Feasibility Study for the eradication of brown rats *Rattus norvegicus* from the Stewart Islands, Outer Hebrides

[N.B. This is a fictitious example intended for training purposes, based on real islands and some real places and references, but with some details altered to present an illustrative scenario. The project story, all names, organisations and incidents portrayed in this document are fictitious. No identification with actual persons (living or deceased), organisations or buildings is intended or should be inferred].

Acknowledgements:

This document draws on both the worked examples devised by the Pacific Invasives Initiative as part of their Resource Kit for Rodent and Cat Eradication (http://pacificinvasivesinitiative.org/rce/) and on the project documents produced by Wildlife Management International Ltd during their extensive work on UK islands. We are very grateful to both organisations.

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Funded by the Seabird Conservation Foundation

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Version History:

VERSION	DATE	AUTHOR	REASON FOR CHANGE
1	10/1/2016	S. Thornhill & R. Mitchell	Initial draft as circulated to technical advisors
2	16/2/2016	S. Thornhill & R. Mitchell	Final document as circulated to stakeholders, following review and input from technical advisors

Citation:

This report should be cited as: Thornhill, S. & Mitchell, R. (2016) Feasibility Study for the eradication of brown rats *Rattus norvegicus* from the Stewart Islands, Outer Hebrides, UK. Unpublished report prepared for the Scottish Wildlife and Conservation Agency (SWCA) and UK Seabird Conservation Trust (UKSCT).

Executive Summary

1. This report considers the feasibility of UKSCT and SWCA eradicating Brown rat *Rattus norvegicus* from Farnuff and Tuchlose Islands from the Stewart Island group, Outer Hebrides, Scotland.

2. The Stewart Islands group consists of three islands: Farnuff, Tuchlose, and Dull. Farnuff (147ha) and Tuchlose (89 ha) are inhabited islands with a population of 34 and 12 respectively. Dull Island (38ha) is uninhabited.

3. Farnuff and Tuchlose have been identified as highly significant sites for conservation. They hold populations of Manx shearwater, a highly restricted species, as well as an assemblage of more widespread but declining seabirds including puffin, shag and razorbill. They hold an endemic sub-species of vole – the Stewart Island vole – and both islands have one pair of breeding white-tailed eagles. European storm-petrel were extirpated from the islands several decades ago. Dull is not currently considered an important site for conservation, although it is possible that Manx shearwater and European storm-petrel once bred there.

4. A key step in restoring Farnuff and Tuchlose islands is the eradication of introduced mammalian species. Brown rats are known to occur on all three islands. Introduced rabbits are also present on Farnuff and Tuchlose. No other non-native species occur in the wild on the islands.

5. The feasibility study concludes that a ground-based rodenticide operation using bait stations is the only viable eradication technique that is available in the UK. Some important issues have been raised during the Feasibility Study and most, but not all of these are considered resolvable. As such, although the Study concludes that eradication of brown rats from **Farnuff** is **feasible**, eradication from **Tuchlose** has been deemed **unfeasible**.

6. The issues raised are:
   a) Tuchlose is only 600m offshore from the island of Lewis, which itself is too large for eradication to be achievable using available techniques. Reinvasion of Tuchlose can be anticipated
   b) Dull island is only 300m away from Farnuff and so will need to be incorporated into any eradication project for Farnuff if it is to meet the 'sustainable' criterion.
   c) The application of rodenticides may pose a risk to the residents of Farnuff, the endemic sub-species of vole, and White-tailed eagles.
   d) The rabbit population of Farnuff cannot be eradicated and is likely to increase in the absence of rats with potential implications on the wider island ecosystem.
   e) Community support for the eradication will need to be sustained.
   f) There will need to be strong community participation and leadership in biosecurity measures if reinvasion is to be avoided, particularly on Farnuff.
   g) A number of approvals will be required.
7. SWCA will be the lead implementing agency on the project. SWCA will be assisted by UKSCT as a project partner. Gaps in expertise, such as leading a ground-based eradication operation and homing a captive population of voles, will be met by contracting external experts.

8. The project is estimated to cost around £350,000. Breakdown by stage: Project Design: £4,000, Operational Planning: £46,800, Implementation: £282,200 and Sustaining the Project: £17,400. Costs for five years of biosecurity measures are included. Following that, funding for biosecurity will be the responsibility of SWCA. Funding for the initial phase of the project will be sought from the Seabird Conservation Fund. Some of the match funding will be provided

by SWCA as the project will help deliver government's international obligations. The rest will be sought from private donors.

Contents

1 INTRODUCTION

The UK Seabird Conservation Trust (UKSCT) have provided expertise *pro bono* to the Scottish Wildlife & Conservation Agency (SWCA) to undertake a Feasibility Study for the eradication of brown rats *Rattus norvegicus* from Farnuff and Tuchlose islands in the Stewart Island group, Outer Hebrides, Scotland. The study was undertaken in November 2015, with a site visit to the islands from 1st-10th November. This Feasibility Study can be used as the basis for an application to the Seabird Conservation Fund funding stream to part fund a full eradication project and help demonstrate the project need to SWCA and other private donors who will be asked to help match funding.

The purpose of this Feasibility Study is to assess the feasibility and viability of eradicating brown rats from Farnuff and Tuchlose islands. It asks three key questions: Why do it? Can it be done? and What will it take?

The remainder of this section explains the regional and international context of the proposed project. The 'Why do it?' section (parts 2,3,4) details the goal, objectives and outcomes of the proposed project, and describes the islands, the impacts brown rats are having on them and the anticipated benefits of eradication. The 'Can it be done?' section (part 5) assesses the proposed project against seven feasibility criteria and determines whether or not it is feasible. The 'What will it take?' section (part 6) identifies the issues that will need to be resolved before the project can commence. We then conclude, all things considered, whether or not the proposed project is likely to be a success.

The UK government has international obligations to tackle the threats from invasive non-native species, including those to seabirds from rodents on offshore islands, through:

- the Convention on Biological Diversity (Article 8(h) requires the control or eradication of alien species which threaten ecosystems, habitats or species)
- the EU Directive on the Conservation of Wild Birds (to protect bird species and the habitats on which they depend)
- the Bern Convention of European Wildlife and Natural Habitats 1979 (Article 11(2b) which requires strict control of the introduction of non-native species)
- the Marine Strategy Framework Directive (whereby a measure of Good Environmental Status is the predation pressure on important seabird breeding colonies).

The seabird populations on Farnuff and Tuchlose are of international importance and both islands are designated as part of a Special Protection Area (SPA). They are also identified as Important Bird Areas by BirdLife International. Building resilience into Manx shearwater and European storm-petrel populations, by bolstering existing colonies and helping the species to colonise/recolonise new areas, forms an integral part of the UKSCT's Saving Nature strategy.

The need for a rat eradication project on the Stewart Islands is identified by the 2014 UK, Isle of Man and Channel Islands prioritisation exercise undertaken by leading conservation organisations in the UK. The exercise sought to identify islands where the greatest conservation benefits could be achieved through the eradication of invasive non-native species and took into account the impacts of invasive species on a range of birds and other species present on islands.

Both Farnuff and Tuchlose ranked within the top 20 islands for conservation gain via invasive species eradication. When reinvasion risk was considered, Tuchlose dropped out of the ranking but the potential conservation gains were deemed sufficiently high as to merit more detailed consideration of the risks via a more detailed feasibility study.

Additional resources used in the production of this report included reports from previous site visits for biological monitoring, rat stomach content analysis and conversations with island residents.

This Feasibility Study will be made available to all relevant UK government authorities, to island residents, partner organisations and other key stakeholders.

We would like to acknowledge the assistance of the following people in the production of this report:

All of the residents of Farnuff and Tuchlose for their interest and willingness to discuss the project proposals and for their support. Thanks also to Jenny Luscombe and Jim Hunter for their hospitality during our stays on the island, and to Mike Broad for the use of his boat to reach Dull Island.

Phil Hill and Gill Pollard for their independent review of the draft feasibility study report.

1.1 The Site

The Stewart Islands

The Stewart Island group is located on the west coast of the Outer Hebrides, Scotland, off the island of Lewis and Harris.

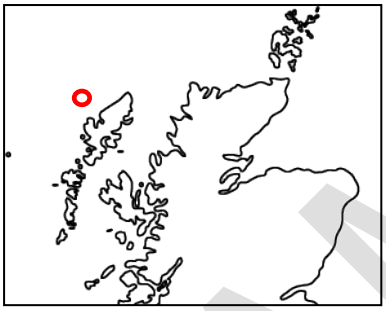

Figure 1: Map showing position of Stewart Island Group in relation to the Outer Hebrides and Scottish mainland.

