MANX SHEARWATER BREEDING SUCCESS ON LUNDY 2007

by
HELEN BOOKER[1], DAVID PRICE[2] & TONY TAYLOR[3]

[1]RSPB, Keble House, Southernhay Gardens, Exeter, EX1 1NT
[2]8 Scattor View, Bridford, Exeter, EX6 7JF
[3]26 High Street, Spetisbury, Blandford, Dorset, DT11 9DJ
Corresponding author, e-mail: helen.booker@rspb.org.uk

ABSTRACT

Surveys over the past 30 years have shown that Lundy has a small population of Manx shearwaters (*Puffinus puffinus).* Until recently, autumn searches failed to find evidence of successful breeding. The principal reason was considered to be predation by rats. A major conservation project, which removed rats from the island, was completed in 2004. Observations of juveniles in 2004, 2005 and 2006 proved successful breeding and led to a more detailed study in 2007. In this study, young birds emerging from burrows prior to fledging were captured and ringed. Using mark-recapture analysis, a productivity estimate has been made.

Keywords: *Manx shearwater, breeding success, mark-recapture, rats*.

INTRODUCTION

Manx shearwaters are colonial, burrow-nesting seabirds, breeding on offshore islands and entering and leaving their burrows during the hours of darkness. On islands free from non-native mammalian predators, this is an effective strategy to avoid predation.

Manx shearwaters occupy disused rabbit burrows (or excavate their own) to incubate a single egg and raise a chick, a process which takes from the end of April through until the end of September. The incubation, which takes around 51 days is undertaken by both adults, which swap over duties at night approximately every 5 days. Chick development to fledging takes a further 10 weeks, during which the nest is unattended for all but the first week. Parents visit the chick at night with food deliveries until it is ready to fledge. A few days prior to fledging, the adults cease feeding the chick, prompting the young bird to emerge at night, exercise its wings and prepare to leave the colony. Manx shearwaters migrate to the Atlantic Ocean off Brazil until they return to breed the following April (Brooke, 1990).

The Manx shearwater *(Puffinus puffinus*) on Lundy has been the subject of seven detailed studies since the 1930s, primarily to produce estimates of population size, with further details of numbers reported in the Annual Reports of the Lundy Field Society. Estimates (based on counts of adults or of burrows occupied in a sample of locations) have varied widely from several thousand to just a hundred pairs (Perry 1940; Taylor,

1986; Thomas, 1982). The first full island survey of burrow occupancy produced a population estimate of 166 breeding pairs in 2001 (Price and Booker, 2002). The authors considered this to be far below the island's potential population based on its size and available habitat.

Earlier studies by Taylor (1986 & 1990) sought to find evidence of successful breeding of Manx shearwaters through daytime burrow inspections and night searches at known colonies. These studies, conducted over five years between 1979 and 1983 and later in 1988, failed to find any evidence of shearwater activity during late August and early September when adults feeding chicks, or emerging young birds, would be expected.

The global importance of the UK for breeding Manx shearwaters (Mitchell *et al,* 2004), the low population on Lundy (in contrast to the huge populations on nearby Skomer and Skokholm), combined with the lack of evidence of successful breeding, prompted an island wide recovery programme for the species. Published evidence on the impacts of rats on seabirds (Moors & Atkinson, 1984; Atkinson, 1985) and anecdotal evidence from the island (Perry, 1940; Studdy, 1949; Taylor, 1986 & 1990), strongly suggested that the principal reason for breeding failure was predation by rats. These findings led to the establishment of a project to eliminate rats from the island (Appleton *et al*, 2006). Following the successful removal of rats by spring 2004, attention turned to assessing and monitoring the breeding success of Lundy's Manx shearwaters.

