Berwick Bank Wind Farm

Additional Environmental Information (AEI) Submission

AEI02: Addendum to the Derogation Case

Section 6 Inchcolm Feasibility Study

Document Title	**Assessment of the Feasibility for the Eradication of Black Rats (*Rattus rattus)* from Inchcolm Island, Firth of Forth, Scotland.**
Document Number	SSER - 004
Location	Inchcolm Island
Client	SSER Berwick Bank Wind Farm

Status	**Signature**	**Name**	**Date**
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Document Issue/ Amendment Sheet:

Issue No.	**Date**	**Description of changes**
1.0	27/09/22	Original draft report.
2.0	27/10/22	Addressed comments from SSER.
3.0	28/10/22	Revised nesting and productivity calculations for Kittiwake and mixed guillemot/razorbill colonies.
4.0	14/07/23	Change to recommended rodenticide and consistency check.
5.0	01/08/23	Addressed client comments.

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B. Cain, I. *et al* (2022b). INCHCOLM Breeding Seabird Survey and Habitat Assessment Report: Tasks 3 and 4: SSER Berwick Bank Wind Farm: Predator Eradication Feasibility Study.
C. Balague, T *et al* 2022. Black rat abundance literature review: Local, regional and global.

EXECUTIVE SUMMARY

Berwick Bank Wind Farm Limited (The Applicant) is proposing to develop the Berwick Bank Wind Farm in the outer Firth of Forth and Firth of Tay.

Several colony-based measures are proposed as compensatory measures for the proposed development. This document concerns the proposed compensation measure for rat eradication and biosecurity to benefit kittiwake, guillemot, razorbill and puffin nesting at Inchcolm, an island in the Firth of Forth.

The study has concluded a well-planned eradication programme managed by experienced operators, adequately funded, and supported by the landowners, community, and stakeholders, would result in the eradication of invasive non-native black rats from Inchcolm and its islets. This would improve the habitat for key seabird species to breed more successfully and for colonies to grow.

Concerns raised by interested stakeholders will be discussed, in particular the status of black rats. A clarification note shall be provided once consultation has been completed.

To accompany the removal of black rats from Inchcolm and its islets, long term monitoring, biosecurity and response measures shall be implemented to prevent re-invasion as part of this compensation package.

The eradication of rats on Inchcolm shall ensure there will not be a requirement for continued long term use of lethal traps and/or rodenticides (apart from biosecurity and incursion response), removing the long term risk of secondary poisoning to non-target species.

1.0 INTRODUCTION

Berwick Bank Wind Farm Limited (The Applicant) is proposing to develop the Berwick Bank Wind Farm. Berwick Bank comprises of up to 307 wind turbines and will be located in the outer Firth of Forth and Firth of Tay Figure 1, within the former Round 3 Firth of Forth Zone.

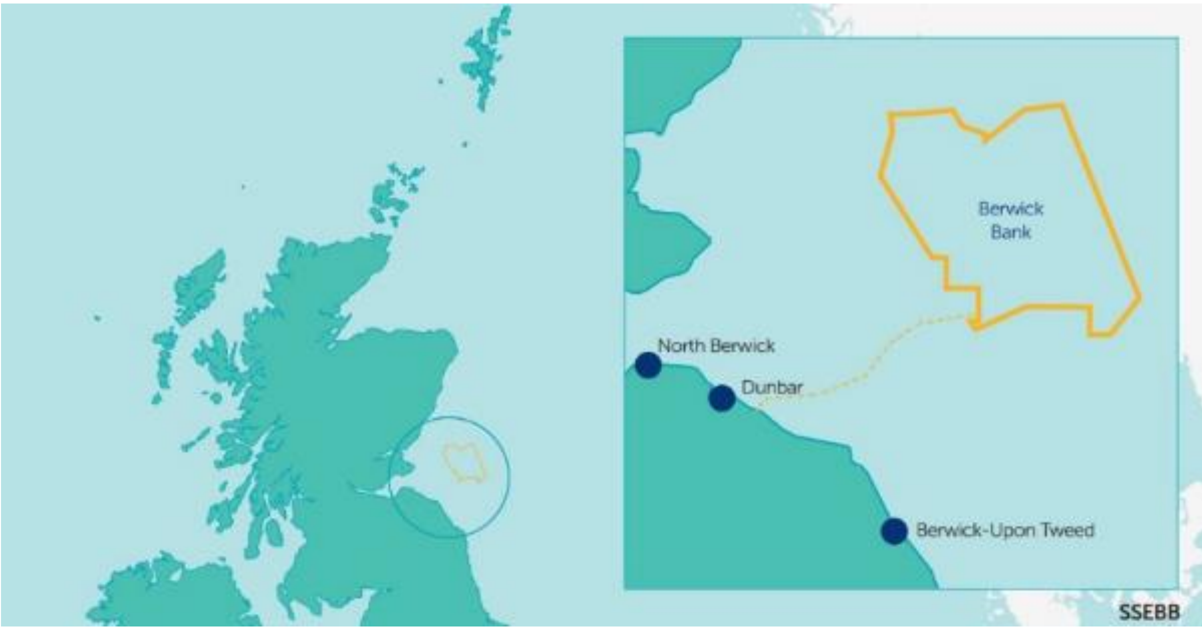

Figure 1. Location of the proposed Berwick Bank Wind Farm (map downloaded from https://www.berwickbank.com/project).

Berwick Bank will include both offshore and onshore infrastructure including the array, offshore export cables to landfall and onshore transmission cables leading to an onshore substation with electrical balancing infrastructure, with subsequent connection to the electricity transmission network. The Scottish Ministers are the primary Regulatory Authority in respect of the necessary consents and licences required for the construction and operation of an Offshore Wind Farm project in Scotland. To allow the Scottish Ministers to properly consider the development proposals, Berwick Bank is required to provide information which demonstrates compliance with the relevant legislation and allows adequate understanding of the material considerations.

The applicants Report to Inform Appropriate Assessment (RIAA) concluded that an adverse effect on site integrity could not be ruled out for Black-legged Kittiwake (hereafter Kittiwake) *Rissa tridactyla*, Common Guillemot (hereafter Guillemot) *Uria aalge*, Razorbill *Alca torda*, and Atlantic Puffin (hereafter Puffin) *Fratercula arctica*. These are collectively referred to as the 'key species'.

Several colony-based measures are proposed as compensatory measures for the proposed development[1]. This document concerns the proposed compensation measure for rat eradication and

[1] EOR0766_Berwick Bank Wind Farm Application - 4. Derogation Case - Colony Compensatory Measures Evidence Report

biosecurity to benefit kittiwake, guillemot, razorbill and puffin nesting at Inchcolm, an island in the Firth of Forth.

The scope of work for the feasibility study on Inchcolm comprises the following 4 tasks:

Task 1: Field studies in June 2022 (Appendix A) to:

- Determine the presence and abundance of mammalian predators.
- Gather evidence of predation pressure.
- Assess early stakeholder opinion.

Task 2: Field studies in June 2022 (Appendix B) to:

- Collate seabird census data for Inchcolm and the other islands in the Firth of Forth.
- Assess the availability of potentially suitable nesting habitat that are currently unoccupied which may indicate that rats are preventing nesting by key species in these locations.

Task 3: Assessment against the following seven key feasibility criteria described in the UK Rodent Eradication Best Practice Toolkit (Thomas, Varnham, & Havery, 2017):

- Technically feasible
- Sustainable
- Socially acceptable
- Politically and legally acceptable
- Environmentally acceptable
- Have Capacity, and be
- Affordable.

Task 4: Feasibility Study Report (this document) shall document the results of the site visit and desk study and will report the findings against the seven feasibility criteria. Based on these answers the key feasibility criteria have been considered and recommendations made on whether eradication is feasible or not. Where additional data is required to support the method of eradication these have been described.

2.0 ENVIRONMENTAL SETTING

Inchcolm lies in the Firth of Forth, 1 km off the south coast of Fife opposite Braefoot Bay (separated from the Fife mainland by a stretch of water known as Mortimer's Deep), 6 km east of the Forth Road Bridges and 9 km northwest of the City of Edinburgh (Figure 2 and Figure 3).

