

**SCOTTISH
NATURAL
HERITAGE**



COMMERCIAL IN CONFIDENCE

STATEMENT OF REQUIREMENTS

**MONITORING OF BROWN RAT ACTIVITY AROUND THE MANX
SHEARWATER COLONY – ISLE OF RUM 2009 - 2010**

Statement of Requirement

Monitoring of Brown Rat Activity Around the Manx Shearwater Colony – Isle of Rum 2009 - 2010

1. Background

The Isle of Rum is a National Nature Reserve (NNR), Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC) and Special Protection Area (SPA) managed by Scottish Natural Heritage (SNH).

Rum is designated an SPA for its colony of Manx shearwater, *Puffinus puffinus*. The most recent survey, by Murray et al in 2001, estimated the number of breeding pairs as 76,000 and 120,000 (by visual assessment and tape-playback methodologies respectively). The colony is of huge international importance, perhaps comprising up to 30% of the world population.

Over recent years individuals involved in the ringing of fledging chicks at the colony have reported an overall reduction in the number of fledging birds and patches of the colony barely producing any fledglings at all (e.g. Ramsay 2005).

Annual monitoring of shearwater productivity has been undertaken at around 100 study burrows since 1994. During the 2004 breeding season, five of the study burrows lost eggs due to rat predation, the first time this has been recorded at the Rum colony (Ramsay 2004). A further five ratted eggs were encountered by fieldworkers undertaking productivity monitoring in 2005 (Ramsay 2005). Warm winters on Rum have been cited as potentially leading to an increase in rat numbers at the colony (it should be noted that the Rum shearwater colony is at high altitude, with the majority of burrows over 580m). Considering the proven potential for rats to have devastating effects at shearwater colonies it is essential that SNH establishes a programme of monitoring rats and investigate rat impact on shearwater breeding success.

SNH wishes to appoint suitable contractors to undertake detailed annual monitoring of rat activity around the manx shearwater colony on Rum National Nature Reserve. This project is a continuation of a monitoring programme began in 2006.

2. Objects and Scope of Surveyor

Scottish Natural Heritage (hereafter referred to as the “Client”) requires a competent contractor(s) who will provide a high quality service, whilst offering good value in the expenditure of public funds. The Contractor(s) shall work in partnership with the Client to deliver the required rat monitoring service.

The services will be required from 6th April 2009. The contract will be for a maximum period of 11 months unless terminated in accordance with the provisions of the Contract Conditions.

3. Objectives

The main aim of the rat monitoring aspect of the Manx Shearwater Project on Rum is to determine an index of abundance for rats at the colony Hallival, Askival and Trollaval). The method to obtain this index needs to be reliable and repeatable.

4. Range of Services

The Contractor shall provide the following services to the Client. It should be noted that this list is not intended to be exhaustive as further additional services may be added.

Rat Monitoring

- Ideally indices of rat abundance will be recorded on a monthly basis throughout the year. However, the resource implications of such thorough monitoring may cause SNH to revise this plan. When tendering for the rat monitoring work it would be very useful to break the quote down into cost per monthly visit.
- Indexes of rat abundance will be ascertained with a number of trapping grids. SNH will advise the contractor on the location of the trapping grids. The grids will be located
 1. Within areas where shearwater productivity/occupancy are being monitored
 2. In areas where there are no shearwaters (but similar habitat and close to active parts of the colony)
 3. In areas of the colony where there is no monitoring of productivity / occupancy

In addition, there will be parts of the colony where productivity and occupancy are being monitored but there is no trapping of rats. This will hopefully inform us whether the removal of rats at trapping grids is confounding our results by masking the impact of rats on breeding shearwaters.

- The trapping index grids are based on the snap-trap index of abundance (Cunningham and Moors 1993). The grids will be 300mx300m with traps 25m apart, comprising 169 traps. Each 'trap' will actually consist of two 'Trapper T-Rex' traps set back-to-back and probably baited with rolled oats soaked in peanut oil. The traps will be covered, probably by a fine mesh rabbit caging with narrow entrances leading to the traps at either end. The opening will be reduced to prevent access by shearwaters. The traps and covers will be securely staked to minimise disruption of the trapping grid by red deer.
- SNH needs to be advised on wood mouse bycatch at the colony before SSSI consent can be granted. If wood mouse bycatch is found to be unacceptable SNH may consider using live traps. If live traps are used

then it would be expected that the contractor humanely dispatches the rat as a released rat is unlikely to return to a trap and this will confound the calculation of an index of abundance.

- The trapping grids will be run for three nights at the same time every month (thus controlling for the lunar cycle)
- Dead rats will be collected and passed on to SNH staff (for dissection, providing information on feeding and breeding biology)
- Whilst conducting fieldwork, the contractor is expected to record any observations of relevance to the project such as evidence of rat activity/ predation. Noting the position of extensive rat burrows with GPS would be particularly useful as opening such burrows may allow for rat faecal pellet analysis.
- The contractor is expected to present the monthly indexes of rat abundance (including a map to show the relative abundance at the different areas of the colony sampled). The analysis and presentation of rat abundance and the relationship with shearwater productivity and occupancy is to be conducted by the contractor.

6. Evaluation of the Results/Outputs

- On completion of fieldwork, the contents of field record sheets should be transferred to a spreadsheet and all data should be made available to SNH.
- A full report detailing methods, results and conclusions will be provided within 2 months of completing the project.
- For all work three paper copies of the report and final maps should be supplied along with 3 photocopies of the maps. Computer files of the report (in Word for Windows) with supporting data (in Excel) and photographs (as .jpg files) should be provided on a CD ROM.

7. Service Requirements

7.1 General

- The contractor shall not have use of SNH vehicles. The contractor is entitled to bring their own vehicle which shall only be used on existing roads on the island. At no time shall the contractor take a vehicle off road. Any vehicle brought to the island for use by the contractor must be suitable for the island's rough roads.
- The contractor is entitled to make use of the shearwater hut on the island to aid access to fieldwork sites.
- SNH shall provide 'Trapper T-Rex' traps. The contractor is responsible for providing all other equipment necessary to carry out the work required of them. The contractor shall not rely on SNH to provide any of this necessary equipment.

7.2 Management and Staffing

Contract Manager

- The Contractor shall nominate an individual who will act as the first point of contact for the Client. The Contractor shall ensure adequate supervision of all its staff, including subcontractors' staff, whether permanent, temporary or relief.

Staffing Levels

- The Contractor shall ensure that there is a sufficient level of trained and competent staff to provide the services.
- Only those staff contracted by the Contractor (whether permanent or temporary) shall be permitted to participate in fieldwork on the island.
- The Contractor shall, at no time, pay wages lower than the legal minimum wage, and shall take account of local demographic and employment characteristics, to set a rate of pay that will attract a good calibre of staff.

7.3 Confidentiality

During the course of their duties, the Contractor's agents, employees, subcontractors and representatives may become aware of confidential information. Should this be the case, such information must not be communicated to any third party and the Client should be informed.

The Contractor shall co-operate with the Client in any subsequent investigation. The Client will regard all information obtained by the Contractor and his staff concerning the Client, its members or business as confidential.

8. Specific Instructions

8.1 Health and Safety

All contractors have legal responsibilities under the Health and Safety at Work Act to ensure the health and safety of their employees and any other person who may be affected by their actions or omissions. As this survey will involve work in difficult, sometimes mountainous, terrain the contractors should therefore indicate the following in their tender response:

- the contractor's safety policy and procedures,
- the level of training and experience in such terrain.

Before any field work is undertaken the contractor will need to demonstrate to the Nominated Officer that field staff will be equipped with suitable personal protective equipment and that adequate daily reporting procedures and contingency plans are in place for lone and hazardous working situations.

A risk assessment must be completed and agreed by the Nominated officer before the work is undertaken. To assist in making a risk assessment the relevant parts of the generic risk assessment for SNH upland staff will be provided to the successful contractor. SNH would expect contractors to operate to similar levels of risk assessment and risk control.

8.2 Public Liability insurance

The contractor must hold relevant public liability insurance to the value of £1,000,000.

8.3 Pre Fieldwork Meeting

Prior to commencement of fieldwork, the contractor shall meet with SNH Reserve Staff to discuss the fieldwork plan and finalise details of data collection.

8.4 Accommodation

It is expected that hostel style accommodation will be provided by SNH in Kinloch castle on the Isle of Rum.

8.5 Fieldwork

- Fieldwork will be carried out between April and August 2009.
- There is the possibility that members of SNH, Isle of Rum reserve staff will be available to assist with fieldwork.

8.6 Quality Assurance

SNH will examine the outputs of the project and the contractor will be called upon to correct any errors, provide missing data, or answer queries regarding any of the outputs, at their own cost. Tenders should make an allowance for at least two site visits by the SNH nominated project officer, each lasting about a day, to observe recording and Health and Safety procedures in the field. Tenderers should also indicate what internal quality assurance procedures they will undertake. Final payment will only be made on approval of the second draft report by SNH's internal Quality Assurance procedure, which may take up to 3 months following submission of the report.

