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Long-term trends from Citizen Scientists: 24 years of breeding success data of African Oystercatchers *Haematopus moquini* in the Garden Route

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Long-term data on breeding success in beach-nesting birds in southern Africa are scarce. Citizen science projects have risen to the forefront of large dataset collection efforts globally, with several local projects helping us unpack long-term trends for species in southern Africa. A long-term monitoring project on African Oystercatcher *Haematopus moquini* breeding success in parts of the Garden Route on the south coast, conducted by the Lakes Bird Club, enables us to determine whether conservation efforts are positively influencing the species there. Since the onset of the study in 1997/1998, there has been a steady increase in the number of breeding pairs at Knysna and Sedgefield, but not at Brenton-on-Sea. A similar increase in hatching success is recorded, with an overall increase in the number of fledglings per adult pair over the area throughout the study. Collectively, this indicates that some local and national conservation efforts, such as the beach driving ban and awareness campaigns like #ShareTheShores, have been successful, leading to positive trends in these parameters for this species. This article highlights the usefulness of long-term datasets for corroborating outcomes from other large datasets, like the Southern African Bird Atlas Project 2.

Études à long terme grâce aux citoyens scientifiques: 24 ans de données sur le succès de la reproduction de l'Huîtrier de Moquin *Haematopus moquini* sur la Garden Route, Sud Afrika

Les ensembles de données à long-terme sur le succès de la reproduction des oiseaux se reproduisant sur les plages d'Afrique australe sont rares. Au niveau mondial, les projets de science citoyenne se sont hissés au premier plan de la collecte de données à grande échelle, avec plusieurs projets locaux permettant identifier les tendances à long terme pour des espèces d'Afrique australe. Un projet de suivi à long terme du succès de la reproduction de l'Huîtrier de Moquin *Haematopus moquini* dans certaines parties de la Garden Route, mené par le Lakes Bird Club, nous permet de déterminer si les efforts de conservation ont une influence positive sur l'espèce. Depuis le début de l'étude en 1997/1998, il y a eu une augmentation constante du nombre de couples reproducteurs à Knysna et Sedgefield, mais pas à Brenton-on-Sea. Une augmentation similaire du taux d'éclosion et du succès de la reproduction est enregistrée, avec une augmentation globale du nombre de jeunes par couple au cours de la période de l'étude. Collectivement, cela indique que les efforts de conservation locaux et nationaux, tels que l'interdiction de conduire sur les plages et les campagnes de sensibilisation comme #ShareTheShores, ont bien succédé, conduisant à des tendances positives dans ces paramètres de la reproduction de l'espèce. Cet article souligne l'utilité des ensembles de données à long terme pour corroborer les résultats d'autres ensembles de données, comme le Southern African Bird Atlas Project 2.

Keywords: breeding pairs, Brenton-on-Sea, coastal birds, hatchlings, fledglings, Knysna Lagoon, Lakes Bird Club, Sedgefield

Introduction

Coastal regions are rich in biodiversity but are also subject to increasing pressures from expanding human settlement, resulting in a disturbance-prone environment, with conflicting needs for conservation and recreation. Shore-breeding birds are a good indicator of the quality of coastal areas (Hockey 1983). The southern African endemic African Oystercatcher *Haematopus moquini* (family Haematopodidae) is one such species that nests along the offshore islands and mainland of the southern African coastline. Over the last two decades real strides have been made towards protecting the coastline and its shore-breeding bird species in South Africa. Since 2000 there has been a nationwide ban on off-road vehicles on South African beaches (Anonymous 2004; DEAT 2004), leading to improvement in the breeding success of the African Oystercatcher (Williams et al. 2004). Additionally, the proliferation of the alien invasive black mussel *Mytilus galloprovincialis* along the coast has greatly benefitted the species by increasing its food supply (Hockey and van Erkom Schurink 1992). These factors

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have allowed the range of the African Oystercatcher to expand (Brown and Hockey 2007), while the general reporting rate has increased (Brown et al. 2019), leading to the species being seen as a modern-day conservation success story. Sadly, despite these conservation efforts and success with the African Oystercatcher, other coastal bird communities appear to still be in decline in South Africa. Migrant waders from the families Scolopacidae (Sandpipers) and Charadriidae (Plovers) have seen the greatest decreases (Ryan 2013), with a more than 50% reduction in numbers and up to 93% reduction in some species (i.e. the Sanderling *Calidris alba* and Curlew Sandpiper *C. ferruginea*); as another example, the common White-fronted Plover *Charadrius marginatus* decreased by 37% over 30 years.

The African Oystercatcher is a rare example of a recent conservation success story (Brown et al. 2019); between 1979/80 and 2020/2021 its population is estimated to have increased by 37% to ~6 700 individuals (Taylor et al. 2015) and its distribution has expanded, while the reporting rate has increased in recent years (Brown and Hockey 2007; Brown et al. 2019). Summers and Cooper (1977) identified two direct threats to the survival of African Oystercatchers: human disturbance, especially through off-road vehicles in nesting areas, and the introduction of mammal predators (predominantly on islands). Unintentional destruction of nests by beach walkers happens frequently, together with chicks being killed by dogs (Jeffrey 1987; Leseberg et al. 2000; Loewenthal et al. 2016). Such disturbance affects different beach-nesting birds differently but is known to have a high impact on African Oystercatchers (Brown et al. 2019). Another growing concern is human overexploitation of coastal resources, like intertidal invertebrates for food and bait (Hockey 1983). Oystercatchers, like other ground-nesting birds, also experience indirect pressures on their breeding success, including the death of unattended chicks and eggs through exposure to heat under summer sun (Webb 1987; Adams et al. 1999; Brown and Downs 2003; Brown and Brown 2004; Van de Voorde et al. 2015). Such pressures, direct and indirect, are suggested to increase with expanding human use of the coast (Watson and Kerley 1995).