They are comprised of three islands:

- Farnuff Island, 147ha, permanent population 34
- Tuchlose Island, 89ha, permanent population 12
- Dull Island, 38ha, population 0 (permanent or seasonal)

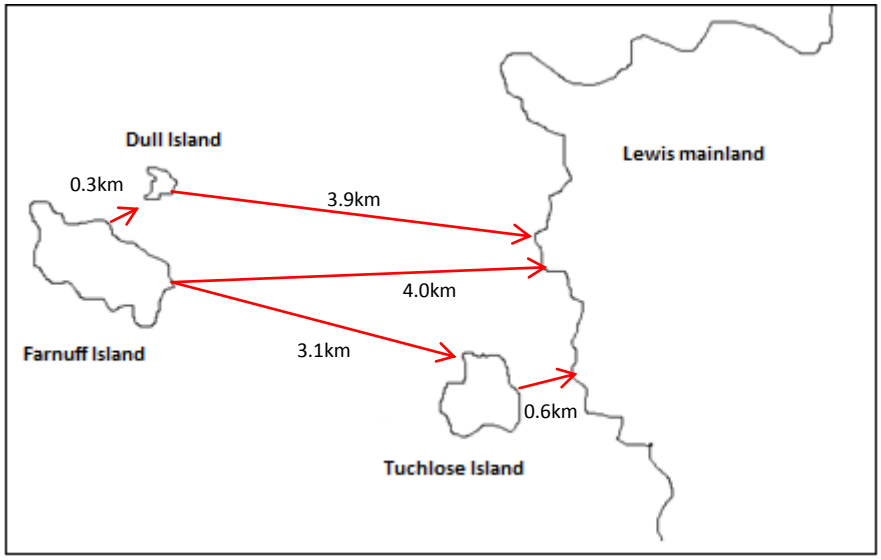

Figure 2: Map showing position of islands within the Stewart Islands group and their distances from each other and the Isle of Lewis

The islands are privately owned by the Clipper family. Farnuff and Tuchlose islands form part of the Stewart Island Special Protection Area (SPA). There are no other offshore islands within 15km of the Stewart Island group.

Farnuff Island

Farnuff Island is an inhabited island (34 permanent inhabitants) of 147ha. It has a saddle shaped topography, rising to 138m above sea level (a.s.l.) with sheer cliffs along the north and west coast and to 85m on the south east. The rest of the coastline is either rocky with boulders that can be scrambled over, or comprised of grassy slopes that can be traversed, with care. The island's residents live along the central, low lying belt of the island – there are three farms, a shop (groceries/post office/general store), and ten houses. The majority of houses and the shop are situated close to the jetty on the north coast. There are a number (c.20) of other buildings/sheds/stores around the inhabited area. The farms predominantly keep sheep although one farm has a very small number of cattle as well. Two households keep chickens and both pet cats and dogs are kept on the island. The population lives year-around on the island, but the (currently eight) children are all at secondary school on the mainland and are present only at weekends and school holidays.

The area around the island is fished, mostly by the island's inhabitants, although a few boats travel from Lewis and Harris to fish. The island is serviced three times a week by a passenger ferry run by Caledonian MacBrayne from Lewis and Harris. There is a weekly rubbish collection boat and a larger supply boat which occasionally brings farming equipment or a larger stock run for the shop. There is a secondary landing site on the south coast which is mainly used by residents to launch fishing boats. Tourism is not an important feature of the island, although some small yachts usually moor up in summer and once a week during seabird breeding season a tripper boat circumnavigates the island to view the seabird colonies – this vessel does not land on the island.

The island is covered in grassland with wet heath on the more exposed areas. Low-lying scrub covers some of the slopes on the northern coast where it is more sheltered. This is predominated by European gorse. There are no known non-native invasive plants on the island. The main conservation interest on the island is around the north and south cliffs and adjacent grassy slopes which house the main seabird colonies (razorbills, shags, puffins, Manx shearwater, guillemot, kittiwake). Lesser black-backed gulls and carrion crows are also present. One pair of white-tailed eagles nests on the northern cliffs. A number of passerines are recorded from the island, including wheatears, skylarks and twite.

The Stewart Island vole is found across the island, but is less common in the heath/wetter parts. Common shrew is the only other native mammal, although otters have been recorded in the past. Rabbits are prevalent in the grassland areas and are seen to cause damage to the stone walls due to burrowing. House mice are thought to be absent from the island (historically present but last reported in the 1970s), but brown rats are recorded.

Farnuff Island is only 300m away from Dull Island, but all other islands are outside of rodent swimming distance.

Dull Island

Dull Island (38ha) lies 300m off the north coast of Farnuff. It is not within rodent swimming distance of any other island. It is mostly a low-lying island, although it rises to around 48m to the west. It is predominated by grasses with some scrubby patches in sheltered areas. It is uninhabited, but has two small landing sites and three buildings – a bothy and two smaller buildings used as stores/shelter by fishermen. It is not thought to attract any other visitors. The cliffs are not sheer here and are largely vegetated - they may once have supported Manx shearwater and puffin. Similarly, the eastern coast has a field of boulders that would appear to be ideal habitat for European storm-petrel, but none have been recorded from the island. It is possible that the presence of brown rat has lead to the extirpation of these species. There are no known species of conservation interest on the island, although it is home to a small colony of seabirds predominated by gulls. The Stewart Island vole and house mice have never been recorded on the island, but common shrews and brown rats are known to be present.

Tuchlose Island

Tuchlose Island has 12 permanent inhabitants and lies 600m from the Lewis and Harris coast. It is 89ha in size with a sloping topography from the western cliffs (115m a.s.l.) down to the eastern coast. There are a number of sheltered beaches and landing sites on the east, whilst the west is not accessible by boat. The island is covered in grasses with patches of heath and scrub. Rhododendron has been recorded in small patches, but these are being treated as part of an initiative to clear the island of this invasive non-native species.

There are nine dwellings on the island, including one farm (cattle) and three holiday cottages (mostly inhabited in the summer months). There are at least 18 other buildings on the island, including a shop and a pub. The island has a year-round tourism interest, with people landing to see breeding grey seals along the east coast over winter and the large seabird colony on the west coast in summer. The island is serviced three times a week by the Caledonian MacBrayne ferry (and experiences a large number of day trippers) and has a weekly rubbish collection. Two tourism operators also land boats throughout the year. Most boat traffic goes to the main jetty at Southport on the South coast of the island. The two more northerly landing sites are used as alternatives when landing at the main jetty is prohibited by bad weather or rough seas.

A dwindling population of Manx shearwater are recorded from the western colony, along with shag, razorbill, guillemot and a small number of puffins. The role of predation by brown rats on the seabird colony is unquantified, but assumed to be a significant part of its decline. A pair of white-tailed eagles breeds on the island, and it is home to the Stewart Island vole.

All three islands experience typical eastern Atlantic coastal weather patterns of wet, windy and mild winters and cool, unpredictable summers. Winter storms are frequently at gale force 8 or more, whilst snow almost never settles. Frequent rain means the vegetation is often slippery and can become very muddy along well-trodden routes, including around livestock areas. On gloomy days in midwinter there can be as few as 5.5 hours of daylight. Landing on all three islands can be difficult in winter, and

scheduled boats are often cancelled due to weather conditions. There are designated helicopter landing sites on the inhabited islands in case of medical emergency at such times.

- *A map or an aerial photo with key features is essential.*

1.2 Target Species: Brown rat *Rattus norvegicus*

The brown rat *Rattus norvegicus* is thought to be present across the entirety of all three islands, with greater abundance around the coast, seabird colonies and around areas of habitation. Distribution information has been gleaned both from historic research (Ding, 2002) and is supported by the index trapping undertaken as part of this study. They are assumed to depend upon the human population and rabbits for sustenance during winter on Farnuff and Tuchlose, but no winter dietary studies have been undertaken.

It is not known how the rats survive on Dull Island over winter – it is possible they do not, but instead reinvade the island periodically from Farnuff. However, since Dull is only 300m from Farnuff, well within the known swimming distance for brown rats, both islands need to be treated together as a single 'eradicable unit'.

Typically, it is assumed that brown rats do not breed this far north throughout the year. However, examination of a preserved carcass brought in by a cat indicates that a female was still lactating in late November. With the presence of people, livestock and prey items such as rabbits and voles, it is possible that rats are able to breed all year on the islands.

1.3 Impacts

No brown rat dietary studies have been undertaken outside of summer. Results from summer indicate predation on seabird eggs and chicks, hence it is very likely that brown rats are having a negative impact on the seabird interest of the Stewart Islands (Goldwire 2009). This study also showed that rats are predating upon vegetation and invertebrates, thus causing impacts to species throughout the islands' ecosystem. It is likely that they are also preying upon mammal species, including young rabbits and the endemic Stewart Island vole. Rats will therefore be impacting on the whole ecosystems of the three islands and at all trophic levels.

The Stewart Islands are designated as a Special Protected Area due to their nationally and internationally important breeding seabird colonies. However, numbers of many species are in decline and bird species sensitive to the presence of rats, such as Manx shearwaters, appear to be particularly badly affected. Numbers of Manx shearwaters, puffins, razorbills and shags have all been declining in the Stewart Islands for the last twenty years (SWCA 2014), while rat numbers are reported to currently be at high levels after a series of mild winters. Brown rats are implicated in this decline as they are known to have an impact of the breeding success and range of these seabird species. It is likely that the presence of rats on the islands is restricting bird populations to significantly lower levels than would otherwise be expected.

On Tuchlose and Farnuff islands, the rat population is controlled most years around the farms and houses using second generation anticoagulant baits containing bromadiolone. Such baiting has been conducted for at least 15 years. The effect of this on the Stewart Island vole is unquantified, but voles elsewhere are known to consume such bait, and to be affected by it.

The cost of rats to the farming businesses on the islands are approximately £4000 per year in spoilt feed, damage to machinery (through chewing through wires), and the cost of poison and labour. The costs to the tourist businesses are around £500 per year for bait, labour and repairing damage caused by rats.

Social and health costs associated with rats are less easily quantified. Rats carry diseases and while there are no suspected cases from the islands, the risk of their transmitting diseases such as Leptospirosis and Salmonella poisoning always remains. The majority of householders on Farnuff and Tuchlose reported ongoing problems with rat infestation of their homes, with damage to property and stored food supplies. The islanders on Farnuff and Tuchlose are keen to support complete eradication for a number of reasons, including economic, social and health.

