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Bucking the trend: the African Black Oystercatcher as a recent conservation success story

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The African Black Oystercatcher *Haematopus moquini* is a charismatic, southern African near-endemic, wader species, that is often seen as a flagship species for coastal bird conservation, as it was recently down-listed regionally to Least Concern on the IUCN Red List of Threatened Species. To celebrate this rare conservation success story, BirdLife South Africa named it the 2018 Bird of the Year and ran a year-long programme in collaboration with the Nature's Valley Trust highlighting aspects of the species' biology, current threats, and conservation success. We used data collected by the Southern African Bird Atlas Project (SABAP1 and SABAP2) to examine changes in the species' range and relative abundance, both in the records between the two projects, as well as trends within the SABAP2 sampling period (2008–2017). This case study enabled us to assess whether such metrics can accurately reflect abundance and distributional changes in a species. We found increases in the reported range and the reporting rates between the two Atlas projects, and that the SABAP2 reporting rate was stable. Regionally, across four coastal categories, the reporting rate was lowest in KwaZulu-Natal, though this region also showed an increase in the probability of reporting during the SABAP2 period. While corroborating the recent change in the species' conservation status, we also provide good evidence that the long-term SABAP data can be used successfully to assess population trends and range changes over time.

Contrer la tendance: les huîtriers pies noirs africains: un exemple de réussite récente en matière de conservation

L'Huîtrier pie noir d'Afrique *Haematopus moquini* est une espèce charismatique quasi endémique d'Afrique australe, récemment classée dans la catégorie 'menacée à moindre préoccupation,' qui est souvent considérée comme une espèce phare pour la conservation des oiseaux côtiers. Pour célébrer cette rare réussite en matière de conservation, BirdLife South Africa l'a nommée 'oiseau de l'année 2018' et a mené un programme d'un an en collaboration avec le Nature's Valley Trust, soulignant les aspects de la biologie de l'espèce, les menaces actuelles et le succès de la conservation. Sur la base de l'augmentation signalée de la taille de la population et de l'aire de répartition de l'espèce, nous utilisons les données recueillies dans le cadre des projets d'atlas des oiseaux d'Afrique australe (SABAP1 et SABAP2) afin d'examiner les modifications de l'aire de répartition et de l'abondance relative, au même titre que les tendances pour la période d'échantillonnage SABAP2 (2008–2017). Cela nous permet d'évaluer si ces paramètres peuvent indiquer avec précision de tels changements chez une espèce. Nous montrons que la portée et le taux de rapport ont augmenté entre les projets de l'atlas et que le taux de rapport pour SABAP2 est globalement stable. Au niveau régional, dans quatre groupes côtiers, le taux de rapport est le plus bas dans le KwaZulu-Natal, mais cette région montre également une augmentation de la probabilité de déclaration au cours de la période SABAP2. Tout en corroborant les changements récents dans l'état de conservation de l'espèce, le présent document fournit également de bonnes preuves que l'utilisation des données d'atlas à long-terme de SABAP peut être utilisée pour évaluer les tendances de la population et les modifications de l'aire de répartition dans le temps.

Keywords: abundance, citizen science, *Haematopus moquini*, Red List Index, reporting rate, Southern African Bird Atlas Project

Introduction

Modern-day conservation success stories are sadly few and infrequent, with most recent literature on conservation typically relating a continuously poor outlook. Of all taxa, birds are perhaps the group most well-studied, best understood, and most-often used as indicators of biodiversity health (BirdLife International 2018). Long-term studies enable scientists to compare long-term trends of species to showcase how the picture changes over time, which is particularly important for assessing the impacts of climate change (Wormworth and Mallon 2006) and other anthropogenic influences (BirdLife International 2018). The global outlook for birds is concerning: at least 40% of bird

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species worldwide are in decline, with the Red List Index (RLI), compared over a 30-year period, indicating that the conservation status of most species is worsening (BirdLife International 2018). The outlook on a regional level in South Africa is very similar, with a total of 132 species in the country now listed as threatened at some level (Taylor et al. 2015; Taylor and Peacock 2018), and the number listed as Critically Endangered having increased from five to 13 since 2000 (Taylor and Peacock 2018).