Globally, there is an unfortunate paucity of long-term data on breeding success in birds. Longer-term data importantly improve our understanding of dynamic systems that function over a large scale, where trends are often unclear in shorter time-frames. Citizen science is proven to be a successful approach for overcoming the challenges of maintaining long-term and large-scale studies.

Citizen scientists are volunteers, in most instances with little or no science background, who participate in scientific studies as field assistants, by monitoring plants or animals or other environmental parameters, with no compensation (Cohn 2008; Tulloch et al. 2013). These volunteers often collect the data on which scientific studies are based. Dating back to the early 1700s, most scientists started off as citizen scientists, before science became a paid profession (Silvertown 2009). The earliest record of modern citizen science is most likely the annual Christmas Bird Count, run by the National Audubon Society in the United States since 1900 (Dickinson 2007; Silvertown 2009). Citizen science has since become more refined, with most citizen scientists working with professional institutions on projects that have been designed and adapted with the layperson in mind (Silvertown 2009). In addition, applications of data sourced from citizen scientists are growing and include large-scale conservation planning (Barnard et al. 2017). Citizen science has increased the scale of ecological research and bridged the gap between the public and scientists (Nadkarni and Stevenson 2009; Dickinson et al. 2010). The prevalence of citizen science-based programmes has been on the rise for some time, especially given the ease of access to contribute through technology (Tulloch et al. 2013). These programmes allow for deeper public engagement with nature, instil greater appreciation for the environment, promote scientific thinking and improve data-collection skills (Cooper et al. 2007; Tulloch et al. 2013). In the South African context, citizen science projects have long been appreciated as a valuable tool for professional biologists, and as having a positive influence on the citizen scientists themselves (Wright et al. 2015). Within the first decade of its completion, the first Southern African Bird Atlas Project (SABAP), which had contributions from over 5 000 citizen scientists, resulted in over 50 research publications and at least eight MSc or PhD degrees completed (Harrison et al. 2008). Such datasets can be extremely powerful and unrivalled when looking at large systems from the perspective of conservation and broader biodiversity (Brooks et al. 2022). Since the inception of SABAP2 in 2007, even more papers have been produced, with some studies applying recorded changes in distribution patterns over time to facilitate better conservation planning (e.g. Hoffmeyr et al. 2014; Lee et al. 2017; Brown et al. 2019).

The Lakes Bird Club, an affiliate of BirdLife South Africa, has operated in the Garden Route vicinity on the south coast of South Africa for over 30 years; contributions by its members have produced an impressive dataset on breeding success in the African Oystercatcher, spanning 24 years, across three study areas. This article presents results from this citizen science project.

Materials and methods

The initial survey was instigated by The Lakes Bird Club chairman Norman Elwell, following suggestions by the late Professor Phil Hockey, director of the FitzPatrick Institute of African Ornithology, Cape Town, and members of the club. Monitoring of African Oystercatcher nests commenced during the breeding season in the summer of 1997/1998, with monitoring in three sections of coastline, at Sedgefield, Knysna and Brenton-on-Sea, occurring each year since then (Figure 1). The sites were chosen for their presence of African Oystercatcher breeding pairs and their accessibility, as well as for being representative of each of the three coastal sections. The same methods were used consistently in each area over the 24-year study period (1997/1998–2020/2021). Accordingly, the results (both per site and collectively) could be consistently compared over the 24 seasons. Observations noted on each patrol were transcribed to a report of the day's activities. At the end of the breeding season, team leaders wrote a summary for