1.4 Benefits of eradication

Eradicating brown rats from Farnuff and Dull will create valuable habitat free from invasive mammals within the Stewart Islands SPA. It will make resident seabird populations more secure and enable other seabird species to establish on the islands. As detailed above, rats are known to be predating upon a wide range of species and it is likely that removal, while not restoring all the damage they have caused during their tenure, will at least stop further damage and will allow key species to regenerate. It is highly likely that the islands' bird populations will increase markedly in the short to medium term, especially for species highly vulnerable to the presence of rats such as Manx shearwaters and European storm petrels. Populations of these species are known to have increased following rat eradication projects on other UK islands, including Lundy, Ramsey and St Agnes. Numbers of Manx shearwaters are expected to increase following the eradication of rats and it is likely that European storm petrels will recolonise the island. The nearest European storm petrel colony is found on Shillay, some 35km south of Farnuff and it is possible that prospecting birds from this colony may reach the Stewart Islands.

Benefits to other species are also likely, including vegetation and invertebrates which are likely to make up the majority of rats' diet, especially in the months when seabirds are not nesting. It will also protect and enhance populations of land birds present on the islands, including wheatears, skylarks and twite. Migratory waders and waterfowl species, such as barnacle and Greenland white-fronted geese, that use the islands will also benefit.

Eradication of brown rats will also help to meet the conservation obligations of the UK government in the following ways:

- It will protect and enhance the seabird populations present on the islands, under the requirements of SPA designation under the EU Directive 79/409/EEC on the Conservation of Wild Birds to protect bird species and the habitat upon which they depend (`the Birds Directive').
- As UK Government is a signatory to the Convention on Biological Diversity, Article 8(h) requires the control or eradication on alien species that threaten ecosystems, habitats or species.
- Under the UK Biodiversity Action Plan there need to be operations to remove rats affecting breeding seabirds on maritime cliff and slope sites identified by Seabird 2000 and other surveys.
- As UK Government is a signatory to the Bern Convention on European Wildlife and Natural Habitats 1979, Article 11(2b) requires strict control of the introduction of non-native species.
- The EU Marine Strategy Framework Directive (2008/56/EC) requires that all member states' waters are considered to be in 'Good Environmental Status' by 2020. The conservation status of seabirds is one measure of this, another is that non-native introduced species do not adversely alter the ecosystems.

There will also be economic benefits to local residents, due to an end to rat damage to personal and business equipment and in a likely increase in tourism as the seabird potential of the islands improves. Health benefits are also likely to occur, due to an end of the risks of rat-borne diseases, as well as an end to the risks to island children and livestock (as well as non-target wildlife) through the ongoing use of rodenticide bait.

2 GOAL, OBJECTIVES AND OUTCOMES

The goal of the project is to conserve the natural bird communities and wider ecosystem of the Stewart Islands, preventing further losses to invasive rats and allowing the populations of key species to increase. The objectives that this project will achieve and the outcomes that will be seen as a result of achieving these objectives are:

Objectives	Outcomes
1. Eradicate brown rats (*Rattus norvegicus*) from Farnuff Island	1.1 No brown rat population on Farnuff
	1.2 Increase in population size of Manx shearwater on Farnuff
	1.3 Recolonisation of Farnuff by European storm-petrel
2. Eradicate brown rats (*Rattus norvegicus*) from Tuchlose Island	2.1 No brown rat population on Tuchlose
	2.2 Increase in population size of Manx shearwater on Tuchlose
	2.3 Recolonisation of Tuchlose by European storm-petrel
3. Safeguard native populations of conservation interest/importance	3.1. Stewart Island vole population exceeds pre-eradication level two years after eradication is complete
	3.2 No mortality of white-tailed eagles on either island attributable to rodenticide use during the eradication phase of the project
4. Improve the capacity of partner organisations to undertake complex eradication projects	4.1 Partner organisation staff have skills to lead eradication projects of a similar size and complexity to current project
5. Maintain invasive-rodent-free status of islands via appropriate biosecurity measures	5.1 Islands remain free of invasive rodents

3 FEASIBILITY

In this section we present and analyse the information available for each of the seven feasibility criteria to enable the feasibility of eradication brown rats from the Stewart Islands to be determined.

3.1 Technical feasibility

The relatively low vegetation and flat terrain of most of the islands mean that a ground based project is considered technically feasible. The biggest technical challenge comes from the presence of vegetated ledges on the cliffs

Brown rats can be targeted using a 50m grid, but we advise reducing this around areas of habitation to an approximate 25m grid (stations should be placed in appropriate sites based around this bait point density, equating to 16 stations per hectare). Extra stations should be placed along stone walls and reduced grid size should be considered around the seabird colonies, particularly as wintering gulls may provide an important food source for rats in winter. Bait stations locations will be determined using GIS with staff then using handheld GPS units to locate and mark their positions on the ground. The largely open nature of the terrain (almost entirely low grassland with occasional areas of scrub) mean that little track cutting will be required. The project should be carried out in the winter when the availability of natural food for rats is at its lowest. This has proven successful in other UK rat eradication including on Canna and the Shiant Isles in the Hebrides.

Specialist rope workers will be required to service some of the areas of cliffs on both Farnuff and Tuchlose. A specialist rope access worker was invited to join the site visit as part of this feasibility study and concluded that all areas could be accessed safely and that the rocks were sufficiently stable to put in anchor points where necessary. He suggested a team of three rope workers would be required to undertake the work safely. These people would need to be on the islands for the duration of the operation in order to achieve the required frequency of checks of bait stations. Whilst feasible, this will add to the costs of the operation.

Access to Farnuff is unlikely to present any problem due to the regular scheduled ferry service operating from mainland Lewis. While the occasional ferry may be cancelled due to bad weather, this is extremely unusual. Figures from the ferry's operator, CalMac, show that the ferry has been cancelled on fewer than five occasions in each of the last three years. Boat access to Dull will be more likely to be affected by the weather. However, the necessary field team of four people, including one rope access worker) can be safely and securely accommodated in the bothy on Dull, once it has been adequately renovated. We propose that the team on Dull stay there for around a week at a time, and are relieved by a different team at the end of this time. Substantial stores of food, water and fuel for the generator, heating and cooking facilities (at least a six-week supply) should be stored on the island in case the weather conditions prevent boat access.

Voles and mice

Stewart Island voles will be susceptible to the bait used on the eradication project. While their home ranges are smaller that the proposed grid size and it is highly likely that some would survive the baiting operation this would be a high risk option. We propose that a captive population of shrews is established for the duration of the poisoning and long term monitoring phase, and returned to the island once the eradication has been declared a success (two years after the last sign of rats). A suitable project partner would need to be found to house the captive animals. Possibilities include Edinburgh Zoo, the Scottish Animal Park or the University of Glasgow.

The presence of house mice would complicate the project and would add considerably to the financial cost of the operation and the amount of work required. It was therefore important to find out whether nice were present on any of the islands. House mice have never been recorded from either Tuchlose or Dull islands. Island residents report domestic cats occasionally bringing in voles, shrews and rats but not house mice. There are reports from other islands of house mice coexisting in very low numbers with rats, but their populations increasing sharply following the removal of rats (e.g. Witmer et al. 2007). Animals at low densities may not be obvious to the island's human population so it is important to check whether or not they are present. As part of this study we used tracking tunnels and live-capture small mammal traps (Longworth traps) to survey the island's small mammal fauna. Stewart Island voles and common shrews were both caught in the live capture traps and their footprints were recorded from tracking tunnels, but no evidence of house mice was found. We therefore recommend proceeding on the assumption that mice are not present, but with plans in place to adapt the eradication to include mice should evidence of them be found later.

3.1.1 Choice of method

Options for reducing impacts of brown rats

Table A presents the pros and cons and practicality of the control and eradication methods considered for the proposed eradication of rats from the Stewart islands. While long term control is an option it is likely to lead to larger long-term cumulative costs in terms of animal welfare, rodenticide and equipment and financial commitment. The only realistic option to reduce rodent impacts on seabirds (and the islands' ecosystem) is the eradication of rats.

Options for brown rat management

The different management options for the rat population on Farnuff and Dull are explored in table B. Of the methods available, the use of anticoagulant rodenticides is currently the most widely recognised effective method of eradicating rodents from islands.

The use of anticoagulant rodenticides is considered inhumane (Pesticides Safety Directorate 1997), however, the lack of alternatives and the ultimate outcome of preserving and restoring the breeding seabird colonies on the Stewart Islands have to be weighed against their use.

In the UK, aerial or hand broadcasting operations cannot be carried out as the risks to the environment, people and other non-target species from toxic bait will be considered too high. This leaves us to consider the feasibility of deploying a hand baiting operation using bait stations. This technique has been used in most UK rat eradication projects to date, including on Ramsey, Lundy, Canna and St Agnes, with great success.

Options for rodenticide choice

We recommend that the project use a wax block bait formulation, as has been successfully used on other UK eradication projects. Experiments using non-toxic wax bait blocks (Detex Blox, manufactured by Bell laboratories) on all three Stewart Islands showed a high level of acceptability by rats. Two 20g bait blocks were set out at each of 30 sites for three days and checked daily. 80% showed take by rats within 2 days and 93% within 3 days. For the active ingredient of the bait we recommend considering first generation compounds, such as coumatetralyl. This will reduce non-target risks to the vole population as well as to Farnuff's resident pair of white tailed eagles and other visiting raptors. While it is unusual to use a first generation compound as the primary rodenticide in a rat eradication project, the project on the Isle of Canna in 2005-6 successfully used the first generation diphacinone for almost the entirety of the project, using a second generation back-up product for targeting just a few remaining rats. However, diphacinone is no longer registered for use in the EU and coumatetralyl is not available in a wax block formulation. Second generation compounds are therefore a more realistic option. The range of toxins considered for use is detailed in table C.