In consideration of this, it is important to celebrate conservation success stories when they do occur. One recent example from southern Africa is the situation of the African Black Oystercatcher *Haematopus moquini* (family Haematopodidae). The case of this species epitomises what positive, progressive, conservation work can accomplish, while also representing how people's unregulated beach behaviour can quickly have a negative impact on breeding birds (Underhill 2014; Brown 2018a). Since 1980, the African Black Oystercatcher population has increased, reportedly by 40% (Loewenthal et al. 2015a; Taylor and Peacock 2015), and its distributional range has also increased (Brown and Hockey 2007), leading to a downgrading of the species' regional IUCN Red List assessment, from Near Threatened in 2000 to Least Concern in 2015 (Underhill 2000; Haupt 2005; Taylor et al. 2015). The main drivers of this population increase, and a rare instance of an improved Red Data assessment, appear to have been national conservation efforts, coupled with increased food availability for the birds owing to rapid spread of the invasive alien Mediterranean Mussel *Mytilus galloprovincialis* along the coastline (Hockey and van Erkom Schurink 1992; Anonymous 2004a; Robinson et al. 2005; Coleman and Hockey 2008). However, as Brown and Hockey (2007) point out, population increases of African Black Oystercatcher in some areas started to occur before the mussel spread to those areas, as well as in areas of sandy beaches where the mussel does not occur, indicating other factors are at work. Several conservation interventions have also been credited for assisting the turnaround of the species to date, most notably the nationwide ban of vehicles on beaches implemented in December 2001 (Anonymous 2004b; Williams et al. 2004; Brown 2018a, 2018b) in addition to several conservation-awareness programmes run in different parts of the country (Hockey 1997; Brown 2018a).

Citizen-science programmes have the potential to collect large volumes of standardised data, which ecologists can use to infer changes in biodiversity (Harrison et al. 2008). The bird atlas programme run in southern Africa (SABAP1 and SABAP2) uses standardised techniques to record bird data at a national level (Underhill 2016; Lee et al. 2017). The use of atlas data collected from such citizen-science programmes has become more prevalent in recent times (Harrison et al. 2008), and the development of powerful statistical tools to estimate conservation-friendly metrics now enables researchers and conservation managers to do landscape level analyses based on a large volume of freely available data (Lee and Barnard 2017; Lee et al. 2017; Lee et al. 2018). Testing the validity of these modelled metrics, however, remains understudied (Amar et al. 2016; Lee et al. 2018). Therefore, we aimed to use a comparison of SABAP1 and SABAP2 data as a case study to assess whether such data could accurately depict the recent population and range changes in the African Black Oystercatcher (Brown and Hockey 2007; Taylor et al. 2015).

Methods

Reporting rates and ranges in SABAP1 and SABAP2

SABAP1 ran from 1987–1991, while SABAP2 was initiated in 2007 and is ongoing. The sampling unit for SABAP1 is the quarter degree grid cell (QDGC), while that of SABAP2 is the pentad (five minutes of latitude by five minutes of longitude; areas of roughly 9 x 9 km2). There are 9 pentads in a QDGC, and indices of abundance (reporting rate) are usually calculated for the group of 9 pentads contained in a QDGC when comparing between the two SABAP periods. Reporting rate, a traditionally used measure of abundance, is the number of times a species has been recorded divided by the number of lists (cards) for a location (i.e. a value between 0 and 1, usually reported as a percentage). Records of a species from new areas must be justified through a vetting process to reduce errors.

We downloaded data on reporting-rate changes at the QDGC level for southern Africa, between SABAP1 and SABAP2 from the SABAP2 website (sabap2.adu.org.za) in March 2018 (Figure 1). At this time the African Black Oystercatcher had been recorded in 177 QDGCs within southern Africa. We then filtered data to include only QDGCs that had been surveyed with full protocol cards more than two times during both Atlas projects, leaving 145 QDGCs. To account for probable spatial bias in sampling effects, we then used a bootstrap approach to calculate reporting-rate change between Atlas projects, randomly sampling 50 of the QDGCs 1 000 times, and then calculating the mean reporting-rate change each time, as follows: the mean reporting rate from SABAP2 minus the mean reporting rate from SABAP1, divided by the mean reporting rate from SABAP1 + 1. This gives a value of change relative to SABAP1, with positive values indicating an increase in relative abundance, and negative values indicating a decrease (as per Lee et al. 2017).