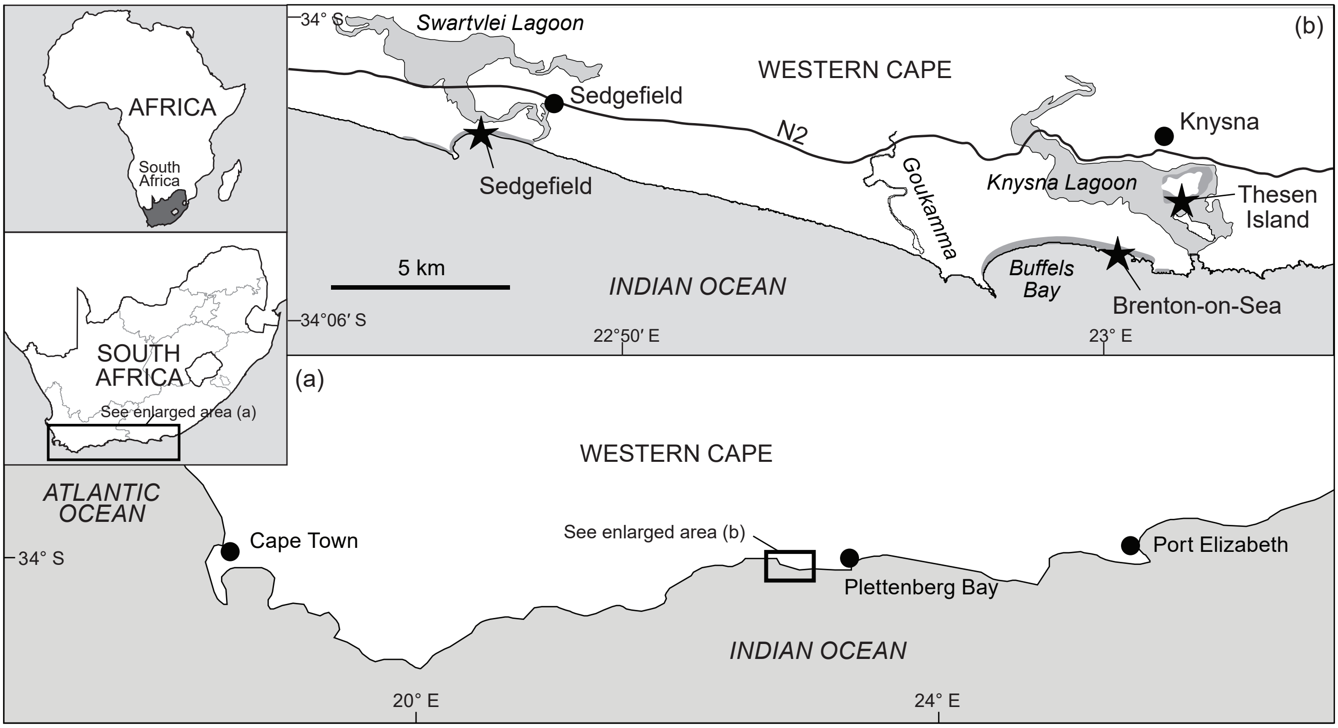

Figure 1: Map showing the south coast of South Africa where the monitoring of breeding success in African Oystercatchers *Haematopus moquinii* took place across 24 years at three study sites: Brenton-on-Sea, Sedgefield and Thesen Island in Knysna

each area, and then a consolidated report was compiled and distributed as an annual report.

The number of nesting pairs varied greatly at each site over the 24 years: Sedgefield ranged from 6–16 breeding pairs (average 10 pairs); Brenton-on-Sea had the fewest number at 2–9 pairs (average 3.8 pairs); and Knysna Lagoon had the highest number at 8–28 pairs (average 15.5 pairs).

Study sites

Sedgefield

The Sedgefield survey area covers ~6 km along the coast, stretching westwards from the Swartvlei Estuary, past the Swartvlei bathing beach, on to Gericke's Point and ~2 km beyond that towards Kleinkrantz. This coastal area falls within the jurisdiction of South African National Parks (SANParks), with strict regulations concerning dogs on beaches and no 4 × 4 vehicle access close to the shoreline. This area comprises two sections of beach. One section is a 2-km stretch between the Swartvlei Estuary and the Swartvlei beach carpark, which consists of a wide beach backed by vegetated dunes. There is no rocky substrate along the shore here, but some debris, such as tree remains brought down by the river, offer cover for any oystercatcher chicks. The other section is a 3.7-km stretch between the Swartvlei beach car park and Journey's End Rocks, with a narrow beach backed by a high (~100 m) sandstone cliff. A wide tidal rock shelf supports mussels (both *Perna perna* and *Mytilus galloprovincialis*) and limpets—but only at the seaward edge where the shelf falls away suddenly. The sand is blown and washed from the beach, which in turn receives sand from the erosion and occasional collapse of the cliff. At spring high tides, the sea reaches the base of the cliff in parts. Gericke's Point (~30 m high) stands clear of the beach and is inaccessible at high tide, as a fast-flowing channel forms between the rocks and beach on the cliff side of the pinnacle. Because of this, patrols in this area were made at low tide (unless there was reason to go at other times, such as to record hatching eggs or to check the status of chicks). Scattered rocks at the base of the cliff and along the beach are found throughout this section, which provide good shelter for any newly hatched chicks to hide. At various heights on the cliff face there are numerous sand shelves used by nesting Kelp Gulls *Larus dominicanus*, Cape Cormorants *Phalacrocorax capensis* and a few African Oystercatchers.

Knysna Lagoon (Thesen Island mudflats)

The Knysna Lagoon is an estuary extending ~12 km inland from the sea to the headlands of two peninsulas (called the Knysna Heads) that partly enclose the estuary mouth. The opening to the sea is relatively narrow: when an off-sea wind corresponds with a spring high tide, a 'pump' effect at the opening can result in a rapid and abnormally high tide in the lagoon. This can inundate bird nests on the mudflats. There are two islands in the lagoon, Thesen Island and Leisure Isle, both connected to the mainland by causeways.