Figure 2. Location of Inchcolm, Firth of Forth, Scotland (Google Earth).

Figure 3. Inchcolm, Firth of Forth (Google Earth).

Inchcolm is 10.5 hectares (ha) in area and 34 m high at its highest point. The island comprises two segments (east and west) which are linked by a narrow isthmus. The east section rises to 30 metres above sea level. The west section is flatter but rises to 30 m cliffs at the western extreme of the island.

The island is privately owned and uninhabited. It is managed by Historic Environment Scotland (HES) with at least four HES stewards based on the island during the day. These staff maintain the island and run the shop for the high numbers of seasonal summer (April to October) visitors. Inchcolm is famous for the 12th century Augustinian Abbey which is in the middle of the island and World War I and II military fortifications.

The grounds of the Abbey and central part of the island are landscaped lawns, ornamental shrubs, and few trees. The rest of the island is dominated by coastal grassland with small shrubs and trees.

The island is recognised for breeding seabirds including the northern fulmar (*Fulmarus glacialis*), common eider duck (*Somateria mollissima*), herring gull (*Larus argentatus*) and lesser black-backed gull (*Larus fuscus*). Inchcolm also has smaller populations of puffin, razorbill, black-legged kittiwake, and European shag (*Gulosus aristotelis*).

Small numbers of grey seal (*Halichoerus grypus*) drop their pups on the shore of Inchcolm each autumn and the common or harbour seal (*Phoca vitulina*) has been known to use the island for pupping during the summer months. The only other mammal recorded on Inchcolm is the black rat.

There are two small barren rocky islets, Carr Craig (to the east) and Haystack (to the west), approximately 500 metres offshore from Inchcolm. Both islets have been important breeding grounds for several species of tern in the past, and in more recent years have hosted important colonies of great cormorant *Phalacrocorax carbo* and European shag.

3.0 SEABIRD ACTIVITY AND HABITAT ASSESSMENT

3.1 SEABIRD CENSUS 2022

The island is recognised for breeding seabirds including the northern fulmar, common eider duck, herring gull and lesser black-backed gull. Inchcolm also has smaller populations of puffin, razorbill, black-legged kittiwake, and European shag.

This study obtained data on seabird numbers and breeding success from three primary sources:

i. Forth Heritage Group, Appendix B.
ii. Forth Seabird Group[2]. Single day counts.
iii. Observations made by the consultants during the Task 3 field work June 2022.

Significant findings for the target species are presented and discussed in the accompanying Task 3 and 4 Field Study Report (Appendix B) and summarised below.

3.1.1 Razorbill

The razorbill was first observed in the waters around Inchcolm on June 1st, 1993, when a group of 20-25 birds were seen (Morris, 2003). Razorbills have continued to be present in relatively small numbers during the spring and summer months. Between two and four pairs bred on the island over the period 1996-1999. Eleven nest sites were counted in 2000 and 2002. These small numbers of birds appear to have stabilised with twelve nest sites counted in 2022.

3.1.2 Atlantic puffin

From the late 1980s up until 1991, small numbers of Atlantic puffin were seen frequenting the waters around Inchcolm during their breeding season, but no birds were seen ashore. Four nest sites were observed on Inchcolm in 1993. Breeding has been observed at low levels each year since. The puffin colony originally established itself in the boulder slopes of the south side of Inchcolm' s eastern part, but some birds spread to the grassy slopes of the northwest of the island and in more recent years the whole colony relocated to this area. It has been speculated by the Forth Heritage Group (Appendix B) that this movement may have been influenced by rat predation amongst the more accessible boulder fields of the southeast. In 1995, 89 birds were counted on and offshore, in 2002 58 birds were counted on and offshore. In 2022 the numbers of occupied burrows have been estimated to be a maximum of 11 burrows (i.e. 22 adult birds)

3.1.3 Black-legged kittiwake

Kittiwake breeding was first recorded in 1991 when about 20 pairs were observed nesting at the northwest cliffs. Numbers built up at the colony over the following years reaching a recoded peak of

[2] http://www.forthseabirdgroup.org.uk/pages/wcount-tables.htm)

190 nests in 1995. But in the following years the breeding population declined with only 42 pairs observed to be nesting in 2001. A slight recovery may have started to take place in more recent years with 63 nest sites observed in 2021 and 77 in 2022.

3.1.4 Other species

Gulls (lesser black-backed gull, 1930 apparently occupied territories and herring gull, 2054 apparently occupied territories in 2022) are abundant and breeding successfully in high numbers across Inchcolm.

No breeding guillemot or species of terns have been observed on Inchcolm in recent years despite the abundance of suitable breeding habitat.

Fulmars appear to be breeding successfully in moderate numbers on Inchcolm’s steep rocky cliffs, with approximately 259 birds counted in May 2022.

Eider duck have been observed on Inchcolm in moderate numbers with some 134 nest sites recorded in May 2022. However, during the consultants Task 1 and 2 field work no more than 10 occupied eider nest sites were observed, suggesting fledging had largely completed and/or eggs and chicks had been predated and/or nests abandoned.

4.0 PREDATOR SPECIES, ABUNDANCE AND BEHAVIOUR

4.1. PREDATOR SPECIES AND ABUNDANCE ON INCHCOLM

The Task 1 and 2 Field study (Appendix A) to assess the presence of mammalian predators adopts the methodologies described in the UK Rodent Eradication Best Practice Toolkit (UK Biosecurity for Life) (Thomas et al, 2017).

Index trapping (using traps and tracking tunnels) and trail cameras were used to identify the species, density, and distribution of rats on Inchcolm (see Appendix A for methodology and detailed results, Quy *et al.,* 1993, and Cunningham and Moors, 1996). There were 80 traps, 12 tracking tunnels and nine cameras placed across the island. All rats caught in the traps were necropsied. Samples were collected for DNA and resistance testing.

Only black rats were caught on Inchcolm; 28 rats (11 female, 12 males, 5 unknown). The rats were evenly distributed across the island.

Abundance (or rat density) is recognised as low (less than 10%), moderate (between 11-25%), high (between 26-50%) and very high over 50% (Moors 1985, King & Forsyth, 2021). Islands usually vary between 5-25% (rats per 100 trap nights), but there have been exceptions such as Campbell Island with 123% (King & Forsyth, 2021), Mauritius with 102% (E. Bell, WMIL, unpublished data) and Redonda (Antigua & Barbuda, Caribbean) with 127% (E. Bell, WMIL, unpublished data). The index of rat abundance for Inchcolm was 8 rats per 100 trap nights. This suggests a low rat abundance across the island, but this result may be complicated by the trapping time (summer, June 2022) and abundance of natural food reducing trapping efficacy. This possibility of rat trapping efficacy being compromised in the summer months is confirmed when the trapping results are compared to the data obtained for the tracking tunnel index (this recorded rats were active in 27 tunnels per 100 tunnel nights). These additional monitoring data suggests that black rat numbers might be more accurately categorised as moderate to high on Inchcolm.

When matched against the Global DNA Library, the tissue samples taken from the Inchcolm rats suggested a novel genotype that has not yet been recorded elsewhere in the world (Appendix A). To add context, the Global DNA library for island populations of black rats is not comprehensive. The consultants are aware only of two black rat populations, namely the population that previously existed on Lundy prior to eradication, and the population on Sark that have been subject to this type of genetic analysis.

The genetic analysis does provide the study with a DNA 'fingerprint', against which any renewed black rat activity that is observed after an eradication is completed can be compared; thus enabling a determination to be made of whether the activity is associated with a reinvasion, or if the eradication had failed.

The DNA analytical results show there were no rodenticide resistance genotypes in the black rats trapped on Inchcolm Island. This suggests that rats could be controlled/eradicated using first generation or second-generation anticoagulant rodenticides (FGARs or SGARs). Rodenticides such as coumatetralyl or bromadiolone could be used to control/eradicate these populations rather than utilising the more toxic brodifacoum or flocoumafen required for resistant populations.

The proximity of Inchcolm to the Fife mainland means the island is at risk from reincursion of brown rats (*Rattus norvegicus*) by swimming or transported by vessel following a successful eradication of the black rats. However, given that brown rats have never been recorded on Inchcolm, this suggests that the risk is low and could be managed by good biosecurity. Further consultation and engagement with stakeholders to gain their support for long term biosecurity has been incorporated in the design of the pre eradication operational strategy.