Interannual trends in, and covariates of, the reporting rate, from SABAP2 data

We downloaded data on monthly reporting, by pentad (areas of roughly 9 x9 km^2), from the SABAP2 website in March 2018. This database contained all pentads (16 530; >250 000 cards) surveyed during the Atlas project. This was filtered to include all pentads where an individual African Black Oystercatcher had ever been recorded (363 pentads). We excluded the years 2007 and 2018, as both were incomplete in terms of annual coverage. Next, we calculated a monthly reporting rate, for each month of each year, for each of the surveyed pentads. For this, we divided the number of cards noting oystercatchers as present by the total number of cards submitted. That is, if pentad 1900_1545 had 10 cards submitted for November 2016, with the species recorded on 5 of these cards, then the reporting rate was 0.5 (or 50%). We then calculated the mean reporting rate by year, and to determine overall population trends we examined the effect of year on mean annual reporting rate through a linear model. To further explore changes in probability of reporting over time, we

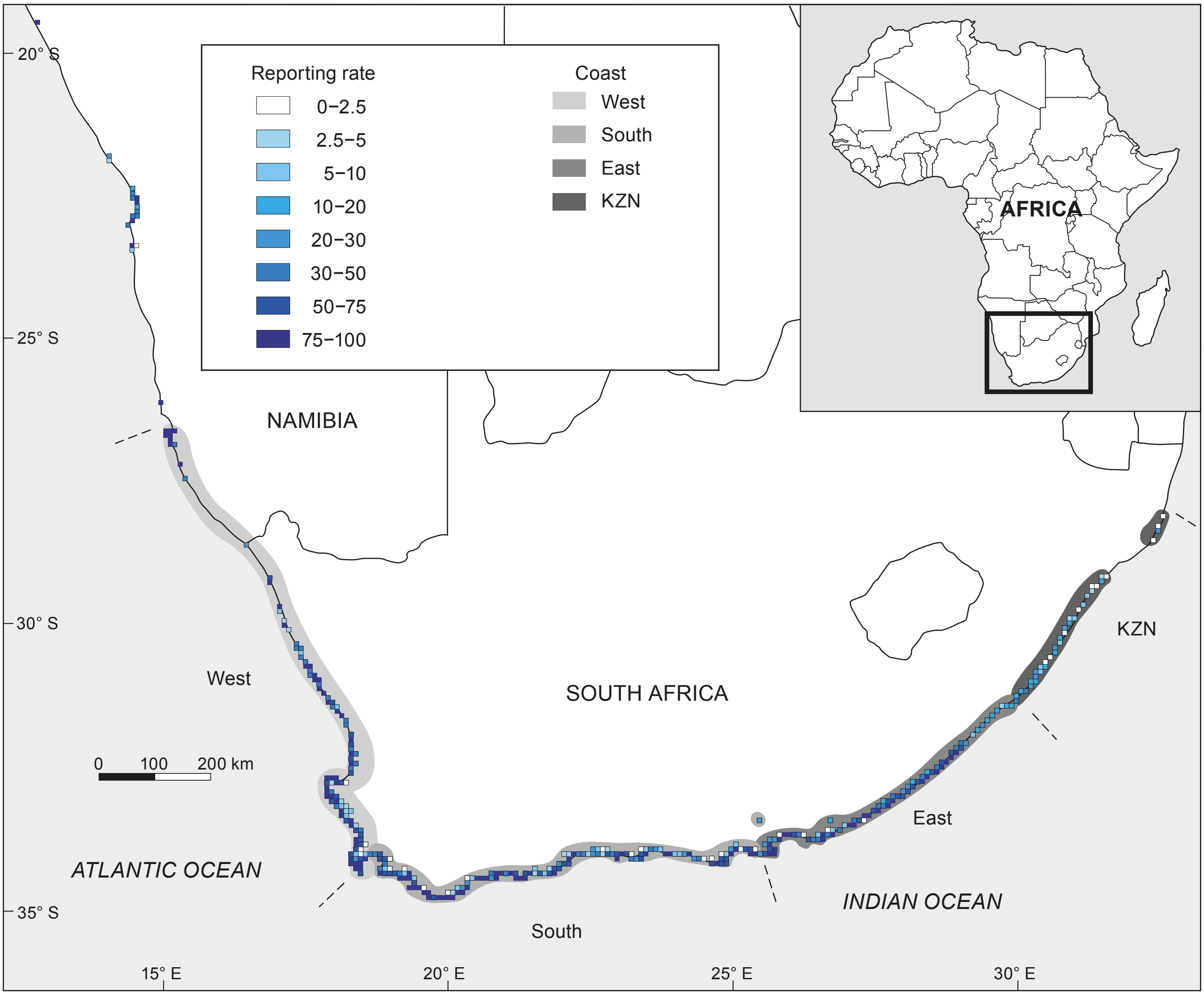

Figure 1: Map of southern Africa showing coastal areas surveyed by SABAP2 in relation to the relative abundance of African Black Oystercatcher. Reporting-rate data are from SABAP2 (2008–2017) and were divided into four coastal categories for our analysis

ran a generalised linear mixed model (GLMM) of presence/absence in a pentad, as a function of year and period (pre-2015/post-2015), with a binomial error, logit link, and number of cards in the offset, with pentad as a random effect, using the lme4 package (Bates et al. 2014), with *p*-values obtained using lmerTest (Kuznetsova et al. 2014). The period was included as there have been changes in reporting rates attributable to introduction of the BirdLasser app (Lee and Nel, unpublished data).

To examine regional trends in reporting rate over the survey period, we divided the coastline into four categories (Figure 1): West Coast (all pentads west of 18.5° E), South Coast (pentads between 18.5 and 25.5° E), East Coast (between 25.5 and 30° E), and KwaZulu-Natal (KZN) (east of 30° E). We used the glmer function from the lme4 package to specify a GLMM with a binomial error structure and a logit link. The reporting rate was the response variable (‘1’ = reported; ‘0’ = not reported), the fixed covariate effects were year and region, and we used pentad to specify random intercepts to account for repeated sampling within each pentad. We used the subset of pentads of the species’ range that had been sampled across more than four years (n = 267 pentads).