Table 1: Alternative options for reducing the impacts of brown rats on the Stewart Islands

Option	Outcome	Decision
1. Do nothing	The natural ecosystem of the Stewart Islands will continue to degrade, especially the survival of breeding seabirds on the islands. This would also contravene both national and international obligations.	UNACCEPTABLE
2. Undertake long-term rodent control	The rat population would be controlled through lethal or non-lethal means. However, targeted rat control measures would have to take place prior to and throughout the seabird breeding season in perpetuity. The costs of an on-going control operation would be considerable: • Welfare cost. The long-term cumulative effect could be greater than a one-off eradication operation • Financial cost. The implementation of a regular rat control programme would require personnel and equipment to be present for at least six months (or year round) on the islands • Ecological and environmental cost, risk of resistance and persistence of toxin greatly increased.	IMPRACTICAL
3. Relocate the entire rodent population	The safety of breeding seabirds and the islands' ecosystem would be protected while trying to ensure the highest standards of welfare for rodents. However, for this option to succeed every rat would have to be caught and relocated (remaining rats would quickly multiply, rendering any biodiversity gains only temporary). This option is simply not feasible as it is too challenging (and time-consuming and expensive) for personnel to be able to capture the entire rat population on the Stewart Islands. In addition, it would be difficult to obtain permission to relocate the rats that would satisfy community, conservation, disease and welfare concerns.	IMPRACTICAL
4. Eradicate the entire rodent population	This involves lethal eradication of all rats on the Stewart Islands using anticoagulant rodenticides. Although the one-off welfare cost of this option would be high, it offers a sustainable and financially cost-effective solution with possibly fewer welfare costs to rats and non-target species in the long-term than ongoing control. Options were considered to determine eradication methods that could be used (Table B). Trapping, gassing, glue boards, repellents, prevention and alternative toxin options were considered not feasible due to labour requirements, welfare issues, access, number required or non-target impacts. The only suitable option to eradicate rats from the Stewart Islands is a ground-based operation (i.e. apply anticoagulant rodenticide bait in bait stations) and eradicating the entire rat population *in situ*. This option is considered technically feasible as islands larger than the Stewart Islands have had invasive rat populations eradicated using this method in the UK and around the world (Howald et al. 2007, Thomas et al. 2017).	PRACTICAL: RECOMMENDED

Option	Advantages	Disadvantages	Decision
1. Prevention (i.e. rat-proofing)	• Non-lethal • Environmentally clean • Proofing areas prevents damage and effects of rats	• Useful for buildings and small areas only • Does not deal with rats already present (which can still cause damage or have impacts) • Rat-proof fencing expensive • Non-lethal; can move problem to another location • Usually combined with other methods • Best suited for small areas • Little value alone	INEFFECTIVE
2. Repellents	• Sound or chemical options • Non-lethal • Targeted control • No welfare impacts	• Little to no success (Mason & Litten 2003) • Rats habituate to repellent • Non-lethal • Can move problem to another area • Little to no use in an island-wide situation	INEFFECTIVE
3. Aluminium phosphide (fumigation)	• Targeted control (burrows only) • Lethal method	• Needs knowledge of habitat and location of all rat burrows • Risks to general public • Risks to other non-target species • Professional use only • Outdoor use only • Ethical concerns • Untested for island-wide eradication projects	IMPRACTICAL
4. Immuno-contraception	• Could be long-term solution • Humane • Environmentally clean	• At research stage only • Concerns regarding loss of control • Non-target species concerns • Irreversible • Public concern	IMPRACTICAL (EXPERIMENTAL ONLY)

5. Biological control	• Long-term solution • Involves releasing another possible problem animal	• Non-target impact concern • Ethical concerns • Legal issues	IMPRACTICAL
6. Kill traps (i.e. snap, spring or break-back traps)	• Lethal (rapid death) • Targeted control • Environmentally clean • Can be used by general public • Range of traps commercially available	• Labour-intensive • Expensive • Welfare issues and ethical concerns • Need to be checked twice daily (if set permanently) • Only legal traps can be used (under relevant UK and Scotland Pest Control and Trapping Acts) • Experienced trappers required for large-scale operations • Requires good accessibility • Non-target issues • Untested for island-wide eradication projects • Risk to non-target species (particularly lizards)	IMPRACTICAL (LEGALITY ISSUES & UNTESTED)

7. Live trapping	• Humane • Environmentally clean • Non-target species can be released unharmed • Targeted control • Range of traps commercially available • Can be used by the general public • Rats can be released to an alternative location	• Labour-intensive • Expensive • Need experienced trappers for large-scale operations • Requires good accessibility • Welfare issues (while animal in trap & kill method) • Need to be checked twice daily • Only legal traps can be used (under relevant UK and Scotland Pest Control and Trap Acts) • Rats have to be humanely killed (under relevant UK and Scotland Animal Welfare Acts) • Untested for island-wide eradication projects • Release of rats may have impacts at release site or welfare issues for animals • Ethical concerns	IMPRACTICAL (LEGALITY ISSUES & UNTESTED)
8.Glue boards	• Targeted control • Environmentally clean • Non-toxic	• Labour-intensive • Welfare issues and ethical concerns • Need to be checked twice daily (if set permanently) • Animals must be killed humanely (under relevant UK and Scotland Animal Welfare Acts) • Non-target issues • Untested for island-wide eradication projects • May be removed from international markets shortly as perceived to be inhumane	IMPRACTICAL (LEGALITY ISSUES)
9.Alphachloralose	• Humane	• Illegal for use on rats in UK • Use of toxin • Non-target impacts • Ethical concerns • Untested for island-wide eradication projects	IMPRACTICAL (ILLEGAL)

10.Anticoagulant rodenticides	• Efficient • Large areas covered quickly • Most widely used approach to control rats • Most cost-effective method of controlling substantial infestations • Tested and successful method for one-off island-wide eradication projects • Range of application methods • Can be used in bait stations to reduce risk to non-target species • Antidote available • Range of rodenticides available (e.g. first generation or second generation) • Range of formulation available (e.g. grain, wax block, pellets etc.) • Available for use by the public and professionals	• Use of toxin • Persistence in environment (toxin dependent) • Non-target impacts • Ethical concerns • Resistance issues with prolonged use • Legal requirements for certain rodenticide use (i.e. brodifacoum restricted to indoor use only, bait station use required for some rodenticides, etc.) • Implies coverage of whole area • Requires use of adequate baits and bait stations • Disposal requirements • Health and Safety concerns	PRACTICAL & RECOMMENDED (TESTED AND EFFECTIVE)

Table 2: Different rodenticides considered for the brown rat eradication on the Stewart Islands (adapted from Bell 2013)

Toxin	Advantages	Disadvantages	Outcome
FIRST-GENERATION			
Warfarin	• Low potency • Delayed onset of symptoms (i.e. prevents neophobia and bait shyness) • Less persistent than second generation anticoagulants • Reduced risk of non-target poisoning • Reduced secondary poisoning risk • Very low risk to raptors • Cheaper than second generation anticoagulants • Antidote available	• Low potency • Multiple feed • Large quantity required • Repeated applications required • Longer access to bait required • Low persistence (metabolised quickly) • Non-target species have longer to access bait (i.e. competition with rats) • Not currently available in wax block formation in the UK • Resistance issues	NOT RECOMMENDED
Pindone	• Low potency • Delayed onset of symptoms • Less persistent than second generation anticoagulants • Reduced secondary poisoning risk • Reduced risk of non-target poisoning • Cheaper than second generation anticoagulants • Antidote available • Low solubility in water • Binds strongly to soil and breaks down slowly • Not registered for use in UK	• Low potency • Moderate risk to birds • Multiple feed • Large quantity required • Repeated applications required • Non-target species have longer to access bait (i.e. competition with rats) • Low persistence (metabolised quickly) • Untested for island-wide rat eradications	NOT REGISTERED FOR USE IN UK

Diphacinone	• Low potency • Delayed onset of symptoms • Less persistent than second generation anticoagulants • Reduced secondary poisoning risk • Reduced risk of non-target poisoning • Low toxicity to raptors (and mice) • Used successfully on island eradications in UK • Cheaper than second generation anticoagulants • Antidote available • De-registered in UK (unavailable for use)	• Low potency • Repeated applications required • Longer access to bait required • Less persistent (metabolised quickly) • Non-target species have longer to access bait (i.e. competition with rats)	NOT REGISTERED FOR USE IN UK
Coumatetralyl	• Low potency (higher than warfarin and pindone) • Delayed onset of symptoms • Less persistent than second generation anticoagulants • Reduced secondary poisoning risk • Reduced risk of non-target poisoning • Cheaper than second generation anticoagulants • Antidote available • Binds to soil and breaks down slowly	•Not available in a wax block formulation in the UK •Low potency • Multiple feed • Repeated applications required • Longer access to bait required • Less persistent (metabolised quickly) • Non-target species have longer to access bait (i.e. competition with rats) • Few successful island-wide eradications	COULD BE USED AS BACK UP TO A WAX BLOCK FORMULATION

SECOND-GENERATION			
Bromadiolone	• Moderately potent • Single feed • Delayed onset of symptoms • Effective on rats (Rattus norvegicus in particular) • Antidote available • Not readily soluble in water • Binds strongly to soil and breaks down slowly • Previously successfully used in UK eradications	• Persistence issues (> 9 months in some species) • High secondary poisoning risks • Slightly less potent than brodifacoum and flocoumafen • Some resistance issues suspected • Limited data on non-target impacts	RECOMMENDED
Difenacoum	• Moderately potent • Single feed • Delayed onset of symptoms • Effective on rats • Antidote available (but long-term treatment required) • Insoluble in water • Binds strongly to soil and breaks down slowly • Previously successfully used in UK eradications	• Persistence issues (> 9 months in some species) • High secondary poisoning risks • Limited data on non-target impacts • Slightly less potent than bromadiolone • Less potent than brodifacoum and flocoumafen	NO ADVANTAGES OVER BROMADIOLONE AS MAIN RODENTICIDE