9. Costs and Payment

Payment will be made upon submission of an invoice and the delivery of the specified outputs of a quality standard to the satisfaction of the SNH Nominated Officer. The SNH Nominated Officer will check the reports, and if necessary the contractor will make approved amendments. Advance payments will not be made; payment will be made only on acceptance of outputs (e.g. completed field survey forms). A schedule of payments should be suggested in the submission, but a final schedule will be negotiated with

SNH prior to award of a contract. The invoices should be for the actual amount of work undertaken and outputs delivered.

10. Sustainability in Procurement

All SNH contracts are selected on the basis of delivering the best value that meets all of our needs. These needs include sustainability criteria. SNH operates an Environmental Management Programme to ensure our own operations meet high standards of sustainability by: managing our resources more sustainably, reducing our CO2 emissions, and making our corporate processes more sustainable.

The following sustainability criteria apply to all goods & services procured by SNH:

All costs are on a whole-life basis – therefore quotes should take this into account;

- Low use of paper and other consumables;
- Use of recycled and reusable products;
- Waste minimisation and use easily recyclable products;
- Sustainable management of our National Nature Reserves, offices and visitor centres
- Low energy use;
- Promotion of Renewable Energy use;
- Low carbon emissions;
- Positive impact on biodiversity;
- Promotion of sustainable (low carbon) travel

We expect all suppliers of goods and services to SNH to be able to demonstrate how they can meet the relevant sustainability requirements, and where possible, variants have been indicated to encourage suppliers to provide variants to their tenders that allow SNH to choose a supplier that adds sustainability value to the supply of the goods or services, all other aspects being equal.

Further information on SNH's Environmental Management Programme is available from the SNH website at <http://www.snh.org.uk/about/greening/ab-gr-01.asp>

SNH publications and commissioned research

Whole-life costing	<ul style="list-style-type: none">• design• materials and printing• delivery and storage• recycling and/or waste disposal at end of life (EOL)
Low use of paper and consumables	<ul style="list-style-type: none">• non-paper options to be considered (eg publication as web pages, PDF, or as CD/DVD)

	<ul style="list-style-type: none"> • print minimum realistic numbers of copies
Use of recycled and reusable products	<ul style="list-style-type: none"> • use recycled paper (ideally 100% post-consumer waste, Total Chlorine Free (TCF) wherever possible • use maximum percentage of recycled paper content consistent with operational necessities • use water-based and non-toxic inks wherever possible • commissioned reports to be printed double-sided • SNH publications to state type and proportion of recycled paper used
Minimise waste and use easily recyclable products	<ul style="list-style-type: none"> • printed commissioned reports to be made so that they can be separated into single materials for recycling (eg comb-bound rather than glued) • all printed materials must be able to be recycled • SNH publications to include text asking people to return, pass on or recycle the publication
Low energy use	<ul style="list-style-type: none"> • no mandatory criteria. variant – supplier to demonstrate measures to reduce energy use in their business
Promote Renewable Energy use	<ul style="list-style-type: none"> • no mandatory criteria. variant – supplier to demonstrate use of RE in their business
Low carbon emissions	<ul style="list-style-type: none"> • no mandatory criteria. variant – supplier to demonstrate measures to reduce CO2 emissions from their business
Positive impact on biodiversity	<ul style="list-style-type: none"> • no mandatory criteria. variant – supplier to demonstrate measures to enhance biodiversity in their business
Encourage sustainable (low carbon) travel	<ul style="list-style-type: none"> • minimise numbers of deliveries and other vehicle journeys required to fulfil the contract. variant – supplier to demonstrate measures to promote sustainable travel modes in their business

11. Terms and Conditions

Scottish Natural Heritage Condition of Contract for Research, Survey and Monitoring Services will apply. A copy is enclosed for your reference.

12. Timetable for Procurement

Suppliers are requested to provide:

- One paper copy of their tender submission.
- An electronic submission to be sent to procurement@snh.gov.uk

The intended timetable for this tender process is:

Activity	Date
Issue Invitation to tender	09 March 2009
Tender return date	30 March 2009
Evaluate Proposals	01 April 2009
Award Contract	03 April 2009

13. Evaluation of Criteria

To provide a means of negotiating payment for work actually carried out, in the event that the number of survey plots required is fewer than stated, submissions should also provide costs based on an average per sample location, as well as an estimate of overall cost.

Submissions received will be assessed according to the following criteria, and the appropriate types of information should be supplied to enable these assessments to be made.

1. Adherence to the project objectives and methods outlined above. All specified objectives and methods must be adhered to.
2. Relevant field experience and expertise of staff involved. At least one member of the field survey team should have at least 6 months field experience.
3. Relevant project management experience. Scoring will be based on the following: the number of projects managed by the project manager for this project; the number of years of experience of managing projects by the project manager for this project; if subcontractors will be involved, the number of projects managed by the project manager for this project which have involved the management of subcontractors.
4. Project management structures and procedures that will ensure timely and satisfactory progress of the project.
5. Competitive but realistic costs. Full details of all costs should be provided. Assessment will be based on relative ranking for comparable work undertaken.

Those compiling tender submissions should ensure that they read, and take account of, the SNH Conditions of Contract for the Provision of Research, Survey and Monitoring Services. It is a mandatory requirement that submissions should provide all the information asked for above.

14. Nominated Officer

Any Supplier requiring further clarification of any points in this Specification should address their enquiries in writing to the contacts listed below.

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SNH CONTRACT NO.: 27397

TITLE: MONITORING OF RAT ABUNDANCE AT THE MANX SHEARWATER COLONY ON RUM NNR 2009-2010

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SUMMARY

MONITORING OF BROWN RAT ABUNDANCE AT THE MANX SHEARWATER COLONY ON RUM NNR 2009 - 2010

Commissioned Report No.:

Contractor: Wildlife Management International Limited
Published:

BACKGROUND

The Isle of Rum is a National Nature Reserve, Site of Special Scientific Interest, Special Area of Conservation and Special Protection Area managed by Scottish Natural Heritage (SNH). Specifically Rum was designated as an SPA for the Manx shearwater (*Puffinus puffinus*) colony. The Rum colony is situated on the mountains of the island with the majority of the burrows over 580 m. At present the number of breeding pairs has been estimated between 76,000 and 120,000 (Murray *et al.*, 2001) making the Rum colony one of huge international importance, perhaps comprising of 30% of the world population.

Annual monitoring of Manx shearwater productivity has been undertaken using study burrows since 1994. During the 2004 breeding season, it was recorded that a number of study burrows lost eggs due to rat predation; the first record from the Rum colony (Ramsay, 2004). The following season additional rat predation was recorded and a reduction in the number of fledging birds and areas within the colony were identified that did not produce any fledglings successfully was reported (Ramsay, 2005).

The presence of rats at the colony and the potential for major impacts on the Manx shearwater colony, SNH commissioned a rat monitoring programme to investigate the impact of rats on Manx shearwater breeding success which began in 2006 (Bell, 2008). This report outlines the methods, results and conclusions of this work.

MAIN FINDINGS

- The total number of brown rats (*Rattus norvegicus*) caught at the Rum Manx shearwater colonies between September 2006 and March 2010 was 78.
- The total number of wood mice (*Apodemus sylvaticus*) caught at the Rum Manx shearwater colony was 211.
- The total number of rats that were necropsied was 52; 31 males and 21 females (the remainder of the rats were too damaged or decomposed to necropsy).
- Most of the rats (29) were caught in the No Shearwater (HNS) trapping grid on Hallival.
- Most of the rats were caught in autumn (September, October or November).
- Of the necropsied rats, 30% of all identified female rats were lactating (i.e. feeding young) and 42% were pregnant.
- **Of the necropsied rats, 22% had evidence of eating live Manx shearwaters or eggs** (either chicks 10% or adult shearwaters 4% and eggs 8%); positive sign included fresh flesh, skin, blood and albumen in the stomachs.
- **Of the necropsied rats, 81% of necropsied rats had evidence of scavenging dead chicks and eggs** (chicks 48% and eggs 33%); positive sign included feathers, down and egg shell.
- There was evidence of **rat predation on ADULT Manx shearwaters** as two rats caught in May 2007 had fresh flesh, feathers and blood in stomach.

ACKNOWLEDGEMENTS

Thanks to Lesley Watt (SNH, Isle of RUM) for her support and logistical arrangements on Rum.

Thanks to all SNH staff on Rum for their support and assistance during the course of the project. Thanks also to Andy Douse (SNH, Inverness) for his support and interest in the project.

We would like to thank the following for assistance in the field; [REDACTED]
[REDACTED]

Thanks also to WMIL staff for reading and commenting on early drafts of this report.