For each pentad with >4 cards we calculated the length of shoreline and what percentage could be classed as rocky or sandy, as well as whether adjacent land had a shoreline road, some form of access road, and what percentage of the available land was urbanised or used for agricultural or mining purposes. Spatial data was gathered with Google Earth Engine (Gorelick et al. 2017). Landsat 8 TOA imagery were spatially and temporally filtered, within 2017, to create images with the least cloud cover for every SABAP2 pentad where the oystercatchers have been recorded. From these filtered images, a supervised classification was conducted based on the red, green and blue composite. This resulted in coloured images of 4 categories (urban, agriculture, water and vegetation), of which the surface area was calculated. The shoreline length and type were measured from Landsat 8 imagery from Google Earth Pro. We then used beta parameters obtained for each pentad from a linear regression of reporting rate on year: positive values indicate an increasing trend in reporting rate, while negative values indicate a decreasing reporting rate. These values were normally distributed, so we created a full model of these 'trend' values and the predictor values described above. We used the 'step' function in R v3.5.2 (R Core Team 2017) to determine the best model through backward selection. To identify variables associated with reporting rate, we created a similar model, but used SABAP2 reporting rate as the dependent variable, and for which we present only the full model. Linear-modeling assumptions were tested using the gvlma package (Pena and Slate 2019).

Results

Changes in reporting rates and ranges between SABAP1 and SABAP2

Mean reporting rate for African Black Oystercatchers for the set of sites logged more than two times in each Atlas period was 34.4 ± 28.2% for SABAP2, and 29.7 ± 25.8% for SABAP1. This represents an overall increase of 4.7% in reporting rate across the whole range between the two Atlas periods. Bootstrapping of a random subset of the range gave a mean reporting-rate change between Atlas projects of 16.2% (95% CI: 13.4–19.1%), suggesting a historical overall increase in relative abundance. Oystercatchers were reported from 103 QDGCs in SABAP1, and 114 in SABAP2. For QDGCs surveyed more than two times in each project there was an increase in range of 7.5% (95% CI: 5.7–9.4%), indicating moderate range expansion.