Mudflats, grasses and salt marshes surround much of the lagoon and the two islands. On Thesen Island, access to the mudflats surrounding the island is rigorously controlled by the Thesen Island Homeowners Association under SANParks guidelines. Consequently, access to the salt marshes is efficiently managed and human and other disturbances are thus strictly precluded. Two predominant geographical features here are used by African Oystercatchers for breeding: natural levees of slightly higher ground on the perimeter of the mudflats surrounding the island, and manmade berms closer to the housing, which were built by the developers. The majority of African Oystercatchers nests are found on both of these features, as these provide appropriate nesting sites, food and cover for these birds and other waders. Knysna Estuary is vulnerable to flooding and silting from the Knysna River as well as debris and pollution from channels and gutters leading down from the town. All these factors affect African Oystercatchers and their breeding. Therefore, the specific site monitored for the current study was the Thesen Island mudflats.

Brenton-on-Sea

Brenton-on-Sea, south of Knysna and the Knysna Lagoon, and situated on the sea, is a popular holiday area consisting of many houses, most of which are used only in the December/January vacation period. The bathing beach is small. A large rock called Castle Rock is situated right next to the bathing beach, where one breeding pair usually has a nest. Beyond this the beach extends westwards to Buffalo Bay, the Goukamma River mouth and the Goukamma Nature Reserve. This beach area is backed by dunes. Another breeding pair usually nests in the dunes ~1 km from Castle Rock. The coastline eastwards towards the Knysna Heads is rocky with a few small sandy bays flanked by large rocky promontories, which are popular angling spots. Typically, two breeding pairs can be found on one of these rocks, called Die Blokke.

Conservation initiatives

To our knowledge there were no real changes in terms of hands-on conservation efforts at each site, either by management authorities or nongovernmental organisations, during the study period. The beach driving ban which came into effect in 2000 will have affected two of the three sites (Brenton-on-Sea and Sedgefield, but not Knysna). Past conservation efforts include the Oystercatcher Conservation Programme initiated in 1998 by the late Prof Phil Hockey at the Fitzpatrick Institute for African Ornithology, which aimed in part to increase public awareness of African Oystercatchers and their conservation. In addition, the eradication of feral cats from some islands has likely allowed growth in the population of birds, with their numbers possibly spilling over to the mainland (Loewenthal et al. 2015). More recently, the #ShareTheShores programme was initiated by the Nature's Valley Trust in the summer of 2016/2017 in the greater Plettenberg Bay region, and subsequently extended to Port Elizabeth/Gqeberha, Witsand, the Overberg region and Scarborough. Programme actions included making available locally relevant beach information boards, signage and rope fences to protect nests, zoning beaches for dogs (on leash, off-leash and no dog zones), education work and the development of strong, positive social media campaigns. BirdLife South Africa also chose the African Black Oystercatcher as Bird of the Year in 2018, with an intensive education and awareness campaign around the species and its conservation rolled out.

Data collection

Lakes Bird Club volunteers conducted regular surveys at all three study areas throughout each breeding season. Monitoring was consistently done every two weeks from November to April at all sites. Specific egg-laying dates and hatching dates were not known since monitoring was only done every two weeks, and success was noted only when chicks were observed with their parents. Located nests were monitored for hatching and fledging success, and where possible additional visits were done with a SAFRING registered bird ringer to ring chicks. African Oystercatchers are known to remove all the egg remains and traces thereof directly after hatching has taken place. When monitoring nests that were active during prior weeks and no egg remains are visible, we assumed that it had successfully hatched and recorded it as such. This was followed up by continued monitoring of the chicks until fledging. We recorded occasions where eggs were left in the nest consistently for more than three weeks after the initial 5-week period, and these were recorded as failed hatching. Other instances noted included eggs that had been destroyed (for instance by a predator, accidently or inclement weather), which was also recorded as a failed hatching.

For each season, we report the following parameters for each site and for overall monitoring: 1) mean number of eggs per pair; 2) mean number of hatchlings per pair; 3) mean number of surviving fledglings per pair; and 4) the overall mean breeding success per pair (number of fledglings per number of eggs produced by a breeding pair). Assumptions were made in some instances: for example, if a nest scrape was inaccessible but a bird was observed sitting for lengthy periods, we assumed it was incubating, and we further assumed these individuals had an average clutch size of two.

Statistical analysis

All statistical analyses were performed using R statistical software (R Core Team 2021). To determine whether there were significant differences in breeding success and the number of fledglings per pair among the three study areas, we conducted an analysis of variance (ANOVA), followed by pairwise comparisons using the Tukey method. We also used Poisson backward stepwise regression analysis to examine trends in the number of breeding pairs and fledglings per breeding pair over time. In these regression models the response variables were either breeding success or number of fledgelings per pair, and as the starting explanatory variables the interaction between breeding season (year) and the sites. The significance level was set at $p < 0.05$ for all analyses.

Results

Both the Sedgefield and Knysna study sites had a steady increase in the numbers of breeding pairs present over the course of the 24 years of monitoring, while the Brenton-on-Sea site saw no change in numbers (Figure 2). In addition, hatching success, which varied between years, showed an overall increase over time for both Sedgefield and Knysna, with no change overall for Brenton-on-Sea (Figure 3). Our two regression models both showed that only Year (breeding season) significantly contributed positively towards breeding success ($p < 0.001$) and fledglings per year ($p = 0.014$).

