Chapter 9

Estimating African Penguin population size: a comparison of census techniques

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Estimates of population size of African Penguins are obtained from counts of individuals undergoing moult and from counts of nests or nest sites. Population estimates based on moult counts appear to be more accurate, but are labour-intensive and are not feasible at breeding localities that are not regularly monitored. At such localities, nest counts provide the only means of estimating population size. Nest count procedures need to be standardized to allow comparisons between breeding localities and to yield accurate population trend calculations.

Keywords: Population estimate, moult count, active nest, nest site, census method

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Introduction

African Penguins breed throughout the year, with peak nesting activities varying between breeding localities and years (Wilson 1985, Kemper 2006). African Penguins may lay replacement clutches and are able to successfully raise second clutches after fledging chicks in the same breeding season (Randall 1983, La Cock & Cooper 1988, Kemper 2006). After fledging, African Penguins spend most of their time at sea until they return to land to moult, aged 12 to 23 months (Randall 1983, Kemper & Roux 2005), when they moult into adult plumage for the first time. After this juvenile moult, they are indistinguishable from adults but are not necessarily sexually mature. Age at first breeding averages five years and ranges between two and eight years (Crawford *et al*. 1999, Whittington *et al*. 2005a). Moult in the adult African Penguin takes place annually (Randall & Randall 1981, Kemper 2006). Serial moult counts can therefore be used to estimate the population size of birds in adult plumage each year (Randall *et al*. 1986, Crawford & Boonstra 1994, Crawford *et al*. 1999, 2000, Kemper *et al*. 2001). Counts of juvenile moulting penguins can be used as a measure of recruitment into the adult population. Because a population of adult African Penguins will include non-breeders, peak counts of active nests have been used extensively to estimate the proportion of breeding adults in a population (Shelton *et al*. 1984, Crawford *et al*. 1990, 1995a, 1995b, 2001, Crawford & Boonstra 1994, Kemper *et al*. 2001).

Previous estimates of population size and trends of African Penguins have been obtained from an array of methods, including aerial censuses (e.g. Rand 1963) and ground counts. Ground count methods differed between localities and were done at different times of the year. Ground counts have been undertaken using a variety of sampling units, including total head counts of individuals or of separate age classes (adult, juvenile, chick) (e.g. Frost *et al*. 1976), moult counts (e.g. Kemper *et al*. 2001), active nests (containing eggs or chicks) (e.g. Kemper *et al*. 2001) , nest sites (including nests containing fresh nesting material or defended by an adult) (e.g. Crawford *et al*. 1995a) and extrapolations from partial nest counts (e.g. Shelton *et al*. 1984). This report aims to give brief descriptions of the two census methods currently used to estimate African Penguin populations throughout the species' range; these methods are described in greater detail in the BCLME predator project manual for seabirds. Merits and shortcomings of each method are discussed.

Active nest counts

Nest counts are currently the most common census method applied at African Penguin breeding localities throughout the region, and the most practical census method in areas which are seldom visited. For counts of active nests to be comparable between localities, the definition of what constitutes an active nest needs to be clarified. In Namibia, an active nest is defined as one containing eggs or chicks. However, counts done in Namibia before 1994, as well as counts done at South African localities, also include nests containing nesting material or those defended by an adult. Historical and recent counts in Namibia, as well as counts at different localities are therefore not strictly comparable and should be interpreted with caution.

Breeding synchrony at a given locality may be poor. This was found to be the case at Halifax Island in Namibia, although breeding was well synchronized within colonies and between years (Kemper 2006). The highly fragmented nature

Table 1: Timing of juvenile and adult moult peaks for localities for which timing is known. Timing is expressed as moult peak month or peak half month. FH = first half, SH = second half