MONITORING OF BROWN RAT ABUNDANCE AT MANX SHEARWATER COLONY ON ISLE OF RUM NNR 2009-2010

1 ABSTRACT

The Isle of Rum holds one of the world's most important breeding colonies of Manx shearwaters; numbering up to 120,000 breeding pairs. The colony is found on the mountain range (Hallival, Askival and Trollaval) of the island. Manx shearwaters breed from April to September. Annual monitoring of Manx shearwater breeding success and productivity has been undertaken since 1994. Recently, evidence of rat predation on eggs and a reduction in the number of fledging birds was recorded. Since 2006, regular indices of rat abundance have been completed to confirm the presence of rats at the colonies, assess the range of rats, confirm the occurrence of predation and assess the abundance of rats on the mountains. Nearly 80 rats have been caught at the colony and 11% have evidence of eating live shearwaters (i.e. stomach contents contained blood, flesh and feathers). Rats were caught throughout the year, but most rats were caught in autumn. Over 35% of all females caught were either lactating or pregnant. There is potential for rats to have a major impact on the shearwater colony on Rum particularly if numbers and range increase. A wide-scale control programme should be implemented immediately to reduce the number of rats at the colony. Investigation into the feasibility and costs of an island-wide eradication should also be completed.

Key words: brown rat, Manx shearwater, trapping, index of abundance, necropsy, predation, control, eradication

2 INTRODUCTION

The Isle of Rum is a National Nature Reserve, Site of Special Scientific Interest, Special Area of Conservation and Special Protection Area managed by Scottish Natural Heritage (SNH). Specifically Rum was designated as an SPA for the Manx shearwater (*Puffinus puffinus*) colony. The Rum colony is situated on the mountains of the island with the majority of the burrows over 580 m.

At present the number of breeding pairs has been estimated between 76,000 and 120,000 (Murray et al 2001) making the Rum colony one of huge international importance, perhaps comprising of 30% of the world population.

Annual monitoring of Manx shearwater productivity has been undertaken using study burrows since 1994. During the 2004 breeding season, it was recorded that a number of study burrows lost eggs due to rat predation; the first record from the Rum colony (Ramsay, 2004). The following season additional rat predation was recorded and a reduction in the number of fledging birds and areas within the colony were identified that did not produce any fledglings successfully was reported (Ramsay, 2005).

The presence of rats at the colony and the potential for major impacts on the Manx shearwater colony, SNH commissioned a rat monitoring programme to investigate the impact of rats on Manx shearwater breeding success which began in 2006 (Bell, 2008).

3 OBJECTIVE

The main aim of the brown rat monitoring project (as part of the larger Manx Shearwater Project) on Rum is to determine a reliable and repeatable index of abundance for rats at the colony (in particular at Hallival and Askival).

4 METHODS

The easiest and most reliable method to obtain a reliable and repeatable Index of Abundance for rats is using the Cunningham and Moors (1993) method; a similar method to that used in the 1950's (Zippin, 1958). The Cunningham and Moors method has been used for decades in New Zealand to obtain reliable Indices of Abundance that are comparable over time, seasons and locations. The main assumption is that the removal trapping (i.e. kill traps being used) will not be affected by immigration. This is not usually a problem when the trapping is only run for over a few nights (usually three).

To determine impact of rats on shearwaters, index trapping grids were established in three areas; (i) where no shearwaters were present (NS); (ii) where shearwaters were present, but not being monitored for breeding success (SNS); and (iii) where shearwaters were present and were being monitored for breeding success (SS). These three grids were established on Hallival in September and October 2006. In addition, a further trapping grid was established on Askival in the shearwater monitoring area in March 2007. This was to enable comparison between two main Manx shearwater colony sites.

Monitoring points were also used next to the trap sets to obtain an additional index of abundance which can be compared with the trapping grids as well as detect trap-shy individuals. Monitoring can detect and monitor changes of activity (Quy *et al.*, 1993) and is comparable with tracking tunnels and trapping indexes (Blackwell *et al.*, 2002, Brown *et al.*, 1996).

Indices of Abundance were calculated as the whole area covered by each grid (i.e. a single figure per site) and a colony as a whole (with Askival compared to Hallival). Rat captures were mapped within the colonies and was related to site, habitat and burrow (both shearwater and rat) location.

The grids were 100 metres by 200 metres. Two Trapper T-Rex® traps (or a single monitoring point) were set at each site (i.e. the traps were set back to back) and the sets were 25 metres apart (Figure 1); 45 trap sets per grid (90 traps or 45 monitoring points).

Figure 1 Example of trap set used on Isle of Rum



Trap sets locations were marked by a numbered wooden stake (Figure 1). Traps were tied to the wooden stake to prevent rats (or deer or goats) from removing the traps. The traps were covered with wire mesh to prevent birds gaining access to the traps and being accidentally caught (as recommended by Weihong *et al.*, 1999). Traps are baited with a mixture of peanut butter and rolled oats (mixed into a thick paste).

The monitoring points were a piece of chocolate wax (candle wax containing cocoa powder). Monitoring points were secured to the ground by a piece of wire. The number of the monitoring point corresponded to the trap set number.

Traps and/or monitoring were run for between one and five nights at about the same time each month depending on weather (Figure 2).

Figure 2 **Number of trapping and/or monitoring nights at each site between September 2006 and March 2010**

Month and Year	Number of nights	
	Hallival	Askival
September 2006	2	-
October 2006	1	-
November 2006	2	-
January 2007	2	-
April 2007	2	3
May 2007	3	3
June 2007	3	3
July 2007	3	3
August 2007	3	3
September 2007	3	2
October 2007	4	4
February 2008	4	-
March 2008	2	-
April 2008	5	5
May 2008	3	3
August 2008	3	3
September 2008	5	2
October 2008	3	-
May 2009	3	3
June 2009	4	4
July 2009	2	2
August 2009	2	2
September 2009	1	1
October 2009	4	4
March 2010	3	-

All rats caught in the trapping grid were dissected. Morphometric data such as head-body length, tail length, ear size, foot size (with and without claw) and weight were taken. Breeding status, age, body condition and stomach contents were also examined.

General observations of rat activity and burrow locations within the study area (including predation events) were recorded.

5 RESULTS

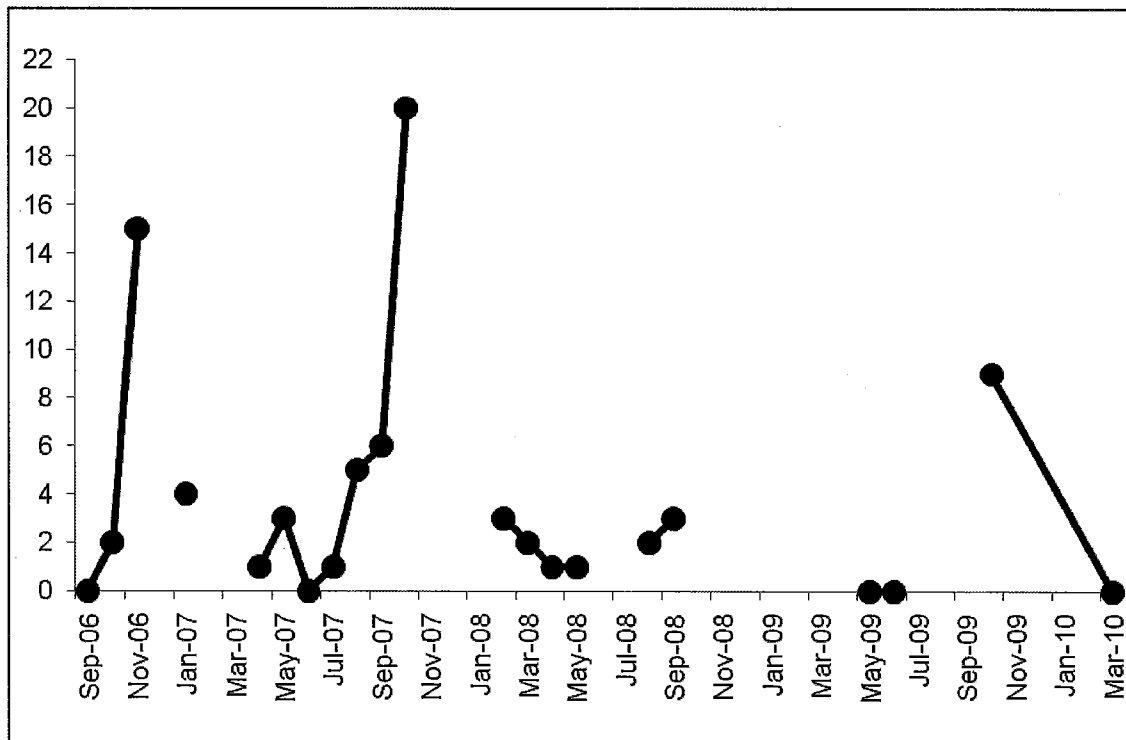
There have been 78 rats caught in traps at the Rum Manx shearwater colony sites between September 2006 and March 2010 (Figure 3). Of these, 59 were caught on Hallival and 19 were caught on Askival (Figure 3).