Studies in 2005 and 2006

In 2005, a sample of 50 occupied burrows (25 at Old Light and 25 at Tibbett's colonies) was detected using tape-playback and each burrow labelled, during visits on 21 and 22 May. During a return visit on 28 and 29 August, an endoscope was used to locate chicks in the burrows. Supplementary night visits to search for juveniles were also conducted on these dates and other evidence gathered such as presence of down inside tunnels. No chicks were located using the endoscope due to multiple corners or length of the tunnels. However, two juveniles were observed on the surface at night at Tibbett's colony on 29 August and five at the Old Light colony on a further visit on 31 August and there was considerable evidence of shearwater activity in the form of down and fresh droppings inside the tunnels (pers. obs.). A final visit was conducted on 5 September, when a further five juveniles were recorded (pers. obs.). This approach proved successful breeding, but was not suitable for quantifying productivity because juveniles were highly mobile and it was not possible to match birds to occupied tunnels.

In 2006, a mark-recapture approach was trialled at the Old Light colony. An assessment of occupied burrows was carried out in June using tape playback, although burrows were not marked as no further burrow inspections were to be carried out. This was followed up by visits in late August through to mid September to search for and ring juvenile Manx shearwaters. Despite its limitations (discussed further below) this method was considered the most suitable approach for future assessment of productivity as it allows individual birds to be identified.

METHOD

Field survey spring 2007

Burrow checks using tape playback of duetting (male and female) Manx shearwater calls were played at the mouth of each burrow at the Old Light colony within a demarcated area, approximately 100m by 100m in area (Figure 1). The survey was undertaken in two parts, with half the colony checked on 23 May 2007 and the remainder on 6 June 2007. The number of responses from birds occupying the burrows and the approximate location within the study area was recorded (Dalrymple, pers. obs.).

Field survey autumn 2007

Between 1 and 12 September 2007 nightly visits were made to the coastal sidelands north of Old Light to search for young shearwaters within the demarcated area. The young emerge on several nights prior to departure to exercise their wings and prepare to leave. The study area was searched systematically, usually adopting horizontal transects across the steeply sloping siding, using torches to illuminate the search area. All birds encountered were captured by hand, checked for existing rings and if none were present, a new ring was fitted (Figure 2). All birds were aged, wing lengths and weight were measured and an assessment of the amount of down remaining on juveniles was recorded. Additionally the location of each bird captured was recorded on a map.

Weather conditions on most nights were favourable, with little wind, virtually no light from the late rising moon and no significant precipitation. Survey and ringing activities were undertaken between 21:30 and 01:00.

Data analysis

All records were tabulated and adults excluded from the dataset. Records were then divided between initial capture of juveniles, and the recapture of some of these birds on subsequent nights. It is recognised that not all juvenile birds will have been encountered on each survey, so the mark-recapture methodology seeks to accommodate this by using the actual retrap rate over a period, relative to total numbers ringed, to calculate a probable total population.

The Schnabel calculation was applied to the mark-recapture data to provide a population estimate for the total number of juveniles fledged from the Old Light colony (Greenwood, 1996). The calculation uses the number of birds caught on each visit, the number of these already marked and the total number in the population marked. The formula for the total population (N) is given by:

$$N = \Sigma(CtMt) / \Sigma(Rt),$$

where:

Ct = total number of individuals captured in sample t

Mt = total number of individuals marked in population at sample t

Rt = number of individuals already marked in sample t.

The method is designed for closed populations (where there are no additions or deductions to the total population) so it does have limitations for this study where it is likely that new birds were emerging from burrows or fledging and leaving the colony during the study period. It is therefore likely to lead to an over-estimate of the population (Greenwood, 1996).

In order to try to accommodate these limitations an estimate of the number of birds that may have left was made based upon the finding rates at the start and end of the study period. An adjustment for this using an average percentage reduction per night was introduced into the Schnabel calculation. It is recognised that this is a crude adjustment but it is considered that it improves the reliability of the calculation and provides a more representative result. No adjustment could be made to account for new birds emerging from burrows.

RESULTS

Burrow occupancy checks in May and June 2007 located 64 apparently occupied burrows (AOBs) (Dalrymple, pers. obs.). According to Brooke (1978), approximately one in 12 birds will not respond to a taped call. To accommodate this factor, in the previous all-island survey of occupied burrows in 2001 (Price and Booker, 2002) Brooke's correction factor of 1.08 was applied to the results to obtain an estimate of the total population. This same correction factor applied to the 64 occupied burrows located in 2007 gives a population estimate of 69 AOBs for the Old Light colony.