Flocoumafen	• Very potent • Single feed • Delayed onset of symptoms • Effective on rodents • Good availability • Antidote available (but long-term treatment required) • Not readily soluble in water • Binds strongly to soil and breaks down slowly	• Not registered for use in open areas in UK • Not widely used in eradications • Persistence issues (> 9 months in some species, and can be longer than with brodifacoum) • High secondary poisoning risks • Limited data on non-target impacts • Expensive	NOT REGISTERED FOR USE IN OPEN AREAS IN UK
Brodifacoum	• Very potent • Single feed • Delayed onset of symptoms (i.e. prevents neophobia and bait shyness) • Very effective on rodents • Insoluble in water • Binds to soil (slowly degraded) • Widely used in eradications • Successfully used in island eradications worldwide • Efficacy data widely available • Non-target impact data widely available • May be possible to get permit from HSE to allow use in open areas • Widely available • Range of bait formulations available • Antidote available (long-term treatment required)	• Not registered for use in open areas in UK • Persistence issues (> 9 months) • High secondary poisoning risks • Non-target impacts recorded • Expensive	NOT REGISTERED FOR USE IN OPEN AREAS IN UK

3.1.2 Non-target impacts

Table 3: Risk assessment for non-target species during the eradication of brown rats on the Stewart Islands

Species	**Impact risk (1^o/ 2^o poisoning, or trophic)**	**Description of impacts and possible mitigation measures**	**Risk of impact**
Stewart Island Vole	1^o: High 2^o: Low T: High	Cannot be excluded from bait stations. Likely to take the bait and be killed by it. However, bait station grid size means that many individuals will not encounter bait stations and will survive. Numbers likely to increase, possibly sharply, following rat eradication due to an end to predation and competition.	High
Common shrew	1^o: Low 2^o: Low T: High	Cannot be excluded from bait stations. May take the bait and be killed by it, although as insectivores they are unlikely to eat significant quantities. May consume invertebrates which have eaten bait and be killed via secondary poisoning. However, bait station grid size means that many individuals will not encounter bait stations and will survive. Numbers likely to increase, possibly sharply, following rat eradication due to an end to predation and competition.	Medium
Rabbit	1^o: Low 2^o: Low T: High	Use of wires to reduce size of entrance holes in bait stations. Only young animals will then be able to enter bait stations and, as herbivores, they are unlikely to consume wax block bait in harmful quantities. Numbers are likely to increase following rat eradication as predation decreases.	Medium
White tailed eagle	1^o: Low 2^o: Medium T: Low	Birds of prey may take poisoned rats. This can be mitigated by carefully searching for and disposing of dead and dying rats.	Low
Feral cats	1^o: Low 2^o: Medium T: Low	Too big to enter bait stations and unlikely to eat wax block bait. May consume poisoned rodents and thus be at risk of secondary poisoning. This risk can be reduced by diligently collecting and disposing of dead and dying rodents.	Low

Pet cats	1^{o}: Low 2^{o}: Low T: Low	Too big to enter bait stations and unlikely to eat wax block bait. May consume poisoned rodents and thus be at risk of secondary poisoning. This risk can be reduced by diligently collecting and disposing of dead and dying rodents. Antidote can be offered to any individuals known or suspected to have eaten bait	Low
Pet dogs	1^{o}: Low 2^{o}: Low T: Low	Too big to enter bait stations, though may eat wax block bait if encountered. May take bait crumbs dropped by operators or dislodged by rats. This can be mitigated by taking care not to drop crumbs and to pick up bait fragments found outside of stations. May consume poisoned rodents and thus be at risk of secondary poisoning. This risk can be reduced by diligently collecting and disposing of dead and dying rodents. Antidote can be offered to any individuals known or suspected to have eaten bait	Low
Domestic poultry (chickens and geese)	1^{o}: Low 2^{o}: Low T: Low	Too big to enter bait stations and in any case will be kept in areas with no bait stations. Granivorous species may take bait crumbs dropped by operators or dislodged by rats. This can be mitigated by taking care not to drop crumbs and to pick up bait fragments found outside of stations. Antidote can be offered to any birds known or suspected to have eaten bait	Low
Cows	1^{o}: Low 2^{o}: Low T: Low	May kick over any bait stations they find and eat bait but can be kept away from areas with bait stations. Antidote can be offered to any individuals known or suspected to have eaten bait	Low
Sheep	1^{o}: Low 2^{o}: Low T: Low	May kick over any bait stations they find and eat bait but can be kept away from areas with bait stations. Antidote can be offered to any individuals known or suspected to have eaten bait	Low
Crows	1^{o}: Low 2^{o}: Medium T: Low	Crows may try to open bait stations by sliding the doors but can be deterred by using ‘crow clips’ to prevent doors moving. They will eat bait fragments found outside bait stations. This risk can be mitigated by taking care not to drop crumbs and to pick up any bait fragments found outside of bait stations. They may also eat poisoned rats, rabbits, other small animals or invertebrates. Diligently collecting and disposing of dead or dying rodents will reduce this risk.	Low

Gulls	1^{o}: Low 2^{o}: Medium T: Low	Unable to enter bait stations but likely to eat bait fragments if found outside bait stations. This risk can be mitigated by taking great care not to drop crumbs and to pick up any bait fragments found outside of bait stations. They may also eat poisoned rats, rabbits, other small animals or invertebrates. Diligently collecting and disposing of dead or dying rodents will reduce this risk.	Low
Land birds (passerines)	1^{o}: Low 2^{o}: Low T: Low	Cannot be excluded from bait stations but unlikely to enter. Granivorous species may take bait crumbs dropped by operators or dislodged by rats. This can be mitigated by taking great care not to drop crumbs and to pick up any bait fragments found outside of bait stations. Insectivorous species may be at risk of secondary poisoning by eating invertebrates which have themselves eaten the bait	Low

3.1.3 Key issues to resolve before operation proceeds

1. Renovate bothy and outbuildings
2. Identify suitable project partner for housing captive vole population
3. Determine numbers needed for captive population and collect sufficient voles for it
4. Carry out resistance testing for coumatetralyl and difenacoum in the rat populations on Farnuff and Dull Islands
5. Produce action plan for what to do if mice are found to be present on Farnuff or Dull

3.2 Sustainability

Table 4: Potential invasion pathways for the Stewart Islands

Species	Source	Pathway	Risk	Prevention Strategy
Species Name	*Where will invasive species come from?*	*How will it travel to the island? And how likely is it to happen?*	*How severe would the impacts of establishment be?: Critical(C) High(H) Medium(M) Low(L)*	*How will you prevent the species using the pathway to re-invade*
Brown rat	Lewis and Harris	Swim – **Tuchlose** Likelihood not known without connectivity study, but within known swimming distance. Swim – **Farnuff / Dull** considered extremely unlikely as is more than twice the furthest known swimming distance for brown rats	Critical	Could use rat traps on likely dispersal points on coast of Lewis (ongoing rodenticide use not recommended) Focus monitoring devices in parts of island where dispersing rats are likely to arrive.
Brown rat	Lewis and Harris, possibly elsewhere	Ferry and leisure boats – **Tuchlose, Farnuff & Dull** Possible	Critical	Bait stations on ferry. Inform & educate boat users (inc. ferry passengers). Focus monitoring devices around piers & moorings. Unpack cargoes with care. Install rodent proof room for unpacking bulky high-risk cargoes e.g. animal feed & building materials
House mouse	Lewis and Harris, possibly elsewhere	Ferry and leisure boats – **Tuchlose, Farnuff & Dull** Possible	Medium	(as for brown rat)
Black rat	Passing ship	Swim – no known	Critical	(as for brown rat)

		colonies within swimming distance, though could swim from a passing infested ship. Unlikely but possible		
Black rat	Lewis and Harris, possibly elsewhere	Ferry and leisure boats – **Tuchlose, Farnuff & Dull** Unlikely but possible	Critical	(as for brown rat)

The proximity of Tuchlose to islands from which rats cannot be eradicated (Lewis and Harris) means we recommend that sustainable eradication on Tuchlose be considered unfeasible. A DNA connectivity study should be considered to help understand the reality of this risk in practice. This is likely to cost around £10,000, however it should be noted that its results cannot be conclusive as established populations can prevent new arrivals from settling and breeding, giving the appearance that dispersal is less likely than it actually is (Fraser et al. 2015). Although rats would have to swim against a current to reach Tuchlose, there are small 'stepping stone' rocks between the island and the mainland of Lewis and Harris which further add to the risk of reinvasion. Experience from other restoration projects has found that there can be periods of slack either side of the tide turning. The risks of reinvasion are considered too high and the degree of biosecurity that would be needed to mitigate these risks is considered unrealistic for an island with such a small resident population.