Annual trends in reporting rate from SABAP2 data

Oystercatchers were reported from 363 pentads during SABAP2. There was no change in mean monthly reporting rate as a function of year for the species overall (linear model summary: estimate of percentage change per year = −0.05 ± 0.2, $t = -0.259$, $p = 0.8$), and no decline in the probability of reporting when accounting for pentad (−0.051 ± 0.046, $Z = -1.115$, $p = 0.265$). We identified no variables associated with trends at the pentad level: the best model dropped all predictor variables, with the exception of the presence of a shoreline road, for which reporting-rate trends were positive (0.016 ± 0.006, $t = 2.801$, $p = 0.0055$) (Table 1). This is almost certainly an observer effect: when an access road is present observers are more likely to access oystercatcher habitat, learn where the birds are, and report them. The second-best model by Akaike's information criterion (ΔAIC from best model = 2), in addition to a shoreline road, contained the proportion of agricultural land as a nonsignificant predictor. Mean reporting rate was best explained by the presence of an access road and the proportion of rocky shoreline, for which the effects were positive (Table 2). Reporting rate was significantly lower for pentads with more agricultural and urban land (Table 2).

Regional trends

The probability of reporting was lowest in KZN as compared with the other three coastal stretches (Table 3). However, whereas the probability of reporting was stable for the other coastal regions, there was a significant increase for KZN (Table 3; Figure 2).

Discussion

A comparison of data collected for SABAP1 and SABAP2 confirms both a range expansion and population increase (inferred from increases in the standardised reporting rate) for African Black Oystercatcher in recent decades, corroborating the recent regional down-listing on the IUCN Red List, from Near Threatened to Least Concern, and suggesting the SABAP data can be used to conduct such assessments accurately for species with good data coverage. The reporting rate over the last 10 years (SABAP2

Table 1: The influences of land-use and access on trends in the SABAP2 reporting rate for African Black Oystercatcher (i.e. trend determined as increasing or decreasing in a pentad). Adjusted R^2 for the best model = 0.03; df = 243. AIC = Akaike's information criterion; Estimate = variable coefficient; SE = standard error of the estimate

	Estimate	SE	*z*-value	*p*-value
	Best model (AIC = −838.1)			
Intercept	−0.01	0.004	−2.475	0.014
Shoreline road	0.016	0.006	2.801	0.006
	Second-best model (AIC = −836.2)			
Intercept	−0.011	0.005	−2.254	0.025
Shoreline road	0.016	0.006	2.808	0.005
Proportion of agricultural land	0.004	0.011	0.316	0.752
	Full model (AIC = −830.3)			
Intercept	−0.013	0.009	−1.474	0.142
Shoreline road	0.015	0.007	2.312	0.022
Access road	0.002	0.009	0.206	0.837
Proportion of urban land	−0.001	0.013	−0.057	0.955
Proportion of agricultural land	0.005	0.013	0.362	0.718
Proportion of rocky shoreline	0.001	0.008	0.147	0.884

Table 2: The influences of land-use and access on the SABAP2 reporting rate for African Black Oystercatcher. Adjusted R^2 for the best model = 0.24; df = 243. AIC = Akaike's information criterion; Estimate = variable coefficient; SE = standard error of the estimate

	Estimate	SE	*z*-value	*p*-value
Best model (AIC = 93.08)				
Intercept	0.306	0.056	5.461	<0.001*
Access road	0.260	0.050	5.160	<0.001*
Proportion of urban land	−0.246	0.083	−2.985	0.003
Proportion of agricultural land	−0.245	0.083	−2.940	0.004
Proportion of rocky shoreline	0.178	0.051	3.456	0.001*
Full model (AIC = 93.21)				
Intercept	0.303	0.056	5.419	<0.001*
Shoreline road	−0.058	0.043	−1.354	0.177
Access road	0.293	0.056	5.236	<0.001*
Proportion of urban land	−0.213	0.086	−2.474	0.014
Proportion of agricultural land	−0.231	0.084	−2.758	0.006
Proportion of rocky shoreline	0.173	0.052	3.356	<0.001*

