel's narrowing of the purpose as one to protect African Penguin foraging grounds[62] from anthropogenic interference in the form of competition from industrial fishing).

70. It is thus misleading to suggest that the "*trade-off curve [describes] the trade-off relationship between costs and benefits*". That is not what the curve is designed to do. Rather the curve is used to show which closure option, when compared to all others for a particular colony, achieves an optimal balance between costs to fisheries and benefits to penguins, noting that the purpose of closures is to

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[62] "**AM14**" p 34.

protect foraging grounds and the purpose of the curve is to assist the Minister in identifying which closure to select in meeting her own criteria for such selection.

71. The Industry Respondents' misunderstanding of the purpose of the trade-off mechanism is reflected in the criticisms levelled by Dr Bergh at the trade-off curve. In essence, he complains that it does not meet "standard statistical methods" in accounting for the data plotted on the graphs which are presented in Ms Weideman's affidavit. But, as explained in Dr Christian's affidavit, this is a critical misreading of the purpose of the graphs (or "plots") and this particular type of trade-off curve. It is not the type of graphical exercise used in "standard statistical methods". This is explained in more detail at paragraph 114 below.

The Industry Respondents misunderstand the meaning of "benefit" in the context of the trade-off

72. The Industry Respondents contend that the applicants' understanding and application of the mIBA-ARS method is flawed and place enormous (and undue) emphasis on the Panel's recommendation that the mIBA-ARS should be "validated" using dive data".[63] They do so, apparently, to demonstrate that the relief sought by the applicants cannot be implemented due to scientific uncertainty and, it seems, to also attack the merits of the applicants' claim (although this is not clear). However, they entirely misunderstand the role of mIBA-ARS and the meaning of "benefit" in the context of the trade-off mechanism; the scientific underpinnings for the mIBA-ARS method and the

[63] AA paras 284; 286.

recommendations of the Panel in this regard; and the Panel's recommendations regarding dive data. I address each in turn.

The role of mIBA-ARS in the trade-off mechanism

73. As explained in my founding affidavit, the method referred to as "mIBA-ARS" is a method for determining a spatial area (and location) according to African Penguins' use of foraging habitat. This method underlies the "mIBA-ARS" closure options which are to be assessed for their benefits to penguins and costs to industry – and then compared to the benefits and costs of other closure options including "UD90", "DFFE2021", "CAF", "CAF Industry" and so on. Each closure delineation option thus has costs and benefits i.e. entails some kind of trade-off. The "trade-off mechanism" is the tool to compare these trade-offs to each other in order to find the option which best balances costs and benefits. In effect, the Industry Respondents have conflated the mechanism for comparing closure options with one of the options to be compared.

The Industry Respondents' misunderstanding of the science pertaining to the mIBA-ARS method and the Panel's endorsement of this method

74. At paragraph 126 of the answering affidavit, the Industry Respondents refer to Dr Bergh's affidavit to attack the application of the applicants' mIBA-ARS and UD90 calculations. However, Dr Bergh's understanding of UD90 and mIBA-ARS is incorrect.

75. He states at, paragraph 57 of his affidavit that "UD90 and mIBA-ARS are both understood by me to be the result of the application of the Area Restricted Search

methods to discriminate between foraging and other activity, but they differ in regard to how much of the total foraging area they encompass". This is simply not what is spelt out at paragraph 11 of Ms Weideman's affidavit, namely, that UD90 uses a range of methods published in the set of articles listed at paragraph 11.1 and that "Area Restricted Search" is the method for determining a concentration of foraging effort. The ARS method is not used to determine UD90 – and Ms Weidemann does not say that it does. Given that this error constitutes the premise of Dr Bergh's subsequent analysis, its flaws become self-evident.

76. It is also evident that Dr Bergh's understanding of the purpose of the ARS method and what it identifies is incorrect – and not consonant with African Penguin behaviour. In particular, paragraph 59 of Dr Bergh's affidavit states "*ARS is an acronym for Area Restricted Search and necessarily incorporates a numerical calculation whose aim is to identify and specify areas where penguins forage, to the exclusion of other activities, e.g. transiting*". Dr Bergh clearly does not understand that, given the manner in which penguins feed, transiting and foraging are not necessarily totally distinct activities. Penguins can (and do) forage while in transit.

77. This particular error reflects a key issue in relation to how Dr Bergh and the Industry Respondents appear to understand the entire scientific basis for determining "African Penguin benefits" and what the island closures seek to achieve. Insofar as the Industry Respondents have misunderstood, this is not through lack of clarity in the Panel Report.

77.1 At paragraph 43,[64] the Report states: "The marine habitat available to penguins varies spatially and temporally, with some areas being preferred, given the availability of prey. Determining such preferred areas is important, especially if resource competition with fisheries is a concern". In other words, the Panel states that, in circumstances where a management intervention seeks to reduce competition between Industry and penguins for fish, it is important to identify the areas in which African Penguins prefer to hunt.

77.2 The Report then goes on to state "Estimating areas of preferred foraging habitat can be achieved through numerical spatial analysis of telemetry (tracking) data. Different analytical approaches are available, but in recent years robust methods that identify marine Important Bird Areas (mIBA) have become widely accepted (Lascelles et al., 2016; Dias et al., 2018), including for identification of Key Biodiversity Areas (e.g. Handley et al., 2020)".

77.3 Next, the Report turns to the particular modelling possibilities or "numerical calculations" and recommends "ARS methods" as "*the best scientific basis for delineating the preferred foraging habitats during breeding*". This can leave no room open for claiming that the mIBA-ARS method is in dispute in the context of this case.

78. Dr Bergh also levels criticism at the "*determination of the smoothing parameter*" including inferring that Ms Weideman has deliberately obscured the basis for her

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[64] "**AM14**" p 34.

analysis (referred to paragraph 126.2 of the Industry Respondents' answering affidavit). The argument is a technical one which reveals that Dr Bergh unfortunately does not appear to understand what a smoothing parameter is – as would be familiar to an expert in the field of penguin ecology and behaviour. It is clear that he has not understood the discussion in the Report which is the basis of the approach adopted by the applicants and Ms Weideman's explanations and that he misunderstands the context of the criticisms by "*Dias et al*" on which he relies.

78.1 At page 34 of the Report,[65] the Panel clearly states that the smoothing parameter or so-called "h-value" to be used when calculating marine Important Bird Areas for purposes of determining the African Penguin preferred foraging areas is "ARS" (I underline the relevant text).

> *"Kernel density analysis calculates the density of locations by fitting a bivariate normal function with a pre-defined radius (smoothing parameter, h) around each location and summing up the values to create a smooth density surface. The kernel utilisation distribution (UD) is the isopleth that contains a certain percentage of the density distribution. To obtain core usage areas for foraging seabirds the 50% UD has often been selected (Lascelles et al., 2016). To align the smoothing parameter (h-value) to the scale at which birds use their marine habitat, behavioural characteristics evident within the telemetry data can be used. For example, periods of Area Restricted Search (ARS) when birds are actually feeding, can be identified through First Passage Time (FPT; Fauchald and Tveraa, 2003). Such methods are now commonly used (e.g., Trathan et al., 2008; Scheffer et al., 2010) in the analysis of penguin telemetry data."*

[65] "**AM14**" p 33.

78.2 Moreover, insofar as Dr Bergh infers that Ms Weideman has sought to be obscure, he entirely ignores that her expert affidavit has been provided in the context of this application which addresses the rationality or otherwise of the Minister's decision (as well as whether or not it is lawful) and that her explanations are provided to assist the Court in understanding the relief sought by the applicants. It is not provided as a scientific excursus. In any event, the detailed explanations Dr Bergh appears to require, which pertain to the calculation of foraging ranges and core foraging areas has been detailed in a scientific publication to which Ms Weideman has contributed (attached as "**RA3**"). Here the "h-value" for core foraging areas is again clearly reflected as adopting the Panel's recommended use of ARS, while the smoothing parameter for the full foraging range uses an "h-value" of 7 as per the very publication by Dias et al on which Dr Bergh relies.

78.3 Finally, the reference to "Dias et al" invokes arguments that Dr Bergh presented to the Panel (and which it apparently rejected), including the articles cited at footnotes 19 and 24. To state, as Dr Bergh does, at paragraph 71 of Dr Bergh's affidavit that "*One must conclude… that the scientific literature considers that the choice of h, a critical determinant of the mIBA-ARS is not a settled matter, and at present involves a degree of arbitrariness"* is simply incorrect.[66]

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[66] I note that, insofar as Dias et al provided criticisms in relation not "PTT-Argos-based location data" (see Dr Bergh's affidavit para 67), this is not applicable to the tracking data used by the applicants

The Industry Respondents misunderstand the irrationality of the Interim Closures

79. The Industry Respondents misunderstand the Terms of Reference and Panel findings on future research.

80. Throughout their answering affidavit, the Industry Respondents have adopted the approach that certain research tasks were necessary before the trade-off mechanism could be employed to select closure options.[67] Particular areas of research which the Industry Respondents emphasise are (1) the need for "dive data" to verify mIBAs; (2) the need for improved OBM data; and (3) the determination of the "real" or "primary" reason for African Penguin population declines using the MICE model. Not only is this interpretation incorrect but it is also perverse insofar as it has the effect of enabling Industry to permanently delay implementation of the trade-off mechanism by simply failing to improve the OBM data.

81. I have already addressed the errors pertaining to the Industry Respondents' insistence on dive data above and will address the issue of OBM data below. In what follows, I provide some background regarding the Industry Respondents' insistence on "MICE".

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in the calculations of the mIBA-ARS delineations. There are different types of tracking devices which are used to collect data during different stages of African Penguin life-histories. "PTT-Argos" devices are <u>not</u> used during the breeding season. Instead, seabird scientists use GPS tracks. The telemetry or tracking data used in the calculations of the mIBA-ARS delineations (and, for that matter, in the calculation of the Penguin Utility Index) were collected using GPS data applicable to penguin behaviour during the breeding stage of their life-history (see "**AM63**" para 2.6). Accordingly, the criticisms of Dias et al and Bergh have no bearing on the data (or methods) used by the applicants.

[67] See AA paras 15.2; 15.4.1; 15.4.3; 34; 39; 44; 46; 50; 52.5; 75; 79; 81-90; 101.1-101.2; 104; 116; 121; 124; 126.1, 158; 209; 213.2; 243; 244; 248; 256; 257; 387.

MICE

82. In this context, the Industry Respondents' emphasis on identifying the "primary cause" of African Penguin population declines and emphasis on application of MICE is overstated. It is, in part, linked to a fundamental misunderstanding of the wealth of data and research undertaken by seabird scientists in relation to African Penguins. It also appears to have been invoked to contest the role of competition with fisheries as "a" threat that needs to be appropriately managed.

83. In this regard, it is relevant to note that the Panel's recommendations regarding the development of an ecosystem model is one of a number of research tasks linked to "*Understanding and mitigating reasons for the decline in African penguins due to factors other than fishing near breeding colonies*" (Record p 360). There is no indication that fishing closures cannot (or should not) be imposed while this research is progressed – and this approach would be entirely irrational.

84. Similarly, the emphasis placed by the Industry Respondents on MICE modelling is out of proportion with the priorities given to a range of research areas – and time-horizons for their conclusion. Among the tasks relating to threats to African Penguins, for example (identified in Table 7.1 under heading 3), development of a MICE/integrated ecosystem model, shares priority with testing whether the current Operational Management Procedures (OMP) for sardine is sufficiently precautionary; further research into the impacts of bunkering-related noise on African Penguin foraging behaviour; and research into the relationship between adult African Penguin survival and sardine availability. Of these four "high

priority" research tasks, research into bunkering noise impacts is identified as being required over the short-term with the remainder to be conducted within a time-horizon of up to five years. MICE modelling is thus certainly not the determinant of conservation measures to be taken to intervene in the decline of the African Penguin population.

85. What is abundantly clear is that the Panel contemplated certain future research actions which would serve to refine the input data for the various closure delineations, to be weighed by the trade-off mechanism (for example, dive data validation and refinement of the OBM). These actions are separate from the recommendations regarding the trade-off mechanism, which must be immediately implemented (the Panel having concluded that closures benefit Penguins).

THE INDUSTRY RESPONDENTS' REFUSAL TO ACCEPT THE PANEL'S FINDINGS REGARDING THEIR OWN DATA AND METHODS

The Industry Respondents persist in discredited arguments pertaining to costs to resist relief

86. At paragraphs 17.4, 143 to 145, and 216 to 217 of their answering affidavit, the Industry Respondents assert that the costs to Industry resulting from the Proposed Closures (as opposed to the Interim Closures) militate against the substituted relief sought by the applicants. Significantly, the Industry Respondents do <u>not</u> claim that the "costs" to Industry are relevant to the merits of this application. Nor could they be: the decision taken by the Minister accepted that there <u>would</u> be costs to Industry. Problematically, however, the Minister

failed to adopt the trade-off mechanism to ensure that these were properly taken into account when selecting closures which were fit for conservation purpose.

87. It is important, for the purposes of the Industry Respondents' arguments regarding relief, to address why the "costs" claimed by the Industry Respondents are neither reliable, nor relevant. In doing so, I do not discount the importance of assessing (and minimising) costs to Industry – this is what the Minister had determined the trade-off mechanism should do when she gazetted the Panel's Terms of Reference. Moreover, I do not claim that further research will not provide a more accurate assessment of what short- and long-term socio-economic impacts, if any, are in fact felt by Industry and coastal communities as a result of the closures. However, the scope of such research and impact is not relevant to this dispute.

88. The Industry Respondents costs argument appears to be as follows:

88.1 Taking all six Interim Closures together, *"the direct cost"* to Industry is a rounded-up figure of the rand-value costs which Industry will experience if Interim Closures are imposed, being R89,000,000 per annum (or R90,000,000 or R88,859,113 per annum depending on which paragraph one reads).

88.2 Taking all six Proposed Closures together, *"the direct cost"* to Industry is a rounded-up figure of the rand-value costs which Industry will experience if the Proposed Closures are implemented, being R190,000,000 per annum (or R189,877,010 per annum).

88.3 Using these figures, the Industry Respondents claim that the Proposed Closures will "cost" Industry just more than double the "cost" incurred by the Interim Closures.

88.4 Because the economic impact is "eye-wateringly high"[68] and will "cripple" Industry,[69] it is thus not just and equitable to impose substitution as a remedy.

89. This argument is flawed for a number of reasons related to the calculations used by the Industry Respondents, findings of the Panel regarding the reliability of this data, and information that is notably absent from the calculations put before this Court. I note that footnote 114 at paragraph 143 of the answering affidavit concedes a number of these flaws.

90. First, the Industry Respondents, and Dr Bergh, rely on the outcomes of the Opportunity Based Model (**OBM**) to present their predicted costs. However, the OBM does not model costs in rand-values. Similarly, it does not in fact consider economic impact of closures – whether directly or otherwise (as claimed in paragraphs 17.4 and 143 of the Industry Respondents' answering affidavit). The OBM, estimates percentages of the catch which is "lost" when closures to fishing are in place. It does so by considering, *inter alia*, how much of the catch is "lost" because vessels are unable to "replace" fish they would have caught in the closure areas, by fishing elsewhere. The Panel heavily critiqued the results of

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[68] AA para 17.4.
[69] AA paras 143, 217.

the OBM when discussing the model and its application.[70] Their findings and recommendations include:

90.1 The OBM likely underestimated the potential for opportunities for replacing catch "lost" because vessels could not fish inside closed areas on a particular day;[71]

90.2 The figures representing the percentage of the catch which was "lost" were likely overestimates due to the assumptions built into the model (conceded by the Industry Respondents at paragraphs 49, 143, footnote 114, 299). The Panel highlighted that these assumptions were "restrictive" when considering alternative fishing practices when particular areas were closed (in other words, there were behaviours that fishers might adopt due to their experience and the realities of fishing practice which were unaccounted for by the assumptions in the model).[72] I note that the assumptions used in the OBM data presented in Dr Bergh's affidavit have not cured these defects.

90.3 The overestimates of "lost" catches were "*of uncertain magnitude but may be large*".[73]

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[70] "**AM14**" pp 29-30.
[71] "**AM14**" pp 29; .
[72] "**AM14**" pp 29; 31; 44; 65. See the concessions in this regard at paragraph 143, footnote 114.
[73] "**AM14**" pp 31; 36; 46; 65.

91. Accordingly, the figures on which Dr Bergh and the Industry Respondents rely to estimate the lost catch for each year have been called into question by the Panel as overestimates – and cannot be relied upon.

92. Second, even assuming that the percentage of catch loss figures are accurate (which I deny for the reasons already canvassed), they cannot be directly converted into economic losses or rand value figures as the Industry Respondents seek to do by multiplying the total estimated lost catch by a per-ton rand value. This is because the relationship between "lost catch" and economic impacts is not linear. It is for this reason that SAPFIA commissioned Urban-Econ Development Economists (**Urban-Econ**) to prepare an analysis of the economic costs of closures which was presented to the Panel. The Panel clearly distinguished between the OBM data (at paragraph 3.2 of the Report)[74] which was used to estimate lost catch; and Urban-Econ's "Social Accounting Matrix" (**SAM**) analysis which sought to quantify economic impacts and is considered at paragraph 3.3.[75] It is clear from the Panel's discussion of the SAM that any "direct" multiplication of lost catch data from the OBM by a rand-per-ton figure, is entirely inappropriate as a measure of economic impacts of island closures on Industry and coastal communities linked to small-pelagic fisheries.[76]

93. The Panel's recommendations regarding what is needed to assess socio-economic impacts in the future indicate that there are fatal flaws in the Industry Respondents' claims of costs: no net revenue figures are provided (i.e. it is

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[74] "**AM14**" pp 29-30.
[75] "**AM14**" pp 29-32; 36.
[76] The Report is clear that a simple multiplication of "percentage catch loss" x "cost per ton" is not an appropriate measure of economic impact.

impossible to indicate what the economic costs on revenue of business actually is); the data is calculated as a lump sum and not differentiated by region (let alone community); and the figures which are "constants" do not account for fluctuations over time of other economic variables – including end prices of fish products, how fishers are in fact remunerated, shifts in the fish biomass itself, the impacts of fishing quotas and allocations and so on. It is difficult to understand how an (overestimated) "cost" of R190 million per annum could "cripple" an industry which, on the Industry Respondents' version, is *"sitting at around R5.5 billion at present".*[77]

94. Third, insofar as the OBM and SAM data indicated the impact of closures, this was limited. The Panel indicated that:

94.1 the SAM analysis could only quantify social effects of closures in terms of job losses – not regional economies / GDP;[78]

94.2 the reliability of the results of the OBM estimates had a material impact on the results of the SAM i.e. if the OBM was unreliable (and included large overestimates), any economic analysis produced by the SAM relating to revenue, profit, jobs and so on, would, similarly, reflect a "worse" economic position than would otherwise be the case;

94.3 due to the overestimates in the lost catch data, the OBM should be (1) considered in a relative sense in the context of the trade-off for

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[77] AA para 25.
[78] "**AM14**" p 38 .

purposes of ranking closure options within a region;[79] and (2) is primarily useful as a measure of short-term impacts (as is the SAM).[80] I highlight the Industry Respondents' concession at paragraph 143, footnote 114 but denial at paragraph 301;

94.4 it is necessary to consider catch replacement / lost catch on an island-by-island basis;[81] and

94.5 the OBM data could be used in a "relative" sense, for purposes of ranking closures (see Industry Respondents concession at paragraph 143, footnote 114 regarding the utility of the OBM data "in a relative sense").

95. The Industry Respondents appear to have ignored these findings in the claims they make regarding economic impact.

96. Fourth, as already explained above, the decision to be made by the Minister was not a choice between the Interim Closures and the Proposed Closures, but regarding a decision about what closures achieve the maximum benefit to African Penguins for the least cost to Industry – a question to be answered using the trade-off mechanism recommended by the Panel.

97. Finally, I note that the current closures have been in place since September 2022. It is perhaps noteworthy that Industry has not sought to present the actual

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79 "**AM14**" p 36; 44; 46.
80 "**AM14**" p 44.
81 "**AM14**" p .

costs to Industry as a whole, individual businesses or impacts on coastal communities over the past two years.

THE APPLICANTS' PROPOSED CLOSURES WITHSTAND SCRUTINY AND THE INDUSTRY RESPONDENTS' ATTACK DOES NOT DISTURB THE RELIEF SOUGHT

98. A significant portion of the Industry Respondents' affidavit is occupied by attempting to demonstrate that the scientific basis for the Proposed Closures is flawed – and they do so by relying on Dr Bergh's affidavit.

99. I have already addressed key errors pertaining to the meaning of "benefit" to African Penguins, the weaknesses in the Industry Respondents' own "costs" data and their misunderstanding of the purpose and operation of the trade-off mechanism. What remains is to address the specific attack launched on the Proposed Closures. This is contained primarily in paragraphs 138 to 180 of the Industry Respondents' affidavit. I do not address each and every averment in what follows, simply because much of what is stated is in error, and to do so would amount to an enormous amount of repetition. However, the accuracy of the Industry Respondents' and Dr Bergh's entire analysis should be taken to be denied.

The flawed analytical approach presented by the Industry Respondents

100. The starting point for the Industry Respondents' analysis is to compare "benefits to penguins" and "costs to industry" and to complain that "*Neither the Founding*

Affidavit, nor Weideman, compares the costs and benefits between the Interim Closures and the Applicants' proposed closures".[82]

100.1 I have already explained why the comparative approach undertaken by Dr Bergh does not withstand scrutiny.

100.2 I have also explained the flawed nature of the economic analysis conducted by Dr Bergh.

100.3 However, at paragraphs 138 to 146, the Industry Respondents appear to set out Dr Bergh's comparison again as a precursor to their critique of the analysis provided by Ms Weideman. Accordingly, I provide the comments which follow in this specific context dealing with this section as a whole. My explanations and denials should be taken to apply to the colony-by-colony analysis provided by the Industry Respondents and Dr Bergh.

101. The averments in paragraphs 138 to 146 of the Industry Respondents answer are based on the analysis set out by Dr Bergh at paragraphs 19 to 31 of Dr Bergh's affidavit. This, in turn, invokes the "analysis" submitted to the Minister dated 24 November 2023 which is attached to the founding affidavit marked "**AM76**" and which Dr Bergh acknowledges he authored.

102. There are two important reasons why the applicants question the relevance of these paragraphs to the question before this Honourable Court.

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[82] AA para 138.

102.1 First, the analysis provided appears to be an attempt by the Industry Respondents to contest the findings of the Panel regarding the outcome of the ICE – a matter which is not, and should not be, before the Court.

102.2 Second, insofar as Dr Bergh has presented his approach to measuring "benefit to African Penguins" to the Panel, it was rejected. It moreover contains material errors as already canvassed above.

The attempt to re-open debates

103. The attempt to re-open the debates which were "closed" by the Panel is best illustrated by paragraph 2.1 of the "**AM76**".[83] Here, the "SAPFIA Comments" set out the "benefits of island closures to penguins" as follows:

> *"The IRP's rationale for and conclusions about the benefits for penguins from ICE are noted. SAPFIA notes that the use of these results to infer the benefits at Stony Point and Dyer, St Croix and Bird Island (Algoa Bay) would require extrapolation of results from only two West Coast islands to the other four breeding sites. This is less than satisfactory, particularly given the IRP's recommendations that trade-off decisions should be specific to each breeding site/island.*
>
> *In reaching its estimates of benefits, the IRP effectively disregards the entire body of foraging data collected during ICE and recommends that future improvements be made when collecting and or interpreting such data. These omitted foraging data suggest that the estimates of penguin benefits reported by the IRP for Dassen and Robben Islands are too large."*

[83] "**AM76**" pp 3-4"

104. The clear implication of these paragraphs is to question the conclusion and recommendation of the Panel in response to their task to evaluate the competing analyses of the ICE data which had been subject to contention throughout the JGF, ETT, CAF – and the Panel process itself. In other words, SAPFIA (and Dr Bergh) were seeking to re-open the very debate that the Panel had settled and expressly regarded as "closed".

The errors in Dr Bergh's approach

105. The Industry Respondents appear to conflate the assessment of ICE results and design in terms of an understanding of "benefit" to African penguins, with the Panel's recommendations on how "benefit" should be treated in selecting appropriating closure design and the trade-off mechanism. It is in fact entirely unclear why Dr Bergh undertakes the analysis in paragraphs 15 to 19 of Dr Bergh's affidavit. He seems to be struggling with the question of how to measure "benefit to African Penguins". However, Dr Bergh's efforts are entirely misplaced.

106. The question of what "benefit to African Penguins" means is not in dispute. The Panel was specifically tasked to "Make recommendations about whether a percentage (%) of penguin foraging range and other biological criteria (such as regional representation, population recovery potential, monitoring and evaluation potential) provide a basis for determining benefits from closures for penguins and assess the merits of different proposed methods to delineate important penguin

foraging habitat."[84] At paragraph 4.3 of the Report,[85] the Panel addressed this aspect of the Terms of Reference. Here it made clear that the "benefit" was "protection of the penguins' foraging area".

107. Moreover, paragraph 4.4 of the Report, which discusses the "trade-off space" states, inter alia "Based on the ICE experiment, it is not possible to assign quantitative estimates of the change in population growth rate associated with closed areas that differ from 20km around colonies, but the qualitative changes in benefits to penguins with increasing closure areas are likely robust (increasing at a decreasing rate). Furthermore, for a given total closure area, closures that more adequately reflect preferred foraging areas will have greater benefits than those that simply close less valuable foraging areas".[86]

108. It is these considerations of preferred foraging areas, not increasing numbers of penguin breeding pairs (or the numbers of penguins that "don't die" to paraphrase the Industry Respondents), that is relevant to the trade-off mechanism. Moreover, the considerations regarding area are, as explained above, not simply about "size".

109. Much as Dr Bergh and SAPFIA would like this to be a numbers game, they have simply failed to account for the realities of African Penguin behaviour – and the recommendations of the Panel of experts which do.

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84 "**AM13**" para 5(c).
85 "**AM14**" p 34 .
86 "**AM14**" p 36.

Dr Bergh's four primary complaints

110. At paragraphs 148 the Industry Respondents provide a summary of Dr Bergh's expert analysis in respect of each closure. A careful reading of what appears in Dr Bergh's analysis, however, reflects some important concessions regarding the validity of Ms Weideman's analysis (at paragraphs 111 and 113 to 115 of Dr Bergh's affidavit). In essence, Dr Bergh concedes the validity of Ms Weideman's analysis subject to four primary criticisms – each of which is answerable.

111. First, Dr Bergh repeats his criticisms of the mIBA-ARS delineation.[87] As already explained, Dr Bergh appears not to understand the method which was endorsed by the Panel – nor its role in defining a closure option to be compared with other existing options for the purposes of the Minister selecting a closure which strikes the appropriate balance between benefiting African Penguins and minimising costs to Industry.

112. Second, Dr Bergh complains that the closures to be compared using the trade-off mechanism have not been specified and their selection is arbitrary.[88] However:

    112.1 The Panel made it clear at pages 36 to 37 of the Report[89] that the selection for which the trade-off mechanism is to be used is the set of existing closure options – including mIBA-ARS and UD90.

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87 Dr Bergh's affidavit paras 111.1; 1113.1, 116, 128.
88 Dr Bergh's affidavit paras 111.2; 111.5; 113.2 (and paras 90.1; 90.2; 92.2; 97; 98; 100; 107.1; 108).
89 "**AM14**" pp 36-37

112.2 At paragraphs 15 to 16 of Ms Weideman's affidavit she clearly explains that the closures assessed using the trade-off mechanism are those considered by the Panel with two additions, namely "ETT Industry" and "CAF Industry".

112.3 At paragraph 16 of Ms Weideman's affidavit, she clearly explains that the reasons for including these closure options is that they correspond with closure options relevant to the Interim Closures. In other words, the closure options assessed through the trade-off mechanism include all those before the Panel (including mIBA-ARS delineations and UD90 delineations) and all Interim Closures.

112.4 This is certainly not an arbitrary selection as Dr Bergh contends.

112.5 Moreover, it bears noting that at paragraph 111.2 of Dr Bergh's affidavit, Dr Bergh expresses his critique by stating that closures were "*either arbitrary and/or because they were (selected from only) those for which information was available*".

112.6 Insofar as trade-off curves could not be produced for certain species, it is true that this was due to lack of information provided by Industry.

112.7 Using data that is available to present information for the purposes of the Minister's decision-making is certainly not arbitrary. Insofar as Industry did not provide the relevant data, it cannot now rely upon this to claim that no decision can be made – to do so would put Industry in

the position to indefinitely withhold data to prevent Ministerial decision-making and resolution of the impasse. This is clearly illogical.

112.8 Moreover, the precautionary principle expressed in section 2(4)(a)(vii) of NEMA (and which applies to the Minister's decision) states "*a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions*". I am advised that this decision-making principle applies to precisely the conditions which Dr Bergh seeks to raise to negate the validity of Ms Weideman's conclusions.

113. Third, Dr Bergh complains that the method of "scaling" the values on the two axes is flawed[90] for three reasons: (1) the scaling is subjective; (2) different choices could be made by another analyst (in effect, is insensitive to other factors); and (3) the scaling used on the axes could influence the position of the "balance point" (the yellow dots on the graphs in Ms Weideman's affidavit). This, in turn, could affect the optimal closure that each graph reflects.. I refer to Dr Christian's affidavit which explains that in the context of the purpose of the trade-offs (which Dr Bergh appears to misunderstand) as well as the recognised method which was adopted, these criticisms lack foundation.

113.1 It is simply incorrect to consider that any trade-off analysis would be entirely "objective" in the sense that the Industry Respondents seem to contemplate. Inherent in a trade-off and the scaling adopted is the

[90] Bergh affidavit paras 12.5; 13.3; 82; 90.3; 92.3; 95; 99; 104; 107.2; 109.1; 111.3; 111.5; 113.3; 119 (Dassen Island); 129-130 (Dyer Island); 137 (St Croix Island); 138 (Bird Island).

need for compromise (which the Industry Respondents acknowledge) and some set of assumptions about "preferences". Given the scientific data available, the scaling used was that which limited bias to the greatest extent possible and was most consistent with the Panel's recommendations. It was therefore entirely appropriate to use the values that we did. In any event, as Dr Christian illustrates, relatively simple questions can be asked to mitigate any concerns regarding these values. Moreover, it does not lie in Industry's mouth to rely on the very data that it has not provided to claim that the trade-off cannot be implemented.

113.2 Moreover, Dr Christian points out that this argument suggests that Industry has been prejudiced through the scaling adopted. However, this argument could apply equally to African Penguins (as some colonies are larger or more vulnerable than others for instance).

114. Fourth, Dr Bergh complains that the applicants have not explained how the "trade-off curves" that are used in the trade-off mechanism are constructed. The essence of his complaint appears to be that Ms Weideman has not applied "*recognisable statistical methods*" and "*contain unexplained features which are arbitrary or subjective*".[91] There appear to be two components of Dr Bergh's complaint: (1) the selection of closure options to use in the analysis are arbitrary; and (2) his difficulties with the method for drawing the trade-off curve.

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[91] AA para 128; Dr Bergh's affidavit paras 13.5. See also paras 12.7; 92.1; 93; 107.3; 109.2; 111.4; 111.5; 113.4; 117 (Dassen Island); 125-126 (Robben Island); 137 (St Croix Island); 138 (Bird Island).

114.1 I have already explained the basis for selecting closures and why this was not arbitrary in the circumstances.

114.2 In respect of the method for drawing the trade-off curve, Dr Bergh makes a number of incorrect assumptions: primarily related to confusion between "standard statistical methods" and their purpose, and the purpose of the type of curve recommended by the Panel and its application in the applicants' trade-off analysis.

114.3 As Dr Christian explains in his expert affidavit, "standard statistical curves" are used for purposes of describing an entire data set (and thereafter to draw certain inferences). By contrast, the purpose of a trade-off curve is not to describe a full data set, but instead to help a decision-maker make a choice about which closure option (represented as a plot point) would be the best option in terms of the pre-selected parameters (in this case "maximising penguin benefit" and "minimising Industry cost).

114.4 From a practical perspective, when "drawing" the curve, it is not necessary to account for options that clearly will not be viable, i.e. if an option will have such enormous costs or such tiny benefits that they can be discounted, the curve need not "pass" through these points (which would be the case with the "standard statistical curves" that Dr Bergh references).

114.5 As Dr Christian points out, the method used to construct these curves uses the concept of the "Pareto front" or "efficiency frontier". Using this

method was not arbitrary, but rather justified by the Panel's referral to Halpern et al., 2023 which utilised this approach.

115. The fact that Dr Bergh's "reservations" are ill-founded, is destructive of the remainder of his criticism of Ms Weideman's colony-by-colony analysis.

AD SERIATIM RESPONSE

116. I now respond, to the extent necessary, to specific paragraphs of the Industry Respondents' answering affidavit. Where I do not respond specifically to any aspect of their affidavits, it is to be taken as denied to the extent it is not consistent with the contents of this affidavit and the applicants' founding and supplementary affidavits.

117. I do not respond on an ad seriatim basis to Dr Bergh's affidavit, as the errors in his approach are dealt with extensively above. Suffice it to state that I deny the contents of his affidavit to the extent it is not consistent with the contents of this affidavit, the applicants' founding and supplementary founding affidavits and the applicants' various expert affidavits.

AD paragraph 3

118. I note that Dr Bergh's expertise lies in quantitative resource assessment analyses and, in particular, the management of small pelagic and demersal fish stocks including advising and liaising with South Africa's fishing industry and developing "*alternative harvesting strategies and approaches where appropriate*

in consultation with these bodies".[92] Such expertise differs from that of myself and Ms Weideman who specialise in seabird (and particularly African Penguin) ecology.

AD paragraph 6

119. The decision relates to closure areas around six African Penguin breeding colonies, five of which are islands. Stony Point is a land-based colony.

120. I note the Industry Respondents' concession that the purpose of the island closures is to serve "*as a measure to conserve the penguins*". In particular, the Panel clarified that the "*purpose of closing areas around penguin colonies is to protect penguin foraging habitat"*.[93] In other words, the conservation measure at the heart of this dispute is to further the conservation of African Penguins by protecting their foraging habitat. The harm sought to be prevented through this conservation measure is competition with industrial fishing of African Penguin prey, namely, sardine and anchovy.

AD paragraph 7

121. I deny that the applicants' Proposed Closures are, in all cases, "*greater extents of island closures*". This is clear from the maps presented in Ms Weideman's expert affidavit, the founding affidavit (which notes the error relating to the Interim Closure at Dyer Island which is not in fact "DFFE2021" but "Industry CAF" reflecting a split fishing zone as I explain in paragraphs 97.1 and 172 to174 of

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92 Dr Bergh's Affidavit paras 4; 10.
93 "**AM14**" p 34.

the founding affidavit) and at paragraph 44 of Dr Bergh's affidavit as well as in the figures in Table 13 at para 82 of Dr Bergh's affidavit.

AD paragraph 9

122. I admit the contents of this paragraph insofar as it accurately reflects the origins and purpose of the ICE.

AD paragraph 11

123. I admit the contents of this paragraph insofar as it accurately reflects the contents of the Terms of Reference.

AD paragraph 12.1

124. I note the Industry Respondents' concession that the Panel found that data from the ICE demonstrated that fishing closures around breeding colonies is likely to reduce the rate of population decline. I note, however, that they seek to limit the findings of the Panel by (1) failing to explain why the Panel focused on the ICE findings at Dassen and Robben islands (which produced the most reliable data especially in relation to data that could inform population benefits); and (2) by emphasising the Panel's reference to a "small extent" without contextualising how even this small extent is in fact meaningful in the context of assessing conservation impacts – a matter already addressed above.

AD paragraph 12.2

125. It is correct that the Panel found that island closures needed to be implemented as one of a range of conservation measures as explained above. However, I deny that island closures will constitute "*only a small part of the measures required to slow or reverse the population of the African penguins*". This was not stated by the Panel, nor is it borne out by the results of the ICE as analysed by the Panel, the comparative studies cited by the Panel[94] nor Ms Grigg.

AD paragraph 12.3

126. I deny that this is an accurate summary of the relevant text in the Report's Executive Summary or of the underlying Report analysis, conclusions and recommendations. Further, in the context of the impugned decision, it is incorrect to state that "*a trade-off decision is a policy matter*". This is largely because the Minister did not take a decision which purports to apply a trade-off mechanism.

127. However, to the extent the Minister's decision may nonetheless be regarded as one of a policy nature, the applicants deny that this in any way immunises the decision from review on the grounds advanced by the applicants.

128. I also note that the trade-off sought was between maximising benefits to African Penguins while minimising costs to Industry. This does not entail a direct "balance" between harms as the Industry Respondents suggest.[95]

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94 "**AM14**" pp 25-26.
95 See "**AM14**" p 8.

AD paragraphs 12.4 and 12.5

129. I admit these paragraphs insofar as they accurately reflect the contents of the Executive Summary of the Report.

AD paragraph 13

130. The "crux" of the applicants' case is that the Minister failed to make a decision which could survive scrutiny against the standards of rationality and lawfulness.

AD paragraph 14

131. I deny that the Industry Respondents have demonstrated that the applicants' case is flawed. I refer to what I have said above in this regard.

AD paragraph 15

132. I deny the contents of this paragraph.

AD paragraph 15.1

133. I deny the contents of this paragraph. I refer to what I have said above in this regard.

134. The Industry Respondents repeat the claim that the Panel did not fulfil the Terms of Reference elsewhere in their answering affidavit (see paragraphs 290; 371; 388; and 410). At paragraphs 290 to 296, the Industry Respondents state that the Panel did not fulfil the objectives set out at paragraphs 2(a), 2(c), 2(c)(a), 2(d), 5(c) of the Terms of Reference (noticeably omitting paragraph 5(d)).

135. If this is the case, it is curious that the Industry Respondents have not taken issue with the fact that the Naidoo Memo ignored the requirement of the Terms of Reference to make recommendations in terms of these provisions as I set out at paragraph 39 of the supplementary founding affidavit.

136. Further, in denying that the Panel fulfilled its purpose, the Industry Respondents concede that the Panel was called for the purposes of establishing whether island closes were of benefit to African Penguins and, if so, to provide a trade-off mechanism to determine what closures should be imposed (see paragraph 383). At the same time, they contradict themselves by denying the irrationality of the Minister's decision being based on approvals sought in the Naidoo Memo which are at odds with the purpose of the Panel and its recommendations (para 389).

AD paragraph 15.3

137. The contents of this paragraph are denied. The Industry Respondents conflate the recommendations regarding the best available scientific method for determining African Penguins' preferred foraging range / core foraging areas with the Panel's recommendations regarding a trade-off mechanism.

138. For the reasons set out above, the Panel placed the Minister in a position to adopt a trade-off mechanism with sufficient guidance provided for this purpose in Chapter 4 of the Report. All that was required was to apply this to the delineation options. This was a matter that could easily have been directed by the Minister

139. Moreover, the Panel expressly recommended that the best available scientific method for determining the core foraging areas of the African Penguins, namely mIBA-ARS – and delineation options based on this method -- have been prepared by the applicants (and were considered by the Panel as well as subsequent peer-review).

AD paragraph 15.4

140. I deny that further research was required in order to take a trade-off decision. I refer to what I have set out above in this regard. I also deny that the purpose of any validation is to provide objective identification of foraging locations, rather than commuting or travelling locations. I refer to what I have said above in this regard.

AD paragraph 15.4.1

141. I deny that the Panel found that mIBA-ARS should first be validated by means of dive data before being used in trade-off analyses.

142. I note the concession that the Panel found that "delineating mIBA-ARS represent the best scientific basis for delineating the core area of foraging habitat during breeding."

AD paragraph 15.4.2

143. I deny this allegation for the reasons explained above.

AD paragraph 15.4.3

144. I admit that further data must be gathered for purposes of refining the OBM. In fact, the data regarding costs to industry was heavily criticised by the Panel, including as likely being an overestimation.

145. It is for this reason that the Panel indicated that the OBM data could be used in a "relative sense" – in other words comparing the (flawed) data applicable to different delineation options in a ranking / comparative exercise. This did not preclude immediate implementation of the trade-off mechanism that was recommended. If that were the case, the Panel would not have recommended that the OBM data be used in a ranking / comparative sense.

AD paragraph 16

146. I deny that it was rational for the Minister to extend the Interim Closures for the reasons set out above and in the applicants' previous affidavits.

AD paragraph 16.1

147. I deny that the Panel's Report did not put the Minister in a position to delineate new closure areas. I also deny that the Panel report explained what more needed to be done before new closure areas could be determined.

AD paragraph 16.2

148. I deny that this was the intention behind the Minister's decision. There is no objective evidence to support this assertion. The Naidoo Memo (insofar as it

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provides insight into the rationale for the Minister's decision) did not indicate that Interim Closures were extended because there was no trade-off mechanism recommended by the Panel, nor to enable future research (or monitoring, for that matter). It clearly was based on a preference for consensus: a preference that had clearly run its course.

AD paragraph 16.3

149. The Minister's decision does provide for a review of closures after six years and did impose Interim Closures (subject to alternatives agreed by Industry and the conservation sector). However, there is no evidence that the Minister's decision imposed the Interim Closures in recognition that further research needed to take place in respect of the mIBA-ARS and any trade-off mechanism, nor that closures needed to "wait" for research into "*other causes of the penguin decline*". This is evident from the separate approvals sought (and granted) by the Naidoo Memo.[96]

150. The Panel's recommendations regarding the trade-off mechanism were not contingent on either "monitoring" actions or "future research" being conducted – and there is no evidence that Dr Naidoo or the Minister in fact construed the Panel's recommendations as saying so.

AD paragraph 16.4

151. It is not the applicants' case that the Interim Closures are meaningless because they do not correspond with the Proposed Closures. They are independently

[96] "**SFA9**" pp 10-11.

inadequate. I refer to what I have stated in the founding affidavit regarding the Interim Closures in addition to what is explained above regarding the fundamental errors of Dr Bergh's analysis and his use of area as a proxy for benefit to African Penguins.

AD paragraph 17

152. I deny that the applicants have not made out a case for the relief sought.

AD paragraph 17.1

153. I deny that anything turns on the Panel's suggestion that the determination of island closures is a policy matter for the reasons set out above.

AD paragraph 17.2

154. The contents of this paragraph are denied for the reasons set out above.

AD paragraphs 17.3 to 17.3.2

155. I deny that Dr Bergh's affidavit demonstrates flaws in the applicants' application of the trade-off mechanism – let alone the two flaws that are highlighted in paragraphs 17.3.1 and 17.3.2. As explained above, Dr Bergh has misunderstood the Panel's recommendations regarding mIBA-ARS and the trade-off mechanism (including the interrelationship between the two) and has not appreciated the scientific basis for either.

AD paragraph 17.4

156. For the reasons set out above, I deny that Dr Bergh has demonstrated the "*estimated direct cost*" to the fishing industry – or that the comparison he undertakes is valid or relevant. Moreover, I deny that the alleged costs to Industry presented by the Industry Respondents are accurate, or should militate against the relief sought by the applicants for the reasons provided above.

157. It is curious that the Industry Respondents have sufficient data to estimate their loss of revenues yet claim that there is insufficient data to apply the trade-off mechanism.

AD paragraph 17.5

158. I deny the contents of this paragraph for the reasons set out above. As already explained, the Industry Respondents have misconstrued the import of the Panel's finding on the benefits of closures as a conservation measure and seek to rely on "cost" figures based on methods assessed as unreliable by the Panel. I specifically deny that the comparison between Interim and Proposed Closures urged by the Industry Respondents has any relevance, save to prove the irrationality of the Minister's decision.

AD paragraph 17.6

159. I have already dealt with the Industry Respondents' misunderstanding of the issue before the Court. In this regard, I deny that the Court is called upon to navigate a matter which is "*scientifically complex, polycentric and policy-laden*".

I further deny that the Industry Respondents have shown that the impacts of island closures threaten the "future of their businesses" for the reasons addressed above.

160. I note that the Industry Respondents assert that the role of balancing interests and conservation imperatives is "a role to be played by the expert decision-makers within the Department, who have the unenviable task of weighing all these competing considerations". However, as is abundantly clear from the history of this matter, the "expert decision-makers" within the DFFE proved unable to make this decision which is one of the reasons that the Minister ultimately sought to have the Panel appointed. It is, further, clear from the Naidoo Memo that even with the benefit of the Panel's recommendations, the "experts" within the DFFE still failed to make a determination that did not, once again, delegate the decision to the very Industry and conservation sector whose "interests" were in competition. And while the DFFE's experts failed to decide, African Penguin populations have continued to decline.

AD paragraph 18

161. I deny the contents of this paragraph for the reasons set out above. It is perverse for the Industry Respondents to rely on their own continued disagreement with the scientific position (which is premised on material scientific errors evident in their expert's affidavit and which ignores the issues settled by the Panel) to claim that the "*proposed closures are scientifically contentious, disputed and incomplete*". In any event, even if the Proposed Closures were contentious, disputed and incomplete – which I deny is the case – that would not preclude this

Honourable Court from exercising its just and equitable discretion to direct that they be implemented. The point is that these Proposed Closures flow from the Panel's Report and ought to have been implemented by the Minister as a natural consequence of accepting the Panel's Report.

AD paragraph 19

162. I note the concessions in this paragraph which seem entirely destructive of key pillars of the Industry Respondents' argument on the merits.

162.1 First, by indicating that the Interim Closures offer "benefits to penguins" and should be left in place pending the determination of optimum closure areas, the Industry Respondents appear to concede that closures must be imposed. This is destructive of the Industry Respondents' emphasis on the "small extent" of the benefit, apparently in furtherance of an underlying position that closures should not be imposed at all. Moreover, by conceding the benefit of closures (which in turn acknowledges that fishing does have an impact on African Penguin populations) the Industry Respondents undermine their claims that closures may not be a valid conservation measure.[97]

162.2 Second, by recognising that the trade-off analysis must be performed "*to establish the optimum area for closures*", the Industry Respondents concede both that a "*trade-off analysis*" must follow from this decision and that the Interim Closures are sub-optimal.

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[97] See also AA para 369.

163. In making these concessions, the Industry Respondents effectively concede the applicants' position that the premise of the Minister's decision was whether or not closures were a valid conservation measure and that, if this was accepted, the "*key substantive issue for purposes of the Minister's decision-making related to how those closures should be determined*".[98] This is contrary to their denial in paragraph 370 of their answering affidavit.

164. In fact, the Industry Respondents do not deny that a trade-off was required. They merely offer various (and contradictory) statements regarding the trade-off mechanism, namely (1) asserting (erroneously) that "*a trade-off decision of a policy nature is still required*;[99] (2) that the trade-off mechanism was unclear;[100] (3) that there was no recommended trade-off mechanism;[101] (4) that the trade-off mechanism could not be applied by the Minister;[102] (5) that a trade-off decision requires further data regarding OBM catch data.[103]

165. I repeat that there is no rational basis for the Minister having accepted the recommendation regarding the benefits of closures but not applying the mechanism to ensure that closures achieve a suitable trade-off between their conservation objective (benefits to African Penguins) and their impact on Industry.

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[98] See SFA paras 10-12.
[99] AA paragraph 370.
[100] AA para 120.
[101] AA para 372; 373; 403.
[102] AA para 386.
[103] AA para 387; 391.

AO7

AD paragraph 24

166. The relevance of the Total Allowable Catch (**TAC**) to these proceedings is unclear. The applicants have not challenged the TAC for either sardines or anchovies and this issue was not before the Minister when she took the Impugned Decision. If the Industry Respondents provide this information to demonstrate that there are "plenty fish in the sea", closures which affect where they may fish (not how much they may catch) should not have the dramatic impacts on Industry for which they contend.

AD paragraphs 25 and 26

167. I note that no evidence is provided in support of these figures. They present as no more than the deponent's guestimates.

AD paragraph 27

168. I note the contents of this paragraph, specifically that the small-pelagic fishing sector does not include "small scale fishers" as understood in the MLRA.

AD paragraph 28

169. I cannot comment on the figures provided by the Industry Respondents. However, I deny that the Industry Respondents have demonstrated a "*direct impact*" of island closures on fishing communities, noting in particular, the absence of data in this respect.

AD paragraphs 29 to 30

170. I note that the Industry Respondents do not dispute the purpose of the Panel nor the contestations between scientists and stakeholders which led to the Panel being convened.

AD paragraph 31

171. I admit the contents of this paragraph to the extent that they accurately reflect the contents of the Terms of Reference.

AD paragraph 32

172. I deny that the applicants have created any impression which is not supported by the objective facts. In respect of the claims pertaining to the Panel's failure to fulfil their Terms of Reference, I refer to what I have stated above.

AD paragraphs 33 and 34

173. I deny that the applicants' case is fundamentally flawed for the reasons provided by the Industry Respondents.

174. I note that their contentions are based on paragraph 6.3 of the Report. This deals with "Understanding and mitigating reasons for the decline in African penguins due to factors other than fishing near breeding colonies" and appears in Chapter 6 of the Report addressing "Future Research other than Monitoring".

175. The Report clearly states "Section 6 [of the Report] outlines improvements to data collection and analysis to facilitate an evaluation of the effect of any closures on the fishery and associated communities".[104] Again, I emphasise that the Industry Respondents have conflated the recommendations of the Panel regarding implementation of the trade-off mechanism with recommendations regarding future monitoring and research.

176. By referring to a portion of Chapter 6, the Industry Respondents ignore the recommendations made by the Panel which did respond to the urgent need for determining an appropriate conservation intervention.

AD paragraph 35

177. The applicants do not deny that closures need to be part of a package of conservation measures. However, as I have explained in the founding affidavit, the reason the Panel was called is "contestation" between stakeholder groups. And this included persistent opposition to closures as an intervention from, *inter alia*, Industry. Moreover, I refer to Ms Grigg's affidavit which suggests that closures will likely intervene to reverse the rate of decline.

AD paragraphs 36 and 37

178. I note the concession that the Panel made a set of relevant findings regarding a "trade-off". I deny the remainder of these paragraphs for the reasons canvassed above.

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[104] "**AM14**" p 34.

AD paragraph 38

179. I deny the contents of this paragraph for the reasons set out above.

AD paragraph 39

180. It is not correct that the "Panel identified further research that needs to be done and tasks that need to be performed in order for this poly-centric decision-making to be advanced". I have addressed the role of future research above.

181. It would be entirely irrational to consider that a trade-off mechanism could only be implemented after six years of further research given the urgency attached in the Terms of Reference to precautionary conservation measures (see paragraph 2(b)).

182. On the Industry Respondents' version, it would not be possible for the Minister to take a decision regarding implementation of appropriate closures until at least 2029 (if not later).

AD paragraph 40

183. I admit the contents of this paragraph insofar as they accurately reflect what appears in chapter 4 of the Report. I note that the Industry Respondents ignore key portions of this chapter and the considerations presented by the Panel.

AD paragraph 41

184. The Industry Respondents' summary is selective and thus inaccurate.

185. The Report states:[105] "The purpose of closing areas around penguin colonies is to protect penguin foraging habitat. Relatively little was known about the foraging behaviour of African penguins, especially about their preferred foraging habitats at the start of the ICE. The ICE had therefore been set up using a fixed 20 km radius as the open-closed management option (Figure 1.1). With recently available telemetry data, closures may be designed to achieve a more effective protection of the penguins' foraging area". This statement opens paragraph 4.3 of the Report which deals with quantification of at-sea habitat area.

186. What is important is that penguin foraging habitat is to be protected from competition with industrial fishing. This does not mean preventing fishing operations throughout the habitat of African Penguins. In fact, the portion of the report referenced here deals with precisely how to narrow the spatial area so that closures actually cover preferred foraging areas, i.e. those areas where telemetry data has shown that African Penguins prefer to fish. This is a degree of precision which is overlooked by Industry's synopsis of the "purpose".

AD paragraph 42

187. Again, the Industry Respondents are selective. In consequence, they have altered the import of the relevant text. Critically, they exclude those details which explain the relevance of the timing of data-collection regarding African Penguin foraging behaviour, including the statement that:

[105] "**AM14**" p 34.

"For African penguins, due to their disturbance sensitivities, most information about foraging is only available during the early chick rearing phase when foraging scales are likely to be most constrained. During this period adults can only travel short distances given their need to return to their chick at short temporal intervals. Thus, resource availability during early chick-rearing is critical, given parents are less flexible. Consequently, all estimates of preferred foraging habitat based on tracking data from early chick-rearing are likely to be conservative."

188. This is critical in the context of the recommendations provided by the Panel in this section of the report, i.e. that the approach to quantifying at-sea habitat area should use the mIBAs and the ARS approach – and that this method would produce a conservative preferred foraging range for African Penguins due to the input data being collected at a time when the foraging range is most restricted.

AD paragraph 43

189. The statements made in this paragraph reflect the recommendation corresponding with paragraph 5(c) of the Terms of Reference, i.e. "*Make recommendations about whether a percentage (%) of penguin foraging range and other biological criteria (such as regional representation, population recovery potential, monitoring and evaluation potential) provide a basis for determining benefits from closures for penguins and assess the merits of different proposed methods to delineate important penguin foraging habitat*".

AD paragraph 44

190. I have addressed the Industry Respondents' misunderstanding of the Panel's recommendations regarding mIBA-ARS and dive data above.

AD paragraph 45

191. The findings of the Panel regarding the OBM and SAM data have been dealt with above. I note that the Industry Respondents acknowledge that the Panel found that the OBM "*likely overestimates the potential lost opportunities outside the closed area on a given day*"; and that "[t]*The OBM and SAM model can be used to rank closure options in terms of economic effects*".

AD paragraph 46

192. I admit that further research tasks are identified in respect of lost catches, GPD and economic data in Table 7.1 of the Report. However, I deny that these tasks needed finalisation prior to application of the trade-off mechanism.

