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WHAT IS A BAD SEASON FOR YELLOW-EYED PENGUINS?

(Short Answers in Conservation Science)

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WHAT IS A BAD SEASON FOR YELLOW-EYED PENGUINS?

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INTRODUCTION

Recently, conservation managers and researchers have been talking about "good" and "bad" seasons for Yellow-eyed Penguins (*Megadyptes antipodes*), without a clear understanding of what this means. The situation will become clearer as several current research projects proceed, including the analysis of the banding database (Efford *et al.* 1994). In the meantime, I have attempted in this analysis to categorise different types of breeding seasons with reference to historical information and population figures.

RESULTS AND DISCUSSION

1. Types of Breeding Season

Different types of Yellow-eyed Penguin breeding seasons are categorised in Table 1. The figures are based mainly on Richdale (1957), supplemented by my own data on chick production. They are not definitive, but give an idea of their relative importance in different seasons.

Table 1. Suggested Classification of Yellow-eyed Penguin Breeding Seasons in Terms of Survival and Breeding Success

	ADULT DISAPPEAR-ANCE[1]	JUVENILE DISAPPEAR-ANCE[2]	CHICK PRODUCTION PER NEST[3]	EXAMPLE YEARS
POPULATION CRASH	>40%	>70%	<0.8	Jan. 1990
BAD SEASON	>20%	>70%	<0.8	1938-39
LOW SURVIVAL YEAR	>20%	>70%	>0.8	1951
POOR BREEDING SEASON	14%	59%	<0.8	1946
AVERAGE SEASON	14%	59%	0.8-1.2	1991-92
GOOD SEASON	<10%	<50%	>1.2	1992-93

Key: [1] The percent of banded adults that are not seen the following season, and are presumed dead.
[2] The percent of fledged chicks that are not seen the following season.
[3] Mean number of chicks reared per nest.

A 'population crash' for Yellow-eyed Penguins is when large numbers of breeding adults die over a short period, resulting in significant disruption to the breeding population and a decrease in numbers breeding the following season (e.g. >40%). There will also be little chick production or juvenile survival if the 'crash' occurs during the breeding season and conditions are still bad during the winter.

In a 'bad season' the mortality of adults is also high. Richdale's (1957) average level of adult disappearance from one season to the next was 14%, and the highest level was 26%. A season could be considered 'bad' if more than 20% of birds were not seen the following season. There will also be low breeding success (<0.8 chicks reared/nest), and low survival of juveniles (>70% of reared young never seen again). This results in a population decrease, which has a flow-on effect through at least the subsequent season.

'Low survival years' have high adult mortality and possibly also high juvenile mortality, but breeding success is high. There may be a population decrease in the following year, if recruitment was not high enough to offset the losses.

'Poor breeding seasons' have low breeding success (<0.8 chicks/nest) but adult survival is still high, so there is little long-term effect on the population. Several poor breeding seasons in a row, however, may result in a population decrease.

The features of 'average' and 'good seasons' are also categorised in Table 1.

These terms can be used at a local study area level or population level, but will have different implications. ' Population crash' and 'bad season' may be overly emotive terms if they are simply one end of the spectrum of population fluctuations. It is probably the frequency of occurrence of adverse events which is important, rather than the events themselves. If they occur at a low frequency, natural population fluctuations result. At high frequency, a population decline may occur. This could be tested using models such as those developed by C.J.R. Robertson (pers. comm.) and M. Efford (pers. comm.).

2. Historical Perspective

In the mid 1980's to early 1990's it appeared that 'bad seasons' had been increasing in frequency. However, even in the 1930's and 1940's, during Richdale's (1957) long-term study, there were fluctuations in survival and breeding success. There was one particularly 'bad season' in 1938-39 when everything went wrong in his study area. This season stood out as "being markedly different from all the others" (Richdale 1957). Chick production was low (0.6 chicks/nest), a low proportion of juveniles were resighted (22%), moulting was later than usual, and adult survival was low (74%). This flowed on to the following season (1939-40), causing a lower population (-25%), and a later than usual laying date (6 days later than the mean of 24 September). It was bordering on being another 'bad season' or at least a 'low survival year', with moderate-low breeding success (0.9 chicks/nest), while only 74% of adults and 17% of juveniles turned up the next year. There was another small decrease in the local population. Richdale (1957) suggested that an unusual event at sea was affecting the food supply, and that the first season affected the following one. Although there appeared to be problems in the Catlins and on Stewart Island, the lack of local recruitment at Otago Peninsula from 1938-39 to 1941-42 was compensated for by an influx of new breeders from

outside the study areas.