4.2 Black rats: regional and global abundance

Believed to have originated on the Indian subcontinent, black rats are now found throughout the world (Nowak, 1999; King & Forsyth, 2021; Yu *et al*., 2022; ISSG, 2010; Seebens *et al*., 2017; CABI, 2022; Thomson *et al*., 2022) (Figure 4).

Figure 4. Global distribution of black rats.

A literature review indicates black rats were inadvertently introduced into Europe and the United Kingdom (UK) by the Romans with grain imports and other trade movements in the 3rd Century but were apparently wiped out towards the end of the Roman period (5th Century), before being reintroduced with Viking trade in the 8th Century. They were well established across the UK by the 12th Century (Matheson, 1939; Nowak, 1999; McCormack, 2003; Rielly, 2010; Puckett *et al*., 2020). They were often recorded within 10 km of coastal areas or ports in areas associated with trade routes or settlements (McCormack, 2003; Rielly, 2010; Puckett *et al*., 2020). Black rats declined or disappeared from many UK locations following the arrival of more competitive brown rats in the UK in the 18th century (Rielly, 2010; Puckett *et al*., 2020; Yu *et al*., 2022).

There is a general impression that black rats may have existed on Inchcolm since the 12th Century. However, a review of available literature has found a record that suggests black rats may have arrived on Inchcolm as recently as the start of the 20th century (Dickson, J, 1899).

Evidence collected in this study suggests black rats may be more widespread across the UK and Europe than is currently appreciated by stakeholders. Observation records suggest black rat activity is under reported in the UK, even amongst trained pest control technicians and public health officials. This is understandable given the many similarities (particularly colour) between black rats and the UKs more common brown rat when sighted outdoors (See section 5.3).

Over recent years, black rats have been recorded in other locations in Scotland and the wider UK, including the Channel Islands (island populations are present on Alderney and Sark), and UK mainland ports including Rosyth, Southampton, Essex, and London (Figure 5 and Figure 6). A 2022 survey by the British Pest Control Agency showed UK pest control companies often came across black rats during their work, again, mostly at docks and port cities (S. Johnstone, BPCA, personal communication September 2022).

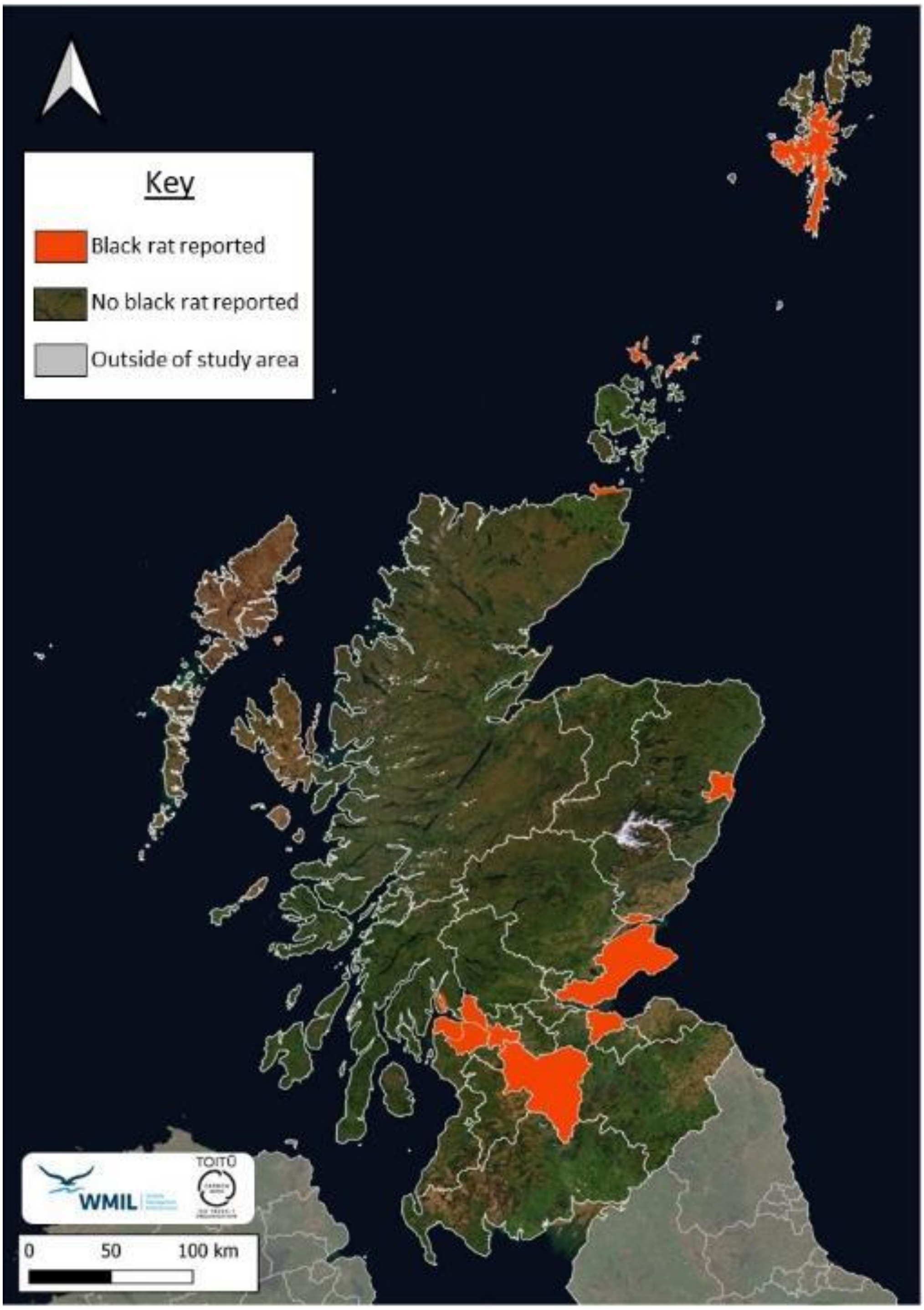

Figure 5. Perceived distribution of black rats in Scotland.