AD paragraphs 47 to 48

193. I admit the contents of these paragraphs insofar as they accurately reflect the contents of the Report.

AD paragraph 50

194. I deny the contents of this paragraph for the reasons already canvassed.

AD paragraphs 51 to 52.1

195. The issue of "policy" has been addressed above and, to the extent necessary, will be addressed further in argument. I note that the Industry Respondents regard the Naidoo Memo as evidencing the impugned decision as well as its reasons.[106]

AD paragraph 52.2

196. The Industry Respondents have lifted this statement selectively from paragraph 5.2.1 of the approval page of the Panel Report Workflow ("**SFA9**" to the supplementary founding affidavit). I have dealt with how the Industry Respondents misconstrue the significance of the reduction in rate of decline in paragraph 26.1 above.

AD paragraphs 52.3 to 52.4

197. I have addressed the errors and irrationality pertaining to the Interim Closures above.

AD paragraph 52.5

198. It is denied that the Minister's decision expressly recognised the need for further data collection "because she linked the review of the Island Closures to the further data collection that would take place over the next six years". The

[106] See AA para 372.

Industry Respondents conflate the role of review and monitoring to evaluate closures with further research and scientific improvement.

AD paragraph 52.6

199. The irrationality of the Minister leaving "open the possibility that the conservation and fishing sectors may be able to reach agreement on the delineation of closure areas different to the Interim Closure areas" has been extensively addressed by the applicants in this review. It is denied that six months was provided for such agreement to be reached. I have already addressed the error in the Industry Respondents' contention that future research was the foremost objective in the Minister's decision.

AD paragraphs 53 to 67

200. It is clear that the Industry Respondents "contest" the interpretation of the Panel report. However, it is denied that this is at all relevant to this application. Accordingly, I deny the contents of these paragraphs save insofar as they accurately reflect the contents of the documents to which they refer.

201. I specifically deny the adverse inference that the Industry Respondents level at Adj Prof Pichegru as well as the scientific analysis conducted by the applicants in the Assessment (which the Industry Respondents call the "CSG Assessment").

202. I also deny that "*SAPFIA duly presented*" its submissions to the Minister. As appears from the founding affidavit, SAPFIA provided its Interim Comments and

the "SAPFIA Comments" after delay – and this was certainly not part of an orderly agreed process as the Industry Respondents would represent.

AD paragraphs 68 to 69

203. I have explained how the applicants became aware of the SAPFIA Comments at paragraph 162 of the founding affidavit.

AD paragraph 70

204. To the extent that this paragraph accurately describes the contents of the SAPFIA Comments, its contents are admitted. I deny that the SAPFIA Comments provide a "trade-off assessment" within the meaning of the trade-off mechanism required of the Panel – or at all. Appendix A / Section 6 merely makes statements regarding SAPFIA's understanding of penguin benefits followed by their assessment of costs to Industry. To the extent that these statements have been repeated in the Industry Respondents' answering papers, I have dealt with the relevant averments in this reply.

AD paragraph 72

205. I deny that this paragraph accurately reflects the position taken by SAPFIA (with which the Industry Respondents persist in their answering affidavit). At p 2 of the SAPFIA Comments, the following is stated:[107]

> *"SAPFIA also understand the Minister's decision on closures (Appendix B here) to be the definitive position of the government on closures as*

[107] "**AM76**" p 2.

guided by the current state of knowledge, and that a formal decision based on a quantitative trade-off decision (as recommended by the IRP) is not possible at this time given lack of finality on the cost estimate. Considerable further work informing the quantitative estimates of some of the key inputs into trade-off calculations is required. This includes further work on the OBM model, as well as more work on specifying mIBAs, including along the lines suggested by the IRP. This cannot be achieved in the short (next few months) term and is only feasible in the medium term.

SAPFIA's strongly held view includes that given that the IRP has confirmed that the impact of fishing around breeding islands is small, attention should now rather focus on determining the real reasons for the decline of the penguin population."

206. Curiously, just a few days previously, the Initial Comments (which in substance are the same as the SAPFIA Comments) concluded the opening paragraph with the bold and underlined text stating: "**In SAPFIA's view, given its knowledge and opinion of the economic impacts, and the benefits reported by Punt et al (2023) there should be no closures**."[108]

AD paragraph 73

207. To the extent that this paragraph accurately reflects what appears at paragraph 2.1 of the SAPFIA Comments, it is admitted. However, I deny any implication that the contents of this paragraph accurately reflect the Panel's recommendations. In particular, I deny the claim that "*The use of these results to infer the benefits…is less than satisfactory, particularly given the Panel's recommendations that trade-off decisions should be specific to each breeding site/island"*. This reflects a misreading of the Panel's recommendations and their

[108] "**AM69**".

A01

import. In particular, it conflates the Panel's interpretation of the results of the ICE with the Panel's recommendations regarding a suitable trade-off mechanism. Moreover, these comments reflect SAPFIA's attempt to contest the findings of the Panel in relation to the ICE – an approach with which the Industry Respondents persist in these proceedings.

AD paragraph 74

208. While the SAPFIA Comments assert that Industry has been collecting additional data, at page 8 the SAPFIA Comments state that "Appendix A summarises SAPFIA's estimates of the cost of closures to the fishing industry and to the economy, based on Bergh et al (2016) and Bergh and Horton (2023), and further information provided to Punt et al (2023) as requested". There is no indication that Automatic Identification System (**AIS**) data – or any other improvements to the accuracy of the OBM data – have in fact been made.

AD paragraph 75

209. It is correct that the SAPFIA Comments discuss the apparent criticisms made by the Panel of mIBA-ARS. However, it denies that SAPFIA's statements are correct. To the extent that these are repeated in the Industry Respondents' answering affidavit, I have addressed the errors in the approach above. I note that the Industry Respondents' understanding of the mIBA-ARS method is critically flawed: it is incorrect that the mIBA-ARS is a "*concept which provides an improved basis for specifying closure areas based on separating transiting and food-searching behaviour*".

AD paragraph 76

210. To the extent that this paragraph accurately reflects the contents of the SAPFIA Comments, it is admitted. However, the description of the "CSG Assessment" is not admitted: it is selective and contains material errors in terms of the understanding of the Assessment and how it applies the recommendations of the Panel. By of example, the statement regarding the impossibility of quantitative assessment of fisheries cost data is misleading: the approach adopted in the Assessment followed the recommendations of the Panel due to flaws in the data provided by Industry. These flaws have not been remedied – however, this does not invalidate the application of the trade-off mechanism in the Assessment and as explained by the applicants in this review. I further deny the attempt at a negative inference by reference to "qualitative" data (a matter I address below).

AD paragraph 77

211. I deny the contents of this paragraph. To the extent that the Industry Respondents have repeated arguments raised in the SAPFIA Comments in their answering affidavit, I have dealt with them extensively in this affidavit. I note that, for the most part, they are either irrelevant to these proceedings – or entirely misconstrue the scientific position and that of the Panel.

AD paragraph 78

212. I deny that any such assessment was undertaken.

AD paragraph 79

213. To the extent that this paragraph reflects the contents of the SAPFIA Comments, its contents are admitted. However, I deny that SAPFIA's views are consistent with the recommendations of the Panel or prove the rationality or lawfulness of the Minister's decision.

AD paragraphs 82 to 90

214. The relevance of the tabling of Dr Butterworth and Dr Ross-Gillespie's MICE document to the rationality or otherwise of the Minister's decision (or its lawfulness) is denied. Similarly, it is unclear how the "tabling" of this proposal is at all relevant to the issue of implementation of island closures as a conservation measure. I have already addressed the relevance of the so-called "small" impact of closures on the rate of population decline, and how MICE pertains to future research recommended by the Panel, and not immediate implementation of the trade-off mechanism. It is not denied that it is necessary to identify and ameliorate all factors which are contributing to African Population decline. However, it is not conceded that it is rational to delay conservation interventions regarding competition with Industry in a quest to identify some other threat – and then to ameliorate that threat without intervening to address competition with Industry.

215. In the context of this application, it is thus not necessary to respond to each and every averment made by the Industry Respondents regarding the "2024 MICE documents".

AD paragraph 86

216. I note that the "PSSWG" has not been formed by the DFFE – more than a year after the Panel's Report was provided to the DFFE and the Minister, more than a year after the Minister took her decision, more than a year after this decision was announced, and more than a year into the "one-to-two" year time-horizon identified by the Panel for refinement to the estimated effects of closures on catches, GDP and jobs through improvements to the OBM and SAM data; the need to summarise between-year variation of mIBAs, investigation into the impacts of bunkering as well as various monitoring actions spanning the entire period (which are ongoing) and improvement to communication and collaboration.[109]

AD paragraph 88 to 88.3

217. I note that of these hypotheses, only the issue of the effect of fishing on forage food availability remains "unmanaged" (subject to the closures now in place which are subject to this application). The management of the long-term impacts of historic guano harvesting is comprehensively managed through artificial nest boxes.[110] "Problem seals" are similarly managed by the DFFE and the conservation management authorities.

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[109] "**AM14**" p 45.
[110] "**AM14**" pp 13; 14; 43; 45; and 61; .

AD paragraphs 89 to 90

218. The importance of the MICE approach to the issue of island closures is denied. I have dealt above with why the Industry Respondents' emphasis on MICE is misplaced.

219. The Panel indicated that the competition with fisheries could not be removed as a hypothesis in terms of threats to African Penguin declines, based on the available data and their analysis of the ICE. It is for this reason that the island closures remain a valid conservation intervention – which needs to be implemented in a manner which is meaningful, fit for purpose and rational.

AD paragraphs 91 to 93 and paragraphs 96 to 98

220. I note that the correspondence attached as "**MC6**" was addressed to the DFFE and did not include myself or other seabird scientists (or data holders) in copy.

221. I deny the inference sought to be drawn that BLSA or myself were being obstructive – or that the data was requested for the purposes of "*further scientific deliberations*". In fact, the e-mail from Dr Bergh to Dr Naidoo states "*I am therefore submitting a request via you that these data be made available to participants in the scientific deliberations including myself and my colleagues at OLSPS…. There are certain critical investigation which hinge on having access to these data"*. The nature of such investigations or the purpose for which the data was to be used was not specified. This is particularly relevant as the African Penguin tracking data and relevant R code relate to areas of scientific expertise which do not fall within the ambit of the expertise of Dr Bergh nor his staff.

222. In fact, as appears from paragraph 96 of the answering affidavit the purpose of the data request was "so that an independent scientist could understand how the mIBAs are calculated and to repeat those calculations to check their veracity, as is the standard scientific process". It is entirely unclear why OSLPS and/or SAPFIA should seek to establish such "veracity" when the mIBA-ARS data had been presented to the Panel (which included experts in seabird science) and had been analysed by seabird experts (including myself). The inescapable inference is that OSLPS and SAPFIA wished to interrogate the data so as to undermine its credibility and/or the expertise and skill of the community of seabird scientists – including myself – whose core expertise lies in this particular area of science.

223. In any event, when the request was relayed to me via the DFFE, I made it clear that the reason for not providing such data was that the reason for the request was unclear (this was not conveyed to myself) and that the data was subject to imminent peer review. This response is reflected in paragraph 98 of the Industry Respondents' affidavit. In the interim, the data has been made available together with the published and peer-reviewed article to which I referred. For the sake of clarity:

223.1 the data is available at Github:https://github.com/amcinnes723/African-Penguin-No-take-zones.

223.2 Tracking data for inputs into the code for the delineation of core foraging areas (mIBA-ARS) and foraging ranges (mIBA-UD90) can be accessed with permission from data providers for each colony at BirdLife International's Seabird Tracking Database:

223.2.1 Dassen Island https://data.seabirdtracking.org/dat aset/2212;

223.2.2 Robben Island https://data.seabirdtracking.org/dataset/2213;

223.2.3 Stony Point https://data.seabirdtracking.org/dataset/2214;

223.2.4 Dyer Island https://data.seabirdtracking.org/dataset/2217;

223.2.5 St Croix Island https://data.seabirdtracking.org/dataset/2215; and

223.2.6 Bird Island https://data.seabirdtracking.org/dataset/2216.

AD paragraph 100

224. The contents of this paragraph are denied. The applicants, together with other seabird scientists, have continued to analyse and work with the data requested by OSLPS and SAPFIA including by attending to the short-term research task of analysing between-year variability. The improvements required of the OBM and SAM data do not depend on the data in question – which in any event is not all "owned" by BLSA. I pause to note that Industry has not made any of its actual financial data available (to the applicants' knowledge) throughout the many years of debates regarding the costs of closures to Industry but instead relied only on predictive modelling (which has been critiqued by the Panel).

225. Moreover, the relevance of OLSPS / SAPFIA's insistence on obtaining the tracking data is entirely unclear.

AD paragraphs 94 to 95 and 101

226. I note that until receipt of the Industry Respondents' answering affidavit, the applicants were unaware of the Minister's letter of 14 January 2024. I flag that, to date, the conservation sector has received no substantive response from the Minister to the Assessment save an acknowledgment of receipt dated 18 January 2024 (attached as "**RA4**"). This is despite the Minister clearly having engaged in SAPFIA's critiques of the Assessment in her letter of 14 January 2024.

227. In respect of the letter itself, this appears to be the origin of the Industry Respondents' theory that the delay in implementing the trade-off mechanism was for purposes of conducting future research. That this might have been the Minister's position at the time the decision was taken is not evident from the Rule 53 Record, is not evident in the Minister's approvals of the Naidoo Memo and is not evidenced by the announcement of the Minister's decision – and is entirely irrational for the reasons set out above.

228. Moreover, I note that the letter thanks Mr Copeland for "*accepting my proposal on continuing with the interim closed areas while additional science is being undertaken*". Neither the Industry Respondents, nor the Rule 53 Record reveal when such proposal was made, however, a clear inference to be drawn is that the Industry Respondents had some influence over the Minister's decision regarding the extension of Interim Closures – particularly in relation to their insistence on the conduct of MICE assessments, a research task the Panel had identified as having a time-horizon of 2-5 years. Insofar as this letter reflects the Minister's reasoning at the time of the taking of her decision (which seems to be

the position contended for by the Industry Respondents), this is entirely unrelated to the advice sought, the urgency of the need for meaningful closures and, moreover, indicates clear bias. For all these reasons, this correspondence clearly highlights the irrationality and unlawfulness of the Minister's decision.

AD Paragraphs 102

229. I note that the Industry Respondents have not seen fit to attach the relevant e-mail (which I have attached as "**RA1**").

230. I note that this e-mail, sent after the 31 December 2023 deadline for agreement states that "In response to correspondence received from stakeholders, the DFFE Branches: Oceans and Coasts and Fisheries Management have agreed to meet during the week of 26 February 2024 with the aim of plotting the way forward based on the current Ministerial decisions as well as the recommendations made by the international Panel of Experts". A first meeting of the envisioned "Penguin Scientific Task Team" was mooted for March 2024.

231. This e-mail says nothing about closure delineations and a reasonable reading of this communication is that the envisaged task team was to address the range of recommendations for "Future Research" contained in Chapter 6 of the Report – and was a response to "Task 5" of Table 7.1. This is particularly so if regard is had to Dr Naidoo's e-mail of 19 December 2023 which indicated that Interim Closures would *"run from 15 January 2024"* (i.e. the start of the 2024 small-pelagic fishing season).

AD paragraphs 103 to 105

232. I deny the contents of these paragraphs save insofar as DFFE representatives have (erroneously) invoked this litigation to avoid furthering the recommendations regarding future research (and I emphasise that this has been in the hands of the DFFE – and not the applicants).

233. The Minister's letter of 14 January 2024 could have had no bearing on the launch of this application. It was not addressed to the applicants, nor did they receive a copy.

234. Moreover, as I have pointed out above, it does not reveal that the Minister understood the work of the Panel or its recommendations at all. To the contrary: it reveals a number of significant errors in understanding the recommendations pertaining to closures; the role of future research; the relative unimportance of the MICE research compared to, for example, the Industry producing reliable socio-economic data and improvements to the OMP.

235. It also displays fundamental irrationality in deferring the implementation of closures until five years have passed (if not more) to engage in the research recommended by the Panel – particularly given the years since the benefits of closures to African Penguins had been identified, the Terms of Reference which emphasised the need for urgent intervention, the time and expense of the Panel, their recommendations and even the approvals she had provided in relation to the Naidoo Memo.

236. Finally, it gives the concerning impression that the Minister bowed to Industry's position.

237. In respect of the February e-mail, this can hardly be said to reveal the Minister's comprehension of the Panel's recommendations regarding closures. It appears entirely unrelated and – moreover – contemplated only a first meeting at an unspecified date in March – a meeting which has not taken place to date.

AD paragraphs 106 to 108

238. The Industry Respondents' opposition is noted. I note that they have not accurately reflected the applicants' review grounds in referring only selectively to the founding and supplementary founding affidavit. Moreover, their reliance on Dr Bergh's affidavit is misplaced for the reasons canvassed above.

AD paragraphs 109 to 116

239. I deny that the applicants' interpretation of the findings of the Panel is fundamentally flawed for the reasons canvassed above.

240. I note the Industry Respondents' denial of the allegations relating to the implementation of closures not being subject to dispute. It is incongruous for the Industry, on the one hand, to endorse the rationality of the Minister's decision to impose the Interim Closures (thus conceding that closures are a necessary conservation measure), while on the other hand denying this (in this regard, the Industry Respondents suggest, in paragraph 113, that closures may not be justified given the costs).

241. I have already dealt with the implications of the Panel's findings that the positive impact on population growth rate may be "small".

242. I note the concession in paragraph 115. However, the qualification provided in paragraph 116 is denied for the reasons already provided.

AD paragraph 117

243. I admit the contents of these paragraphs.

AD paragraphs 118 to 121

244. I have already explained the Industry Respondents' misunderstandings relating to the trade-off mechanism. For these reasons, I deny the contents of these paragraphs.

AD paragraphs 123 to 124

245. I deny the relevance of Dr Bergh's evidence in demonstrating that the Proposed Closures are "*contentious, disputed and incomplete*" or to the merits regarding the rationality of the Minister's decision. In amplification of such denial, I refer to the errors set out above.

Ad paragraph 125

246. I deny that the applicants' underlying rationales and methods would not pass "*any reasonable and independent scientific assessment*". The analysis informing the applicants' legal arguments was submitted to the ICES Journal of Marine

Science on 4 April 2024, accepted on 30 June 2024 and subsequently published on 20 August 2024.

247. The ICES Journal of Marine Science is published by Oxford University Press on behalf of the International Council for the Exploration of the Sea. Publication in the ICES Journal of Marine Science is contingent on peer review and this article was subject to review by two anonymous reviewers.

248. SAPFIA is well aware of this publication. The e-mail from the editor-in-chief attached as "**RA5**" indicates that SAPFIA contacted the journal complaining of an alleged conflict of interest due to the fact of litigation. It can only be surmised that this complaint was raised for purposes of attempting to further discredit the scientific analysis and credentials of myself and the other authors. Pursuant to a meeting with the editor-in-chief, the authors who are linked to this litigation have agreed to amend their "conflict of interest" statements to indicate their involvement. They maintain, however, that this is for purposes of ensuring absolute transparency – and not because this constitutes any "conflict" *stricto senso*.

Ad paragraph 126

249. I deny the contents and inferences of this paragraph. Dr Bergh's affidavit, on which the Industry Respondents rely, seeks to impugn the credibility and reasoning contained in Ms Weideman's affidavit. However, this attempt merely illustrates critical flaws in the reasoning presented by Dr Bergh, including his failure to appreciate core scientific principles relevant to penguin ecology; his misunderstanding of the purpose and objectives of the Panel's tasks; his

misunderstanding of the role and purpose of the trade-off mechanism; and his failure to appreciate the role of mIBA-ARS as a scientific method in the context of delineating island closures. I refer to what I have said in this regard above.

Ad paragraph 126.1

250. I deny the contents and import of this paragraph. Dr Bergh conflates a recommendation concerning method with a recommendation regarding data validation. Moreover, his opinion reflects a misreading of the Panel's recommendation.

AD paragraph 126.2

251. The contents of this paragraph are denied as I have explained above.

AD paragraph 126.3

252. The averments and inferences in this paragraph are denied as already addressed. I specifically deny the inference of potential falsification and the relevance of BLSA providing the computer code and telemetry data to Dr Bergh.

AD paragraph 127

253. I deny the contents and implications of this paragraph for the reasons canvassed above.

AD paragraph 128

254. I deny the averments and inferences of this paragraph. In particular, I deny that the methods used by the applicants and explained by Ms Weideman are arbitrary or biased in favour of conservation interests.

AD paragraph 129

255. I deny that the Proposed Closures are not consistent with the trade-off methodology for "some of the islands". Dr Bergh only takes issue with Dassen Island.

256. It is unclear what Dr Bergh means by the "optimal closed area". However, I assume that he means "optimal in terms of benefits to African Penguins" – as this is what is meant by Ms Weideman's explanation provided in paragraph 27 of her affidavit.

257. Ms Weideman clearly explains why the mIBA-ARS closure, rather than the DFFE 2021 closure, is recommended. She does so with reference to the purpose of closures, the practical implications of spatial geography, and scientific knowledge about the behaviour of anchovies and African Penguins.

AD paragraph 130

258. This statement is denied. There is no omission.

259. As I explained at paragraphs 93 to 101 of the founding affidavit, the Interim Closures were imposed in September 2022 based on a range of previous

proposals. At paragraph 97, I mention correspondence from the DFFE which records the origin of each closure and explains the origin of the Interim Closure at Dyer Island. Moreover, I expressly specify which closure options align with the Interim Closures in the founding affidavit as follows:

259.1 at paragraph 165, I explain that the Dassen Island Interim Closure is the closure option proposed by the DFFE in 2021 i.e "DFFE 2021";

259.2 at paragraph 169, I explain that the Robben Island Interim Closure is the closure option proposed by the DFFE in 2021 i.e "DFFE 2021";

259.3 at paragraph 172, I explain that the Dyer Island Closure includes a split closure including 1) an area that completely prohibits purse-seine fishing inshore, which was originally proposed by Industry during CAF and 2) an area that is open to vessels of 26m (and less), the boundary of which corresponds to the DFFE 2021 proposal.

259.4 at paragraph 175, I explain that the Stony Point closure is the closure option proposed by Industry during the CAF, i.e. "Industry CAF";

259.5 At paragraph 181, I explain that the St Croix Interim Closure is the closure option proposed by Industry during the ETT, i.e. "Industry ETT"; and

259.6 At paragraph 189, I explain that the Bird Island Closure is the closure option proposed by Industry during the CAF, i.e. "Industry CAF".

260. The accompanying maps clearly show where these Interim Closures are the same as the DFFE 2021, Industry ETT, or Industry CAF closure options using dashed dark blue/orange; red/orange; and purple/orange lines. This is clearly explained in the text.

261. In Ms Weideman's affidavit, figures 2, 5, 7, 9, 11 and 13 present the trade-off plots for Stony Point, Dassen Island, Robben Island, Dyer Island, St Croix Island and Bird Island respectively.

262. Each graph presented in these figures reflects the penguin utility score (also referred to as the penguin utility index) and estimated fisheries catch loss for every closure option – including those corresponding with the Interim Closures. This is subject to availability of data – as is explained clearly by Ms Weideman (and Dr Christian in his affidavit).

AD paragraphs 131 to 135

263. Save to note the Industry Respondents' concession of the limitations of using area as a proxy for benefits to African Penguins, I deny the contents of these paragraphs. They flow from Dr Bergh's contention that it is necessary to compare the difference in space between the Interim and Proposed Closures in order for the Court to make its decision – and his flawed assumption that "bigger area equals bigger benefit", or "bigger total area across all closures equals bigger benefit". However, this is not the case as explained above and is an approach expressly rejected by the Panel. I specifically deny the applicants have failed to explain the extent of the "alleged benefit to penguins".

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AD paragraph 136

264. I deny the contents of this paragraph for reasons already canvassed above.

265. The Court is not being asked to carry out the "balance the alleged further benefit [to African Penguins], as against the impact of increasing the closure areas on the small pelagic fishing industry and the local communities they support." The Court is being asked to determine whether the Minister acted lawfully and rationally in terms of what ought to have been done when she took her decision announced on 4 August 2023, and in so acting, to follow-through on the procedure she herself set in motion to put just and equitable measures in place pending a determination by the Minister.

266. I note that the Industry Respondents have not provided any evidence regarding the local communities they claim to support.

AD paragraphs 138 to 142

267. I deny the contents of these paragraphs, save to the extent they accurately reflect the contents of the Panel's Report. The reasons for such denial appear above.

AD paragraphs 143

268. I deny the contents of this paragraph for the reasons already canvassed. I specifically deny that the OBM reflects the "*direct lost value per annum*" and note the concessions made by the Industry Respondents in footnote 114 (as already canvassed). In addition, I note the Industry Respondents have indicated the need for "future research" which will "*take some time to do*". In this regard, I draw

the Court's attention to the requirement of the Terms of Reference that the Panel recommend areas where future research is required and what I have stated above regarding future research.

AD paragraph 144

269. For the reasons set out above I deny the contents of this paragraph.

AD paragraph 145

270. I deny the contents of this paragraph. I note that both Mr Copeland and Dr Bergh rely on figures produced by Urban Econ – and neither purports to hold the expertise to opine on the veracity of these figures. No affidavit from Urban Econ has been placed before the Court.

271. In terms of the Minister's decision-making, she had before her the Panel Report which had assessed Urban Econ's analysis regarding job losses as having limited (if any) reliability. This was not only because it relied upon the data produced by Dr Bergh in relation to the OBM which was assessed as producing exaggerated costs – but also due to significant assumptions and limitations of the model employed by Urban Econ (the Social Accounting Matrix or SAM). It is for this reason, that among the recommendations for future research, the Panel specifically recommended refinement of the SAM over a one-to-two year horizon – ultimately identifying the task of developing and employing an alternative model to capture the relevant data over the six-plus year horizon.

272. It is also why, for the purposes of a recommended trade-off mechanism, the Panel indicated that it was not possible to utilise the SAM data (other than regional figures for jobs which did not assist with colony-by-colony trade-offs as explained in Dr Christian's affidavit).

AD paragraph 146

273. For the reasons canvassed above, I deny the relevance of Dr Bergh's analysis and the contents of this paragraph to the question to be decided by this Honourable Court.

AD paragraph 147

274. I deny the contents of this paragraph, except insofar as it accurately reflects what I set out in the applicants' founding affidavit and what Ms Weideman has set out in her expert affidavit.

275. I specifically deny that Dr Bergh has the expertise to opine on the matters referred to in paragraphs 142 to 170 of Dr Bergh's affidavit. The flaws in his analysis have been dealt with above.

AD paragraph 148

276. I deny that the sections following this paragraph provide an accurate summary of Dr Bergh's expert analysis. I have addressed the Industry Respondents' contentions and Dr Bergh's analysis above.

AD paragraphs 149 to 154

277. I deny the contents of these paragraphs save insofar as they accurately reflect the analysis and averments in the applicants' founding and supplementary founding affidavits and the analysis presented by Ms Weideman in her expert affidavit. I further deny the validity or relevance of Dr Bergh's comparators (particularly in relation to area extent and overlap of the Interim Closure and Proposed Closure) for the reasons explained above.

278. I expressly deny that the African Penguin utility score has not been determined for Dassen Island – either in respect of the Interim Closure or the Proposed Closure.

AD paragraph 155

279. I deny the contents of this paragraph. It is troubling that the Industry Respondents appear to ignore the legal context in which the Minister has taken her decision. In this context, rationality requires that the island closures imposed must achieve their objective as being a meaningful conservation measure. On the Industry Respondents' own version, the Interim Closure around Dassen Island will cause large costs to Industry. One can only assume that if an island closure was imposed that caused such losses and also failed to achieve its conservation purpose, the Industry Respondents would be among the first to point out the irrationality of Ministerial decision-making. That it has not done so, reflects the critical misunderstanding of the legal position and what it is that island closures must do.

AD paragraphs 156 to 157

280. The Industry Respondents conflate the applicants' criticism of the irrationality of the Interim Closures with the results of a systematic decision-making mechanism solicited by the Minister to help her determine closure options. The fact that the DFFE 2021 Dassen Island closure is not based on the best available scientific measure of preferred foraging area does not mean that in all cases any DFFE 2021 closure for any island is precluded from being the option that optimises penguin benefits while minimising Industry costs.

281. Nothing in the trade-off mechanism precluded the resulting analysis indicating that a previous delineation was suitable – in fact, quite the contrary: the mechanism proposed was designed to assess whether one or other of a set of previous closure delineations may entail a trade-off that best balanced the extent to which penguins would benefit and fisheries would carry costs.

AD paragraph 158

282. I deny the contents of this paragraph for reasons explained above.

AD paragraph 159

283. The contents and inferences of this paragraph are denied.

284. The Industry Respondents' reference to a "qualitative argument" infers that there is something inherently problematic with arguments that are "qualitative" or not numerically measurable. This is entirely misleading: models invariably rely on inputs which are, by their very nature "qualitative". Moreover, data that is

observed in the biological sciences is essential if such science is to be "ground-truthed". Similarly, insofar as decision-making processes, such as the one which is subject to this review, use models, they still need to be legally justifiable including in terms of the principles of administrative decision-making and the requirements of rationality and lawfulness.

285. In this context, it is entirely valid to point to well-known and accepted data regarding the southward movement of anchovy along the west-coast – and the consequences of this should the Minister in this case apply the result of the trade-off analysis. This does not invalidate the analysis. It also does not mean that the mechanism recommended by the Panel cannot be implemented.

AD paragraphs 160 to 162

286. I deny the contents of these paragraphs save insofar as they accurately reflect the analysis and averments in the applicants' founding and supplementary founding affidavits and the analysis presented by Ms Weideman in her expert opinion. I further deny the validity or relevance of Dr Bergh's comparators as well as his critiques of Ms Weideman's analysis for the reasons explained above.

AD paragraphs 163 to 168

287. As already explained, Dr Bergh's areal analysis is flawed and for this reason, I deny the relevance of the comparison provided between Interim and Proposed Closure extents.

288. I note the calculations that the Industry Respondents provide regarding the "split" fishing zone. However, this is based on a number of assumptions which are not necessarily supported by the behaviour of local fishers (with vessel sizes under 26m) around Dyer Island which has a particularly high concentration of fishing.

289. The reliability of the updated catch loss estimates submitted by SAPFIA on 24 November 2023 are questionable. These estimates do not include the accompanying methods to identify how they calculated estimated catch losses and, as such, are incomprehensible and could not be used for trade-off assessment. No methods are provided for how the searchability costs have been determined other than the source of the data (i.e. AIS data from vessels). Further, no details have been provided on the parameters used for estimating catch replaceability, i.e. how outside catches are selected to replace catches inside a closure, how often an outside catch can be used to replace a catch inside a closure, and whether alternative catches could be used on the same day or on days before and after the inside catch. Without this information it is impossible to relate these outputs to the data that was provided by the Panel and that was used in the applicants' trade-off assessments. In addition, the updated estimates provided by SAPFIA do not include all the closure options provided by the Panel, such as the estimates for the mIBA-UD90, i.e. the conservation sector's preferred closure options that were submitted to the Panel and that have been used in all trade-off assessments explained in the founding affidavit and in Ms Weideman's affidavit.

AD paragraphs 169 to 170

290. The contents of these paragraphs are denied for the reasons explained above in relation to the flaws in Dr Bergh's areal comparisons.

AD paragraphs 171 to 174

291. I deny the contents of these paragraphs which, once again, rest on the flawed method of areal comparison and which ignore that it is the underlying rationale for closures which determines their rationality – and not their identity as "DFFE 2021" or "mIBA-ARS". In doing so, they critically confuse the applicants' arguments on the merits, with the demonstration of the outcome of application of the trade-off mechanism which goes to the relief sought in this application.

AD paragraph 175 to 176

292. I deny the contents of these paragraphs for the reasons already stated above regarding Dr Bergh's flawed areal analysis.

293. In addition, I note that Figure 11 referenced in the Industry Respondents' affidavit, deals with St Croix Island and not Bird Island which is the subject of these paragraphs.

AD paragraphs 177 to 180

294. The contents of these paragraphs is denied. In particular, I deny their relevance. It is in fact entirely unclear why Dr Bergh has sought to make an argument regarding Marine Protected Areas (**MPAs**) at all. Other than the Interim Closure

around Robben Island, restricted MPA extents were not assessed in the trade-off analysis as these were not among the closure options considered by the Panel, nor those which are in place as the Interim Closures.

295. Insofar as the applicants referred to certain MPAs in explaining the irrationality of the Interim Closures, this was purely to indicate that their objectives are not for purposes of protecting African Penguin foraging areas. This, in turn, explains why it is not possible to assume that an MPA is appropriate in the context of being a conservation measure to intervene in the problem at hand.

296. I note further that the Industry Respondents seek, once again, to raise issues relating to the ICE that have been settled by the Panel.

AD paragraphs 181 to 190

297. Save to admit that the Minister provided her approvals to the Naidoo Memo on 23 July 2023; had, at the time, received the Panel's Report; and that Interim Closures were due to expire at the end of July 2023, I deny the contents of these paragraphs for the reasons canvassed above.

AD paragraphs 191 to 198

298. I have addressed the Industry Respondents' contentions above. I deny that the applicants have not made out a case on lawfulness. I note the Industry Respondents' concession in paragraph 198.1 that the Minister's legal obligation requires her to rationally and reasonably strike a balance between the competing

interests at stake. I contend that had the Panel-recommended trade-off mechanism been applied, this would have been achieved.

AD paragraphs 200 to 203

299. I deny the contents of these paragraphs for the reasons set out above. I note that implicit in the Industry Respondents' defence of the Minister's decision is the concession that island closures should be in place.

AD paragraphs 204 to 209

300. The contents of these paragraphs are denied. The Industry Respondents' contentions are based on the false premise (and Dr Bergh's error) regarding the relationship between scientific advice, policy and decision-making as well as their misreading of the Panel's recommendations (particularly regarding the trade-off mechanism). Similarly, the Industry Respondents simply fail to appreciate the legal and factual context in which the Minister sought and obtained the Panel's recommendations pertaining to closures. These errors have been canvassed above.

301. It is notable that the Respondents state "*The scientists do not agree and they are the experts*". "The scientists" here are Dr Bergh on the one hand and the applicants on the other. The "disagreement" between these scientists was precisely why an international panel of scientific experts was called – and precisely why it is irrational to send the decision "back" to the conservation and Industry sectors. At the same time, the Industry Respondents overstate the case that "*there are on-going hotly contested aspects of the Applicants' approach*".

The "hotly contested issues" arise from the Industry Respondents' (and their consultants') refusal to accept the findings of the Panel, and the error of Dr Bergh's approach has been demonstrated in this affidavit.

302. Moreover, the law does not permit the Minister to endlessly defer for research and analysis to be carried out. This is not necessary in respect of the trade-off mechanism (as demonstrated by the applicants' ability to apply the Panel's recommendations and as explained in Dr Christian's affidavit). This is not necessary in respect of the OBM data (which the Panel stated could be used in a relative sense – although not to calculate rand-value figures). This is certainly not necessary to identify the "real reason" of African Penguin declines based on MICE analyses that the Panel recognised would take up to five years to conduct.

AD paragraph 210

303. This paragraph is denied. The Industry Respondents seem to conflate expertise with legal powers. The Minister has the ability to call for more research, more data and further representations. She has manifestly been doing this since at least 2018 (if not since the commencement of the ICE in 2008 through her Department). The lengthy delays and indecision caused by the exercise of this "ability" is precisely what led to the crisis point which eventually resulted in the calling of the Panel and its work in 2023. It could not reasonably be inferred that the Minister called the Panel, tasked it with providing recommendations – including regarding the matters which had been disputed for years – simply to continue with more rounds of discussion, research and delay.

304. It is clear from the Rule 53 Record that the Minister had before her the Panel's Report and Naidoo Memo. These are before the Court. Moreover, the Court has had the benefit of the information demonstrating the futility of seeking "agreement" – as well as a clear application of the trade-off recommendations of the Panel. All these factors considered together demonstrate why substituted relief is eminently reasonable in the circumstances.

AD paragraph 211

305. As I have explained above, it is denied that the Court is being called upon to make a policy decision.

AD paragraphs 212 to 214

306. I deny the contents of this paragraph. The Industry Respondents have not put up any evidence to indicate that the African Penguin population will not be severely prejudiced should the relief sought by the applicants not be granted. To the contrary, their own evidence shows that the harm to the African Penguin population will be greater if the relief sought is not granted.

307. I agree that the Minister's decision must be considered against a proper account of the Panel's findings. However, I deny that the Industry Respondents have provided such an account. I have addressed the errors in the Industry Respondents' reading of the Report above.

AD paragraph 215

308. I deny the contents of this paragraph. In particular, I note the inherent contradiction in the Industry Respondents' contention which is made in the context of opposing the relief sought by the applicants.

309. The issue of relief arises if this Honourable Court finds that the Minister's decision was irrational and/or unlawful. It is thus illogical to state that "*the impugned decision was a rational result of a complex process. The Minister can make one again, in the event that the decision is set aside*".

310. The Industry Respondents have provided no evidence to show that the Minister would not merely repeat the errors in the decision if not otherwise directed. Moreover, they have provided no evidence to demonstrate that the Minister would be better placed than the Court to determine the proper approach to the question: "If island closures have been shown to be of benefit to African Penguins, what is the trade-off mechanism that should be used to select between the various closure options on the table?".

311. It is for this reason that the applicants have sought substitution of the Minister's decision (by demonstrating the results of the application of the trade-off mechanism). However, should this Honourable Court find that such relief is not suitable in the circumstances, at the very least, it should be clear that the matter cannot be remitted to the Minister without clear parameters to ensure that the irrationality of the decision is not merely repeated and without the Proposed Closures being imposed on an interim basis.

AD paragraphs 216 to 217

312. For the reasons already canvassed above, I deny the contents of these paragraphs.

AD paragraphs 218 to 219

313. I deny the contents of these paragraphs. I specifically deny that the Industry Respondents have shown that the applicants' case for alternative relief is flawed. As argued above, the Industry Respondents have sought to manufacture scientific contention by reopening debates settled by the Panel and through their own expert's misunderstanding of key scientific findings and applications of the science – including in respect of the implications of the trade-off mechanism, its design and purpose. Moreover, as explained above, the purported impact to Industry that is claimed is not supportable.

AD paragraphs 220 to 221

314. I deny the contents of these paragraphs. I specifically deny the suggestion that this application seeks to give "effect to BLSA's vision" or that the applicants "lose sight of the need for sustainable and equitable use of natural resources".

315. There is no inference to be drawn from the Industry Respondents' contentions regarding the composition of the CSG. The Industry Respondents do not deny the applicants' standing to bring this application. That the applicants did so without all the members of the CSG is irrelevant. Nothing turns on the membership of what is, ultimately, a loose grouping of organisations to which

seabird scientists are affiliated and which have, at various times been recognised by the DFFE as the "Conservation Sector Group".

AD paragraph 222

316. I deny the contents of this paragraph. The Industry Respondents' statement is simply bizarre. Dr Sherley's expert affidavit (and the BirdLife International Recommendation attached as "**SFA1**") both reflect that population trajectories likely meet the requirement for reclassification as "*Critically Endangered*" according to IUCN criteria. The IUCN identifies a threat status of "Critically Endangered" as the step prior to "Extinct in the Wild".

AD paragraph 223

317. The contents of this paragraph are denied. The Industry Respondents have simply repeated their mantra regarding a "small benefit" and "more research". Both have been shown to be insupportable by the findings of the Panel as well as the explanations I have provided above. The Industry Respondents have, moreover, entirely misunderstood the legal principle of precaution – a matter that will be addressed further in argument.

AD paragraphs 224 to 226

318. The Industry Respondents have, once again, relied on their own contestation of the scientific evidence to justify the Minister's delays. Scientific contestation is <u>not</u> a basis for failing to adopt precautionary conservation measures. Moreover, the Industry Respondents rely <u>repeatedly</u> on the contestation over Sherley et al

2018. It is clear from the Panel Report (at paragraph 2.2.1) that this contestation has been put to bed and, moreover, was one that had little bearing on the ultimate impacts shown by the ICE and the validity of closing fishing grounds to Industry in order to intervene in the decline of African Penguin populations.

319. Insofar as the Industry Respondents describe the ICE, it is unclear what they seek to demonstrate. The 20km radius used for the ICE closures were in most cases larger than those which Industry now disputes (while not being properly aligned to preferred African Penguin foraging areas). Moreover, on the Industry Respondents' own version, the feasibility study itself demonstrated a "*statistically significant effect could be detected from the analyses of the impacts of purse seine fishing in the vicinities of breeding islands*" which is <u>why</u> the experiment continued.

AD paragraph 227

320. The relevance of the Industry Respondents' statement is unclear – unless it is to point out that yet another scientific process is about to commence to cover the same ground regarding the merits and delineations of closures (as the Industry Respondents' appear to suggest). If so, this is patently irrational and cannot possibly be a lawful response by the Minister vis-à-vis her trusteeship of South Africa's biodiversity and obligations regarding threatened species.

AD paragraph 228

321. I deny the contents of this paragraph and the implication attributed to the applicants. The purpose of the Panel is clear from the Terms of Reference – and

it is nonsensical to suggest that the Panel would make recommendations before considering the evidence. The Industry Respondents appear to envisage an endless round of evidence gathering which is patently irrational and contrary to the principle of basing conservation management decisions on the best scientific evidence available and use of the precautionary principle.

AD paragraph 229

322. The Industry Respondents' denial is noted. It is difficult to comprehend how they can sustain this denial in the face of what appears from the Report. Moreover, this denial is entirely destructive of any claims by the Industry Respondents that it could ever have been reasonable for the Minister to contemplate "agreement" over closures by 31 December 2023.

AD paragraph 230

323. The basis for the Industry Respondents' denial is unclear.

AD paragraph 231

324. The contents of this paragraph are denied. I have addressed the Industry Respondents' criticisms and misunderstandings of the Report above. The rationale for the Proposed Closures appears from the founding affidavit and Ms Weideman's affidavit as supplemented by the explanations I have provided above (including with reference to Dr Christian's affidavit).

AD paragraphs 232 to 233

325. I note the concession that no agreement was reached by 31 December 2023. I deny that such non-agreement was not predictable and could not have been anticipated by the Minister. Moreover, the "review" period on which the Industry Respondents rely, now five years' away, is not a guarantee of revised closures – the Minister's decision says nothing of the sort and in the context of the Panel's recommendations, "review" after a six-to-ten year period was recommended in the context of evaluation of properly designated closure areas in line with the third "trade-off axis" identified by the Panel at paragraph 4.1.[111]

AD paragraph 234

326. I deny that the Industry Respondents have disturbed the grounds of review on which the applicants rely for reasons already set out in this affidavit.

AD paragraphs 235 to 240

327. As set out above, the Industry Respondents have not put up any evidence to displace the unlawfulness of the Minister's decision. If the Minister has not acknowledged that island closures are a necessary conservation measure (as contended for by the Industry Respondents), it is difficult to understand why Interim Closures were imposed from August 2023 (and this would be entirely irrational). Moreover, the Industry Respondents here seem to state that the Minister established the Panel "*to ensure that any decisions made are scientifically justified and demonstrate an appropriate cost benefit trade-off*". I

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[111] "**AM14**" p. 33.

agree. However, she has now not followed the advice of the Panel to ensure such scientific justification or appropriate trade-off if delineating closures – this is a manifest failure to adhere to her obligations to prevent a continuing threat to an endangered species. No amount of reliance by the Industry Respondents on the "policy" nature of the Minister's decision can excuse the failure by the Minister to adhere to her legal and constitutional obligations. For this reason, the applicants persist in this ground of review.

328. I also deny that the applicants have opted to launch court proceedings rather than participate in the Penguin Scientific Working Group. Had such a group been established (which it has not), the applicants would willingly participate. In any event, there is no indication that any such group will be able to address the issue at the heart of this application for which this Honourable Court's intervention is sought.

AD paragraphs 241 to 242

329. The contents of these paragraphs are denied for the reasons explained above. The applicants' relief is set out in the amended Notice of Motion.

AD paragraph 243

330. The Industry Respondents' statements in this paragraph are puzzling. Legal protection does require identification of the main factors causing African Penguin decline and does require efforts to ameliorate those factors. Prey availability has been identified as one of the main factors (if not the main factor) affecting population declines and reducing competition with fisheries a key management

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intervention to address this factor. Moreover, the threat status of the African Penguin appears clearly from what is set out in the founding affidavit, Dr Sherley's affidavit (**AM4**) and the BirdLife International Recommendation (**SFA1**). The dwindling numbers of African Penguins is clear from the annual African Penguin counts. It is clear that the trajectory of population decline likely meets the criteria for uplisting to "Critically Endangered" – and this means that the species is considered to be facing an extremely high risk of extinction in the wild.

AD paragraph 244

331. As pointed out in paragraph 35 of the founding affidavit, the Policy on the Management of Seals, Seabirds and Shorebirds: 2007 is among a series of milestones over the past three decades indicating recognition – including by the DFFE – of the threatened status of the African Penguin and the role of competition with Industry as a threat.

332. There has certainly been extensive research into various threats to African Penguins since 2007 – including through the ICE which was initiated by the DFFE to investigate the impacts of competition with fisheries on African Penguins' population declines. As appears from the Report, the Panel has resolved long-standing disputes over this data raised by Industry, Dr Bergh and Drs Butterworth and Ross-Gillespie.

333. No MICE analyses have been comprehensively undertaken nor verified to date: the documents attached to the Industry Respondents' answering affidavits serving as working documents only and without the benefit of peer-review.

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AD paragraph 245

334. The Industry Respondents' comment is misplaced. The relevance of the CITES listing is recognition of the threat status of the African Penguin in the terms understood in Appendix II of CITES.

AD paragraph 246

335. I note the Industry Respondents' insistence on contestation. However, this does not alter the recognition of the threat, including by the DFFE in the gazetting of the 2013 African Penguin BMP. It is also unclear what the Industry Respondents mean by the "Penguin Working Group" and "Oceans and Coasts" (in respect of the latter, it was not a branch of the DFFE). Moreover, insofar as the Industry Respondents suggest that the ICE was established as a consequence of contestations relating to the 2013 African Penguin BMP, this is demonstrably incorrect. The ICE was initiated by the DFFE and commenced in 2008 as a feasibility study (and later experiment) for purposes of testing empirically whether closures would have benefits to penguins based on prior hypotheses regarding the relationship of prey availability to African Penguin decline.

AD paragraph 247

336. I deny the contents of this paragraph. The Panel did not confirm the "*key scientific input by Dr Sherley et al*" was invalid[112] – although it is correct that Industry contested this analysis (as continues to be the case). The Industry

[112] See "**AM14**" para 2.2.1 at p 17-20.

Respondents cannot rely on their own continued contestation to nullify the scientific evidence that has long been before the Minister.

AD paragraph 248

337. The applicants' focus is on island closures as this is the issue before this Honourable Court. In addition, the Industry Respondents adopt a curious approach that seems to suggest that, because there are multiple conservation measures required to deal with different threats, no measures to deal with competition with Industry should be imposed. This is clearly irrational. Moreover, the Industry Respondents offer only a bare denial in terms of the comparable example of Namibia. The data referenced by the applicants in paragraph 54 of the founding affidavit simply goes to show the material impact of failure to act in respect of prey availability in the only other jurisdiction where the African Penguin is found.

AD paragraph 250

338. I deny the contents of this paragraph. I refer to what is stated above regarding the Industry Respondents' insistence on "small" benefit.

AD paragraph 251

339. I note the concession in this paragraph regarding the Panel having dealt with the ICE results. This is contrary to the Industry Respondents' contentions at paragraph 280 of the answering affidavit.

AD paragraphs 252 to 254

340. The contents of these paragraphs are denied. I note that the Industry Respondents have simply failed to appreciate the findings of the Panel regarding the ICE and the recognition by the Panel of both its findings and limitations. I also note the Industry Respondents' determination to ignore scientific advances in relation to understandings of African Penguin biology, life-cycle and behaviour all of which have been reviewed and confirmed by the Panel. As a consequence, the denials in these paragraphs are inconsistent with the Panel report and have no bearing on the status quo pertaining the Minister's decision – save as to reflect the historic position and the Industry's flat refusal to accept the findings of the best available science.

AD paragraph 255

341. I deny the contents of this paragraph and refer to Figure 1.4 of the estimated total stock biomass of western sardine from 1984 to 2019 at page 12 of the Report.[113] I refer also to the Minister's understanding of the position expressed in the announcement of her decision on 4 August 2023.[114]

AD paragraph 256

342. The Industry Respondents' "disagreement" is noted, however, it does not alter the issue before the Court nor the scientific position.

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[113] "**AM14**", p.12.
[114] See "**AM15**".

343. I note that the Panel Report states in relation to "forage fish abundance" (i.e. dealing with the relationship between forage fish biomass and African Penguin threats): "*Based on the available evidence (de Moor and Butterworth, 2015; Robinson et al., 2015; de Moor, 2021) lower survival and low sardine biomass appears to have been likely to have been one of, and possibly the single, most powerful driver of African penguin population dynamics in recent years, at least at Robben Island.*"[115]

AD paragraph 257

344. I deny the contents of this paragraph for the reasons set out above. The Panel's findings do not confirm that fisheries scientists' views were (or are) correct. I refer to what is set out above regarding the "small" benefit of closures.

AD paragraph 258

345. I deny the contents of this paragraph which bears little relationship to the "conclusions" of AM26 which go to the ETT process and what it considered / did not consider.

AD paragraphs 259 to 260

346. I note the concessions in these paragraphs.

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[115] "**AM14**", p 13.

AD paragraph 261 to 262

347. The Industry Respondents' version of events is noted but not admitted. It is readily apparent that the conservation sector and Industry have, for a considerable period, been far apart in terms of perception and their ability to agree on what in fact has occurred in relation to closures – even when both parties were clearly dissatisfied with the CAF process and both saw an international panel as a means of resolving such dissatisfaction.

348. I deny the Industry Respondents' statements regarding the Interim Closures for the reasons set out above. Similarly, I deny that the Panel "*justified the industry concerns with the prior interpretations of the ICE relied upon by the Conservation Sector Group*". This is simply incorrect[116] as is the contention that it did not provide a "*firm set of clear and consolidated recommendations*".

349. Finally, insofar as the Minister appears to merely have rubber-stamped Dr Naidoo's recommendations in the Naidoo Memo, she certainly did not take an independent decision. Moreover, she provided no reasons for following certain of the Panel recommendations but not others – and certainly none explaining why the trade-off mechanism she had sought should not be applied.

AD paragraph 264

350. The contents of this paragraph are denied. The documents speak for themselves.

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[116] "**AM14**" p 20.

AD paragraph 265

351. I note the persistent refrain of the Industry Respondents of the "small benefit" of closures to Penguins. I have addressed this misconception above.

AD paragraph 266

352. I note the Industry Respondents' view that it is a "misapprehension that a panel could be appointed which would reach an outcome in respect of island closures which everyone, including the Minister, would simply abide by". I deny that the applicants contend that the Minister should have "abided" by the Panel's recommendations. However, to appoint a panel to provide advice and to only partially accept it without clear reasons for rejecting the critical mechanism sought – is plainly irrational. Moreover, if the conservation sector was under the misapprehension that Industry would "abide by" the findings and recommendations of the Panel – so was the Minister as is evidenced by the DFFE statement attached as "**AM43**". In this context, the Industry Respondents' denial of the Panel's conclusions should be carefully considered – it is clear that the Industry Respondents have no intention of recognising their validity.

AD paragraphs 267 to 270

353. It is not denied that there were post-CAF attempts to agree on closures. However, as is clear from the contents of these paragraphs and the correspondence to which the Industry Respondents refer, agreement was <u>not</u> possible. Moreover, the approach taken by Industry (which persists) is one based on calculation of percentages of total closure areas – an approach now

definitively rejected as inappropriate by the Panel. It is similarly clear that the Industry, like the conservation sector, saw the need for an international panel to settle the long-standing scientific disputes. It is thus perplexing that Industry now claims that this was not among the purposes of the Panel and refuses to accept those recommendations of the Panel which do settle such disputes – where they are contrary to the prior positions of Industry.

354. Insofar as the Industry denies the contents of the correspondence and documents referenced in paragraphs 86 to 88 of the founding affidavit, their contentions are denied.

AD paragraphs 271 to 276

355. I admit the contents of these paragraphs insofar as they accurately reflect the contents of the relevant correspondence and report.

AD paragraphs 277 to 279

356. Save to note that the Industry was not happy with the Dassen, St Croix and Dyer Interim Closures, I deny the contents of these paragraphs. The documents speak for themselves and I have addressed the issue of Interim Closures in the founding affidavit and the errors in Dr Bergh's analysis above. I note that the Industry Respondents have not indicated what has changed their position regarding their "happiness" with the Dassen, St Croix and Dyer islands' closures.

357. I note that closures and the outcome of the trade-off mechanism are not about "wins" and "losses" between the conservation sector or CSG and Industry, but

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about the legal obligations on the State to protect threatened species and a means of doing so which is based on the best available science and a rational means of addressing the opposition and competing interests of Industry.

AD paragraphs 280 to 282

358. The contents of these paragraphs are denied. The Industry Respondents appear to put up denials in the face of the plain text of the Terms of Reference and Report. Moreover, if the purpose of the Terms of Reference was not to provide conclusive advice to the Minister after years of "dichotomous views", the question is raised as to what the purpose of the Panel was at all. Moreover, if the Panel did not (as the Industry Respondents contend) fulfil the Terms of Reference, and the Minister did not base her decision on their recommendations, the entire procedure would be irrational from beginning to end (and the Industry Respondents would certainly not be able to contend that it was rational for the Minister to accept the need for future research to determine a trade off on the basis of what the Panel did or did not conclude).

359. In addition, to the extent that the Industry Respondents seek to draw a negative inference from the applicants' highlighting of facts material to the issues which are relevant to this review, such inference is denied.

