Predation on Hutton's shearwater by stoats: effect of a mast seeding year

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Summary

Recent research has suggested that predation by stoats *(Mustela erminea)* probably does not threaten the viability of Hutton's shearwater *(Puffinus huttoni)* populations. However, no mast seeding years occurred during this research. As mast seeding is usually associated with irruptions in stoat abundance, the impact of stoats might be greater than has been suggested. Widespread mast seeding in autumn 1999 provided the opportunity to measure the mortality rate of adult shearwaters in a mast year relative to that in 3 non-mast years by comparing the density of shearwater carcasses on the ground surface within a breeding colony in each of these four years. Carcass density was calculated using line transect `distance sampling' techniques. No increase in carcass density was detected following mast seeding in 1999. Although the precision of density estimates was low, it is concluded that mast seeding probably does not increase adult mortality enough to threaten the viability of the shearwater colony.

1. Introduction

Hutton's shearwater *(Puffinus huttoni)* is a threatened petrel that currently breeds in only two remote valleys in the Seaward Kaikoura Mountains. These two breeding areas are relics of a former breeding range that once extended throughout the Seaward Kaikouras and into the Inland Kaikoura Mountains (Harrow 1976; Sherley 1992). This contraction is probably related to the activities of humans and other exotic animals (Bell 1986; Sherley 1992). At least 14 other species of petrel have become extinct on mainland New Zealand for similar reasons; only four species remain (Wilson 1999).

The larger of the two remaining Hutton's shearwater colonies is now protected as a nature reserve; the other is on private land. Both colonies are remote and the land is very steep. The exclusion of pigs *(Sus scrofa)* by bluffs and waterfalls is thought to be the primary reason for the persistence of these two colonies (Cuthbert 1999). Exotics present in the colonies on a regular basis are chamois *(Rupicapra rupicapra),* stoats *(Mustela erminea),* hares *(Lepus europaeus occidentalis)* and various small passserines and weeds (R. Cuthbert 2000, pers. comm.). Of these, stoats have been identified as a potential threat and a priority for research. Indeed, examination of stoat scats from the Kowhai River colony indicated that stoat diet consists almost entirely of shearwaters (Cuthbert 1999, Chapter 4).

Cuthbert (1999) made the first attempt to quantify the impact of stoat predation on a Hutton's shearwater breeding colony. He estimated that stoats remove 0.25% (0.08-0.43, 95% CI) of adult shearwaters, 12% (2.5-17.4, 95% CI) of their chicks and none of their eggs each year (Cuthbert 1999, Chapter 6). Population modelling suggested that removing 0.25% of adults reduced population growth by 0.2% (0-0.46, 95% CI). Removing 12% of chicks reduced population growth by 0.66% (0.22-1.10, 95% CI), bringing the total impact of stoats to a reduction in population growth of 0.86% (0.42-1.30, 95% CI) per year (Cuthbert 1999, Chapter 6).

A sensitivity analysis showed that the rate of growth within the Hutton's shearwater population is strongly influenced by the adult survival rate and the between-year variation in adult survival (Cuthbert 1999, Chapter 5). These parameters could be influenced by the masting ecology of snow tussocks *(Chionochloa* spp.) and southern beeches *(Nothofagus* spp.) which dominate the vegetation of the Kaikoura ranges. Mast years occur in New Zealand's mountains every five years on average (Wardle 1984; Allen & Platt 1990) and they generally lead to an irruption in stoat numbers (King 1983). Determining whether a mast year led to an increase in the mortality of adult Hutton's shearwater is the primary focus of this report.

2. Methods

Mast seeding occurred throughout South island in autumn 1999, providing an opportunity to investigate the effect of mast seeding on the mortality of adult shearwaters.

2.1 STUDY AREA

Our investigation took place entirely within the Kowhai River Hutton's shearwater colony. This is the larger of the two remaining colonies; an estimated 160 000 shearwater pairs breed here (Sherley 1992). This colony can be divided into around thirty reasonably distinct areas of burrows that are separated from each other by streams, cliffs and screes.