To assess the number of fledged young, ten visits were made at night to the Old Light colony between 01 and 12 September 2007. In total, 51 juveniles were ringed at the colony during the mark-recapture study. From these there were 23 recaptures on subsequent nights involving 18 individuals (see Table 1).

Table 1: Numbers of juvenile Manx shearwaters captured and ringed 1 to 12 September 2007.

Night (Sep 07)	New Birds	Recaptures (already ringed)	Total Birds caught
Sat 1/2	5	0	5
Sun 2/3	8	2	10
Mon 3/4	4	5	9
Tue 4/5	5	5	10
Wed 5/6	10	2	12
Fri 7/8	6	4	10
Sun 9/10	6	1	7
Mon 10/11	1	1	2
Tues 11/12	6	2	8
Wed 12/13	0	1	1
Totals	**51**	**23**	**74**

Using the Schnabel formula, an estimate of the total number of juveniles fledged from the colony during the study period was calculated. This produced a potential total of 73 juveniles (calculation details are given in Appendix 1). As noted earlier, this figure is likely to be an over-estimate as it is calculated for a closed community and takes no account of the potential net loss of birds during the study period or of new birds emerging from burrows. The actual number of fledglings therefore lies between 51 and 73.

In order to try to accommodate the population not being closed, some measure of the anticipated loss of birds is required. Towards the end of the study period the number of birds being located was noticeably fewer than at the start (an average of 9 birds were caught per night up to 6 September, but this was down to 5.6 for the next five nights). It therefore seems likely that there was a net loss of birds (by death or departure) over the period of approximately a third of the population.

Working on the assumption that around one third of the birds may have left by the end of the study period this equates to an average rate of 4% reduction each night for the 11 nights (an overall loss of 36%). If this factor is applied to the formula, the number of marked birds in the population at any time (Mt) can be adjusted down appropriately.

Recalculating the Schnabel formula with these adjusted figures gives an estimated total of 62 young fledged from the colony (see Appendix 2 for revised calculation).

Taking the actual number of fledglings found (51), and the Schnabel-based estimate of the fledgling population (62), and applying these to the earlier estimate for the number of nests (69 AOBs) gives a productivity rate in the range of 0.73 to 0.9 fledged young per AOB.

DISCUSSION

Whilst the results given above require some qualification, it is apparent at the outset that the Manx shearwaters breeding at the Old Light colony had a successful season in 2007, with a minimum of 51 birds fledged (the actual number caught) and an estimate of 62 young in total. Obtaining a precise figure for productivity depends upon the accuracy of the estimates for the number of occupied burrows and for total birds fledged. The reliability of these estimates is discussed further below.

Considering the estimate for AOBs first, the 64 responses to the tape playback lead to an estimate of 69 AOBs based on a published conversion factor for responses to a tape of duetting calls (Brooke, 1978). However, studies from other colonies have re-assessed the response rate of incubating Manx shearwaters to male tape-playback and found differences in the response rate between and within colonies. A study on Skomer found the average response to male tape calls was 43%, but varied between 30% and 53% (Smith *et al,* 2001). This compares to Brooke's figure of 50.6% for responses to a male call. With this in mind, it is possible that the 92% response rate for duetting calls may be overestimated by up to 14%. If the lower response rate (of 78%) was operating at the Old Light colony, the estimate for the total number of occupied burrows increases to 82. The accuracy of this figure is central to determining a productivity figure for the colony and further study is needed to determine a response rate for Manx shearwaters on Lundy.

In terms of assessing numbers of fledged birds, Lundy's steep slopes and lengthy convoluted burrows make the use of burrow hatches or endoscopes impractical as methods for assessing productivity of Manx shearwaters (pers. obs.). The mark-recapture method was considered the most pragmatic approach for assessing numbers

of fledged birds as it allowed individuals to be identified. The terrain at the colony, with its numerous large rocks and deep bracken, made night time searches for juvenile shearwaters a challenging procedure and it is considered likely that some birds were missed.

The Schnabel calculation, which produced an estimate of 73 juveniles, assumed a closed population, i.e. that all birds were available for capture each visit and that no birds joined (newly emerged from burrows) or left the population (fledged or died) during the study period. This was clearly not the case with our study and the indications are that around one third of the young birds may have left by the end of the study period. The adjusted Schnabel calculation, factoring in an estimated average loss of 4% of the population each night gives a total population of 62 young produced from the Old Light colony.