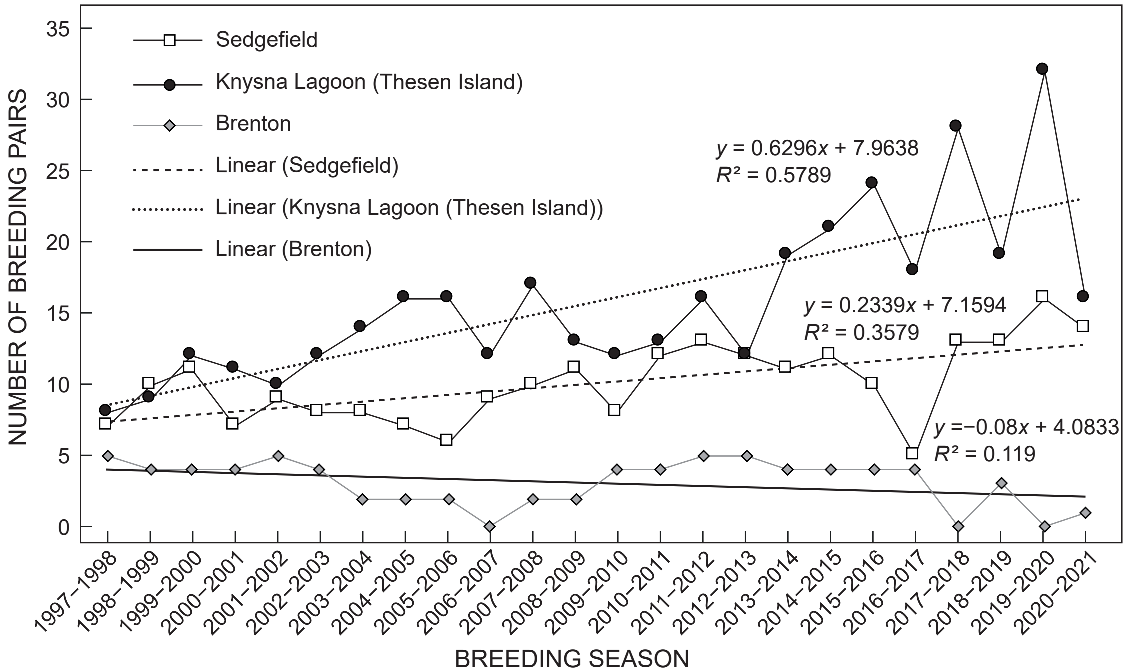

Figure 2: Number of African Oystercatcher *Haemantopus moquinii* breeding pairs recorded for each breeding season from 1997 to 2021 at three study sites on the south coast of South Africa

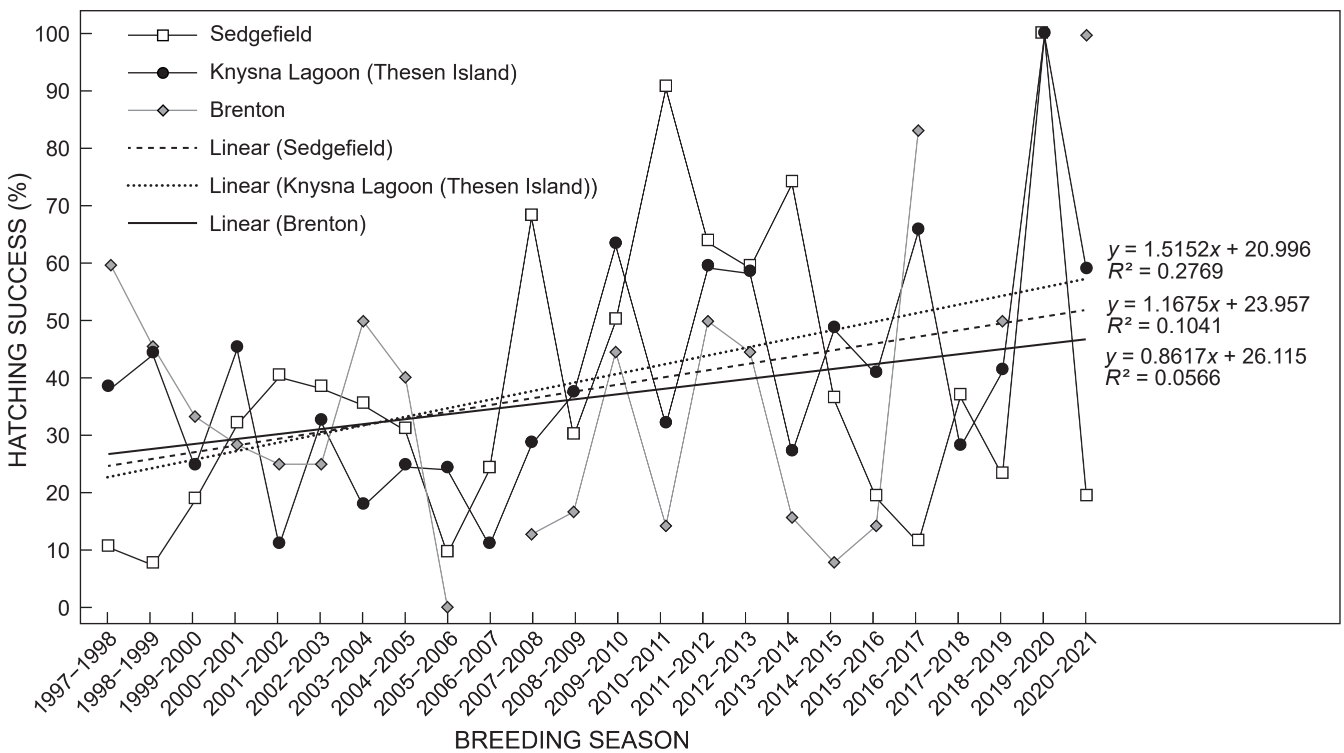

Figure 3: African Oystercatcher *Haemantopus moquinii* hatchling success for each breeding season from 1997 to 2021 at three study sites on the south coast of South Africa