Figure 3 Total numbers, sex and age of rats caught on Hallival and Askival between September 2006 and March 2010

Area	Total	Unknown	Juveniles	Adults	Males	Females	Pregnant	Lactating
Hallival	59	12	1	56	25	15	3	3
Askival	19	4	0	15	6	7	3	2
TOTAL	78	16	1	71	32	22	6	5

Figure 4 shows the total number of rats caught per month on Rum; there is a distinct pattern of capture, with the rate of capture increasing over winter and decreasing in summer. The pattern is almost identical when each trapping grid is treated separately.

Figure 4 Total numbers of rats caught per trapping session on Rum between September 2006 and March 2010

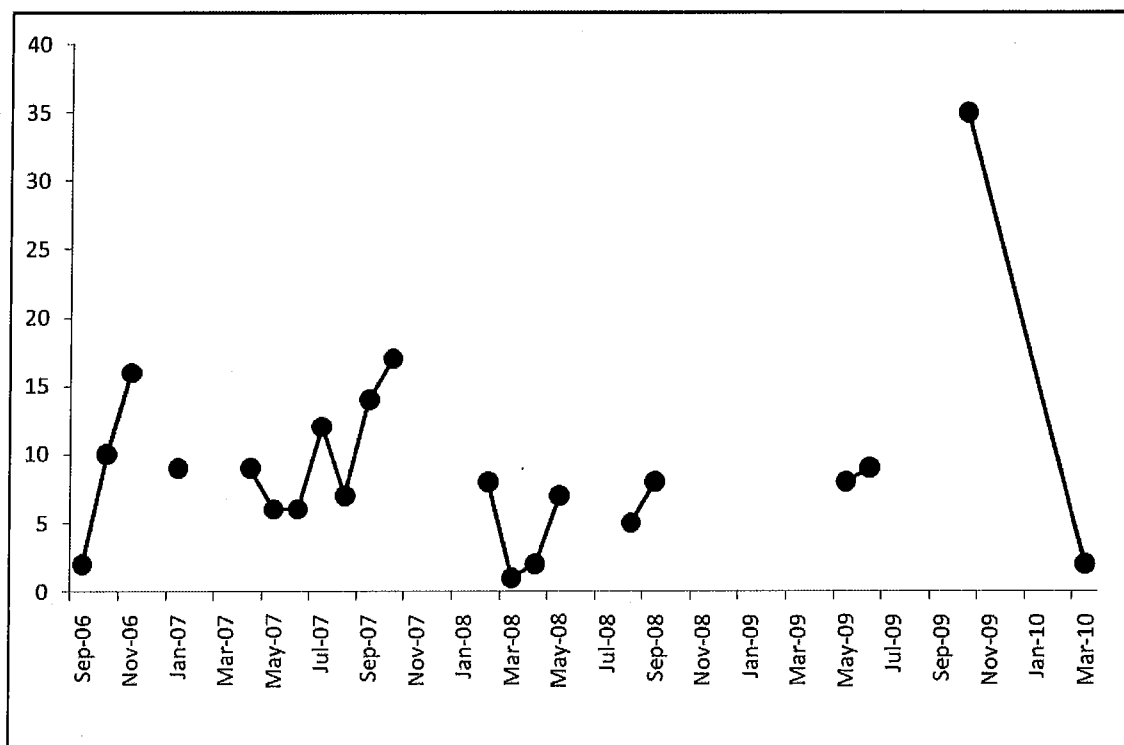


It is interesting that there were good levels of rat captures in September through to November most years which may relate to the presence of late-fledging shearwaters and availability of scavenging dead chicks and abandoned eggs. However more recently rat captures have reduced and rat activity has been limited during winter months. This was probably due to the extremely poor weather in winter with heavy snow (which remained on the ground from several weeks). It should also be noted that trapping may have reduced the number of rats in the area, which would reduce the probability of captures.

Although rat captures were reduced over winter, rat activity was recorded in during summer months (i.e. droppings and tracks) with much higher rat activity noted in during August through to September (i.e. very obvious with droppings, tracks and scavenged food visible in all areas). Overall rat sign has decreased in many parts of the Hallival shearwater colony areas, but was still being noted in some nearby locations and near the hut (pers. obs.). Rats are still being caught at the hut site (pers. obs.), despite less captures at the shearwater colony. Rat sign was noted in areas between the colonies, and this means rats are still present on the mountain.

The number of wood mice captures is shown in Figure 5. Similar to the rat trapping results, this also shows a cyclic pattern of captures with more mice caught in autumn and winter months and mice being caught every month of trapping.

Figure 5 Total numbers of wood mice caught per trapping session on Rum between September 2006 and March 2010



The number of rats and wood mice caught at each of the Hallival and Askival trapping grids is given in Figure 6. Most rats were caught in the area with no shearwaters present (37%). Although mice were caught in all trapping sessions (although not necessarily at all trapping grids), the most wood mice were also caught in the area with no shearwaters present (31%), but the area with shearwaters present also had 30% of the total wood mice caught.

Figure 6 *Number of rats and wood mice caught at the Hallival (HSS, HSNS, HNS) and Askival (ASK) trapping grids between September 2006 and March 2010*

	HSS		HSNS		HNS		ASK	
	Rats	Mice	Rats	Mice	Rats	Mice	Rats	Mice
Sept 2006	0	1	0	1	-	-	-	-
Oct 2006	0	4	2	6	-	-	-	-
Nov 2006	7	4	3	2	5	10	-	-
Jan 2007	1	1	2	3	1	5	-	-
Apr 2007	0	4	0	3	1	2	0	0
May 2007	1	0	0	0	1	1	1	5
Jun 2007	0	0	0	4	0	1	0	1
July 2007	0	1	0	3	0	5	1	3
Aug 2007	0	4	2	1	1	1	2	1
Sept 2007	0	4	0	2	2	6	4	2
Oct 2007	7	6	1	1	3	7	9	3
Feb 2008	0	3	0	3	3	2	-	-
Mar 2008	0	1	0	0	2	0	-	-
Apr 2008	0	2	0	0	1	0	0	0
May 2008	0	0	0	1	1	3	0	3
Aug 2008	1	1	0	3	1	1	0	0
Sept 2008	1	6	0	0	2	2	0	0
Oct 2008	7	6	1	1	3	7	9	3
May 2009	0	4	-	-	0	4	-	-
Jun 2009	0	0	0	0	0	2	0	7
Oct 2009	0	15	2	9	5	11	2	18
Mar 2010	0	0	0	0	0	2	-	-
TOTAL	18	61	12	42	29	65	19	43
%	23	29	15	20	37	31	24	20

Figure 7 shows the total numbers of adults, juveniles or unknown age rats caught in each area and Figure 8 shows the total numbers of males and females or unknown sex of rats caught in each area.

Despite 20% of the rats being in decomposed or damaged condition (unable to confirm sex and obtain stomach contents); adult rats were most commonly caught (70%) over the whole area.

On Hallival, almost all rats were adults (63%, or 98% of all rats caught on Hallival) and 32% were males (or 62.5% of confirmed sex, Figures 7 and 8).

On Askival, again most rats were adults (17%, or 100% of all rats caught on Askival), but there was an even number of males and females (Figure 7).

Figure 7 *Total numbers of adults, juveniles and unknown rats caught on Rum between September 2006 and March 2010*

Month	Total		Unknown		Juvenile		Adult	
	Hallival	Askival	Hallival	Askival	Hallival	Askival	Hallival	Askival
Sept 2006	0	-	0	-	0	-	0	-
Oct 2006	2	-	0	-	1	-	1	-
Nov 2006	15	-	0	-	0	-	15	-
Jan 2007	4	-	0	-	0	-	4	-
Apr 2007	1	0	0	0	0	0	1	0
May 2007	2	1	0	0	0	0	2	1
Jun 2007	0	0	0	0	0	0	0	0
July 2007	0	1	0	1	0	0	0	1
Aug 2007	3	2	3	2	0	0	3	2
Sept 2007	2	4	0	0	0	0	2	4
Oct 2007	11	8	2	1	0	0	9	7
Feb 2008	3	-	3	-	0	-	3	-
Mar 2008	2	-	1	-	0	-	2	-
Apr 2008	1	0	0	0	0	0	1	0
May 2008	1	0	0	0	0	0	1	0
Aug 2008	2	0	0	0	0	0	2	0
Sept 2008	3	0	0	0	0	0	3	0
May 2009	0	-	0	-	0	-	0	-
June 2009	0	0	0	0	0	0	0	0
Oct 2009	7	2	0	0	0	0	7	2
Mar 2010	0	0	0	0	0	0	0	0
TOTAL	59	19	10	4	1	0	49	15
% total captures	76	24	14	5	1	0	63	17
% total known age					2	0	98	100

Figure 8 Total numbers of male, females or unknown rats caught on Rum between September 2006 and March 2010