AD paragraphs 283 to 286

360. I note that in the absence of being able to outrightly deny the findings and recommendations of the Panel, in respect of each recommendation, the Industry

Respondents seek to find a limitation. However, their approach is not supported by the facts as I have explained at length above.

AD paragraph 287

361. The irrationality of the Minister's expectation of agreement is clear from the facts set out in the affidavits to which I have deposed in this application.

AD paragraphs 288 to 289 and paragraph 320

362. I note that the Industry Respondents do not deny the events set out at paragraphs 110 to 111 of the founding affidavit, but then provide a blanket denial of the accuracy of these paragraphs (in paragraph 112). I note further that, at paragraph 320 of the answering affidavit, the Industry Respondents assert that the collapse of discussions pertaining to the Eastern Cape closures is irrelevant (which I deny). In any event, I specifically deny the contents of paragraphs 288 to 289 and 320. The course of events pertaining to the Eastern Cape closures is material in revealing the lack of possibility for consensus between Industry and the applicants and the basis on which the Industry Respondents contend for their irrelevance is entirely unclear.

363. I pause to note that the Industry Respondents go on to complain that the conservation sector sought to "bypass" Industry. However, the Industry Respondents themselves appear to ignore the role of ESCPA/ECPA in denying the presence of Industry at the meeting of 24 October 2023 (when ESCPA's chair, Mr de Maine was present) (see para 353) and in their denials of the import of the collapse of the Eastern Cape closure agreement.

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AD paragraph 290

364. I deny the contents of this paragraph for reasons already canvassed.

AD paragraph 291 to 293

365. I deny the contents of these paragraphs. Paragraph 2(c)(a) of the Terms of Reference clearly refer to "duration of the closures, considering life history traits, e.g., age when most birds start breeding, and associated duration required to signal potential population benefits."

366. At page 33 of the Report, the Panel made two separate recommendations relating to the life-history of African Penguins and various time-periods. Recommendations pertaining to the duration of closures were that they should be year-round (as opposed to, for example, seasonal). Recommendations regarding the appropriate period for review was that review-periods should correspond with breeding age (and the ability to measure other important population traits like survival) i.e. from six to ten years. The Panel did not recommend that the duration of closures should be limited to six to ten years.[117].

367. The Industry Respondents' view, expressed at paragraph 293, is directly contrary to the recommendations of the Panel.

AD paragraphs 294 to 295

368. I deny the contents of these paragraphs for the reasons set out above.

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[117] "**AM14**", pp 33; 46.

AD paragraph 296 to 297

369. I deny the contents of this paragraph as already canvassed.

AD paragraphs 298 to 302

370. These paragraphs are denied. I have dealt with the Panel's recommendations regarding the OBM and SAM data above. I note that the Industry Respondents have been selective in their quotation of the Report. They ignore what is stated in paragraph 4.4 of the Report which addresses the trade-of mechanism[118] i.e. that: *"Given that the OBM analysis likely provides an overestimate of uncertain magnitude of the loss in catch (see section 3.2) and these losses are then used in the SAM analysis, the results on economic costs (lower GDP, jobs) and lost catches should be considered in a relative sense and hence used for ranking closure options within a region."*

AD paragraphs 303 to 304

371. These paragraphs amount to bare denials in the face of what appears in the Report. The Industry Respondents' error pertaining to the Panel's recommendations regarding mIBA-ARS and areas of value to African Penguin foraging has been extensively canvassed above.

[118] "**AM14**", p 36.

AD paragraphs 305 to 310

372. I deny the contents of these paragraphs. The errors in the Industry Respondents' reading of the Report, understanding of "benefits" to penguins, the Panel's conclusions on the ICE, the scientific basis for and findings pertaining to mIBA-ARS, the recommendations pertaining to the trade-off mechanism and the Industry Respondents' approach to "policy" have been addressed above.

AD paragraphs 311 to 313

373. The contents of these paragraphs are denied. As already addressed above, the effect of the Industry Respondents' denials is entirely contradictory in the light of their construction of the Minister's decision elsewhere in their answer. Moreover, their denials are simply insupportable in the face of the clear text of the Minister's announcement as well as the Naidoo Memo (and contradict their own concessions including at paragraph 232 of the answering affidavit).

AD paragraphs 314 to 318

374. It is correct that no agreement was reached between Industry and the conservation sector by 15 January 2024. No agreement has been reached to date. It is bizarre that the Industry Respondents have thus denied that no agreement was reached between August and December 2023: the period during which reaching agreement for purposes of displacing the Interim Closures is material. To the extent that there is doubt about whether the 2023 fishing season ended on the date the 2023 permits expired (31 December 2023) or by the time

the new seasons commenced (on 15 January 2024), this is simply hair-splitting in the face of the fact that no agreement was reached.

375. If the Industry Respondents were waiting for constitution of a working group in order to reach agreement, this is similarly absurd: the DFFE only formally raised the issue of a working group in the e-mail of 21 February 2024 (already attached as "**RA1**"). Moreover, if this was the condition for any agreement to be reached, the inference of inaction or obstruction levelled against the applicants in respect of "bypassing" Industry by seeking to engage with ECPA (one of the two Industry bodies), Oceania and holders of small-pelagic fishing rights; not dealing with SAPFIA directly but providing their Assessment to the DFFE; and "refusing" telemetry data requested by SAPFIA's consultant is simply farcical.

AD paragraph 319

376. The basis for the denial in this paragraph is unclear. It is, moreover, difficult to understand the denial, when the narrative presented by Industry and their denials throughout their *ad seriatim* response indicate the degree to which disagreement existed – to the extent that they express disagreement even in the face of the plain language of documents to which the applicants refer; deny the purpose of the Panel as expressed in the Terms of Reference; the findings of the Panel as expressed in the Report; and the contents of the Minister's decision as expressed in her announcement of 4 August 2023 and the approvals of Dr Naidoo's recommendations of 23 July 2023. If nothing else, this demonstrates the fundamental error made by the Minister that anything had altered a landscape to render agreement between Industry and the conservation sector possible.

AD paragraph 320

377. I have addressed this paragraph at paragraph 362 to 363 above.

AD paragraphs 321 to 329

378. The bases for the denials in these paragraphs are unclear as they either constitute bare denials or contradict what is manifest from the e-mail exchange between Drs Waller and Naidoo. In addition, I specifically deny what is stated in relation to the mIBA-ARS method for the reasons canvassed above. I note the statement that "*the decision was made by the Minister, not the DFFE*" and point out that the extent to which the Minister made an independent decision is doubtful; question the relevance of the "Penguin SWG" to the Minister's decision (and note that no such working group has been established to date); and note the Industry Respondents' position that the six-year review period was not the "monitoring" period. In respect of the latter, if this was indeed the position of the Minister, it highlights the irrationality of her decision as canvassed above. I deny that it was contemplated that a trade-off decision would await a six-year period of research – as already discussed above.

AD paragraph 329

379. The Industry Respondents' denial is baseless: the Interim Closures have, demonstrably, been retained – this appears from the Minister's decision as well as the fact that these are currently in place. Moreover, this is demonstrated by the chain of correspondence referred to in the founding affidavit and to which this denial relates.

AD paragraphs 330 to 332

380. I note the concession that agreement was part of Dr Naidoo's approach (as noted above, the Panel's "encouragement" of consensus is neither here nor there). Insofar as any "further engagement" was required for purposes of ensuring that the Panel's recommendations pertaining to trade-offs were implemented, this is a function of the Minister's flawed decision – and not inherent to what she was capable of determining on the basis of what had been recommended. Accordingly, I deny the contents of these paragraphs. The matter of the DFFE and Minister's legal obligations is one that will be elaborated upon in legal argument.

AD paragraphs 333 to 335

381. The contents of these paragraphs is denied, in particular, the Industry Respondents' allegations of impropriety and assertion of what the Minister's decision "contemplated". The applicants have explained their reasons for engaging with Oceana and the basis for doing so. It was perfectly reasonable for Mr Smith and I to have sought to meet with Oceana under the auspices of the Responsible Fisheries Alliance (**RFA**): WWF-SA convenes the RFA and BLSA and Oceana are members. SAPFIA is not. Given the principles of responsible fishing practices to which Oceana subscribes through the RFA, seeking to discuss voluntary avoidance of fishing in African Penguin preferred foraging areas was imminently sensible in the light of the findings of the Panel and its potential impact on Oceana's fishing practices.

AD paragraphs 336 to 340

382. I note the statements that SAPFIA and ECPA are the recognised industry bodies under the MLRA, however, that not all rights holders belong to these associations. I also note the statement that "*Details pertaining to rights holders could be obtained from information that is tabled at the SWG-PEL and/or from the recent fishing rights allocation process*". The Industry Respondents appear to suggest that the rights holders' details were readily obtainable through the SWG-PEL or from the fishing rights allocation process. However, SWG-PEL is a scientific working group of the DFFE and the fishing rights allocations are provided by the DFFE.

383. It was thus imminently sensible for the applicants to have requested the details of the rights holders through the DFFE to ensure these details were obtained through appropriate channels. Moreover, the Industry Respondents' claims are entirely at odds with the DDG: Fisheries' (and later Minister's) insistence on obtaining these details using a PAIA request: either the details required a PAIA request (in which case, it is reasonable to assume that the same would apply should such details be requested from SAPFIA and/or ECPA) or they did not (in which case the response from the DFFE and Minister misconstrued the law). In either case, ECPA and SAPFIA's denial of intransigence is clearly misplaced: their continued denial of the Panel's recommendations, applicability of the trade-off mechanism and validity of seabird science is evident from their answering affidavit.

AD paragraph 341

384. This paragraph consists of a bald denial: the Industry Respondents have put up no evidence or explanation to displace the conclusions of the applicants.

AD paragraphs 342 to 345

385. I deny the contents of these paragraphs – much of which is repetition. It is entirely unnoteworthy that the applicants sent the Assessment to the Minister and DFFE rather than to Industry. The Minister and her department were the authorities responsible for the impugned decision and its implementation. In any event, the applicants expressly requested that the Assessment be shared with Industry. The "impression" referenced by Industry is erroneous. Their own assessments were sent to the Minister.

386. Further, if as the Industry Respondents contend, the Panel did not make recommendations which could immediately and readily be implemented, and their Initial Comments presented no new data, it is difficult to understand the basis of this Assessment. In this respect, I note that the "assessment" that appears in Appendix A is identical to that in the SAPFIA Comments attached dated 24 November 2023 (which, in all material respects are the same, save as to add further motivation for implementation of the MICE and to remove the telling statement that Industry does not support closures).

AD paragraph 346

387. I deny the contents of this paragraph which in any event has little relevance to the meeting of 24 October 2023 during which the DFFE's incomplete analysis of the Panel's recommendations became apparent. I flag that Dr Naidoo himself alluded to the DFFE's analysis being incomplete in his correspondence attached as "**AM71**".

AD paragraphs 347 to 348

388. The contents of these paragraphs are noted.

AD paragraph 349

389. The Industry Respondents' denial is inexplicable except by taking an extremely literal approach to the meaning of "statement". The e-mail speaks for itself.

AD paragraphs 350 to 356

390. I note that the Industry Respondents admit that they were not preparing an "equivalent to the Assessment" in November 2023. In this context, their claim that the SAPFIA Comments presents a "trade-off" is entirely disingenuous. As to the remainder of these paragraphs, their contents is denied. The import of the e-mail chain attached as "**AM66**" is clear from the face of the correspondence as well as the context in which it was sent. Further, Mr de Maine was present at the meeting of 24 October 2023 (which has not been denied by the Industry Respondents). It is also simply bizarre that the Industry Respondents seek to deny the rejection of island closures given the unequivocal statement in their

Initial Comments. No amount of a contextual reading can change the plain language of this document, nor the entire tenure of the document which was to reject the findings of the Panel at all points where it had appeared to support the veracity of the scientific findings of seabird scientists and the validity of island closures as a conservation measure.

AD paragraphs 357 and 358

391. The basis of the Industry Respondents' denial is unclear. It is evident from what is set out in the founding and supplementary affidavits, as well as this affidavit, that "agreement" or a "viable solution" were impossible. The two sectors are simply too far apart. The merits of further meetings were patently questionable.

AD paragraphs 359 to 360

392. The contents of paragraph 359 are noted.

393. For the reasons set out above, I deny that the Panel failed to make closure recommendations on the bases contended for by the applicants.

AD paragraph 361

394. The complaint raised by the Industry Respondents has no bearing on the issue before this Honourable Court. The "SAPFIA Comments" do nothing to displace the position that as at 31 December 2023, the date on which the "negotiation period" expired, no consensus had been reached. Similarly, the SAPFIA Comments merely demonstrate that Industry has persisted in its claims and in

undermining the findings of the Panel. What is more, to the extent that Industry has relied upon these comments in their answer, I have responded above.

AD paragraphs 362 to 363

395. The Industry Respondents have offered little more than a bare denial. They have placed nothing before the Court to demonstrate that there is a prospect of agreement between the conservation sector and Industry regarding closures (and in fact, their opposition in the answering affidavit demonstrates precisely the contrary). Their contentions regarding the "*need to investigate and address other factors causing the decline of the African penguin population*" has been addressed above.

AD paragraph 365

396. I deny that the Industry Respondents are in a position to legitimately defend the rationality of the Minister's decision. Furthermore, in spite of their resolute effort, they were simply unable to do so in the face of the evidence contained in the record of decision. For the reasons canvassed above regarding the Industry Respondents' attempts to counter the allegation of irrationality, the contents of this paragraph are denied. The applicants persist in their contentions that the Minister's decision was irrational for the reasons set out in the founding and supplementary founding affidavits as further canvassed in this reply.

AD paragraph 366

397. I deny that the Industry Respondents have made out a case for opposing the applicants' relief for the reasons set out above.

AD paragraph 368

398. I note that the Industry Respondents do not dispute the scientific findings regarding the threat status of the African Penguin. In this regard, I refer to the uplisting submission (accepted by BirdLife International) attached to the supplementary founding affidavit as SFA1 which indicates, *inter alia*, that "*In the absence of any evidence of mitigation for the drivers of these declines they are projected to continue at an extremely rapid rate*".[119] The drivers listed include "*food shortages resulting from shifts in the distribution of prey species, competition with commercial purse-seine fisheries and environmental fluctuations*...."

AD paragraph 369

399. The Industry Respondents' concession regarding the benefits of fishing closures to African Penguins is noted. The facts regarding the Industry Respondents' refusal to acknowledge such benefits to date speak for themselves – including in their attempts to destabilise and minimise the import of the Panel's findings regarding the benefits of closures as a conservation measure they raise in their answering affidavit and which I have addressed above.

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[119] "**SFA1**" p 4.

AD paragraph 370

400. As indicated at paragraphs 162 to 165 above, this statement is contradictory.

AD paragraph 371

401. I note that the Industry Respondents do not deny that the record confirms that the Minister accepted the Panel's findings regarding the validity of island closures as a conservation measure. I have dealt with the Industry Respondents' denials regarding the trade-off mechanism and the contention that the Panel did not fulfil the Terms of Reference above.

AD paragraphs 372 to 374

402. The Industry Respondents' contentions in these paragraphs are simply baffling. As already canvassed, a trade-off mechanism was provided by the Panel in Chapter 4 of the Report. This mechanism was sought (and provided) precisely to account for circumstances where consensus could not be reached. It is thus entirely nonsensical to assert that the reason the Minister could not "take a trade-off decision" was the "absence of consensus reached between stakeholders by negotiation". To the extent that the Minister's decision could be construed as requiring consensus over the trade-off mechanism in order for it to be applied, this merely supports the irrationality of action reliant on agreement between parties who had demonstrably been unable to do so since at least 2016 (if not before).

403. With respect to the absence of reasons for the Minister's decision: there simply are none. The Naidoo Memo provides a set of recommendations presented by Dr Naidoo to the Minister which she marks as "approved". Save for the handwritten note regarding the need to extend the Interim Closures for the purposes of announcing the decision, there is no indication of the Minister doing anything more than signing off on endorsing what Dr Naidoo says – her reasons for doing so are simply absent.

AD paragraph 375

404. The contents of this paragraph are denied. Far from failing to acknowledge competing interests, the applicants are keenly aware of the Industry Respondents' interests in limiting closure extents. It is for this very reason that the Terms of Reference required that the Panel makes recommendations for purposes of the Minister achieving a "trade off" between benefits to African Penguins while minimising costs to Industry. It is the very absence of the Minister's application of the recommended trade-off mechanism which is central to the irrationality of the Minister's decision – and the failure by the Minister to follow the parameters she herself had gazetted after input from Industry, the applicants and the DFFE in 2022.

405. Furthermore, the contents of the Minister's correspondence at "**MC7**" are particularly telling in respect of the Minister's bowing to Industry. In this correspondence, the Minister thanks Mr Copeland "*for accepting [her] proposal on continuing with the interim closed areas while additional science is being undertaken*." There are clearly conversations between Industry and the DFFE to

which the applicants are not party, as no such proposal was made to the Conservation Sector.

AD paragraphs 376 to 377

406. The contents of this paragraph are denied. The Minister certainly did not consider a comparison between the Interim Closures and the Proposed Closures and, accordingly, the Industry Respondents' reference to their own (erroneous) comparison is unclear.

AD paragraph 378

407. The Industry Respondents offer only a meaningless bare denial.

AD paragraphs 380 to 381

408. The Industry Respondents' denials are unsupported by the evidence and ignore the urgency of having meaningful conservation interventions in place in the narrow window of opportunity to reverse population declines before 2035. I emphasise that the Interim Closures do not achieve an appropriate balance of maximising benefits to African Penguins while minimising costs to Industry. They certainly do not achieve the conservation objective of preserving African Penguin foraging areas so as to optimise prey availability. Further, they are not consonant with the applicable legal principles including principle of use of best available science and the precautionary principle – a matter which will be addressed further in argument.

AD paragraph 382

409. The Industry Respondents have not explained their denial.

AD paragraphs 383 to 384

410. The Industry Respondents' denials expressed in these paragraphs (insofar as the basis of their denials are understood) have been dealt with at paragraph 399 above. For the sake of clarity, I deny the correctness of the averment regarding the Panel's recommendations pertaining to the merits of island closures and the recommended trade-off mechanism.

AD paragraphs 385 to 387

411. I deny the contents of these paragraphs for the reasons already canvassed.

AD paragraph 388 to 389

412. These paragraphs constitute repetition and have already been dealt with.

AD paragraphs 390 to 391

413. The contents of these paragraphs are denied. As explained above, the Industry Respondents are incorrect in understanding the purpose of the Interim Closures to have been to enable further research. They were imposed in September 2022 to enable the Panel to conduct its assessment and advise on whether closures were of benefit to African Penguins and if so, the trade-off mechanism to be imposed. As explained in the founding affidavit, the Interim Closures do not

follow a clear rationale, do not provide a reliable base for any assessment and are unlikely to achieve their conservation purpose. Moreover, as I explain in the supplementary founding affidavit, whether or not the Interim Closures were fit for their conservation purpose (or of achieving an appropriate balance with Industry interests, insofar as this was the objective of seeking a trade-off mechanism), this was simply not considered by the Minister. This is clearly irrational.

AD paragraph 392

414. This Industry Respondents' denial is noted but unsupported by evidence. Specifically, the Industry Respondents fail to explain the source of Dr Naidoo's explanations – if they do not purport to flow from the Report. Moreover, given that these recommendations were ultimately approved and appear to have formed the basis of the decision, on the Industry Respondents' version, the Minister's decision is even more egregious for having followed recommendations made by Dr Naidoo which had no basis in the Panel's recommendations (nor held out as reporting on them to the Minister). On this version, the Minister would simply have ignored the entire enterprise undertaken by the Panel – a clear exercise in irrationality. This denial certainly does not assist the Industry Respondents in defending the rationality of the Minister's decision.

AD paragraph 393

415. As above, on the Industry Respondents' version, the Minister's decision cannot be defended as rational. However, the contents of this paragraph are denied.

AD paragraph 394

416. This paragraph consists of a bald denial. The inconsistencies in the Naidoo Memo appear from a comparison with the Report and have been outlined in paragraph 53 of the supplementary founding affidavit.

AD paragraphs 395 to 396

417. The Industry Respondents' denial is repetition. I have dealt with their position elsewhere in this affidavit. In respect of their denial of the contents of context of Dr Fikizolo's correspondence speak for themselves. Moreover, there is nothing in the Industry Respondents' affidavit which displaces the applicants' contention that the Record discloses no consideration by the Minister of the adequacy or otherwise of the Interim Closures as conservation interventions (a matter material to the Impugned Decision and the context in which I have referred to Dr Fikizolo's correspondence).

AD paragraph 397

418. The contents of this paragraph constitute a bare denial. It is clear from the approach of the Industry Respondents that they persist in contesting the scientific basis for closure delineations even in their opposition of this review.

AD paragraph 398

419. I deny that the pattern of contention prior to release of the Panel report is irrelevant to the Minister's decision. These were the conditions known to the Minister in July 2023 and her department which ought to have weighed with the

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Minister when considering and approving the recommendation in the Naidoo Memo that agreement could be reached over alternative closures.

420. As is demonstrated by the events between August and December 2023 (as set out in the founding affidavit), the provision of the Panel Report made no difference. Further, notwithstanding the Panel's findings, the Industry Respondents now seek, again, to reopen debates which the Report has resolved.

AD paragraphs 399 to 400

421. The contents of these paragraphs amount to bare denials. The Industry Respondents put up no evidence to support their views – nor could they, there being nothing in the Rule 53 Record other than her comments on and approvals of the Naidoo Memo to explain her decision. Moreover, neither the Minister, nor the DFFE officials has taken the Court into their confidence to provide any further explanation and all that remains is the inference to be drawn from the documentation.

AD paragraph 401

422. The Panel's recommendations regarding the role of closures as a conservation measure has been addressed above. It is clear from Dr Naidoo's correspondence subsequent to the Minister's decision being announced that he understood the Panel to have confirmed that closures were beneficial, that this was reflected in his recommendations to the Minister in the Naidoo Memo and that she approved these recommendations.

423. I note the Industry Respondents' contention that the Panel did not "*make a recommendation which would resolve the impasse*" between the conservation sector and Industry over closure delineations. I repeat that Industry cannot rely on its own rejection of the Panel's findings to claim no appropriate mechanism was recommended.

AD paragraphs 402 to 403

424. The Industry Respondents' denial is unsupported in the light of what appears from the face of the Naidoo Memo. Moreover, I draw attention to what appears to be Dr Naidoo's clear understanding that a trade-off mechanism was recommended as articulated in his correspondence attached to the founding affidavit as "**AM57**".

AD paragraph 404

425. This constitutes a bald denial. I refer to what is stated at paragraph133 to 136 above.

AD paragraphs 405 to 406

426. The Industry Respondents' denials are a repetition. I have already dealt with the baselessness of their contentions above.

AD paragraph 407

427. The denial in this paragraph is noted but not adequately justified. The contents of the relevant documents and correspondence prepared and sent by Dr Naidoo

which are enclosed with this application speak for themselves. In addition to the Naidoo Memo, I draw specific attention to the correspondence from Dr Naidoo attached to the founding affidavit as "**AM57**" and "**AM71**".

AD paragraph 408

428. The Industry Respondents' denial is noted. However, their position is unfounded as canvassed extensively in this affidavit.

AD paragraph 409

429. The contents of this paragraph are denied. The Industry Respondents have not been able to point to reasons for the decision in the Rule 53 Record – nor could they do so as none appear.

AD paragraph 410

430. This is a repetition. I have addressed the issue at paragraphs 133136.

AD paragraph 411

431. I have addressed the lack of logic in the Industry Respondent's denial at paragraphs 134 to 137 above.

AD paragraph 412

432. The Industry Respondents provide only a bare denial without more. The facts speak for themselves.

AD paragraph 413

433. I deny the contents of this paragraph. The facts speak for themselves and the grounds of review will be addressed in legal argument.

AD paragraphs 414 to 418

434. The Industry Respondents provide what amounts to a set of bald denials to counter the applicants' explanation of the Minister's unlawful conduct as set out in paragraphs 85 to 90 of the supplementary founding affidavit (and paragraphs 210 to 215 of the founding affidavit). Similarly, the Industry cannot alter their consistent opposition of the necessity for island closures by simply denying their existence.

AD paragraph 419

435. I deny that the Industry Respondents have made out a case that the application should be dismissed for the reasons set out in this affidavit. The applicants, accordingly, persist in the relief sought in the amended Notice of Motion.

CONCLUSION

436. For these reasons, in supplementation of those contained in the founding and supplementary affidavits, the applicants pray for relief set out in the amended notice of motion.

ALISTAIR MC INTYRE MC INNES

The deponent has acknowledged that he knows and understands the contents of this affidavit, which was signed and sworn to before me at Cape Town on this the 13th day of **JUNE 2024**, the regulations contained in Government Notice No. R1258 of 21 July 1972, as amended, and Government Notice No. R1648 of 19 August 1977, as amended, having been complied with.

COMMISSIONER OF OATHS

Full Names: Wilhelmina Catharina Wicomb

Capacity: Commissioner of Oaths

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"RA1"

From: Tembeka Selani <TMselani@dffe.gov.za>
Sent: Wednesday, February 21, 2024 12:20 PM
To: Kim Prochazka <KProchazka@dffe.gov.za>; Janet Claire Coetzee <JCoetzee@dffe.gov.za>; Carl David Van Der Lingen <CVDLingen@dffe.gov.za>; Fannie Welcome Shabangu <FShabangu@dffe.gov.za>; Nicola Bredenkamp (van Welgen) <Nicola.Bredenkamp@sanparks.org>; Alison Kock <Alison.Kock@sanparks.org>; Ziyaad Erasmus <zerasmus@capenature.co.za>; gabby@seaworld.org.za; Katta Ludynia <katta@sanccob.co.za>; kmmonwa@wwf.org.za; Cloverly Lawrence <Cloverley.Lawrence@sanparks.org>; Trudi Malan <trudi@amaziko.co.za>; lisanupen@gmail.com; judy@aquariumfoundation.org.za; lynne.shannon <lynne.shannon@uct.ac.za>; wsydeman@faralloninstitute.org; Lorien Pichegru <Lorien.Pichegru@mandela.ac.za>; Arne Purves <Arne.Purves@capetown.gov.za>; slsgra001@myuct.ac.za; vhudson@capenature.co.za; faroeshka.rodgers@sanparks.org; nsafe <nsafe@worldonline.co.za>; csmith@wwf.org.za; Johan Visagie <jvisagie@capenature.co.za>; stembe@capenature.co.za; Lauren Waller <laurenw@ewt.org.za>; Leshia Upfold <LUpfold@dffe.gov.za>; copeland.fishconsult <copeland.fishconsult@gmail.com>; Nkosazana Vanto <NVanto@dffe.gov.za>; Bukiwe Mndayi <BMndayi@dffe.gov.za>; redah@oceangrow.co.za; R.Sherley@exeter.ac.uk; Carryn de Moor <carryn.demoor@uct.ac.za>; Johannes De Goede <JDeGoede@dffe.gov.za>; Andrea Ross-Gillespie <andrea.ross-gillespie@uct.ac.za>; Matt@olsps.com; Christina Hagen <christina.hagen@birdlife.org.za>; Eleanor.Weideman@Birdlife.org.za; Alistair.McInnes@Birdlife.org.za; Doug Butterworth <doug.butterworth@uct.ac.za>; sdbconsultings@gmail.com; johann <johann@sadstia.co.za>
Cc: Ashley Johnson <AJohnson@dffe.gov.za>; Gcobani Popose <GPopose@dffe.gov.za>; Millicent Makoala <MMakoala@dffe.gov.za>; Gerhard Cilliers <GCilliers@dffe.gov.za>; Azwianewi Makhado <AMakhado@dffe.gov.za>
Subject: FW: Penguin email to stakeholders

Dear Stakeholders

As you are aware, the Minister of Forestry, Fisheries and the Environment decided on interim closures around colonies of the African Penguin currently facing the distinct threat of extinction. The decision came after exhaustive work done by an international panel of experts that also made some recommendations for consideration on a way forward in order to find a sustainable long term solution to both the conservation of the species as well as those affected within the Pelagic Fishing Industry.

In response to the correspondence received from some stakeholders, the DFFE Branches: Oceans and Coasts and Fisheries Management have agreed to meet during the week of 26 February 2024 with the aim of plotting the way forward based on the current Ministerial decision as well as the recommendations made by the international Panel of Experts. Teams from the two Branches will then proceed with the drafting of a Terms of Reference and proposed members of the to-be-established Penguin Scientific Task Team. Once agreed and approved, the first meeting will then be scheduled within March 2024.

It is the wish of the DFFE to create a balanced view between the two main stakeholders, namely the Conservations and Pelagic Industry and foster a relationship of mutual benefit, as best as possible under the circumstances. Therefore, the DFFE will try and mediate a solution to ensure the best possible outcome.

As soon as the draft ToRs are complete and members are approved by the two Branches, the stakeholders will be kept abreast of all developments as they unfold.

Kind regards
Tembeka Selani

Office Administrator: CD Oceans & Coastal Research

AUY

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CHAIR'S INTRODUCTION TO DOCUMENTS FROM THE TECHNICAL TEAM ON THE PENGUIN ISLAND CLOSURE EXPERIMENT

Kevern Cochrane, Chair, Penguin Island Closure Task Team[1]

1. Introduction and Structure of Overall Report

This report and the associated documents report on the work undertaken and results obtained by the penguin island closure Technical Team (TT) in accordance with the recommendations from the 2015 IWS meeting, in particular recommendation A2, as well as on some preliminary work on A5.

The report includes the following documents in which the details are provided:

MARAM/IWS/DEC16/Peng Clos/P1a and P1b - 'Penguin power analyses using the approach recommended by the international panel: methods and results'.

This includes the methods and results from the statistical power analysis of the island closure experiment undertaken as the response to recommendation A.2 of the 2015 international panel. The power analysis reported in the document is the culmination of work undertaken under the auspices of the TT since its formation in mid-2015.

MARAM/IWS/DEC16/Peng Clos/P2 - 'A Bayesian approach to understand the effect sizes, uncertainty and demographic impact associated with purse-seine fishing closures around African penguin colonies'.

This is a report submitted by Richard Sherley in response to the request by the TT to determine objective thresholds for penguin response variables for use in the power analysis, and as a start towards following-up on Panel recommendation A.5 to use Bayesian methods to fit operating models.

MARAM/IWS/DEC16/Peng Clos/P3 - On the use of aggregated vs individual data in assessment models.

MARAM/IWS/DEC16/Peng Clos/P4 – "Additional analysis suggested in response to differences in variance estimates in Sherley (2016) and Ross-Gillespie & Butterworth (2016)" by Richard Sherley has been provided as background document. It describes a number of analyses that were undertaken to facilitate comparison between the estimates of precision arising from different treatments of data in the analyses described in documents P1 and P2.

Sensitivity of the power analyses reported in P1a and b to the differing estimates of precision (obtained from P4) will be reported as WP1 during the course of the workshop.

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[1]The Task Team consisted of M.O. Bergh, D.S. Butterworth, K.L. Cochrane (chair), T.L. Morris, R.B. Sherley and H. Winker. A. Ross-Gillespie undertook, on behalf of the Team, all the analyses and tests, under the supervision of D.S. Butterworth.

Appendix 1. Relationship between Changes in Penguin Population Growth Rate and Changes in the Fledging Success Response Variable leading to a value for the corresponding Threshold

2. The Process followed by the Technical Team

Implementation of the Panel recommendations involved the following steps:

a. Finalisation of data to be used and standardisation of raw means for co-variates.

No new data were made available for the power analysis further to those listed in FISHERIES/2015/OCT/SWG-PEL/PENG/DATA1 (Janet Coetzee, October 2015). The standardisation exercises conducted are detailed in MARAM/IWS/DEC16/Peng Clos/P1a.

b. Use of OBM to indicate redistribution of catch on closure.

This is addressed in a separate document MARAM/IWS/DEC16/Peng/BG2 (see specific response there to recommendation A.2.10).

c. Identification of effect sizes.

MARAM/IWS/DEC16/Peng Clos/P2 includes a report on investigations into thresholds for chick condition and chick survival data for use in the power analysis. While those analyses provided interesting information on the relationships between effect sizes and mean population growth rate (λ), the TT concluded that the previously agreed value of 1% as the pre-specified change in population growth rate should be retained. MARAM/IWS/DEC16/Peng Clos/P1a describes the relationship between changes in fledgling success and changes in the growth rate of the penguin population and how this provides the basis for estimation of the corresponding threshold given the pre-specified change of 1%.

d. Conduct of computations and results.

These are described in MARAM/IWS/DEC16/Peng Clos/P1a and b

e. The 2015 IWS made recommendation A.5 "Fit the operating models (not necessarily the estimation models) using Bayesian methods…."

MARAM/IWS/DEC16/Peng Clos/P2 reports on initial work undertaken by Richard Sherley to implement this recommendation.

3. A question on use of data for the power analysis: aggregated or individual data?

An important difference between the analyses reported in MARAM/IWS/DEC16/Peng Clos/P1a and b and MARAM/IWS/DEC16/Peng Clos/P2 is in the data that were used in each. In the case of the power analysis (MARAM/IWS/DEC16/Peng Clos/P1a and b), the approach used fits the operating model and the estimation model to the annual means of the data, as had been agreed by the TT and Panel. For the analyses reported in MARAM/IWS/DEC16/Peng Clos/P2, the individual observations were used. Opinions within the TT differ on which approach is better but, for the case for which a comparison was possible from the original documents, it seems likely that the different approaches lead to considerable differences in the measure of precision for the closure effects. This would be

likely to influence the results of a power analysis. The TT noted, based on the results available in these two documents for which comparisons are possible, that the two approaches seem likely to lead to similar general conclusions.

Documents MARAM/IWS/DEC16/Peng Clos/P3 and P4 address this issue.

Appendix 1. Relationship between Changes in Penguin Population Growth Rate and Changes in the Fledging Success Response Variable leading to a value for the corresponding Threshold

If penguin reproductive maturity is assumed to occur at age 4, the equation for the mature female component of the population (numbering N in year y) may be written:

$$N_{y+1} = N_y S + H_{y-3} S^3 N_{y-3} \quad (1)$$

where S is the mature female annual survival proportion and H is a measure related to the product of egg production and chick survival to the end of the first year (which incorporates fledging success). In a situation where the population is changing at a steady rate:

$$\eta = N_{y+1}/N_y \quad (2)$$

then

$$\eta^4 = \eta^3 S + HS^3 \quad (3)$$

which if H changes by ΔH leads to a corresponding change in penguin growth rate $\Delta\eta$ given by:

$$\Delta\eta = \frac{S^3}{4\eta^3 - 3\eta^2 S}\Delta H \quad (4)$$

The Task Team decided on 1% as the pre-specified change in population growth rate (management objective), effectively then setting $\Delta\eta = 0.01$. Table 1 below gives values of $\Delta H/H$ for ranges of plausible values for S and η which yield feasible solutions – note then that if changes in fledging success dominate any changes in η, then $\Delta H/H$ becomes equivalent to a change in the value of *ln*(fledging success). For much of the Table, the value 0.1 provides a good approximation to $\Delta H/H$. Accordingly power computations were performed for a Threshold value of -0.1 in λ/δ (the effect of fishing parameters) space.

Table 1: $\Delta H/H$ values when $\Delta\eta = 0.01$

η \ S	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95
0.7	0.143	0.244	N/A	-	-	-	-	-
0.75	0.107	0.140	0.241	N/A	-	-	-	-
0.8	0.088	0.104	0.137	0.237	N/A	-	-	-
0.85	-	0.085	0.102	0.135	0.235	N/A	-	-
0.9	-	-	0.083	0.100	0.133	0.232	N/A	-
0.95	-	-	0.072	0.082	0.098	0.132	0.231	N/A
1	-	-	-	0.070	0.080	0.097	0.130	0.230
1.05	-	-	-	-	0.069	0.079	0.095	0.129
1.1	-	-	-	-	0.061	0.067	0.077	0.094
1.15	-	-	-	-	-	0.059	0.066	0.076
1.2	-	-	-	-	-	-	0.058	0.065

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ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

Commercial fishery no-take zones for African penguins minimize fisheries losses at the expense of conservation gains

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Abstract

The African penguin population has declined precipitously in recent decades, and if current rates of decline persist, this species could become extinct in the wild by 2035. Resource extraction of small pelagic fish prey by the purse-seine fishery around African penguin breeding colonies has been identified as a demographically meaningful threat to African penguins. Consequently, long-term, effective no-take zones around breeding colonies have been endorsed by an expert panel of scientists constituted by the South African government. Here, we consider the six largest South African penguin colonies that currently hold 76% of the global population. We evaluate the adequacy of different no-take zone options using a trade-off mechanism recommended by the expert panel. For all six colonies except Bird Island, Algoa Bay, which is subject to the least fishing pressure, the current no-take zone delineations are assessed as having little benefit to the African penguin and little to no cost to the purse-seine fishery. Four of the six current no-take zones include ≤50% of the African penguins' core foraging areas. Alternative no-take zones that approximate a more balanced trade-off offer more impactful alternatives to the current fisheries restrictions. Given the urgent need to implement evidence-based conservation interventions for the endangered African penguin, we recommend the substitution of the current no-take zones with those proposed herein.

Keywords: seabirds; penguins; conservation; fisheries; no-take zone; purse-seine; sardine; anchovy

Introduction

Competition between seabirds and industrial-scale fisheries for common prey resources is a significant and growing threat to many seabird species (Croxall et al. 2012, Dias et al. 2019). Resource competition can negatively impact their foraging performance (Boersma and Rebstock 2009, Bertrand et al. 2012), breeding success (Sherley et al. 2018, Sydeman et al. 2021), and survival (Frederiksen et al. 2004), directly affecting demographic processes. Seabird species with specialized diets and whose prey are also targeted by large commercial fisheries are particularly vulnerable to this threat (Furness and Tasker 2000, Searle et al. 2023). The implementation of fisheries no-take zones in marine habitats has shown positive outcomes in alleviating the negative impacts of resource competition for several species (Sydeman et al. 2017, Searle et al. 2023).

African penguins (*Spheniscus demersus*) are endemic to the Benguela Upwelling Ecosystem off South Africa and Namibia,

where they feed on small pelagic prey, predominantly sardine (*Sardinops sagax*) and anchovy (*Engraulis encrasicolus*) (Hockey et al. 2005). They are currently listed as globally Endangered (BirdLife International 2024), and there is evidence to support uplisting of this species to Critically Endangered (Sherley et al. 2024). The global population has declined at 7.9% per annum over the last 10 years to ~9900 breeding pairs; close to just 40% of the ~24 000 pairs breeding a decade ago. If current trends persist, the African penguin could be extinct in the wild by 2035 (Sherley et al. 2024).

A key driver of the decline in the number of African penguins is regionally poor prey availability; there has been a substantial decrease in the regional biomass of sardine, which has remained low since 2007 (Coetzee et al. 2022a) and has been recognized as a significant factor influencing African penguin survival (Robinson et al. 2015, Crawford et al. 2022). In addition, a spatial redistribution of sardine and to a lesser extent anchovy biomass, likely due to environmental changes in wind and upwelling patterns and disproportionate fishing pressure (Roy et al. 2007, Coetzee et al. 2008), occurred in the late 1990s and has persisted in recent years (Coetzee et al. 2022b). In this context, competition for anchovy and sardine from the commercial purse-seine fishery (Sherley et al. 2018, Sydeman et al. 2021), which is the largest fishery by volume in South Africa (Hutchings et al. 2009), contributes to the overall lack of available food at crucial times during the penguin's lifecycle (Crawford et al. 2022). The threat posed by a lack of available prey is exacerbated by other threats, including underwater noise from increased shipping traffic (Pichegru et al. 2022), predation by seals (Makhado et al. 2006), oil spills (Wolfaardt et al. 2009a), and disease outbreaks (Roberts et al. 2023).

The need to address the cumulative impact arising from these multiple threats is reflected in various national and international policies and agreements, including the African Penguin Biodiversity Management Plan (DEA 2013) and the International Multi-species Action Plan for the Conservation of Benguela Upwelling System Coastal Seabirds (AEWA 2021). These plans provide guidelines for conservation measures to address these threats, and for the most part, the actions have been successfully implemented (Pichegru 2024). However, there has been a lack of urgent and meaningful long-term interventions to curb the major drivers and threats associated with prey availability, a factor that has significantly contributed to the precipitous decline in African penguin numbers (Crawford et al. 2022).

Between 2008 and 2021, an Island Closure Experiment (ICE) was implemented and included no-take zones for small pelagic fishing around four African penguin colonies in South Africa's Exclusive Economic Zone (EEZ) (Punt et al. 2023). The experiment aimed to assess the benefit (if any) of no-take zones to African penguins. The ICE included alternating 3-year open and closed regimes in a 20 km radius around the (then) species' four main breeding sites in two biogeographic regions: Robben and Dassen islands on South Africa's west coast; and St. Croix and Bird islands on the east coast. The 20 km radius was based on what was known at the time about the average foraging range of African penguins when rearing small chicks (Petersen et al. 2006), an energetically demanding period when foraging range is at its most constrained; these birds forage over much larger areas during other parts of their lifecycle (Carpenter-Kling et al. 2022). The reason for the alternating regime was to control for confounding effects such as natural drivers of prey availability (Pichegru et al. 2012, Punt et al. 2023). Design flaws of the ICE included a mismatch between the duration of no-take zones and important events in the African penguin lifecycle, and between the spatial extent of no-take zones and the birds' at-sea distribution (Punt et al. 2023). Notwithstanding these limitations, the study demonstrated a demographically meaningful benefit of no-take zones for African penguins (Sydeman et al. 2021, Punt et al. 2023). Further, the impacts of no-take zones during the ICE on African penguin survival during the non-breeding season were not evaluated but could have had a significant impact on overall population-level benefits as African penguins spent a considerable time (e.g. 49% of tracking time during post-moult foraging around Dassen Island) within these no-take zones before and after their catastrophic land-bound moult (Carpenter-Kling et al. 2022).

Given the concerning conservation status of the African penguin and the results obtained during the ICE, the need for purse-seine fishing no-take zones around African penguin colonies was recognized by the South African government's Department of Forestry, Fisheries and the Environment (DFFE) in 2021 (Coetzee et al. 2021). A set of candidate no-take zones was proposed by a Governance Forum constituted by the DFFE in 2021. However, confirmation on the number, extent, and duration of no-take zones was deferred to engagements between the conservation and purse-seine fisheries stakeholder groups (hereafter referred to as Industry) in an attempt to establish consensus on no-take zone delineations that could minimize costs to the purse-seine fishery and maximize benefits to African penguins. To this end, two stakeholder engagement processes ensued between 2021 and 2022: the Governance Forum Extended Task Team (ETT) and the Consultative Advisory Forum on Marine Living Resources (CAF). Unfortunately, neither process resulted in agreement on mutually acceptable no-take configurations (Punt et al. 2023). This stalemate led the DFFE to institute interim no-take zones around six colonies (out of a total of 12 extant colonies in South Africa) in September 2022; these delineations were based on a mix of previously proposed no-take zone extents, including those originally proposed by the DFFE for Dassen and Robben islands, those proposed by the CAF for Stony Point and Bird Island, those proposed by Industry during the ETT for St. Croix Island, and a new split zone configuration for Dyer Island using delineations originally proposed by the DFFE (vessel size limited zone) and by Industry during the CAF (fully restricted zone). These interim closures (now permanently in place) were not endorsed by the conservation sector but were imposed by the DFFE as a temporary measure to enable a final review of the scientific data by an international panel of experts.

To resolve the impasse, the South African government constituted an international panel of six expert scientists to provide an independent and objective review of the costs and benefits of purse-seine fishery no-take zones. In summary, the panel was tasked with the following:

(1) to review the science underpinning benefits of no-take zones to African penguins;
(2) to evaluate the evidence supporting long-term no-take zones as a precautionary measure;

(3) if benefits of no-take zones are confirmed for African penguins, to recommend a trade-off mechanism to inform no-take zone design;
(4) to advise on delineations of no-take zones around six colonies and the durations of closures considering African penguin life-history traits;
(5) to provide recommendations on a monitoring and evaluation programme; and
(6) to provide short-term research recommendations focusing on the dominant causes of the rapid decline of the African penguin (DFFE 2022).

The panel concluded its assessment in 2023 (International Review Panel's report, IRPR, Punt et al. 2023), which confirmed the demographic benefits of purse-seine fishery no-take zones for African penguins, including a small yet meaningful improvement in population recovery as determined from the ICE (Punt et al. 2023). The panel noted that, considering the limitations in the design and implementation of the ICE, well designed long-term no-take zones are likely to result in additional benefits to the African penguin population, above and beyond those directly accounted for in the ICE, including benefits associated with survival and recruitment. The panel agreed that preferred penguin foraging areas were best delineated using internationally recognized methods to determine marine Important Bird and Biodiversity Areas based on the Area-restricted Search technique (mIBA-ARS, Lascelles et al. 2016). The panel also noted that the Opportunity Based Model (OBM, Bergh, and Horton 2023), submitted by fisheries scientists contracted by the South African Pelagic Fishing Industry Association to estimate economic costs of different no-take zone options to fisheries, likely overestimated those costs. This is largely due to underpinning assumptions regarding the inability of fishing fleets to replace catches outside the no-take zones. Despite these limitations, the panel indicated that the outputs of the OBM could be used in a relative sense to rank different no-take zone options. In this regard, a precautionary strategy requires that the risk to the resource be considered, and that adequate protection be provided to compensate for the absence of robust economic indicators of cost to the fishery. Precaution also implies agreement on action to avoid a crisis. The panel also recommended a specific trade-off mechanism to identify optimal no-take zone designs that maximize benefits to penguins while minimizing costs to the fisheries.

On 4 August 2023, the principle of no-take zones and some recommendations of the IRPR were endorsed by the South African Minister of Forestry, Fisheries and the Environment (such as year-round no-take zones and a closure duration that accorded with African penguin life history). However, the panel recommendations as to how to determine the extent of these no-take zones were not implemented. Instead, the Minister gave the conservation and fishery sectors five months to reach an agreement on the delineations of no-take zones around the six African penguin breeding colonies in issue. In the absence of an agreement, the interim no-take zones would be instituted from the start of the 2024 small pelagic fishing season until the end of 2033. No consensus was reached between the sectors following the announcement by the Minister; therefore, the interim no-take zones (now the current no-take zones) were reflected in the small pelagic fishing permits issued in January 2024.

In this study, we use the trade-off mechanism recommended by IRPR to identify no-take zones that balance the objectives of minimizing costs to fisheries and maximizing benefits to penguins. We consider a set of candidate no-take zones that have been proposed since the ICE, which includes the current no-take zones and for which fisheries cost data are available. To quantify penguin benefits, we defined a utility score that measures how well the penguins' preferred foraging areas are represented in each no-take zone. Based on the results of our trade-off analysis, we recommend the implementation of no-take zone(s) that represent an optimal compromise between conservation and the fishing industry at each of the six colonies.

Methods

Calculating foraging ranges and core foraging areas

Marine habitat use by African penguins was assessed using telemetry data. Adult penguins attending chicks <6 weeks old were equipped with GPS loggers following established procedures for the species (e.g. Pichegru et al. 2010, 2012, Campbell et al. 2019). Logger deployments were conducted between 2008 and 2022 at six colonies in South Africa: Dassen and Robben islands on the west coast, Stony Point and Dyer Island on the south coast, and St. Croix and Bird islands on the east coast (Fig. 1). Procedures for validating tracks are explained in detail in the supplementary material.

To identify important marine habitat for African penguins, i.e. areas mostly available to penguins around each colony (foraging range) and areas of intense or preferred use around each colony (core foraging area), methods developed to identify mIBAs were used (Lascelles et al. 2016, Beal et al. 2021) using the R package *track2KBA* (Beal et al. 2021). This approach has been used widely to identify mIBAs for seabirds (e.g. Soldatini et al. 2022, Carr et al. 2023, Correia et al. 2024), including penguins off the Antarctic Peninsula (Dias et al. 2018), and to assess the adequacy of marine protected areas (MPAs) for marine predators, including penguins, in the Southwest Atlantic Ocean (Handley et al. 2020). We used a 90% kernel utilization distribution contour (UD) to calculate foraging ranges (mIBA-UD90) following Börger et al. (2006) and a 54% UD to determine core foraging areas using optimal isopleth value selection (Vander Wal and Rodgers 2012). For the core foraging areas (mIBA-ARS), we adopted the IRPR's recommended use of ARS for selection of the smoothing parameter (h), and for foraging ranges an h value of 7 km was used following Dias et al. (2018), who adopted this method for Chinstrap (*Pygoscelis antarcticus*) and Adélie (*P. adeliae*) penguins in the South Shetland and South Orkney islands. Several individuals had multiple tracks to and from the colony before the GPS loggers were retrieved. For these individuals, we combined multiple tracks into one foraging trip to avoid issues associated with site fidelity and pseudoreplication, following Dias et al. (2018). Details of the procedures followed using these methods are explained in the supplementary material.

The IRPR proposed trade-off mechanism

The IRPR recommended a trade-off mechanism to select purse-seine fishery no-take zones that equitably balance the competing objectives of minimizing fisheries costs and maximizing benefits to African penguins (Punt et al. 2023). The

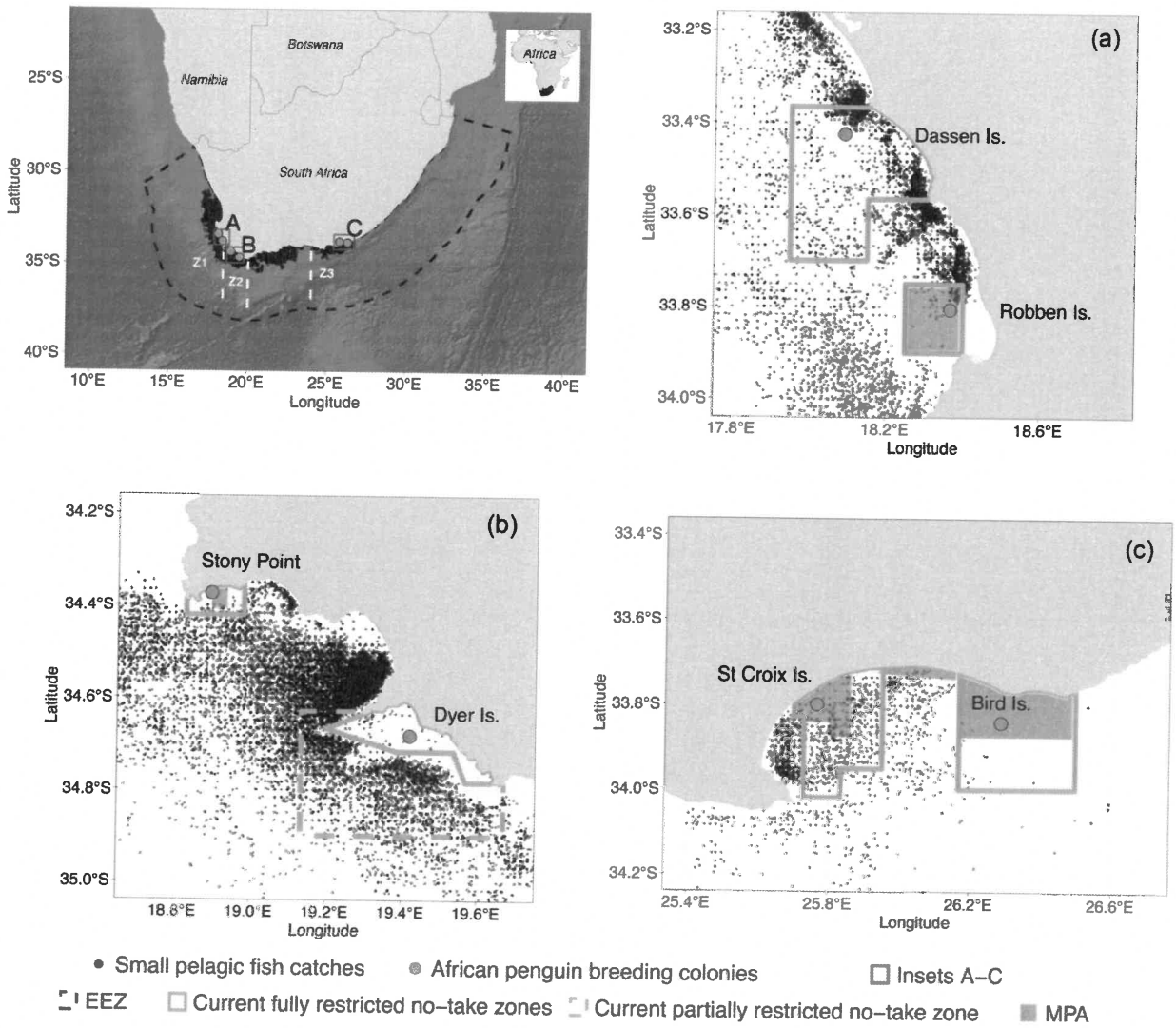

Figure 1. Maps showing the location of the six African penguin breeding colonies included in the assessment. The national map includes the South African Exclusive Economic Zone (EEZ), the purse-seine fishery regional catch zones used in this assessment, Z1–Z3 (vertical dashed lines), and the distribution of purse-seine anchovy and sardine catches between 2011 and 2020. The insets (a)–(c) show the current purse-seine no-take zones around each colony, existing fisheries restriction zones in marine protected areas (MPA), and the distribution of anchovy and sardine catches. The current no-take zone around Dyer Island is a split-zone where no fishing is allowed inside the solid line, but vessels <26 m can fish between the dashed and solid lines.

logic underlying the mechanism can be understood by considering how to choose between two zones, call them A and B. If A and B have similar values in one objective (e.g. fisheries costs), but A has substantially better values in the other objective (e.g. penguin benefits), then A is to be chosen. If A has substantially lower fisheries costs than B, but B has substantially higher penguin benefits than A, then the choice depends on the relative magnitude of these differences. The IRPR mechanism determines which scenario should be chosen in these instances, by plotting the fisheries costs against penguin benefits for all the no-take zones considered and fitting a trade-off curve to these points (details below). The zone achieving the most equitable compromise is that closest to the 'balance point' on the trade-off curve, where the rate of increase in fisheries costs equals the rate of increase in penguin benefits.