Overall breeding success was higher across all three areas in recent years than in the early years of the study (Figure 4). There was a significant difference in breeding success among sites (ANOVA: $F_{1,2}$ = 4.047, p = 0.022), with Knysna pairs exhibiting significantly higher breeding success than pairs at Brenton-on-Sea (p = 0.026) but not at Sedgefield (p = 0.90), with no significant difference in breeding success between the Sedgefield and Brenton-on-Sea sites (p = 0.067).

There was a significant difference in fledglings per pair among sites (ANOVA: $F_{1,2}$ = 7.59, p < 0.01), with Knysna pairs exhibiting significantly more fledglings per pair than Brenton-on-Sea pairs (p < 0.001) but not Sedgefield pairs (p = 0.80), and no significant difference in fledglings per pair between Sedgefield and Brenton-on-Sea (p = 0.21). In addition, there was clearly an increase in the number of fledglings per pair over time (β = 0.015, t = 2.861, p = 0.009), with an overall increase of 0.015 fledglings per pair per year (Figure 5).

Discussion

The long-term data for Knysna and Sedgefield show increased numbers of breeding African Oystercatchers, with higher hatching success and higher overall breeding success over a 24-year period. The data for

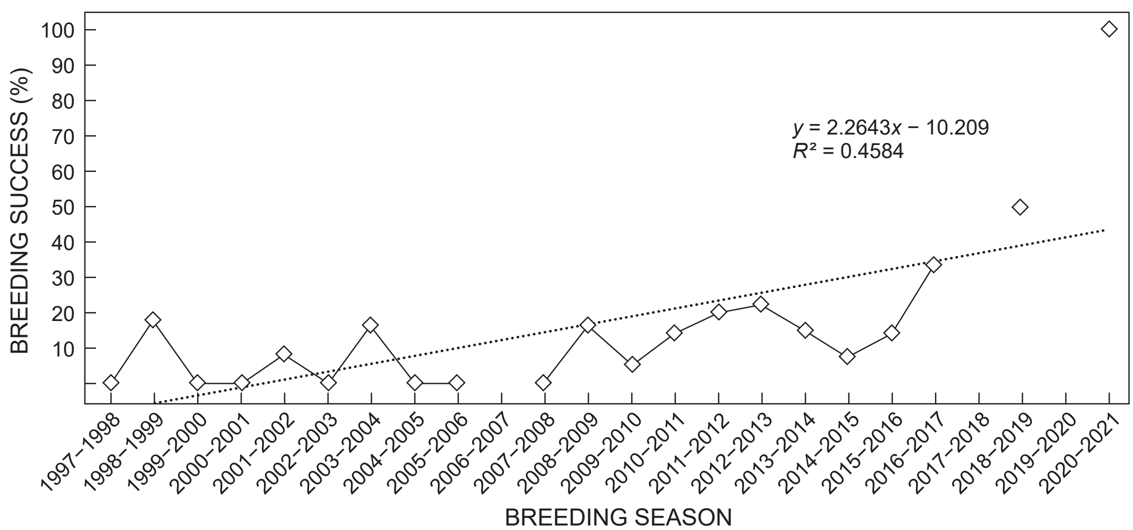

Figure 4: Breeding success of African Oystercatchers *Haemantopus moquinii* at three sites on the south coast of South Africa, for breeding seasons 1997 to 2021