Month	Total		Unknown		Male		Female	
	Hallival	Askival	Hallival	Askival	Hallival	Askival	Hallival	Askival
Sept 2006	0	-	0	-	0	-	0	-
Oct 2006	2	-	0	-	1	-	1	-
Nov 2006	15	-	0	-	10	-	5	-
Jan 2007	4	-	0	-	2	-	2	-
Apr 2007	1	0	0	0	1	0	0	0
May 2007	2	1	0	0	2	0	0	1
Jun 2007	0	0	0	0	0	0	0	0
July 2007	0	1	0	1	0	-	0	-
Aug 2007	3	2	3	2	0	-	0	-
Sept 2007	2	4	0	0	2	2	0	2
Oct 2007	11	8	2	1	5	4	4	3
Feb 2008	3	-	3	-	0	-	0	-
Mar 2008	2	-	1	-	0	-	1	-
Apr 2008	1	0	0	0	0	0	1	0
May 2008	1	0	1	0	0	0	0	0
Aug 2008	2	0	2	0	0	0	0	0
Sept 2008	3	0	0	0	2	0	1	0
May 2009	0	-	0	-	0	-	0	-
June 2009	0	0	0	0	0	0	0	0
Oct 2009	7	2	7	2	-	-	-	-
Mar 2010	0	0	0	0	0	0	0	0
TOTAL	59	19	19	6	25	6	15	6
%	76	24	24	8	32	8	19	8
% of known sex					62.5	50	37.5	50

The breeding condition of the females is shown in Figure 9. There were 52 rats that could be necropsied and sex confirmed. Only 15 confirmed females were caught on Hallival and 6 confirmed females caught on Askival.

Of these confirmed 21 females, 40% were pregnant and 20% were lactating (i.e. feeding young) on Hallival and 50% were pregnant on Askival and 33% were lactating (Appendix 8.1).

Lactating and/or pregnant rats were caught in March, April, May, June, July, August, September, October and November (Appendix 8.1). This means that the rats on Rum are likely to be breeding most of the year round.

Figure 9 Total numbers of pregnant or lactating female rats caught on Rum between September 2006 and March 2010

Month	Total		Female		Pregnant		Lactating	
	Hallival	Askival	Hallival	Askival	Hallival	Askival	Hallival	Askival
Sept 2006	0	-	0	-	0	-	0	-
Oct 2006	2	-	1	-	0	-	1	-
Nov 2006	15	-	5	-	1	-	1	-
Jan 2007	4	-	2	-	0	-	0	-
Apr 2007	1	0	0	0	0	-	0	-
May 2007	2	1	0	1	0	0	0	1
Jun 2007	0	0	0	0	0	0	0	0
July 2007	0	2	0	-	0	-	0	-
Aug 2007	3	2	0	-	0	-	0	-
Sept 2007	2	4	0	2	0	1	0	1
Oct 2007	11	8	4	3	1	1	3	1
Feb 2008	3	-	0	-	0	-	0	-
Mar 2008	2	-	1	-	1	-	0	-
Apr 2008	1	0	1	0	0	-	0	-
May 2008	1	0	0	0	0	-	0	-
Aug 2008	2	0	0	0	0	-	0	-
Sept 2008	3	0	1	0	0	-	1	-
May 2009	0	-	0	-	0	-	0	-
June 2009	0	0	0	0	0	0	0	0
Oct 2009	7	2	-	-	-	-	-	-
Mar 2010	0	0	0	0	0	0	0	0
TOTAL	59	19	15	6	3	2	6	3
% of total captures	76	24	19	8	4	3	8	4
% of female captures					20	33	40	50

Rat measurements showed that males were generally larger than females (Figure 10, Appendix 8.1).

The mean weight of all rats is $262.5\text{g} \pm 12\text{g}$ ♂ $283\text{g} \pm 16\text{g}$ and ♀ $235\text{g} \pm 16\text{g}$ and the mean head/body length (not including tail) is $200\text{mm} \pm 3\text{mm}$ (♂ $205\text{mm} \pm 4\text{mm}$ and ♀ $192\text{mm} \pm 6\text{mm}$, Figure 10). Male measurements for ear and foot were also on average larger than females (Figure 10).

The largest male rat weighed 430 g and the largest female weighed 405 g and the average weight was (Figure 10).

Figure 10 *Weights (g) and measurements (mm) of adult rats caught and necropsied on Rum between September 2006 and March 2010*

Sex	Weight	HBL	Tail	HF (R)	HF (without claw)	Ear (R)
female	280	195	186	42	39	18
female	160	177	155	41	38	18
female	190	184	158	42	39	18
female	210	195	160	42	39	17
female	195	182	174	44	41	18
female	250	201	179	45	43	17
female	181	181	168	38	35	14
female	197	188	179	40	38	15
female	280	203	180	42	39	15
female	235	194	173	42	39	16
female	255	205	172	43	40	15
female	405	221	184	42	39	15
female	180	179	164	40	38	16
female	275	199	178	42	39	
female	275	216	188	41	38	18
female	290	213	158	40	37	
female	50	100	85	31	29	17
female	190	180	155	37	34	17
female	300	209	167	40	37	15
female	200	188	153	40	37	15
female	330	225	193	43	40	18
AVERAGE	235 ± 16	192 ± 6	167 ± 5	41 ± 0.6	38 ± 0.6	16 ± 0.3
male	190	176	166	42	39	16
male	410	241	191	47	44	19
male	280	219	180	42	39	19
male	225	191	172	41	38	12
male	225	193	162	42	40	11
male	405	241	161	40	37	20
male	175	175	170	43	42	18
male	430	221	203	46	45	20
male	300	212	184	47	44	19
male	300	215	196	47	43	19
male	213	181	175	43	40	16
male	141	156	153	39	37	15
male	186	197	156	42	39	16
male	270	197	171	40	37	15
male	345	218	172	43	40	17
male	220	208	167	42	39	12
male	210	188	174	45	42	18
male	290	215	168	42	40	17
male	313	208	171	45	41	17
male	425	232	193	46	43	18
male	360	227	180	46	44	19
male	325	219	186	46	44	15
male	210	200	163	40	38	
male	225	188	179	44	41	17
male	350	216	180	48	45	16
male	200	183	163	40	38	14
male	410	236	183	43	41	18
male		193	156	41	38	16
male		181	173	43	41	17
male	225	195	165	45	43	
male	340	223	176	41	37	21
AVERAGE	283 ± 16	205 ± 4	174 ± 2	43 ± 0.5	40 ± 0.5	17 ± 0.5
TOTAL	263 ± 12	200 ± 3	171 ± 2	42 ± 0.4	40 ± 0.4	17 ± 0.3

In addition to total captures of rats as shown in Figure 4, indices of abundance were calculated for all capture periods and range from 0 rats per 100 trap nights to 4.2 rats per 100 trap nights on Hallival and between from 0 rats per 100 trap nights to 2.8 rats per 100 trap nights on Askival (Figure 11).

The highest index of abundance was for the HSS grid within the Hallival shearwater study area during November 2006 and the highest index of abundance for Askival was 2.8 rats per 100 trap nights during October 2007 (Figure 11). Overall, Hallival has had the highest index of abundance. When the three Hallival trapping grids are treated as one area, the trend is similar with higher indices of abundance in autumn and winter.

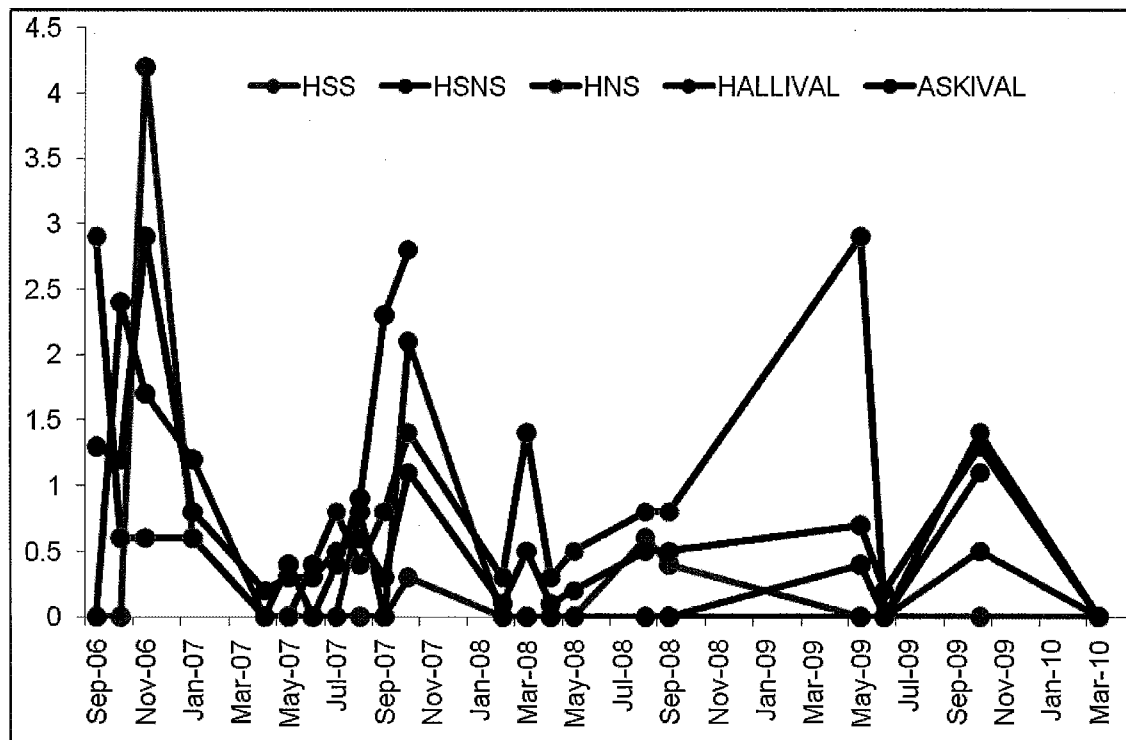
Figure 11 Indices of Abundance (captures per 100 trap nights) for all trapping grids on Rum between September 2006 and March 2010