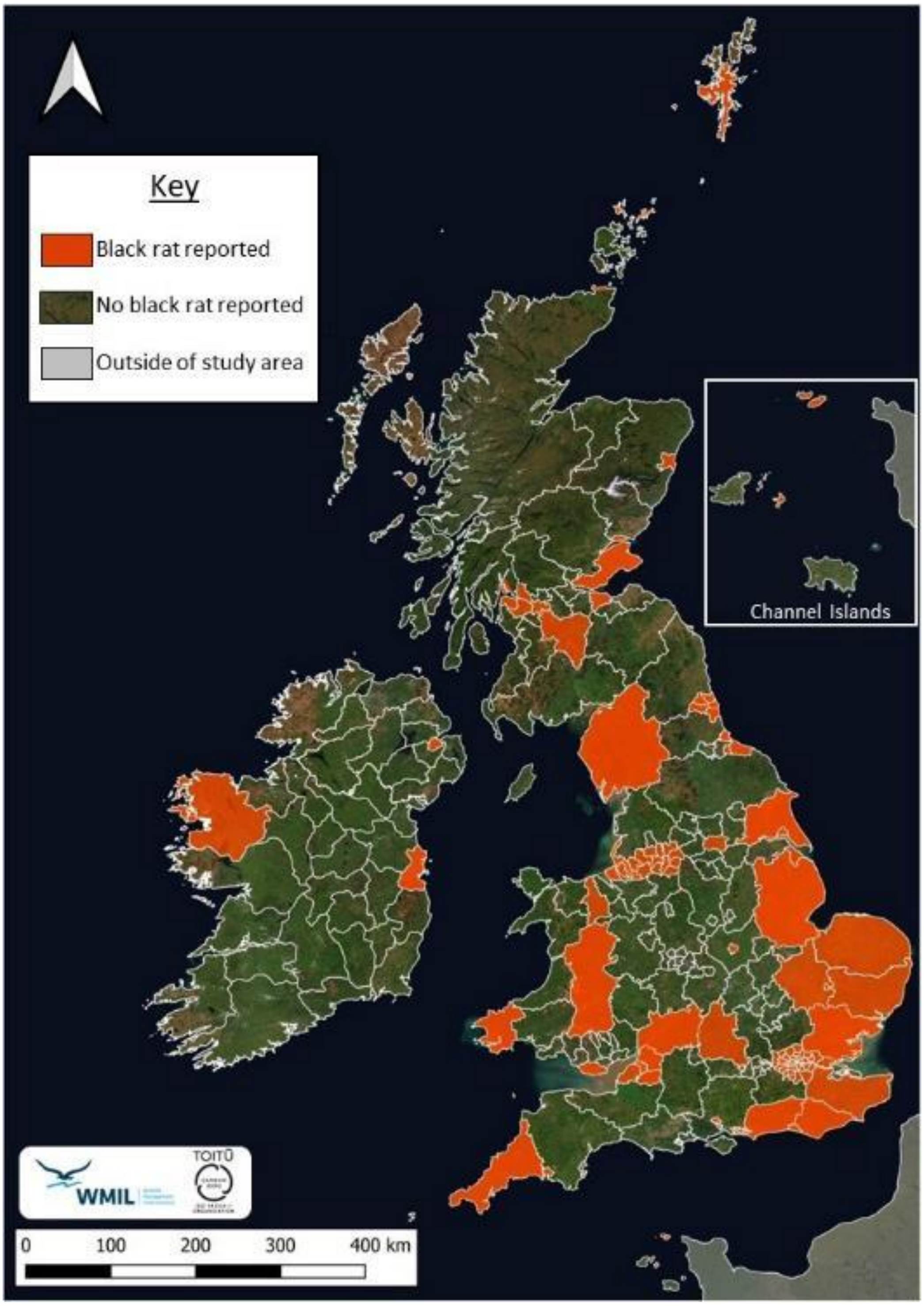

Figure 6. Perceived distribution of black rats in the UK and Ireland.

Black rats are currently listed as naturalised non-native species in the Red List for Britain's Terrestrial Mammals (Mathews & Harrower, 2020) but are also listed in Schedule 9 of the Wildlife and Countryside Act (1981) as a non-native species that should not be released into the wild. Black rats have been identified as one of the world's 100 worst invasive species (Lowe *et al.,* 2000; ISSG, 2010).

4.3 Black rats: characteristics and behaviours

Black rats are large, with a slender body, long scaly tail, large ears, and dark hairy feet (Nowak, 1999; King & Forsyth, 2021). Black rats can grow up to 230 mm in length and weigh up to 300 g (Cunningham & Moor, 1996; King & Forsyth, 2021). There are three recognised colour forms: *rattus* (black back and dark grey belly), *alexandrinus* (brown back and pale grey belly) and *frugivorus* (brown back and white or cream belly). The variation in proportion of colour morphs can vary depending on the location, although *frugivorus* is usually the most common colour phase (Cunningham & Moor, 1993; King & Forsyth, 2021). The *rattus* colour morph was the only colour morph observed on Inchcolm (Appendix A Section, Section 3.3).

Males tend to be larger than females, and when mature, have a prominent scrotum at the base of the tail. Usually only breeding females have visible nipples (Nowak, 1999; King & Forsyth, 2021). Black rats have excellent senses of smell, touch, taste, and hearing (King & Forsyth, 2021). Black rats are omnivorous (but can also be specialist) feeders, taking advantage of any potential food source and will often cache food (Nowak, 1999; King & Forsyth, 2021). When on the ground, black rats prefer to eat food under cover; but in the trees rats will feed on any available flat surface (King & Forsyth, 2021).

Black rats are voracious consumers of vegetation (seeds, nuts, seaweed, and fruit), as well as other animals, insects and birds when available. Natural sources of food tend to be a high proportion of their diet, but human derived products (stores, vegetables, food waste and crops) are also targeted (King & Forsyth, 2021).

Black rats are very agile and skilful climbers of trees and cliffs. They are unwilling swimmers but have been recorded swimming between islands up to 750 m apart (King & Forsyth, 2021).

Black rats do not often burrow, preferring to nest in trees or under thick vegetation or in rock tumbles or crevices (Nowak, 1999; King & Forsyth, 2021). Tracks and runs are common in areas of black rat activity (King & Forsyth, 2021). Black rats are usually associated with forests or vegetated areas but do live in a range of habitats from barren ground, coasts, islands, and grassland to lush forest as well as human dwellings, buildings, and farms (Nowak, 1999, King & Forsyth, 2021).

In natural habitat, black rats do not live in colonies, preferring to disperse throughout the available area (King & Forsyth, 2021). However, in urban areas, a small number of adult females and one dominant male will live together in a territory that will be aggressively defended against other rats (King & Forsyth, 2021). Home range for black rats can vary from 0.1 ha to 1 ha in all types of habitats; this depends on food availability and habitat quality (Moors, 1985; King & Forsyth, 2021). Males have larger home ranges than females (as they prefer to stay close to breeding sites); this may vary depending on habitat quality, food availability, predation pressure and other factors (Nowak, 1999; King & Forsyth, 2021).

Black rats construct nests out of various items including vegetation (twigs and leaves) and feathers, with new material added regularly (Nowak, 1999; King & Forsyth, 2021). They can breed throughout the year, but this generally depends on food availability and habitat (Nowak, 1999; King & Forsyth, 2021). Gestation is between 20 and 22 days and litter size vary from 3 to 10 young (usually 5-6); the average annual production can be up to 40 young per year (Nowak, 1999; King & Forsyth, 2021). The young are weaned when they are between 21 and 28 days old (about 40 g) and can be sexually mature at three months old (Nowak, 1999; King & Forsyth, 2021). Black rats usually live between twelve and eighteen months in the wild, with females generally living longer than males (Daniel, 1972; King & Forsyth, 2021).

Black rats are nocturnal and generally shy; however, this depends on habitat, predation pressure, hierarchy, disturbance, and food availability (King & Forsyth, 2021). They explore all areas and objects within their home range but can be cautious regarding new or strange objects within this area (King & Forsyth, 2021).

Black rats are commonly infested with fleas and mites as well as being known carriers of several diseases, including *leptospirosis* and *salmonellosis* (Shiels *et al*., 2014; King & Forsyth, 2021).

5.0 Predator Impact and Opportunities for Seabird Recovery

5.1 Black Rat Impact on Seabirds

Black rats are one of the most widespread invasive species, occurring on 80% of the world's islands (Atkinson, 1973; Atkinson, 1985; Jones *et al*., 2008; Spatz *et al*., 2014; Dawson *et al*., 2015). Rats have had devastating impacts on islands through predation, competition, and habitat modification (Bell 1978; Imber, 1985; Campbell, 1991; Martin *et al*., 2000; Stapp, 2002; Towns *et al*., 2006; Jones *et al*., 2008; Harris, 2009; Mulder *et al*., 2009; Croxall *et al*., 2012; Shiels *et al*., 2014; Bell *et al*., 2016; King & Forsyth, 2021), but have been successfully removed from islands ranging in size from 1 to 36,000 hectares (Towns & Broome, 2003; Howald *et al*., 2007; Bell, 2019; Martin & Richardson, 2019). Black rats have been recognised to have greater impacts on seabirds, especially burrow-nesting species, compared to other *Rattus* species (Moors & Atkinson, 1984; Towns *et al*., 2006; Jones *et al*., 2008; King & Forsyth, 2021). They have also been implicated in the decline of other small mammals, including bats and wood mice (Harris, 2009; Bell *et al*., 2016). Seeds and fruit are particularly vulnerable to black rat predation and consumption (Auld *et al*., 2010; Shiels & Drake, 2011; Pender *et al*., 2013).

Black rats will be having an impact on the Inchcolm ecosystem (including reduced regeneration of plants and predation of invertebrates and birds). There are a number of seabird species present on Inchcolm that are vulnerable to predation by black rats including puffin, razorbill, guillemot, and kittiwake. Seabird count data from the Forth Seabird Group and the Forth Heritage group suggests that razorbill numbers have fluctuated in recent years between 1 and 15 pairs, puffin numbers have declined from a high of 65 pairs on the island in the mid-1990s to less than 10 pairs in 2022, kittiwake numbers have declined from a high of 190 pairs in 1995 to 77 pairs in 2022, and guillemot numbers are zero[3] (see also Appendix B). Several species of highly vulnerable terns and guillemot that may have previously nested on Inchcolm, are likely to have suffered too from rat predation.