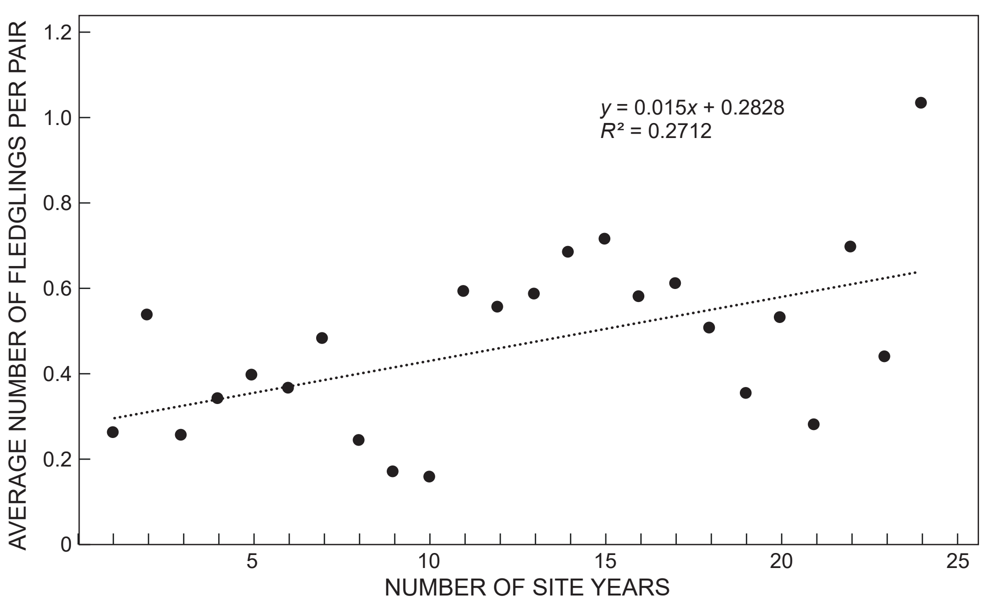

Figure 5: The average number of African Oystercatchers *Haemantopus moquinii* fledglings per breeding pair, at the three sites surveyed for 24 years on the south coast of South Africa

Brenton-on-Sea show no significant change in the number of breeding birds over time, but do indicate increased hatching success and an overall increase in breeding success over the course of the study. The long-term citizen science dataset corroborates other recent work that likewise show increasing numbers of African Oystercatchers and reporting rates (Loewenthal et al. 2015; Brown et al. 2019). These findings suggest that conservation efforts to assist the species are working.

While Brown et al. (2019) reported increases in both the species' range and the reporting rate of citizen scientists, the current study notably demonstrates long-term increases in not only the number of breeding pair but also breeding success. Important work by Loewenthal et al. (2016) showed that breeding success was related to degree of protection of sites, with island populations showing highest number of fledglings per pair, followed by protected mainland sites, and with unprotected mainland sites showing the lowest number of fledglings per pair. Our data, from semi-protected mainland sites, compare favourably to that of Lowenthal et al. 2016. Lowenthal et al. (2016) found that pairs breeding on unprotected mainland had a breeding success rate of 0.34 ± 0.24 fledglings·pair^{-1} year^{-1}, compared with our 24-year averages of 0.29 ± 0.31, 0.46 ± 0.35 and 0.67 ± 0.34 fledglings pair^{-1} year^{-1} for Brenton-on-Sea, Sedgefield and Knysna, respectively. The contrast is even greater when considering recent breeding success rates of about 1 fledgling pair^{-1} year^{-1} (current study: 2021 data).

In addition, Loewenthal et al. (2016) reported hatching success rates of ~25% for mainland sites, irrespective of protected status, which was significantly lower than the hatching success of ~70% for island sites, utilising data collected from 1998 to 2003. More recent data from our study show that the hatching rate has been increasing in two of the three study areas covered, reaching ~66% for Knysna and ~47% for Sedgefield in the last three study years, whereas Brenton-on-Sea had hatching success values similar to that reported by Loewenthal et al. (2016). This supports a conclusion that the ongoing conservation efforts for this species are indeed resulting in increased population numbers and breeding success.

Long-term datasets on breeding success in birds are hard to come by and take great effort to collect. Citizen science programmes hold great promise in this respect. This study emphasizes the importance of long-term data collection by citizen scientists in detecting changes in breeding success over time. Moreover, long-term data reduce the effect of inconsistency and variability, allowing long-term trends to be more accurately assessed.

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References

Adams NJ, Kerley GIH, Watson JJ. 1999. Disturbance of incubating African Black Oystercatchers: is heating of exposed eggs a problem? *Ostrich* 70: 225–228. https://doi.org/10.1080/00306525.1999.9634241

Anonymous. 2004. Off-road vehicle ban. *Oystercatcher Tidings* 3: 3–4.

Barnard P, Altwegg R, Ebrahim I, Underhill LG. 2017. Early-warning systems for biodiversity in southern Africa – how much can citizen science mitigate imperfect data? *Biological Conservation* 208: 183–188. https://doi.org/10.1016/j.biocon.2016.09.011

Brooks M, Rose S, Altwegg R, Lee AT, Nel H, Ottosson U et al. 2022. The African Bird Atlas Project: a description of the project and BirdMap data collection protocol. *Ostrich* 93: 223–233. https://doi.org/10.2989/00306525.2022.2125097

Brown M, Brown KJ. 2004. Nest defense in Crowned Lapwings (*Vanellus coronatus*) – influences of nesting stage and ambient temperature. *Ostrich* 75: 162–164. https://doi.org/10.2989/00306520409485429

Brown M, Downs CT. 2003. The role of shading behaviour in the thermoregulation of breeding crowned plovers (*Vanellus coronatus*). *Journal of Thermal Biology* 28: 51–58. https://doi.org/10.1016/S0306-4565(02)00036-0

Brown M, Hockey PAR. 2007. The status and distribution of African Black Oystercatchers *Haematopus moquini* in KwaZulu-Natal, South Africa. *Ostrich* 78: 93–96. https://doi.org/10.2989/ostrich.2007.78.1.14.58

Brown M, Arendse B, Mels B, Lee ATK. 2019. Bucking the trend: the African Black Oystercatcher as a recent conservation success story. *Ostrich* 90: 327–333. https://doi.org/10.2989/00306525.2019.1679904

Cohn JP. 2008. Citizen science: can volunteers do real science? *Bioscience* 58: 192–197. https://doi.org/10.1641/B580303

Cooper CB, Dickinson J, Phillips T, Bonney R. 2007. Citizen science as a tool for conservation in residential ecosystems. *Ecology and Society* 12: article 11. https://doi.org/10.5751/ES-02197-120211

DEAT (Department of Environmental Affairs and Tourism). 2004. *Guidelines on the implementation of regulations pertaining to the control of vehicles in the coastal zone*. Cape Town: Western Cape Government.