Breeding locality	Position	Juvenile moult	Adult moult
Mercury Island	25°43'S 14°50'E	FH January	SH December, FH May
Ichaboe Island	26°17'S 14°56'E	FH January	SH December, FH May
Halifax Island	26°37'S 15°04'E	FH January	FH January, SH April
Possession Island	27°01'S 15°12'E	January	SH December, FH May
Bird Island (Lambert's Bay)	33°05'S 18°18'E	November	SH October, FH November
Dassen Island	33°25'S 18°05'E	December	December
Robben Island	33°48'S 18°22'E	FH December, March	FH December
The Boulders	34°11'S 18°27'E	FH November	FH December
Stony Point	34°22'S 18°54'E	FH November	SH November, FH December
Dyer Island	34°41'S 19°25'E	November, March	November
St Croix Island	33°47'S 25°46' E	FH December	SH November, FH December

of the breeding colonies following a large decline of the population at Halifax Island most probably contributed to the overall lack of synchrony. It is likely that breeding activities are poorly synchronized at other localities with similar characteristics. Because annual peak counts of active nests provide a poor proxy of breeding population estimates at such localities, the degree of breeding synchrony should be ascertained at each locality. Breeding population estimates using nest counts could be considerably improved by counting discrete colonies at a locality separately and by summing the annual peak counts of the discrete colonies.

Count methodology needs to be standardized across the species' range. At localities where it is feasible, particularly where breeding is poorly synchronized, monthly counts of active nests would be advantageous. At localities where only a single annual nest count may be practical, the degree of breeding synchrony needs to be ascertained (and peak counts corrected if necessary), and breeding seasonality patterns and their variability need to be established so that counts are made as close as possible to the probable breeding peak. A prolonged breeding season, possible deferral of breeding, the ability of raising two clutches in a year or relaying after a failed attempt, and a lack of breeding synchrony implies that counts of active nests at peak breeding provide a poor proxy for breeding population estimates and potentially could lead to gross misinterpretation of trends.

Moult counts

The feather-shedding phase of moult takes about two weeks, during which the penguin is land-bound. Moult counts should therefore be done at roughly two-weekly intervals, to ensure that all moulting individuals are counted. Counts of moulting

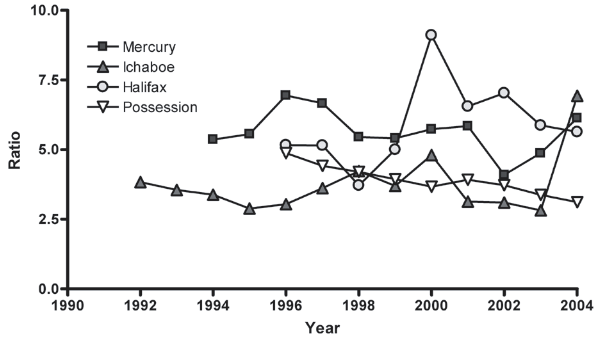

Figure 1: Ratios of estimates of number of African Penguins in adult plumage to annual peak counts of active nests at four breeding localities in Namibia

individuals in adult plumage appear to yield accurate population size estimates at a given locality (Randall *et al*. 1986, Crawford *et al*. 1999, Kemper *et al*. 2001). Since juvenile penguins appear to be less likely to moult at their natal colony than breeding penguins are at their natal / breeding colony (Kemper 2006), estimates of juvenile penguins from moult counts may not be accurate for a particular locality. Although movement of juvenile penguins between regions (defined here as Namibia, Western Cape and Eastern Cape) is common (Whittington 2005b), estimates for a particular region (from summed estimates of all localities within that region) are assumed to be reasonably accurate.

This method is labour-intensive and time-consuming, and is not be feasible at remote localities. At such localities, estimates of the numbers of juvenile penguins moulting into adult plumage may be obtained from one or more counts conducted in early January and counts of moulting adult individuals between late December and early January, as well as between late April and early May at localities in Namibia (Table 1). At localities in South Africa, counts during November and December should yield reasonable annual estimates (Table 1). Moult appears to be less synchronized at localities in Namibia than at localities in South Africa, and more counts around the peak may be required there to improve accuracy of the estimate.

To calculate population size using moult counts, counts are interpolated linearly between actual counts to calculate daily numbers of moulting birds (Underhill & Crawford 1999). Daily estimates are then summed for each year. This total is divided by the average duration of the feather-shedding phase, defined as lasting from the day when the first feather is lost to the day when the last feather is lost.

