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Initial evaluation of the care and rehabilitation success of Cape Cormorants *Phalacrocorax capensis* rescued from Robben and Jutten islands, South Africa, in January 2021

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The population of the endangered Cape Cormorant *Phalacrocorax capensis* more than halved over the last three decades (BirdLife International 2018a). In January 2021, nearly 2 000 Cape Cormorant chicks were found abandoned, suffering from dehydration and heat stress, at two important nesting sites. The chicks were rescued and rehabilitated by the Southern African Foundation for the Conservation of Coastal Birds (SANCCOB, Cape Town, South Africa). About half (53.7%) of the cormorant chicks were successfully rehabilitated and released back into the breeding colonies. This study found a direct link between the initial body mass of cormorant chicks admitted to the rehabilitation centre and their probability of surviving during rehabilitation, with birds that were initially heavier having a greater probability of eventual release. Most cormorant chicks that died (80.7%) did so within the first 5 days of admission. This rescue required SANCCOB to care for and rehabilitate the largest number of Cape Cormorant chicks that has ever been admitted to its rehabilitation centre at one time, making it the first rescue of its kind. Despite the presumably limited positive impact on overall population numbers of Cape Cormorants, the rescue campaign improved SANCCOB's preparedness to respond successfully to future disaster events and to deal with different species, both locally and globally.

Évaluation initiale des soins et du succès de réhabilitation des Cormorans du Cap *Phalacrocorax capensis* sauvés sur les îles de Robben et Jutten, Afrique du Sud, en janvier 2021

La population de Cormoran du Cap, *Phalacrocorax capensis*, une espèce classée *En Danger* sur la liste rouge de l'UICN, a diminué de plus de la moitié au cours des trois dernières décennies (BirdLife International 2018a). En janvier 2021, près de 2 000 poussins de Cormoran du Cap ont été retrouvés abandonnés sur deux importants sites de nidification, souffrant de déshydratation et de stress thermique. Les poussins ont été sauvés et réhabilités par la Fondation d'Afrique Australe pour la Conservation des Oiseaux Côtiers (Southern African Foundation for the Conservation of Coastal Birds [SANCCOB], Cape Town, Afrique du Sud). Un peu plus de la moitié (53.7%) des poussins de cormoran ont été réhabilités avec succès puis relâchés dans les colonies de reproduction. Cette étude a trouvé un lien direct entre la masse corporelle initiale des poussins de cormoran, prise lors de leur admission au centre de réhabilitation, et leur probabilité de survie pendant leur réhabilitation. Les oiseaux initialement plus lourds avaient une plus grande probabilité d´être relâchés. La plupart des poussins de cormorans sont morts dans les cinq premiers jours suivant leur admission (80.7%). SANCCOB a dû prendre en charge le soin et la réhabilitation d'un très grand nombre de poussins de Cormorans du Cap jamais admis jusqu'alors dans son centre de réhabilitation en une seule fois, ce qui en fait le premier sauvetage de cette envergure. Malgré l'impact positif probablement limité sur la population globale de Cormorans du Cap, cette campagne de sauvetage a permis d'améliorer la préparation de SANCCOB pour réagir et répondre avec succès à de futurs catastrophes et de prendre en charge différentes espèces, à la fois au niveau local et global.

Keywords: body mass, breeding colonies, conservation, dehydration, heat stress, seabird

Introduction

The Cape Cormorant *Phalacrocorax capensis* is an endangered seabird endemic to southern Africa, breeding from southern Angola, along the Namibian coastline to the Eastern Cape of South Africa (Crawford et al. 1999; Simmons et al. 2006; BirdLife International 2018a). Cape Cormorants were once abundant along the southwestern coast of Africa (Berry 1976), with an estimated 250 000 breeding pairs in the 1970s (Crawford et al. 2007). This

number decreased substantially to fewer than 50 000 pairs by 2012 (Crawford 2013), after the species was impacted by food shortages (Crawford and Dyer 1995; Crawford et al. 2007, 2014; Hamann et al. 2012), recurring pasteurellosis outbreaks (Crawford et al. 1992; Waller and Underhill 2007) and predation (Makhado et al. 2013).