The trade-off mechanism requires that costs to fisheries and benefits to penguins are measured on relative scales with the values for each ranging between zero and one (otherwise, the location of the balance point depends on arbitrary units of measurement). We defined the cost to fisheries as the proportion of total local catch that would be lost through fishing exclusion from each no-take zone; here, a value of 1 represents the maximum catch loss attributed to the largest candidate no-take zone, which in all instances is the foraging range, i.e. mIBA (UD90). The catch loss values we used were the median cost estimates from the OBM, where each fishing set could be re-used five times (Bergh and Horton 2023, Punt et al. 2023). The effects of closures on economic factors, such as job losses, although estimated using a Social Accounting Matrix (Urban Econ Development Economists 2023), were not used in these analyses as they were calculated at a regional scale, were directly derived from the OBM outputs and were assessed as having significant limitations in their modelling assumptions (Punt et al. 2023).

Table 1. Summary of tracking data from six African penguin colonies showing the total sample size over the specified sampling period.

Colony	Sample period		Sample size (*N*)	
	Year range	Month range	Individuals*	Tracks*
Dassen Island	2008–2019	March–October	136	156
Robben Island	2008, 2010–16, 2018, 2019	April–August	185	207
Stony Point	2017–2022	June–October	60	99
Dyer Island	2009–2012, 2021,2022	May–August	61	64
St. Croix Island	2009–2018	March–July	191	197
Bird Island	2008–2019, 2021,2022	March–July	464	609

*Sample sizes are shown as the number of individual birds tracked and the number of tracks (where there might be more tracks than individual birds if a bird went on more than one foraging trip before the tracking device was removed). These totals represent the sample size after applying filtering procedures (see text for details).

We defined the benefits to penguins as a utility score (U_R) for each no-take zone R:

$$U_R = \frac{\sum_{p \in R} u_p}{\sum_{p \in FR} u_p}.$$

Here, u_p is the number of penguins that regularly forage in pixel p, estimated using package *track2KBA* in program R, and FR is the total foraging range. The utility score quantifies how well each no-take zone represents the total foraging range at the colony (i.e. a value of 1 on the x-axis in the trade-off space), whilst accounting for the fact that penguins do not utilize all regions of space equally. Lastly, we note that although *track2KBA* uses the local population size to calculate u_p's, our utility score is independent of this parameter as it is common to both numerator and denominator.

To construct trade-off curves, we plotted benefit-cost points for all no-take zones (at a given colony), as well as points representing the industry-optimized scenario (fisheries cost = penguin benefit = 0) and the penguin-optimized scenario (fisheries cost = penguin benefit = 1). We then find the convex hull of all these points and construct the trade-off curve by fitting a monotone non-decreasing spline to the points on the boundary of the convex hull. The 'balance point' can then be found by numerically evaluating where the slope of the trade-off curve equals one, that is, where the rate of increase in penguin benefits equals the rate of increase in fisheries costs.

Trade-off plots are provided for four catch types [anchovy, sardine, sardine bycatch, and redeye (*Etrumeus whiteheadii*)] for six of the last remaining large African penguin colonies: Dassen and Robben islands off the west coast, Stony Point and Dyer Island off the south coast, and St. Croix and Bird islands off the east coast (Fig. 1). At each colony, we considered the following no-take zones proposed since the ICE was initiated in 2008: (i) African penguins' foraging range (mIBA-UD90 described above), (ii) African penguins' core foraging area (mIBA-ARS described above), (iii) 20 km no-take zones used during the ICE, (iv) no-take zones proposed by DFFE in 2021, (v) no-take zones proposed by the CAF, and (vi) the current no-take zones where corresponding fisheries cost data were available.

Lastly, to provide context on the relative catch of different small pelagic stocks taken around each colony, we provide the average yearly catches (DFFE, unpubl. data) of each stock caught between 2011 and 2020 for the entire South African EEZ and three regions: (i) west coast, west of Cape Point (Z1, Fig. 1), (ii) south coast between Cape Point and Cape Agulhas (Z2, Fig. 1), and (iii) east coast east of 24°E (Z3, Fig. 1). For each catch type and for all colonies, we further calculated the estimated catch loss (using the OBM outputs, see above) for the African penguins' foraging range (mIBA-UD90), and the no-take zone that best approximated the balance point on the trade-off curve or the one that was motivated for as the preferred no-take zone. The distribution of sardine and anchovy catches between 2011 and 2020 using data provided by DFFE is shown in Fig. 1.

Results

Core foraging areas (mIBA-ARS) and foraging ranges (mIBA-UD90) were determined using 1332 complete tracks from 1097 individuals after applying filtering procedures for African penguins from six colonies between 2008 and 2022 (Table 1).

Trade-off assessments

Dassen Island

Penguin utility scores were generally high ($U_R > 0.83$) for all no-take zone types around Dassen Island (Fig. 2). Anchovy constituted the largest catch around this colony although estimated anchovy catch losses for the African penguin foraging range (mIBA-UD90) and the core foraging area (mIBA-ARS), respectively, were ~4.7% and ~1.6% of the regional catch and ~3.7% and ~1.3% of national catches (Table 2, Fig. 2). The current no-take zone (= DFFE 2021) was most consistently aligned to the balance point in the trade-off space for all stocks, although it omitted 8% of the northern core foraging area (mIBA-ARS) (Fig. 2). There were no catch losses associated with any of the scenarios for sardine bycatch (Table 2).

Robben Island

The current no-take zone (=DFFE 2021), which is part of an existing MPA declared in 2019, had relatively low penguin utility scores (U_R= 0.42) and very low to negligible catch losses (<0.15% of the regional catch) for all stocks around Robben Island (Table 2, Fig. 3). By contrast, the mIBA-ARS no-take zone had high penguin utility scores (U_R= 0.86) and the closest alignment to the balance point in the decision space for anchovy and sardine. As at Dassen Island, anchovy constituted the largest catch around this colony but estimated catch losses for the African penguin foraging range (mIBA-UD90) and the core foraging area (mIBA-ARS) were ≤2.5% of the regional catch and <2% of the national catch (Table 2, Fig. 3). There were no clear alignments of any of the no-take options to the balance point in the trade-off space for redeye; redeye catch losses were very low (~0.7% of the

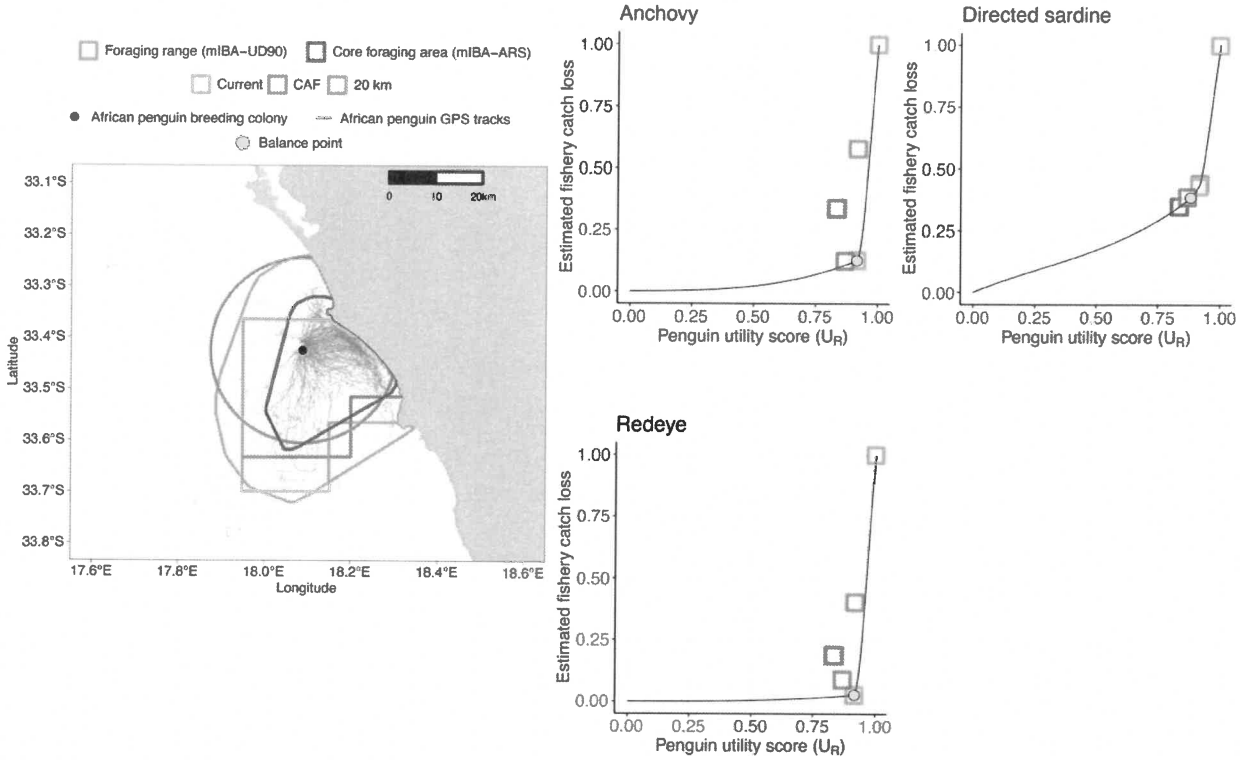

Figure 2. Purse-seine fishery no-take zones around Dassen Island proposed since 2008, including African penguin tracks and the trade-off assessments for different small pelagic fish stocks. The trade-off plots include fishery no-take zone options relative to their corresponding benefits to penguins (penguin utility score) and costs to fisheries (catch loss). The trade-off curves are shown with the balance point at which an increase in the rate of penguin benefits is equal to the rate in increase in estimated catch loss to fisheries.

regional catch) for the foraging range (mIBA-UD90) of African penguins from this colony (Table 2, Fig. 3). OBM outputs for sardine bycatch catch loss produced counter-intuitive outputs with the largest (mIBA-UD90) and smallest (current) no-take zones producing no catch losses despite intermediate no-take zones having positive catch loss estimates; these estimates were assessed as being erroneous and were discarded from the trade-off assessment (Table 2).

Stony Point

The current no-take zone (=CAF) had low penguin utility scores (U_R= 0.34) and mostly negligible catch losses (<0.1% of regional catches) for all stocks fished around Stony Point (Table 2, Fig. 4). Sardine was the largest catch, followed by anchovy (Table 2, Fig. 4). The no-take zone based on the core African penguin foraging area (mIBA-ARS) had a high penguin utility score (U_R= 0.91), was closely aligned to the balance point in the decision space for all fish stocks around this colony, and would result in estimated regional catch losses of ~3.1% for sardine, ~0.6% for anchovy, and ~0.8% for redeye (Table 2, Fig. 4).

Dyer Island

The DFFE (2021) no-take zone had relatively high penguin utility scores (U_R= 0.78) and was most closely aligned to the balance point in the decision space for all stocks around Dyer Island (albeit less so for redeye than the others) (Fig. 5). Anchovy and sardine constituted the largest catches although the relative contribution of the estimated regional catch losses for the DFFE (2021) no-take proposal was ~13.1% for anchovy and ~7.3% for sardine around Dyer Island (Table 2, Fig. 5). However, the current fully restricted no-take zone around Dyer Island had a low penguin utility score (U_R= 0.32). Although there were no corresponding costs available for this and the partially restricted zone around this colony, sardine and anchovy catch locations were primarily concentrated to the north of the DFFE (2021) no-take proposal with very few catches occurring within the current fully restricted no-take zone (Fig. 1).

St. Croix Island

The DFFE (2021) no-take zone was most closely aligned to the balance point in the decision space for sardine around St. Croix Island with a relatively high penguin utility score (U_R= 0.74) (Fig. 6). The current no-take zone included 50% of the African penguin core foraging area (mIBA-ARS) and had a utility score of 0.61. There were no corresponding fisheries catch loss data available for the current no-take zone. Sardine was the only major stock caught around this colony by the purse-seine fishery with estimated lost catch attributed to the African penguin foraging range (mIBA-UD90) amounting to a substantial proportion (~70.9%) of the regional catch, while the estimated catch loss associated with the DFFE (2021) no-take option, while still meaningful, was less than half of that at ~28.7% of the regional catch (Table 2, Fig. 6).

Bird Island

There was very little purse-seine fishing effort around Bird Island (Fig. 1). The ICE 20 km no-take zone had a high penguin

Table 2. Estimated national and regional purse-seine catch losses estimated by an OBM (Bergh and Horton 2023) for different no-take zones for six African penguin colonies in South Africa.

Colony	Catch type	National catch (*kt*)	Regional catch (*kt*)	Estimated % catch loss: Foraging range, National	Foraging range, Regional	Core foraging area, National	Core foraging area, Regional	Current no-take zone, National	Current no-take zone, Regional	Recommended no-take zone, National	Recommended no-take zone, Regional
Dassen Island	Anchovy	220	174	3.7	4.7	1.3	1.6	0.5	0.6	1.3	1.6
	Directed sardine	59	4.4	0.4	5.3	0.1	1.9	0.2	2.3	0.1	1.9
	Redeye	47	34	0.9	1.2	0.2	0.2	<0.1	<0.1	0.2	0.2
	Bycatch sardine	10	8.5	0	0	0	0	0	0	0	0
Robben Island	Anchovy	220	174	2.0	2.5	0.6	0.8	0.1	0.1	0.6	0.8
	Directed sardine	59	4.4	0.2	2.8	<0.1	0.2	<0.1	<0.1	0.0	0.2
	Redeye	47	34	0.5	0.7	0.2	0.3	0	0	0.2	0.3
	Bycatch sardine	10	8.5	0	0	0.45	0.53	0	0	0.45	0.53
Stony Point	Anchovy	220	40	1.0	5.3	0.1	0.6	0	0	0.1	0.6
	Directed sardine	59	34	9.3	16.2	1.8	3.1	<0.1	<0.1	1.8	3.1
	Redeye	47	12	1.1	4.2	0.2	0.8	<0.1	<0.1	0.2	0.8
	Bycatch sardine	10	1.4	1.1	8.4	<0.1	<0.1	0	0	<0.1	<0.1
Dyer Island	Anchovy	220	40	13.6	75.4	6.5	36.4	No data	No data	2.4	13.1
	Directed sardine	59	34	32.7	56.5	8.4	14.5	No data	No data	4.2	7.3
	Redeye	47	12	5.1	19.8	2.1	8.1	No data	No data	0.9	3.5
	Bycatch sardine	10	1.4	7.6	56.4	1.8	13.4	No data	No data	1.1	8.1
St. Croix Island	Directed sardine	59	4.2	5.1	70.9	3.0	41.7	No data	No data	2.1	28.7
Bird Island	Directed sardine	59	4.2	0.2	2.5	0.1	0.8	0.1	0.9	<0.1	0.5

utility score (U_R= 0.96) and was closely aligned to the balance point in the decision space for this colony with very little impact on estimated regional sardine catch loss (~0.5%, Table 2, Fig. 7). The current no-take zone (CAF) has a marginally lower penguin utility score (U_R= 0.93) but results in almost double the catch loss (~0.9% of estimated regional catch) than the ICE 20 km no-take zone (Table 2).

Discussion

Urgency to implement evidence-based conservation interventions

African penguins are recognized as one of three priority penguin species most in need of urgent conservation action (Boersma et al. 2019), and the at-sea distribution of African penguins overlaps with the greatest intensity of purse-seine fishing pressure experienced by any penguin species (Gimeno et al. 2024). The sustainable management of sardine and anchovy stocks has been highlighted as a priority for African penguin conservation efforts (see reviews by Trathan et al. 2015, Boersma et al. 2019). This is partly attributed to the historical correlation between sardine stock and African penguin population collapses following excessive reductions in sardine by purse-seine fishing off Namibia during the 1960s and 1970s (Crawford 2007) with no recovery, and the observed importance of sardine biomass for the survival of adult African penguins in South Africa (Robinson et al. 2015). Sardine and anchovy stocks are also important to several other Benguela predators, including Endangered Cape gannets (*Morus capensis*) and Cape cormorants (*Phalacrocorax capensis*) (Crawford et al. 2022), and ecologically and commercially important linefish species, such as silver kob (*Argyrosomus inodorus*), yellowtail (*Seriola lalandi*), and geelbek (*Atractoscion aequidens*) (Parker et al. 2020).

In recent years, the sardine stocks in South African waters have been considerably below the long-term average biomass; spawning biomass was below 800 000 tonnes (~20% of its maximum recorded value) in 16 of 17 years between 2006 and 2022 (Coetzee et al. 2022a) despite this being 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). Sardine exploitation rates by the purse-seine fishery have also been high off western South Africa in some years during this period, reaching >70% of the western sardine stock biomass in 2016 (de Moor 2023), which was less than 200 000 tonnes (15% of its maximum recorded value) at the time (Punt et al. 2023). In a global context, this exploitation rate exceeds the exploitation threshold recommended by the Lenfest Forage Fish Task Force for lower trophic level species (Pikitch et al. 2012). Moreover, the availability of both sardine and anchovy to seabirds appears to have declined since the early 2000s (Crawford et al. 2019). This is especially concerning for African penguins, whose breeding success and survival are known to respond negatively to periods where prey biomass falls below 33% of its maximum recorded value (Cury et al. 2011, Robinson et al. 2015). A further consideration is the need for cautious management of the forage fish themselves when dropping below 18% of maximum recorded stock sizes as seabird-induced predation mortality is considerably higher at such low stock levels (Saraux et al. 2020). Given that negative impacts of resource competition are

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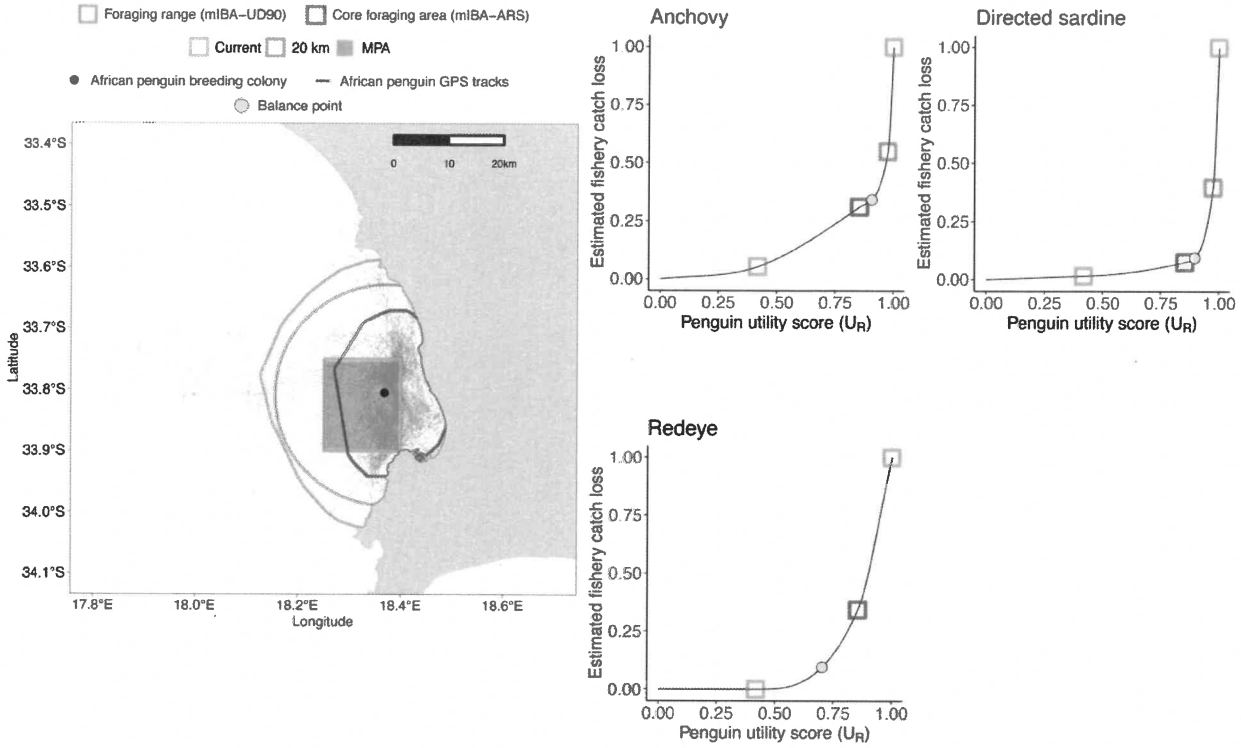

Figure 3. Purse-seine fishery no-take zones around Robben Island proposed since 2008, including African penguin tracks and the trade-off assessments for different small pelagic fish stocks. The trade-off plots include fishery no-take zone options relative to their corresponding benefits to penguins (penguin utility score) and costs to fisheries (catch loss). The trade-off curves are shown with the balance point at which an increase in the rate of penguin benefits is equal to the rate in increase in estimated catch loss to fisheries.

often amplified for seabirds during periods of low prey biomass (Sydeman et al. 2017), it is vital that all efforts to manage the impact of prey depletion are afforded due and timely consideration. Since the inception of the ICE in 2008, South Africa's African penguin population has decreased by 66%. Following the publication of the results that supported demographically meaningful benefits of no-take purse-seine fishing zones for African penguins in 2018 (Sherley et al. 2018), their population has declined by 44%. Colony extinction probabilities are inversely related to colony population size for African penguins with extinction risk disproportionately elevated for colonies <1000 breeding pairs (Crawford et al. 2001). Populations at all but three of South Africa's breeding colonies were below that threshold in 2023 (Sherley et al. 2024) highlighting the urgency to prioritize conservation efforts at the last remaining large colonies. If the declines observed over the last decade are replicated over the next 10 years, then there is a credible risk of this species becoming extinct in the wild by 2035 (Sherley et al. 2024). As a result, there is no longer time available to delay implementation of meaningful, science-led, no-take zones.

Small pelagic fishing restrictions around the proposed African penguin colonies are likely to benefit Endangered Cape cormorants who also predominantly prey on small pelagic fish and have similar foraging ranges to African penguins during their breeding season (Hamann et al. 2012, Pichegru et al. 2009). Four of the largest Cape cormorant colonies are situated at four of the six proposed no-take zones at Dassen, Robben, and Dyer islands and at Stony Point (Crawford et al. 2016). Implementation of measures to improve the population status of African penguins around these colonies will also sustain benefits associated with prey facilitation by African penguins to Cape cormorants and other volant seabird species that are known to take advantage of prey elevated from depths (often >33 m) to the surface by African penguins (McInnes and Pistorius 2019).

Trade-off assessments and current no-take zones

Our results highlight shortfalls with the current no-take zones in protecting the preferred foraging areas for African penguins throughout their range. Four of the six current no-take zones include ≤50% of the African penguins' core foraging areas (Table 3). Although both no-take zones at Dassen and Bird islands cover >90% of their core foraging areas, only the one at Dassen Island sits close to the balance point on the trade-off between protecting penguins and minimizing costs to the fishing industry. Moreover, the current no-take zones around Robben Island and Stony Point significantly underrepresent important foraging areas while having little to negligible costs to the fishing industry. The zone around Robben Island is, in fact, no improvement on the no-take fishing zone implemented when the Robben Island Marine Protected Area was gazetted in 2019, a designation that pre-dated the IRPR (Punt et al. 2023) and was based on a systematic conservation planning process incorporating a diversity of biodiversity features (Kirkman et al. 2021) and not focusing on African penguins in particular. The current no-take zone around Stony Point also pre-dates the IRPR and originated in the CAF process during 2022 as the preferred no-take option of the fishing industry. In contrast to these current inadequate no-take zones, the

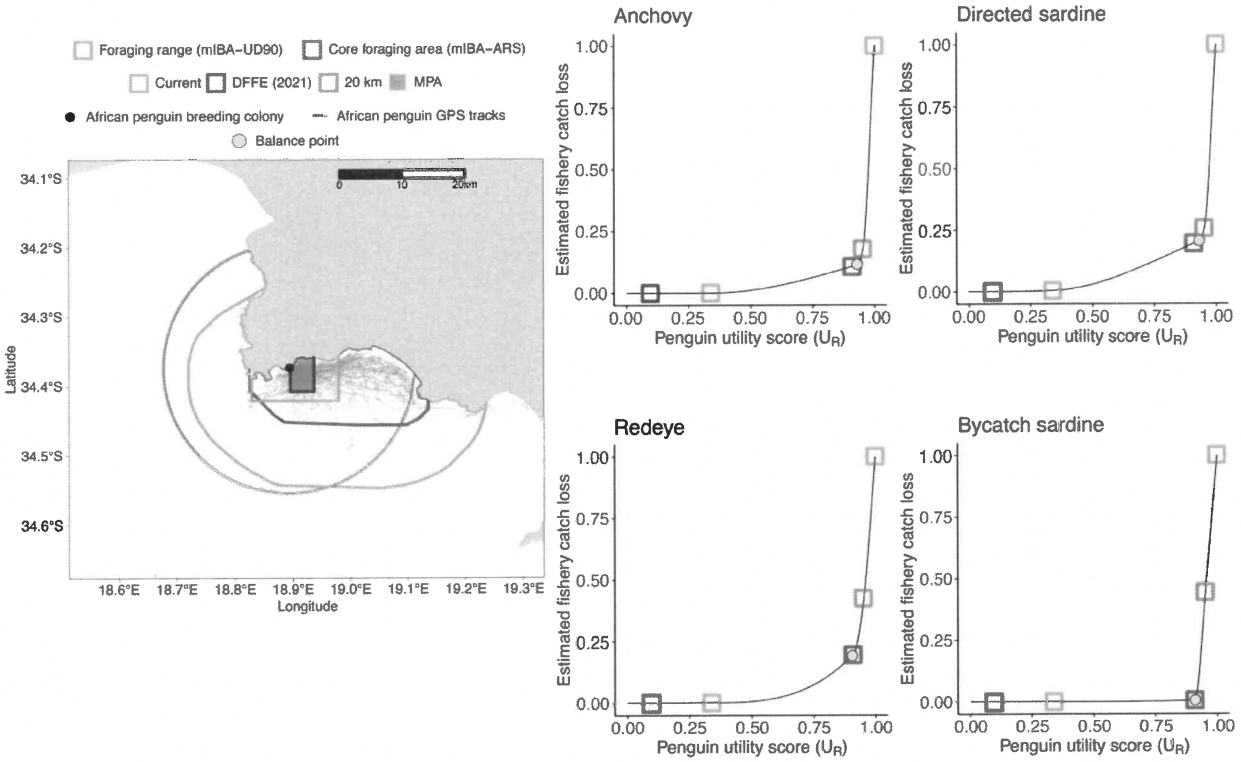

Figure 4. Purse-seine fishery no-take zones around Stony Point proposed since 2008, including African penguin tracks and the trade-off assessments for different small pelagic fish stocks. The trade-off plots include fishery no-take zone options relative to their corresponding benefits to penguins (penguin utility score) and costs to fisheries (catch loss). The trade-off curves are shown with the balance point at which an increase in the rate of penguin benefits is equal to the rate in increase in estimated catch loss to fisheries.

designs using the mIBA-ARS method recommended by the IRPR represent a substantial improvement in penguin benefits and closely approximate the balance points in the trade-off space for these two colonies.

Estimates of catch loss were not available for the current no-take zones around St. Croix and Dyer islands. Nevertheless, based on relative penguin utility scores, the configuration of these no-take zones is inadequate regarding penguin benefits. Penguins from St. Croix Island frequently travel >30 km from this colony, and the 20 km no-take zone in place during the ICE has been shown to be inadequate for these birds (Fig. 6, Pichegru et al. 2012). The current no-take zone around St. Croix Island is even smaller than the 20 km zone, covers only half their core foraging area (Table 3), and is therefore unlikely to provide sufficient benefits to penguins from this colony. For Dyer Island, the current configuration includes a split zone with the total prohibition on purse-seine fishing limited to a relatively small area inshore, where there has been very little fishing in recent years (Fig. 1, Bergh and Horton 2023) and where benefits to penguins are small. This area was the fishing industry's no-take option proposed during the CAF. The larger partial no-take zone around Dyer Island, which aligns to the DFFE (2021) zone is accessible to vessels <26 m in length. The relative benefits of this split-zone configuration to African penguins could not be assessed, but any benefits could be nullified by the current configuration, given that there is still pressure from the purse-seine fishing fleet. The DFFE (2021) no-take configurations outperform other available configurations for these two colonies (Dyer and St. Croix) with the closest approximation in the trade-off decision space for minimizing costs to industry and maximizing benefits for African penguins.

Currently Bird Island is afforded meaningful protection from purse-seine fishing but, paradoxically, the waters around this colony are least attractive for fishers compared to the other colonies (Fig. 1, Bergh and Horton 2023). Despite the benefits of the current no-take zone, the trade-off assessment identified the 20 km no-take zone as best in terms of balancing costs to the purse-seine fishery while still affording African penguins greater benefits.

The current no-take zone around Dassen Island corresponds with the best approximation of the balance point in the trade-off decision space for anchovy and, based on this assessment alone, is the rational choice for maximizing benefits to penguins whilst minimizing costs to industry. However, the exclusion of the northern parts of the core foraging area in the current no-take zone is significant for several reasons. First, it forms part of the African penguins' core foraging area proximate to the Dassen Island breeding grounds. Second, small-pelagic fishing concentrated in this northern portion of the mIBA-ARS is likely to have downstream effects (i.e. fishing the line, e.g. Pichegru et al. 2012) on prey availability for African penguins in the remainder of their core foraging area due to the inshore southward movement of anchovy recruits during autumn/winter (Hampton 1987). These months correspond with the most important breeding season for penguins from this colony (Wolfaardt et al. 2009b). Therefore, the model predicting utility scores underperforms in terms of its ability to

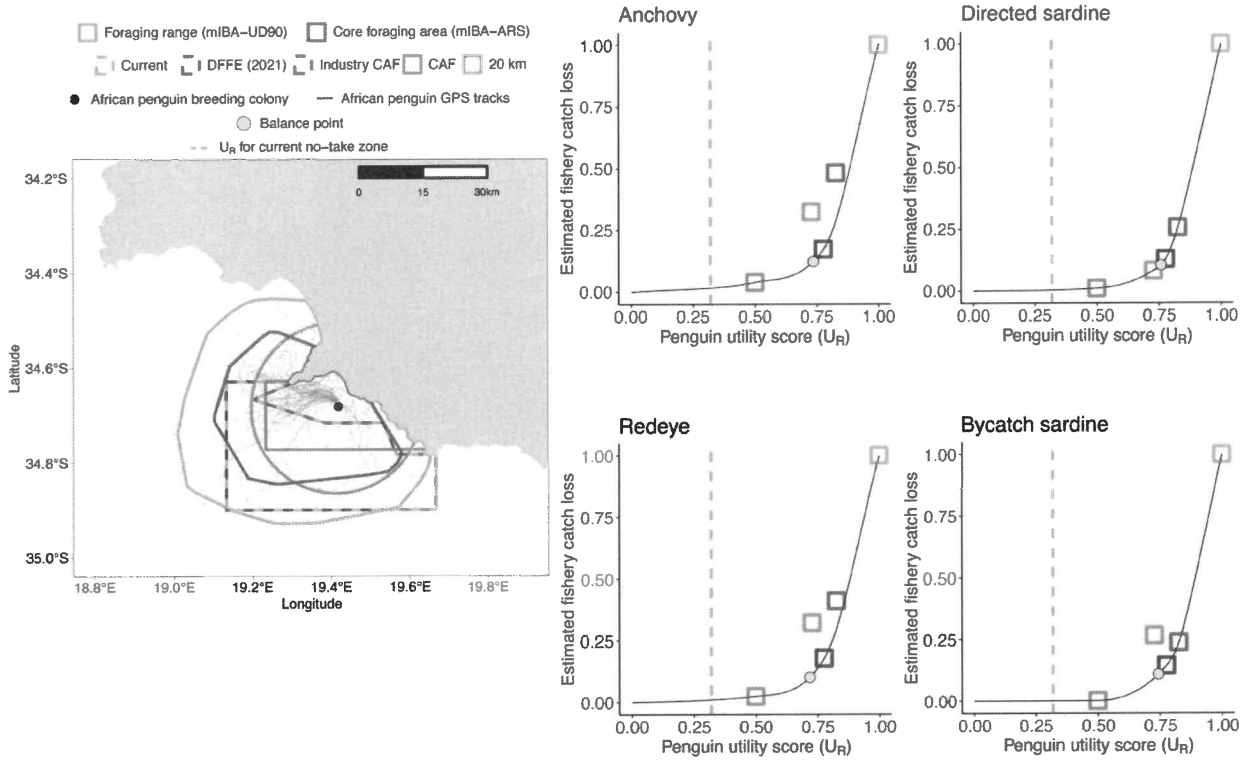

Figure 5. Purse-seine fishery no-take zones around Dyer Island proposed since 2008, including African penguin tracks and the trade-off assessments for different small pelagic fish stocks. The trade-off plots include fishery no-take zone options relative to their corresponding benefits to penguins (penguin utility score) and costs to fisheries (catch loss). The trade-off curves are shown with the balance point at which an increase in the rate of penguin benefits is equal to the rate in increase in estimated catch loss to fisheries. The current no-take zone is a split zone with the Industry CAF zone fully restricted and the no-take zone aligned to the DFFE (2021) zone is open to fishing to vessels <26 m. The vertical dashed line in the trade-off plots denotes the penguin utility scores for the fully restricted area (Industry CAF); catch loss data was not available for the current no-take zone.

incorporate the benefits of the northern areas of Dassen Island to African penguins. Considering this discrepancy and that this colony is the only one that still held >2000 breeding pairs in 2023, we would argue that the mIBA-ARS no-take zone is more likely to yield biologically meaningful protection and should be the preference for this colony. Although this could slightly increase costs for the industry, the estimated losses from the OBM are still <2% of regional catches (Table 2) and are likely overestimates compared to actual losses (Punt et al. 2023). Moreover, ignoring an opportunity to optimize the efficacy of this zone (within the trade-off space identified) could mean it fails to yield a conservation benefit, in which case, any losses for the industry would have been needless.

Broader conservation management considerations

There are several broader considerations for conservation management of both African penguins and sardine and anchovy stocks that are relevant for improving the application of the trade-off mechanism and use of no-take fishing zones as a conservation measure. This was recognized by the IRPR, which provided recommendations for a monitoring and evaluation programme to assess the adequacy of no-take zones implemented using the trade-off mechanism as well as recommendations for additional research to improve data inputs (Punt et al. 2023). The South African government has committed to adopt a monitoring programme with a review of no-take zones in 6 years. In terms of the IRPR's recommended approach, various parameters should be evaluated, including breeding population counts, breeding success (chick condition and chick survival), foraging performance (using telemetry data and automated penguin monitoring system data), recruitment and adult survival. The results of this monitoring and evaluation programme will determine if the no-take zone configuration that is ultimately implemented within this 6-year period is fit-for-purpose in terms of limiting resource competition by the purse-seine fishery.

The IRPR trade-off mechanism aims to reduce subjectivity in selecting balanced closure options. Once specific quantitative measures of cost and benefit are chosen, the method determines which scenario is to be preferred without the need for further judgment. However, subjectivity remains in the choice of these measures of cost and benefit. For example, measuring penguin benefits in terms of a demographic variable e.g. adult survival could result in the selection of different no-take zone scenarios. However, precise estimates of demographic or population-level variables that would result under each no-take zone are not available. Therefore, our choice has been dictated by the available data on fisheries costs and the penguin utility scores based on existing tracking data.

Among specific issues to be considered are those relating to improving the data inputs used in the trade-off mechanism. The first of these relates to ongoing refinements relating to tracking data. The proposed no-take zones in this assessment use tracking data recorded from African penguins attending small chicks. Currently, there is no available tracking data for

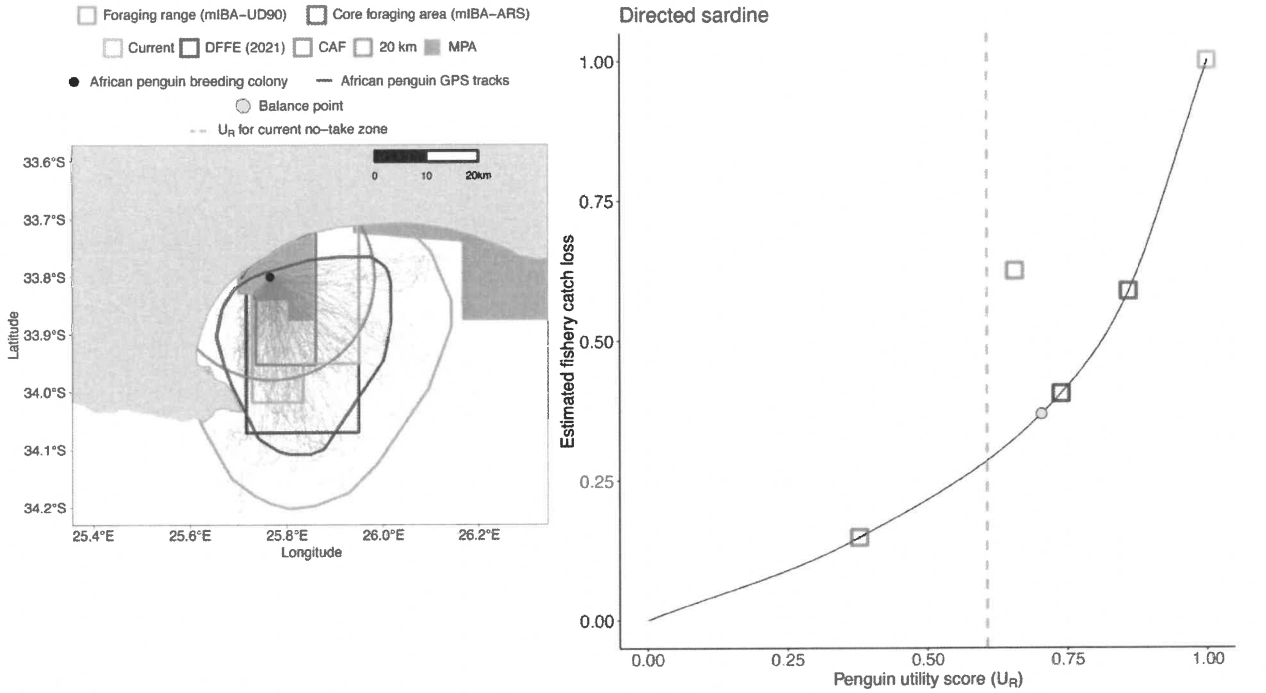

Figure 6. Purse-seine fishery no-take zones around St. Croix Island proposed since 2008, including African penguin tracks and the trade-off assessment for sardine. The trade-off plot includes fishery no-take zone options relative to their corresponding benefits to penguins (penguin utility score) and costs to fisheries (catch loss). The trade-off curve is shown with the balance point at which an increase in the rate of penguin benefits is equal to the rate in increase in estimated catch loss to fisheries. The current no-take zone = Industry ETT. The vertical dashed line in the trade-off plot denotes the penguin utility score for the current no-take zone; catch loss data was not available for the current no-take zone.

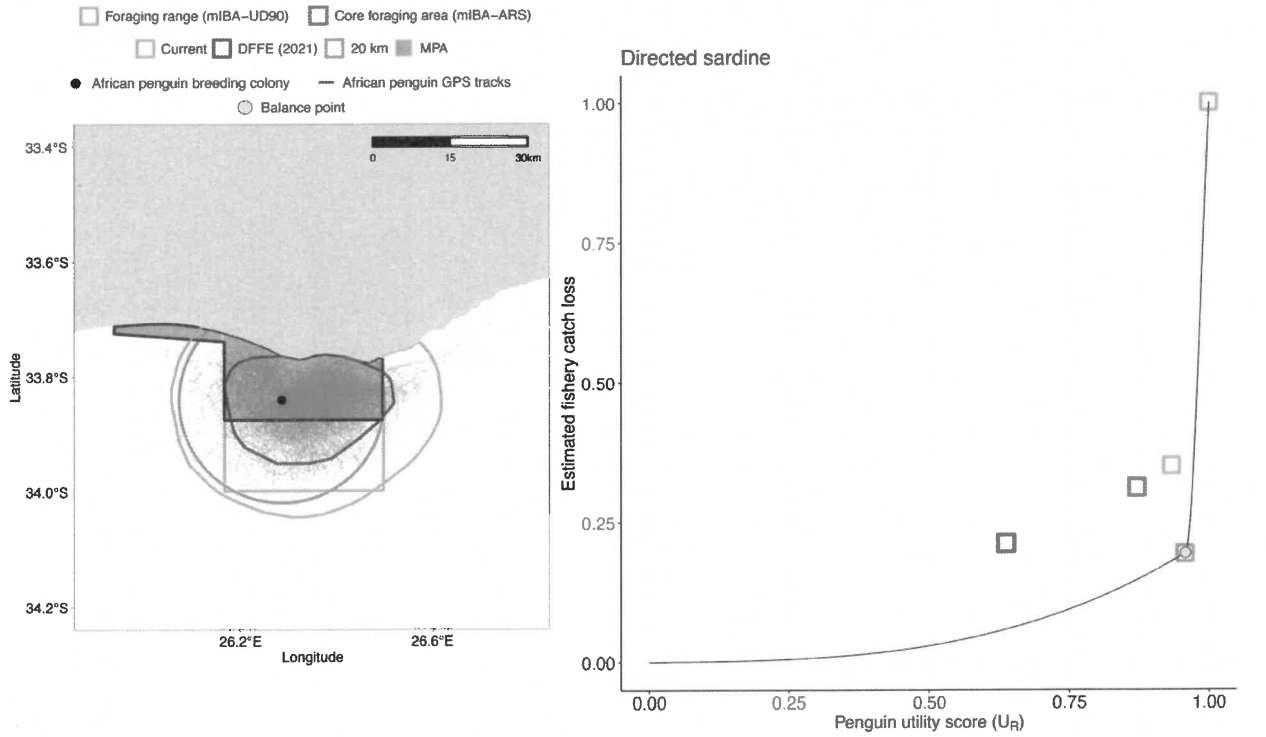

Figure 7. Purse-seine fishery no-take zones around Bird Island proposed since 2008, including African penguin tracks and the trade-off assessment for sardine. The trade-off plot includes fishery no-take zone options relative to their corresponding benefits to penguins (penguin utility score) and costs to fisheries (catch loss). The trade-off curve is shown with the balance point at which an increase in the rate of penguin benefits is equal to the rate in increase in estimated catch loss to fisheries. The current no-take zone = CAF.

Table 3. Proportion (%) overlap of the current purse-seine fishery no-take zones around six African penguin colonies with African penguin core foraging areas (mIBA-ARS) and foraging ranges (mIBA-UD90).

		% overlap	
Island	Current area (km^2)	Core foraging area (mIBA-ARS)	Foraging range (mIBA-UD90)
Dassen Island	948	92.4	66.2
Robben Island	227	43.4	22.3
Stony Point	84	30.2	10.0
Dyer Island	260	20.8	12.5
St. Croix Island	581	50.0	29.7
Bird Island	826	97.8	59.0

this species during incubation during which stage several penguin species are known to travel further from their colonies, e.g. for chinstrap (*P. antarcticus*, Dias et al. 2018), northern rockhopper (*Eudyptes moseleyi*, Steinfurth et al. 2020), and Magellanic (*Spheniscus magellanicus*, Dee Boersma and Rebstock 2009) penguins. Moreover, adults attending older chicks during the crèche period are also likely to forage for longer durations than during the brood phase [e.g. for southern rockhopper penguins (*Eudyptes chrysocome*), Tremblay and Cherel 2005]. As such, the proposed restriction zones are likely conservative in their estimation of preferred foraging areas during the breeding season.

An important data-refinement during the monitoring period is obtaining more accurate measures of fisheries costs. If the IRPR was correct in suspecting an over-estimation of costs, future trade-off assessments using more accurate estimates of fisheries costs and foraging areas aligned to the foraging distributions of African penguins during all breeding stages, including buffer areas to mitigate against fishing-the-line effects (anticipated after a 6-year monitoring period), may reveal a different set of improved priority candidate no-take zones than the ones proposed here. Nevertheless, following the IRPR's recommended trade-off mechanism using the data currently available demonstrates the inadequacy of the current no-take zone extents in protecting core foraging areas during chick rearing and with little to no cost to fisheries in many instances. The current no-take zones have not been delineated using the IRPR's recommendations for reasons that are unclear. However, these no-take zones, based on a range of historic delineation proposals are likely ineffective and, at the very least, should be substituted by the proposed no-take zones in this assessment until more representative data on costs to fisheries and benefits to penguins can be achieved. Doing so is an approach consonant with reliance on best available scientific data, application of the principle of precaution, and both international and domestic best practice.

A final consideration is the role of the no-take zones as part of a broader set of conservation interventions to prevent African penguin declines and to consider the population health of sardine and anchovy biomass as a key element of the Benguela Upwelling System as a whole. The demographic benefits attributed to African penguins due to no-take zones during the ICE were during a period (2008–2020) of below-average sardine biomass, which has persisted in recent years (Coetzee et al. 2022b). Notwithstanding the need to limit resource competition around breeding colonies, no-take zones of this kind should not be viewed in isolation of other priority measures linked to the sustainable management of small pelagic fish. There are various potential avenues to improve the latter including those recommended by the IRPR. Firstly, the Operational Management Procedures should be tested to assess if they are adequately sensitive to the sustainable management of sardine stocks (Punt et al. 2023). Secondly, the harvest control rules (HCRs) that form part of the OMP process should be reviewed in terms of their suitability to seabirds that predominantly prey on small pelagic fish and the longer-term harvests of fisheries. Alternative HCRs, as proposed by Koehn et al. (2021), which provide mutually acceptable outcomes for seabirds and fisheries, should be evaluated in the context of the South African small pelagic fishery. Lastly, the spatial management of the small pelagic fishery should be reviewed to incorporate the distribution of African penguins during the non-breeding season to mitigate resource competition during crucial life-history stages such as post-moult.

Conclusion and recommended no-take zones

This study focuses on the critical role and efficacy of no-take zones in tackling one of the most significant contributors to the crisis facing the African penguin, which is the competition between seabirds and industrial-scale fisheries for common prey. The results of our study, using the trade-off mechanism recommended by an international expert panel, have demonstrated that the current no-take zones in place around six of the largest African penguin colonies off the coastline of South Africa, are inadequate for addressing the biological needs of the species they are intended to serve and, in most instances, incur little to no cost to the fishing industry (Table 4). Four African penguin colonies currently have no-take zones that restrict purse-seine fishing in $\leq$50% of the African penguins' core foraging areas, and the current no-take zone around Dassen Island excludes a critical area of their core foraging area to its north. The results of this assessment have shown that there are substantially improved fit-for-purpose no-take configurations available that can be implemented in the short-term to urgently address the negative impacts of resource competition on African penguins. Accordingly, we recommend that the design of the no-take zones be based on the best trade-off possible, within the limitations of available data. These are the mIBA-ARS no-take zones for Dassen Island, Robben Island, and Stony Point; the DFFE (2021) no-take zones for Dyer and St. Croix islands; and lastly, the 20 km no-take zone for Bird Island.

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Author contributions

Conceptualisation: A.M.M., E.A.W., T.C.-K., M.C., A.K., C.L., L.S., R.B.S., C.S., L.W.; data collection: A.M.M., E.A.W., T.C.-K., P.B., J.S.G., C.H., K.L., A.M., L.P., R.B.S., A.S., L.U., L.W.; data analyses: A.M.M., E.A.W., T.C.-K., M.C.; drafting and review of manuscript: all authors.

Table 4. Summary of current protection offered to African penguins through purse seine fishing no-take zones, estimated trade-off between protection for penguins and estimated catch loss for purse seine fishery, and recommended no-take zone based on this assessment.

Colony	Currently implemented extent of protection through area closure to purse seine fishing	Source of current no-take zone	Comment on extent of balanced conservation-fishery trade-off	Recommended no-take zone based on this assessment
Dassen Island	More than 90% of core foraging area protected	DFFE (2021)	Balanced overall but note the exclusion of northern area detrimental to penguin foraging, and that the current closure represents no sardine bycatch loss	mIBA-ARS
Robben Island	Less than 50% of core foraging area protected	Robben Island MPA (2019), DFFE (2021)	Limited protection with negligible costs to fishery, existing MPA (pre-dating IRPR)	mIBA-ARS
Stony Point	Less than 33% of core foraging area protected	CAF	Limited protection with negligible loss to fishery	mIBA-ARS
Dyer Island	20% of core foraging area protected	DFFE (2022)	Small benefits to penguins with minimal cost to fishery	DFFE (2021)
St. Croix	50% of core foraging area protected	ETT Industry	Limited protection and uncertain degree of loss to fishery	DFFE (2021)
Bird Island	Almost all core foraging area protected	CAF	Good protection for penguins which exceeds trade-off extent of 20 km radius; uncertain loss to fishery but catches are minimal here	20 km

Supplementary data

Supplementary data is available at *ICES Journal of Marine Science* online.

Conflict of interest: The authors have no conflict of interest to declare.

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Data availability

All code for this assessment as well as the data for the trade-off analyses can be accessed via Github: https://github.com/amcinnes723/African-Penguin-No-take-zones. Tracking data for inputs into the code for the delineation of core foraging areas (mIBA-ARS) and foraging ranges (mIBA-UD90) can be accessed with permission from data providers for each respective colony at BirdLife International's Seabird Tracking Database: Dassen Island https://data.seabirdtracking.org/dataset/2212, Robben Island https://data.seabirdtracking.org/dataset/2213, Stony Point https://data.seabirdtracking.org/dataset/2214, Dyer Island https://data.seabirdtracking.org/dataset/2217, St Croix Island https://data.seabirdtracking.org/dataset/2215 and Bird Island https://data.seabirdtracking.org/dataset/2216.

References

AEWA. 2021. 1st meeting of the AEWA Benguela Coastal Seabirds International Working Group. *AEWA Benguela Coastal Seabirds International Working Group Report*. https://www.unep-aewa.org/sites/default/files/document/benguela_iwg_report_workplan_final_2021.pdf

Beal M, Oppel S, Handley J *et al.* track2KBA: an R package for identifying important sites for biodiversity from tracking data. *Methods Ecol Evol* 2021;**12**:2372–8. https://doi.org/10.1111/2041-210X.13713

Bergh M, Horton M. 2023. Estimates of the impact of closing fishing around six penguin breeding sites on pelagic catches. *Report submitted by OLSPS Marine to the international review panel regarding fishing closures adjacent to South Africa's African penguin breeding colonies*, 1–64.

Bertrand S, Joo R, Arbulu Smet C *et al.* Local depletion by a fishery can affect seabird foraging. *J Appl Ecol* 2012;**49**:1168–77. https://doi.org/10.1111/j.1365-2664.2012.02190.x

BirdLife International. *Species Factsheet: Spheniscus demersus*. 2024. https://datazone.birdlife.org/species/factsheet/african-penguin-spheniscus-demersus (21 February 2024, date last accessed).

Boersma PD, Borboroglu PG, Gownaris NJ *et al.* Applying science to pressing conservation needs for penguins. *Conserv Biol* 2019;**34**:103–112. http://doi.wiley.com/10.1111/cobi.13378

Boersma PD, Rebstock GA. Foraging distance affects reproductive success in magellanic penguins. *Mar Ecol Prog Ser* 2009;**375**:263–75. https://doi.org/10.3354/meps07753

Börger L, Franconi N, De Michele G *et al.* Effects of sampling regime on the mean and variance of home range size estimates. *J Anim Ecol* 2006;**75**:1393–405. https://doi.org/10.1111/j.1365-2656.2006.01164.x

Campbell KJ, Steinfurth A, Underhill LG *et al.* Local forage fish abundance influences foraging effort and offspring condition in an endangered marine predator. *J Appl Ecol* 2019;**56**:1365–2664. https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.13409

Carpenter-Kling T, de Blocq A, Hagen C *et al.* Important marine areas for endangered African penguins before and after the crucial stage of moulting. *Sci Rep* 2022;**12**:1–13. https://doi.org/10.1038/s41598-022-12969-w

Carr P, Trevail AM, Koldewey HJ *et al.* Marine important bird and biodiversity areas in the Chagos Archipelago. *Bird Conserv Int* 2023;**33**:1–8. https://doi.org/10.1017/S0959270922000247

Coetzee J, de Moor C, Van der Lingen C *et al.* 2022a. A summary of the South African Sardine (and anchovy) Fishery. *Fisheries and the Environment report MARAM/IWS/2022/Sardine/BG1*, 19 pp.

Coetzee J, Makhado A, van der Lingen C *et al.* 2021. African penguin colony closures: finding a balance between minimizing costs to the small pelagic fishing industry while maximizing coverage of foraging area for breeding African penguins. *South African Department of Forestry, Fisheries and the Environment. O&C/2021/SEP/Extended Penguin TT/01:12*.

Coetzee JC, Shabangu F, Maliza L *et al.* 2022b. Final results of the 2022 pelagic biomass survey. *South Africann Department of Forestry,*

Fisheries and the Environment. FISHERIES/2023/FEB/SWG-PEL/02.: 1–9.

Coetzee JC, Van Der Lingen CD, Hutchings L *et al.* Has the fishery contributed to a major shift in the distribution of South African sardine? *ICES J Mar Sci* 2008;**65**:1676–88. https://doi.org/10.1093/icesjms/fsn184

Correia E, Beal M, Gomes N *et al.* Foraging movements and important sites for conservation of the West African Crested Tern *Thalasseus albididorsalis* breeding in Guinea-Bissau. *Mar Biol* 2024;**171**:1–17. https://doi.org/10.1007/s00227-023-04338-6

Crawford R, Randall R, Cook T *et al.* Cape cormorants decrease, move east and adapt foraging strategies following eastward displacement of their main prey. *Afr J Mar Sci* 2016;**38**: 373–383.