Randall (1983) calculated the mean feather-shedding interval to be 12.7 days (SD = 1.37 days) for 45 African Penguins undergoing moult at St Croix Island. Population estimates based on serial moult counts have generally been based on this figure (Randall *et al*. 1986, Underhill & Crawford 1999, Kemper *et al*. 2001, Kemper 2006), although Crawford & Boonstra (1994) and Crawford *et al*. (1999) used an interval of 14 days to calculate population size at Robben Island. Cooper (1978) determined an average duration of moult for 22 penguins at Dassen Island of 17.7 days, with range 15–20 days. However, in this study, moult duration was defined as the period the penguin spent ashore during moult. This period is longer than the feather-shedding phase (Randall *et al*. 1986). Kemper (2006) calculated an average length of the feather-shedding period for penguins undergoing rehabilitation in Namibia of 16.1 days, three days longer than that used for calculating population estimates. It is, however, conceivable that moult duration differs between birds in the wild and those stressed by a combination of injury or starvation and captivity.

Although population trends would not change if different feather-shedding intervals are applied, population estimates would. If a value of 16.1 days is used, the adult population estimates for the Namibian penguin population would be 21.1% lower than currently estimated. Even if the feather-shedding duration was set at one day longer than the duration estimate commonly used, at 13.7 days, total annual population estimates for the four breeding localities in Namibia would, on average, be 7.3% lower. If duration was set at one day shorter, annual estimates would be underestimated by 8.6%. This highlights the sensitivity of the moult count census method to estimates of feather-shedding duration. In terms of conservation management planning, it is therefore critical that the feather-shedding duration of moult is investigated more thoroughly.

The relationship between breeding population estimates obtained from AN counts and total adult population estimates obtained from moult counts

Crawford & Boonstra (1994) found that penguins in adult plumage at Robben Island outnumbered the peak active nest count by a ratio of 3.24, but this was during a time when the population there was rapidly increasing. This value is similar to the ratio of 3.53 calculated for the Saldanha Bay Islands in the Western Cape region from numbers of moulting penguins in adult plumage (Furness & Cooper 1982) and breeding pair estimates based on transect nest counts (Shelton *et al*. 1984). A ratio of 3.2 has subsequently been applied to estimate the total number of adult penguins from nest counts and *vice versa* throughout the range (e.g. Crawford *et al*. 1995a, Cordes *et al*. 1999). While this may be useful at localities where no other ways of assessing population size is possible, it is unlikely that the same factor should apply to all breeding localities because it does not take locality-specific dynamics and age structure into account.

In Namibia, the mean ratio was found to be 4.86 (range = 2.82–9.10) (Figure 1), considerably higher than 3.24 of Crawford & Boonstra (1994). The ratio varied between localities and years. A large ratio implies that there are comparatively few breeders in the adult population and suggests that Namibian localities either support fewer individuals of breeding age or that the proportion of penguins of breeding age breeding in a year fluctuates widely between years and localities for some reason, such as lack of food, mate or nest site. Lack of breeding synchrony at most Namibian breeding localities is likely to be a key factor contributing to the large ratio. For population size estimates at localities where moult counts are impractical, the ratio between active nests and number of adults should be ascertained.

Conclusion

Population estimates based on serial moult counts appear to be more accurate than alternative methods. However, this approach depends critically on the duration of the feather-shedding phase of moult; fieldwork is required to focus on variability of this period between breeding colonies and between years. The current practice, the universal application of a conversion factor of 12.7 days, might prove to be misleading. Population estimates obtained from active nest counts are less accurate than serial moult counts, and may lead to misinterpretation of population trends. At localities which are visited rarely, an active nest count at the time of the visit is the only option for obtaining an estimate of the size of the colony. In that case, counting procedures should be standardized to allow comparisons between localities and accurate trend calculations. In addition, the ratio between moult counts of individuals and nest counts needs to be specified for each locality. Interannual changes in the ratio may yield important clues about factors influencing population trends.

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