Should the eradication plans proceed then a full biosecurity plan will be produced. The essence of island biosecurity is to identify the pathways by which invasive species might reach the island and to then place multiple obstacles along that pathway. Briefly, there are three opportunities for preventing rats reaching the island – to prevent them leaving their current location, prevent them from reaching the island and, finally, to prevent them from forming breeding populations if they do reach the island. Table 4 above suggests some of the measures that could be used to minimise the risks of rodents invading or reinvading the islands. These include placing bait stations and/ or appropriate traps or other monitoring devices on boats travelling to the islands as well as at the harbours they are likely to travel from and also where they will moor when reaching the islands. Training and awareness-raising of boat users, particularly staff on the CalMac ferry, is extremely important. A set of protocols informing ferry staff, other boat users and island visitors what to do in the event of finding rat sign will also be produced. A surveillance strategy for both Farnuff and Dull islands will be developed, using a range of different techniques including flavoured wax blocks and tracking tunnels. A full incursion response plan will also be produced, detailing exactly what should happen in the event of rodent sign being found on the islands.

3.3 Political & legal acceptability

A number of regulatory requirements may need to be fulfilled for the proposed eradication programme, including:

- Animal Ethics approval to undertake many of the research and monitoring components of the plan,
- Review of the Feasibility Study and Operational Plan by a member of the UK Island Restoration Advisory Group (UK-IRAG) to ensure the proposed techniques comply with best operating practises for island rat eradications.
- Review of the Feasibility Study and Operational Plan by the Health and Safety Executive (HSE) to ensure the safety of operational staff, volunteers and visitors.
- Training personnel in rodent management and safe bait use and handling (an appropriate training course is available for this, managed by the Campaign for Responsible Rodenticide Use's Stewardship Scheme.)

- Ensure operation is valid under the Control of Pesticides Regulations 1986
- Apply for permission from SWCA for any track cutting that may be needed, since the islands are an SSSI

SWCA will also need to give permission for the temporary removal of a captive population of Stewart Island voles

3.4 Social acceptability

The communities on Farnuff and Tuchlose and the islands' owner have been involved in preliminary discussions over the possibility of a rat eradication project over the last three year. When the islands were identified as priorities for rat eradication in the prioritisation exercise carried out by the UKSCT further discussions were held and all parties agreed to a feasibility study being carried out, with no obligations on any of the parties involved.

Table 5 : Key Stakeholders on Farnuff Island

Name	Capacity of stakeholder	What will they have to do for project to succeed?	Notes/comments incl details of all previous communication
Bob Clipper	Owner of islands	Write letters of support, e.g. for funding applications, allow (and facilitate) access to the islands, allow improvements to accommodation on Dull	Historic connection with SWCA over land management as part of SPA, lead contact at SWCA **Bill George.** Long running interest in conservation and Hebridean natural history
Graham MacDonald, Jan & Jock Fry, Alice MacLeod	Farmers on Farnuff	Comply with mitigation and biosecurity measures, potentially be prepared to move livestock around island	Supportive of the idea of eradication, though some concerns over risks to animals.
Jenny Godber, Paul & Jim MacLeod, Frank Day (plus farmers)	Pet owners on Farnuff	Comply with mitigation measures for pets during poisoning operation	Supportive of the idea of eradication, though some concerns over risks to animals.
Pam & Jack Francis, Alice Macleod, Julie & Guy Soady, Ed Roberts	Parents of Farnuff children	Assist with education of children over toxin risks	Supportive of the idea of eradication, though some concerns over risks to children.
All residents	Farnuff residents	Adhere to biosecurity measures	Some questions about practicality of quarantine and biosecurity measures that will be needed.

Public meetings were held on Farnuff and Tuchlose as part of this feasibility study, though only the results of the public consultation on Farnuff are included here. We met with all island residents on two occasions, at the beginning and end of the trip. On the first meeting we introduced ourselves and gave a brief presentation on the aims, objectives and methods of the proposed eradication project, followed by an open question and answer session. Over the course of the week we then visited every household on the island and spoke in more detail about the plans, focussing on the potential implications for island residents (both positive and negative) as well as the conservation benefits that could be expected. We then held another meeting at the end of the week to discuss our findings, give more detail on what would need to be done and to take any further questions about the project.

The main concerns about the project were the safety of people and domestic animals and the impacts that could be expected to peoples' daily lives. Residents were reassured to hear about how the use of bait stations would minimise the chances of livestock coming into contact with the bait and also that there was an antidote available. The farmers asked if the costs of testing any animals for rodenticide residues before shipping them to market would be covered by the project. This will need to be considered by the project finders and is not currently included in the estimated budget included in this report.

3.5 Environmental acceptability

The eradication of brown rats from Farnuff and Dull islands are likely to have strong positive environmental benefits. Rat predation of seabirds on the islands, believed to be a major factor in the decline of several species, will end, as will their impacts upon other prey species including many of the islands' plants and invertebrate species. The biggest potential negative impact from removing rats is likely to be an upswing in the numbers of rabbits, leading to impacts on the islands' vegetation caused by increased grazing pressure. The rabbit population should therefore be monitored before and after the rat eradication and we recommend that the Operational Plan includes provision for controlling rabbits if their populations increase above a pre-determined threshold.

The poisoning phase of the operation is likely to cause some losses to non-target mammal species, including Stewart Island voles, common shrews and rabbits. Impacts on rabbits will be reduced by using wires to reduce the size of the bait station entrance holes. No population level impact on rabbits is considered likely. Population level impacts on shrews are also considered to be unlikely as the species have home range sizes smaller than the proposed 50m x 50m baiting grid, meaning that many shrews are unlikely to encounter bait stations. The Stewart Island vole is likely to be similarly protected, as the available data suggest their home range size is only around 200m^2 (equating to a circle approximately 16m in diameter) (Hausberg 2006). However, the endemic status of the vole means that serious consideration should be given to establishing a captive population for the duration of the project. We recommend drawing up plans to collect and maintain a captive vole population, either on Farnuff or elsewhere. This should be included in the Operational Plan.

By reducing the risk of primary poisoning for these three mammal species we will also be reducing the risk of secondary poisoning to the white-tailed sea eagles and other raptors. The use of a first generation rodenticide as the primary bait for the eradication project will also decease the chance of secondary poisoning of non-target raptor species since it is markedly less potent than the second generation compounds more commonly used in eradications and does not persist in biological tissues to the same extent. It is estimated that a white tailed eagle would have to eat It will also reduce the theoretical risk of secondary poisoning to insectivorous birds such as skylarks, which may eat invertebrates which have themselves eaten the bait.

Risks to livestock are also extremely low. While some interference with bait stations has been reported from the rat eradication projects on Lundy and Canna, caused by ponies and cows, this did not lead to any harmful effects for the animals involved. However, it is best practice to avoid any unnecessary consumption of bait by on-target species. If livestock are found to be interfering with bait stations additional efforts will be made to reinforce the stations (e.g. by weighing them down with rocks) or, if it does not conflict with the operational plan, the bait could be wired into the stations. Discussions with the animals' owners could also take place to see if any animals known or suspected to be interfering with the bait stations could be moved to a different location for the remainder of the poisoning phase. The details of this should be presented in the operational plan.

The long term impacts on any of the islands' native vertebrate species are likely to be extremely positive once the pressure of competition and predation by rats. The islands' birds are likely to be at

extremely low risk from the eradication if it is carried out safely – i.e. bait only deployed inside fixed bait stations.

The overall impacts of removing invasive brown rats from the ecosystems of Farnuff and Dull are likely to be extremely positive. Ecological networks are delicate and complex systems however and there is always the possibility of unwanted unforeseen effects. Theoretically, any of the species currently subject to predation or competition by rats could increase once these pressures are removed, potentially markedly so. Consequently we recommend that a range of invertebrate and plant species are included in the pre- and post-eradication monitoring plans, as well as rabbits, seabirds and land birds and the remaining mammal fauna. Impacts on these species are often overlooked in post-eradication monitoring studies. Detailed protocols for the pre- and post-eradication ecological monitoring surveys will be provided in the monitoring and evaluation plan.

3.6 Capacity

Table 6: Key Skills needed to complete the project to eradication brown rats from the Stewart Islands

KEY SKILL	PURPOSE	METHOD TO OBTAIN SKILLS
Leadership of rat eradication projects	Lead technical phase of rat eradication	Tender for specialist
GIS expertise	Create and maintain maps of islands and associated rat eradication data (locations of bait stations, monitoring equipment etc.)	Tender for specialist
Boat handling skills	Transporting staff and equipment safely between islands	Locally available
Overall project management skills	Oversee project management	Available within SWCA and UKSCT
Community liaison expertise	Advise on how to engage with and advocate to the community	Available within SWCA and UKSCT, may consider tendering for specialist expertise
Climbing expertise	Set up rope access points where needed and use these to safely and effectively monitor rat activity	Hire experienced climbers as part of eradication team
Rodent trapping and husbandry skills	Capture and maintenance of captive vole population	Available within Scottish Animal Park (project partner)

3.6.1 Project management

The UKSCT have the necessary skills in-house to manage the project, including several highly experienced project managers.

3.6.2 Specialist input

The project will also employ an experienced rodent eradication contractor to the lead the eradication and intensive monitoring phases of the project. Experienced climbers will be used for the rope access work, while boat operators familiar with local sea conditions will be used for work needing boat access.

3.6.3 Staffing

Project manager: The UKSCT and SWCA have allocated Kate Vickerman to the role of project manager for the duration of the project. She has extensive project management and rat eradication experience.

Operations (Technical) Manager: A technical rat eradication expert will be required to act as the technical co-ordinator in the project team. They will provide technical expertise, guidance and take responsibility for completing the technical activities. They will assist the PM in planning the technical activities. The role of operations manager will be put out to tender in order to attract a world-class eradication specialist.

Deputy Operations Manager: Sam Peason of SWCA will take the role of Deputy Operations Manager. Sam has worked as a team leader on previous UK rat eradication projects in addition to his experience of invasive species projects overseas. Sam's involvement at this level will continue to build capacity for practical rat eradication skills within UK conservation organisations.