Crawford RJM, David JHM, Shannon LJ *et al.* African penguins as predators and prey—coping (or not) with change. *S Afr J Mar Sci* 2001;**23**: 435–47. https://doi.org/10.2989/025776101784528836

Crawford RJM, Sydeman WJ, Thompson SA *et al.* Food habits of an endangered seabird indicate recent poor forage fish availability off western South Africa. *ICES J Mar Sci* 2019;**76**:1344–1352. https://doi.org/10.1093/icesjms/fsz081

Crawford RJM, Sydeman WJ, Tom DB *et al.* Food limitation of seabirds in the Benguela ecosystem and management of their prey base. *Namib J Environ* 2022;**6**:1–17.

Crawford RJM. Food, fishing and seabirds in the Benguela upwelling system. *J Ornithol* 2007;**148**:253–260.

Croxall JP, Butchart SHM, Lascelles BEN *et al.* Seabird conservation status, threats and priority actions: a global assessment. *Bird Conserv Int* 2012;**22**:1–34. https://doi.org/10.1017/S0959270912000020

Cury PM, Boyd IL, Bonhommeau S *et al.* Global seabird response to forage fish depletion–one-third for the birds. *Science* 2011;**334**:1703–6. https://doi.org/10.1126/science.1212928

de Moor C. 2023. Updated assessment of the South African sardine resource using data from 1984-2022. *Unpublished report of the South African Department of Forestry, Fisheries and the Environment, Cape Town, South Africa FISHERIES/2023/MAR/SWG-PEL/03.*

DEA. 2013. African peguin biodiversity management plan. *Government Gazzette No. 36966. South African Department of Environmental Affairs.*

Dee Boersma P, Rebstock G. Foraging distance affects reproductive success in magellanic penguins. *Mar Ecol Prog Ser* 2009;**375**:263–75. https://doi.org/10.3354/meps07753

DFFE. 2022. Call for nominations—proposed establishment of a panel of experts to advise on the propposed fishing-area closures adjacent to South Africa's African penguin breeding colonies and the decline in the penguin population. *Government Gazzette No. 47373. South African Department of Forestry, Fisheries and the Environment.* 1–4. http://www.greengazette.co.za/pages/national-gazette-37230-of-17-january-2014-vol-583_20140117-GGN-37230-003

Dias MP, Carneiro APB, Warwick-Evans V *et al.* Identification of marine important Bird and biodiversity Areas for penguins around the South Shetland Islands and South Orkney Islands. *Ecol Evol* 2018;**8**:10520–9. https://doi.org/10.1002/ece3.4519

Dias MP, Martin R, Pearmain EJ *et al.* Threats to seabirds: a global assessment. *Biol Conserv* 2019;**237**:525–37. https://linkinghub.elsevier.com/retrieve/pii/S0006320719307499

Frederiksen M, Wanless S, Harris MP *et al.* The role of industrial fisheries and oceanographic change in the decline of North Sea black-legged kittiwakes. *J Appl Ecol* 2004;**41**:1129–39. https://doi.org/10.1111/j.0021-8901.2004.00966.x

Furness R, Tasker M. Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. *Mar Ecol Prog Ser* 2000;**202**:253–64. https://doi.org/10.3354/meps202253

Gimeno M, Giménez J, Chiaradia A *et al.* Climate and human stressors on global penguin hotspots: current assessments for future conservation. *Glob Change Biol* 2024;**30**:1–18. https://doi.org/10.1111/gcb.17143

Hamann M, Grémillet D, Ryan P *et al.* A hard-knock life: the foraging ecology of Cape cormorants amidst shifting prey resources and industrial fishing pressure. *Afr J Mar Sci* 2012;**34**:233–40. https://doi.org/10.2989/1814232X.2012.709960

Hampton I. Acoustic study on the abundance and distribution of anchovy spawners and recruits in South African waters. *S Afr J Mar Sci* 1987;**5**:901–17. https://doi.org/10.2989/025776187784522450

Handley JM, Pearmain EJ, Oppel S *et al.* Evaluating the effectiveness of a large multi-use MPA in protecting Key biodiversity areas for marine predators. *Diversity Distrib* 2020;**26**:715–29. https://doi.org/10.1111/ddi.13041

Hockey PAR, Dean W, Ryan P. 2005. *Roberts—Birds of Southern Africa, 7th edn.* Cape Town: The Trustees of the John Voelcker Bird Book Fund.

Hutchings L, Augustyn CJ, Cockcroft a *et al.* Marine fisheries monitoring programmes in South Africa. *S Afr J Sci* 2009;**105**:182–92.

Kirkman SP, Mann BQ, Sink KJ *et al.* Evaluating the evidence for ecological effectiveness of South Africa's marine protected areas. *Afr J Mar Sci* 2021;**43**:389–412. https://doi.org/10.2989/1814232X.2021.1962975

Koehn LE, Siple MC, Essington TE. A structured seabird population model reveals how alternative forage fish control rules benefit seabirds and fisheries. *Ecol Appl* 2021;**31**:e02401. https://doi.org/10.1002/eap.2401

Lascelles BG, Taylor PR, Miller MGR *et al.* Applying global criteria to tracking data to define important areas for marine conservation. *Diversity Distrib* 2016;**22**:422–31. https://doi.org/10.1111/ddi.12411

Makhado A, Crawford R, Underhill L. Impact of predation by Cape fur seals *Arctocephalus pusillus* pusillus on Cape gannets *Morus capensis* at Malgas Island, Western Cape, South Africa. *Afr J Mar Sci* 2006;**28**:681–7. http://www.tandfonline.com/doi/full/10.2989/18142320609504216 (4 June 2013, date last accessed).

McInnes AM, Pistorius PA. Up for grabs: prey herding by penguins facilitates shallow foraging by volant seabirds. *R Soc Open Sci* 2019;**6**:190333. https://doi.org/10.1098/rsos.190333

Parker D, Coetzee JC, Winker H *et al.* Accounting for linefish dependency in management of the South African small pelagic fishery. *Afr J Mar Sci* 2020;**42**:183–94. https://doi.org/10.2989/1814232X.2020.1788160

Petersen SL, Ryan PG, Gremillet D. Is food availability limiting African Penguins *Spheniscus demersus* at Boulders? A comparison of foraging effort at mainland and island colonies. *Ibis* 2006;**148**:14–26. https://doi.org/10.1111/j.1474-919X.2006.00459.x

Pichegru L, Grémillet D, Crawford RJM *et al.* Marine no-take zone rapidly benefits endangered penguin. *Biol Lett* 2010;**6**:498–501. https://doi.org/10.1098/rsbl.2009.0913

Pichegru L, Ryan PG, van Eeden R *et al.* Industrial fishing, no-take zones and endangered penguins. *Biol Conserv* 2012;**156**:117–25. https://doi.org/10.1016/j.biocon.2011.12.013

Pichegru L, Vibert L, Thiebault A *et al.* Maritime traffic trends around the southern tip of Africa—Did marine noise pollution contribute to the local penguins' collapse? *Sci Total Environ* 2022;**849**:157878. https://doi.org/10.1016/j.scitotenv.2022.157878

Pichegru L. 2024. The first biodiversity management plan for African Penguins 2013–2018—a review of the implementation and success of conservation actions anf stakeholders' perceptions. *South African Department of Forestry, Fisheries and the Environment, internal report.*

Pichegru L, Ryan P, Le Bohec C, *et al.* Overlap between vulnerable top predators and fisheries in the Benguela upwelling system: implications for marine protected areas. *Mar Ecol Prog Ser* 2009;**391**:199–208.

Pikitch E, Boersma PD, Boyd IL *et al. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs.* Washington, DC, 2012, 108.

Punt A, Furness R, Parma A *et al.* 2023. 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 (DFFE). Pretoria, South Africa.*

Roberts LC, Abolnik C, Waller LJ *et al.* 2023. Descriptive epidemiology and management of the highly pathogenic avian influenza (H5N8) epidemic in South African coastal seabirds, 2018. *Transboundary and Emerging Diseases, 2023*.

Robinson W, Butterworth DS, Plagányi É. Quantifying the projected impact of the South African sardine fishery on the Robben Island penguin colony. *ICES J Mar Sci* 2015;**72**:1822–33. https://doi.org/10.1093/icesjms/fsv035

Roy C, van derLingen CD, Coetzee JC *et al.* Abrupt environmental shift associated with changes in the distribution of Cape anchovy *Engraulis encrasicolus* spawners in the southern Benguela. *Afr J Mar Sci* 2007;**29**:309–19. https://doi.org/10.2989/AJMS.2007.29.3.1.331

Saraux C, Sydeman WJ, Piatt JF *et al.* Seabird-induced natural mortality of forage fish varies with fish abundance: evidence from five ecosystems. *Fish Fish* 2020;**22**:262–279.

Searle KR, Regan CE, Perrow MR *et al.* Effects of a fishery closure and prey abundance on seabird diet and breeding success: implications for strategic fisheries management and seabird conservation. *Biol Conserv* 2023;**281**:109990. https://doi.org/10.1016/j.biocon.2023.109990

Sherley RB, Barham BJ, Barham PJ *et al.* Bayesian inference reveals positive but subtle effects of experimental fishery closures on marine predator demographics. *Proc R Soc B* 2018;**285**:1–9.

Sherley RB, Makhado A, Crawford RJM *et al.* The African Penguin should be considered critically endangered. *Ostrich* 2024;**95**:1–7.

Soldatini C, Albores-Barajas YV, Rosas-Hernandez MP *et al.* A novel combination of methods identifies priority conservation areas for an endemic California current seabird. *Aquat Conserv: Mar Freshwr Ecosyst* 2022;**32**:1416–27. https://onlinelibrary.wiley.com/doi/abs/10.1002/aqc.3855

Steinfurth A, Oppel S, Dias MP *et al.* Important marine areas for the conservation of northern rockhopper penguins within the Tristan da Cunha Exclusive Economic Zone. *Endanger Species Res* 2020;**43**:409–20. https://doi.org/10.3354/esr01076

Sydeman W, Thompson S, Anker-Nilssen T *et al.* Best practices for assessing forage fish fisheries—seabird resource competition. *Fish Res* 2017;**194**:209–21. https://doi.org/10.1016/j.fishres.2017.05.018

Sydeman WJ, Hunt GL, Pikitch EK *et al.* South Africa's experimental fisheries closures and recovery of the endangered African penguin. *ICES J Mar Sci* 2021;**78**:3538–43. https://doi.org/10.1093/icesjms/fsab231

Trathan PN, Garcia-Borboroglu P, Boersma D *et al.* Pollution, habitat loss, fishing, and climate change as critical threats to penguins. *Conserv Biol* 2015;**29**:31–41. https://doi.org/10.1111/cobi.12349

Tremblay Y, Cherel Y. Spatial and temporal variation in the provisioning behaviour of female rockhopper penguins *Eudyptes chrysocome filholi*. *J Avian Biol*, 2005;**36**:135–45. https://nsojournals.onlinelibrary.wiley.com/doi/abs/10.1111/j.0908-8857.2005.03309.x

Urban-Econ Development Economists. 2023. The pelagic fishing industry: socio-economic impact assessment. *Document FP/PANEL/WP/13. Submitted to the international review panel regarding fishing closures adjacent to South Africa's African penguin breeding colonies and declines in the penguin population.*

Vander Wal E, Rodgers AR. An individual-based quantitative approach for delineating core areas of animal space use. *Ecol Modell* 2012;**224**:48–53. https://doi.org/10.1016/j.ecolmodel.2011.10.006

Wolfaardt A, Williams A, Underhill L *et al.* 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. *Afr J Mar Sci* 2009a;**31**:31–54. https://doi.org/10.2989/AJMS.2009.31.1.3.774

Wolfaardt AC, Underhill LG, Visagie J. Breeding and moult phenology of African penguins *Spheniscus demersus* at Dassen Island. *Afr J Mar Sci* 2009b;**31**:119–32. (http://www.informaworld.com/openurl?genre=article&doi=10.2989/AJMS.2009.31.2.1.873&magic=%7C%7CD404A21C5BB053405B1A640AFFD44AE3 12 March 2012, last accessed).

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"RA4"

Attachments: African Penguins_Island Closures_Conservation Sector letter to Minister Creecy_13 Dec 2023.pdf; Assessment of interim closures for African Penguins_20231017 (final clean).pdf

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Sent: Thursday, January 18, 2024 3:15 PM
To: Mark Anderson <ceo@birdlife.org.za>
Cc: Janine Buitendag <jbuitendag@dffe.gov.za>; Liesl Jacobs <lijacobs@dffe.gov.za>; Itebogeng Chiloane <ichiloane@dffe.gov.za>; Buchule Mbuli <BMbuli@dffe.gov.za>; Nomonde Magagula <NMAGAGULA@dffe.gov.za>; Lee-Anne Levendal <llevendal@dffe.gov.za>
Subject: FW: African Penguin conservation/Island Closures - letter from Conservation Sector Group to Minister Barbara Creecy

Good day

On behalf of the Minister of Forestry, Fisheries and the Environment, Ms B D Creecy, MP, I acknowledge with thanks receipt of your correspondence, in the above regard.

Regards

Liesl Jacobs
Assistant Appointment Secretary and Administration Department of Forestry, Fisheries and the Environment
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"RA5"

From: ICES Journal of Marine Science <onbehalfof@manuscriptcentral.com>
Sent: Tuesday, September 3, 2024 3:04 PM
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Cc: valerio.bartolino@slu.se
Subject: Commercial fishery no-take zones for African penguins minimize fisheries losses at the expense of conservation gains

03-Sep-2024

ICESJMS-2024-102.R1 - Commercial fishery no-take zones for African penguins minimise fisheries losses at the expense of conservation gains

Dear Dr. McInnes et al.,

ICES JMS has been contacted by representatives of the South African Pelagic Fishing Industry Association (SAPFIA) about your recent article:

https://academic.oup.com/icesjms/advance-article/doi/10.1093/icesjms/fsae109/7736707

They have informed us that several of you are involved in litigation, brought by Birdlife SA against the Department of Forestry, Fisheries and the Environment (DFFE) with SAPFIA cited as a correspondent. Specifically, Dr. McInnes is the signatory for Birdlife's affidavit. In addition, and affidavit submitted by Dr. Weidemann providing technical support seems to overlap extensively with the content of the article that you have just published in ICES JMS.

Given that this litigation process began before you submitted your manuscript to ICES JMS, I must say that I am surprised and concerned that you did not disclose it. I am also concerned that none of you declared any competing interest, particularly in the context of ICES JMS's policy:

https://academic.oup.com/icesjms/pages/General_Instructions#Conflict%20of%20Interest

As a member of the Committee on Publication Ethics, ICES JMS follows their guidelines when it comes to handling undisclosed competing interests in a published article:

https://publicationethics.org/resources/flowcharts/clone-conflict-interest

Thus, I request a video call with you and the other co-authors involved in the litigation at your earliest convenience.

Sincerely,

Howard Browman
Editor-in-Chief, ICES Journal of Marine Science

IN THE HIGH COURT OF SOUTH AFRICA
GAUTENG DIVISION, PRETORIA

Case No: 2024-029857

In the matter between:

BIRDLIFE SOUTH AFRICA	First Applicant
SOUTH AFRICAN FOUNDATION FOR THE CONSERVATION OF COASTAL BIRDS	Second Applicant
and	
THE MINISTER OF FORESTRY, FISHERIES AND THE ENVIRONMENT	First Respondent
THE DEPUTY DIRECTOR-GENERAL: FISHERIES MANAGEMENT, DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT	Second Respondent
THE DEPUTY DIRECTOR-GENERAL: OCEANS AND COASTS, DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT	Third Respondent
THE SOUTH AFRICAN PELAGIC FISHING INDUSTRY ASSOCIATION	Fourth Respondent
EASTERN CAPE PELAGIC ASSOCIATION	Fifth Respondent

SUPPORTING AFFIDAVIT

I, the undersigned,

KATRIN LUDYNIA

do hereby make oath and state that:

1. I am an adult female with identity number 7506021590186 and am the Research Manager at South African Foundation for the Conservation of Coastal Birds, the Second Applicant (**SANCCOB**), the second applicant. My particulars and details appear from "**AM3**" to the founding affidavit.

2. The facts and circumstances set out in this supporting affidavit are within my personal knowledge and belief, unless otherwise stated or as appears from the context – and are to the best of my belief both true and correct.

3. I have read the replying affidavit deposed to by **ALISTAIR MC INTYRE MC INNES** together with all confirmatory and expert affidavits to be filed with it and confirm that their contents are true and correct insofar as they pertain to me as well as SANCCOB.

KATRIN LUDYNIA

The deponent has acknowledged that she knows and understands the contents of this affidavit, which was signed and sworn to before me at Cape Town on this the 13th day of **SEPTEMBER 2024**, the regulations contained in Government Notice No. R1258 of 21 July 1972, as amended, and Government Notice No. R1648 of 19 August 1977, as amended, having been complied with.

COMMISSIONER OF OATHS

Full Names: **Wilhelmina Catharina Wicomb**
Capacity: **Commissioner of Oaths**
Designation: **Practising Attorney**
Legal Resources Centre
Address: **Aintree Office Park, Block D, Ground Floor**
cnr Doncaster & Loch Roads, Kenilworth
Cape Town 7708

IN THE HIGH COURT OF SOUTH AFRICA

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THE DEPUTY DIRECTOR-GENERAL: OCEANS AND COASTS, DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT	Third Respondent
THE SOUTH AFRICAN PELAGIC FISHING INDUSTRY ASSOCIATION	Fourth Respondent
EASTERN CAPE PELAGIC ASSOCIATION	Fifth Respondent

EXPERT AFFIDAVIT

I, the undersigned,

MURRAY BRIAN CHRISTIAN

do hereby make oath and state that:

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1. I am an adult mathematician and a postdoctoral researcher at the Centre for Statistics in Ecology, the Environment and Conservation at the University of Cape Town.

2. The facts and circumstances set out in this Affidavit are within my personal knowledge and belief, unless otherwise stated or as appears from the context – and are to the best of my belief both true and correct.

3. My qualifications are set out in my curriculum vitae, attached marked "**MBC1**". In brief my qualifications and expertise are as follows:

   3.1. I hold a PhD in Mathematics from the University of Cape Town (2019) which focused on "*Constant mean curvature ½ surfaces in H^2xR*".

   3.2. I have co-authored seven articles in peer-reviewed journals, including serving as a co-author on McInnes et al. (2024) (attached to the replying affidavit as "**RA3**").

   3.3. I worked as part of the team, which included Ms Weideman and Dr McInnes, which prepared the trade-off curves according to the guidance provided in the *Report of the International Review Panel Regarding Fishing Closures Adjacent to South Africa's Arican Penguin Breeding Colonies and Declines in the Penguin Population* (**the Report**).[1]

4. I have read:

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[1] The Report is "**AM14**" to the founding affidavit. Where I refer to page numbers, these are the original numbers that appear on the face of the Report.

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4.1. the expert affidavit deposed to by Dr Michael Olaf Bergh in support of the answering affidavit filed by the fourth and fifth respondents (**Dr Bergh's affidavit**);

4.2. the founding, supplementary founding and replying affidavits deposed to by Dr McInnes; and

4.3. Ms Weideman's affidavit submitted as "**AM5**" to the applicants' founding affidavit.

5. In this affidavit, I respond to specific critiques provided in Dr Bergh's affidavit to the approach taken in the construction of the trade-off plots to the extent these issues are not already answered by Ms Weideman's affidavit or the affidavits submitted by Dr McInnes in these proceedings.

6. I do so by:

6.1. explaining our reasoning and the mathematics behind the construction of the trade-off plots presented in Ms Weideman's affidavit;

6.2. addressing Dr Bergh's criticisms of:

6.2.1. the interpretation of the Panel's trade-off recommendation; and

6.2.2. the relative scaling of fisheries costs to penguin benefits;

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6.3. setting out considerations that would answer Dr Bergh's critique in respect of use of the trade-of mechanism, to the extent his comments might improve the mechanism design.

REASONING AND MATHEMATICS BEHIND THE CONSTRUCTION OF THE TRADE-OFF PLOTS

Reasoning behind the construction of the trade-off plots

7. Dr Bergh has raised several objections to how we have constructed the trade-off plots. To contextualise the response provided in this affidavit, I have set out some of our key considerations when analysing the Panel's recommendations that appear in Chapter 4 of their Report.

8. The Panel did not "prescribe" all elements of a trade-off analysis in the sense that Dr Bergh has contemplated in his affidavit (for example, at paragraphs 77 and 91). However, paragraph 4.4 of the Report clearly indicates that some form of structured decision-making approach is being recommended: it identifies broad objectives ("penguin benefits", "fisheries cost") on the figure axes (at pages 37 and 38 of the Report) and explicitly recognises the need to measure a trade-off between the objectives.

9. There are several methods that can be used to achieve this. However, these differ in form rather than substance and I would not have expected the Panel to recommend any one specific method. For this reason, the fact that the Panel did not specify all steps in a specific approach or set out all parameters of the mechanism does not

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prohibit the implementation of standard, specific trade-off methods consistent with their approach. In paragraph 4.4 of the Report the Panel provides sufficient guidance.

10. We approached paragraph 4.4. with regard to the following considerations:

10.1. The purpose of the trade-off curves, which is to aid the decision-maker in selecting between closure options.

10.2. The set of closure options considered by the Panel and used for the Interim Closures (**the closure options**).

10.3. The availability of OBM data for different closures and fish stocks.

10.4. The trade-off curves in Figure 1 of Halpern et al. (2013)[2] (attached as "**MBC2**").

10.5. The approach to scaling in Hilborn et al. (2021)[3] (attached as "**MBC3**").

10.6. Figure 4.6 of the Report which offers a conceptual framework for selecting a closure.

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2 Halpern, B.S., Klein, C.J., Brown, C.J., Beger, M., Grantham, H.S., Mangubhai, S., Ruckelshaus, M., Tulloch, V.J., Watts, M., White, C., and Possingham, H.P., 2013. Achieving the triple bottom line in the face of inherent trade-offs among social equity, economic return, and conservation. *Proceedings of the National Academy of Sciences* 110: 6229--6234.

3 Hilborn. R., Akselrud Allen, C., Peterson, H., and Whiterhouse, G.A. 2021., The trade-off between biodiversity and sustainable fish harvest with area-based management, *ICES Journal of Marine Science* 78: 2271-2279.

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The Halpern Example and Fundamental Logic of Trade-off Space

11. The trade-off curves presented in Halpern et al. (2013) plot points in a trade-off space and depict trade-off curves that pass through the subset of points that are not "suboptimal" options. Halpern et al. (2013) describes these types of trade-off curves by saying "*The outer edge of the points is drawn to approximate the efficiency frontier; points interior to this frontier … are suboptimal.*" We define the meaning of these terms and explain their relevance below.

12. The fundamental, elementary logic of trade-off space is illustrated by considering when to select between two options: "A" and "B".

    12.1. If "A" has better values for both objectives (i.e. greater "penguin benefits" and lower "fisheries costs") than "B", then "A" is the preferred option over "B". In this instance we say that:

        12.1.1. "B" is dominated by "A"; and

        12.1.2. "B" is sub-optimal because at least one objectively better choice exists (namely "A").

    12.2. On the other hand, if "A" has better values for one objective and worse values for the other objective (e.g. greater "penguin benefits", but also greater "fisheries costs") than "B", then the choice of "A" versus "B" is not automatic and must be based on the decision makers' preferences (an issue we discuss below).

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12.3. We distinguish between all points dominated by some other point (i.e. the points or options which represent sub-optimal choices) and all those points not dominated by another point (i.e. the points which still require a choice to be made). The latter set of points is called the "efficiency frontier" (or "Pareto front"). This is discussed in Halpern et al. (2013).

13. For the purpose of selecting a closure option, the key implications of these definitions are that:

13.1. an "optimal" solution must be one of the points on the efficiency frontier; and

13.2. one cannot choose between points on the efficiency frontier based on any one point dominating another. Therefore, another means of selection is required. The purpose of the trade-off curve and balance point is to provide this means of selection for choosing between the options which are on the efficiency frontier (i.e. which remain after excluding the options which are "dominated" or suboptimal).

14. To illustrate these concepts, it is helpful to consider the trade-off options for directed sardine at St. Croix Island (presented at Figure 11 of Ms Weideman's affidavit, which I reproduce below).

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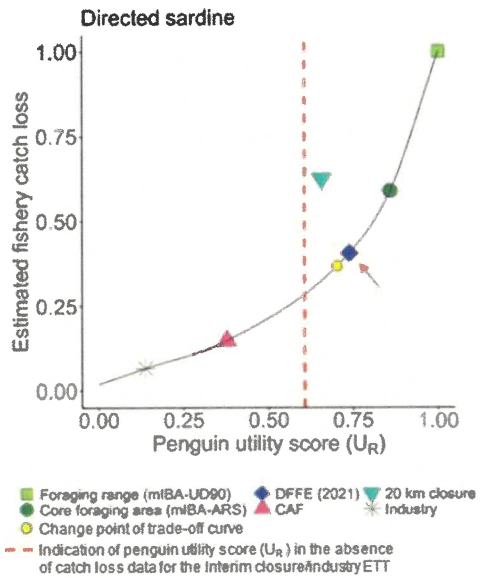
Figure 11 from Ms Weideman's affidavit ("AM5" to the founding affidavit)



14.1. The 20km closure option (the turquoise inverted triangle) has both higher fisheries costs and lower penguin benefits than the DFFE (2021) option (dark blue diamond) and is therefore sub-optimal. In fact, the 20km closure option is dominated by both the DFFE (2021) and the core foraging area / mIBA-ARS options (the latter, the dark green dot).

14.2. In contrast, for each of the Industry (grey asterisk), CAF (pink triangle), DFFE (2021) (dark blue diamond), Core foraging area / mIBA-ARS (dark green dot) and foraging range / UD90 (light green square) options, there is no option that "dominates" them. Therefore, these five options together constitute the efficiency frontier. As a first step, the decision maker may discard the 20km closure option,

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before proceeding to a second step in which the curve is used to aid selection among options on the efficiency frontier. The use of the curve is discussed in the section which follows.

The curve: Figure 4.6 of the Report read with Halpern et al. (2023) and Hilborn et al. (2021)

15. Figure 4.6 of the Report illustrates a trade-off curve where the values for both penguin benefits and fisheries costs lie between 0 and 1. The curve passes from the bottom-left corner representing a "fisheries-optimised" scenario (with zero fisheries costs and zero penguin benefits), to the top-right corner, representing a "penguin-optimised" scenario (with fisheries costs and penguin benefits both equal to the maximal value of "1"). Most "raw" measures of "penguin benefits" or "fisheries costs" will not naturally lie between the bounds of zero and one, so some scaling is necessary to achieve that. We followed the standard approach used in Hilborn et al. (2021), which obtains the 0-1 scaling by dividing all values by the maximum possible value.

16. Figure 4.6 does not show any points representing closure options, and there is no explicit guidance in the text of the Report as to how the curve should relate to such points. Therefore, we were guided by Halpern et al. (2013), which the Report cited as an example of a trade-off analysis, and which does show convex trade-off curves in relation to a set of points representing different options.

17. Taken together, these considerations characterise a trade-off curve as a curve that:

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17.1. passes from the bottom-left corner to the top-right corner whilst remaining between 0 and 1 on both axes;

17.2. is convex (i.e. only bends upwards, like a “smiley face”, or the right half of the letter “U”); and

17.3. passes through the "outer” edge of the plotted points, such that all the points lie on the side of the curve where fisheries costs are higher and/or penguin benefits are lower.

18. Consequently, our algorithm for constructing trade-off curves consists of (1) selecting the points on the boundary of the “convex hull” of all points, and (2) fitting an “increasing spline” through these points.

18.1. The “convex hull” can be understood as follows: imagine that trade-off space is plotted on a square wooden table, and a nail is hammered into the table at the location of each closure option and at the top-left corner of the table. Now place a rubber band around all the nails and allow it to contract. The region of trade-off space that it surrounds is the convex hull. The points selected are those that the rubber band touches (except the point in the top-left corner). These points are precisely the points on the efficiency frontier/Pareto front that could be chosen as optimal based on the slope of the trade-off curve.

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18.2. An "increasing spline" is a curve that only increases (i.e. the curve only goes upwards, or remains horizontal, as it moves from left to right, but never downwards), yet is flexible enough to pass through all these points.

The "balance point" on the trade-off curve: Figure 4.6 of the Report

19. On page 36 of the Report, with reference to Figure 4.6, the Panel explain how a trade-off curve can be used to select between options on the efficiency frontier. Their recommendation is "*to find the point at which the change in penguin benefits (by increasing closures) matches the change in costs to society*". We term this point the balance point and discuss it further in relation to Dr Bergh's criticisms below.

Decisions made in applying the Panel recommendations

Selection of closure options for purposes of decision-making

20. We included all closure options considered by the Panel, including Interim Closures, for which the estimated costs to fisheries were available from the OBM. We used this set of closures because this was the approach of the Panel (e.g. at page 37 of the Report) and included the Interim Closures because these are the closures which are currently in place (and a decision-maker would likely need to consider their costs/benefits among the various options in play).

21. Dr Bergh's proposal to consider "*a series of shapes differing only by a single parameter*",[4] such as "*a family of mIBA-ARS areas [obtained by] varying the value of*

[4] Dr Bergh's affidavit, para 90.2.

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the UD %"[5] is not feasible with the data available. Furthermore, the options considered were those for which stakeholders (including conservation and fisheries sectors and DFFE) had expressed a preference as already described above.

22. Among the closure options that were considered by the Panel, which included the Interim Closures, there were certain options where OBM data for one or other species was not available. In the cases of the Interim Closures for Dyer Island and St Croix Island there was no OBM data available at all. OBM data-availability was thus the sole basis on which we made any kind of selection among the options.

23. This was consistent with the approach we had understood was taken by the Panel i.e. to construct the trade-off mechanism and conduct the trade-off analysis using best available data – and which recognised that the OBM data could be used without further refinement in a "relative" sense which suggested its utility at least for comparative purposes between closure options (I address this further in the next section). We had sufficient data, in our view, to construct trade-off plots for the purposes of an immediate decision especially given that the closure options assessed included the most relevant closure delineations submitted by the conservation and fisheries sectors and DFFE since the Joint Governance Forum was concluded by DFFE in 2021, including the preferred closures by the conservation and fisheries sectors submitted to the Panel in 2023. These considerations from the team of scientists provided the context for how we interpreted the Panel's recommendations and applied the maths.

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5 Dr Bergh's affidavit, para 100.

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Reasons for data used to represent "costs to industry"

24. We used the OBM data, because the Panel stated at page 36 "*Given that the OBM analysis likely provides an overestimate of uncertain magnitude of the loss in catch (see section 3.2) and these losses are then used in the SAM analysis, the results on economic costs (lower GDP, jobs) and lost catches should be considered in a relative sense and hence used for ranking closure options within a region*". The Report also said that the trade-off should be carried out on an island-by-island basis.[6]

25. The SAM data (which was provided by Urban Econ and which included the jobs data) was provided regionally but not locally / on a colony-by-colony basis. For the purpose of demonstrating how the trade-off should be implemented and applying it immediately and in following the Panel's recommendation to conduct the analysis by locality, we therefore could not use this regionally aggregated data. However, the OBM data was available for each colony as well as, in most cases, each fish stock species (subject to what is stated above about certain data gaps). For this reason, we were able to use the OBM outputs which reflect a percentage of lost catch of specific fish-stock species[7] as a proxy for "costs to industry" in a "relative sense" as the Panel had recommended.

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6 Report, p 36.

7 The OBM model produced several estimates to predict catch loss for each closure type for each fish stock species based on a combination of assumptions related to the replaceability of catches outside a given closure including: (i) how outside catches are selected to replace catches inside a closure (we used the median available catch opportunities as was used in the Dr Bergh affidavit); (ii) how often an outside catch can be used to replace a catch inside a closure (we used five time in the same way as Dr Bergh used his affidavit), and (iii) whether alternative catches could be used on the same day or on days before and after the inside catch (we used the same day catch as was used in the Dr Bergh affidavit). We used these in a relative sense owing to the critiques expressed by the Panel.

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Reasons for data used to represent "benefits to penguins"

26. The penguin utility index / score shows how intensively a particular portion of African Penguin habitat is foraged. It is calculated per colony in two steps:

    26.1. First, telemetry data (i.e. data collected from GPS tracking) are used to create a "heat map" of space use around a colony. Space is divided into pixels and each pixel is assigned a "utility value". The "utility value" is the number of penguins that regularly use that pixel. Visually, the "heat map" shows how penguin activity is distributed around a colony, with "warmer" areas used by more birds, and "cooler" areas by fewer birds.

    26.2. Second, the total utility of each closure option is calculated by adding up the utility value of each pixel within the region encompassed by that closure. Then the utility score of each closure option is calculated by dividing its total utility by the total utility of the entire foraging range (which is the "mIBA-UD90").

27. These steps mean that the penguin utility index/score of each closure option describes how important that closure region is for penguins at that colony, as a proportion of the importance of their foraging range ("mIBA-UD90"). This index accounts for the fact that African Penguins do not use their ocean habitat around each colony equally: some areas are used more intensively than others (just as some shopping malls may be used more intensively than others by people living in a particular suburb or town or "colony"). The most intensively used areas are the areas that are most valuable to

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African Penguins, around each colony. It is therefore appropriate to use this utility index (or utility "score") as the metric for "penguin benefit".

Reasons for creating trade-off plots by species

28. At paragraph 96 of his affidavit, Dr Bergh states that "*it seems premature at this stage to conclude that species-specific trade-offs should be considered*". However, we dealt with each trade-off by fish stock species because this was the manner in which the OBM data (prepared by Dr Bergh) was provided i.e. on a species-by-species basis. I note also that the Panel provided species-specific examples at Figures 4.4 and 4.5 appearing on page 37 of the Report.

Reasons for the scaling used

29. For clarity, "scaling" refers to the relative weight or preference for each objective in the trade-off. In our case, these objectives were:

    29.1. the penguin utility index/score (used on the x-axis to represent "penguin benefit" and which measures the intensity of foraging for different closures); and

    29.2. fishery catch losses (used on the y-axis to represent "fisheries costs, defined by the "total local catch lost" i.e. the total loss of a catch of a particular fish stock species for each closure option). The figures on the y-axis expressed these figures as a proportion of the maximum potential catch loss (i.e. catch loss if no fishing were allowed in the entire foraging range being the largest possible

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closure option of "UD90" which is reflected in light green on the graphs and maps provided in Ms Weideman's affidavit).

30. We interpreted the recommendation to select a closure at "*the point at which the change in penguin benefits (by increasing closures) matches the change in costs to society*"[8] to mean that we should find the point on the trade-off curve where the slope of the curve equals "1".

    30.1. A slope of "1" implies that in order to gain a small additional amount on the x-axis (for example, two units) one must lose precisely the same amount on the y-axis (two units), and *vice versa*. At any other point (i.e. where the slope is not "1"), gains on the x-axis require disproportionately large losses on the y-axis, or *vice versa*. This appears a reasonable interpretation of the Panel's statement.

31. In our analysis, a fixed-size change in the penguin utility index is assigned the same relative value as a fixed-size change in proportion of catch lost, across all stock species and colonies.

    31.1. Dr Bergh argues that this relative value should depend on, for example, the magnitude or monetary value of catch lost (see, for example, Dr Bergh's affidavit at paragraphs 130 and 131).

    31.2. We treated stocks and colonies independently because (1) this was the way data was presented to us; and (2) ensuring comparability across stocks or colonies

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[8] Report, p 36.

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requires linking stock- or colony-specific catch magnitude or monetary value to overall fishery cost.

31.3. In respect of the latter, it was not possible to link catch-loss magnitude to a monetary value because the Panel had indicated that the attempts to make these links were insupportable. The best available data provided (which I understand was provided by Industry) did not permit a factual (or principled) assessment of, for example, the vulnerability of different communities or subjective judgements about how different communities should be prioritized. For this reason, treating stocks and colonies independently provided the best possible unbiased assessment of the available closure options in the circumstances.

RESPONSE TO DR BERGH'S CRITICISMS

The relative scaling of fisheries costs and penguin benefits

32. Dr Bergh raises two slightly different issues regarding scaling:

32.1. the relative scaling of fisheries costs to penguin benefits in each plot i.e. for a particular species at a particular colony; and

32.2. the scaling of fisheries costs between different colonies and for different fish relative to each other.[9]

[9] Dr Bergh's affidavit, para 129.

33. Dr Bergh objects that the scaling of fisheries costs to penguin benefits in our trade-off spaces (1) is subjective; (2) is insensitive to various contextual factors that should be accounted for, and (3) could strongly influence the position of the "balance point" and hence the optimal closure chosen.[10]

34. In respect of these criticisms, I note the following:

34.1. *Regarding (1) ("subjectivity")*: any trade-off analysis necessarily involves some element of subjectivity. The nature of a trade-off decision is that there is no option that performs objectively better in each and every criterion (here, penguin benefits and fisheries costs). Some degree of compromise is necessary, and the extent of that compromise is unavoidably subjective. We made the choices that appeared, to us, least open to criticisms of bias in either direction. Subjectivity should not be used as a way of avoiding making a decision transparently – because some decision must be made, and any decision (including the Interim Closures) can be traced back to an implied set of preferences.

34.2. *Regarding (2) ("insensitivity")*, Dr Bergh argues that relative value should depend on, for example, the magnitude or monetary value of catch lost at a colony. His simple illustrative example argues that, because the monetary value of catch lost is 12 times larger at one colony than another, the relative trade-off weight should also be adjusted by a factor of 12. While superficially persuasive, this is misleading because:

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[10] See for example Dr Bergh's affidavit, paras 90.3; 92.3; 99.

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34.2.1. First, linking monetary value to preference value is far more difficult than described (for example, the Report states that "*Future work should consider broader social consequences of reduced catches*" and we know that such work is going to take some time which mitigates against the purpose of a trade-off mechanism to aid decision-making in the current set of circumstances). In addition, linking monetary value to preference value necessarily requires the kinds of subjective judgments (prioritizing stocks and colonies) that Dr Bergh criticises. In effect, this particular line of argument allows for indefinite postponement until the analysis is done "objectively" which will never be the case.

34.2.2. Second, it gives the impression that fisheries have been prejudiced, but exactly the same argument applies to penguin benefits. Some colonies are larger or more vulnerable than others. There is no bias in either direction here (which is one reason for the choice made). Given the above, treating stock and colonies independently is a reasonable approach.

34.3. *Regarding (3) ("effect on balance point")*: the scaling of fisheries costs to penguin benefits will influence the position of the balance point and hence the optimal closure chosen. However, for the reasons described above, we maintain that our choices are justified, and that any other choices would be more open to critiques, particularly of bias, than ours are.

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The procedure for constructing trade-off curves

<u>The algorithm used to "fit" the curve to a given set of points</u>

35. Dr Bergh objects to the appearance of the curves by stating the following:

35.1. "*The standard scientific approach would be to specify the function of the curve, and estimate the function parameters by a minimisation procedure, but this does not seem to have been done*".[11]

35.2. Referring to the trade-off curves for anchovy and redeye at Dassen, he says "*Were the curve to be estimated using a standard statistical approach, it would have passed close to the points in such a manner that some points lie above and some points lie below the curve.*"[12]

35.3. Referring to the trade-off curves for Robben, he says "*The shape of these trade-off curves is puzzling and again raises the question as to how these curves have been drawn and constructed. The curve for anchovy is notably odd since it does not seem to be based on a simple underlying mathematical equation, but rather to involve different components that pass from one point to the next regardless of the shape of the eventual overall curve. The final result appears to be inconsistent with a general statistical preference for parsimony in the mathematical form describing the best fitted curve.*"[13]

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[11] Dr Bergh's affidavit, para 79.
[12] Dr Bergh's affidavit, para 117.
[13] Dr Bergh's affidavit, para 125.

M-C.

35.4. Again, referring to trade-off curves for Robben Island, he says "*Given that this is a curve fitting exercise, it is very unusual that the curve passes through all 5 points shown in the plot. This violates a number of statistical principles and requirements for curve fitting.*"[14]

36. It is clear from these statements that Dr Bergh regards the fitting of trade-off curves as a job for standard statistical curve-fitting methods. However, the purpose of "standard statistical curves" and "trade-off curves" are fundamentally different.

36.1. The purpose of "standard statistical curves" (linear regression, generalised additive models and relatives) is to provide a model-based description of an entire dataset from which one can infer parameters of interest.

36.2. In contrast, the purpose of trade-off curves is not to describe all the data (i.e. all the points representing the different closures), but rather to guide the decision maker in choosing an optimal closure.

37. Practically, this means that points that are clearly sub-optimal choices – because they have both greater costs and smaller benefits than some other choice – do not need to be "fit" by the trade-off curve. I have explained how this works in relation to the "efficiency frontier" / "Pareto front" above, where the principle is illustrated for the case of directed sardine at St. Croix.

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[14] Dr Bergh's affidavit para 126.

M-C.

38. Dr Bergh repeatedly impugns the validity of the trade-off curves because they pass directly through some points whilst missing other points.[15]

38.1. This is only unusual for "standard statistical curves" that are supposed to provide a representation of an entire dataset, which as we have explained, is not the purpose of the trade-off curves.

38.2. There is nothing unusual about a trade-off curve passing directly through a subset of points and avoiding others. Indeed, Halpern et al. (2013), cited by the Panel as an example of trade-off analyses, displays trade-off curves with these features in their Figure 1.

39. There is also nothing arbitrary or subjective about the subset of points which the trade-off curve passes through.

Criticisms relating to the "balance point"

40. Dr Bergh provides two criticisms relating to the "balance point":

40.1. First, he suggests that a different curve-fitting algorithm would produce different trade-off curves. For this reason, he says, the location of the balance point is unreliable, which in turn means that the selected closure is unreliable; and

[15] See for example Dr Bergh's affidavit paras 126, 138.

M.C.

40.2. Second, Dr Bergh objects that the construction of the trade-off curves is too flexible and could, in principle, result in more than one balance point and hence more than one closure option being eligible for selection.[16]

41. In respect of the first of these complaints, it is my professional mathematical judgement that the algorithm we used provides a good "*approximation of the efficiency frontier [Pareto front]*" (Halpern et al. (2013)) for the given data. The location of the "balance point" would change very little if a different algorithm were used, provided that the algorithm ensured that the resulting curve bounds the plotted closure options (which it would have to do, if the exercise was to be helpful to a decision-maker).

42. In respect of the second complaint, Dr Bergh's contention is false: mathematically, the approach we used guarantees that there will always exist a unique point on the curve where the slope is one.

43. Furthermore, criticisms about how the curve was constructed are likely moot because the same conclusions can be drawn (i.e. about which of the available set of closure options should be preferred) without recourse to the curve, by moving a line with 1:1 slope across the plot, starting in the bottom-right corner and moving towards the top-left corner, and selecting the closure option that the line touches first (see figure below). This is mathematically equivalent to equation 6 in Hilborn et al. (2021) with an equal weight on penguin benefits and fishery costs, which is itself a widely used model of decision-making (a Multi-attribute Value Theory model).

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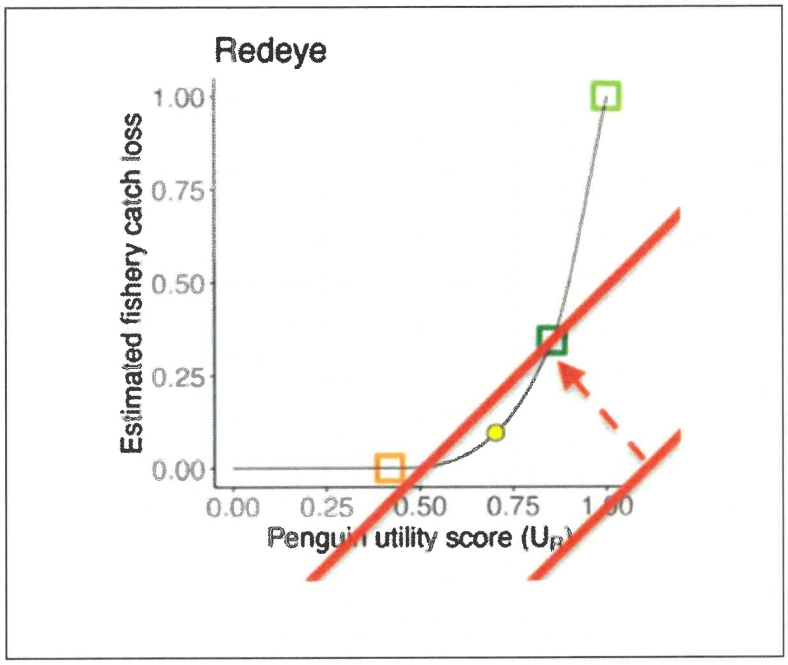
[16] See the statement at footnote 33 of on page 125 of Dr Bergh's affidavit.

 M-C.



CONSIDERATIONS THAT WOULD ANSWER DR BERGH

44. While we consider our analysis to be fair and free of error, Dr Bergh's objections to our relative scaling choices could be addressed relatively quickly by the following steps:

44.1. *The assessment of trade-offs between changes in fishery costs of different stocks at each island*. These assessments could be based on currently available OBM data in which case (for example) a loss of 1kt of Anchovy would receive the same weight as a loss of 1kt of Sardine. This assessment could be made with reference to data held by DFFE: Fisheries or Industry and the Minister could easily obtain this assessment on request within a short period and without further analysis being required, noting that this is a value judgment to be made by the Minister's departmental experts (or Industry as the most interested stakeholder group).

M-C.

44.2. *The assessment of trade-offs between changes in fishery costs of the same stock species at different islands*. These assessments could be based on currently available OBM data, in which case (for example) a loss of 1kt of Anchovy at Island A would receive the same weight as a loss of 1kt of Anchovy at Island B. As above, this assessment could be made in short-order with a simple request from the Minister to their departmental experts or Industry.

44.3. *The assessment of trade-offs between changes in the penguin utility index at different islands*. These assessments could be based on currently available colony sizes (relative to that of the global and national population), extinction probabilities and other relevant factors. Following this weighting, for example, a loss of 100% of the penguin utility index at Island A might be valued the same as a loss of 60% of the penguin utility index at Island B. This assessment could be made through a simple request for input by the Minister to their experts within DFFE: Oceans & Coasts and/or to the seabird scientists operating within the conservation sector / academia (as the group with most expertise in this particular area).

45. The assessments above effectively provide new "worst" and "best" cases (0 and 1 points) that are comparable across all analyses. Where these assessments cannot be agreed upon, the closure decision at each island must be considered entirely independently, as done in the current analysis. Following this, a 1:1 slope (equally weighting the maximum possible change in penguin benefits and fishery costs) would be used to determine which of the available closure options is preferred at each island.

MURRAY BRIAN CHRISTIAN

The deponent has acknowledged that he knows and understands the contents of this affidavit, which was signed and sworn to before me at Cape Town on this the 13th day of **SEPTEMBER 2024**, the regulations contained in Government Notice No. R1258 of 21 July 1972, as amended, and Government Notice No. R1648 of 19 August 1977, as amended, having been complied with.

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Assessing the efficacy of conservation measures for African Penguins using PIT tag data and integrated population modelling.

Marion Island Marine Mammals Program, University of Pretoria — *Postdoctoral Researcher*

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Integrated Population Modelling of southern elephant seals.

Karolinska Institutet, Stockholm, Sweden — *Postdoctoral Researcher*

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RECENT TALKS

ISEC 2024, Swansea, Wales July 2024

A product-multinomial likelihood for multi-event mark-recapture models.

EURING 2023, Montpellier, France April 2023

Accurately estimating the demographic contribution of immigration: a southern elephant seal case study.

SEEC Toolbox Seminar, Department of Statistics, UCT August 2022

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Mathematical modelling

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January 2013 - December 2019

Constant mean curvature ½ surfaces in H^2xR, supervised by Dr. Jesse Ratzkin.

University of KwaZulu-Natal, Durban, South Africa — *BSc.*

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Majors in Mathematics and Applied Mathematics.

STUDENT SUPERVISION

Fikile Mahlangu, Statistics Honours, University of Cape Town - Cosupervised with Res Altwegg January 2024 - present

State-space modelling of Sociable Weaver population dynamics.

PUBLICATIONS

McInnes, A., Weideman, E., Carpenter-Kling, T., Barham, P., Christian, M. and others. (2024). ***Commercial fishery no-take zones for African penguins minimise fisheries losses at the expense of conservation gains.*** ICES Journal of Marine Science, fsae109. DOI:10.1093/icesjms/fsae109

Christian, M., Oosthuizen, W. C., Bester, M. N., & de Bruyn, P. J. N. (2024). ***Robustly estimating the demographic contribution of immigration: Simulation, sensitivity analysis and seals.*** Journal of Animal Ecology, 93(5), pp. 632–645. DOI:10.1111/1365-2656.14053

Roxhed N, Bendes, A, Dale M, Mattsson C, Hanke L, Dodig-Crnkovic T, Christian M, Meineke B, Elsasser S, Andrell J and others. (2021). ***Multianalyte serology in home-sampled blood enables an unbiased assessment of the immune response against SARS-CoV-2.*** Nature Communications. Vol 12 (1), pp. 3695-3773. DOI: 10.1038/s41467-021-23893-4

Castro Dopico X, Muschiol S, Christian M, Hanke L, Sheward DJ, Grinberg NF, Rorbach J, Bogdanovic G, Mcinerney GM, Allander T and others. (2021). ***Seropositivity in blood donors and pregnant women during the first year of SARS-CoV-2 transmission in Stockholm, Sweden.*** Journal of internal medicine. Vol 290 (3), pp. 666--676. DOI: 10.1111/joim.13304

Ma J, Tibbitt CA, Georen SK, Christian M, Murrell B, Cardell L, Bachert C and Coquet JM. (2021). ***Single-cell analysis pinpoints distinct populations of cytotoxic CD4+ T cells and an IL-10+ CD109+ TH2 cell population in nasal polyps.*** Science Immunology. Vol 6 (62), pp. 6356 - 6367. DOI: 10.1126/sciimmunol.abg6356

Stark JM, Liu J, Tibbitt CA, Christian M, Ma J, Wintersand A, Dunst J, Kreslavsky T, Murrell B, Adner M, and others. (2022). ***Recombinant multimeric dog allergen prevents airway hyperresponsiveness in a model of asthma marked by vigorous TH2 and TH17 cell responses.*** Allergy. Vol 77 (10), pp. 2987--3001. DOI: 10.1111/all.15399

McKechnie AE, Ashdown RAM, Christian MB and Brigham RM (2007). ***Torpor in an African caprimulgid, the freckled nightjar Caprimulgus tristigma.*** Journal of Avian Biology. Vol 38 (3), pp. 261 - 266. DOI: 10.1111/j.2007.0908-8857.04116.x

M.C.

PRESS

Nater, C.R., 2024. ***Redefining 'state-of-the-art'for integrated population models with immigration***. *Journal of Animal Ecology*, *93*(5), pp.520-524. https://doi.org/10.1111/1365-2656.14087

MANUSCRIPTS SUBMITTED OR IN PREPARATION

Oosthuizen, W.C., Christian, M. and Ngwenya, M. ***Comment on Krüger (2023): Decreasing Trends of Chinstrap Penguin Breeding Colonies in a Region of Major and Ongoing Rapid Environmental Changes Suggest Population Level Vulnerability***. (submitted to *Diversity*).

Christian, M. and Clark, A.E. ***A product-multinomial likelihood for multi-event mark-recapture models***. (*in prep.*)

Grigg, J.L., Ludynia, K., Barham, B., Barham, P.J., Abadi, F., ... , Christian, M., ... , and Sherley, R.B. ***A combined Bayesian integrated population model-population viability analysis to assess alternate fisheries management scenarios for an Endangered seabird*** (*in prep.*)

M.C.

Achieving the triple bottom line in the face of inherent trade-offs among social equity, economic return, and conservation

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Achieving the triple bottom line in the face of inherent trade-offs among social equity, economic return, and conservation

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Triple-bottom-line outcomes from resource management and conservation, where conservation goals and equity in social outcomes are maximized while overall costs are minimized, remain a highly sought-after ideal. However, despite widespread recognition of the importance that equitable distribution of benefits or costs across society can play in conservation success, little formal theory exists for how to explicitly incorporate equity into conservation planning and prioritization. Here, we develop that theory and implement it for three very different case studies in California (United States), Raja Ampat (Indonesia), and the wider Coral Triangle region (Southeast Asia). We show that equity tends to trade off nonlinearly with the potential to achieve conservation objectives, such that similar conservation outcomes can be possible with greater equity, to a point. However, these case studies also produce a range of trade-off typologies between equity and conservation, depending on how one defines and measures social equity, including direct (linear) and no trade-off. Important gaps remain in our understanding, most notably how equity influences probability of conservation success, in turn affecting the actual ability to achieve conservation objectives. Results here provide an important foundation for moving the science and practice of conservation planning—and broader spatial planning in general—toward more consistently achieving efficient, equitable, and effective outcomes.

marine protected areas | environmental justice | marine spatial planning | ecosystem-based management | social-ecological systems

Conservation and resource management require decisions about where, when, and how to allocate limited financial, human, social, and/or political capital resources (1). Whether designing protected areas, prioritizing restoration activities and locations, or limiting, promoting, or allocating certain uses of the landscape or seascape, the spatial and temporal distribution of management actions requires decisions about who may benefit and who may pay costs (2, 3). A large body of literature on conservation and spatial planning has been developed to help guide management strategies and decisions to be as efficient as possible at meeting stated goals (e.g., refs. 4–7). However, the goal of equitable distribution of costs or benefits across individuals or communities from use restrictions is rarely explicitly assessed in the planning process (8).