Apart from 1938-39 and 1939-40, there was one other 'low survival year' during Richdale's study. In 1951-52, survival was only 76%, but other parameters were good. Adult survival was below average during 1944-45 to 1946-47 and there was also a fairly 'poor breeding season' in 1946-47 with about 0.7 chicks/nest produced, a result of an unexplained low hatching rate of only 57% (mean for the study was 78%). This suggests that things were below par during the late 1930's, mid 1940's and early 1950's. The converse was true, with ' good' or 'average' seasons in the intervening periods. This was especially evident in the early 1940's (e.g. 1940 had 94% adult survival, 44% juvenile survival and 1.4 chicks produced per nest). Richdale (1957) considered that the advent of economic depression and war activities elsewhere reduced the destructive agencies at work locally, so that there was no interference on the breeding grounds and there was an adequate food supply at sea.

A small number of nests monitored in three areas in 1971-72 ranged from low to high breeding success. The conclusion was that farm animals and human interference were adversely affecting egg and chick survival (Roberts and Roberts 1973). Eight areas on Otago Peninsula had high success in the early 1980's (Darby and Seddon 1990), which suggests they were probably 'good seasons'.

Another 'bad season' occurred in 1985-86 at Otago Peninsula and the Catlins, with low adult weights (monthly means mostly 200-400g lower than the previous year), delayed moult (2-3 months late), high mortality of adults (5-10% of adults were unlikely to survive the moult as they looked in poor condition) and high mortality of juveniles (<1% were subsequently seen) (van Heezik and Davis 1990). At Nugget Point in the Catlins, chick fledging weights were low (mean 4.lkg), 18% of chicks starved and breeding success was low (van Heezik and Davis 1990). This was apparently caused by a poor food supply about 40-55 days after chicks hatched (van Heezik 1991). It was not an absolute food shortage, but a dietary shift from favoured fish species to squid and less favoured prey (van Heezik 1990). The effects were less pronounced at Otago Peninsula where eight areas had moderate success of 1.1 chicks/nest (Darby and Seddon 1990). This was lower success than previous years because of predation and starvation of chicks. There was a substantial decrease in numbers on the South Island after the 1985-86 season from 600 down to 220 breeding pairs on the South Island (Darby and Seddon 1990), but a more recent analysis suggests the decrease was from 520 to 320 pairs (Darby *et al*. 1992).

The 1986-87 season in eight areas of Otago Peninsula was a 'poor breeding season' with only 0.5 chicks/nest produced because of high levels of chick predation. There was a smaller population decrease after 1986-87, but a recovery to around 400 pairs in 1988-89. Presumably 1988-89 was a 'bad season' or 'low survival year' as the South Island population decreased again to about 300 pairs in the following season (Darby *et al*. 1992).

A 'population crash' occurred in 1989-90, with about 150 adults dying over a short period. Numbers of breeding pairs on the South Island declined to about 140 (Gill and Darby 1993), a decrease of 42%. Although there was some evidence for food shortage (e.g. squid was possibly being eaten more than usual, most chicks were underweight and moulting was delayed) none of 13 autopsied birds had starved, nor had they died from obvious pathogens or toxins. Because "red tides" of algae had been observed at the time it was suggested that

an unidentified toxin may have been involved in the deaths (Gill and Darby 1993).

Early in the 1990-91 breeding season there was concern that all was not well. Laying was late, there was a high proportion of unemployed birds, birds were arriving late in the evening to landing sites, a few dead penguins had been found, local shag colonies had been deserted and the flatfish fishery had declined (Darby and Patterson 1990). However, I would contend that, rather than necessarily heralding another crash, some perturbations in the breeding pattern were flow-on effects of the previous 'bad season'. For -example, in three areas on Otago Peninsula, I estimated the mean laying date of the first egg to be 30 September. This is the same date that Richdale (1957) recorded in 1939, the year after a 'bad season'. The late laying date and high proportion of unemployed birds may have resulted from birds experiencing a hard winter and taking longer to reach breeding condition, or skipping at least a year of breeding after not locating a new mate. Interestingly, at three areas on Otago Peninsula, there were two male birds found breeding in 1993-94 that had not been recorded breeding since 1983-1987 (banding database, Efford *et al.* 1994), a gap of three or more years without breeding (there was no monitoring in the three areas in 1988 or 1989).

Although chick production was low in 1990-91, this was partly a result of egg removal by DoC staff. A 'bad season' had been anticipated, and it was hoped to protect the adult penguins by removing from them the stress of rearing chicks (J. Darby pers. comm.). After 1990-91 the South Island population bounced back quickly to over 300 pairs, then increased slowly (Darby and Edge 1993). The partial recovery has been a combination of recruitment and breeders returning after not breeding in 1990-91. In effect, all years since the crash have been 'average' or 'good seasons'.