Stomach contents of black rats trapped on Inchcolm were primarily composed of digested food, including fragments of flesh, vegetation, and suspected eggshell (Appendix A, Section 3.3.2).

Stable isotope analysis of whiskers taken from a sample of the Inchcolm rats shows the rat's diet does comprise a marine high trophic level signature, which could be indicative of a seabird predation. As samples could not be taken from target seabird species, this test was unable to differentiate between a seabird food source and another high trophic source such as a dead seal (Appendix A).

[3] http://www.forthseabirdgroup.org.uk/pages/wcount-tables.htm

5.2 Predatory gulls

The target seabird species on Inchcolm are also at high risk of predation from gulls (notably herring gull, lesser black back gull and to a lesser extent great black-backed gulls), and at moderate risk to a pair of resident nesting peregrine falcons (*Falco perigrinus*).

Gulls tend to attack a greater percentage of nest sites located at the upper sections of cliffs and grassy slopes than at lower sections. Successful foraging by gulls in calm conditions is largely constrained by ledge width (whereby nests on broad ledges are more likely to be attacked), whereas increased wind speed enables gulls to attack nests more successfully on both narrow and broad ledges.

5.3 Opportunity for seabird recovery following rat eradication

5.3.1 Global experience

The successful eradication of brown rats from Ailsa Craig, Scotland (100 ha; Zonfrillo, 2001; 2002), Ramsey Island, Wales (256 ha; Bell *et al.,* 2000; Bell *et al*., 2019), black and brown rats from Lundy Island, England (500 ha; Appleton *et al*., 2006; Lock, 2006; Bell, 2019), brown rats from Isle of Canna & Sanday (1314 ha; Bell *et al*., 2011), brown rats from St Agnes & Gugh, Isles of Scilly (142 ha; Bell *et al*., 2019) and the black rats from the Shiant Isles (143 ha; Main *et al*., 2019) further demonstrates how these techniques can be utilised on islands around the UK.

Following the successful eradication of black rats from islands, native species, particularly seabirds, have increased in density and range and often diversity (Bellingham *et al*., 2010; Daltry *et al*., 2010; Varnham 2010, Buxton *et al*., 2016; Newton *et al*., 2016; Booker *et al*., 2018; Brooke *et al*., 2018; King & Forsyth, 2021). Native plant biomass on islands has also increased often within 10 years of removing rats (Towns *et al*., 2006; Daltry *et al*., 2010).

Both cliff nesting and burrowing seabird species have shown significant increases following the eradication of black rats from islands within the UK and around the globe (Dunlop *et al*., 2015; Capizzi *et al*., 2016; Booker *et al*., 2018; RSPB, 2018). On Lundy Island, guillemot, razorbill, kittiwake, and puffin, have all increased in number and distribution across the island since 1981 with the most significant increases following the 2002 rat eradication (Booker *et al*., 2018). Similar trends for Manx shearwater (*Puffinus puffinus*) and European storm petrels (*Hydrobates pelagicus*) have been recorded on Lundy Island (Booker & Price, 2014; Booker *et al*., 2018) and after the brown rat eradication on Ramsey Island (Bell *et al*., 2019). The breeding success and productivity of puffin and razorbill increased on the Shiant Isles following the black rat eradication (RSPB, 2018). Storm petrels were also confirmed to be breeding on the Shiants and bred successfully in 2018 for the first time on record (RSPB, 2018).

5.3.2 Opportunity for seabird recovery on Inchcolm

The Inchcolm study has identified good opportunities for the target seabird species (kittiwake, razorbill, guillemot, and puffin) to breed more successfully on Inchcolm island following an eradication of predatory black rats (Appendix B)

Figure 7 illustrates those aspects of Inchcolm Island that were observed and assessed as providing the most suitable habitat to support the expansion of the target seabird species following a rat eradication.

Figure 7. Areas of Inchcolm assessed as most suitable for supporting the expansion of target seabird species.

These aspects provide plentiful unoccupied ledges and soft ground to support growing numbers of breeding razorbill, guillemot, kittiwake, and puffin amongst other seabird species. Example images are shown in Figure 8. A full and descriptive record is presented in Appendix B).

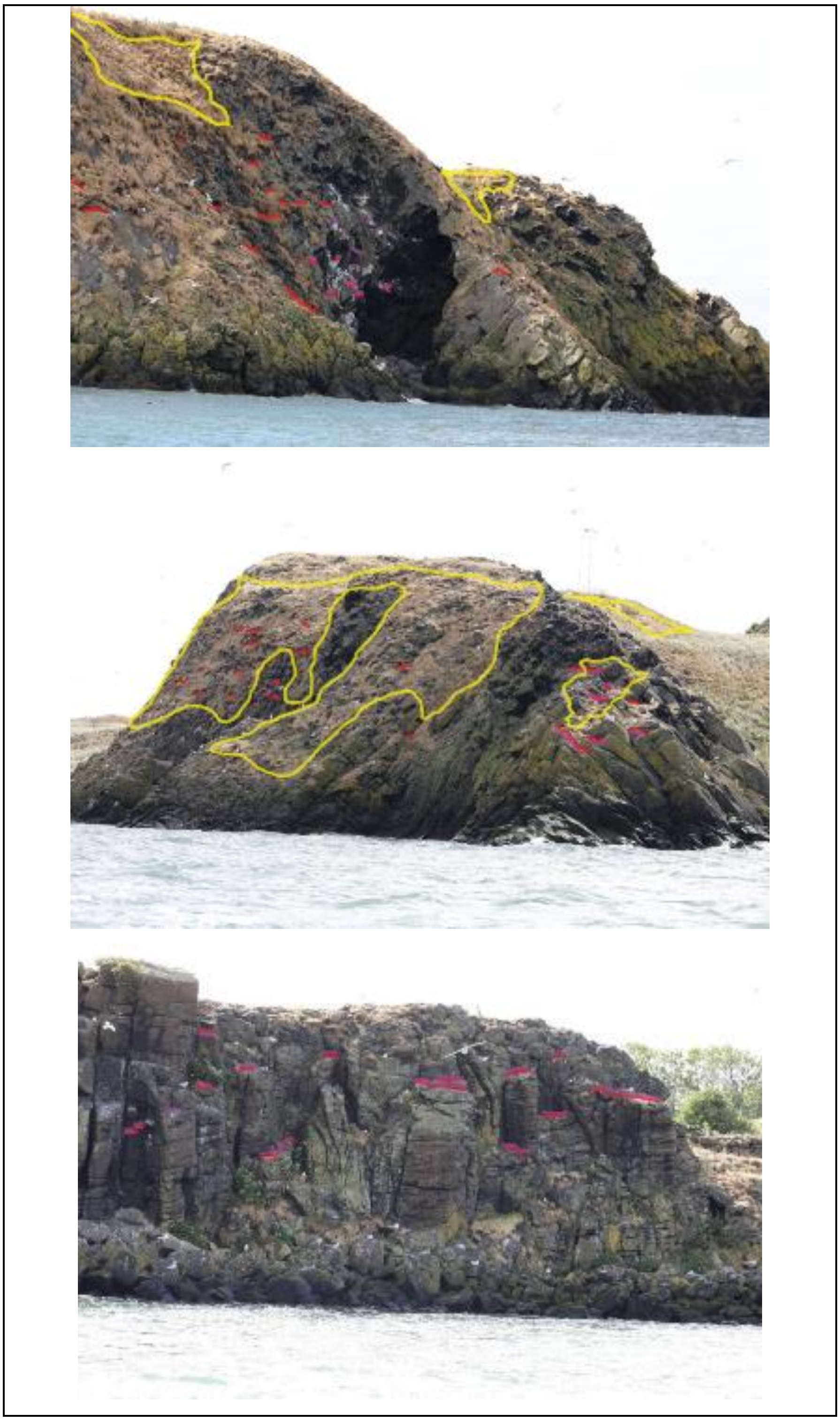

Figure 8. Example images showing unoccupied ledges (pink/ purple) and soft ground (yellow) assessed as suitable to support growing numbers of breeding razorbill, guillemot, kittiwake, and puffin.