A fundamental tenet of conservation planning is that identifying optimal allocations of actions in space and time requires formulating the problem with explicit objective(s), constraints, potential actions, and system models that translate those actions into outcomes (1, 9). Objectives can take different forms, but the ultimate aim is to find the feasible set of actions that maximizes the value of those objectives (e.g., maximum gain in value, minimum area needed to achieve the objective). In most biodiversity conservation optimization problems, objectives are biological and framed as quantities, such as species viability or habitat representation, that are usually traded off against, or constrained by, economic outcomes. In the context of spatial planning and ecosystem-based management, objectives focus on particular services, but otherwise the problem formulation remains the same. In either case, economic outcomes are typically total cost (e.g., dollars spent) or opportunity cost (i.e., the monetary gains expected in the absence of conservation actions). Trade-offs can place in conflict those who prioritize economic versus biodiversity (or service) value (10); but in other cases, biodiversity conservation and economic value positively covary (e.g., ref. 6), such that strategic planning can deliver win–win solutions.

In many planning processes, there is awareness of social equity issues, where equity may be a function of, for example, equality of engagement in the planning process or reallocation of benefits or costs accrued under a management decision. In fact, achieving equity along with economic and environmental benefits—the "triple bottom line"—is commonly seen as the ideal outcome of conservation (11). However, rarely is equity incorporated into decision making in a formal way. Formalizing equity as a quantifiable and high-priority goal for conservation planning is feasible, as we discuss and demonstrate below. However, explicitly including this additional objective could compromise biodiversity conservation, or in other words create another potential trade-off among planning objectives (12).

Equity relates to how a person or group perceives the proportional availability of goods and services (e.g., is a given pool of resources evenly distributed and/or available?) or the relative deprivation compared with others (e.g., do others have more than I do?) (13). Despite the stated importance of equity in management and decision-making processes (e.g., ref. 14), there is no formal theory for addressing it in the conservation or spatial planning literature. Furthermore, perceived or real inequity can turn interested and cooperative participants into vocal opponents (15), leading to noncompliance or destructive actions (16, 17). Thus, equity can be a critical component of management and conservation success. Here, we explore the nature of potential

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trade-offs between equity and conservation objectives, test this theory in three case studies from around the world, and outline potential modifications to the theory that future empirical work could explore. Although our focus is on conservation planning, results are equally relevant to broader questions addressed within spatial planning contexts. Our work suggests that triple–bottom-line solutions to conservation are possible, but that such solutions depend on the form of equity being pursued. Importantly, including equity as an explicit planning objective leads to clearer delineation of trade-offs among multiple objectives.

Equity and Its Trade-Offs

Equity can manifest itself in a number of ways, with important implications for how it gets incorporated into conservation planning and the potential impacts it has on achieving conservation targets. There are two key dimensions to measuring equity: (*i*) what is measured, which can include monetary loss or gain, access to resources gained or lost, and level of participation in a process (18), and (*ii*) how it is measured, either in absolute or relative terms. The former defines the metric(s) used to assess equity; the latter determines how groups are compared with each other. The metrics used essentially link to three classes of problems in conservation prioritization: economic benefits such as money or rights to use resources are being distributed among a suite of political entities (e.g., countries, states, regions, nongovernment organizations, or local governments) (19); conservation actions, such as reserves or restrictions on uses, are being put in place that are believed to impact or benefit a variety of communities or industries (20); and voice or opportunity is given to different groups in a deliberate process (e.g., stakeholder involvement or gender equity) (e.g., refs. 21, 22). Here, we empirically explore the first two problem types, but acknowledge that participatory equity may be more important for achieving desired outcomes than the other types of equity in some cases.

Once the type of equity to be measured is defined, the target objective for equity can be set in a number of ways. To date, most policy has focused on avoiding extreme cases of inequity, in particular those producing unethical conditions, within a framework of environmental justice (e.g., refs. 23, 24). More recently, attention has also focused on optimizing social equity through instances where all stakeholders are included in the planning process (18) or are affected equally by actions (12, 25, 26), and to a lesser extent through consideration of intergenerational equity (27, 28). It is typically assumed that increased equity comes at the cost of financially optimal conservation solutions, but the nature and shape of that trade-off is generally unknown (29). In theory, the trade-off could take any potential shape (Fig. S1), as is seen with trade-offs among ecosystem services (10, 30). Through three case study assessments, we evaluate the shape of these trade-off curves and explore the implications of such trade-offs for achieving conservation objectives.

Case Studies

Our three case studies include the following: (*i*) the central coast of California (United States), where a network of marine protected areas (MPAs) was recently created with consideration of impacts on local fisheries, (*ii*) an MPA in the southern Raja Ampat region of Indonesia where proposed no-take zones may differentially impact villages' fishing access; and (*iii*) the Coral Triangle region where international aid money is being distributed among six countries to mitigate threats to their marine resources. As such, these cases evaluate two different metrics of equity—dollars and access—and for the Coral Triangle example in particular we explore implications of considering absolute versus relative (i.e., proportional) changes in equity.

California Marine Protected Areas. California recently completed an extensive, 8-y planning process to design and implement a network of MPAs in its state waters, initiated by the Marine Life Protection Act (MLPA) (31). Synthesis of existing information and development of new analytical frameworks provided a vast array of information on the potential trade-offs between conservation and fisheries values under different MPA network designs (32, 33). We focus here on the central California region within the MLPA process (Fig. S2*A*), because data for the area are published and available (26). Previous analyses for this region focused on the trade-off between how well conservation objectives were met within a given MPA network and the potential total costs to fisheries (7). Here, we focus on implementing marine reserves only (the MLPA process included less restrictive MPAs as well) and define equity as cost in dollars to eight separate commercial fisheries, and measure equity using the Gini coefficient [defined as the dissimilarity in costs or benefits among different entities (*Materials and Methods*)]. We explore how different overall budget constraints on the combined value lost by fisheries interact with equity to influence the nature of the trade-off between conservation goals and equitable fisheries impact.

Given budgets set to 3–20% of total fisheries value, equity traded off nonlinearly (concavely) with the degree to which conservation goals could be achieved for all budgets (Fig. 1*A*). Greater levels of both equity and conservation goals could be achieved with higher total budgets (Fig. 1*A*). The points in Fig. 1 approximate the "efficiency frontier" where optimal solutions lie, and represent different importance (weight) given to conservation versus equity goals under each budget scenario. The absence of solutions with equity less than 0.6 suggests that it is possible to avoid highly uneven impacts on fisheries under any budget scenario; given the budgets considered here (≤20% of the total value of fisheries), any reserve network solution still leaves substantial area open to each fishery. The nonlinear shape in the trade-off curves shows that substantial increases in achieving conservation goals can be achieved with minimal cost to equity, and vice versa, especially for higher budgets. The result that higher total budget increases equity emerges from the increased flexibility to "impact" higher value fisheries (with a small total budget, total impact is less, but one or a few fisheries experience the brunt of it). As expected, greater total budget allows for greater conservation outcomes for a given level of equity (7).

We also found that when conservation goals were prioritized at a low level relative to equity (i.e., weighted less than ~10% in the objective equation in *Materials and Methods*), solutions all

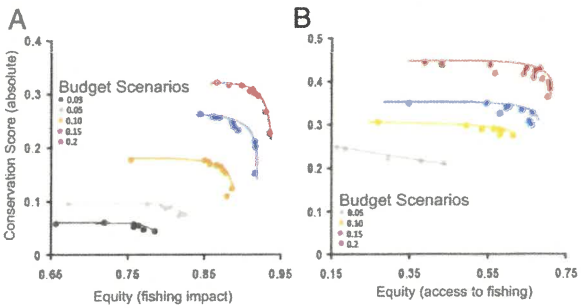

Fig. 1. Trade-offs between achieving conservation goals and equity, measured under the following budget scenarios: (*A*) monetary impact to the fishing industry in central California with different budget constraints in place or (*B*) loss of fishing grounds in the Misool region of Raja Ampat, Indonesia. In both cases, the plots represent absolute measures of conservation objectives. The outer edge of the points is drawn to approximate the efficiency frontier; points interior to this frontier resulted from simulations but are suboptimal.

converged on perfect equity plans without marine reserves (i.e., no conservation gain but also no cost to any fishery; result not shown in Fig. 1). Solutions exist with modest conservation and high equity outcomes (Fig. S3), but the trade-off with equity (when equity is weighted highly, >90%) makes these solutions too costly, because much greater overall value of combined objectives can be achieved with the no-reserve solution. Using smaller (i.e., higher resolution) planning units could resolve this issue by creating more planning options and thus greater flexibility. However, our results here are realistic because our resolution mirrors what was used in the actual planning process and is practical for most situations.

Southeast Misool Marine Protected Area. There is an ongoing process to zone a network of multiuse MPAs in Raja Ampat in eastern Indonesia to support biodiversity conservation and sustainable fisheries (12). We focus here on Southeast Misool MPA (Fig. S2*B*). Thirty villages have customary marine tenure and rights to the MPA, which governs where each village can fish. The tenure system in eastern Indonesia is complex, such that declaring a no-take marine reserve within the larger MPA affects different individuals, families, clans, or villages. We simulated different no-take reserve network designs and assessed their performance in representatively protecting different types of coral reef habitat (and mitigating stressors to locations) and affecting equity across villages in lost fishing grounds. We varied a constraint on the maximum area in no-take reserves as a proxy for different conservation budgets for the creation of marine reserves.

Trade-offs were direct (close to linear) when total (area) budgets were small (<10% of total area within the MPA placed in marine reserves; Fig. 1*B*) and became weaker (concave) with larger budgets. The concave shape suggests that initial gains in conservation objectives or equity can be achieved with minimal cost to the equity objective. When assessed as proportional rather than absolute differences in how well conservation objectives were achieved, most trade-off curves were nonlinear (Fig. S4).

Interestingly, the point at which equity overrides conservation objectives, forcing solutions to the zero-reserve outcome, is when equity is prioritized only slightly more than conservation (i.e., weighted >60–75%), rather than 90% as in the California example (Fig. S5). This difference emerges because solutions with reserves had lower equity scores in Southeast Misool than California, due to the fact that about one-half of the coral reef habitat features in the Misool MPA occurred in fewer than 20% of the fishing grounds. These sites are critical to achieving overall conservation objectives, causing greater inequity to villages that fish those sites. This uneven distribution of key habitats therefore requires higher weighting on conservation versus equity objectives to overcome this effect. As with the California example, higher resolution planning units would likely allow for solutions with higher equity targets, but such small planning units are generally not feasible for implementation or enforcement. Habitats restricted to a few fishing grounds also cause a much larger range of equity values for conservation solutions on the frontier in the Indonesia example than is seen in the California example.

Coral Triangle. The Coral Triangle is composed of six countries (Indonesia, Philippines, Malaysia, Timor Leste, Solomon Islands, and Papua New Guinea), divided into 16 ecoregions (Fig. S2*C*), whose waters contain the highest global coral biodiversity, but also some of the most threatened systems (34). The multilateral Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (formalized in May 2009) is the focus of significant global conservation attention with financial commitments of at least US$400 million (www.coraltriangleinitiative.org).

Previous work explored the costs and benefits of investing in land versus marine conservation to help guide the distribution of financial resources (35). Here, we expand this analysis and explore two types of equity, the distribution of funds (total and per capita) to each ecoregion and the costs from restricted access due to MPA creation per ecoregion. We evaluated how the type of equity affects conservation outcomes for the Coral Triangle, measured as the reduction in total fishing impact to reefs across the Coral Triangle region. As such, this case study allows exploration of two metrics of equity (access and money) and both methods of assessment (absolute and proportional). Furthermore, we explore how decisions about whether to initially allocate portions of the total budget (or area set aside in marine reserves) equitably versus cost effectively influences outcomes. The difference reflects that budgets can be split between different objectives (e.g., budget allocated each to equity and cost effectiveness objectives), with the order in which this is done potentially affecting results. Such decisions are likely common to almost any planning process.

For the two scenarios that allocate low-to-moderate amounts of money to ecoregions (US$80 and US$160 million), there is a nearly direct trade-off between equitable distribution and the ability to achieve conservation objectives (i.e., mitigate fishing impacts; Fig. 2*A*). For very high total budgets, the trade-off curve becomes concave. This nonlinearity emerges because when more than ~60% of funding is allocated equitably, entire ecoregions receive sufficient funding to fully meet conservation objectives before the total budget is spent for that region (and it is not reallocated to other regions). Thus, this nonlinearity is due in part to the coarse scale of planning units; nonlinearity in the California example instead emerged from underlying biophysical properties of the system. Nearly identical results emerge when measuring equity as per-capita allocation of funds (Fig. 2*B*). A notable exception is the unexpected results for equitable-first allocations at 75% and 80%—these two solutions have lower equity than solutions that allocated less equitably first (65% and 70%) because the smallest, least populated ecoregion contains

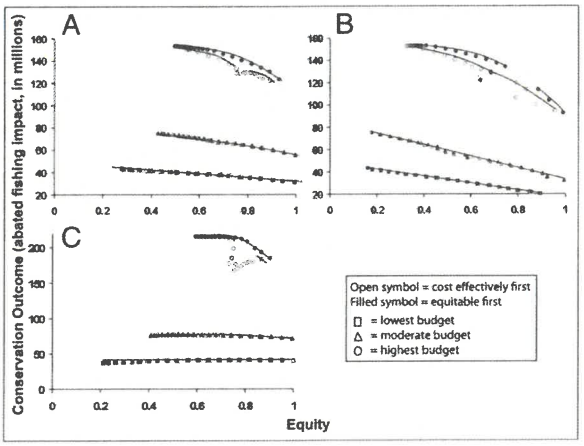

Fig. 2. Trade-off between measures of conservation impact (mitigated fishing pressure) and the equity of distribution of that impact across ecoregions in the Coral Triangle region for (*A*) total budget, (*B*) regional per-capita budget, and (*C*) total area protected. The open symbols represent allocations that were done first cost effectively, and then equitably; the closed symbols are the reverse. Each point represent 5% additional amount distributed cost effectively or equitably first, respectively. In *A* and *B*, total budget is US$80 million, US$160 million, and US$650 million. In *C*, total area set aside is 2,801 million, 5,602 million, or 22,408 million km^2, representing 5%, 10%, and 40% of the total region, respectively. The outer edge of the points is drawn to approximate the efficiency frontier; points interior to this frontier resulted from simulations but are suboptimal.

relatively cost-effective sites and, when resources are allocated at least 30% cost effectively, the entire region receives protection. Once that proportion drops to 25%, resources are freed for allocation to other ecoregions, increasing inequity across ecoregions. These solutions are far inside the efficiency frontier and so should never be selected, i.e., one could achieve the same amount of equity but much higher conservation outcome with lower amounts of funds allocated first equitably (Fig. 2*B*).

Surprisingly, there is no trade-off when equity is instead measured as area within marine reserves (i.e., reduced access) for low and medium amounts of total area protected, such that one should always strive for perfect equity in these cases because one can achieve the same conservation outcome at all levels of equity (Fig. 2*C*). This result emerges because when equity in area across ecoregions is ignored, the most cost-effective sites are selected for protection, resulting in several ecoregions receiving almost no protected areas (Table S1). Instead, when emphasis is placed on achieving equity, a portion of each ecoregion must be protected. In some cases, these protected places mitigate more threat than in the more cost-effective scenarios, even though they are not cost effective, i.e., considerably more expensive to mitigate equivalent amounts of threat. In this particular example, the trade-off between cost effectiveness and equity led to nearly identical conservation outcomes; it seems unlikely that this would hold in other cases.

Two additional key results emerge from this case study. First, for low and moderate budgets, there is essentially no difference if one first allocates funds (or area) equitably and then selects locations that cost effectively meet conservation objectives, or vice versa. This result does not imply that no trade-off exists between objectives—higher equity comes at the direct, linear cost to conservation—but it does mean that for any given level of equity, one can allocate funds equitably first and still achieve the same conservation outcomes.

Second, for very large budgets, the trade-off becomes nonlinear, as noted above, but in ways that differ for approaches that allocate resources first equitably versus cost effectively. "Cost-effective–first" solutions mitigate less threat than "equitable-first" solutions. This result emerges because equitable-first solutions require area within each ecoregion to be protected, even if those areas are not the most cost effective over the entire region; they reduce more threat, but at higher cost. We do not see this result for lower total budgets because no ecoregion is receiving sufficient funds to protect the whole area under these budgets, so both equitable-first and cost-effective–first solutions select similar, cost-effective sites for protection. Furthermore, for the highest total area budget (Fig. 2*C*), the equitable-first approach produces the typical concave trade-off curve, whereas the cost-effective–first approach produces a split curve, with the initial half showing the typical concave trade-off, whereas the second half shows a strong positive relationship. These solutions interior to the frontier are inferior and should not be chosen, such that one would always favor the full-equity solution in this latter region of the curve and the low-equity, high-conservation solutions in the early region of the curve (Fig. 2*C*). This split-curve result emerges because cost-effective–first approaches will select the best sites across the whole region first, leading to all sites within small ecoregions being selected once equity reaches about 0.75; as equity increases beyond this, more expensive high-value sites in other regions get selected, causing the conservation outcome to increase. The relative size of each region and the distribution of conservation targets within those regions should have a strong influence on the presence and shape of this split curve. The split curve is not seen when allocation is done equitably first because the priority is to have protected areas spread among regions, making it less likely that entire ecoregions will be protected under any given budget.

These stark differences in the nature and shape of the trade-off between equity and conservation objectives when using different metrics (monetary cost versus access to areas) and methods (absolute versus per capita) highlight the critical importance of defining which metrics of equity and methods for assessing it matter most to people engaged in, or affected by, a planning process. The set of optimal solutions will vary greatly under these different approaches to incorporating equity, and management focus on an inappropriate metric could significantly decrease the probability of success of a proposed solution.

Equity and the Probability of Success

The above analyses and discussion do not address an important aspect of equity that may allow for combination of the two currencies into a single measure of triple–bottom-line outcomes. Highly inequitable solutions are more likely to fail because those who are disenfranchised from the benefits or outcomes of the process often feel little motivation to adhere to the agreement (15). Increases in equity are typically believed to improve the probability of success by increasing likelihood of self-enforcement of new regulations because people perceive the regulations as fair (36, 37), yet it is equally likely that management will fail if the needs or desires of particularly vocal or powerful minorities are not met. Most of these assumptions remain untested.

Here, we simulate the consequences to conservation prioritization of considering both social equity and its impact on the probability that a plan is enacted or upheld. Empirical assessment of these interactions would require a large sample of conservation actions where equity and conservation effectiveness are measured, information that currently does not exist and a field of research that merits significant attention. For now, we assume probability of success increases asymptotically with increasing equity, and that extremely inequitable solutions have near-zero probability of success and that the best case scenario has very high but not guaranteed chance of success (*Materials and Methods*). If instead probability of success peaked at mid-levels of equity, for example if powerful stakeholders influence the outcome, then our results would be even more pronounced.

We assume that expected conservation success is the product of the probability of success and the biodiversity outcome given particular levels of equity. Simulations using simple assumptions about the relationship between social equity and probability of success show a clear peak in achieving conservation objectives with modest levels of equity (Fig. 3). This result is striking in that it highlights how final conservation outcomes could be made much more durable with even modest consideration of equity effects, by avoiding inequitable outcomes that have little probability of success, but also better achieve desired outcomes by avoiding high-equity solutions that excessively compromise conservation objectives. In other words, the low probability of success when equity is low erases nearly all potential conservation benefit, whereas the cost to conservation objectives with very high equity offsets the value added from increased probability of success (Fig. 3). These results may seem intuitive, but the framework developed here provides a tool for quantifying these interactions and helping to optimize decision-making outcomes. Effort early in the planning process to engage and elicit stakeholder preferences for different dimensions of equity would significantly improve our understanding of what the probability of success curve actually looks like. In fact, research has shown that participatory processes that do not engage those with significant stakes in the outcome of the decision (but often little voice) are less likely to address equity issues (e.g., ref. 21).

Discussion

The spatial patterns of underlying mechanisms that produce conservation objectives (species distributions, spatial patterns of threat, and costs to mitigate those threats, etc.) generally require

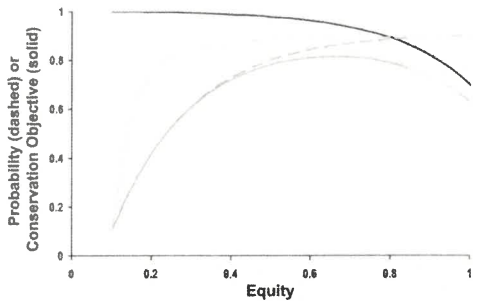

Fig. 3. The relationship between equity and biodiversity, and how probability of success given different levels of equity modifies the ability to achieve biodiversity conservation targets. the solid black line shows the trade-off between conservation objectives and equity. The dashed gray lines show two hypothetical shapes for the relationship between equity and probability of success, and the solid gray lines are the resulting consequences of these probability curves on the degree to which conservation objectives are met.

inequitable distribution of resources to achieve optimal conservation outcomes. However, few planning processes focus solely on achieving conservation objectives, given stakeholder interest in minimizing negative impact to specific groups or maximizing economic gain. This tension among values sits at the heart of perceived and real trade-offs among conservation objectives, total economic gains (or losses), and social equity. To date, the issue of equity has largely been addressed indirectly, through implicit assumptions about spreading costs or benefits, or as a secondary concern, as with post hoc comparisons of the equity of outcomes (36). We have shown here that explicit assessment of how equity influences the ability to achieve conservation outcomes produces a more nuanced and realistic picture of the effects of any given conservation objective on different groups, and may indicate under what conditions significant trade-offs are likely to occur. Hopefully, applying this framework will lead to solutions unrecognized without direct consideration of equity.

The solutions that lie along the "frontier" in the case studies are triple–bottom-line solutions, where one can optimize conservation goals and equity while minimizing costs. Solutions interior to these frontier solutions (most of which are not plotted) are all possible and represent the many ways decision making can miss the mark on the triple bottom line. As in other trade-off assessments (5, 6, 30), finding the frontier does not then prescribe a single correct solution but instead presents the range of options, all optimal, that represent the trade-off between stated goals. As the case studies show, there is almost always a trade-off between biodiversity conservation and equity, but the extent of this trade-off varies depending on the context and the exact formulation of the objective function. Ignoring issues of equity in conservation planning will likely produce suboptimal outcomes and risks failure in prioritization efforts and durability of implemented actions.

We have focused here on a few types of equity, namely the distribution of costs and access to resources. Although these two types are likely the most common to conservation planning exercises, many other types clearly exist, most notably gender (16, 17), intergenerational (22, 23), and geographic equity [such as with global trade and its displacement of environmental impacts, and the corollary, climate change impacts (38)]. These different kinds of social and economic equity likely constrain conservation prioritization and planning in different ways, yet to be explored formally.

Two key assumptions affect our results and suggest important areas for further research. First, we measured biodiversity objectives by tracking how much threat was abated in a given location. This is a proxy at best for true changes in conservation values and outcomes, and so the actual shape of the trade-off between equity and conservation objectives may differ from what we found here. Perhaps more importantly, threat abatement can be achieved more quickly than ultimate conservation goals, such as number of species recovered to stable population sizes. Because the consequences of social equity play out relatively quickly whereas conservation goals tend to take time to achieve, full treatment of equity issues in conservation planning need to address the temporal as well as spatial components. Second, the shape of equity-probability curves characterizing how equity affects the likelihood of success of a plan remains largely unknown. Empirical research focused on determining the shape of this curve would provide the key to combining the two currencies into a single metric, allowing for more accurate identification of triple–bottom-line solutions.

Conservation planning, whether in the ocean or on land, strives to find optimal solutions in the face of inherent constraints. Triple–bottom-line outcomes remain highly prized, but they cannot be achieved regularly without formal approaches to considering equity alongside the more traditional focus on minimizing costs and maximizing conservation objectives. Incorporating equity can produce nonintuitive results, as with the California and Raja Ampat case studies where strong emphasis on equity leads to zero-MPA solutions. More importantly, it produces realistic results, and that realism will go a long way toward building stakeholder acceptance of management plans and outcomes.

We have focused here on marine conservation planning problems, but the approach and implications of the results are relevant to a broader spatial planning context, where planning objectives can include ecosystem services other than biodiversity conservation. Social and economic equity is almost always on the minds of stakeholders involved in these processes; the framework and theory we have developed here provides a means to make such concerns explicit and quantitative.

Materials and Methods

In each case study, we implemented marine reserves (i.e., no-take areas) and assumed that their implementation eliminates fishing from the reserve region and that the fishing is not redistributed. The conservation benefit of reserves varied across case studies, described below and in *SI Text*. Although the type of equity measured in each case study was different, we use the same metric to evaluate equity, the widely recognized and used Gini coefficient (39). In our context here, the Gini coefficient measures the dissimilarity in costs or profits among different entities. It indicates the difference between a perfectly equitable distribution and the actual distribution of a resource. Although the Gini coefficient is commonly used as a measure of inequality of wealth (40), it has also been applied to describe other types of inequalities (41–44). We adapt the Gini coefficient to measure equality rather than inequality by using its inverse (1 − Gini, henceforth referred to as "equity"), where a value of 1 represents perfect equality and a value of zero represents maximal inequality (Eq. S1). Details for data used in each case study are provided in *SI Text*.

California and Raja Ampat Case Studies. For the California and Raja Ampat case studies, we examined the trade-off between conservation and equity goals constrained by a fixed budget. The budget was defined as the total monetary cost to fisheries and the total area lost within fishing grounds, respectively. For California, we present trade-off curves with the budget ranging from 3% to 20% of the combined value of fisheries. Optimal solutions on the trade-off frontier were searched for using the objective function Obj = max $[\alpha E_1\mu + (1 - \alpha)E_2]$, subject to the budget constraint $\Sigma(C_k) \leq B$, where α is the conservation weighting, E_1 is the equity in habitat representation in reserves, E_2 is the equity in fishery impacts of reserves, and μ is the minimum representation of a habitat in reserves (Eq. S1; see Table S2 for parameters used to calculate E). Thus, a reserve plan with either low representation equity or low representation of a single habitat would have a low conservation score. C_k is the costs to each fishery of the reserves and B is the total budget (e.g., see ref. 45). Varying the conservation weighting 0–1 gives the optimal solution for different points on the trade-off frontier. The set of possible reserves is too large to explore exhaustively (2^{3610} possibilities in CA and 2^{670} in RA), so we used simulated annealing to find near-optimal solutions (46, 47). For all annealing simulations, we compared the objective function value for the

near-optimal solution to its value with no marine reserves, setting $\mu = 0$ and $E_2 = 1$. Although true optimal solutions cannot be found without an exhaustive search, the performance of the optimization algorithm was checked by comparing its results to outcomes from 1 million randomly sampled marine reserve plans for each case study. The frontier found using simulated annealing was considerably better than random.

Coral Triangle Case Study. We used the Coral Triangle boundaries and ecoregions ($n = 16$) defined by Veron et al. (48) on the basis of coral diversity and endemism. We used the global coral reef atlas (49) to determine the presence/absence of coral reefs for each 1-km^2 cell in each ecoregion. The objective of this case study was to minimize fishing impacts on coral reefs through investment in marine reserves, given a fixed budget that could be used to compensate for changes in economic opportunity arising from given actions, such as for lost fishing opportunity. To determine the priority of an area for designation as a marine protected area, we calculated return on investment of protecting each 1-km^2 reef unit, where return was measured as reduction of fishing and investment as cost of reducing each threat. Using this information, we allocated resources using two different methods: (*i*) "cost-effective" allocation, where resources are allocated to coral reefs with the highest return on investment; (*ii*) "equitable" allocation, where resources are divided equitably between each of the 16 ecoregions, and then allocated cost effectively within each ecoregion and visa versa. We analyzed the trade-off between conservation (i.e., reduction of fishing pressure) and equity (i.e., distribution of resources to ecoregions) for scenarios that range from spending 100% of the budget cost effectively for conservation to 100% equitably for the community. We implemented different types of budget constraints: (*i*) financial budget of $80 million, $160 million, and $650 million; (*ii*) financial budget per capita, such that, when allocated equitably, is split equally among people; and (*iii*) area budget of protecting 2,801, 5,602, and 22,408 km^2 of coral reef (5%, 10%, and 40% of the total region, respectively). Financial budget constraints were based on a value that, when distributed equitably, was insufficient to protect any ecoregion entirely (US$160 million), and one-half and four times that amount (for illustrative purposes). Area budget constraints were based on a 10% target (5,602 km^2), a common target for protection, and equivalent one-half and four times changes as with the monetary budget.

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1. Possingham HP, Ball IR, Andelman S (2000) *Quantitative Methods for Conservation Biology*, eds Ferson S, Burgman M (Springer, New York), pp 291–305.
2. de Groot R (2006) Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. *Landsc Urban Plan* 75(3–4): 175–186.
3. Adams VM, Pressey RL, Naidoo R (2010) Opportunity costs: Who really pays for conservation? *Biol Conserv* 143(2):439–448.
4. Lester S, et al. (2009) Biological effects within no-take marine reserves: A global synthesis. *Mar Ecol Prog Ser* 384:33–46.
5. White C, Halpern BS, Kappel CV (2012) Ecosystem service tradeoff analysis reveals the value of marine spatial planning for multiple ocean uses. *Proc Natl Acad Sci USA* 109(12):4696–4701.
6. Nelson E, et al. (2009) Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Front Ecol Environ* 7(1):4–11.
7. Klein CJ, et al. (2008) Striking a balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas. *Conserv Biol* 22(3): 691–700.
8. Tallis, H, Polasky S, Lozano JS, Wolny S (2012) Inclusive wealth accounting for regulating ecosystem services. *Inclusive Wealth Report 2012. Measuring progress toward sustainability* (Cambridge Univ Press, Cambridge, UK).
9. Margules CR, Nicholls AO, Pressey RL (1988) Selecting networks of reserves to maximize biological diversity. *Biol Conserv* 43(1):63–76.
10. Cardinale BJ, et al. (2012) Biodiversity loss and its impact on humanity. *Nature* 486(7401):59–67.
11. Ehrlich PR, Kareiva PM, Daily GC (2012) Securing natural capital and expanding equity to rescale civilization. *Nature* 486(7401):68–73.
12. Grantham HS, et al. (July 23, 2013) A comparison of zoning analyses to inform the planning of a marine protected area network in Raja Ampat, Indonesia. *Mar Policy* 38:184–194.
13. Loomis DK, Ditton RB (1993) Distributive justice in fisheries management. *Fisheries (Bethesda, Md.)* 18:14–18.
14. Jodha N, Russell D (1997) *Beyond Fences: Seeking Social Sustainability in Conservation*, ed Borrini-Feyerabend G (IUCN, Gland, Switzerland).
15. Miller BW, Caplow SC, Leslie PW (2012) Feedbacks between conservation and social-ecological systems. *Conserv Biol* 26(2):218–227.
16. Fernandez PR (2007) Understanding relational politics in MPA governance in Northeastern Iloilo, Philippines. *J Coast Res* SI 50:38–42.
17. Beger M, Harborne AR, Dacles TP, Solandt J-L, Ledesma GL (2004) A framework of lessons learned from the community-based marine reserves and its effectiveness in guiding a new coastal management initiative in the Philippines. *Environ Manage* 34(6):786–801.
18. Layzer JA (2002) Citizen participation and government choice in local environmental controversies. *Policy Stud J* 30(2):193–207.
19. James AN, Gaston KJ, Balmford A (1999) Balancing the world's accounts. *Nature* 401(6751):323–324.
20. West PC, Igoe J, Brockington D (2006) Parks and peoples: The social impact of protected areas. *Annu Rev Anthropol* 35:251–277.
21. Badola R, Hussain SA (2003) Conflict in paradise: Women and protected areas in the Indian Himalaya. *Mt Res Dev* 23:234–237.
22. Foale S, et al. (2013) Food security and the Coral Triangle Initiative. *Mar Policy* 38:174–183.
23. Adger WN, Paavola J, Huq S, Mace MJ (2006) *Fairness in adaptation to climate change* (MIT, Cambridge, MA).
24. Low N, Gleeson B (1998) *Justice, Society and Nature* (Routledge, London).
25. Halpern BS, White C, Lester SE, Costello C, Gaines SD (2011) Using portfolio theory to assess tradeoffs between return from natural capital and social equity across space. *Biol Conserv* 144(5):1499–1507.
26. Klein CJ, Steinback C, Watts ME, Scholz AJ, Possingham HP (2010) Spatial marine zoning for fisheries and conservation. *Front Ecol Environ* 8(7):349–353.
27. Portney PR, Weyant JP (1999) *Discounting and Intergenerational Equity* (Johns Hopkins Univ Press, Baltimore, MD).
28. Lauwers L (2012) Intergenerational equity, efficiency, and constructibility. *Econ Theory* 49(2):227–242.
29. Pascual U, Muradian R, Rodriguez LC, Duraiappah A (2010) Exploring the links between equity and efficiency in payments for environmental services: A conceptual approach. *Ecol Econ* 69(6):1237–1244.
30. Lester SE, et al. (2013) Evaluating tradeoffs among ecosystem services to inform marine spatial planning. *Mar Policy* 38:80–89.
31. California Department of Fish and Game (2008) *California Marine Life Protection Act: Master Plan for Marine Protected Areas*, revised draft January 2008 (California Department of Fish and Game, Sacramento, CA).
32. Airame S, et al. (2003) Applying ecological criteria to marine reserve design: A case study from the California Channel Islands. *Ecol Appl* 13(1):S170–S184.
33. Gleason M, et al. (2012) Science-based and stakeholder-driven marine protected area network planning: A successful case study from north central California. *Ocean Coast Manage* 53(2):52–68.
34. Burke L, Reytar K, Spalding M, Perry A (2012) *Reefs at Risk Revisited* (World Resources Institute, Washington, DC).
35. Klein CJ, et al. (2010) Prioritizing land and sea conservation investments to protect coral reefs. *PLoS One* 5(8):e12431.
36. White C, Costello C, Kendall BE, Brown CJ (2012) The value of coordinated management of interacting ecosystem services. *Ecol Lett* 15(6):509–519.
37. Hoel AH (1998) Political uncertainty in international fisheries management. *Fish Res* 37(1–3):239–250.
38. Rayner S, Malone EL (2001) Climate change, poverty, and intergenerational equity: The national level. *Int J Glob Environ Issues* 1(2):175–202.
39. Gini C (1921) Measurement of inequality and incomes. *Econ J* 31:124–126.
40. Allison P (1978) Measures of inequality. *Am Soc Rev* 43(6):865–880.
41. Barr LM, et al. (2011) A new way to measure the world's protected area coverage. *PLoS One* 6(9):e24707.
42. Brown MC (1994) Using Gini-style indices to evaluate the spatial patterns of health practitioners: Theoretical considerations and an application based on Alberta data. *Soc Sci Med* 38(9):1243–1256.
43. Damgaard C, Weiner J (2000) Describing inequality in plant size or fecundity. *Ecology* 81(4):1139–1142.
44. Bradford JB, D'Amato AW (2012) Recognizing trade-offs in multi-objective land management. *Front Ecol Environ* 10(4):210–216.
45. Game ET, Watts ME, Wooldridge S, Possingham HP (2008) Planning for persistence in marine reserves: A question of catastrophic importance. *Ecol Appl* 18(3):670–680.
46. Ball I, Possingham HP, Watts ME (2009) *Spatial Conservation Prioritisation: Quantitative Methods and Computational Tools*, eds Moilanen A, Willson KA, Possingham HP (Oxford Univ Press, Oxford).
47. Cocks KD, Baird IA (1983) Using mathematical programming to address the multiple reserve selection problem: An example from the Eyre Penninsula, South Australia. *Biol Conserv* 49(3):113–130.
48. Veron JEN, deVantier L, Turak E, Green A, Kinnimonth S (2009) Delineating the Coral Triangle. *Galaxea* 11:91–100.
49. Spalding MD, Ravilious C, Green EP (2001) *World Atlas of Coral Reefs* (Univ of California Press, Berkeley, CA).

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Contribution to the Themed Section: '*A Tribute to the Life and Accomplishments of Sidney J. Holt*'

The trade-off between biodiversity and sustainable fish harvest with area-based management

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While fisheries provide food and employment for hundreds of millions of people, they also can have significant impact on biodiversity. We explore the potential of area-based fisheries management to simultaneously maintain biodiversity and high levels of sustainable food production. We used two illustrative examples of fisheries that have different gear types, areas, and species to evaluate the trade-off between biodiversity and harvest. We calculate the optimal effort by gear and area that maximizes a weighted objective function of biodiversity and harvest, ranging from 100% of the weight on harvest to 100% on biodiversity. We found for both case studies that the trade-off was highly convex, with win–win solutions allowing for high levels of both fishery harvest and conservation. This is achieved by reducing or eliminating fishing effort that negatively impacts high conservation value species while maintaining fishing effort with gears and in areas where there is low conservation impact. We suggest that, in most fisheries, such situations can be found and that effective area-based management can provide for high levels of biodiversity protection and food production.

Keywords: area-based management, biodiversity, conservation trade-off, harvest

Introduction

Fishery managers seek the optimal balance between two conflicting objectives: economics and conservation. In 2015, the United Nation's Sustainable Development Goals (SDGs) were adopted by 193 nations. The SDGs aim to provide food security and improved nutrition (SDG 2), while also sustainably managing and protecting marine and coastal ecosystems (SDG 14.2). Harvesting marine fish contributes to both of these goals and produces goods and services that 40 million people depend on for income (FAO, 2018) and much of the world for food. However, fishing also has negative impacts on biodiversity that can include reduced abundance of target and non-target species, impacts on benthic biota from bottom-contact gear, and changes in marine food webs (Garcia, 1994). Societal objectives include both maximizing the benefits from fishing and minimizing the negative impacts of fishing on biodiversity (SDG 14.2).

Reducing the impact of fishing on biodiversity is increasingly recognized as an international objective, and 196 nations adopted the Aichi targets of the Convention on Biodiversity (CBD) (https://www.cbd.int/sp/targets/, accessed 20 April 2020), which aim to have 10% of coastal and marine areas "conserved through effectively and equitably managed, ecologically representative and

well connected systems of protected areas and other effective area-based conservation measures". The CBD defines protected areas as "a geographically defined area, which is designated or regulated and managed to achieve specific conservation objectives" (Article 2 of the Convention). But what is the most effective mix of area-based management approaches to achieve societal objectives?

Area-based management is a central element in most conservation and fishery management approaches (Hilborn, 2011), and it may include no-take areas, prohibition of specific gears in certain areas, and, most commonly, regulation of fishing effort or catch by area. For example, in the federally managed fisheries of Alaska (Figure 1), all of these tools are used (https://www.npfmc.org/habitat-protections, accessed 20 April 2020). All Arctic waters are closed to fishing until management plans are developed. Most state waters and almost all federal waters in southeast Alaska are closed to bottom trawling as are large portions of the Aleutian Islands and the Bering Sea. Numerous areas around sea lion (*Eumetopias jubatus*) colonies are closed to all fishing, and species-specific catch is regulated by area. Nursery areas for crabs are closed.

The trade-offs resulting from area-based management have been explored across multiple forms of goods and services, including fisheries, wind energy, whale watching (White *et al.*, 2012), coral reef protection, and fisheries harvest (Brown and Mumby, 2014), and between fisheries yield and abundance of target species (Rassweiler *et al.*, 2014). In each case, a spatially explicit numerical model was used to evaluate the trade-off, which was usually found to be convex, meaning that area-based management rules were found where you had both high catch and high biodiversity. In most regions of the world, there is a mix of different fishing gears and both target and non-target species, leading to many possible spatial configurations of area-based regulations.

There is considerable debate about the relative effectiveness of exclusive no-take areas compared with other forms of area-based management, which maintain biodiversity and permit exploitation. Lubchenco and Grorud-Colvert (2015) argue that only no-take marine protected areas (MPAs) constitute biodiversity protection, meaning that the area-based management seen in Alaska does not constitute protection nor meet the CBD targets—that only no-take MPAs constitute biodiversity protection (Lubchenco and Grorud-Colvert, 2015). However, Rice *et al.* (2018) argue that area-based management of fishing effort can provide biodiversity protection that does meet the CBD targets.

The trade-off between sustainable yield and abundance of fish stocks does emerge from both single-species and multispecies models. The logistic population model (Figure 2) shows a trade-off between population size and sustainable yield, as does an

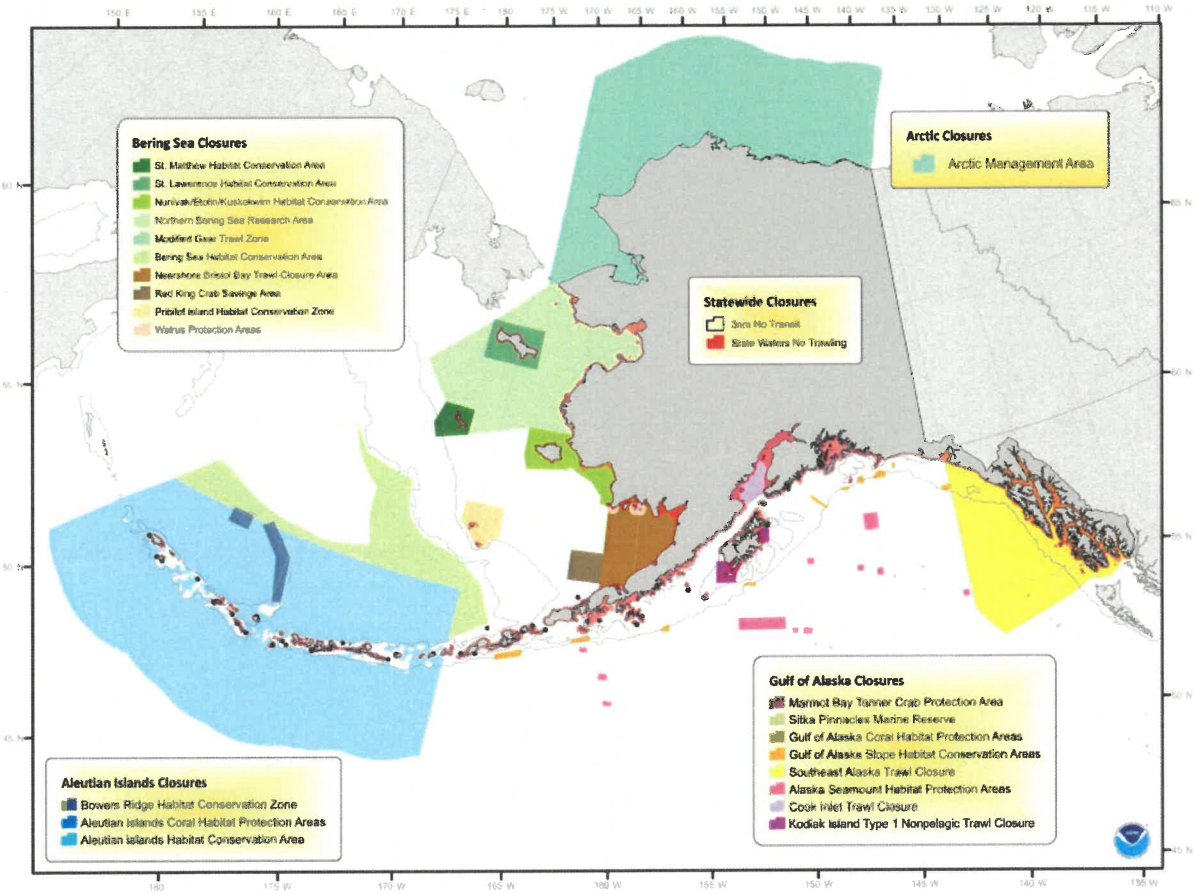

Figure 1. Spatial management in Alaska. Different colours or shades indicate different kinds of protection. In addition, effort and catch of species of fish and invertebrates are also allocated by area. Figure courtesy of John Olsen of the National Marine Fisheries Service.

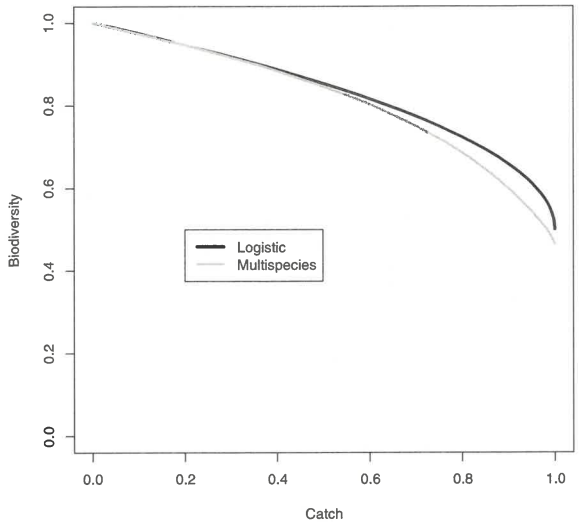

Figure 2. The trade-off between total abundance of fish and the sustainable harvest for a single-species model (dark line) and a multispecies ecosystem (Worm *et al.*, 2009) (light line).

ensemble of EwE models (Worm *et al.*, 2009). These models serve as a baseline for considering the trade-off between biodiversity and sustainable harvest, using total abundance of fish as a metric for biodiversity, but neither considers either multiple areas or multiple gears or bycatch species. In both cases, the convex trade-off allows for roughly 80% of the potential harvestable yield, while maintaining 70% of the biodiversity. Adding area-based management and gear management should generally improve the optimization of harvest and conservation.

We explore two case studies of the trade-off between biodiversity and fisheries yield using a spatially explicit model that includes both target and bycatch species and different gear types. The management options will be the allocation of effort by gear and area, so that no-take areas where all gears are prohibited are the options, whereas selective prohibition of gear by area is another option. We examine to what extent biodiversity can be maintained while sustainably harvesting fish stocks.

An immediate impediment to such an analysis is the lack of an operational definition of biodiversity. While we can use landed value as a quantitative measure of fisheries harvest performance, there are a wide range of measures of biodiversity, none of which are broadly accepted as preferred. Biodiversity concerns can be ranked by the risk of extinction. Thus, species that are threatened with extinction are often given a high priority for protection, followed by charismatic species and overfished species. Breeding or nursery sites are also often given special protection, as are areas of particular cultural or recreational interest. If we examine the area-based management system of Alaska, we see each of these priorities addressed. Our approach is to define biodiversity as a weighted function of the relative abundance of each species and to place high weights on species considered of high conservation value or concern. Any other definition of biodiversity could be evaluated within the modelling context so long as the species needed to calculate biodiversity are included within the model.

Table 1. Definition of parameters used in (1)–(6).

Parameter	Definition
B_{sa}	Abundance of species s in area a (tonnes)
E_{ga}	Effort by gear g in area a
C_{sa}	Catch of species s in area a (tonnes)
r_s	Intrinsic rate of increase for species s
k_{sa}	Unfished stock size for species s in area a (tonnes)
u_{sa}	Exploitation rate for species s in area a
q_{gs}	Exploitation rate by one unit of effort of gear g on species s
R_{ga}	Revenue from gear g in area a ($)
p_s	Price for species s ($)
D	Total value of biodiversity
v_s	Relative biodiversity value of species s
V	Total value to be optimized
W	Proportion of total value assigned to revenue
D_{max}	Maximum value of biodiversity
R_{max}	Maximum value of revenue ($)

Methods

We designed a model that calculates the equilibrium abundance of each species by area, considering both target and bycatch species. Table 1 gives the defination of the symbols. The control variable is the amount of fishing effort allowed by fishing gear (or fishing method) and by area. The objective function is a weighted measure of biodiversity and fishing revenue. Initially, we calculate the trade-off between revenue and biodiversity by estimating the amount of effort by gear and by area to achieve maximum revenue. Then, in a gradual series of optimizations, we reduce the weighting on revenue and increase the weighting on biodiversity until the objective function is maximized only for biodiversity. The NLMINB function in the "stats" package in R (R Core Team, 2020) was used to do the optimization. In all cases, as a result of model assumptions, biodiversity is maximized when no fishing is allowed.

We assume that the time dynamics of the populations are governed by the logistic growth equation with species and area subscripts omitted in the following equation, but included in (2). No trophic interactions are considered:

$$B_{t+1} = B_t + rB_t\left(1 - \frac{B_t}{k}\right) - u_t B_t,$$
$$C_t = uB_t, \qquad (1)$$
$$u = \sum_g E_g q_g.$$

The equilibrium abundance (B^*) for a species and area is thus:

$$B_{sa}{}^* = k_{sa}\left(\frac{r_{sa} - u_{sa}}{r_{sa}}\right). \qquad (2)$$

We will assume that the objective of fishing is to maximize total revenue (R), which is the sum across gears and areas of the revenue (R_{ga}):

$$R = \sum_{ga}(R_{ga}). \qquad (3)$$

The revenue is catch times price (p):

$$R_g = \sum_{s,a} B^*_{a,s} E_{g,a} q_{gs} p_s. \quad (4)$$

We will assume that the biodiversity objective (D) is the sum of the total biomass (B) of each species as a fraction of the unfished biomass times the "biodiversity value" (v) we place on each species. This allows us to place more weight on species of conservation concern

$$D = \sum_s \frac{\sum_a B^*_{s,a}}{\sum_a k_{s,a}} v_s. \quad (5)$$

The total value of the fishery (V) will be a weighted sum of the revenue (R) and the biodiversity (D). First, we calculate the maximum value by optimizing profit with no value placed on diversity to find R_{max} and then optimize biodiversity with no value placed on revenue (D_{max}):

$$V = w\frac{R}{R_{max}} + (1-w)\frac{D}{D_{max}}. \quad (6)$$

Having calculated R_{max} and D_{max}, we then begin with $w=1$ (all weight on revenue), calculate the optimal allocation of effort by gear and area and resulting revenue and biodiversity, and then step over values of w from 1 to 0 in increments of 0.01.

We include results for two representative case studies. Each of these should be considered illustrative. We have attempted to make the r biologically reasonable with long-lived species having a lower r ensuring that their sustainable exploitation rate is lower than short-lived species. The interaction with non-target species is set to make sure that in the absence of weight on biodiversity, there would be considerable impact. This is not meant to represent the level of bycatch impact that actually occurs. The key element of the models is that each gear has a different impact on each species, and the distribution of species (especially those of most concern) is usually different between areas.

Bering Sea and Aleutian Islands

The species or groups are modelled after benthic corals and sponges, albatross (family Diomedeidae), fur seals (*Callorhinus ursinus*), walleye pollock (*Gadus chalcogrammus*), Pacific cod (*Gadus macrocephalus*), yellowfin sole (*Limanda aspera*), halibut (*Hippoglossus stenolepis*), and crabs (*Chionoecetes* spp. and *Paralithodes* spp.). We consider four fishing gears: (i) trawling, which targets pollock, yellowfin sole, and Pacific cod and also impacts corals/sponges and has a minor impact on albatross; (ii) crab potting, which we assume only impacts crabs; (iii) longline, which targets cod and halibut but impacts albatross and has some impact on corals/sponges; and (iv) seal harvesting, which is a directed fishery. We consider five areas (Figure 3a): (i) the Pribilof Islands where the fur seals breed and where minor stocks of the other species are found; (ii) the inner Bering Sea, which has most of the yellowfin sole and also some pollock, cod, halibut, and crabs; (iii) the middle Bering Sea, which has all species except fur seals; (iv) the outer Bering Sea, which has most of the pollock and cod; and (v) the Aleutian Islands, which have most of the species and also most of the corals/sponges and many albatross. Values of the parameters are shown in Supplementary Table S1. We assign a biodiversity weight of 10 to corals/sponges, 5 to albatross and fur seals, and 1 to other species.

California coastal fishery

This model is styled after a range of fisheries off the coast of California in which there are five fishing gears: (i) bottom trawling targeting two high-value bottom fish—black cod (*Anoplopoma fimbri*) and halibut, and also having negative effects on vulnerable marine ecosystems (VMEs); (ii) pot fishing catching black cod and crabs (*Metacarcinus magister*), with a slight impact on VMEs; (iii) hook-and-line fishing catching black cod and halibut, with no impact on non-target species; (iv) purse seining targeting squid (*Doryteuthis opalescens*), with an impact on birds and mammals; and (v) a dive fishery for sea urchins (*Mesocentrotus franciscanus*) that has no impact on any other species.

We consider five areas (Figure 3b): (i) regions around bird nesting sites that are key to bird foraging; (ii) nearshore areas where mammals and VMEs are common, as are squid and urchins; (iii) the north coast includes black cod, crab, urchins, and mammals but no birds or VMEs; (iv) the central coast includes black cod, halibut, crab, squid, mammals, and some VMEs; and (v) the south coast includes black cod, halibut, squid, urchins, mammals, and some VMEs. We assigned a biodiversity weight of 10 to the birds, mammals, and VMEs and a value of 1 to the other species. Parameters of this model are presented in Supplementary Table S2.

Results

Bering Sea and Aleutian Islands

When all the weight is placed on revenue from fishing, each targeted stock is maintained at or near the maximum sustainable yield abundance, and the sensitive corals/sponges and albatross are extirpated (Figure 4a). Fur seals are at one-half of their carrying capacity ($0.5k$), which maximizes their sustainable yield. As soon as any weight is placed on biodiversity, trawling is closed in the Aleutian Islands, and at 10% weight, longlining in the Aleutian Islands is also closed. These changes cause the corals and sponges to be at two-third of their carrying capacity (the other one-third of the corals/sponges are in the outer Bering Sea). Fur seal harvest is gradually reduced as the value of biodiversity increases. When the weight on biodiversity reaches 30%, longlining is closed in the outer Bering Sea to protect albatross. The next big jump in biodiversity occurs when trawling in the outer Bering Sea is closed and coral and sponge biodiversity increases while revenue plummets.