Dickinson JL, Zuckerberg B, Bonter DN. 2010. Citizen science as an ecological research tool: challenges and benefits. *The Annual Review of Ecology, Evolution and Systematics* 41: 149–172. https://doi.org/10.1146/annurev-ecolsys-102209-144636

Harrison JA, Underhill LG, Barnard P. 2008. The seminal legacy of the Southern African Bird Atlas Project. *South African Journal of Science* 104: 82–84.

Hockey PAR. 1983. The distribution, population size, movement and conservation of the African Black Oystercatcher *Haematopus moquini*. *Biological Conservation* 25: 233–262. https://doi.org/10.1016/0006-3207(83)90038-1

Hockey PAR, van Erkom Schurink C. 1992. The invasive biology of the mussel *Mytilus galloprovincialis* on the southern African coast. *Transactions of the Royal Society of South Africa* 48: 123–139. https://doi.org/10.1080/00359199209520258

Hofmeyr SD, Symes CT, Underhill LG. 2014. Secretarybird *Sagittarius serpentarius* population trends and ecology: insights from South African citizen science data. *PLoS ONE* 9: e96772. https://doi.org/10.1371/journal.pone.0096772

Jeffery RG. 1987. Influence of human disturbance on the nesting success of African Black Oystercatchers. *South African Journal of Wildlife Research* 17: 71–72.

Lee ATK, Altwegg R, Barnard P. 2017. Estimating conservation metrics from atlas data: the case of southern African endemic birds. *Bird Conservation International* 27: 323–336. https://doi.org/10.1017/S0959270916000307

Leseberg A, Hockey PA, Loewenthal D. 2000. Human disturbance and the chick-rearing ability of African Black Oystercatchers (*Haematopus moquini*): a geographical perspective. *Biological Conservation* 96: 379–385. https://doi.org/10.1016/S0006-3207(00)00076-8
Loewenthal D, Paijmans DM, Haupt PW, Hockey PAR. 2015. Trends in African Black Oystercatcher *Haematopus moquini* populations between the early 1980s and early 2000s with consideration of the influence of protected habitats and food availability. *Ostrich* 86: 9–21. https://doi.org/10.2989/00306525.2015.1029030
Loewenthal D, Paijmans DM, Hockey PAR. 2016. Factors affecting the breeding success of the African Black Oystercatcher (*Haematopus moquini*): a perspective on protection and food availability. *African Zoology* 51: 193–202. https://doi.org/10.1080/15627020.2016.1261001
Nadkarni NM, Stevenson RD. 2009. Symposium 9: linking scientists with non-traditional public audiences to enhance ecological thought. *Bulletin of the Ecological Society of America* 90: 134–137. https://doi.org/10.1890/0012-9623-90.1.134
Ryan PG. 2013. Medium-term changes in coastal bird communities in the Western Cape, South Africa. *Austral Ecology* 38: 251–259. https://doi.org/10.1111/j.1442-9993.2012.02397.x
Silvertown J. 2009. A new dawn for citizen science. *Trends in Ecology and Evolution* 24: 467–471. https://doi.org/10.1016/j.tree.2009.03.017
Summers RW, Cooper J. 1977. The population ecology and conservation of the Black Oystercatcher *Haematopus moquini*. *Ostrich* 48: 28–40. https://doi.org/10.1080/00306525.1977.9634076
Taylor MR, Peacock F, Wanless RM (eds). 2015. T*he Eskom Red Data Book of birds of South Africa, Lesotho and Swaziland*. Johannesburg: BirdLife South Africa.
Tulloch AIT, Possingham HP, Joseph LN, Szabo J, Martin TG. 2013. Realising the full potential of citizen-science monitoring programs. *Biological Conservation* 165: 128–138. https://doi.org/10.1016/j.biocon.2013.05.025
Van de Voorde S, Witteveen M, Brown M. 2015. Differential reactions to anthropogenic disturbance by two ground-nesting shorebirds. *Ostrich* 86: 43–52. https://doi.org/10.2989/00306525.2015.1029558
Watson JJ, Kerley GIH. 1995. A survey of dune-breeding birds of the Eastern Cape, South Africa. *Ostrich* 66: 15–20. https://doi.org/10.1080/00306525.1995.9632707
Webb DR. 1987. Thermal tolerance of avian embryos: a review. *Condor* 89: 874–898. https://doi.org/10.2307/1368537
Williams AJ, Ward VL, Underhill LG. 2004. Waders respond quickly and positively to the banning of offroad vehicles from beaches in South Africa. *Wader Study Group Bulletin* 104: 79–81.
Wright DR, Underhill LG, Keene M, Knight AT. 2015. Understanding the motivations and satisfactions of volunteers to improve the effectiveness of citizen-science programs. *Society and Natural Resources* 28: 1013–1029. https://doi.org/10.1080/08941920.2015.1054976

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