2.2 TIMING OF THE STUDY

Stoats living within Hutton's shearwater colonies are known to prey almost exclusively on shearwaters, but the age of the birds that they target depends on the phase of the shearwater breeding cycle. Analysis of 788 stoat scats showed that stoats eat only adult shearwaters until chicks become available in mid-December. After this, stoats make a complete diet switch and eat only chicks (Cuthbert 1999, Chapter 4). As we were interested in the effect of mast seeding on the mortality of adults, we conducted our study between October (when snow starts to melt) and early January.

2.3 AN INDEX OF SHEARWATER MORTALITY

Cuthbert (1999, Chapter 6) estimated that approximately one-fifth of all stoat-killed shearwaters are left above ground and that the remaining four-fifths are left in the burrows in which they were killed. Rather than monitoring individual burrows, we used the density of the carcasses above ground as an index of overall shearwater mortality. This was the easiest and least destructive option, and carcass density estimates for the previous three years indicated that we should have had a reasonable chance of detecting a change in 1999 (Figure 1, figures are in Appendix 1).

Following Cuthbert (1999), we used 'distance sampling' (Buckland et al. 1993) to estimate the density of shearwater carcasses on the ground in spring 1999. We established line transects in 11 different burrowed areas, seven of which had been used by Cuthbert (pers. comm.). The total length of our transects was 5.36 km. Transects followed the general layout used by Cuthbert (1999), which was to zigzag through the burrowed area. We measured the length of the transects to the nearest metre using a hip-chain measuring device. We marked the transects so that at least two markers were always visible to the observer (one ahead and one behind). We walked transects slowly, stopping every 1-2 m to scan 360 degrees for carcasses. When we found a carcass we placed a small pole on the transect, directly between the two transect markers visible to the observer. We then attached a hip chain to this pole and measured the perpendicular distance to the carcass. Distances were recorded to the nearest 10 cm. Carcasses were removed for autopsy to try to determine the cause of death using the techniques of Cuthbert (1999) and of Lyver (in press). We walked our transects five times between mid-October 1999 and mid January 2000, a very similar sampling effort to that used in 1996-1998. Cuthbert (1999) suggested that carcasses were very likely to persist for the 2-3 weeks between transect sessions.

Critical assumptions inherent in DISTANCE sampling are (1) that no carcasses lying directly on the transect line are missed, (2) that transect lengths and perpendicular distances are measured accurately, and (3) that transects are placed randomly with respect to habitat (Buckland et al. 1993).

Richard Cuthbert kindly provided us with the data from the previous three years. As Cuthbert had walked transects until late summer, we trimmed his data set to include only the period in which we sampled in 1999 (early October to early January). We used program DISTANCE (Laake et al. 1994) to analyse the data. Model selection was based on Akaike's Information Criterion (AIC; Akaike 1973; Burnham &Anderson 1992)

2.4 RELATIVE ABUNDANCE OF STOATS

We placed 17 wooden Edgar live-traps in the same locations as Cuthbert had in 1997 and 1998. Traps were baited with a chunk of rabbit meat. They remained set for 24 hours per day and were checked daily whenever we were present in the colony. All animals caught were marked in both ears with a numbered stainless steel tag so that we could tell recaptured animals from those that were caught for the first time. We tested for differences between years using a contingency table analysis in which the number of trap nights were divided into those when a stoat was caught and those when one was not.

3. Results

3.1 SEASONAL VARIATION IN THE NUMBER OF CARCASSES

The frequency with which we found dead shearwaters increased from very low levels initially to a peak in early December, before declining again to very low levels in early January (Figure 3). This supports Cuthbert's (1999) finding that dead adults were found more frequently during the pre-egg and incubation periods than in the chick-rearing period.