Applying the actual number of fledglings found and the estimated juvenile population to the revised estimate of 82 AOBs gives a productivity range of 0.62 (based on 51 fledglings) to 0.76 (based on 62 fledglings) young per AOB. This range for productivity is in line with other islands that are free from rats and other mammalian predators. The Welsh islands of Skomer and Bardsey reported productivity of 0.56 and 0.79 chicks fledged per Apparently Occupied Burrow (AOB) respectively, in 2005 (Mavor *et al.* 2006).

The evidence for success of Lundy's Manx shearwaters since the eradication of rats is in stark contrast to Taylor's studies in the 1980s when no shearwater activity was recorded on the island in the autumn. The breeding success therefore paints a highly encouraging picture, indicating that the population could increase as fledged young recruit back into the colony on reaching breeding maturity. If Lundy is a closed population, with no immigration from other islands, the population recovery will be slow, as the age of first breeding is five or six. A full repeat of the 2001 survey of Lundy's Manx shearwater breeding population is planned for 2008, which it is hoped will provide a better perspective on the population dynamics and the incidence of immigration. With the first stage of the rat eradication completed by spring 2003 (Appleton *et al*, 2006), 2008 will be the sixth year of rat-free breeding, when birds that fledged in 2003 might be recruiting back into Lundy's breeding population.

Between 1957 and 2007, fifteen ringed Manx shearwaters have shown movements between Lundy and other breeding colonies. Six were ringed as full-grown birds, so that their precise ages were unknown. The remaining nine were ringed as chicks on Skomer or Skokholm and then controlled on Lundy. Their ages when visiting Lundy were three years in four cases and four years in two cases, the remainder being five, six and ten years old (Taylor, 1986 & 1990). Since Manx shearwaters breed when five or six years old, most of these were immature birds at ages when they were prospecting for future breeding sites and forming pair-bonds. Such birds, originally from the large Welsh colonies, might have been important in sustaining Lundy's population while rats were present and could contribute significantly to any subsequent growth.

CONCLUSION

Studies in the 1980s found no evidence of successful breeding, and the lack of any indication of successful breeding during the 1990s strongly suggest that Lundy's Manx shearwaters have been unproductive for several decades. However, since the removal of rats in 2003 and 2004, there has been annual confirmation of successful breeding through observations of juveniles at known colonies (pers. obs.).

This study has shown that, whilst it has proven problematic to quantify productivity precisely, breeding success is certainly at a level that is comparable with other rat-free islands. This is considered a direct result of the rat eradication programme and indicates an optimistic future for Lundy's Manx shearwater population.

ACKNOWLEDGEMENTS

Our thanks go to Adrian Plant, Nicola Saunders, Elisabeth Price, and Duncan Gillespie for assistance with the mark-recapture fieldwork and to Sarah Dalrymple for undertaking the tape-playback survey to determine burrow occupancy in the spring. This survey formed part of the *Action for Birds in England* programme, a partnership between Natural England and the Royal Society for the Protection of Birds. Thanks also to Dr Andy Brown, Dr David Bullock and Dr Norman Ratcliffe for comments on this paper.

REFERENCES

Appleton, D., Booker, H., Bullock, D.J., Cordrey, L. & Sampson, B. 2006. The Seabird Recovery Project: Lundy Island. *Atlantic Seabirds* 8, 51-59.

Atkinson, I.A.E. 1985. The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. In Moors, P.J. (ed), *Conservation of island birds*. ICBP Technical Publication 3, 35-81.

Brooke, M. 1978. Sexual differences in the voice of and individual vocal recognition in the Manx shearwater (*Puffinus puffinus*). *Animal Behaviour* 26, 622-629.

Brooke, M. 1990. *The Manx Shearwater*. London: Poyser.

Greenwood, J.J. (1996) pp 11- 109 in *Ecological Census Techniques. A Handbook* Ed. W.J. Sutherland. Cambridge University Press.