Dates	HALLIVAL				ASKIVAL
	SS	SNS	HNS	Total	
Sept 2006	0	0	2.9	1.3	-
Oct 2006	0	2.4	0.6	1.2	-
Nov 2006	4.2	1.7	0.6	2.9	-
Jan 2007	0.6	1.2	0.6	0.8	-
Apr 2007	0	0	0	0.2	0
May 2007	0.4	0	0	0.3	0.4
Jun 2007	0	0	0.4	0.3	0
July 2007	0	0	0.8	0.5	0.4
Aug 2007	0	0.8	0.4	0.6	0.9
Sept 2007	0	0	0.8	0.3	2.3
Oct 2007	0.3	2.1	1.4	1.1	2.8
Feb 2008	0	0	0.3	0.1	-
Mar 2008	0	0	1.4	0.5	-
Apr 2008	0	0	0.3	0.1	0
May 2008	0	0	0.5	0.2	0
Aug 2008	0.6	0	0.8	0.5	0
Sept 2008	0.4	0	0.8	0.5	0
May 2009	0	0	2.9	0.7	0.4
Jun 2009	0	0	0	0.2	0
Oct 2009	0	0.5	1.4	1.3	1.1
March 2009	0	0	0	0	-

An index of 4 or more captures is usually interpreted as low to moderate (or medium) density of rats at the site. The Hallival HSS grid had the highest index of abundance (4.2 rats per 100 trap nights in November 2006) which is interpreted as medium (to low) density of rats. When Hallival is treated as one entire area (results from all three grids used to calculate an index) the highest index of abundance is 2.9 rats per 100 trap nights, also from November 2006. This is usually interpreted as a low density of rats at the site.

Figure 12 shows the trend in the Index of Abundance figures suggesting that there are higher rat numbers during winter. Again, this may be related to “trap-ability” (i.e. rats more likely to go for “alternative food” in the traps as there is little natural food around the area) rather than actual numbers of rats. It should also be noted that as rats are trapped out of an area, the trapping level reduces, resulting in lower indices of abundance. This is also evident in Figure 12 as the overall trend in the indices of abundance lowers over the four year trapping period.

Figure 12 Index of abundance for all trapping grids (ASK, HSS, HNS, HSNS and Hallival as whole) between September 2006 and March 2010



Monitoring for rat activity (using visual points, tracking plates or chocolate wax blocks) was used in each of the four grid sites to determine rat presence or absence, rat movement and densities within the area (as a comparison with, and in addition to the trapping index) during the summer (July and August) months (as well as other occasions throughout the year) without requiring the use of traps).

Monitoring showed varying levels of rat and mouse activity throughout the year and that rats were present at the colony without being caught in traps, particularly in summer (Figure 13). However, the level of rat activity appeared to vary throughout the year; this shows it is important to use a variety of monitoring tools and techniques to detect rat presence or absence.

Figure 13 Comparison of rat monitoring and rat trapping results on Rum between September 2006 and March 2010
 Where rat sign: = 1 block or rat ■= 2 blocks or rats ■= 3 blocks or rats ■= 4 blocks or rats

HALLIVAL – SHEARWATER STUDY (HSS)
 Chocolate monitoring for rats

45	44	43	42	41	40	39	38	37
28	29	30	31	32	33	34	35	36
27	26	25	24	23	22	21	20	19
10	11	12	■	14	15	16	17	18
9	8	7	6	5	4	3	2	1

HALLIVAL – SHEARWATER STUDY (HSS)
 Trapping for rats

45	44	43	42	41	40	39	38	■
28	29	30	31	32	33	34	35	36
27	26	25	24	23	22	■	■	19
10	11	12	13	14	15	16	17	18
9	8	7	6	5	4	3	2	■

HALLIVAL – SHEARWATER NON-STUDY (HSNS)
 Chocolate monitoring for rats

90	89	88	87	86	85	84	83	82
73	74	75	76	77	78	79	80	81
72	71	70	69	68	■	66	65	64
55	56	57	■	■	60	61	62	63
54	53	52	51	■	49	48	47	46

HALLIVAL – SHEARWATER NON-STUDY (HSNS)
 Trapping for rats

90	89	88	87	86	85	84	83	82
73	74	75	76	77	78	79	80	81
72	71	70	69	68	67	66	■	64
55	56	57	58	59	■	61	62	63
54	53	52	51	50	49	48	47	46

HALLIVAL – NO SHEARWATERS (HNS)

Chocolate monitoring for rats

135	134	133	132	131	130	129	128	127
118	119	120		122	123	124	125	126
117	116	115		113	112	111	110	109
100	101	102	103	104	105	106	107	108
99	98	97	96	95		93	92	91

HALLIVAL – NO SHEARWATERS (HNS)

Trapping for rats

135	134	133	132		130		128	127
118	119	120	121	122	123	124	125	126
117		115	114	113	112	111	110	109
100	101	102	103	104	105	106	107	108
99	98	97	96			93	92	

ASKIVAL – SHEARWATER STUDY (ASK)

Chocolate monitoring for rats

	179	178	177	176	175	174	173	172
	164	165	166	167	168	169	170	171
162	161	160	159	158			155	154
145		147	148	149	150	151	152	153
144	143	142	141	140	139	138	137	136

ASKIVAL – SHEARWATER STUDY (ASK)

Trapping for rats

	179	178	177	176	175	174	173	172
163	164	165	166	167	168	169	170	171
162	161	160	159	158	157	156	155	154
145	146	147	148	149	150	151	152	153
144	143	142	141		139	138	137	136

Figure 14 Comparison of wood mouse monitoring and trapping results on Rum between September 2006 and March 2010
Where mice sign: □ = 1 block or mouse ■ = 2 blocks or mice ■ = 3 blocks or mice ■ = 4 blocks or mice

HALLIVAL - SHEARWATER STUDY (HSS)

Chocolate monitoring for mice

45	44	43	42	41	40	39	■	37
28	■	30	■	32	33	34	■	36
27	■	■	■	23	22	■	20	19
10	■	■	13	■	15	16	17	18
■	■	7	6	5	4	3	2	1

HALLIVAL - SHEARWATER STUDY (HSS)

Trapping for mice

45	44	43	42	41	40	■	38	37
28	29	30	■	32	33	■	35	36
27	26	■	■	23	22	21	20	■
10	11	12	13	14	15	16	■	■
■	■	7	6	5	■	3	2	1

HALLIVAL - SHEARWATER NON-STUDY (HSNS)

Chocolate monitoring for mice

90	89	88	87	86	■	84	83	82
73	74	75	76	77	78	79	80	81
■	■	70	69	68	■	■	■	64
■	■	57	58	■	■	61	62	63
54	■	52	■	50	49	48	47	46

HALLIVAL - SHEARWATER NON-STUDY (HSNS)

Trapping for mice

■	89	88	87	86	85	84	83	82
73	74	75	76	77	78	79	80	81
72	■	■	■	68	67	66	65	64
55	■	■	■	■	60	61	62	63
54	■	52	51	50	49	48	47	46

HALLIVAL – NO SHEARWATER (HNS)

Chocolate monitoring for mice

135	134	133		131	130	129	128	127
118				122	123	124	125	126
							110	109
100			103	104		106		
99		97	96			93	92	91

HALLIVAL – NO SHEARWATER (HNS)

Trapping for mice

	134	133		131			128	127
118	119	120	121		123	124	125	126
117	116	115		113	112		110	
		102		104	105	106		108
		97	96			93		

ASKIVAL (ASK)

Chocolate monitoring for mice

	179	178	177	176	175	174	173	172
163		165		167	168	169	170	171
	161		159	158		156		154
			148				152	153
				140	139		137	136

ASKIVAL (ASK)

Trapping for mice

180	179	178	177	176	175	174	173	
163	164	165	166	167	168	169	170	171
162		160	159	158	157			154
		147	148	149	150			
144		142		140	139	138	137	

Comparison of chocolate monitoring and trapping results shows the range of rats in the shearwater areas (Figure 13). Rat sign (predation evidence, droppings, fur, trails etc.) was also noted in the area at various times throughout the monitoring period. Mice were also detected in all grids throughout the year (Figure 14). Despite rats being detected infrequently on the chocolate wax monitoring over summer months (particularly June and July), definite rat sign (i.e. droppings, chews, predation on Manx shearwater eggs and chicks etc.) was recorded at both the Hallival and Askival colonies.