Breeding appears to have been stabilising in recent years. The estimated mean laying date for the first egg at three sites on the Otago Peninsula has moved gradually from 30 to 25 September between 1990-91 and 1993-94, mean hatching date has moved from 16 to 11 November, and similarly, the mean fledging date has moved from 1 March to 22 February. At three areas in the Catlins, mean hatch date has moved from 16 to 9 November. At Codfish Island the estimated mean fledging date has moved from 13 to 3 March between 1991-92 and 1993-94. As the population has levelled off, the proportion of new breeders at three sites on Otago Peninsula has decreased from 47 to 12% between 1991-92 and 1993-94. At the Catlins, there was still an influx of 53% new breeders in 1992-93, decreasing to 13% the following year. Conversely, the proportion of experienced breeders has increased. Presumably, adult survival has been high from 1990-91 to 1993-94, since the proportion of breeders that are not seen again has been 4-11%.

3. Population Change on Otago Peninsula

Recent literature has suggested that only since 1981 has any real attempt been made to assess Yellow-eyed Penguin numbers (Darby and Seddon 1990). I believe that while previous workers were very aware of the need to census penguins, much of this information has been lost or remains unpublished. The impression of lack of early records comes from Richdale (1957), who did not identify his study areas and made little mention of nest numbers. Individual surveys can be difficult to interpret because of a lack of information on methods, amount of effort and timing, but trends appear as more data has.been discovered.

Richdale (1957) suggested at the start of his study in 1936-37 that the penguin population had

suffered from the conversion of breeding areas to farmland and the encroachment of human destructive agencies. He was certain that he was studying a remnant of a formerly greater population, and breeding areas outside the main study area were "equally barren of birds". The population decrease he was witnessing suggested that local extinction would occur. In an unpublished manuscript, Richdale (1942) described some of the negative human impacts as commercial collectors prior to the 1920's; a series of devastating massacres by youths with pea-rifles, with up to 40 penguins killed in one afternoon; and continual egg robbing, with a whole colony being deprived of eggs in 1939-40.

Four areas made up the "main study area" (Richdale 1957), with Penguin Beach, at the north end of the Otago Peninsula, being the principal area (Richdale 1942). He estimated that in 1940-41 there were no more than 130 breeding and unmated adult penguins on the Otago Peninsula, and found 44 nests in all known areas. There were six or seven breeding area groupings, and birds had recently disappeared in two other areas.

By 1959-60 penguin numbers had increased to at least 169 nests (Sharpe 1993), or about 182 nests if losses prior to the survey of some areas are estimated (Richdale 1957, PJM unpubl.). Another survey by Sharpe found 227 nests, probably in the early 1960's (Sharpe 1993). By 1980, when regular surveys began again, there were 231 nests, rising to a peak of 257 in 1985, fluctuating down to a low of 79 in 1990 and increasing again to 184 in 1992 (Darby pers. comm., Darby and Patterson 1991, Darby and Edge 1993).

It would appear then, that penguin numbers at the known breeding locations of the Otago Peninsula increased steadily from the early 1940's to the 1960's, since when numbers have fluctuated at around 200 breeding pairs. Even the 'population crash' in 1990 has been followed by a partial recovery. Over the period of 50 years, penguins have disappeared from some areas (e.g. area Z at Cape Saunders by 1959, Dicks Bush by 1990) and appeared at others (e.g. Highcliff, Alfred & Cecily by 1960's). Abundance and distribution has changed in different areas. For example, Penguin Beach increased from possibly as few as 6 nests in 1934 (Richdale pers comm to Sharpe), and 15 nests in 1940 (Richdale 1942), to a peak of 56 nests in 1966 (Sharpe 1993), but has had less than 30 nests ever since. Sandymount was the second most populous area in the 1960's, but is insignificant now. In contrast, Pipikaretu and Ryans beaches and Highcliff had few penguins in the 1960's but are important areas today. This leaves the impression of local areas pulsing in abundance at different rates, as part of a larger fluctuating population.

CONCLUSIONS

In the late 1980's to early 1990's there was real concern that Yellow-eyed Penguins on the mainland were heading towards local extinction. However, data from the 1930's and 40's and in recent years show that the species is capable of bouncing back quickly from so-called 'population crashes' and 'bad seasons', and these are probably a part of natural fluctuations.

A full annual census by beach counts, and nest searches in as many areas as possible is important to monitor the dynamics of population change, the periodicity of adverse events and the different trends within and between regions. Efforts to research historical information should continue, to document previous changes and the factors that have influenced them.

Laying dates, nest numbers and the proportion of birds breeding are unlikely to be useful factors for predicting good or bad seasons, as the past evidence suggests that these factors are anomalous only in years *after* bad seasons.

Fortunately, the four relatively 'good seasons' since the crash in 1990 have allowed penguin numbers to build up and for breeding patterns to stabilise. Consequently, I do not believe that direct management, such as egg or chick removal, is necessary if another 'bad season' occurs. Similarly, it will not be necessary in a year following a 'bad season', as most breeding anomalies will be the flow-on effects of the previous season.

The protection and enhancement of penguin breeding habitat and control of introduced predators should continue. This should give the species the greatest chance of withstanding any food supply or environmental fluctuations.

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