The main breeding season of Cape Cormorants is from September to February (Crawford et al. 1999), which coincides with the seasonal availability of small pelagic fish shoals during intense upwelling in the Benguela system (Crawford and Shelton 1978). Sardine *Sardinops sagax* and anchovy *Engraulis encrasicolus* are the main prey species of Cape Cormorants (Crawford 2007), and direct links have been made between cormorant breeding success and the availability of these prey species (Adams et al. 1992).

When the availability of prey declines and becomes scarce, Cape Cormorants have been observed to abandon their nests and defer their breeding until the prey species becomes more abundant (Crawford and Dyer 1995; Crawford et al. 2001). Cape Cormorants regularly change their breeding locality (Crawford et al. 1994), so the distribution of the birds has shifted to match the southward and eastward movement of their main prey (Crawford et al. 2016). Once abundant in the northwest of South Africa up until the 1990s, Cape Cormorant numbers decreased in the north as the abundance of anchovy diminished, primarily because of harvesting by industrial fisheries (Crawford et al. 2007, 2015; Hamann et al. 2012). Following changes in the distribution of anchovy, between 2010 and 2014, two-thirds of the Cape Cormorant population occurred in southwestern South Africa (Crawford et al. 2016). The sardine stock in South Africa, particularly west of Cape Agulhas, is at very low levels, such that it is considered depleted (DEFF 2020). This is likely to have a negative impact on predators like the Cape Cormorant that are reliant on sardines for food (Shannon and Waller 2021).

Environmental factors such as temperature have also been found to impact breeding. For example, Cook et al. (2020) found that increased air temperature forced adults of the Endangered Bank Cormorant *P. neglectus* to trade off thermoregulatory demands with offspring survival: any behavioural adjustment that improved the survival of adults under increased air temperature, negatively affected egg and chick survival. Similarly, Voorbergen et al. (2012) found that human disturbance caused Cape Cormorants to leave their nests, which facilitated Kelp Gull *Larus dominicanus* predation by up to 200-times the natural rate.

In January 2021, at least 2 000 Cape Cormorant chicks were found abandoned in their nests at breeding colonies on Robben and Jutten islands on the southwest coast of South Africa, during a period of high ambient temperatures in combination with presumably low food availability. These chicks formed part of a late breeding attempt as most of the colonies' Cape Cormorant chicks had already fledged (A Mdluli, pers. obs.; P Nel, South African National Parks (SanParks), pers. comm.). The abandoned chicks were found dehydrated and heat stressed and were subsequently transported to the seabird rehabilitation centre of Southern African Foundation for the Conservation of Coastal Birds (SANCCOB) in Cape Town. The resulting rescue was the largest Cape Cormorant rescue ever attempted by SANCCOB.

The aim of this study was to evaluate the success of the rehabilitation and release of the abandoned Cape Cormorant chicks, by identifying which physical factors were associated with increased survival during rehabilitation. This would be determined by: (1) statistically testing whether the initial body mass of individual chicks on arrival at the rehabilitation centre influenced their survival during their rehabilitation; and (2) identifying at what stage most mortalities of Cape Cormorant chicks during the rehabilitation process occurred. This study only looked at rehabilitation success from rescue to release back into the wild. Post-release survival of released and ringed individuals will be evaluated in future studies.

Methods

Rescue sites

Robben Island (33°48′27.36″ S, 18°22′16.32″ E) (Figure 1) is South Africa's largest island (~3.3 km long, ~1.9 km wide), located in Table Bay. Humans have inhabited and exploited the island for several hundred years and the island has consequently undergone extensive alteration (BirdLife International 2021a). Jutten Island (33°04′59.88″ S, 17°57′18″ E) (Figure 1) is the largest island (~800 m long, ~500 m wide) within the West Coast National Park, Saldanha Bay. It is mostly uninhabited except for field rangers that observe and monitor the birds during the breeding season (BirdLife International 2021b). Robben Island is ~11 km from the mainland harbour from where birds can be transported to SANCCOB by road (~20 km), whereas Jutten Island is ~9 km from the mainland harbour which is ~110 km from SANCCOB by road.

Rescue and admission to the rehabilitation centre

A mass abandonment of Cape Cormorant chicks on Robben Island was observed by a SANCCOB seabird ranger on 12 January 2021, and after consultation with the managing authorities and government departments in charge of seabirds, a rescue was initiated. A total of 1 865 abandoned Cape Cormorant chicks were rescued from Robben Island between 12 and 14 January 2021. Similar observations were made on Jutten Island over the same days, and then a further 173 Cape Cormorant chicks were rescued there between 20 and 24 January 2021. Upon collection at their breeding site, chicks were placed into cardboard boxes (58 × 43 × 37 cm) and, depending on their body sizes, between 3 and 8 birds were placed in each box. The birds were then transported to the SANCCOB seabird rehabilitation centre in Table View (33°50′00.6″ S, 18°29′29.04″ E) (see Figure 1) by boat and vehicle.