Rat sign and activity was recorded at the shearwater colonies with rat predated or scavenged eggs, chicks and adults being found (Figure 15). Moderate levels of rat predation on Manx shearwaters were recorded from the stomach contents of trapped rats (Appendix 8.1). Of the necropsied rats, 7% contained evidence of live shearwater chick predation, 2% containing evidence of live-egg predation and 4% containing evidence of predation of live adult shearwaters (Figure 16). This was especially evident in the rats trapped at Askival during 2007; three of the four rats caught in September and six of the eight rats caught in October had evidence of eating live shearwater chicks (Appendix 8.1). In addition, 44% of necropsied rats had evidence of scavenging dead shearwater chicks and 13% had evidence of scavenged eggs (Figure 16).

Figure 15 Rat predation on a Manx Shearwater chick (Askival colony) in July 2008



Natural food levels available to the rats (i.e. eggs, seeds, vegetation, dead animals and birds etc.) in autumn and winter were much lower than in spring and summer. Rats will always prefer natural food and may remain suspicious of “unnatural or alternative food” (such as bait, lures on traps or monitoring chocolate). Of all the necropsied rats, 78% had natural food in their stomachs which included seeds (58%), vegetation (69%) and insects (60%, Figure 16).

Evidence of rats predated wood mice was also recorded, with 19% of necropsied rat stomach contents containing evidence of wood mice (i.e. fur, blood, bones, etc., Figure 16). At least two samples found in the rat stomachs were from wood mice that were scavenged out of the traps (Appendix 8.1).

Figure 16 Stomach contents of 52 adult rats caught on Rum between September 2006 and March 2010

No.	DEAD CHICK	LIVE CHICK	LIVE ADULT	DEAD EGG	LIVE EGG	FEATHERS	FLESH	BONE	FUR	BLOOD	SEEDS	VEGETATION	INSECTS	FISH
Females (n=21)	15	3	0	12	3	21	10	11	7	7	14	17	18	3
Males (n=31)	10	2	2	5	1	30	19	19	7	14	16	19	13	0
TOTAL (n=52)	25	5	2	17	4	51	29	30	14	21	30	36	31	3
%	48	10	4	33	8	98	56	58	19	40	58	69	60	6

The stomach contents may relate to the time of capture as more rats were caught in autumn and winter when the presence of late-fledging shearwaters and availability of scavenging dead chicks and abandoned eggs would be attractive food sources for rats.

6 CONCLUSION

The trapping programme on Rum has produced a number of interesting results and clarified whether rats are present at the colony sites throughout the year. Although the number of rats trapped varied throughout the year, with increased numbers of rats trapped in autumn and winter (August through to February), it was apparent that rats are present at the Manx shearwater colonies throughout the year. Low trapping levels may relate to the availability of natural food and increased difficulty of trapping in summer.

It is interesting that there were good levels of rat captures in September through to November most years which may relate to increased pressure for food and the presence of late-fledging shearwaters and availability of scavenging dead chicks and abandoned eggs.

However more recently overall rat captures have reduced and rat activity has been limited at the colonies. This may be due to the extremely poor weather in winter with heavy snow (which remained on the ground from several weeks). It should also be noted that trapping may have reduced the total number and range of rats in the area, which would reduce the probability of captures. It is important to continue to monitor the number, range and density of rats on Rum, particularly at the Manx shearwater colonies.

Although rat captures were reduced, rat activity was recorded during the year (i.e. droppings and tracks) with much higher rat activity noted in during August through to September (i.e. very obvious with droppings, tracks and scavenged food visible in all areas). Overall rat sign has decreased in many parts of the Hallival shearwater colony areas, but was still being noted in some nearby locations and near the hut (pers. obs.). Rats are still being caught at the hut site (pers. obs.), despite less captures at the shearwater colony. Rat sign was noted in areas between the colonies, and this means rats are still present on the mountain.

The Indices of Abundance at both Hallival and Askival show that the densities of rats at the shearwater colonies on Rum are at low to medium levels. The densities were higher during the autumn and winter months and dropped over summer, however this was likely to be

related to "trap-ability" and food availability (i.e. rats more likely to go for "alternative food" in the traps as there is little natural food around the area) rather than actual numbers of rats or rat behaviour.

Reduced trapping of rats may relate to the previous trapping impacting on the number of rats in the area and overall suspicion of the traps (particularly those which have to be replaced after deer or goat damage). The use of the chocolate wax has helped to detect the presence of rats when trapping was less effective.

Chocolate wax monitoring showed that rats were present at the colony throughout the year with teethmarks recorded on wax each month. Rat sign (predation evidence, droppings, fur, trails etc.) was also noted at the shearwater colonies (and wider area of the mountains) at various times throughout the year. Mice were also detected in all monitoring grids throughout the year. It appeared that the rats were foraging on natural resources rather than the chocolate wax or entering traps through summer, and that detection (of rat presence) must also be monitored by using observations on natural feeding events or other sign (droppings, tracks, fur etc.) as well as other practises and techniques (e.g. soap, wax, tracking plates etc.).

Interestingly despite there being low number of rats at the Manx shearwater colonies, they were having an impact on the productivity of the shearwaters (i.e. fledging chicks) as well as adult shearwaters. Recently productivity (chicks fledged from eggs laid) has increased in areas where trapping has been completed (A.D.K. Ramsay, pers. obs.). This shows that it is important to maintain some level of control at the colony sites, particularly prior to the shearwater breeding season. As rats appear to be more attracted to "alternative" food in autumn and winter, control (i.e. a localised poisoning campaign) should be undertaken at this time. It would be best to ensure the bait is in bait stations and these stations could be filled with poison in February through to April and again from August through to November.

Rodent eradications are becoming a valuable tool for restoration of island ecosystems, in particular seabird colonies (Atkinson, 1985; Towns *et al.*, 2006; Jones *et al.*, 2007). Rodents have been successfully eradicated from islands ranging in size from 1 to 11,200 ha throughout the world. The majority however, have been conducted in New Zealand where the technique was first developed; methods range from ground-based (bait station or hand spreading) to aerial broadcasting operations, and in some cases a combination of these methods.

The successful eradication of rats (either one species or a combination of brown and ship rat) from Ailsa Craig (100 ha; Zonfrillo, 2001, 2002), Ramsey Island (256 ha; Bell *et al.*, 2000), Lundy Island (500 ha; Bell, 2004) and Canna (1300 ha; Bell *et al.*, 2006), demonstrates how these techniques, difficulties, requirements and solutions of ground-based poisoning operations can be utilised successfully on islands around the UK and Europe.

Rats are known seabird predators (Moors & Atkinson, 1984) and this project was developed to investigate whether the brown rats on Rum were having an impact on the Manx shearwaters breeding on the island. This work has confirmed that brown rats have an impact on the internationally important Manx shearwater colony on Rum. As such it should be a priority to investigate the feasibility of an island-wide eradication. A detailed feasibility investigation covering all aspects of an eradication including (but not restricted to) non-target species, technical requirements and difficulties, interested parties, community involvement and liaison, governmental department involvement, legalities, infrastructure, transport, logistics, personnel, bait options, timing and funding should be commissioned.

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8 APPENDICES

8.1 Necropsy data from rats caught on Rum between September 2006 and March 2010

No.	TRAP	DATE OF CAPTURE	DATE OF DISSECTION	SEX	AGE	WGT (g)	HBL (mm)	TAIL (mm)	HF (right) (mm)	HF (right) (no claw) (mm)	EAR (right) (mm)	BELLY COLOUR	NOTES	STOMACH CONTENTS
1	61a	14/10/06	16/10/06	male	juvenile	120	157	117	38	35	12	grey	scavenging dead chick	fur; worms; insects; blood; seeds; feathers; downy feathers (Manx shearwater)
2	65a	14/10/06	16/10/06	female	adult	280	195	186	42	39	18	light grey	lactating; 10 nipples; recently given birth, scavenged dead chick	feathers; down; seeds; flesh; grit (bone fragments?)
3	105b	2/11/06	8/11/06	male	adult	190	176	166	42	39	16	light grey	not in breeding condition	slugs; vegetation; seeds; feathers
4	21a	2/11/06	8/11/06	male	adult	410	241	191	47	44	19	cream	discoloured liver; old rat	grass; seeds; fur; vegetation
5	22b	2/11/06	8/11/06	female	adult	160	177	155	41	38	18	medium grey	coming into season (swollen left ovaries, slightly swollen right ovaries); scavenged dead chick	slugs; down; feathers; vegetation; seeds; grit; insects
6	36a	2/11/06	8/11/06	female	adult	190	184	158	42	39	18	light grey	coming into season	vegetation; slugs; seeds; insects; fur