3.2 NUMBER OF CARCASSES

The number of dead adult shearwaters seen from transects in each year from 1996 to 1999 were 22, 27, 22, and 50, respectively (Table 1, note that transect lengths were different in each year).

3.3 CAUSES OF DEATH

We confidently diagnosed the cause of death of only 10 of the 50 (20%) carcasses we found (Table 3). Most carcasses were either too decomposed or had no diagnostic signs.

3.4 DENSITY OF CARCASSES

The probability of detecting a carcass obviously decreased with its distance from the transect (Figures 2 and 4). After examination of histograms of the perpendicular distances, we truncated the data set at eight metres. We modelled the detection function based on pooled data for all four years and then estimated the density for each individual year using this model. We could not adequately model a separate detection function for each year, as a minimum of 60-80 observations is required to do so (Buckland et al. 1993).

Model selection using AIC identified a hazard-rate key function with cosine expansion (Figure 4) as the best model, although its AIC was only very slightly lower than those of several competing models. All of these models gave very similar density. The hazard-rate model with cosine expansion fitted the data well (Chi-square goodness of fit test, x2=0.34, df = 2, probability of a greater Chi-square value = 0.84).

We did not detect any increase in the density of shearwater carcasses on the ground in the season following mast seeding (Figure 5).

3.5 RELATIVE ABUNDANCE OF STOATS

We caught four different stoats from a total of 432 trap nights (Table 3). The first three stoats were adult males and the gender of the fourth stoat was not determined. On no occasion did we capture a stoat wearing ear tags. We failed to detect any changes in stoat abundance between years (x2 =2.35, df = 2, p = 0.31).

4. Discussion

4.1 PRECISION OF DENSITY ESTIMATES

The estimates of carcass density we have generated for 1996 - 1998 are very imprecise compared to those given by Cuthbert (1999) (Figure 5 cf. Figure 1). Although our trimming of Cuthbert's data set slightly reduced sample sizes for these years, the subsequent loss of precision was greater than we had anticipated. Unfortunately, this reduced our statistical power for detecting between-year changes in Shearwater mortality. The confidence intervals shown in Figure 5 are realistic for the given sample sizes (Harald Steen pers. comm.). Using the density of carcasses on the ground surface as an index of predation is not an ideal method with which to answer questions about changes in rates of predation on Hutton's shearwaters. This is due to the large effort required to obtain an adequate sample size. A sample size of 60-80 carcasses per year would have been desirable (Laake et al. 1994) but would have taken much more sampling effort.

4.2 EFFECT OF MAST SEEDING

Our result is consistent with the null hypothesis that the density of Shearwater carcasses does not increase following mast seeding. Cutherbert's (1999) research indicated that the rate of predation would have to increase by an order of magnitude before predation by stoats would cause a significant decline in the size of population. Our techniques should have been able to detect a change of this magnitude. We conclude, therefore, that cuthbert's conclusion is not altered by the phenomenon of mast seeding.

One might expect that a mast year would have little impact on the survival of adult shearwaters because peak stoat abundance normally occurs after mid-December (King 1983), by which time stoats have stopped eating adult shearwaters (Cuthbert 1999). It seemed conceivable to the Hutton's Shearwater Recovery Group, however, that a mast-seeding year might allow more stoats to `winter over' in and around the Shearwater colonies due to an increased abundance of rodents and invertebrates. Our results suggest that if such a mechanism is in operation, it does not have a large effect.

5. Acknowledgements

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Table 1. Numbers of shearwater carcasses found on transects between early October and early January, 1996-99.

Year	# Carcasses	Transect length (km)
1996	22	1.94
1997	27	2.61
1998	22	2.17
1999	50	5.36

Table 2. Autopsy results for the 50 carcasses found in 1999.

	Too eaten or decom osed	Sign inconclusive	Probable stoat	Accident	Fed on by harrier
Number	26	14	7	3	8
Proportion (%)	52	28	14	6	16

Table 3. Stoat trapping summaries for the three years 1997-99.