The overall trade-off is quite convex (Figure 4b) such that it is possible to achieve 87% of maximum revenue while maintaining biodiversity at 77%. In this example, high-value biodiversity species (corals and albatross) can be largely or even fully protected from bottom-contact gear (for corals), or eliminating the fishing gear that causes mortality (for albatross) by closing areas where these species occur. No-take areas that are closed to all fishing do not appear until the weight on biodiversity reaches over 90%. Crab potting is the last fishing gear to be totally eliminated, as it has no impact on the three primary species of biodiversity value in this model. Trawling is eliminated from the Aleutian Islands when there is any weight on biodiversity, from the Pribilof Islands when biodiversity weight is 42%, from the outer Bering Sea (where there are some corals and sponges) when biodiversity weight reaches 70%, and from the middle and inner Bering Sea when biodiversity weight reaches 90%.

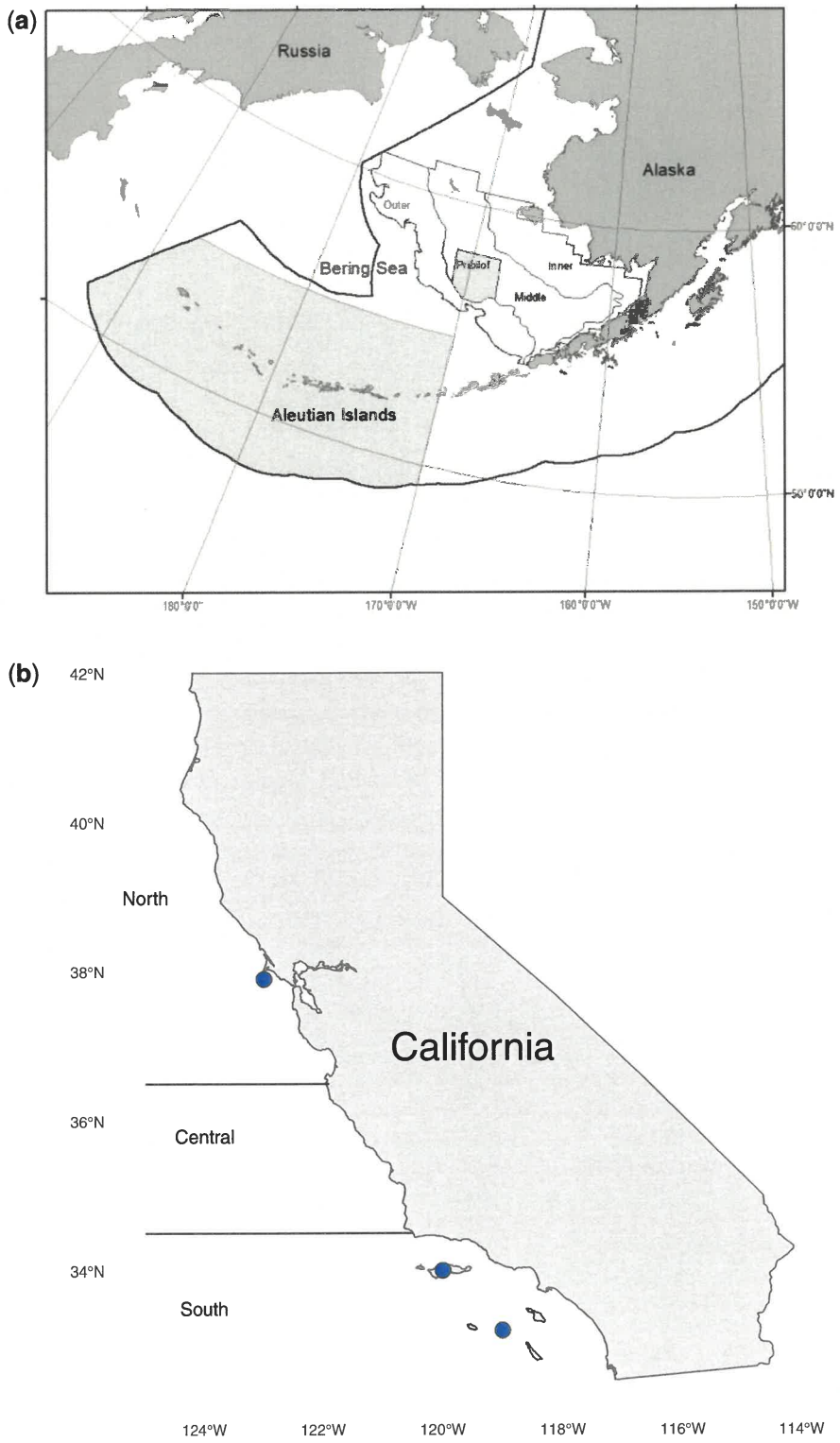

Figure 3. Maps of the regions for the Bering Sea case study (a) and the California Current (b).

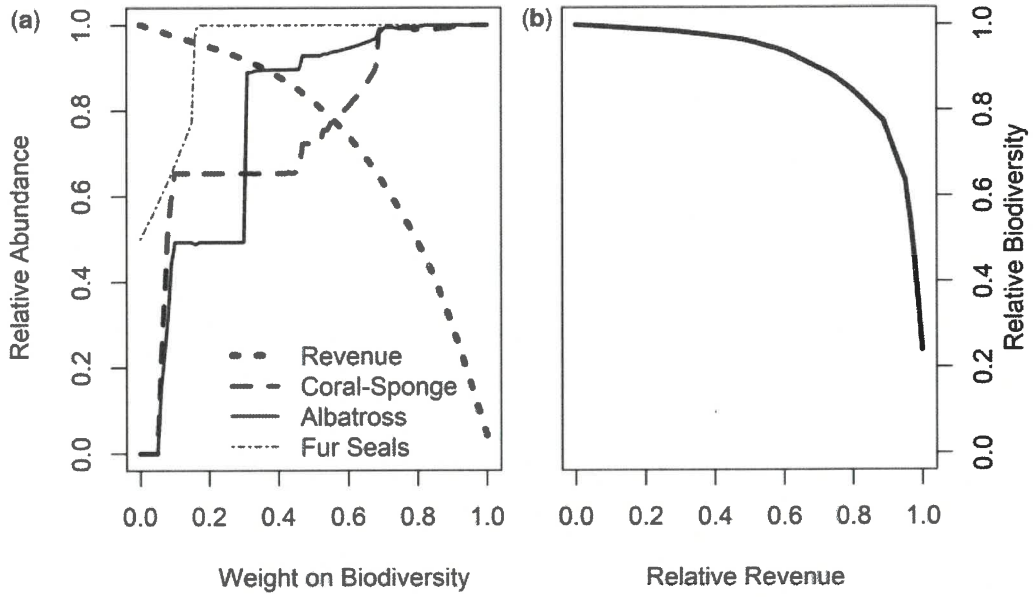

Figure 4. (a) The abundance of three species and total revenue for different weighting of biodiversity. (b) Trade-off between fishing revenue and biodiversity value for the Bering Sea and Aleutian Islands case study.

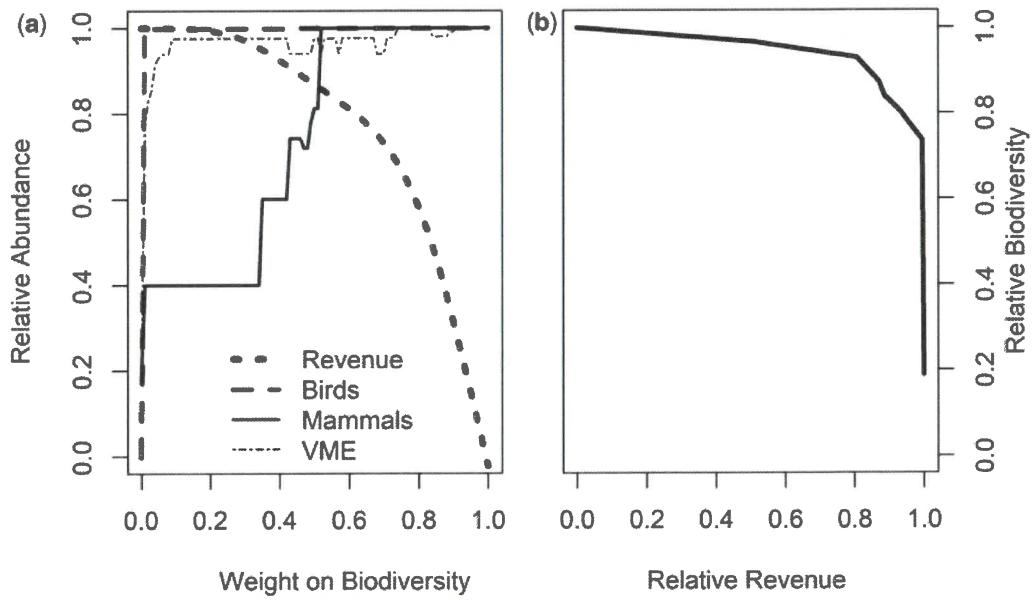

Figure 5. (a) The abundance of three species and total revenue for different weighting for biodiversity. (b) Trade-off between fishing revenue and biodiversity value for the California Current case study.

California coastal fishery

When no value is assigned to biodiversity birds and mammals, VMEs are extirpated and target species are managed to produce maximum revenue (Figure 5a). As soon as value is assigned to biodiversity, all fishing except diving is closed in the bird nesting areas, and trawling is closed everywhere except the central region, which has low VME abundance. The result is that biodiversity increases from 0.2 to 0.75 with almost no loss of revenue (Figure 5b) because pot fishing can harvest the black cod and hook-and-line fishing harvests the halibut. Mammals recover to a value of 0.4, but because they are affected by seine gear and are found in all areas, their abundance rises gradually as weight on biodiversity is increased and the intensity of seine fishing declines. When the weight on biodiversity is ~0.5, all seine fishing and trawling have ceased. Hook-and-line fishing continues in the south and central regions, and dive fishing everywhere except the

central region (where there are no urchins) until biodiversity weight reaches 90%, at which time everything is closed to fishing.

A sensitivity test

The ability to find convex trade-offs between biodiversity and yield depends critically on differential impact on biodiversity and target species by gear or by space. We ran a sensitivity/demonstration of this by simplifying the California Current model to a single gear (bottom trawl), two target species (black cod and halibut), and a single bycatch species (VMEs). The abundance of each species was equal in all areas. In this case, there is a linear trade-off between the VME and target species catch. As more area is closed to trawling, there is less target species catch, but higher VME abundance.

Discussion

Can area-based management contribute to reducing global hunger while protecting biodiversity? These examples demonstrate that there is potential to maintain high levels of biodiversity without sacrificing much food production. The key feature of these examples is that important components of biodiversity are either spatially isolated and/or differentially affected by various fishing gears. Both of these conditions are common to many fisheries. VMEs and sensitive biota are typically spatially isolated and almost always sensitive to some gears, but not others. Sensitive benthic species, such as corals and sponges, are found in high density in relatively few locations, are particularly vulnerable to mobile bottom-contact gear such as bottom trawls or dredges, are somewhat impacted by bottom longlining, but are generally unaffected by gear that does not touch the bottom. Marine birds are typically caught by longline gear, but not by purse seine, although in some cases, purse seining may reduce prey abundance or disperse fish aggregations reducing bird foraging efficiency (Tasker *et al.*, 2000). Dive fisheries and hook-and-line fishing commonly have little direct impact on other species—thus, some of the fisheries for tuna that are recommended by the Seafood Watch programme of Monterey Bay Aquarium or have received MSC certification have generally been hook-and-line fisheries.

Detailed data are available for benthic ecosystems, and there is clear evidence that vulnerable biota are highly concentrated (Parker *et al.*, 2009), as is bottom-trawl fishing effort (Amoroso *et al.*, 2018). Bird species are particularly vulnerable near nesting sites (Cury *et al.*, 2011) and to longline gear (Melvin *et al.*, 2004). Different marine mammals are impacted by a range of fishing gears, with whale entanglement in pot gear and hooking on longline gear for smaller cetaceans perhaps the most common. Turtles are also impacted by longline gear.

When target species are found in a different area than biota of concern, then there are win–win solutions using spatially explicit "mosaic closures" (Walters and Martell, 2004). However, modern fisheries management requires analysis of impacts on multiple species at the same time, and the differential impact of specific gears on species of concern provides further potential for win–win solutions.

These examples are illustrations and may have exaggerated the impact of fishing gears on non-target species. Thus, in both cases, biodiversity in the revenue maximization case was very low. This may or may not be true of most real fisheries, but the critical element of these examples—that biodiversity can be protected by spatial and gear management—can be considered a hypothesis to be further explored.

These illustrative models omit a number of factors that can be important. We have not considered movement between areas or trophic impacts. In addition to regulation by space and gear, many fisheries have bycatch avoidance by temporal closures of area and we have not considered modifications to fishing gear or fishing behaviour that have been a major method used to reduced impact on non-target species of conservation interest. Finally, we have not considered the economics of fishing; we have only looked at revenue maximization.

The win–win solutions would likely be even better if fisheries profit was considered rather than revenue. Profit is typically maximized at a lower fishing effort than yield (Grafton *et al.*, 2007), so there will be less biodiversity impact of a profit-maximizing solution than a revenue-maximizing solution.

We have shown that area- and gear-based effort regulations can provide for high levels of biodiversity and harvest. Perhaps most striking in these two examples is that no-take areas do not prove optimal until almost all weight is placed on maximizing biodiversity. This is largely because, in our two examples, there are fishing gears that had little or no impact on the key species of conservation concern, so those gears were still part of the optimal mix even when there was high weight on biodiversity maximization. Again, this is a hypothesis to be tested in any individual ecosystem.

When there is no separation of bycatch and target catch by area or gear, we demonstrated in the sensitivity run that the trade-off becomes linear. An important area for further research is to examine the empirical data on the spatial correlation of these factors.

This result runs contrary to the arguments that only no-take areas protect biodiversity adequately (Lubchenco and Grorud-Colvert, 2015). By definition, each of our modelled areas was an MPA, but true no-take areas were rarely an optimal outcome. Society may indeed want no-take areas as protection of historical sites, tourist destinations, and scientific reference areas, but it seems unlikely that no-take areas are necessary to protect biodiversity if gear and area-specific regulation of fishing effort can be implemented.

These examples provide evidence that well-implemented area-based fisheries management can achieve biodiversity protection and should be counted as "other effective area-based conservation measures" that contribute towards the Aichi and IUCN targets. The closure of the large portions of the Aleutian Islands to bottom trawling has protected much of the most sensitive benthic communities and streamer lines in longline fisheries have been much more effective at protecting marine birds than setting aside 30% of the area as a no-take area. To achieve the potential win–win solutions, several steps must be taken. First, the species of highest priority for protection need to be identified and their distributions mapped. Second, the threats that different fishing gears pose to specific species need to be clearly defined. Modification in fishing gear or methods may be the most effective way to reduce a threat, but if the threat cannot be reduced by changing fishing practices, closing the areas of high abundance of species of concern to the gear that impacts them needs to be implemented and enforced. While many countries currently lack effective enforcement, the

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growing availability of inexpensive vessel tracking devices should enable almost all countries to implement area closures for specific gears.

We have not examined several other specific approaches to area-based management that have shown effective reductions in fishing impact on species of concern and make win–win solutions even more likely. One approach is time–area closures, where certain areas are closed to specific gears at certain times of the year when species of concern are particularly vulnerable (Hoos *et al.*, 2019; Smith *et al.*, 2020). The second approach is real-time closures, where impact on specific biota is monitored in real time and hot spots of impact closed (Little *et al.*, 2015). Third are so-called "move-on rules" in which vessels are required to leave an area if they reach specific bycatch targets (Cournane *et al.*, 2013; Dunn *et al.*, 2014). Finally, various jurisdictions have implemented bycatch quotas where individual vessels or fleets have a quota for the catch of species of concern and the vessel or fleet must cease fishing if it reaches the quota (Wallace *et al.*, 2015). This provides strong incentives for vessels to avoid areas where catch of species of concern is likely, but bycatch quotas and move-on rules do require at-sea monitoring of the catch. These and other area-based management measures have the capacity to maintain high levels of biodiversity, while simultaneously allowing high levels of fishing revenue and provision of an important and sustainable global food source.

Supplementary data

Supplementary material is available at the *ICESJMS* online version of the manuscript.

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Data availability

The data underlying this article are available in the Supplementary material.

Author contributions

RH was involved in the conceptualization of the study, formal analysis, investigation, development of methodology, project administration, procurement of resources, software, supervision, validation, and writing. CAA, HP, and GAW were involved in data curation, formal analysis, visualization, reviewing, and editing.

References

Amoroso, R. O., Pitcher, C. R., Rijnsdorp, A. D., McConnaughey, R. A., Parma, A. M., Suuronen, P., Eigaard, O. R., *et al.* 2018. Bottom trawl fishing footprints on the world's continental shelves. Proceedings of the National Academy of Sciences of the United States of America, 115: E10275–E10282.

Brown, C. J., and Mumby, P. J. 2014. Trade-offs between fisheries and the conservation of ecosystem function are defined by management strategy. Frontiers in Ecology and the Environment, 12: 324–329.

Cournane, J. M., Kritzer, J. P., and Correia, S. J. 2013. Spatial and temporal patterns of anadromous alosine bycatch in the US Atlantic herring fishery. Fisheries Research, 141: 88–94.

Cury, P. M., Boyd, I. L., Bonhommeau, S., Anker-Nilssen, T., Crawford, R. J., Furness, R. W., Mills, J. A., *et al.* 2011. Global seabird response to forage fish depletion—one-third for the birds. Science, 334: 1703–1706.

Dunn, D. C., Boustany, A. M., Roberts, J. J., Brazer, E., Sanderson, M., Gardner, B., and Halpin, P. N. 2014. Empirical move-on rules to inform fishing strategies: a New England case study. Fish and Fisheries, 15: 359–375.

FAO. 2018. The State of World Fisheries and Aquaculture 2018—Meeting the Sustainable Development Goals. Rome, Licence: CC BY-NC-SA 3.0 IGO.

Garcia, S. M. 1994. The precautionary principle: its implications in capture fisheries management. Ocean and Coastal Management, 22: 99–125.

Grafton, R. Q., Kompas, Q., and Hilborn, R. W. 2007. Economics of Overexploitation Revisited. Science, 318: 1601.

Hilborn, R. 2011. Future directions in ecosystem based fisheries management: a personal perspective. Fisheries Research, 108: 235–239.

Hoos, L. A., Buckel, J. A., Boyd, J. B., Loeffler, M. S., and Lee, L. M. 2019. Fisheries management in the face of uncertainty: designing time-area closures that are effective under multiple spatial patterns of fishing effort displacement in an estuarine gill net fishery. PLoS ONE, 14: e0211103.

Little, A. S., Needle, C. L., Hilborn, R., Holland, D. S., and Marshall, C. T. 2015. Real-time spatial management approaches to reduce bycatch and discards: experiences from Europe and the United States. Fish and Fisheries, 16: 576–602.

Lubchenco, J., and Grorud-Colvert, K. 2015. Making waves: the science and politics of ocean protection. Science, 350: 382–383.

Melvin, E. F., Sullivan, B., Robertson, G., and Wienecke, B. 2004. A review of the effectiveness of streamer lines as a seabird by-catch mitigation technique in longline fisheries and CCAMLR streamer line requirements. CCAMLR Science, 11: 189–201.

Parker, S. J., Penney, A. J., and Clark, M. R. 2009. Detection criteria for managing trawl impacts on vulnerable marine ecosystems in high seas fisheries of the South Pacific Ocean. Marine Ecology Progress Series, 397: 309–317.

R Core Team. 2020. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Rassweiler, A., Costello, C., Hilborn, R., and Siegel, D. A. 2014. Integrating scientific guidance into marine spatial planning. Proceedings of the Royal Society B: Biological Sciences, 281, doi: 10.1098/rspb.2013.2252

Rice, J., Garcia, S. M., and Kaiser, M. J. 2018. Other Effective Area-Based Conservation Measures (OEABCMs) Used in Marine Fisheries: A Working Paper. https://www.cbd.int/doc/c/0689/522e/7f94ced371fa41aeee6747e5/mcb-em-2018-01-inf-04-en.pdf (last accessed 20 April 2020).

Smith, J. A., Tommasi, D., Sweeney, J., Brodie, S., Welch, H., Hazen, E. L., Muhling, B., *et al.* 2020. Lost opportunity: quantifying the dynamic economic impact of time-area fishery closures. Journal of Applied Ecology, 57: 502–513.

Tasker, M. L., Camphuysen, C., Cooper, J., Garthe, S., Montevecchi, W. A., and Blaber, S. J. 2000. The impacts of fishing on marine birds. ICES Journal of Marine Science, 57: 531–547.

Wallace, S., Turris, B., Driscoll, J., Bodtker, K., Mose, B., and Munro, G. 2015. Canada's Pacific groundfish trawl habitat agreement: a global first in an ecosystem approach to bottom trawl impacts. Marine Policy, 60: 240–248.

Walters, C. J., and Martell, S. J. 2004. Fisheries Ecology and Management. Princeton University Press, Princeton NJ. 448 pp.

White, C., Halpern, B. S., and Kappel, C. V. 2012. Ecosystem service tradeoff analysis reveals the value of marine spatial planning for multiple ocean uses. Proceedings of the National Academy of Sciences of the United States of America, 109: 4696–4701.

Worm, B., Hilborn, R., Baum, J. K., Branch, T. A., Collie, J. S., Costello, C., Fogarty, M. J., *et al.* 2009. Rebuilding global fisheries. Science, 325: 578–585.

Handling editor: Emory Anderson

IN THE HIGH COURT OF SOUTH AFRICA

GAUTENG DIVISION, PRETORIA

Case No: 2024-029857

In the matter between:

BIRDLIFE SOUTH AFRICA	First Applicant
SOUTH AFRICAN FOUNDATION FOR THE CONSERVATION OF COASTAL BIRDS	Second Applicant
and	
THE MINISTER OF FORESTRY, FISHERIES AND THE ENVIRONMENT	First Respondent
THE DEPUTY DIRECTOR-GENERAL: FISHERIES MANAGEMENT, DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT	Second Respondent
THE DEPUTY DIRECTOR-GENERAL: OCEANS AND COASTS, DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT	Third Respondent
THE SOUTH AFRICAN PELAGIC FISHING INDUSTRY ASSOCIATION	Fourth Respondent
EASTERN CAPE PELAGIC ASSOCIATION	Fifth Respondent

EXPERT AFFIDAVIT

I, the undersigned,

JENNIFER LEIGH GRIGG

do hereby make oath and state that:

1. I am an adult female and am in the final stages of completing a doctorate at the University of Exeter. My research concerned the use of powerful demographic models to determine the rates that govern population dynamics of African Penguins and to project the impact of potential conservation actions on population trajectories.

2. The facts contained in this affidavit are within my personal knowledge and belief, unless otherwise stated or appears from context, and are to the best of my ability both true and correct.

3. My qualifications are set out in my curriculum vitae, attached marked "**JLG1**". In brief my qualifications and expertise are as follows:

    3.1. I hold a Bachelor of Science (Honours) in Animal Science (Behaviour and Welfare) from the University of Bristol, a Masters by Research on the topic of conservation biology from the University of Bristol and, as indicated, am close to completing my doctorate.

    3.2. I have co-authored four papers in peer-reviewed journals and have one lead author paper in review. I have published a chapter on African penguin ecology and conservation in a book outlining a synthesis of the world's imperilled species and ecosystems. I have served as a peer-reviewer for five journals concerned with marine ecology and conservation biology.

    3.3. I have undertaken multiple professional demographic modelling training courses, including those on the topic of multistate and multievent capture-mark-recapture analysis and Bayesian integrated population monitoring.

3.4. I am the lead author of the article "*Bayesian population viability analysis reveals impacts of fisheries management on an Endangered seabird*", which is currently in preparation to be submitted to the peer-reviewed journal *Proceedings of the Royal Society B: Biological Sciences*. I have attached to this affidavit, an up-to-date draft of this article as "**JLG2**". For ease of reference I refer to my analysis as "**the demographic projection analysis**".

4. The demographic projection analysis presents the calculations and outcomes of a modelling process, used to derive estimates of important demographic rates for the African penguin populations at Robben Island and Stony Point and assesses the viability of these populations when projected into the future under five alternate fisheries management scenarios. The five interventions modelled are:

4.1. no fisheries management;

4.2. small-scale (20 km) fishing closures at breeding colonies;

4.3. wider spatial fisheries closures in important foraging areas used by pre-breeders and non-breeding adults (with a modelled impact on survival across all ages classes);

4.4. wider spatial fisheries closures implemented in conjunction with small-scale closures at colonies; and

4.5. wider spatial fisheries closures implemented in conjunction with small-scale closures at colonies (with a modelled impact on only adult survival).

5. The demographic projection analysis uses the results of population counts, capture-mark-recapture data and breeding success data from five breeding colonies in the Western Cape of South Africa: Robben Island, Stony Point, Dassen Island, Simon's Town and Dyer Island, from between 2013 and 2020.

6. This data is analysed using a combined integrated population model-Bayesian population viability analysis (**IPM-BPVA**). IPM-BPVAs are considered a robust modelling framework for quantifying the impacts of potential management actions on forecasted population dynamics.

7. The IPM-BPVA is used to derive the following demographic rates:

    7.1. the survival of juvenile, immature and adult African penguins;

    7.2. the dispersal of penguins breeding for the first time; and

    7.3. fecundity (the number of successful fledglings produced by each breeding female) for the period 2013 to 2020.

8. The model also projects the population 13 years into the future (i.e. until 2033) and assesses population viability under the alternate fisheries management scenarios referenced above.

9. Population viability is assessed based on the following metrics:

    9.1. population growth rate from 2020 to 2033; and

    9.2. probability that the population size would be smaller in 2033 than in 2020.

10. The model estimates demographic rates and population viability for Robben Island and Stony Point. I also used data from Dassen Island, Simon's Town and Dyer Island in the model so that movement between Robben Island, Stony Point and other colonies in the Western Cape can be estimated. However, there is not sufficient data to estimate separate parameters or viability for these three additional sites.

The findings in relation to slowing of the rate of decline

11. The demographic projection analysis concludes, through a combination of observed and projected data, that implementing small-scale (20 km) fishing closures around Robben Island will significantly benefit African penguins.

12. The results of modelling indicate that the impacts of fishing closures on the population growth rate at Robben Island are sufficiently large relative to the local reductions in penguin abundance, to reverse the current trend in decline if implemented on long-term basis.

    12.1. The demographic projection analysis demonstrates that the annual population growth rate (λ_t) of the population at Robben Island, when projected with 20 km closures implemented in the vicinity of the breeding colony, rises above 1, indicating positive population growth by 2025 (the fifth year of projections). Within the short-time scales of these projections, this was not sufficient to drive population recovery. However, this suggests that, given more time, the observed effect of the 20 km closures would be sufficient on their own to reverse the trend of decline.

12.2. Further to this, the results presented in the demographic projection analysis demonstrate that, by 2033, the size of the population at Robben Island, when projected with 20 km closures implemented in the vicinity of the colony is 1052 breeding pairs. Comparatively, the size of the population when projected with no fisheries management is 808 breeding pairs. This indicates that the projected population in 2033, with 20 km small-scale fishing closures, is approximately 30% larger than without fishing closures.

12.3. In other words, if 20 km fishing closures are implemented until the end of 2033 at Robben Island, I would expect the population to be growing, and considerably larger, than under a scenario with no closures.

13. In respect of Stony Point, the demographic projection submission concludes that implementing small-scale (20 km) fishing closures around this colony allow the population to recover more quickly than under a scenario with no fisheries management at Stony Point.

13.1. The results presented in the demographic projection submission demonstrate that, by 2033, the size of the population at Stony Point when projected with 20 km closures implemented in the vicinity of the colony is 2199 breeding pairs. Comparatively, the size of the population when projected with no fisheries management is 1842 breeding pairs. This indicates that the projected population in 2033, with 20 km small-scale fishing closures, is approximately 20% larger than without fishing closures.

What this means in terms of other islands / any limitations (e.g. the relationship between the 20km and other closure options)

14. The modelling process used to generate the projections presented in the demographic projection analysis are only based on improvements in demographic parameters measured as part of the ICE, namely chick condition (which in turn influences juvenile survival; the relationship between these two parameters is included in this model) and chick survival.

15. In African Penguins, adult survival is correlated with forage fish abundance, and evidence from other seabirds suggest that fisheries can affect survival. Therefore, it is possible that small-scale closures may positively influence immature and adult survival, which was not accounted for in our models. As such, the impacts of the small-scale fishing closures on the projected populations demonstrated in the demographic projection analysis are likely to be underestimated.

16. I was unable to project the impact of the small-scale closures on the populations at Dassen Island, Simon's Town or Dyer Island separately due to limited data available for these sites. However, given that the closures had significant positive effects at Robben Island and Stony Point, it is reasonable to assume that these closures would induce similar population effects at these colonies.

17. Given my qualifications and experience, as set out above, I am duly qualified to express an expert opinion on the data provided in the demographic projection analysis.

18. I confirm the content of the demographic projection analysis and the expert opinion expressed therein. I further confirm that the methods and data relied upon are robust and credible.

_____

JENNIFER LEIGH GRIGG

The deponent has acknowledged that she knows and understands the contents of this affidavit, which was signed and sworn to before me at _____ on this the _____ day of **_____2024**, the regulations contained in Government Notice No. R1258 of 21 July 1972, as amended, and Government Notice No. R1648 of 19 August 1977, as amended, having been complied with.

_____

COMMISSIONER OF OATHS

Full Names:

Capacity:

Designation:

Address:

"JLG1"

JENNIFER LEIGH GRIGG

29 Bramble Drive, Chippenham, SN15 3PH · jenlgrigg@gmail.com · +44 (0)7429412963

Relevant Experience

Job title: **PhD Researcher**
Employer name: University of Exeter
Employment period: September 2018 – August 2024
Nature of role:

- PhD student, undertaking research using powerful demographic models to determine the vital rates that govern population dynamics of African penguins and project the impact of potential conservation actions on penguin population trajectories; alongside research to determine the at-sea behaviour of immature African penguins.
- Responsibilities include: planning and conducting research including international fieldwork and statistical analysis of demographic and spatial data; obtaining the necessary ethics approval and permits; completing associated reporting for government and conservation authorities; and communicating outputs through publications in academic journals, book chapters and conference presentations.

Job title: **Volunteer Field Team Leader (South African Penguin Project)**
Employer name: **(South African Penguin Project), Earthwatch Institute**
Employment period: March 2015 – August 2019
Nature of role:

- Volunteer expedition assistant/leader for African penguin research project. Leading one team per year for five consecutive breeding seasons at Robben Island, South Africa.
- Duties include: carrying out/overseeing African penguin nest surveys, molt counts and chick condition measurements; overseeing of data entry; and leading and planning volunteer activities.

Job title: **Volunteer Research Assistant (Storm Petrel Project)**
Employer name: **A ROCHA, Portugal**
Employment period: June 2014
Nature of role:

- Research assistant position where I worked as part of a small team to monitor Storm petrel populations on Portugal's Algarve coast.
- Duties included: assisting in ringing, weighing and taking morphometric measurements of Storm petrels; assisting in setting up call playback systems and mist-nets; and recording environmental variables i.e. sea surface temperature, wind speed.

Job title: **Seabird Rehabilitation/Seabird Chick-Rearing Intern**
Employer name: **Southern African Foundation for the Conservation of Coastal Birds**
Employment period: November 2011 – August 2012
Nature of role:

- Internship position, where responsibilities included: providing care for ill and oiled seabirds; managing artificially incubated eggs; hand-rearing African penguin chicks; maintaining detailed daily records for all bird's growth, health, medication; and training and supervising volunteers. I also gained experience in collecting and analysing seabird blood samples.

Employment History

Job title: **Freelance Academic Editor**
Employer name: Cactus Communications
Employment period: September 2019 – December 2020
Nature of role:

- Free-lance position as an academic editor, working part-time alongside my PhD.
- Responsibilities included: editing manuscripts in the field of natural sciences for structure, flow and language, in preparation for submission to academic journals. Role involved working to tight deadlines and managing multiple commissions simultaneously.

Job title: **Policy Officer**
Employer name: Department for Environment, Food and Rural Affairs
Employment period: May 2017 – September 2018
Nature of role:

- Policy co-ordinator role working on EU Exit and agri-food policy.
- Responsibilities included: co-coordinating work from central teams to policy staff across multiple Directorates; compiling and synthesising updates and information from policy teams into regular progress reports and when required publications for use in cross-Whitehall forums; providing secretariat function for governance meetings; leading work with the Devolved Administrations to agree post-Exit UK frameworks for food policy.

Education

Name of institution: University of Bristol
Dates attended: January 2015 – November 2016
Qualification: MSc by Research, Biological Sciences

Name of institution: University of Plymouth
Dates attended: September 2009 – July 2013
Qualification: BSc (Hons), Animal Science (Behaviour and Welfare), First Class

Key skills and attributes

Analytical skills
Proficient at data management, analysis and visualisation using the software, R. Statistical analysis skills include modelling of seabird demographic data with Integrated Population Models within a Bayesian framework, Population Viability Analysis, capture-mark-recapture analysis; and spatial analysis of seabird tracking data using R and GIS. Experienced in managing large datasets including demographic data and seabird movement data derived from biologging devices.

Field skills
Experienced in handling a wide variety of seabird species. Proficient at catching, processing and tagging seabirds (passive-integrated transponders), and attaching biologging devices. Experienced carrying out surveys of burrow-nesting species and collecting demographic data at the colony level. Understanding of health and safety legislation and undertaking risk assessments. Experience of remote fieldwork in the UK and internationally.

Communication and collaboration skills
Proficient in producing technical reports outlining research findings for government permit and funder requirements, academic manuscripts and book chapters; and drafting policy documents and briefings for government ministers. Experience in leading and facilitating technical discussions of complex research to government working groups and in communicating research findings at academic conferences. Experience collaborating with stakeholders on applied issues relating to seabird conservation e.g. Environmental Impact Assessments, litigation proceedings against the South African Government in relation to delineation of fishing closure delineations.

Training

2021 - Nimble Workshop, *University of California*, *Berkeley*
2020 - Bayesian Integrated Population Modelling using JAGs, *Centre d'Ecologie fonctionelle et evolutive Montpellier, France*
2019 – Multistate and multievent capture-mark-recapture analysis, *The Mediterranean Institute for Advanced Studies, Mallorca*
2019 – Remote outdoor first aid, *University of Exeter*
2018 – Introduction to capture-mark-recapture analysis, *The Mediterranean Institute for Advanced Studies, Mallorca*

Prizes, Awards, Grants and Honours

2019 - National Geographic Early Career Research Grant
2016 - RSPB Prize for Best Student Conservation Talk (9th International Penguin Congress)
2016 - Bristol Alumni Foundation Travel Grant
2016 - 9th International Penguin Congress Travel Grant
2015 - 2nd Prize for Best Poster (17th Student Conference on Conservation Science)
2015 - The Mohamed bin Zayed Species Conservation Grant
2015 - The Riverbanks Conservation Support Grant
2013 - Science, Technology and Engineering Student of the Year Award - Nominee
2013 - Universities Federation for Animal Welfare Prize for Best Animal Behaviour & Welfare Student
2013 - University of Plymouth Dean’s list of academic excellence

Paper Reviews

2023 - Oecologica
2021 - Journal of Applied Ecology
2021 - Population Ecology
2020 - Marine Ecology Progress Series
2018 - Seabird

Publications

Grigg JL, Ludynia K, Barham BJ, Barham PJ, Abadi F, Geldenhuys D, Makhado AB, McGeorge C, Mdluli A, Parsons NJ, Upfold L, Visagie J, Waller LJ, Hodgson D, Christian M, Votier SC, McCabe GM, Sherley RB (2024) A combined Bayesian integrated population model-population viability analysis to assess alternate fisheries management scenarios for an Endangered seabird. In preparation for submission to Biological Conservation

Grigg JL, Ludynia K, Barham BJ, Barham PJ, Geldenhuys D, Makhado AB, McGeorge C, Mdluli A, Parsons NJ, Upfold L, Visagie J, Waller LJ, Cotton AJ, Votier SC, McCabe GM, Sherley RB (2024) Conservation implications of variation in African penguin (*Spheniscus demersus*) dispersal. Resubmission invited to Ecosphere

Glencross JS, Jewell A, **Grigg JL**, McInnes A, Sherley RB (2024) African penguin *Spheniscus demersus* foraging on jellyfish-fish associations. In review at Seabird 36 https://doi.org/10.61350/sbj.36.5

Grigg JL, Sherley RB (2022) The Decline and Conservation Status of the African Penguin. In: DellaSala, D.A., Goldstein, M.I. (Eds.), Imperiled: The Encyclopedia of Conservation, vol. 1. Elsevier, pp 8–18. DOI: https://dx.doi.org/10.1016/B978-0-12-821139-7.00220-8

Leith FW, **Grigg JL**, Barham BJ, Barham PJ, Ludynia K, McGeorge C, Mdluli A, Parsons NJ, Waller LJ, Sherley RB (2022) Intercolony variation in reproductive skipping in the African penguin. Ecology and Evolution 12:e9255. DOI: https://doi.org/10.1002/ece3.9255

Sherley RB, Barham BJ, Barham PJ, Campbell KJ, Crawford RJM, **Grigg JL**, Horswill C, Mcinnes A, Morris TL, Pichegru L, Steinfurth A, Weller F, Winker H, Votier SC (2018) Bayesian inference reveals positive but subtle effects of experimental fishery closures on marine predator demographics. Proceedings of the Royal Society B: Biological Sciences 285:2017244. DOI: http://doi.org/10.1098/rspb.2017.2443

Bayesian population viability analysis reveals impacts of fisheries management on an Endangered seabird

ABSTRACT

Conservation decision making is often delayed because of insufficient evidence to support interventions. However, models that quantify the impacts of potential management actions on forecasted population dynamics can provide a mechanism for ecological decision-making. Here we combine integrated population modelling with a Bayesian population viability analysis to estimate demographic rates and assess population viability at two important colonies for the Endangered African penguin *Spheniscus demersus*, under five alternate fisheries management scenarios. Without fisheries management, between 2020 and 2033 the population at Robben Island was predicted to decline by 26%, representing an annual loss of ~2%; and at Stony Point was simulated to increase by 7%, representing growth of ~0.5% per annum. With small-scale fishing closures at breeding colonies (the scenario that most closely represented current interventions), the annual population growth rate (λ_t) at Robben Island improved, eventually achieving positive growth. However, not sufficiently for the population to fully recover during the limited timeframe of our simulation. Overall, the population was predicted to decrease by 4% at Robben Island and increase by 28% at Stony Point. Interventions that improved adult survival, namely fisheries closures operating at a wider spatial scale, afforded the most benefits to penguins. When modelled in conjunction with closures at colonies, the projected population at Robben Island and Stony Point showed significant recovery, increasing by 52% and 72%, respectively. Our results provide further evidence that small-scale fishing closures at breeding colonies can benefit penguins. However, halting the population decline requires fisheries management interventions

implemented at a wider spatial scale and that target important foraging habitats used by immature individuals and adults outside of the breeding season.

Introduction

As human activities continue to alter ecosystems around the globe, increasingly more species are threatened with extinction (Prakash & Verma 2022). However, the conservation actions that are required to reverse population declines are often delayed as lack of biological evidence to support interventions leads to uncertainty regarding outcomes (Meek *et al*. 2015). Decision makers may face opposing pressures leading to debates regarding whether to adopt a precautionary approach using the available data, or to defer action until there is sufficient evidence to indicate that management will be successful. Decisions can be especially difficult where conservation interventions have socio-economic repercussions, for instance by restricting human activities within areas important for industries or communities (Grip & Blomqvist 2020).

In marine ecosystems, one of the largest threats to biodiversity is the poor management of commercial fisheries (Agardy 2000). Marine Protected Areas (MPAs) are well-known tools for protecting important marine habitats and their biodiversity. However, their establishment, particularly where they incorporate no-take zones, often have economic and social costs associated with fishing restrictions (Eriksson *et al*. 2019). There is increasing evidence that well-managed MPAs are beneficial, even for mobile apex predators (Koldewey *et al.* 2010; Albano *et al*. 2021), whose populations can have significant cascading effects on ecosystem structure and function (Baum & Worm 2009; Kiszka *et al.* 2015). Yet, relative to the rate of marine biodiversity loss and requirement for spatial protection, the area and level of protection afforded by current MPAs is insufficient (Jones *et al*. 2020). Gathering robust data in the marine environment to demonstrate causality between human activity and adverse effects on biodiversity is time-consuming and costly (Rush & Solandt 2017). Furthermore, for many threatened species that would benefit from area-based protection, quantifying the

effect of management interventions on population growth is often extremely difficult due to a lack of experimental data (Saunders *et al*. 2018).

Traditional population viability analysis predicts population growth and extinction risk under alternate management or climate scenarios, but due to the requirement for long-term datasets, its applications can be limited (Doak *et al*. 2005). Integrated population models (IPMs) provide data-informed estimates of population size, trajectory, and demographic rates; and quantify how ecological processes affect these rates and subsequently regulate populations (Besbeas *et al*. 2002; Schaub & Abadi 2011). They also allow for all data to be analysed in a single model with one joint likelihood. Compared to traditional approaches which combine multiple, separate analyses with different likelihoods (e.g. Oppel *et al*. 2023) this allows for the better estimation of parameter estimates with reduced uncertainty (Schaub & Abadi 2011; Frost *et al*. 2023). IPMs are also useful tools for guiding population management decisions, as they can be used to identify the demographic rates which have the largest influence on the projected population size and trajectory. Increasingly, IPMs have been combined with population viability analysis within a Bayesian framework (IPM-BPVA) to project populations for the purpose of conservation management (Oppel *et al*. 2014; Saunders *et al*. 2018; Rosenblatt *et al*. 2021; Davis *et al*. 2023). For species that require urgent conservation interventions, IPM-BPVAs are a powerful tool for quantifying the impacts of potential management actions on forecasted population dynamics and provide a mechanism for ecological-decision making, so that interventions which will confer the most benefit can be prioritised (Arnold *et al*. 2018; Crawford *et al*. 2018a).

The African penguin (*Spheniscus demersus*) is an Endangered seabird endemic to the Benguela upwelling ecosystem (BirdLife International 2020). It breeds at 26 localities in Namibia and South Africa, the latter of which holds ~85% of the breeding pairs (Sherley *et al.* 2024). The South African population has decreased by ~77% since 1993, from ~40,000

breeding pairs to ~8,750 in 2023 (Sherley *et al*. 2024). The rate of decline has been particularly pronounced off the West Coast, where the population has decreased by ~75% within the last 30 years, compared to the neighbouring South-West Coast where the population has fallen by ~31% (Sherley *et al.* 2024). Numerous threats including predation, oiling, disease and lack of breeding habitat have contributed to this trend (Grigg & Sherley 2022). However, the primary driver of the decline is insufficient prey availability, due to changes in the abundance and distribution of sardine (*Sardinops sagax*) and anchovy (*Engraulis capensis*), combined with competition with purse-seine fisheries (Crawford *et al.* 2011, 2018b, 2019), which has resulted in high adult mortality, (Robinson *et al*. 2015) and low juvenile survival (Sherley *et al.* 2014a, 2017). Thus, conservation interventions that increase prey availability are critical to prevent further population decline (Sydeman *et al*. 2021, 2022).

Since 2013, African penguin research and conservation has been guided by the African penguin Biodiversity Management plan (APBMP), which aims to ensure no extant colonies become extinct; for populations in all three regions of South Africa to be stable or increasing, and to increase the overall South African population size by 5% (Government Gazette of South Africa 2013, 2022). One of the objectives for achieving these aims is to ensure the availability of forage fish in key foraging areas used throughout the African penguin lifecycle (Government Gazette of South Africa 2022).

Between 2008 and 2021, experimental small-scale (20 km radius) fishing closures were alternated around two pairs of neighbouring islands (Robben Island and Dassen Island in the Western Cape; Bird Island and St Croix in the Eastern Cape), to determine if protecting foraging areas in proximity to breeding colonies confers advantages to penguins (Punt *et al.* 2023). These closures have had positive impacts on chick survival and chick condition, and decreased foraging effort (Pichegru *et al*. 2010, 2012; Sherley *et al.* 2018, 2022). Recently,

following an evidence review by an international scientific panel (Punt *et al*. 2023), the South African Government agreed to implement permanent no-take zones at the six largest breeding colonies (the four used in the experiment plus Stony Point and Dyer Island, Figure 1) from 2023 to 2033 (see https://www.dffe.gov.za/node/2001). However, the evidence base for the closed areas will be reviewed in 2030, the scope for competition with fisheries is apparent across the penguins' foraging range, and previous work has suggested that the small-scale closures alone are unlikely to be sufficient to reverse the species' decline (Sherley *et al.* 2017, 2018, 2022). Interventions are also required that protect important foraging areas used by juveniles, immatures and adults throughout the rest of the annual cycle. For example, adaptive no-take zones that come into effect seasonally, or when prey drops below certain critical thresholds.

To assess the effectiveness of alternate fisheries management strategies against achieving the aims of the APBMP, we developed a combined IPM-BPVA within a Bayesian framework. Using population counts, capture-mark-recapture and breeding success data from five breeding colonies in the Western Cape of South Africa, representing ~60% of the global population, we aim to: 1) estimate African penguin demographic rates; and 2) project the population 13 years into the future and assess population viability under alternate fisheries management scenarios. We compare five possible interventions: 1) no fisheries management; 2) small-scale fishing closures at breeding colonies; 3) wider spatial fisheries closures in important foraging areas used by pre-breeders and non-breeding adults (with a modelled impact on survival across all ages classes); 4) wider spatial fisheries closures implemented in conjunction with small-scale closures at colonies; and 5) wider spatial fisheries closures implemented in conjunction with small-scale closures at colonies (with a modelled impact on only adult survival).

Methods

Study sites

We used data collected between 2013 and 2020, from five African penguin colonies in the Western Cape of South Africa: Dassen Island (33°25'S, 18°05'E) and Robben Island (33°49'S, 18°22'E) on the West Coast, north of Cape Town (Figure 1); and Simon's Town (34°11'S, 18°27'E), Stony Point (25°43'S, 014°49'E), and Dyer Island (34°41'S, 19°24'E) on the South-West Coast, south and east of Cape Town (Figure 1). Following a steep decline from a peak population of ~8,500 breeding pairs in 2004, the Robben Island population remained relatively stable during the study period, fluctuating between ~1,000 and ~1,400 breeding pairs (Sherley *et al*. 2020, 2024). In contrast, the Stony Point population, which was increasing until 2015, reaching ~2,500 breeding pairs, subsequently declined to ~1,700 pairs in 2020 (Sherley *et al*. 2020, 2024). Comparatively, Dassen and Dyer Island, declined (2013: ~ 2,600 breeding pairs, 2020: ~1,900 pairs) and remained relatively stable (2013: ~1,300 pairs, 2020: ~1,050 pairs), respectively. Simon's Town was the only consistently increasing population (2013: ~600 pairs, 2019: ~900 pairs) during the study period (Sherley *et al*. 2020, 2024).

Demographic data collection

Population count data were derived from annual censuses of breeding pairs carried out between May and August at all sites (Sherley *et al*. 2020, 2024), thus represent the number of breeding females. African penguin nests were monitored for breeding success between January and December at Dassen Island (due to the extended breeding season) and March and September at all other sites. Active nests with eggs were identified and subsequently visited weekly or bi-weekly and the contents recorded until chicks died or were presumed to have fledged (Sherley *et al.* 2012). Chicks were assumed to have fledged if they were seen at ≥ 45

days old and could not be found on a subsequent visit. Annual estimates of chick survival and egg survival were calculated using an extension of the Mayfield method and parametric survival models (Sherley *et al*. 2012, 2013, 2018; Ludynia *et al.* 2014). These two datasets were used alongside published estimates of clutch size and the number of clutches per year to estimate fecundity (the number of successful fledglings produced by each breeding female; see Appendix S1.B3). To correspond with the constraints of the capture-mark-recapture data (see below), population count and breeding success data for Dassen Island, Dyer Island and Simon's Town were averaged to create a new site 'Elsewhere in the Western Cape' (hereafter referred to as 'Elsewhere').

Since 2013, at all sites named above (plus Bird Island and St Croix in the Eastern Cape), breeding adults and fledglings have been marked with subcutaneous passive integrated transponders (PITs) (e.g. Leith *et al*. 2022). Fledglings removed from these sites as eggs or chicks and hand-reared in captivity are also marked with PITs prior to release (Sherley *et al*. 2014b; Stander & Klusener 2020). Resighting data was collected using hand-held readers (RS420 EID Reader, Allflex®, UK) during the routine monitoring of breeding success, and at all colonies except Dassen Island, using automatic ground readers (IS1001 Reader, Biomark®, USA) installed on penguin "highways" to/from sea (Sherley *et al*. 2010; Leith *et al.* 2022). However, an outbreak of Avian Influenza meant that during 2018, penguins were not marked in colonies and procedures for using hand-held readers were modified (Molini *et al.* 2020). Annual multi-state capture histories were created by combining resightings of individuals between March and October into a single annual encounter, based on location, age and breeding status. Encounters from Dassen Island, Simon's Town and Dyer Island were pooled to form a new location 'Elsewhere' (see below and Appendix S2), to account for movement to/from Robben Island and Stony Point. Three age classes were considered: juveniles (0-1 years old), immatures (1-2 years old) and adults (>2 years old). All birds

177 marked as adults entered the dataset as breeders. Individuals marked as chicks were defined
178 as breeders if (upon reaching maturity) they were observed guarding a nest site, incubating
179 eggs, attending chicks; or if they were at least three years old and recorded on the ground
180 reader on more than six different occasions over a minimum of 12 days and a maximum of
181 120 days (Williams & Cooper 1984; Seddon & van Heezik 1991; Whittington *et al*. 2005). In
182 total, capture histories from 5,890 penguins were used (1,658 birds marked as adults; 4,232
183 marked as chicks).

184

185 *Integrated population model*

186 We analysed the three datasets using an IPM (Kéry & Schaub 2011; Schaub & Abadi 2011)
187 fitted in a Bayesian framework, to estimate probabilities of survival and dispersal; fecundity
188 abundance and population growth rates.

189

190 *Population model*

191 We first developed a stage-structured demographic model that linked population sizes and
192 demographic rates using a projection matrix model framework (Caswell 2000). The model
193 was based on a pre-breeding census and was female-based (as population count data was
194 based on the number of breeding pairs and did not include pre-breeders), with transitions
195 between states based on an annual time step aligning with the African penguin breeding
196 season in the Western Cape. Based on previous knowledge of African penguin life history,
197 we assumed that individuals did not begin breeding until they reached 3 years old
198 (Whittington *et al*. 2005) and could not change location once they had begun to breed
199 (Sherley *et al*. 2014a). We constrained the model so that non-breeding individuals could not
200 change location (until they recruited for their first breeding attempt; to allow for the

estimation of natal dispersal); so that individual birds only had one breeding attempt per year, the sex ratio of fledglings was equal and there were no effects within each stage class (i.e., no individual effects). The model had a total of 12 states, based on a combination of age, location and breeding status. For each location (Robben Island, Stony Point and 'Elsewhere') states were defined for: 1 year-old non-breeders; 2 year-old non-breeders, >2 year-old non-breeders (i.e. adults that had not yet recruited) and >2 year-old breeders (i.e. adults that had recruited). The number of individuals in each of the 12 states at time *t* was a function of the number of individuals in the relevant states at *t*-1, combined with age- and location-specific probabilities of survival, and location-specific probabilities of dispersal and fecundity (these parameters were only applied to adults i.e., individuals >2 years old). 'Elsewhere' states (comprised of data from Dassen Island, Simon's Town and Dyer Island) were incorporated so that movement between Robben Island, Stony Point and other colonies in the Western Cape could be estimated, as there were not sufficient data to estimate separate parameters for each of these sites. However, as each of these sites have different population trajectories and underlying demographic rates (Ludynia *et al*. 2014; Sherley *et al*. 2014a, 2020) we did not expect the model to produce meaningful 'Elsewhere' parameter estimates that reflected the true state of the population (see Appendix S2 for more details). As such, parameter estimates for 'Elsewhere' are not presented here. We included demographic stochasticity by using Poisson and binomial distributions to specify the relationships between the state-specific abundance at year *t*+1 and *t*. Environmental stochasticity was incorporated by allowing demographic rates (for adult survival at Robben Island and Stony Point and fecundity at all sites) to vary randomly by year. A detailed description of the model, including the life cycle graph and list of states and state transitions are provided in Appendix S1.

Estimation of model parameters

Parameter estimates (the annual state-specific population sizes and demographic rates) were obtained from analysis of the joint likelihood of the IPM (Besbeas *et al*. 2002). This was composed from the likelihood of: 1) a state-space demographic model for the population count data; 2) a multi-state capture-mark-recapture model for the individual capture histories; and 3) Poisson regression models for the fecundity data.

The state-space model for the count data incorporated a population state-process model consistent with that of the population model described above, and a Poisson observation model to account for error in detection during monitoring (de Valpine 2003).

In the multi-state-capture-mark recapture model, transition probabilities were modelled in two steps: (1) survival and (2) dispersal. Survival was assumed to vary by location and age (juvenile: 0-1 years old, immature: 1-2 years old and adult: >2 years old), based on *a priori* knowledge of survival in African penguins (Sherley *et al*. 2014a). Annual survival estimates were obtained for adults at Robben Island and Stony Point. Due to data sparsity, all other survival estimates were kept constant over time. The encounter structure for all sites depended on location, age and time. For dispersal, transitions from non-breeding to breeding states (representing natal dispersal/natal site fidelity) could vary by location. Model selection was used to confirm the model structure was supported by the data and was conducted outside of the Bayesian framework; see Grigg et al (in press) for full details.

Breeding success data (egg and chick survival, clutch size, clutches per year) were used to determine annual site-specific estimates of fecundity (the number of successful fledglings produced by each breeding female) with a Poisson regression model. Several derived parameters were calculated within the IPM, including estimates of fecundity used for the Poisson models (see Appendix S1.D). The annual population growth rate λ_t for each location was calculated by dividing the number of breeding pairs in year t+1 by the number of pairs in

year *t* and the growth rate for the entire study period ($\bar{\lambda}_t$) was calculated separately as the geometric mean of all the log-transformed annual λ_t estimates (Oppel *et al*. 2014; Saunders *et al.* 2018). A full description of these models, including the likelihood functions can be found in Appendix S1.