The removal of predatory rats will benefit the breeding numbers of target seabirds on Inchcolm. Once it has reached capacity, it is projected that the currently unoccupied habitat classified as 'good' could, support:

- **Up to 420 additional pairs of breeding guillemot and/or razorbill, producing an estimated 240 fledged chicks per annum.**
- **Between 144 and 207 additional pairs of breeding kittiwake, producing an estimated 128 to 184 fledged chicks per annum.**
- **Up to 250 additional pairs of breeding puffin, producing an estimated 173 fledged chicks per annum.**

The eradication of predatory rats is likely to also benefit other vulnerable species, notably several species of tern, eider duck and fulmar.

There is unlikely to be a benefit to the northern gannet, which is considered unlikely to colonise Inchcolm Island.

Gulls (primarily herring and lesser black-back) are firmly established across the island and will present an ongoing predatory threat to the target seabirds.

In practice, a wide range of factors may affect guillemot, razorbill, puffin and kittiwake recruitment and success following predator eradication. These factors are particularly relevant to guillemot, a target species that is currently not breeding on Inchcolm, but which is breeding successfully on the near islands of Inchkeith and Isle of May and from which recruitment could be reasonably expected to take place. Various techniques shall be explored as part of an eradication package of adaptive management to further improve conditions for recruitment and growth in the breeding numbers of target seabird species following a rat eradication, including[4]:

- Artificial ground cover: Cliff ledge nests and burrows on steep slopes are susceptible to avian predation. In a study on a breeding colony of guillemots in California, Parrish and Paine, (1996) showed that areas with artificial covers installed over the cliff tops produced nearly twice as many eggs. Artificial ground cover could thus be considered as an additional measure following predator eradication, to further increase breeding performance at potential cliff-top breeding sites.
- Decoys and playbacks: Social attraction methods, such as playbacks and decoys, can be used to increase the likelihood of recruitment, and has shown to be highly effective in a past study by Parker *et al*. (2007). Breeding guillemots were lost from a colony in California following an oil spill in 1986 and did not naturally recolonise over the following eight years. In January 1996, Parker *et al*. (2007) installed guillemot decoys, playbacks, and mirrors to attempt to attract guillemot. No guillemot were observed before these social attraction techniques were installed. Following social attraction installation, birds were seen on all but two days (observations were carried out until the post-fledging period in August). Over 90% of 68,332 guillemot observations were in decoy plots vs. less than 10% in control plots and

[4] See also: EOR0766_Berwick Bank Wind Farm Application - 2. Derogation Case - Implementation and Monitoring Plan (1) paragraphs 276 through 278.

outside of study plots. Guillemot started breeding on the site during the 1996 breeding season, and numbers increased from 1996 (6 pairs) to 2004 (190 pairs) with continued but decreased use of the social attraction techniques (Parker *et al*., 2007).

- Vegetation management, comprising reduction in height and density of grasses and shrubs and loosening of soils on tops of steep slopes may be adopted prior to the start of the nesting season to optimise conditions and create space and access for target seabird species, notably burrow nesting puffin.
- In some seabird species, white paint has been used to simulate guano at potential breeding sites (Gummer, 2003; Sawyer and Fogle, 2013). This could be used for the auks, potentially alongside the use of vegetation management, decoys, and playbacks, with the aim of increasing colonization rates following rat eradication.

6.0 Predator eradication feasibility study: goals, objectives and outcomes

This scope of work comprises a feasibility study for Inchcolm Island to determine if introduced predators of seabirds, chicks and/or eggs (notably rats) are present and if confirmed to be present, to consider whether it is feasible to remove those predators and provide improved conditions for seabirds to breed more successfully and for colonies to grow.

6.1 Objectives

The objectives of the feasibility study were to:

- Collate and validate census data on key seabird species numbers and breeding success.
- Establish the presence of invasive mammalian predators to species level and the potential overlap the species may have with known key species nesting locations.
- Collate evidence for predation of key species eggs and chicks by invasive mammalian predators.
- Calculate available nesting habitat potentially available to key species following removal of invasive predator pressure.
- Undertake an Options Analysis based on the relevant invasive non-native species and document the rationale for the recommended eradication option.
- Assess the feasibility of the recommended option and identify expected risks, issues, assumptions, operational and legal considerations required for success.
- Ensure the context of the stakeholders is accounted for in project design as far as reasonably practicable without incurring impacts in operational delivery.
- Make recommendations for the stakeholder engagement strategy and techniques that should be used in the key phases of the proposed project, prior, during and after eradication for overall successful project outcomes.
- Provide a framework for the proposed eradication project to manage feasibility issues throughout the life cycle of the project.
- Advise on project design to mitigate unwanted ecological issues that might arise from the eradication.
- Assess the feasibility of establishing biosecurity measures required to maintain the outcome of the recommended option.

6.2 Outcomes

The outcomes of this investigation were:

- A field study successfully completed on Inchcolm.
- The presence and abundance of black rats on Inchcolm confirmed.

- The presence and abundance and breeding success of key seabird species confirmed.
- Predation pressure on seabirds by black rats evidenced.
- Preliminary stakeholder engagement completed.
- Stakeholder questions and/or concerns collated.
- Mitigation methods to address stakeholder questions and/or concerns proposed.
- Potential of Inchcolm to support higher numbers of key seabird species following a black rat eradication confirmed and outlined.
- Assessment of seven feasibility criteria (Technical, Sustainable, Environmental, Social, Political & Legal, Capacity and Affordability) completed.

6.3 JUSTIFICATION

The reasons to remove black rats from Inchcolm are:

- To conserve and enhance regionally important breeding seabird populations, facilitate re-colonisation by other native seabird and land bird species in the future, and provide a secure staging post for migrants.
- To protect and enhance the regionally, nationally, and internationally important populations of seabirds on the islands.
- For the recovery of rare native and endemic invertebrate species.
- To facilitate the recovery and regeneration of rare native and endemic plant species.

7.0 Technical Feasibility

7.1 Options analysis

The following options have been reviewed in line with the principles established by the UK Rodent Eradication Best Practice Toolkit:

- Option 1: Do nothing.
- Option 2: Enhanced rat control.
- Option 3: Black rat eradication.

7.1.1 Option 1: Do nothing

The "do nothing" option is essentially maintaining the status quo for the management of the site (Table 1). This option would not require the resources for the proposed rat eradication and appropriate biosecurity measures. However, this approach would result in no reduction in predation or mammalian predators, continued depredation of breeding seabirds and land birds likely leading to the loss or continued absence of species.

Table 1. Advantages and disadvantages of Option 1: Do nothing.

Advantages	Disadvantages
The effort to deliver the rat eradication project will not be required. HES and the ferry operator, public and landowners can continue with current minimal biosecurity measures and there will be no changes for them. The risks of unintended ecological changes will not happen.	The expected environmental benefits from a successful eradication will not be realised. Risk of disease transmission to humans and other wildlife remains. The ongoing costs of control continue. Rat population remain (and subsequent impacts on seabirds and other species by rats continue).

7.1.2 Option 2: Enhanced rat control

HES undertake limited rat control on an ongoing basis as part of their routine rodent control programme for the abbey and the accommodation buildings. To increase the level of effective rat control to protect the breeding success of seabirds across Inchcolm would require operators to be resourced and to have a comprehensive understanding as to where their controls would be best placed to achieve suitable outcomes (Table 2).

Table 2. Advantages and disadvantages of Option 2: Enhanced rat control.

Advantages	Disadvantages
The effort to deliver the rat eradication project will not be required. HES and the ferry operator, public and landowners can continue with current minimal biosecurity measures and there will be no changes for them. The risks of unintended ecological changes will not happen. Limited level of environmental benefits in areas where rat control is undertaken.	The environmental benefits of targeted controls will not be as great as a successful full-island group eradication. Long term use of rodenticide and traps extends risk of secondary poisoning to non-target species, including gulls and raptors. Rat population remain (and subsequent impacts on seabirds and other species by rats continue). On longer term scale, resource requirements are high and required on a yearly basis. Compared to an eradication, it possible that more animals will be killed in the long term due to a combination of rats killed by rodenticide and traps and seabirds predated by rats.