Mavor, R.A., Parsons, M., Heubeck, M. & Schmitt, S. 2006. *Seabird numbers and breeding success in Britain and Ireland, 2005*. Peterborough: JNCC.

Mitchell, P.I., Newton, S.F., Ratcliffe, N & Dunn, T.E. 2004. *Seabird Populations of Britain and Ireland*. London: Poyser.

Moors, P.J. & Atkinson, I.A.E. 1984. Predation on seabirds by introduced animals and factors affecting its severity. In Croxwall J.P., Evans P.G.H. and Schreiber R.W. (eds), *Status and conservation of the world's seabirds*. Cambridge: ICBP Technical Publication 2, 667-690.

Perry, R. 1940. *Lundy, Isle of Puffins*. London: Drummond.

Price, D. & Booker, H. 2002. Manx shearwaters on Lundy: report on the results of a breeding season survey in May 2001. *Annual Report of the Lundy Field Society 2001,* 51, 95-103.

Smith, S., Thompson G. & Perrins C. 2001. A Census of the Manx Shearwater *Puffinus puffinus* on Skomer, Skokholm and Middleholm, west Wales. *Bird Study* 48, 330-340.

Studdy, R.E. 1949. Report on the Manx shearwater. *Annual Report of the Lundy Field Society 1948,* 2, 25-26.

Taylor, A.M. 1986. Manx shearwaters on Lundy: Ringing studies and other observations. *Annual Report of the Lundy Field Society 1985, 36*, 23-24.

Taylor, A.M. 1990. Manx shearwaters on Lundy: Further ringing studies and observations on breeding status. *Annual Report of the Lundy Field Society 1989,* 40, 31-33.

Thomas, D.H. 1982. The size of the colony of Manx shearwaters (*Puffinus puffinus*) on Lundy. *Annual Report of the Lundy Field Society 1981,* 32, 16-20.

APPENDIX 1

Schnabel analysis

Ct = total number of individuals captured in sample t
Rt = number of individuals already marked in sample t
Ut = number of individuals newly marked and released in sample t
Mt = total number of individuals marked in population at sample t

Sample t	Ct	Rt	Ut	Mt	CtMt
1	5	0	5		
2	10	2	8		
3	9	5	4		
4	10	5	5		
5	12	2	10		
6	10	4	6	32	320
7	7	1	6	38	266
8	2	1	1	44	88
9	8	2	6	45	360
10	1	1	0	51	51
	Σ	**23**		Σ	**1,686**

Total Population : N = Σ(CtMt) / Σ(Rt) = 1,686/23 = 73.3

51 juveniles were caught and ringed between 1 and 12 Sept ember.

Using the Schnabel model, 73 juveniles were estimated to have fledged from the 'Old Light' colony in 2007.

APPENDIX 2

Modified Schnabel analysis - involving adjustment to marked birds by a reduction of 4% per night to accommodate fledged birds leaving the colony

Ct = total number of individuals captured in sample t
Rt = number of individuals already marked in sample t
Ut = number of individuals newly marked and released in sample t
Mt = total number of individuals marked in population at sample t (adjusted)

Sample t	Ct	Rt	Ut	Mt (adjusted)	CtMt
1	5	0	5	0	0.0
2	10	2	8	4.8	48.0
3	9	5	4	12.3	110.7
4	10	5	5	15.6	156.0
5	12	2	10	19.8	237.6
*				28.6	0.0
6	10	4	6	27.5	275.0
*				32.2	0.0
7	7	1	6	30.9	216.3
8	2	1	1	35.4	70.8
9	8	2	6	34.9	279.2
10	1	1	0	39.3	39.3
	Σ	**23**		Σ	**1,432.9**

* Blank lines are nights when no survey was undertaken.

Total Population: N = ∑(CtMt) / ∑(Rt) = 1,432.9/23 = 62.3

Using the Schnabel model but with adjustments for birds leaving the colony during the study period, 62 juveniles were estimated to have fledged from the 'Old Light' colony in 2007.

Figure 1: Manx Shearwater Old Light Colony Area 1. *(Photo: David Price*)

Figure 2: Ringing of Manx Shearwater juvenile. *(Photo: Elisabeth Price)*