SANCCOB is a fully equipped seabird hospital that includes surgical operation theatres, temperature-controlled intensive care units (ICUs) and full-time veterinary and rehabilitation staff, and it is experienced in admitting and caring for large numbers of African Penguin *Spheniscus demersus* chicks and other seabirds (see Parsons and Underhill 2005; Klusener et al. 2018). Standard operational procedures for the admission of Cape Cormorants include a full physical examination and blood sampling, conducted by a veterinarian. However, because of the large number of birds admitted during this rescue, admission procedures

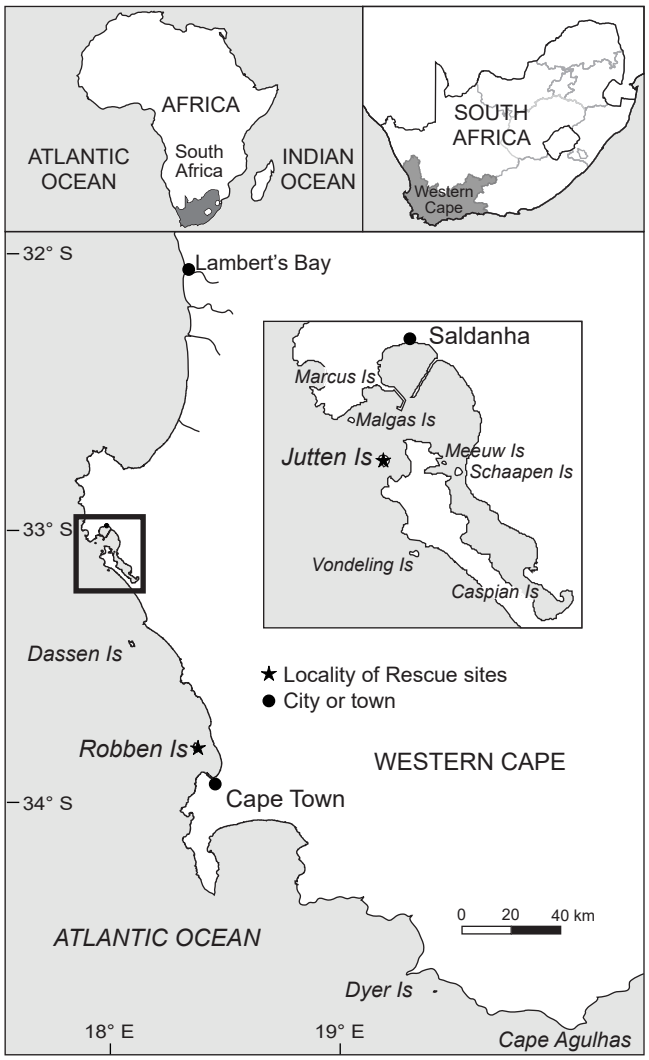

Figure 1: Locations of the Cape Cormorant chick rescues in January 2021, on Robben and Jutten islands, in relation to the SANCCOB rehabilitation centre north of Cape Town, South Africa

were limited to assessments of hydration status and habitus. Birds with a habitus score of 1 (very weak, not able to stand) received subcutaneous Ringer's lactate, all other birds were orally given warmed Darrow's solution (potassium chloride). Insecticide powder was applied to the feathers. All birds were placed in temperature-controlled heated environments and sorted into pens according to their size and condition, with injured birds being admitted directly to the ICU. Following initial hydration, chicks were tube fed with fish formula, made by liquidising fish, seafood and supplements. At a later stage, fish tails were given to free-feeding birds with vitamin powder sprinkled over them and the birds were moved to outside enclosures. Veterinary care was given during the entire rehabilitation process (more detailed information on treatment and rehabilitation plans can be provided by SANCCOB). Each chick was given a unique identifying number, which was used in the recording of all medical information onto an admission sheet and entered into the Wildlife Rehabilitation Medical Database (WRMD). Owing to the large number of birds admitted during a short period of time, only body mass was captured on admission and no information on age and/or body condition (based on morphometric measurements) was available.