*Significant

Table 3: Fixed-effect summary table from the model of probability of reporting as a function of year and coastal region (see Figure 1), including the interaction. Intercept is the estimate for the East Coast when year = 0 (in 2008). Estimate = variable coefficient; SE = standard error of the estimate

	Estimate	SE	*z*-value	*p*-value
Intercept	0.755	0.28	2.699	0.007
Year	−0.042	0.058	−0.725	0.469
KZN Coast	−3.175	0.472	−6.727	<0.001*
South Coast	−0.554	0.333	−1.661	0.097
West Coast	0.002	0.363	0.007	0.995
year : KZN	0.511	0.103	4.969	<0.001*
year : South	0.047	0.07	0.672	0.502
year : West	0.114	0.077	1.477	0.140

*Significant

data only) appears to have stabilised for most regions, but was increasing in KwaZulu-Natal, where ongoing range expansion of the African Black Oystercatcher was previously noted (Brown and Hockey 2007). These results substantiate a recent smaller snapshot analysis done by Lerm and Underhill (2019). Interestingly, of the various parameters tested as reporting-rate drivers, only the presence of a shoreline road positively influenced reporting-rate change significantly. This suggests that citizen scientists perhaps make use of well-known easy-to-access road points to record African Black Oystercatcher on their Atlas cards. The reporting rate was negatively affected by the presence of agricultural land and urban areas, confirming the sensitivity of the species to human influences.

These results are in stark contrast to similar comparisons for other species in southern Africa using citizen-science data, which revealed declining populations, range contractions, and an urgent need to reassess the current conservation status of several species (Amar et al. 2016; Lee et al. 2017). The current research accomplishes two goals. First, it provides more evidence on the usefulness of recently developed statistical approaches to comparing data from large-scale citizen-science programmes for use in conservation biology (Lee et al. 2017), showcasing the validity of such data when compared to independent analysis of a species' conservation status (Taylor and Peacock 2015). Specifically, the latest population estimate of 6 700 adults (Loewenthal et al. 2015a; Taylor and Peacock 2015) is 40% higher than the 4 781 birds estimated by Hockey (1983), which led to the down-listing of the African Black Oystercatcher. Second, the results highlight the conservation success story of the African Black Oystercatcher, a much-needed example in light of population declines for many other species.

As mentioned earlier, the increasing range and population of African Black Oystercatcher are probably attributable to an array of influences. This clearly includes South Africa's ban on vehicles on beaches (Williams et al. 2004), the increased available food supply for oystercatchers as a result of the spread of the invasive Mediterranean Mussel *Mytilus galloprovincialis* (Hockey and van Erkom Schurink 1992; Robinson et al. 2005; Coleman and Hockey 2008), and regional and national species-specific conservation efforts aimed at reducing impacts on the species, especially during the breeding season (Hockey 1997; Brown 2018a). Of these, the latter are ongoing and address the continuing threats to the species.

Although our results show positive increases in the reporting rate and range for African Black Oystercatcher, it is unknown how much of this might be an outcome of increased breeding success across the species' entire range, or whether some sites show increased presence but are not necessarily self-sustaining populations. For example, Vernon (2004) speculated that a large population increase along the coastline at East London (East Coast) is probably due to immigration rather than to improved local breeding. Both mainland and island populations appear to be increasing (Lowenthal et al. 2015a) though there is speculation that mainland populations are artificially boosted by island overflow rather than improved breeding at mainland sites (Loewenthal et al. 2015b), but this remains to be confirmed.

Ongoing threats to the African Black Oystercatcher still occur and vary between different areas. For example, island-breeding populations are affected by unnatural