Data for 1997 and 1998 from Cuthbert (1999) Chapter 6. Differences between years were not significantly different. TNs = trap nights.

Year	TNs on which no stoats were caught	TNs on which a stoat was caught
1997	1460	12
1998	1076	4
1999	428	4

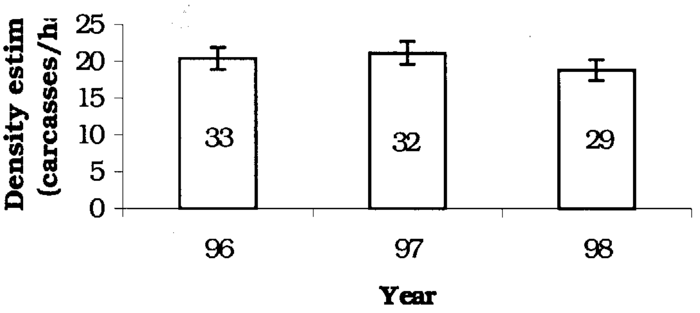

Figure 1. Estimates of carcass density in the three years before 1999, none of which were mast years.
Data from Cuthbert (1999) page 132, Table 5. Numbers in bars are sample sizes for each year.

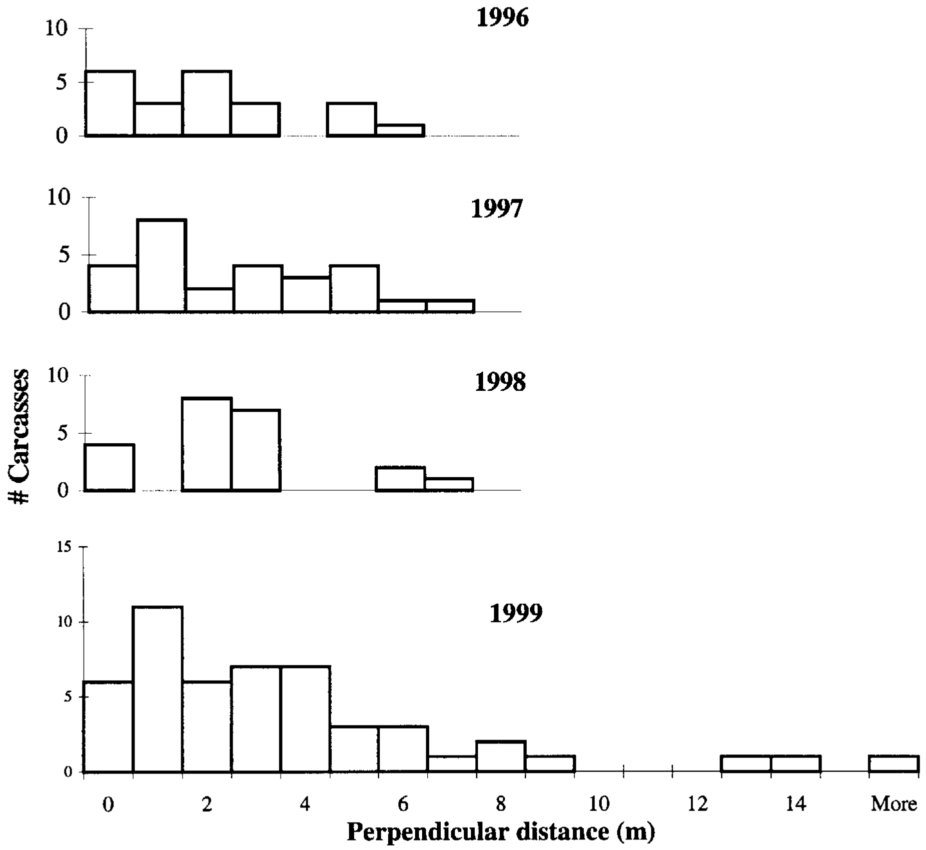

Figure 2. Perpendicular distances from transects to shearwater carcasses in each year from 1996 to 99.