Independent Rat Eradication Technical Advisor: The project will appoint an independent expert to review project documents and conduct the eradication readiness check. The advisor will not be involved with the actual completion of the project but will remain independent in order to provide objective reviews of planning and progress. We will consult the UK Island Restoration Advisory Group for assistance in sourcing a suitable advisor or advisors.

Vole capture and husbandry specialist: An experienced small mammal expert will be needed to design and run a trapping programme to collect a captive population of Stewart Island voles. The voles will also need to be maintained in captivity until the island is declared rat–free. Specialist facilities will need to be available for this on a site with appropriate facilities.

Rope workers: The rope work needed for the project will be put out to tender to find specialists with the appropriate skills and experience.

Boat handler(s): Experienced boat handlers will be needed to transport staff and equipment between Farnuff and Dull Islands. It is likely that appropriate skills, boats and required certifications will be available among the community on Farnuff.

3.6.4 Institutional Support

The project will need the support of the relevant agencies, both government and NGO. Approval by SWCA will be required. SWCA and UKSCT will also need to ensure that agreements to allocate set amounts of staff time to the project are met.

Currently the project management structure and responsibilities between agencies (e.g. SWCA, UKSCT and the landowners) have not been finalised. A clear management structure and consistent support is critical to the outcome of the project and will need to be confirmed.

3.7 Financial viability

Table 7: Indicative project costs for the eradication of brown rats from the Stewart Islands

Item	Details	Cost (£)
Project Design Stage		
Salary: project manager	Planning and writing Project Plan	2 000
Contractors	Planning and writing Project Plan	2 000

	Project Design Stage: sub-total	4 000
Project Design Stage, Expected cost		**4 000**
Operational Planning Stage:		
Contractors	Planning costs – development of biosecurity, monitoring and operational plans	6 000
Salary: Project manager/ administrator	Part time for one year. Covers all stages of project	15 000
Salary: Deputy operations manager	Part time for one year. Covers all stages of project	12 000
Field trip costs	Contract eradication expert, plus project manager	6 000
Operational Planning Stage, Sub-total		39 000
Operational Planning Stage, Contingency (20%)		7 800
Operational Planning Stage, Expected cost		**46 800**
Implementation Stage:		
Bait purchase (primary)	5.5 tonnes Contrac (bromadiolone) blocks	37 400
Bait purchase (back-up)	100kg Neosorexa (difenacoum blocks)	700
Bait transport costs	Road transport, Bristol to Stornoway	2 200
Local storage and transport	Storage in Stornoway	500
Bait shipping costs	Boat, Stornoway to Farnuff	1 200
Contracted Operations manager	7 months @ £3000 per month	21 000
Other contracted staff costs	6 staff for a total of 37 person-months @ £2400	88 800
Staff transport	Travel for staff and volunteers to Farnuff	2 200
Accommodation, en route	Hotel/ B&B for staff travelling to/ from Farnuff, two nights each for up to 15 people	1 500
Accommodation, Farnuff	House rental for 7 months @ £1200/ month (2 properties, includes all utilities)	8 400
Food & subsistence	Food for project staff and volunteers for 62 person-months @ £320	19 840
Bait stations	Plastic tube bait stations, 1000 @ £4 each (10 x 100m rolls of unperforated drainage tube, plus wires for fixing to ground and crow clips	4 000
Bait stations	Wooden boxes with hinged lids (for long term monitoring purposes), 50 @ £25 each	1 250
Monitoring points	Wire for fixing monitoring items to ground, 4 x 200m rolls @ £100 per roll	400
Other equipment for eradication monitoring phase	Includes: flagging tape, marker poles, poison warning labels, vitamin K1, stationery and office supplies, two-way radios, wet weather gear, tools, first aid supplies, safety equipment	12 000

Other equipment for intensive monitoring phase	Includes: tracking tunnels, cards and ink, wax monitoring block materials, soap, cordless drill for making holes in monitoring wax, soap etc.	15 000
Boat hire, transport from Farnuff to Dull	2 x return trips per week for up to 26 weeks @ £50 per trip	2 600
Vole capture and maintenance in captivity	Includes two week trip to Farnuff, trapping equipment and maintenance at Highland Wildlife Park for two years	15 000
Operational review	Contractor, with local input for two weeks	1 200
Implementation Stage, Sub-total		235 190
Implementation Stage, Contingency (20%)		47 038
Implementation Stage, Expected cost		**282 228**
Sustaining the Project Stage:		
Biosecurity: set up	Equipment: tracking tunnels, traps, labour costs etc.	4 000
Biosecurity: Annual running costs	Transport, replacement equipment, labour costs	2 500
Post-operational ecological monitoring	Transport, labour costs, equipment and consumables	4 000
Long term rat monitoring	Transport, labour costs, equipment and consumables (may be able to combine with ecological monitoring trips)	4 000
Sustaining the Project Stage running costs for 5 years (A)		10 500
Sustaining the Project Stage Set up costs (B)		4 000
Sustaining the Project Stage sub-total(C=A+B)		14 500
Sustaining the Project Stage Contingency (D=20% of C)		2 900
Sustaining the Project Stage, Expected 5-year cost		**17 400**
PROJECT TOTAL		**350 428**

No definite sources of funding have been identified at the present time. The Seabird Conservation Fund fund is the most likely source of primary funding. The necessary match funding could come from a variety of sources, with a donation of time and resources from SWCA and UKSCT.

4 CONCLUSION

The eradication of brown rats from Farnuff Island is feasible and, if rats are also eradicated from nearby Dull Island, is also likely to be sustainable in the long term since this pair of islands is beyond brown rats' known swimming distance. Eradicating rats from Tuchlose, however, while technically feasible, is not likely to be sustainable due to its proximity to the island of Lewis and Harris, which is well within the known swimming distance for brown rats. This makes the proposed eradication of rats from this island unfeasible overall.

A joint eradication project on Farnuff and Dull meets all the requirements set out in the 'Can it be done?' section of this report. A proven technical approach is available, and there are no physical reasons why this approach cannot be taken on Dull and Farnuff. With the use of appropriate rope access all sections of the islands can be reached. Once the bothy and outbuildings have been renovated on Dull there will be suitable accommodation and storage space on both islands. The eradication project has the full support from the local community, subject to finalising a few issues around livestock safety. The landowner and SWCA both support the project and the legal permits required should be easily achieved. The environmental impacts of the project can be kept to an acceptable minimum, with very few negative impacts on non-target species envisaged due to the use of regularly checked bait stations and an operational plan following international best practice guidance. The project also has, or can realistically hope to employ the necessary capacity. Sourcing the necessary funding is currently the biggest challenge facing the project; this kind of work is expensive and requires the full funding amount to be secured before it can begin. However, the conservation gains which this project will provide are significant and, coupled with its high chance of success, this should prove appealing to funding agencies.

In addition to securing the necessary funding, the feasibility of this project is however conditional on the following factors. The farming community on Farnuff must commit to adopting new methods of feeding their livestock as the current system involves animal feed pellets being left out in fields overnight. The community will also need to adapt to the biosecurity mindset needed on islands which have been cleared of invasive rodents.

Table 8: The issues considered during the feasibility study for eradication of brown rats on the Stewart Islands and recommendations to resolve these.

Issue	Recommendation
1. Tuchlose is only 600m offshore from the island of Lewis and Harris, which is too large for eradication to be achievable using available techniques.	Consider the merits of a DNA connectivity study which can help establish how likely it is rats would swim to Tuchlose after an eradication. If the study indicates this may be unlikely, eradication could be taken forward, subject to a new feasibility study.
2. Dull Island is 300m away from Farnuff and so will need to be included into any eradication work on Farnuff if it is to meet the 'sustainable' criterion.	Include Dull Island in the project area. Consider the pros/cons of assisted colonisation by Manx shearwater and European storm-petrel, as this may maximise the benefits of its inclusion in the project.
3. The application of rodenticides may pose a risk to the residents of Farnuff, the endemic sub-species of vole, and white-tailed eagles.	Risks to residents can be handled via a good communication and education strategy. Lockable plastic bait stations are recommended for use inside buildings. At least one viable population of the Stewart Island vole should be taken in to captivity off island. Consider diversionary feeding for white-tailed eagles. Conduct resistance testing of the rats to the less potent rodenticides and use the least potent bait that will still be efficacious. Reserve a more potent bait for the latter stages of the eradication where it will be available for a shorter period of time and when there should be few/no rats left.
4. The rabbit population of Farnuff cannot be eradicated and is likely to increase in the absence of rats with potential implications on the wider island ecosystem.	Discuss the implications with the island residents (rabbits will be competing with livestock for grass). Some residents may be prepared to undertake control measures in the long-term.
5. Community support for the eradication will need to be sustained	Continue close communication with island owner and residents, encourage them to discuss any concerns.
6. Issues surrounding the feeding of livestock and how to deal with any potential bait take by these animals need to be finalised in liaison with the local farming community.	Continue close communication with farmers. Organise an additional face to face meeting to discuss these issues, develop a plan for what changes need to be made and seek consensus with farmers.
7. There will need to be strong community participation and leadership in biosecurity measures if reinvasion is to be avoided, particularly on Farnuff.	Discuss the implications with the island residents. Some residents may be prepared to undertake biosecurity measures in the long-term.
8. A number of approvals are required.	We recommend early application for the following permits and permissions: • overall project approval by SWCA • permit from SWCA for track cutting on Farnuff and Dull • permission from SWCA to collect population of Stewart Island voles and remove them from the island

Acknowledgements

We would like to acknowledge the assistance of the following people in the production of this report:

All of the residents of Farnuff and Tuchlose for their interest and willingness to discuss the project proposals and for their support. Thanks also to Jenny Luscombe and Jim Hunter for their hospitality during our stays on the island, and to Mike Broad for the use of his boat to reach Dull Island.