7.1.3 Option 3: Rat eradication

This is the recommended option. Black rats are known predators of ground and cliff and burrow nesting birds and can drive significant and negative impacts on ecological processes (Table 3).

Table 3. Advantages and disadvantages of Option 3: Rat eradication.

Advantages	Disadvantages
The expected environmental benefits (i.e. seabird, invertebrate, and vegetation recovery and expansion) from a successful eradication will be realised. These vectors for disease transmission to humans will no longer be present. Ongoing control costs to HES for rats will cease. Long term use of rodenticides would not be needed on Inchcolm (apart from biosecurity and incursion response), removing the risk of secondary poisoning to non- target species.	The local ferry operator, landowners and members of the public must be engaged in adopting new biosecurity measures. Unintended ecological changes could happen if not diligently managed.

7.2 Eradication Analysis

Any eradication operation is not taken lightly, and this assessment does ensure:

- That the seriousness of the problem has been established.
- That non-lethal measures have been assessed and found not practicable.
- That killing is an effective way of addressing the problem.
- That killing will not have an adverse impact on the conservation status of other non-target species.

Table 4 summarises the advantages and disadvantages and practicality for each rat control or eradication option.

Table 4. Details and practicality of options for eradicating black rats from Inchcolm.

Option	Advantages	Disadvantages	Outcome
Prevention (i.e. rat-proofing).	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. Not suitable for islands within swimming range of rats. Little value alone.	Impractical
Rodent dogs.	Targeted control. Environmentally clean. Use for detection of surviving rats.	Labour intensive. Expensive. Rats have to be humanely killed. Untested for island-wide eradication projects. Ethical concerns.	Impractical
Repellents	Sound or chemical options. Targeted control. No welfare impacts.	Little to no success (Mason & Litten 2003). Rats habituate to repellent.	Impractical

Option	Advantages	Disadvantages	Outcome
		Non-lethal, can move problem to another area. Little to no use on an island-wide situation.	
Aluminium phosphide (Fumigation).	Targeted control (burrows only). Lethal: full eradication.	Needs knowledge of habitat and location of 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
Immuno-contraception.	Could be long-term solution. Humane.	At research stage only. Concerns regarding loss of control. Non-target species concerns. Irreversible. Public concern.	Impractical and experimental.
Biological control	Long-term solution.	Involves releasing another possible problem animal. Non-target impact concern. Ethical concerns. Legal issues.	Impractical.
Kill traps (i.e., snap, spring, A24 or break-back traps).	Lethal (rapid death). Targeted control, good for local small area controls and monitoring projects.	Untested and impracticable for island-wide eradication projects. Labour-intensive.	Impractical and experimental.

Option	Advantages	Disadvantages	Outcome
	None polluting. Can be used by general public. Range of traps commercially available.	Equipment intensive – expensive. Resource consuming; need to be checked twice daily (if set permanently). Welfare issues/ethical concerns if not checked twice per day. Sea and weather conditions will not allow all locations to be checked twice per day. Only legal traps can be used (under relevant legislation). Experienced trappers needed. Requires good accessibility. Risk to non-target species.	
Live trapping.	Non-polluting. Non-target species can be released unharmed. Targeted control. Range of traps commercially available.	Labour-intensive. Expensive. Experienced trappers needed. Requires good accessibility. Welfare issues (i.e. while animal in trap and kill method) if not checked twice per day. Need to be checked twice daily. Only legal traps can be used (under relevant legislation). Rats have to be humanely killed. Untested for island-wide eradication projects. Ethical concerns.	Impractical

Option	Advantages	Disadvantages	Outcome
Electrocution traps.	Targeted control. Lethal (rapid death). Non-toxic.	Needs sufficient current (i.e., power source). Labour-intensive and expensive. Welfare issues and ethical concerns (public perception of traps). Only legal traps can be used (under relevant legislation). Non-target issues. Untested for island-wide eradication projects. No detailed clinical data on efficacy. humaneness, welfare, or other effects.	Impractical and experimental.
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. Follows internationally recognised best practice standards (see below). Range of application methods.	Use of toxin. Persistence in environment (toxin dependent). Non-target impacts (toxin dependent). Ethical concerns (minimised compared to other options). 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.	Practical and effective. Tested and effective. Suitable and sufficient health and safety risk assessment and safe operating procedures.

Option	Advantages	Disadvantages	Outcome
	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 .	Requires use of adequate baits and bait stations. Disposal requirements. Health and Safety hazards including working at height, and exposure to toxic substances.	

The only practical, ethical and effective option to reduce rodent impacts on seabirds and the wider ecosystem is the eradication of black rats using anticoagulant rodenticides.

The use of self-resetting traps (such as A24) as the key eradication option has been discounted due to the size of the island as well as the untested nature of these traps in this environment. It is recommended that A24 traps could be assessed for use on difficult to access cliffs and also for long-term biosecurity potential during the eradication operational planning phase of work.

The use of anticoagulant rodenticides is currently the most widely recognised effective method of eradicating rodents from islands.

Table 5 provides the advantages and disadvantages and practicality of available anticoagulant rodenticides in the UK. Second-generation anticoagulant rodenticides such as brodifacoum or flocoumafen are illegal for use outdoors in the UK and have not been included.

Table 5. Assessment of available anticoagulant rodenticides (outdoor use only) for eradicating black rats from the Inchcolm.

Toxin	Advantages	Disadvantages	Outcome
First-generation			
Warfarin	Low toxicity (reduces risk to non-target species).	Low toxicity (requires rats to consume more, i.e. more visits to bait stations and	Not recommended

Toxin	Advantages	Disadvantages	Outcome
	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. Insoluble in water.	more chance for rats to avoid devices). Multiple feed. Large quantity required. Repeated applications required. Longer access to bait required. Non-target species have longer to access bait (i.e., competition with rats). Low persistence .(metabolised quickly). Resistance issues.	
Coumatetralyl.	Moderate toxicity (higher than warfarin). Delayed onset of symptoms (i.e., prevents neophobia and bait shyness). Less persistent than second generation anticoagulants; thereby minimising risk to the environment. Quickly metabolised by rats presenting reduced secondary poisoning risk to scavenging gulls, skuas and birds of prey. Cheaper than second generation anticoagulants. Antidote available.	Moderate toxicity (lower than second generation). Multiple feed. Repeated applications required. Longer access to bait required. Non-target species have longer to access bait (i.e. competition with rats). Few successful island-wide eradications.	Recommended as a primary bait option (subject to pre-eradication field study palatability, resistance and efficacy trials).
Second-generation			

Toxin	Advantages	Disadvantages	Outcome
Difenacoum.	Moderately to highly toxic. Single feed. Delayed onset of symptoms. Effective on rats. Antidote available (but long-term treatment required). Insoluble in water. 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.	No advantages over bromadiolone as a back up to coumatetralyl.
Bromadiolone.	Single feed. Delayed onset of symptoms. Effective on rats (*Rattus norvegicus* in particular). Antidote available. Not readily soluble in water. Previously successfully used in UK eradications.	Persistence issues (> 9 months in some species). High secondary poisoning risks. Some resistance issues suspected. Limited data on non-target impacts.	Recommended as a possible back up to coumatetralyl (subject to pre-eradication field study palatability, resistance and efficacy trials).

7.3 Recommended Toxin

All anticoagulants work in two, different, ways. As 'acute' poisons when the rats eat enough in a single feed to reach the lethal dose, but also as 'chronic' poisons, where small amounts are eaten over several days, resulting in a cumulative dose which is usually less than that needed in a single feed to achieve the lethal dose. Second generation rodenticides such as bromadiolone are regarded as the most potent, but only as 'acute' poisons. However, most rats will only take small nibbles from any new food source. Like most anticoagulants coumatetralyl works best as a 'multi-feed' bait and it is as potent as bromadiolone based bait when taken in this way.

The primary toxin recommended to be used during the eradication programme on Inchcolm, would be coumatetralyl with bromadiolone probably used as a back-up towards the end of the baiting phase.