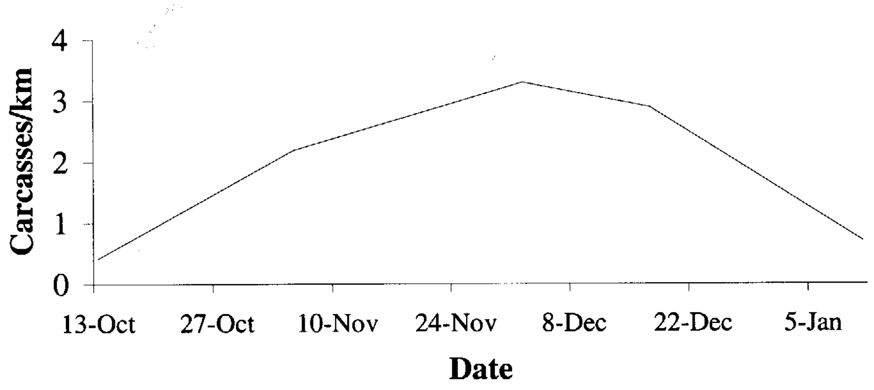

Figure 3. Seasonal changes in the frequency with which shearwater carcasses were found in 1999.

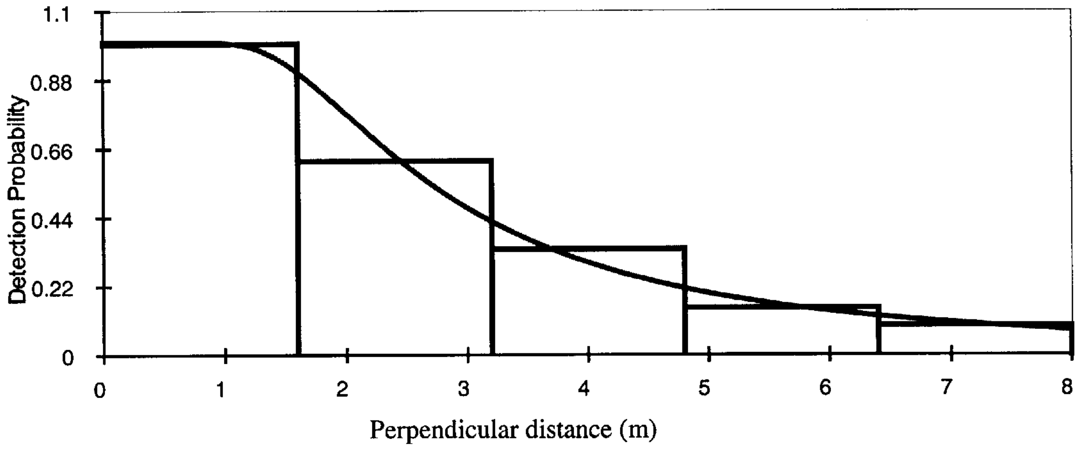

Figure 4. Detection function plot based on the perpendicular distances to the 117 carcasses found over the four years from 1996 to 1999.

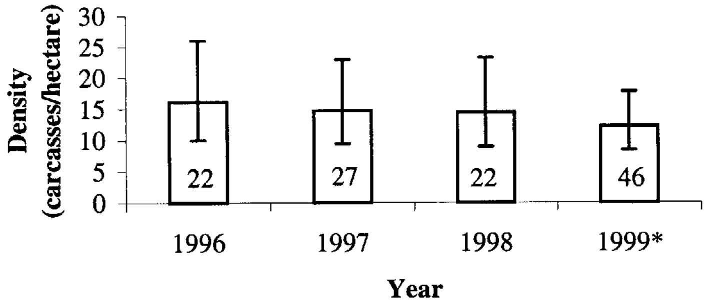

Figure 5. Density estimates and 95 % confidence limits for the four years from 1996 to 1999.

* = season following mast seeding. Numbers in bars are sample sizes for each year.