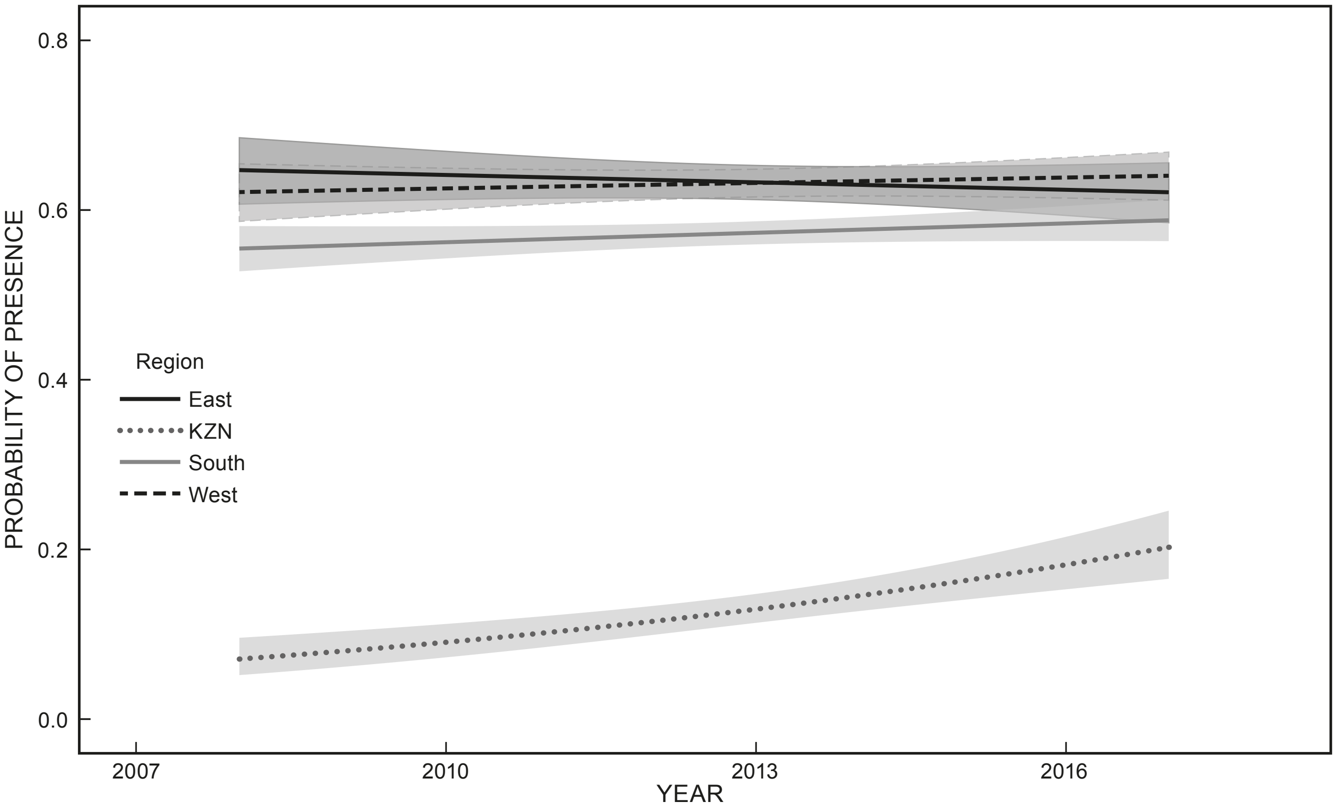

Figure 2: Probability of reporting of African Black Oystercatchers across the SABAP2 period 2008–2017, in four different coastal regions of southern Africa (see Figure 1). Lines are logistic probability curves, with shading representing the 95% confidence interval

predation in some cases (for example, by cats on Robben Island off the West Coast: Tjørve and Underhill 2008), and breeding populations close to high-density urban areas are still negatively influenced when nesting by high rates of disturbance by people and companion animals (Van de Voorde et al. 2015; Loewenthal et al. 2016; Brown 2018b, 2018c). Our analysis of the reporting rate shows that this measure of abundance is lower in relation to increasing areas of urbanized and agricultural lands. Current conservation efforts are finding out that ongoing education, improved signage, and constant engagement with the public trough social media can lead to improved breeding at localised sites for beach-breeding birds (Brown 2018d, 2018e).

Conclusions

This work confirms a steady increase in the population size of the African Black Oystercatcher and indicates that the species' eastern range expansion and population increase are ongoing. The findings justify the recent regional downgrading of the species' IUCN Red List status to Least Concern. Overall, this coastal bird provides a good example of a recent conservation success story. Furthermore, the findings validate the use of citizen-science data for conservation planning.

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