Statistical analyses

The initial body-mass data that was collected and uploaded to the WRMD was used in various statistical analyses to determine whether there was a significant difference in the mean mass of Cape Cormorant chicks that died during rehabilitation and the mean mass of those that survived and were successfully released. Not all chicks admitted to SANCCOB could be weighed immediately because of the large number of chicks that had to be examined. Data from chicks weighed more than two days after rescue were excluded from the data set as their 'initial' body mass entered into the database could not be directly linked to their outcome. Consequently, only those chicks that were weighed within the first two days of arrival (1 418 chicks) were used in the analyses.

To compare the mean initial mass of chicks that died during rehabilitation with those that survived and were released, a Kruskal–Wallis rank-sum test was performed. Data were pooled for the two islands. The null hypothesis for this test was that there was no significant difference in the initial mass between three groups of cormorant chicks; namely, those that: (1) died within 24 h; (2) died after 24 h; or (3) survived and were released. During all statistical analyses, chicks that needed to be euthanised during rehabilitation were placed in the same category as chicks that had died during rehabilitation. Following the Kruskal–Wallis comparison, a pairwise Wilcoxon rank-sum test was performed to calculate pairwise comparisons between the three groups, to determine to what degree the mean initial mass varied between them. Additionally, a Wilcoxon rank-sum test was performed to determine whether there were significant differences in mean initial mass between chicks rescued from Robben Island and chicks rescued from Jutten Island. These nonparametric tests were performed as the data did not fit the assumptions of a parametric test, based on the Shapiro–Wilk test of normality.

Head-length measurements were only available for birds that died during the rehabilitation process. Measurements taken within the first eight days after rescue were used in a linear model to correlate to initial body mass.

All plots were created and all statistical analyses done using R version 4.2.0 (R Core Team 2021). Data are presented as median and interquartile ranges (IQR, Q1 and Q3). Results were considered statistically significant at $p < 0.05$.

Results

Cape Cormorant chicks rescued in January 2021 were released back into the wild between 20 February and 1 October 2021 (total of 233 days since rescue). Of the 1 865 chicks rescued from Robben Island, 930 were released back into the wild; of the 173 rescued from Jutten Island, 165 chicks could be released. This amounted to a release rate of 49.9% and 95.4% for the two islands, respectively (Table 1), and an overall release

rate of 53.7%. The proportion of released chicks was significantly greater for chicks rescued from Jutten Island than from Robben Island (χ^2 test = 130.07, $p < 0.001$). Of all cormorant chick deaths (natural or by euthanasia) during this rehabilitation period, 80.7% occurred during the first five days of care (Figure 2). The chicks rescued from Robben Island had a median body mass of 350 g (Q1: 291 g, Q3: 416 g), while those from Jutten Island, rescued a week later, were significantly larger at a median body mass of 865 ± 158.0 g (Q1: 725 g, Q3: 950 g; W = 214 157, $p < 0.001$) (Figure 3).

There was a significant difference in initial body mass at admission between the chicks that were successfully released and the chicks that died either within 24 h of admission or after more than 24 h in rehabilitation (Kruskal–Wallis rank-sum test = 387.29, df = 2, $p < 0.001$). The median initial body mass of birds that died during rehabilitation was 264 g (Q1: 245 g, Q3: 302 g) and 330 g (Q1: 282 g, Q3: 400 g) for chicks dying within 24 h and after 24 h, respectively, and this difference between the two cohorts was significant ($p = 0.002$). There was also a significant difference from the initial median body mass of 456 g (Q1: 375 g, Q3: 650 g) for chicks that were released successfully after rehabilitation ($p < 0.001$) (Figure 4).

Table 1: Rehabilitation outcomes of Cape Cormorant chicks rescued from Robben and Jutten islands, South Africa, in January 2021

	Robben Island	Jutten Island
Total admitted for rehabilitation	1 865	173
Died within 24 h	152	–
Died after 24 h	736	8
Euthanised within 24 h	3	–
Euthanised after 24 h	44	–
Released	930	165
Release rate	49.9%	95.4%

Initial body mass correlated with head length measured on post-mortem of 503 birds that died within the first eight days after admission ($R^2 = 0.63$, $p < 0.05$).