7	37a	2/11/06	8/11/06	female	adult	210	195	160	42	39	17	light grey	swollen ovaries (well developed and blood vessels to uterus); eaten mouse in trap 82b; scavenged dead chick	fresh flesh; blood; fur; vegetation; slugs; skin; feathers; seeds; insects
8	52b	2/11/06	8/11/06	male	adult	280	219	180	42	39	19	medium grey	scavenged dead egg and dead chick	rotten egg (half grown embryo); bone fragments; feathers; skin
9	65a	2/11/06	8/11/06	male	adult	225	191	172	41	38	12	light grey	not in breeding condition, scavenged dead egg and chick	seeds; egg shell (rotten egg); feathers; vegetation, grit, bone fragments
10	68b	2/11/06	8/11/06	male	adult	225	193	162	42	40	11	light grey	not in breeding condition; scavenged dead chick	feathers; blood, bone
11	91b	2/11/06	8/11/06	male	adult	405	241	161	40	37	20	light grey	scavenged dead chick	feathers; down; skin; bone fragments; slugs; fur; seeds; vegetation
12	131a	3/11/06	8/11/06	male	adult	175	175	170	43	42	18	medium grey	scavenged dead egg	egg shell; few feathers; seeds; maggot
13	131b	3/11/06	8/11/06	female	adult	195	182	174	44	41	18	medium grey	scavenged dead chick	feathers; bone fragments; peanut butter
14	1a	3/11/06	8/11/06	male	adult	430	221	203	46	45	20	light grey	in good condition	vegetation; slugs; bone fragments; seeds
15	37b	3/11/06	8/11/06	female	adult	250	201	179	45	43	17	medium grey	lactating; very early pregnancy (10 pups), scavenged dead egg	few feathers; bone fragments; vegetation; earthworms; insects; slugs

16	44a	3/11/06	8/11/06	male	adult	300	212	184	47	44	19	light grey	scavenged dead chick	small bones; slugs; seeds; maggots (12); feathers
17	94a	3/11/06	8/11/06	male	adult	300	215	196	47	43	19	cream	scavenged dead chick	feathers; bone fragments; skin; slugs
18	60b	26/01/07	23/09/07	male	adult	213	181	175	43	40	16	greyish cream	medium testes	full; grass, peanut butter
19	98b	26/01/07	23/09/07	female	adult	181	181	168	38	35	14	cream	coming into breeding condition	slugs, peanut butter
20	1b	27/01/07	23/09/07	female	adult	197	188	179	40	38	15	cream	coming into breeding condition, scavenged dead chick	blood, fur, flesh, feathers, small bones, seeds, vegetation
21	71b	27/01/07	23/09/07	male	adult	141	156	153	39	37	15	cream	medium testes	slugs, peanut butter, vegetation, seeds
22	95a	14/04/07	23/09/07	male	adult	186	197	156	42	39	16	cream	medium testes	slugs, peanut butter, grass, seeds
23	111a	22/05/07	23/09/07	male	adult	270	197	171	40	37	15	cream	medium testes; eaten live adult	feathers, flesh, blood, bones
24	13a	24/05/07	23/09/07	male	adult	345	218	172	43	40	17	grey	large testes, eaten live egg (embryo)	full; egg shell; feathers; flesh, blood, bones
25	163a	25/05/07	23/09/07	female	adult	280	203	180	42	39	15	cream	lactating (6 nipples), recently given birth	cheese, fur, small bones, vegetation, seeds
26	127a	22/08/07	23/09/07	male	adult	220	208	167	42	39	12	cream	medium testes, eaten live adult	feathers, flesh, blood, bones
27	125b	26/09/07	27/09/07	male	adult	210	188	174	45	42	18	grey	eaten wood mouse caught in trap (92a)	wood mouse; fur; flesh; blood; bones; vegetation
28	152a	26/09/07	27/09/07	female	adult	235	194	173	42	39	16	grey	very good condition (lots of body fat); eaten shearwater regurgitation	fish; oil; (shearwater regurgitation); slugs; grass

29	129b	27/09/07	28/09/07	male	adult	290	215	168	42	40	17	greyish cream	old wound on hind; reasonable condition; scavenged dead chick	down, pinning feathers; "old" flesh; grass; seeds
30	136b	27/09/07	28/09/07	female	adult	255	205	172	43	40	15	cream	very good condition (fat), eaten live chick	slugs; shearwater regurgitation; peanut butter; egg shell; flesh; feathers; bones; vegetation; seeds
31	164b	27/09/07	28/09/07	female	adult	405	221	184	42	39	15	greyish cream	very good condition (lots of body fat); pregnant (3 on right and 4 on left); lactating (6 nipples); eaten live chick	feathers; flesh; bones; skin; blood; egg shell; otolith
32	176b	27/09/07	28/09/07	male	adult	313	208	171	45	41	17	greyish cream	very good condition (fat); eaten live chick	rotten egg (half grown embryo); bone fragments; feathers; flesh; blood; egg shell; vegetation; slug
33	180a	14/10/07	4/05/08	male	adult	425	232	193	46	43	18	greyish cream	scavenged dead chick	slugs; pebbles; bones; seeds; feathers (down)
34	171b	16/10/07	4/05/08	female	adult	180	179	164	40	38	16	greyish cream	scavenged dead chick	feathers; down; flesh; small bones; vegetation; slugs; blood
35	27b	16/10/07	4/05/08	male	adult	225	195	165	45	43		greyish cream	scavenged dead chick	flesh; bones; feathers; blood
36	139a	18/10/07	4/05/08	male	adult	360	227	180	46	44	19	greyish cream	very healthy; scavenged dead chick	peanut butter; lots of down; bones; seeds; slugs; vegetation; blood

37	140a	18/10/07	4/05/08	female	adult	275	199	178	42	39		greyish cream	lactating ; given birth recently; uterus extended; pregnant (4 on left, 3 on right); scavenged dead chick (or old egg)	peanut butter; down; bones; seeds; vegetation; egg shell
38	141a	18/10/07	4/05/08	male	adult	340	223	176	41	37	21	greyish cream		empty
39	144a	18/10/07	4/05/08	female	adult	275	216	188	41	38	18	greyish cream	pregnant (7 on left, none on right), right ovary doesn't look developed, early pregnancy, scavenged dead chick	flesh (very fresh); feathers (black); slugs; blood; peanut butter; grit; seeds; bones
40	14b	18/10/07	4/05/08	female	adult	290	213	158	40	37		greyish cream	lactating; very extended nipples; just given birth; scavenged dead chick	feathers; vegetation; slugs; bones; blood; seeds
41	161b	18/10/07	4/05/08	male	adult	325	219	186	46	44	15	greyish cream	scavenged dead chick	feathers; down; blood; bones; flesh
42	165b	18/10/07	4/05/08	male	adult	210	200	163	40	38		greyish cream		vegetation; seeds
43	18a	18/10/07	4/05/08	female	adult	330	225	193	43	40	18	greyish cream	lactating; pregnant (4 on left, 3 on right); eaten by other rats (stomach, liver and heart eaten)	missing
44	41b	18/10/07	4/05/08	male	adult	225	188	179	44	41	17	greyish cream		empty
45	50a	18/10/07	4/05/08	female	adult	50	100	85	31	29	17	greyish cream	previously been pregnant, lots of fat around ovaries; scavenged dead chick	down; seeds; flesh; vegetation
46	7a	18/10/07	4/05/08	female	adult	190	180	155	37	34	17	greyish cream	only 1 ovary working; lactating	grit; vegetation; seeds; fur (rat)

47	91a	18/10/07	4/05/08	male	adult	350	216	180	48	45	16	greyish cream	eaten live mouse and scavenged dead chick	bones; flesh; feathers; fur; blood
48	95a	18/10/07	4/05/08	male	adult	200	183	163	40	38	14	greyish cream		empty
49	94b	19/10/07	4/05/08	male	adult	410	236	183	43	41	18	greyish cream	scavenged dead chick (or old egg)	slugs; feathers; peanut butter; flesh; blood; rotten egg; egg shell
50	99a	30/03/08	4/05/08	female	adult	300	209	167	40	37	15	greyish cream	pregnant (3 on left and 4 on right - large pups); very ginger in colour; not lactating	vegetation; seeds; grit; peanut butter; slugs
51	91a	24/04/08	4/05/08	female	adult	200	188	153	40	37	15	greyish cream	very ginger in colour; not pregnant; lots of fat around ovaries	peanut butter; insects; slugs; grit; vegetation; fur (rat)
52	126a	21/09/08	24/09/08	female	adult							greyish cream	Lactating	grass; seeds; fur; vegetation; peanut butter
53	116b	23/09/08	24/09/08	male	adult		193	156	41	38	16	cream		grass; seeds; fur; vegetation; peanut butter
54	21a	23/09/08	24/09/08	male	adult		181	173	43	41	17	grey	scavenged dead egg and live chick	feathers; eggshell; down; peanut butter; flesh; blood