Bayesian population viability analysis

African penguin conservation efforts are guided by the APBMP, which aims to ensure no extant colonies become extinct and to increase the South African population size by 5%. To assess the effectiveness of proposed conservation interventions against these aims, we extended the IPM to perform a population viability analysis (IPM-BPVA). We projected the population for 13 years into the future from the end of our study period (2020–2033) under five alternative management scenarios (see below and Table 1 for details of implementation). This aligns with the timeframe over which the recently agreed small-scale no-take fishing closures will continue (subject to the 2030 review).

We projected the penguin population under scenario 1) no fishing closures at any colony; and scenario 2) permanent small-scale closures at all our study sites. In the fecundity estimates used for projections at Robben Island and 'Elsewhere' under scenario one and two, we used priors for chick survival with a colony-specific mean and standard deviation, derived from data collected during 'open' and 'closed' years, respectively (Sherley *et al.* 2018, 2022). As there were no previous experimental closures at Stony Point, so no data to derive informative priors from, we assumed the closure effects for that site to be the same as those observed at Robben Island, and for scenario two manually modified the chick survival estimate used to derive fecundity by increasing it by 11%, following the reported closure effect size at Robben Island (Sherley *et al.* 2018, 2022). Fishing closures also improved chick body condition at

Robben Island (but not at Dassen Island; (Sherley *et al.* 2018, 2022). Although chick condition was not a parameter in our model, for scenario two at Robben Island and Stony Point, we used the observed relationships between fledging mass and chick condition in African penguins (Sherley *et al.* 2017), and between fledging mass and first year survival in Macaroni penguins (*Eudyptes chrysolophus*; Horswill *et al*. 2014), to model the link between increases in chick condition and juvenile survival, following (Sherley *et al.* 2018, 2022).

Wider fishing exclusion zones that target important foraging areas used by juvenile, immature and non-breeding penguins have also been proposed as potential conservation measures (Carpenter-Kling *et al*. 2022). Thus, we also projected the penguin population under: scenario 3) introduction of wider fishing closures, with no small-scale closures at breeding sites; and scenario 4) introduction of wider fishing closures in combination with permanent small-scale closures at all breeding sites. Determining the impact of designating no-take zones in penguin foraging hotspots on demographic rates is challenging. Robinson (*et al.* 2015) used a population dynamics model to project the Robben Island population under scenarios with and without fishing. The projected population was 3.1% higher under the scenario without fishing, based on the modelled relationship between sardine biomass and adult (≥1 year old) penguin survival. Juvenile and immature penguins target similar foraging areas as non-breeding adults (Sherley *et al.* 2017; Carpenter-Kling *et al.* 2022), thus we modelled the impact of wider fishing closures by increasing juvenile, immature and adult survival by 3.1%. To account for uncertainty in the magnitude of change in survival associated with the wider closures, we modelled the increase with a prior drawn from a normal distribution with a standard deviation of 0.05, following Schaub & Kéry (2021). To account for a scenario whereby when introduced in conjunction with small-scale closures at breeding sites, wider fishing closures only effect adult survival, we also projected the penguin population under: scenario 5) introduction of wider fishing closures (that only impact adult

299 survival) in combination with permanent small-scale closures at all breeding sites. The
300 impact of small-scale closures under scenarios three to five were modelled as described for
301 scenario one and two.

302 For all scenarios, estimates of demographic rates between 2020 and 2033 were kept constant.
303 To assess the effectiveness of the alternate management interventions against the aims of the
304 APBMP, we calculated the following metrics for each location across all five scenarios: 1)
305 population growth rate from 2020 to 2033; and 2) probability that the population size would
306 be smaller in 2033 than in 2020.

307

308 *Model implementation*

309 The IPM and BPVA were fitted in a Bayesian framework, thus prior probabilities were
310 specified for each parameter. All priors were vague, except for those for the initial population
311 sizes, which were specified based on the location- and age-specific proportions of the total
312 population sizes. All prior specifications can be found in Appendix S1, Table S2. Markov
313 Chain Monte Carlo (MCMC) methods were used to simulate from the posterior distribution
314 for each parameter, using the software JAGS (Plummer 2003), run from R (R Core Team
315 2018) with the package jagsUI (Kellner 2016). Three independent chains were each run for
316 80,000 iterations, with a burn-in of 40,000 and a thinning rate of 4, meaning that inference
317 was based on 30,000 samples from the posterior distribution. Convergence was assessed
318 using the Gelman and Rubin R-hat statistic (Brooks & Gelman 1998) and through visual
319 inspection of chains and was deemed satisfactory ($\hat{R}$ <1.05 for all parameter estimates). There
320 are no standard methods to measure goodness of fit for IPMs, so the fit of each component
321 model was assessed separately (Besbeas *et al.* 2002; Schaub & Kéry 2021). Posterior
322 predictive checks were applied to the state-space model of the population count data and

Poisson regression model of the fecundity data. Following Besbeas and Morgan (2014), for each model we calculated discrepancy measures (mean absolute percentage error) between the expected values and observed data and expected values and simulated datasets and used these to obtain Bayesian *p*-values. All Bayesian *p*-values for the Robben Island and Stony Point sub-models were between 0.24 and 0.5 thus indicated an appropriate fit (Schaub & Ullrich 2021). Full details regarding the posterior predictive checks and corresponding plots of the Bayesian *p*-values are provided in Appendix S3. Fit of the capture-mark-recapture model was assessed separately in U-CARE (Choquet *et al*. 2009) outside of the Bayesian framework (Grigg *et al.* in press). Parameter estimates are expressed using the means and 95% credible intervals of the posterior distributions. The full IPM-BPVA code can be found in Appendix S4.

Results

Demographic parameters

The African penguin population at Robben Island (based on the modelled number of breeding pairs), was estimated to have decreased by 19% from 1,359 breeding pairs (95% CI: 1319–1399) in 2013 to 1,097 (1,034–1,097) in 2020. The Stony Point population was estimated at 2,040 pairs (2,001–2,080) in 2013 and 1,753 (1,675–1,835) in 2020, representing a total decline of 14%. For both sites the estimates tracked the observed counts closely (Figure 2).

Apparent mean juvenile survival was 0.36 (0.25–0.59) at Robben Island and 0.44 (0.39–0.50) at Stony Point. Meanwhile, mean immature survival was estimated at 0.74 (0.43–0.95) and 0.67 (0.58–0.76), respectively (Figure 3a). Both juvenile and immature survival estimates were relatively imprecise at Robben Island (Figure 3a). Across years, estimates of adult

346 survival varied between 0.59 (0.53–0.65) and 0.84 (0.78–0.91) at Robben Island, and 0.67
347 (0.64–0.72) and 0.98 (0.94–0.99) at Stony Point (Figure 3b).

348 Fecundity ranged between 0.81 (0.71–0.91) to 1.19 (1.07–1.32) at Robben Island and
349 between 0.85 (0.76–0.94) and 1.23 (1.08–1.38) at Stony Point (Figure 3c).

350 Of the fledglings from Robben Island that went on to breed, ~82% did so at their natal site,
351 while ~4% moved to breed at Stony Point and ~13% bred at one of the three colonies
352 grouped under 'Elsewhere' (Figure 3d). At Stony Point, ~62% of those recruiting returned
353 there to breed, with dispersal to Robben Island and 'Elsewhere' colonies occurring ~11% and
354 ~27%, respectively (Figure 3e).

355 The mean encounter probability for adults was 0.65 (0.50–0.78) at Robben Island and 0.93
356 (0.84–0.99) at Stony Point. Mean encounter probability of immatures was 0.23 (0.01–0.70) at
357 Robben Island and 0.35 (0.11–0.68) at Stony Point (Appendix S6, Figure S5).

358

359 *BPVA and impact of management strategies on population growth rate*

360 **Scenario 1 (no fisheries management)** - Based on no fisheries management, the population
361 was projected to decline at Robben Island and increased at Stony Point (% change 2020–
362 2033: Robben Island: −26%; Stony Point: +7%; Table 2, Figure 4a,f). Probabilities that the
363 site-specific populations in 2033 were smaller than that in 2020 were the highest of all
364 management scenarios (Robben Island: 0.76; Stony Point: 0.62; Table 2, Figure 4a,f).
365 Estimates of annual population growth (λ_t) remained < 1 for Robben Island ($\lambda_t < 1$ at Robben
366 Island since 2017/2018) and at Stony Point, $\lambda_t > 1$ after 2024/2025 (Figure 5).

367 **Scenario 2 (small-scale island closures)** - Under this scenario the population at Robben
368 Island was projected to have declined by 4% during 2020–2033 (Table 2, Figure 4b) despite

the fact that λ_t >1 after 2024/2025 (Figure 5). At Stony Point, the population was projected to be 28% higher in 2033 than in 2020 (Table 2, Figure 4g), with λ_t rising to >1 between 2022 and 2023 (Figure 5).

Scenarios 3 - 5 (wider scale closures) - Management scenarios incorporating wider fishing closures produced the largest population sizes when projected 13 years into the future; the simulated African penguin populations at both sites increased and achieved λ_t >1 under scenarios three to five (Table 2, Figure 4c,d,e,g,i,j). However, the largest simulated populations were obtained under scenario four, representing wider fishing closures combined with small-scale closures at breeding sites (% change 2020–2033: Robben Island: +43%; Stony Point: +64%; Table 2, Figure 4gd,i).

Discussion

Increasingly, IPMs are being combined with population viability analysis for threatened species to understand population dynamics and quantify the impacts of conservation interventions on forecasted population dynamics (Oppel *et al*. 2014; Saunders *et al.* 2018; Rosenblatt *et al*. 2021; Davis *et al.* 2023). We developed a coupled IPM-BPVA for Robben Island, Stony Point and three other key African penguin colonies in the Western Cape of South Africa, to estimate demographic parameters and evaluate the impact of various fisheries management scenarios on the projected population. Without any form of interventions, our results indicate that the number of African penguins in the Western Cape will continue to decline unsustainably. Although the population at Stony Point is predicted to increase by 7% between 2020 (the end of our dataset) and 2033, this growth is offset by declines at Robben Island which was projected to lose 26% of its breeding pairs. Recent analysis suggests the global African penguin population has declined by ~80% over the last

30 years and meets the criteria for an IUCN Red List status of Critically Endangered (Sherley *et al.* 2024). If the objectives of the APBMP are to be achieved, immediate and significant conservation actions are required.

Despite experimental results showing that the 20 km radius fishing closures would have a small positive impact on population growth rates (0.71–1.51%) (Punt *et al*. 2023), the decision whether to suspend fishing around breeding colonies on a permanent basis has been the source of much controversy (Sydeman *et al.* 2021, 2022, Butterworth & Ross-Gillespie 2022). Our results support that implementing fishing closures around breeding colonies will benefit African penguins. At Robben Island, under scenario 2 the annual population growth rate (λ_t) had risen above 1 by 2025 (the fifth year of projections), indicating positive population growth. This was not sufficient to drive population recovery during the limited timeframe of our simulation, and the Robben Island population was still smaller than that in 2020 at the end of our projections. However, this suggests that, given more time, the observed effect of the 20 km closures would be sufficient on their own to reverse the trend of decline.

While the above underlines the importance of the South African Government's decision to implement closures at six colonies until 2033, two factors make it difficult to predict how well our models will reflect the real-world outcomes of that decision. First, the spatial extent of the closures implemented at most of these sites are considerably smaller than the original 20 km areas and do not generally adequately protect the penguins' important foraging areas (McInnes *et al.* in press). Thus, their demographic impacts may be smaller than suggested under scenario 1. And second, our model only considers the impact on demographic variables previously shown to be affected by fishing closures, namely breeding success and juvenile

417 survival (Sherley *et al.* 2018, 2022). Given that adult survival is correlated with forage fish
418 abundance (Crawford *et al*. 2011), and evidence from other seabirds suggest that fisheries can
419 affect survival (Frederiksen *et al*. 2004), it is possible that small-scale closures may positively
420 influence immature and adult survival, which was not accounted for in our models.

421 Furthermore, whilst small-scale closures should have a positive impact on the population,
422 they only protect adult penguins during the breeding season when they are central place
423 foraging to provision their chicks. Fishing restrictions at breeding colonies alone will not be
424 sufficient to drive the recovery of the penguin population and must be introduced with other
425 measures that address the wider availability of forage fish. In our model, scenarios that
426 improved adult and immature survival, incorporating fisheries management interventions
427 over a wider spatial scale resulted in the highest projected population sizes in 2033 and
428 positive population growth rates at all sites. When introduced in conjunction with small-scale
429 fishing closures, wider fisheries management produced populations that were 52% and 72%
430 higher than those in 2020 at Robben Island and Stony Point, respectively. Low juvenile and
431 adult survival, linked to poor sardine biomass, appears to be a key component driving the
432 African penguin population decline, especially at Robben Island (Sherley *et al*. 2014a, 2017;
433 Robinson *et al*. 2015). Therefore, the fact that scenarios targeting these rates provided the
434 best conservation outcomes is not surprising as many past estimates of adult survival (e.g.
435 (Sherley *et al*. 2014a; Leith *et al*. 2022) have been below the threshold needed to achieve
436 population equilibrium (Crawford *et al*. 2006). And while these projections of growth may
437 appear to be high, the increases are well within the range of feasible growth. Between 1990
438 and 2002 the African penguin population at Robben Island increased by ~500% (1278 to
439 7099 breeding pairs) and at Stony Point by ~2500% between 2004 and 2015 (98 to 2053
440 breeding pairs). These results indicate that if management interventions can be implemented

441 that address the current poor survival, the African penguin breeding population has potential
442 to recover relatively quickly.

443 When designating MPAs, policymakers need to consider both conservation and social-
444 economic objectives (Grip & Blomqvist 2020). Thus, any benefits to African penguins
445 resulting from fishing restrictions need to be balanced against costs to the fishing industry.
446 However, given the perilous status of the African penguin population, it is imperative that
447 progress is made towards understanding these trade-offs in more detail, so that further
448 management interventions can be implemented (McInnes *et al*. in press). Tracking studies
449 have identified important foraging areas utilised by juvenile and immature penguins, as well
450 as adults during their pre-and post-moult period outside of the breeding season (Sherley *et al.*
451 2017; Carpenter-Kling *et al*. 2022). Wider fisheries closure could be introduced in these areas
452 in the form of adaptive no-take zones enforced seasonally, or when forage fish abundance
453 falls below certain critical thresholds.

454 Under a scenario with no management interventions the projected population size at Robben
455 Island in 2033 was ~800, and with only small-scale fishing closures was just over 1000.
456 During a period of prolonged low prey abundance in Southern Namibia, 33% of African
457 penguin colonies of less than 1000 breeding pairs in 1956 had become extinct within 50 years
458 (Crawford *et al*. 2001). Furthermore, while the largest driver of current decline is abundance
459 of forage fish, threats such as disease (e.g. avian influenza) and oil spill events have had
460 catastrophic population impacts over the past decades and could easily decimate small
461 colonies (Crawford *et al.* 2000; Wolfaardt *et al*. 2001, 2008; Molini *et al*. 2020). Here we
462 only modelled scenarios of fishing interventions. However, a number of other management
463 actions, for example the provision of artificial burrows to improve breeding success (Kemper
464 *et al.* 2007; Sherley *et al.* 2012; Pichegru 2013) and the rehabilitation of oiled and injured

465 penguins and the hand-rearing and release of African penguin chicks (Barham *et al*. 2008;
466 Klusener *et al.* 2018) could be incorporated into future models.

467 Effective conservation is often hampered by delayed decision making, especially where there
468 are little data available to support the success of management interventions and/or where
469 interventions have implications for important socio-economic activities. Our results highlight
470 the need for wide-scale fisheries interventions that target important foraging grounds outside
471 of the breeding season, which will be essential for improving the survival of juvenile,
472 immature and importantly adult penguins. We also demonstrated that actions that target
473 fecundity, such as closing fisheries in foraging areas used by breeding penguins can have
474 important population benefits. However, as the small-scale closures recently introduced at
475 major breeding colonies are considerably smaller than those our projections were based on,
476 these interventions may not provide the same level of realised benefit. Given the ongoing
477 population decline and costs associated with obtaining further experimental data for testing
478 the effects of wider fishing closures, we advocate the use of predictive population models,
479 such as those presented here, to aid in ecological decision making for the African penguin
480 and for other species of endangered seabird.

481

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510 REFERENCES

511 Agardy T. 2000. Effects of fisheries on marine ecosystems: A conservationist's perspective.
512 In: ICES Journal of Marine Science Academic Press, pp 761–765.

513 Albano PS, Fallows C, Fallows M, Schuitema O, Bernard ATF, Sedgwick O, Hammerschlag
514 N. 2021. Successful parks for sharks: No-take marine reserve provides conservation
515 benefits to endemic and threatened sharks off South Africa. *Biological Conservation*
516 261: 109302.

517 Arnold TW, Clark RG, Koons DN, Schaub M. 2018. Integrated population models facilitate
518 ecological understanding and improved management decisions. *Journal of Wildlife*
519 *Management* 82: 266–274.

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

524 Baum JK, Worm B. 2009. Cascading top-down effects of changing oceanic predator
525 abundances. *Journal of Animal Ecology* 78: 699–714.

526 Besbeas P, Freeman SN, Morgan BJT, Catchpole EA. 2002. Integrating Mark-Recapture-
527 Recovery and Census Data to Estimate Animal Abundance and Demographic
528 Parameters. *Biometrics* 58: 540–547.

529 Besbeas P, Morgan BJT. 2014. Goodness-of-fit of integrated population models using
530 calibrated simulation. *Methods in Ecology and Evolution* 5: 1373–1382.

531 BirdLife International. 2020. *Spheniscus demersus*, African Penguin. The IUCN Red List of
532 Threatened Species 8235, e.T22697810A157423361.

533 Brooks SP, Gelman A. 1998. General methods for monitoring convergence of iterative
534 simulations. *Journal of Computational and Graphical Statistics* 7: 434–455.

535 Butterworth DS, Ross-Gillespie A. 2022. Comment on 'South Africa's experimental fisheries
536 closures and recovery of the endangered African penguin' by Sydeman et al. (2021).
537 *ICES Journal of Marine Science* 79: 1965–1971.

538 Carpenter-Kling T, de Blocq A, Hagen C, Harding C, Morris T, Pichegru L, Roberts J, Ryan
539 PG, Wanless RM, McInnes A. 2022. Important marine areas for endangered African
540 penguins before and after the crucial stage of moulting. *Scientific Reports* 12: 9489.

541 Caswell H. 2000. Matrix population models. Sinauer Sunderland, MA, USA.

542 Choquet R, Lebreton JD, Gimenez O, Reboulet AM, Pradel R. 2009. U-CARE: Utilities for
543 performing goodness of fit tests and manipulating Capture-Recapture data. *Ecography*
544 32: 1071–1074.

545 Crawford BA, Moore CT, Norton TM, Maerz JC. 2018a. Integrated analysis for population
546 estimation, management impact evaluation, and decision-making for a declining
547 species. *Biological Conservation* 222: 33–43.

548 Crawford RJM, Altwegg R, Barham BJ, Barham PJ, Durant JM, Dyer BM, Geldenhuys D,
549 Makhado AB, Pichegru L, Ryan PG. 2011. Collapse of South Africa's penguins in the
550 early 21st century. *African Journal of Marine Science* 33: 139–156.

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

555 Crawford RJM, David JHM, Shannon LJ, Kemper J, Klages NTW, Roux J-P, Underhill LG,
556 Ward VL, Williams AJ, Wolfaardt AC. 2001. African penguins as predators and prey
557 – coping (or not) with change. *South African Journal of Marine Science* 23:435–447.

558 Crawford RJM, Davis SA, Harding RT, Jackson LF, Leshoro TM, Meÿer MA, Randall RM,
559 Underhill LG, Upfold L, Van Dalsen AP, Van Der Merwe E, Whittington PA,
560 Williams AJ, Wolfaardt AC. 2000. Initial impact of the treasure oil spill on seabirds
561 off Western South Africa. *South African Journal of Marine Science* 7615: 157–176.

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

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

567 Davis KL, Saunders SP, Beilke S, Ford ER, Fuller J, Landgraf A, Zipkin EF. 2023. Breeding
568 season management is unlikely to improve population viability of a data-deficient
569 migratory species in decline. *Biological Conservation* 283: 110104.

570 de Valpine P. 2003. Better inferences from population-dynamics experiments using Monte
571 Carlo state-space likelihood methods. *Ecology* 84: 3064–3077.

572 Doak DF, Gross K, Morris WF. 2005. Understanding and predicting the effects of sparse data
573 on demographic analyses. *Ecology* 86: 1154–1163.

574 Eriksson B, Johansson F, Blicharska M. 2019. Socio-economic impacts of marine
575 conservation efforts in three Indonesian fishing communities. *Marine Policy* 103: 59–
576 67.

577 Frederiksen M, Wanless S, Harris MP, Rothery P, Wilson LJ. 2004. The role of industrial
578 fisheries and oceanographic change in the decline of North Sea black-legged
579 kittiwakes. *Journal of Applied Ecology* 41: 1129–1139.

580 Frost F, McCrea R, King R, Gimenez O, Zipkin E. 2023. Integrated Population Models:
581 Achieving Their Potential. *Journal of Statistical Theory and Practice* 17: 1–28.

582 Government Gazette of South Africa. 2013. Biodiversity Management Plan for the African
583 Penguin *Spheniscus demersus.* Department of Environmental Affairs. National
584 Gazette No 36160, 15 February 2013, Vol 572.

585 Government Gazette of South Africa. 2022. Biodiversity Management Plan for the African
586 Penguin *Spheniscus demersus*, Department of Forestry, Fisheries and the
587 Environment. National Gazette No 47061, 22 July 2022, Vol 685.

588 Grigg JL, Sherley RB. 2022. The decline and conservation status of the African Penguin. In:
589 Emperiled: The Encyclopedia of Conservation. DellaSala DA, Goldstein MI (eds)
590 Elsevier, p 8–18

591 Grip K, Blomqvist S. 2020. Marine nature conservation and conflicts with fisheries. *Ambio*
592 49: 1328–1340.

593 Horswill C, Matthiopoulos J, Green JA, Meredith MP, Forcada J, Peat H, Preston M, Trathan
594 PN, Ratcliffe N. 2014. Survival in macaroni penguins and the relative importance of
595 different drivers: Individual traits, predation pressure and environmental variability.
596 *Journal of Animal Ecology* 83: 1057–1067.

597 Jones KR, Klein CJ, Grantham HS, Possingham HP, Halpern BS, Burgess ND, Butchart
598 SHM, Robinson JG, Kingston N, Bhola N, Watson JEM. 2020. Area Requirements to
599 Safeguard Earth's Marine Species. *One Earth* 2: 188–196.

Kellner K. 2016. JagsUI: a wrapper around 'rjags' to streamline 'JAGS' analyses. R Package.

Kemper J, Underhill LG, Roux J-P. 2007. Artificial burrows for African Penguins on Halifax Island, Namibia: do they improve breeding success. Final report of the BCLME (Benguela Current Large Marine Ecosystem) project on top predators as biological indicators of ecosystem change in the BCLME Avian Demography Unit, Cape Town, South Africa: 101–106.

Kéry M, Schaub M. 2011. Bayesian population analysis using WinBUGS: a hierarchical perspective. Academic Press.

Kiszka JJ, Heithaus MR, Wirsing AJ. 2015. Behavioural drivers of the ecological roles and importance of marine mammals. *Marine Ecology Progress Series* 523: 267–281.

Klusener R, Hurtado R, Parsons NJ, Vanstreels RET, 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: 1–17.

Koldewey HJ, Curnick D, Harding S, Harrison LR, Gollock M. 2010. Potential benefits to fisheries and biodiversity of the Chagos Archipelago/British Indian Ocean Territory as a no-take marine reserve. Marine Pollution Bulletin 60: 1906–1915.

Leith FW, Grigg JL, Barham BJ, Barham PJ, Ludynia K, McGeorge C, Mdluli A, Parsons NJ, Waller LJ, Sherley RB. 2022. Intercolony variation in reproductive skipping in the African penguin. *Ecology and Evolution* 12: e9255.

Ludynia K, Waller LJ, Sherley RB, Abadi F, Galada Y, Geldenhuys D, Crawford RJM, Shannon LJ, Jarre A. 2014. Processes influencing the population dynamics and conservation of African penguins on Dyer Island, South Africa. *African Journal of Marine Science* 36: 253–267.

623 Meek MH, Wells C, Tomalty KM, Ashander J, Cole EM, Gille DA, Putman BJ, Rose JP,
624 Savoca MS, Yamane L, Hull JM, Rogers DL, Rosenblum EB, Shogren JF, Swaisgood
625 RR, May B. 2015. Fear of failure in conservation: The problem and potential
626 solutions to aid conservation of extremely small populations. *Biological Conservation*
627 184: 209–217.

628 Molini U, Aikukutu G, Roux JP, Kemper J, Ntahonshikira C, Marruchella G, Khaiseb S,
629 Cattoli G, Dundon WG. 2020. Avian influenza H5N8 outbreak in African penguins
630 (*Spheniscus demersus*), Namibia, 2019. *Journal of Wildlife Diseases* 56: 214–218.

631 Oppel S, Dobrev V, Arkumarev V, Saravia-Mullin V, Bashmili K, Bino T, Bounas A,
632 Chardin A, Dobrev D, Duro K, Kapsalis E, Kret E, Marchant MP, Nakev S, Petrovski
633 N, Papaioannou H, Popgeorgiev G, Selgjekaj L, Skartsi T, Stamenov A, Stoychev S,
634 Topi M, Vavylis D, Velevski M, Vorpsi Z, Weston J, Xeka E, Xherri X, Yordanov E,
635 Nikolov SC. 2023. Long-term conservation efforts at flyway scale can halt the
636 population decline in a globally endangered migratory raptor. *Animal Conservation*
637 27: 374–385.

638 Oppel S, Hilton G, Ratcliffe N, Fenton C, Daley J, Gray G, Vickery J, Gibbons D. 2014.
639 Assessing population viability while accounting for demographic and environmental
640 uncertainty. *Ecology* 95: 1809–1818.

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

643 Pichegru L, Grémillet D, Crawford RJM, Ryan PG. 2010. Marine no-take zone rapidly
644 benefits endangered penguin. *Biology Letters* 6: 498–501.

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

Plummer M. 2003. JAGS: A program for analysis of Bayesian graphical models using Gibbs sampling. Vienna, Austria.

Prakash S, Verma AK. 2022. Anthropogenic Activities and Biodiversity Threats. *International Journal of Biological Innovations* 4: 94–103.

Punt A (Chair), Furness R, Parma AM, Plagányi-Lloyd E, Sanchirico J, Trathan P. 2023. Report of the international review panel regarding fishing closures adjacent to South Africa's African penguin breeding colonies and declines in the penguin population. Pretoria, South Africa.

R Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Robinson WML, Butterworth DS, Plagányi ÉE. 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.

Rosenblatt CJ, Gates RJ, Matthews SN, Peterman WE, Stricker NJ. 2021. An integrated population model to project viability of a northern bobwhite population in Ohio. *Ecosphere* 12: e03731.

Rush S, Solandt JL. 2017. Challenges on providing conservation advice for a growing network of English Marine Protected Areas. *Marine Policy* 83: 75–82.

666 Saunders SP, Cuthbert FJ, Zipkin EF. 2018. Evaluating population viability and efficacy of
667 conservation management using integrated population models. *Journal of Applied*
668 *Ecology* 55: 1380–1392.

669 Schaub M, Abadi F. 2011. Integrated population models: a novel analysis framework for
670 deeper insights into population dynamics. *Journal of Ornithology* 152: 227–237.

671 Schaub M, Kéry M. 2021. Integrated population models: Theory and ecological applications
672 with R and JAGS. Academic Press.

673 Schaub M, Ullrich B. 2021. A drop in immigration results in the extinction of a local
674 woodchat shrike population. *Animal Conservation* 24: 335–345.

675 Seddon PJ, van Heezik Y. 1991. Effects of hatching order, sibling asymmetries, and nest site
676 on survival analysis of Jackass Penguin chicks. *Auk* 108: 548–555.

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

680 Sherley RB, Barham BJ, Barham PJ, Campbell KJ, Crawford RJM, Grigg J, Horswill C,
681 McInnes A, Morris TL, Pichegru L, Steinfurth A, Weller F, Winker H, Votier SC.
682 2018. Bayesian inference reveals positive but subtle effects of experimental fishery
683 closures on marine predator demographics. *Proceedings of the Royal Society B:*
684 *Biological Sciences* 285: 20172443.

685 Sherley RB, Barham BJ, Barham PJ, Campbell KJ, Crawford RJM, Grigg J, Horswill C,
686 McInnes A, Morris TL, Pichegru L, Steinfurth A, Weller F, Winker H, Votier SC.
687 2022. Correction to ‘Bayesian inference reveals positive but subtle effects of

688 experimental fishery closures on marine predator demographics'. *Proceedings of the*
689 *Royal Society B: Biological Sciences* 289: 20212129.

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

693 Sherley RB, Burghardt T, Barham PJ, Campbell N, Cuthill IC. 2010. Spotting the difference:
694 towards fully-automated population monitoring of African penguins *Spheniscus*
695 *demersus*. *Endangered Species Research* 11: 101–111.

696 Sherley RB, Crawford RJM, de Blocq AD, Dyer BM, Geldenhuys D, Hagen C, Kemper J,
697 Makhado AB, Pichegru L, Tom D, Upfold L, Visagie J, Waller LJ, Winker H. 2020.
698 The conservation status and population decline of the African penguin deconstructed
699 in space and time. *Ecology and Evolution* 10: 8506–8516.

700 Sherley RB, Ludynia K, Dyer BM, Lamont T, Makhado AB, Roux JP, Scales KL, Underhill
701 LG, Votier SC. 2017. Metapopulation Tracking Juvenile Penguins Reveals an
702 Ecosystem-wide Ecological Trap. *Current Biology* 27: 563–568.

703 Sherley RB, Makhado AB, Crawford RJM, Hagen C, Kemper J, Ludynia K, Masotla MJ,
704 McInnes A, Pichegru L, Tom D, Upfold L, Waller LJ. 2024. The African Penguin
705 Spheniscus demersus should be considered Critically Endangered. *Ostrich* 95(3): 0–0.

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

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

713 Stander N, Klusener R. 2020. African Penguins. In: Hand-Rearing Birds. R.S. Duerr RS,
714 Gage LJ (eds), Wiley, pp 219–236.

715 Sydeman WJ, Hunt GL, Pikitch EK, Parrish JK, Piatt JF, Boersma PD, Kaufman L, Anderson
716 DW, Thompson SA, Sherley RB. 2021. Food for Thought: South Africa's
717 experimental fisheries closures and recovery of the endangered African penguin. *ICES*
718 *Journal of Marine Science* 78(10): 1–6.

719 Sydeman WJ, Hunt GL, Pikitch EK, Parrish JK, Piatt JF, Boersma PD, Kaufman L, Anderson
720 DW, Thompson SA, Sherley RB. 2022. African Penguins and Localized Fisheries
721 Management: Response to Butterworth and Ross-Gillespie. *ICES Journal of Marine*
722 *Science* 79: 1972–1978

723 Whittington P, Klages N, Crawford RJM, Wolfaardt A, Kemper J. 2005a. Age at first
724 breeding of the African Penguin. *Ostrich* 76: 14–20.

725 Williams AJ, Cooper J. 1984. Aspects of the breeding biology of the Jackass Penguin
726 Spheniscus demersus. In: Proceedings of the 5th Pan-African Ornithological
727 Congress. Ledger JA (ed) Southern African Ornithological Society, Johannesburg,
728 South Africa, pp 841–853.

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

732 Wolfaardt AC, Underhill LG, Crawford RJM, Klages NTW. 2001. Results of the 2001 census
733 of African Penguins *Spheniscus Demersus* in South Africa: First measures of the
734 impact of the treasure oil spill on the breeding population. *Transactions of the Royal*
735 *Society of South Africa* 56: 45–49.

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739 TABLES

740

741 **Table 1.** Potential management interventions for the African penguin as modelled in the
742 IPM-BPVA. Populations at each location were projected 13 years into the future (from the
743 end of the current dataset), under five alternate management scenarios: 1) no fishing closures;
744 2) small-scale fishing closures at all colonies; 3) wider fishing closures (targeting important
745 foraging areas used by juveniles, immatures and non-breeding penguins) with no small-scale
746 closures at breeding sites; 4) wider fishing closures in combination with small-scale closures
747 at breeding sites; and 5) wider seasonal fishing closures only affecting adult survival, in
748 combination with small-scale closures at breeding sites. For scenarios one and two, effects on
749 penguin demographic rates were modelled using priors derived from data collected during
750 years when colonies were either 'open' or 'closed' to fishing, or altered directly using effect
751 sizes based on the published impact of closures in Sherley *et al*. (2018, 2022). The effect of
752 wider fishing closures on penguin survival was based on published values in Robinson *et al.*
753 (2015).

Management intervention	**Description of modelling approach in IPM-BPVA for population projections**
Scenario 1: No fishing closures	Robben Island: Fishing closures at Robben Island effect chick survival and chick condition (which in turn influences juvenile survival). Mean chick survival from 'open' years used to derive estimates of fecundity from 'open' years used in state space population model. Stony Point: no change in chick survival estimates used, as no island closures at Stony Point previously. 'Elsewhere': Fishing closures at Dassen Island impact chick survival but not chick condition. Chick survival from 'open' years at Dassen Island used to derive estimates of fecundity.
Scenario 2: Small-scale fishing closures at all sites	Robben Island: Fishing closures at Robben Island effect chick survival and chick condition (which in turn influences juvenile survival). Mean chick survival from 'closed' years used to derive estimates of fecundity. In the state space population model, mean juvenile survival is modified by the relationship between increased chick condition and juvenile survival.

	Stony Point: Fishing closures assumed to have same impact as at Robben Island. Chick survival modified by increasing by 10% (following published effect size of closures, as no direct data to use). In the state space population model, mean juvenile survival is modified by the relationship between increased chick condition and juvenile survival. 'Elsewhere': Fishing closures at Dassen Island impact chick survival but not chick condition. Chick survival from 'closed' years at Dassen Island used to derive estimates of fecundity.
Scenario 3: Wider seasonal fishing closures – no small-scale closures at breeding sites	Juvenile, immature and adult survival increased by 3.1%. Uncertainty in effect size accounted for by specifying a prior for the increase in survival, drawn from a normal distribution. Effect of small-scale closures at breeding sites modelled as per scenario 1.
Scenario 4: Wider seasonal fishing closures (affecting survival of all age classes) – in combination with small-scale closures at breeding sites	Juvenile, immature and adult survival increased by 3.1%. Uncertainty in effect size accounted for by specifying a prior for the increase in survival, drawn from a normal distribution. Effect of small-scale closures at breeding sites modelled as per scenario 2.
Scenario 5: Wider seasonal fishing closures (affecting only adult survival) – in combination with small-scale closures at breeding sites	Adult survival increased by 3.1%. Uncertainty in effect size accounted for by specifying a prior for the increase in survival, drawn from a normal distribution. Effect of small-scale closures at breeding sites modelled as per scenario 2.

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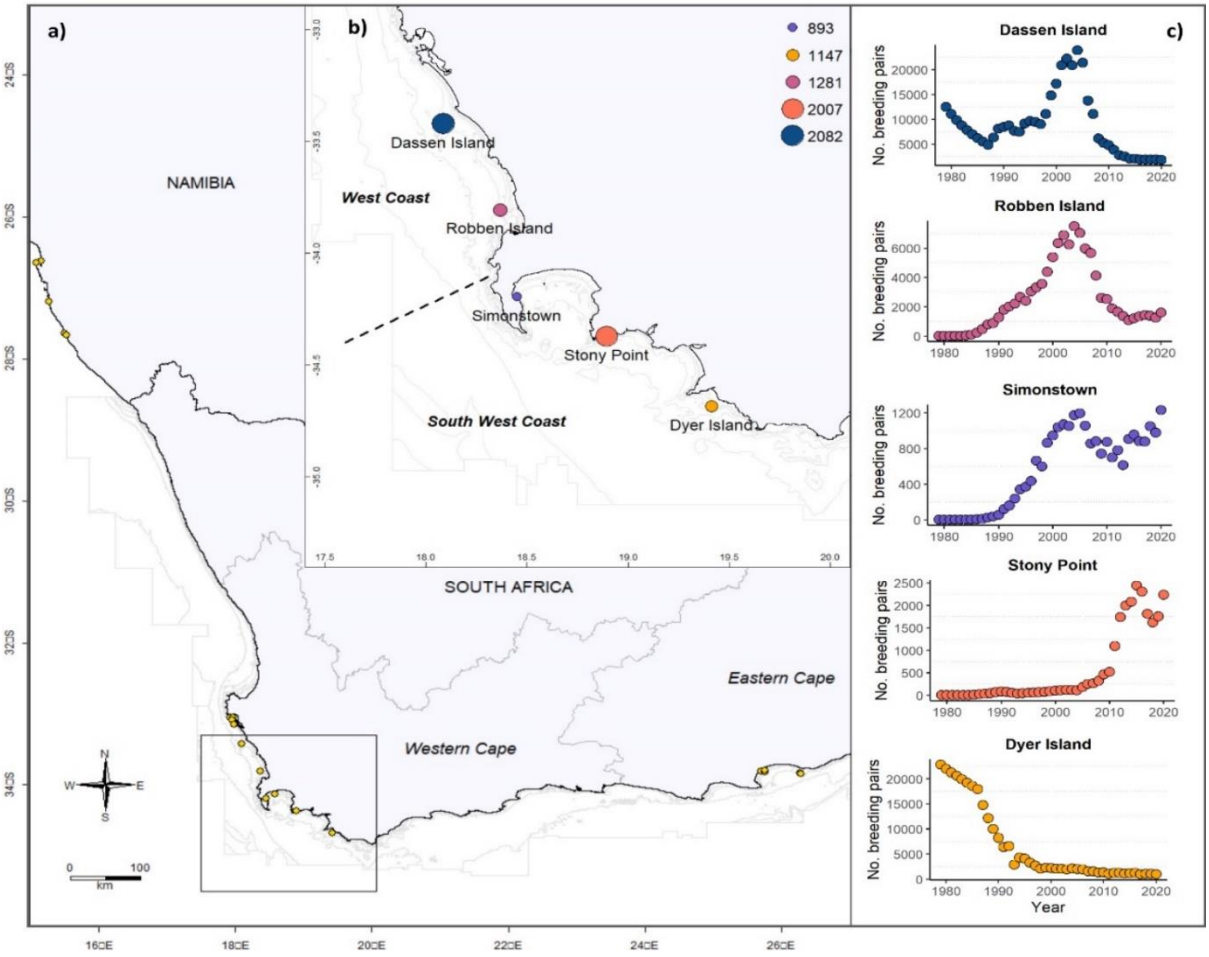
Table 2. Comparison of projected population size, % change in population size (2020-2033) and probability of having a smaller population size in 2035 compared to 2020 at Robben Island and Stony Point under the four management scenarios modelled in the IPM-BPVA: 1) no fishing closures; 2) small-scale fishing closures at all sites; 3) wider seasonal fishing closures and no small-scale closures at breeding sites; 4) wider seasonal fishing closures, in combination with small-scale closures at breeding sites; and 5) wider seasonal fishing closures only affecting adult survival, in combination with small-scale closures at breeding sites. Population sizes for 2020 are interpolated.

		Management scenario				
Location	**Estimate**	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Robben Island (2020: 1099 breeding pairs)	Projected population size 2033	808	1052	1329	1669	1574
	% change 2020-2033	-26%	-4%	+21%	+52%	+43%
	Probability population 2020 > 2033	0.76	0.56	0.54	0.54	0.54
Stony Point (2020: 1772 breeding pairs)	Projected population size 2033	1842	2199	2541	2965	2825
	% change 2020-2033	+7%	+28%	+48%	+72%	+64%
	Probability population 2020 > 2033	0.62	0.48	0.45	0.45	0.45

767 FIGURES



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769 **Figure 1.** A) Distribution of extant African penguin colonies (represented by gold circles)
770 throughout the species' breeding range. B) Location of the five focal breeding colonies in the
771 Western Cape where African penguins have been marked with passive integrated
772 transponders; circle size indicates mean population size over the study period. C) Population
773 trajectories for each of the focal colonies (Sherley *et al*. 2020). In the IPM and IPM-BPVA,
774 Dassen Island, Simon's Town and Dyer Island are grouped under 'Elsewhere'.

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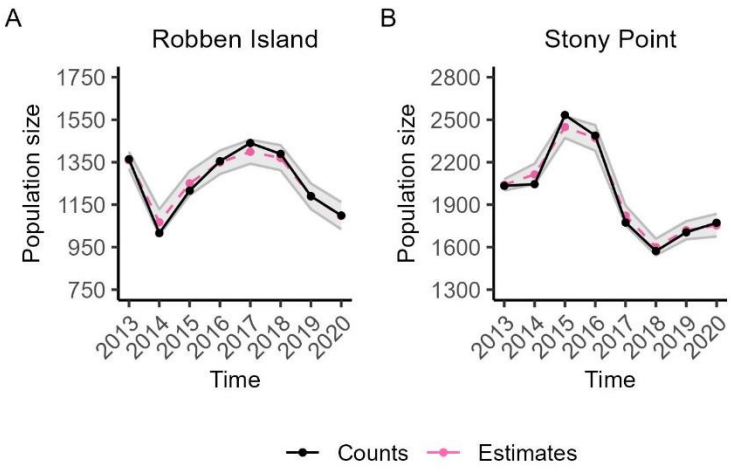

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779 **Figure 2.** Observed (black, solid lines) and estimated (pink, dashed lines) population counts
780 of African penguin breeding pairs, between 2013 and 2020 at A) Robben Island and B) Stony
781 Point. Grey shaded areas represent the 95% credible intervals for the estimated counts.

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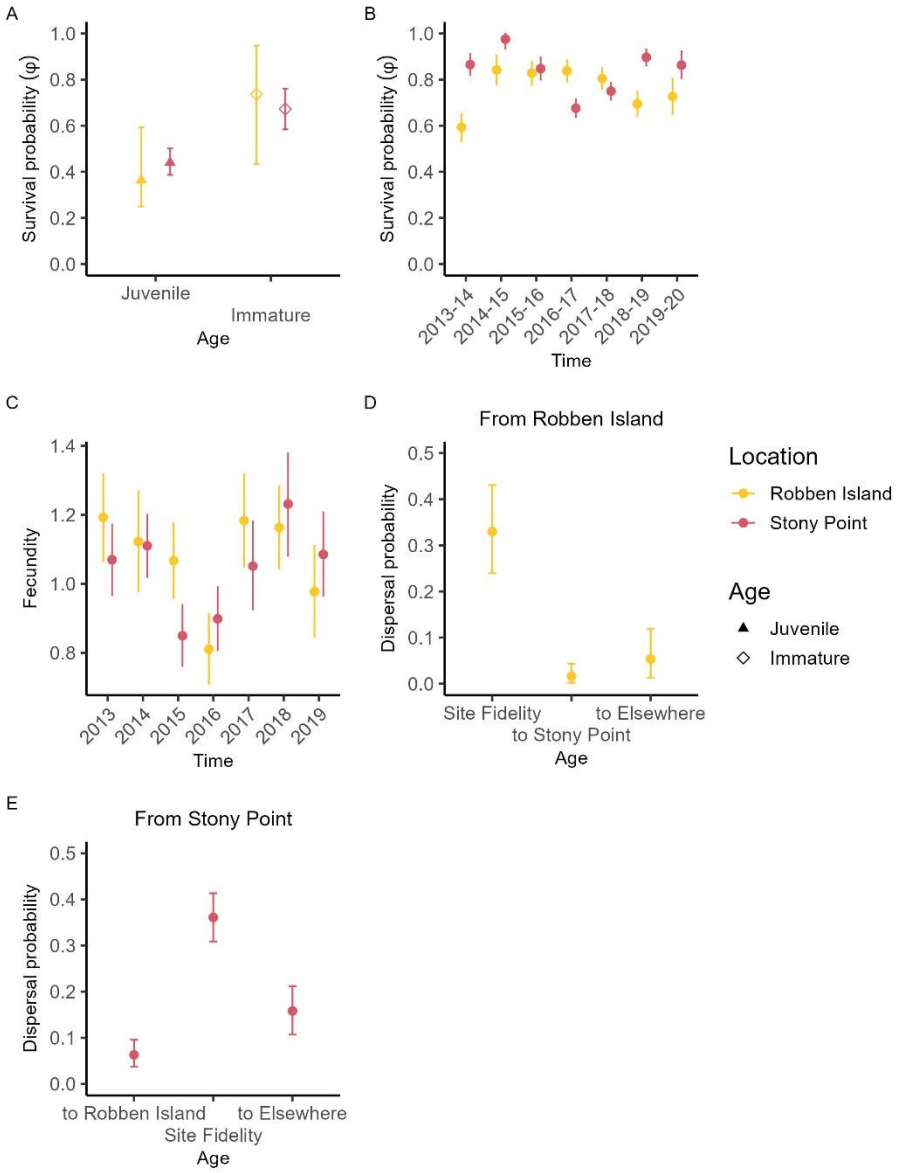

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784 **Figure 3**. Estimates of age-specific survival (A, B), fecundity (C) and natal dispersal (D, E)
785 of African penguins from: Robben Island (yellow) and Stony Point (pink) between 2013 and
786 2020, derived from the IPM. Estimates of dispersal are conditional on survival and are
787 computed as a complement to the other estimates, thus, the sum of the probabilities presented
788 ≠ 1. Error bars represent 95% credible intervals.

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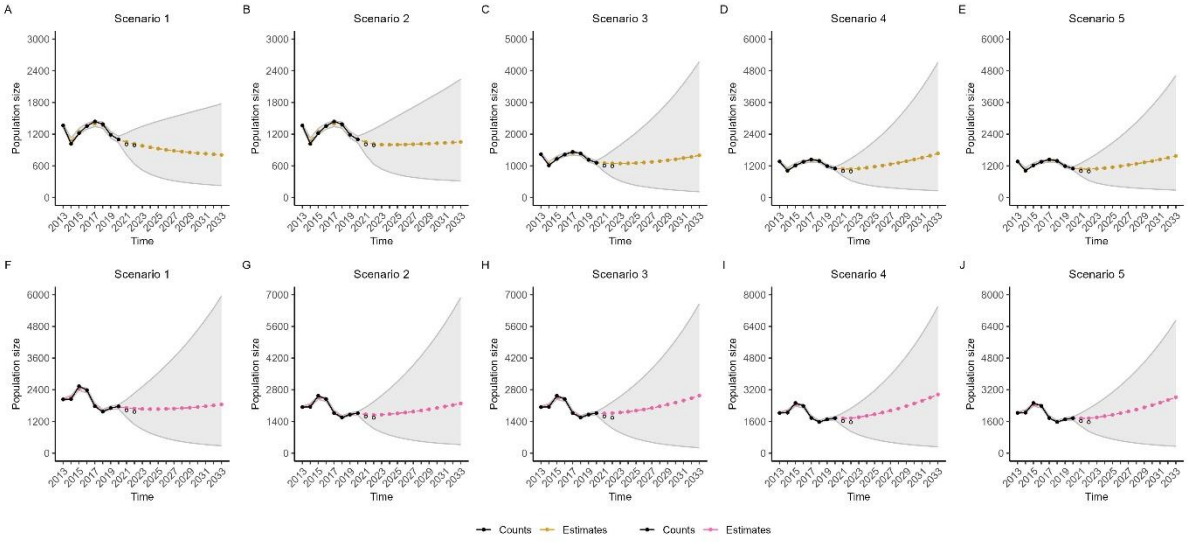
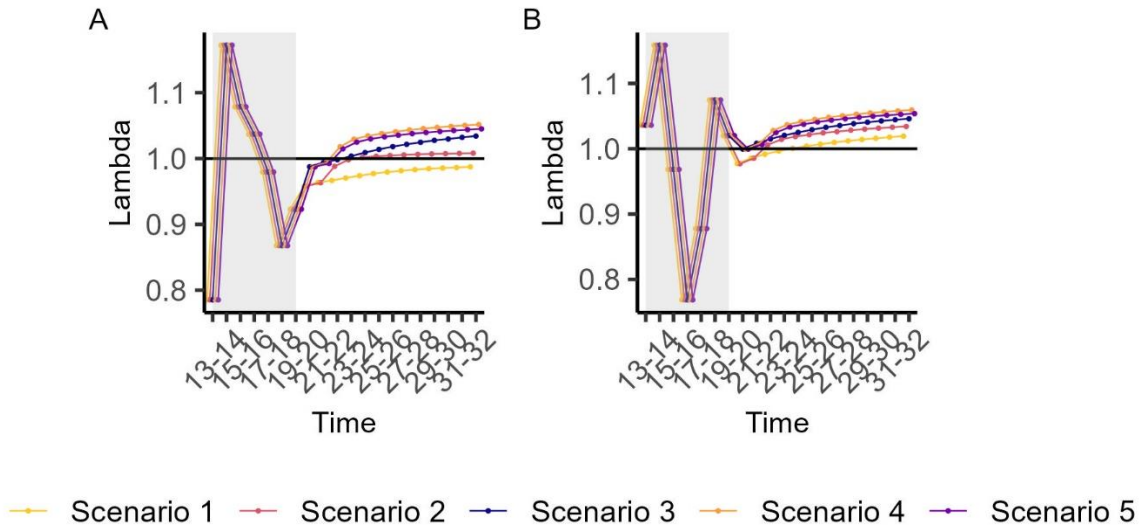


Figure 4. Observed (black circles, solid lines), estimated (coloured circles, dashed lines; years 2013-2020) and predicted (coloured circles, dashed lines, years 2021–2035) population counts of African penguin breeding pairs at Robben Island and Stony Point. Closed black circles represent population count data used in the IPM-BPVA, open black circles represent population counts for years outside of the data timeseries used in the model (from Sherley *et al.* 2024). Estimates for Robben Island are shown in yellow, while those for Stony Point are shown in pink. Populations are projected under five alternate management scenarios: 1) no fishing closures (A, F); 2) small-scale fishing closures at all sites (B, G); 3) wider seasonal fishing closures, no small-scale closures at breeding sites (C, H); 4) wider seasonal fishing closures in combination with small-scale closures at all sites (D, I); and 5) wider seasonal fishing closures only affecting adult survival, in combination with small-scale closures at breeding sites (E, J). Grey shaded areas represent the 95% credible intervals for the modelled counts.



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807 **Figure 5.** Comparison of annual population growth rates (λ_t) for the estimated African
808 penguin populations from 2013 to 2020, and the simulated populations projected 13 years
809 into the future to 2033 at: A) Robben Island and B) Stony Point. Populations were projected
810 under five alternate management scenarios: 1) no fishing closures (yellow line); 2) small-
811 scale fishing closures at all sites (pink line); 3) wider seasonal fishing closures, no small-scale
812 closures at breeding sites (blue line); 4) wider seasonal fishing closures in combination with
813 small-scale closures at all sites (orange line); and 5) wider seasonal fishing closures only
814 affecting adult survival, in combination with small-scale closures at breeding sites (purple
815 line). The single black horizontal line represents a population growth rate of 1 – where λ_t is <
816 1 this indicates population decline, and > 1 represents population growth. The shaded grey
817 area represents λ for years where the penguin populations are estimated from observed data,
818 between 2013 and 2020.

IN THE HIGH COURT OF SOUTH AFRICA
GAUTENG DIVISION, PRETORIA

Case No: 2024-029857

In the matter between:

BIRDLIFE SOUTH AFRICA	First Applicant
SOUTH AFRICAN FOUNDATION FOR THE CONSERVATION OF COASTAL BIRDS	Second Applicant
and	
THE MINISTER OF FORESTRY, FISHERIES AND THE ENVIRONMENT	First Respondent
THE DEPUTY DIRECTOR-GENERAL: FISHERIES MANAGEMENT, DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT	Second Respondent
THE DEPUTY DIRECTOR-GENERAL: OCEANS AND COASTS, DEPARTMENT OF FORESTRY, FISHERIES AND THE ENVIRONMENT	Third Respondent
THE SOUTH AFRICAN PELAGIC FISHING INDUSTRY ASSOCIATION	Fourth Respondent
EASTERN CAPE PELAGIC ASSOCIATION	Fifth Respondent

CONFIRMATORY AFFIDAVIT

I, the undersigned,

ELEANOR ASHLEY WEIDEMAN

do hereby make oath and state that:

1. I am an adult female marine ecologist and conservation biologist and the Coastal Seabird Project Manager at BirdLife South Africa (**BLSA**), the first applicant. I deposed to an expert affidavit in these proceedings which is attached to the applicants' founding affidavit as "**AM5**". My credentials appear from such affidavit.

EW

2. The facts contained in this affidavit are within my personal knowledge and belief, unless otherwise stated or as appears from the context, and are to the best of my belief both true and correct.

3. I have read the replying affidavit deposed to by **ALISTAIR MC INTYRE MC INNES** as well as the expert affidavit deposed to by **MURRAY BRIAN CHRISTIAN** and confirm that their contents are true and correct insofar as they pertain to me as well as the methods described in my expert affidavit and followed by myself, Dr McInnes, Dr Christian and the team which prepared the trade-off curves.

ELEANOR ASHLEY WEIDEMAN

The deponent has acknowledged that she knows and understands the contents of this affidavit, which was signed and sworn to before me at Cape Town on this the 13th day of **SEPTEMBER 2024**, the regulations contained in Government Notice No. R1258 of 21 July 1972, as amended, and Government Notice No. R1648 of 19 August 1977, as amended, having been complied with.

COMMISSIONER OF OATHS

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