Discussion

Our results show a clear distinction between cormorant chicks that ultimately survived rehabilitation (i.e. were released) and chicks that died during rehabilitation, based only on their initially body mass. Body mass in this study was used as a proxy for age and body condition since neither a hatching date (i.e. age) nor morphometric measurements were available (although head measurements of deceased birds were correlated with initial body mass, indicating a link between age and mass). Based on plumage and weight/size, the chicks were assumed to be between one week and one month old (see Berry 1976). Ideally, morphometric measurements should be used to determine body-condition indices (Green 2001; Peig and Green 2009), especially for chicks of unknown age and when comparing different colonies (Lubbe et al. 2014) as it is commonly found in the rescue and rehabilitation of seabirds that birds with a higher body mass, or a better body condition index, tend to have a higher probability of survival. This trend has been shown for penguins (Rodrigues et al. 2010; Vanstreels et al. 2013; Martins et al. 2015; Morten et al. 2017; Parsons et al. 2018; Vanstreels et al. 2019), murres, grebes and scoters (Duerr and Klasing 2015; Duerr et al. 2016), and also in the rehabilitation of terrestrial raptors (Molina-López et al. 2015). These trends are often linked to the nutritional status of the birds on admission and not necessarily to the age of the birds, as presumed in our study. However, during large-scale seabird rescue operations like the one described here, body mass is often the only parameter available, and decisions on rescue, triage and feasibility of rehabilitation must be made based on limited information (Holcomb and Callahan 2003).

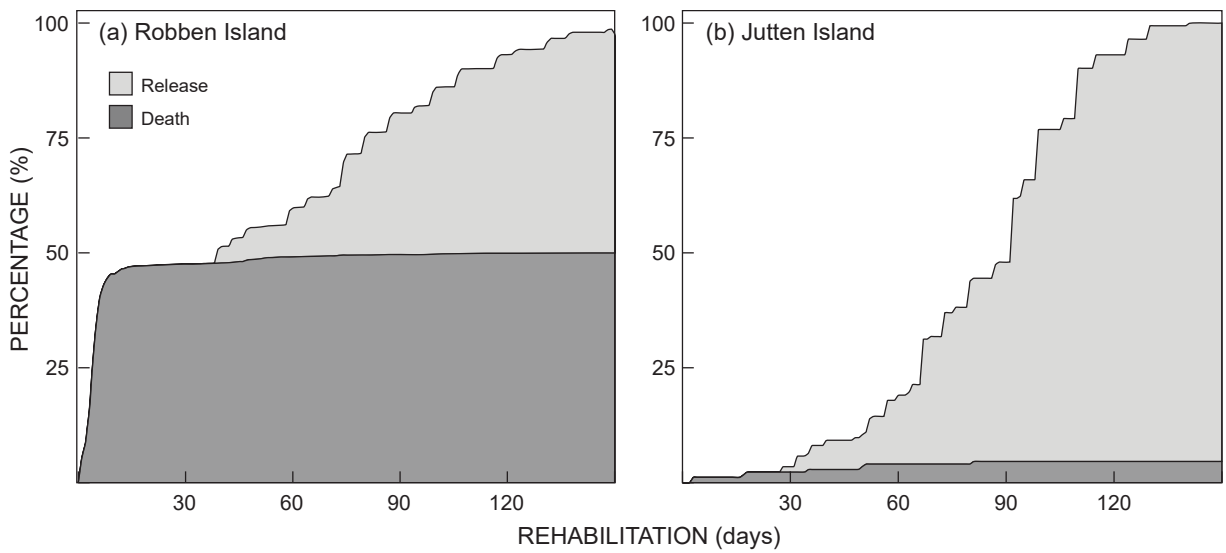

Figure 2: Cumulative distribution of deaths and releases of Cape Cormorant chicks undergoing rehabilitation shown as days since admission. Day 0 represents the day that the cormorant chicks arrived at the rehabilitation centre: that is, 12–14 January 2021 for chicks rescued from Robben Island, and 20–24 January 2021 for chicks rescued from Jutten Island. Deaths include birds that were euthanised