Phil Hill and Gill Pollard for their independent review of the draft feasibility study report.

5 REFERENCES

Genuine references are listed here. Others included in the text are fictional.

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6 APPENDICES

Appendix 1: Site visit

Sylvie Thornhill and Ruben Mitchell visited the Stewart Islands from 4-18th October 2013, including eight nights on Farnuff and six on Tuchlose. Dull Island was visited overnight on 8-9th October, with additional trips to check and set snap traps and Longworth traps on the morning and evening of 10th and 11th October.

Activities

Community liaison

Meetings with the communities of Farnuff and Tuchlose were held on two occasions during the visits to the islands, once at the beginning and once at the end. During the first visit we spoke to the residents about the proposed rat eradication projects, what they would entail, the benefits that could be expected for local wildlife and the impacts it would be expected to have on their daily lives. At these preliminary meetings we also handed out questionnaires (see below) to gather the residents' views on issues such as their perceived severity of the rat problem, to them, their livestock and the islands' wildlife. We also asked about the costs incurred in rat control. In addition we made individual visits to all island households during our visits, completing their questionnaires, discussing their individual experiences of rats and answering any questions they might have. A meeting with the landowner, Bob Clipper, was held at his home in Ruanish on the Isle of Lewis on the 3rd October and a further telephone meeting on October 20th.

Overall, the communities were very positive about the proposed eradication projects. The main questions raised concerned safety to children, domestic animals and livestock. While people were content that the risks to children and domestic animals were minimal (and were reassured to hear about the effective antidote available for anti-coagulant poisons), there were ongoing concerns about the possibility of livestock consuming the bait. The project staff also outlined the issues around current feeding practices for the sheep on Farnuff, where feed pellets are often left out in fields overnight.

Studies of rat and other small mammal activity

We carried out a range of activities to monitor for the presence, distribution and abundance of rats, as well as Stewart Island voles, common shrews and, potentially, house mice.

Index trapping for rats: 25 pairs of T-rex break-back rat traps were placed at 30 m intervals in areas of suitable habitat. They were placed in locations likely to be used by rats, such as along the edges of walls and other linear features, between rocks etc. Rat traps were tied down so that injured rats (or other rats eating the carcasses) could not drag them away. Traps were baited with peanut butter (which was replaced as necessary) and set in the evening and checked and set off the following morning to minimise non-target captures. One index line was run on each of the three islands for three consecutive nights in each location.

Tracking tunnels were also used to find evidence of mammal species present on the islands. Twenty tunnels (Black Trakka tunnels from www.gotcha.co.nz) were set on each of Farnuff and Tuchlose islands and fifteen on Dull. These tunnels, each sited in a location likely to appeal to small mammals, were held in place with wire pegs. They were each lined with an inked tracking card and baited with peanut butter.

Longworth traps were also used to survey for small mammals, in particular to see if house mice were present on Farnuff (they are anecdotally reported to have died out there in the 1970s), Tuchlose and Dull (where they have never been recorded). Twenty traps were set in pairs, each pair 30m apart, for three nights on each of the three islands. The traps were baited with peanut butter and a small

amount of casters (blowfly pupae) to sustain any shrews which may have been caught). The traps were set in places likely to appeal to small mammals such as along linear features and in natural tunnels between rocks.

Non-toxic bait blocks (Detex Blox, manufactured by Bell laboratories) were set out on all three Stewart Islands in sites of likely rat activity (e.g. along walls, near feed stores and in seabird colonies), two 20g blocks at each of 30 sites. These were checked daily for signs of rat activity.

Results

Index trapping: Forty-six rats were caught across the three islands, 20 on Farnuff, 19 on Tuchlose and 10 on Dull, comprising of 21 males and 25 females. Indices of abundance (also referred to as rat densities) were calculated for each site using the methods of Cunningham & Moors (1996) and are shown below. Indices under 10% are considered 'low', those between 11 and 25% 'moderate'.

Island	Number of corrected trap nights	Rat captures	Index of abundance
Farnuff	133	20	15.0
Tuchlose	130	19	14.6
Dull	135	10	7.4

Tracking tunnels: The tracking tunnels showed footprints of rats, Stewart voles (on Farnuff and Tuchlose) and common shrews but no sign of house mice. The number of cards that had rat tracks present were used to estimate the tracking index (TI, or abundance, e.g. 4 out of 10 tunnels with rat tracks = 40% abundance). The TI values varied slightly between islands but broadly in line with the rat densities calculated from the rat traps. Farnuff had a TI of 25% (5 out of 20 cards), Tuchlose 20% (4 out of 20 cards) and Dull 13% (2 out of 15 cards)

Longworth traps: Over the course of the three nights trapping Stewart Island voles were caught on both Farnuff and Tuchlose (12 and 8 animals respectively). Common shrews were caught on all three islands (Farnuff = 3, Tuchlose = 1, Dull = 6). No house mice were caught, or encountered, on any if the three islands.

Non-toxic bait: The blocks showed a high level of acceptability by rats. Overall, 80% showed take by rats within 2 days and 93% within 3 days. There were no significant differences between the rates of take by rats between the three islands – all showed take of between 90 and 95% after three days.

Index trapping and tracking tunnels are an effective way of monitoring changes to rodent densities and activity in specific habitats (Brown et al. 1996, Blackwell et al. 2002). However, it is important to place tracking tunnels in similar or the same habitat (Blackwell et al. 2002). It is also important to realise that the tracking tunnels are susceptible to the same individual tracking through a number of tunnels and that the spacing needs to take into account the home range of the rat (Blackwell et al. 2002).

Habitat assessment

We also surveyed the three islands extensively to check for access (all parts of the island will need to be accessed during any future rat eradication project), in particular to see which areas would require rope access, trail cutting or other special requirements. Cliffs in parts of the north and west coasts of Farnuff will require rope access or at least guidance ropes, as will the cliffs on the west of Tuchlose. No cliff access will be needed on Dull, though guide ropes in some steep parts of the west of the

island are advisable. Small sections of trails will need to be cut on both Farnuff and Dull, through gorse and other low scrub vegetation.

Biosecurity measures

Where possible, equipment was transported in plastic crates with sealable lids. These were all checked for signs of rodent gnawing before loading onto boats for the trips to the various islands. All other equipment was repacked on the day of departure to dislodge any small mammals which may have sneaked in overnight. Boots and other outdoor equipment (particularly the camping equipment used on Dull) were checked and cleaned thoroughly before leaving the mainland to ensure no seeds or invertebrates were inadvertently carried to the islands.

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Questionnaire for island residents:

1. Which Island do you live on?
2. Do you think seabirds are an important part of the Stewart Islands?
3. Were you aware that their populations were declining?
4. Do you think that their populations should be protected and enhanced?
5. Have you noticed more rats recently?
6. Do you think rats are a problem on your island?
7. Would you like something done about the rats?
8. Have rats been a problem for you?
9. If so, specify how (Damage to: food, crops, property, animals, home, business, farm, boat. Attacking animals or people. Bites, fleas, other)
10. Would you support a programme to remove rats from your island if it was found to be feasible?
11. Rodenticide is already used on the islands to control rats. This currently is the most effective method of removal. Would you support this method?
12. Would you advocate another method?
13. Any work would need to be carried out between October and March. Would this be a problem? If yes, why?
14. How much you spend privately on controlling rats, repairing any damage, rat proofing your property, etc?
15. What is the estimated cost from loss of products caused by contamination, damage or consumption by rats?
16. Please rank the following issues in terms of their importance to you: Waste Management, Public and Animal Health, Access to Private Land, Private Gardens or Farms, Non-Target Species, Project Management, Communication, Community Involvement, Transport, Cargo Movements, Re-Invasion, Livestock, Keeping Chickens, Pets, Terrain, Weather and Adequate Funding.
17. Do you use the following methods of waste storage and disposal? Rat-proof dustbin, unprotected bin bags, private burning of waste, rat-proof wheelie bin, compost heaps, private dumps (home/ farm/ garden waste)
18. Would you be happy to change this temporarily/permanently if this helped remove food for rats?
19. Even if you did not consider that rats were present, would you be happy to have rat bait stations located on your property?
20. Would there need to be any conditions applied to their presence (Please state)?
21. Do you keep any livestock on your property and if so, which is it?
22. Do you store anything that would be a potential food source for rats on your property and if so, what?
23. Would you be happy to provide access? To which areas: all, buildings, gardens, other land
24. Do you have, or are you aware whether the following animals are present on your land? Pet cat, pet dog, any other pets which go outside
25. Do you own a boat and use it for travelling between/to the islands?
26. Do you transport any potential food sources for rats? Food, livestock feed, other (please state)
27. Do you store this on any of the quays?
28. If it was thought that there was a risk of transportation of rats on your vessel, would you be happy to install a bait station?
29. Would you be interested in assisting with any contingency/ incursion response operation?
30. Would you like training in rodent detection and identification?
31. Would you like to be trained in interview and site inspection procedures and methods?
32. Would you want to be involved in long-term monitoring for rodents?
33. Would you be happy to check for rodent damage to your own cargo?
34. Would you be happy to install and maintain a bait station on your vessel and/or property?
35. Would you be happy to transport food to and between islands in rodent-proof containers?
36. Would you be interested in supporting or getting involved in the project in addition to above? Becoming a partner, in-kind logistical support, volunteering time, financial, other

37. Do you have any comments/ suggestions/ concerns you would like answering?
38. Would you like more information on the project?