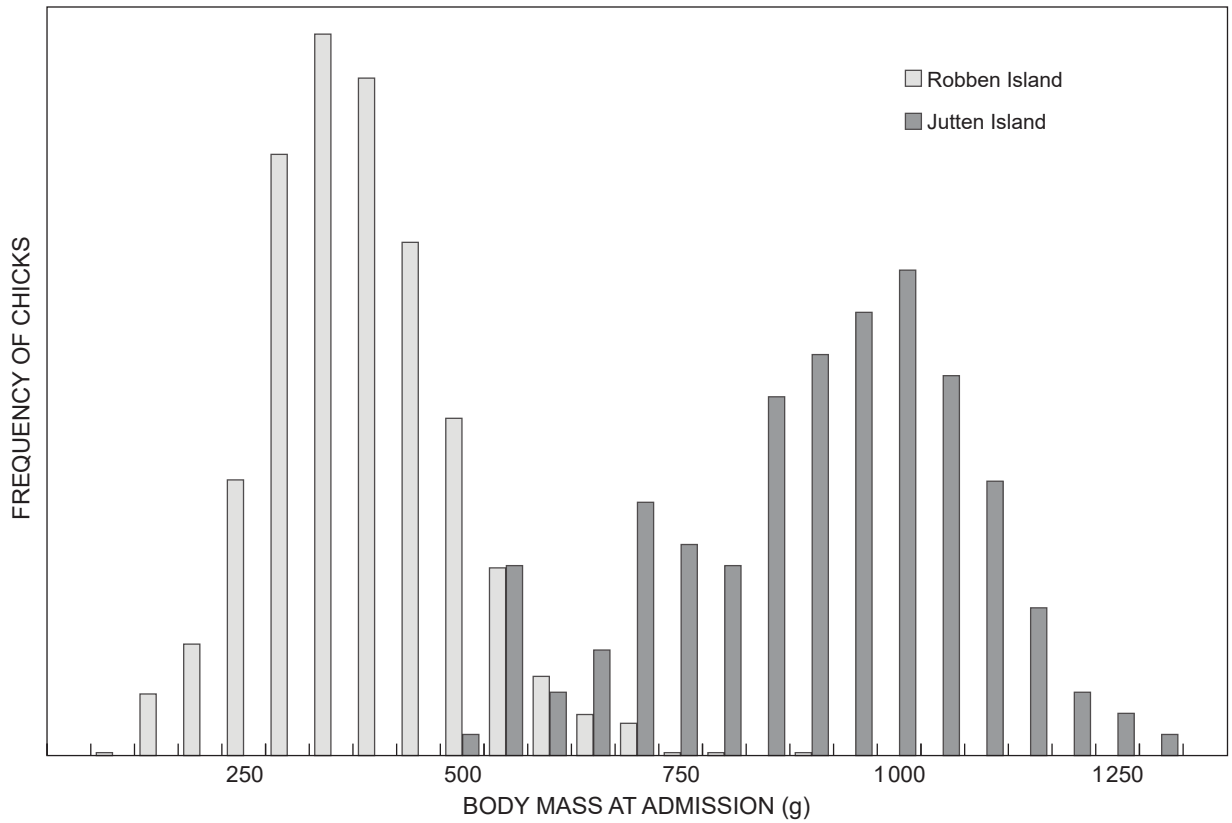

Figure 3: Comparison of the range of body mass (g) of the Cape Cormorant chicks rescued from Robben and Jutten islands upon admission to the SANCCOB rehabilitation centre. Frequency is represented by the proportion of chicks rather than a count, to better visualise both groups of chicks on the same set of axes

The significantly higher release rate of chicks rescued from Jutten Island compared with those from Robben Island can be directly linked to the body mass at admission since the Jutten Island chicks had a significantly higher mean body mass and were thus most likely older. However, the rescue of chicks from Robben Island involved more than ten-times the number of birds than the Jutten Island rescue; thus, part of the mortalities within the first five days could also have been related to crowding and a lack of individual care. The initial abandonment on Jutten Island seemed to have taken place at the same time as the abandonment observed on Robben Island (PeliWatch, comment on logbook kept on Jutten Island, 2021), and likely only stronger, larger and thus older chicks survived long enough to be rescued. Several hundreds of smaller chicks were found dead around the nest sites on Jutten Island (P Nel, SanParks, pers. comm.), indicating that the initial mortality of young and small chicks occurred on the island instead of at the rehabilitation centre.

Previous rescue and rehabilitation efforts of Cape Cormorants have included oiled and injured adult and juvenile birds as well as chicks; 384 Cape Cormorants were admitted to the SANCCOB seabird rehabilitation centre over a period of two years (2001–2002), with an overall release rate of 40% (Parsons and Underhill 2005). SANCCOB's release rates are considerably lower for Cape Cormorants than for African Penguins; between 2001 and

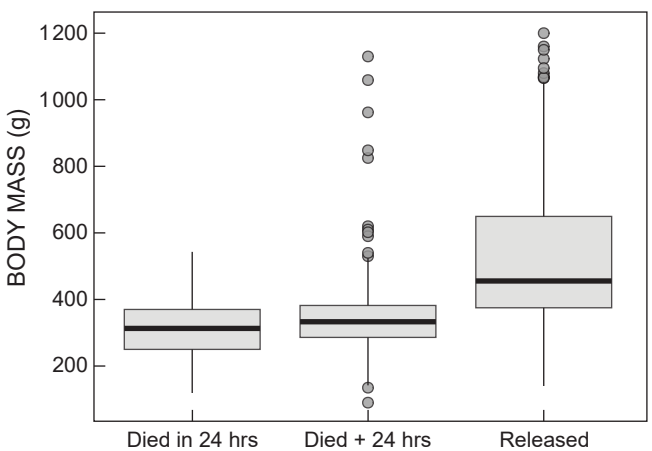

Figure 4: Body mass (g) at admission of Cape Cormorant chicks that died within 24 hours of rehabilitation (Died in 24 h), died during rehabilitation after 24 hours in care (Died +24 h), and those that survived the rehabilitation process and were later released back to the wild (Released). Deaths include birds that were euthanised

2020, the average release rate for Cape Cormorants was 26% (range 6–48%), whereas the release rate for African Penguins was 78% (range 64–87%) (SANCCOB, unpubl. data). However, Parsons and Underhill (2005) report an

80% release rate for 118 Cape Cormorant chicks, with the highest mortality in hatchlings (meaning birds with the lowest body mass on admission). Our study highlights the low success rate for very young Cape Cormorant chicks of low body mass during rehabilitation.

Most Cape Cormorant chick mortalities during this rescue were observed during the first five days after admission. Similar findings were reported for other Cape Cormorant rescues (Parsons and Underhill 2005), African Penguin chicks (Vanstreels et al. 2019) and other wildlife rescues (e.g. Crawford et al. 2000; Molony et al. 2007; Duerr et al. 2016). Capacity at rehabilitation centres as well as age, body mass and condition (including levels of oiling or injuries) may require triage to focus the rescue and rehabilitation efforts on birds with the highest probability of release (Gartrell et al. 2019). The development of easily usable charts to assess age or condition based on size, plumage or body mass could facilitate a more successful triage and rescue process in future events.

It is unlikely that the rescue and subsequent release of the 1 090 cormorant chicks back into a breeding colony will have a significant impact on the Cape Cormorant population in South Africa, bearing in mind that the current global population of Cape Cormorants is over 230 000 individuals. Additionally, an outbreak of highly pathogenic avian influenza (HPAI) in late 2021 caused the death of 24 000 (mostly adult) Cape Cormorants in South Africa (Western Cape Government 2021), which will have further long-term effects on the population trend of this endangered species. However, as we expect an increase in extreme heat events with ongoing climate change (van Wilgen et al. 2016) and low food availability (DEFF 2020), mass abandonment events in seabirds are likely to occur more often and to affect more species, especially threatened species. A heat-related mass mortality event resulted in the death of over 85% of Imperial Shag *Leucocarbo atriceps* chicks in Argentina in 2016 (Quintana et al. 2022). Thus, rescues like the one described here assist in improving preparedness, building rehabilitation capacity and fine-tuning techniques, and highlight infrastructure needs for future natural disasters events as well as oil spills. Lessons learnt from this study, especially for mass abandonment events including chicks of unknown ages, can be applied to future rescues, not only for Cape Cormorants but globally for other species. Several cormorant species are listed as threatened (Dias et al. 2019). The Chatham Shag *L. onslowi* is listed as Critically Endangered by the IUCN (BirdLife International 2018b) and has been highlighted as a priority species to be considered for rescue and rehabilitation during an oil spill (Chilvers and Battley 2019). Almost one-third of all seabird species are understood to be threatened by climate change and severe weather, often leading to mass abandonment, and hence rescue preparedness is key for successful conservation (Dias et al. 2019).

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