As noted in Table 5, **Coumatetralyl** is a first-generation anticoagulant which also acts by reducing the animal's ability to coagulate blood. Death usually occurs with five to ten days after consuming a lethal dose (Eason & Wickstrom, 2001). It is important to note that research has shown rats can survive large single doses (50 mg/kg) but cannot survive multiple doses (1 mg/kg over 5 days; Eason & Wickstrom, 2001).

Coumatetralyl is rapidly metabolised in rats, and in the unlikely event their bodies are then eaten by predators or scavengers such as overwintering gulls or inquisitive birds of prey, there is very little likelihood that they will be adversely affected.

The formulation recommended for the eradication project is Romax ® Rat CP which is a ready-to-use bait, based on 100g 'soft blocks'. The soft blocks are based on vegetable fats and carbohydrates which exceptionally attractive to rats, especially when other food sources are scare, and temperatures are cold. This results in extremely rapid and high acceptance of the bait.

As noted above **Bromadiolone** is a second-generation anticoagulant poison that act by reducing the animal's ability to coagulate blood, i.e., inhibits the synthesis of Vitamin K and as a result rats and mice die of internal haemorrhaging (Eason & Wickstrom, 2001). This toxin was developed after rats developed resistance to first-generation poisons such as warfarin (Bull, 1976; Eason & Wickstrom, 2001). Death usually occurs between three and ten days after consumption of a lethal dose (LD50, i.e. 50% of test subjects will die from level of poison ingestion) as a result bait shyness is avoided. For a 400 g brown rat, the LD50 for bromadiolone (0.005%) is 12 g of bait. Rats require multiple feeds over several days to obtain a lethal dose.

The antidote for both bromadiolone and coumatetralyl is Vitamin K1, which is available in injection and tablet form from any veterinary clinic. It is recommended that an adequate supply of Vitamin K1 is available throughout the proposed eradication programme.

The bait will be distributed at a nominal dose rate of 6.4 kg of bait per hectare, per bait round (4 x 100g blocks per bait station) for a 25m x 25m grid. It is expected to require up to 10 rounds of bait in each station to ensure the eradication of all the rats. At this rate up to 650 kg of bait will be required to cover the island (10.5 ha) area over the five-month baiting phase of the eradication programme.

7.3.1 Bitrex

Bitrex™ (denatonium benzoate) is a bittering agent added to anticoagulant bait to deter human consumption. It is a legal requirement in the UK that Bitrex™ (or alternative bittering agent) is added to all rodenticides.

Bait containing bittering agents have been used successfully on rat eradications around the world, so the presence of a bittering agent is not expected to be a reason for rats to reject the bait on the Inchcolm Island project, but the operator should be alert to this possibility. It will be important to monitor bait take effectively and relate it to rat sign and activity to be able to assess whether any rats are actively avoiding the bait. Alternative methods (such as trapping, alternative bromadiolone baits, etc.) may have to be used to target these last surviving rats.

7.4 Resistance

Resistance to rodenticides in rats (particularly brown rats) was first detected following long-term use of warfarin in the UK and has now been found in a range of first and second-generation rodenticide around the world, including bromadiolone and difenacoum (Greaves *et al.*, 1982; Lund, 1984; Bailey & Eason, 2000; Eason & Wickstrom, 2001; Pelz *et al.*, 2005).

Both difenacoum and bromadiolone have evidence of resistance in brown rats in the UK since the 1980's, mainly from urban or farm sites with long histories of baiting (Lund, 1984). Resistance in brown rats has been reported from Wales, southern England, Midlands, and western Scotland (Greaves *et al.*, 1982; Lund, 1984; Bailey & Eason, 2000). Most rats that have been found to be resistant to these second-generation anticoagulants were resistant to warfarin recognising the genetically linked relationship, i.e. resistance is transmitted as an autosomal dominant trait (Greaves *et al.,* 1982, Lund, 1984; Pelz *et al.*, 2005).

It has also been noted that a higher strength toxin (0.002% rather than 0.0005%) can result in a complete kill of resistant rodents (Lund, 1984; Buckle *et al.*, 1994), but this increases the risks to other non-target species and environment. It is important to note that trials have shown that bait attractiveness and uptake may also affect the effectiveness of the baiting regime rather than assuming it is resistance to the toxin (Quy *et al.*, 1992).

There is no evidence of resistance on Inchcolm with all samples tested so far being negative for the VKORC1 mutation (Appendix A).

7.5 Application method

It is recommended that the eradication programme on Inchcolm is a ground-based operation using bait stations.

The use of bait stations will reduce the impact (and unnecessary mortality) on non-target species, reduce the amount of bait in the environment, will ensure that all bait is accounted for, and bait take (and consumption) by rats can be recorded. Each bait station should have an individual number, plotted using GPS and all data put into a GIS-linked database. Bait take should be recorded in the field via a database app.

It is important to note that although the use of bait stations reduces the risk to non-target species, despite all preventative methods it is possible that some incidental loss to non-target species may occur. However, this small risk should be balanced against the long-term benefits to native species and ecosystem recovery.

7.5.1 Bait station design

Bait stations must allow ready access for rats to the bait but must also prevent entry by key non-target species (such as gulls).

The recommended bait station design is the novacoil version (Figure 9). These are made from 750 mm lengths (100 mm diameter) of corrugated plastic drainage pipes, with wire "legs" to peg them to the ground to prevent movement by animals and/or wind. Additional wires are pushed through both entrances to limit the size of the entrance and further secure the station. Bait is held in the centre of the station by two wires set low in the station. Both entrances are lifted slightly off the ground (using the curve of the tube) to deter entry by smaller insects. Access to the bait station to replace and monitor bait is via the small hole cut in the top, which is covered with an additional short section of pipe. The lid is held in place by another piece of wire - a 'crow clip' devised during the Lundy Island eradication programme (Bell *et al*., 2019) which makes the stations more secure in the wind and stops stock, crows and gulls removing the lids. This bait station design is well proven in a number of eradication programmes around the world, including on Ramsey, Lundy, Isle of Canna, St Agnes & Gugh and Shiants (Bell *et al*., 2011; Bell *et al.,* 2019).

Figure 9. Recommended bait station design for the black rat eradication on Inchcolm (as shown from the St Agnes & Gugh brown rat eradication).

Note: removable inspection lid open to show access hole to reach bait. Bait wired into station and 'crow clip' not shown in this image.

Alternatively, commercially available bait stations could also be used (Figure 10). The advantages of these stations is they can be secured (lockable) and as such a number of these stations should be used around public areas. However, unit cost for these stations are much higher than the nova coil design. Rats may also prefer the wider less restrictive entrances to the nova coil stations compared to the smaller entrances on the commercial bait stations, albeit this also does allow the nova coil stations to be more vulnerable to access by non-target species.

Figure 10. Alternative commercial lockable bait station design (shown open).

Note: Bait station shown open. Bait wired into station on pins.

Wooden bait stations and/or rodent motels may also be needed for permanent locations (such as high-risk areas like the quay, shop, and seabird colonies) for long-term biosecurity (Figure 11). These rodent motel and permanent bait station devices can be discretely located on Inchcolm to ensure the aesthetics of the island are maintained while still ensuring biosecurity.

Figure 11. Example of wooden bait station (left) and rodent motel (right) recommended for permanent locations (pictures courtesy of E. Bell, WMIL).

Note: these wooden stations can be used as a trap station or as a bait station or monitoring station. Bait can be placed in the centre of the box (on the raised central block). Bait can be secured into the station by large nails or wires.

7.5.2 Bait station grid density

The key to the success of the eradication project is the spacing of the bait station grid. On Inchcolm it is recommended that the bait stations be established on a 25-metre x 25-metre grid over the island. With the size of Inchcolm and the recommended bait station grid, approximately 170 bait stations will be required.

It is important that bait stations are placed on all offshore islets which have vegetation, or which are connected to the main island. Bait stations in areas with difficult access will be loaded with more bait and may not be checked daily, but rather when weather conditions suit.

The coastlines of the island will also have a line of bait stations. The interior habitat of Inchcolm will offer little difficulty to establish parallel bait station lines across the entire island. However, the western cliffs will require rope access and shore access to target the ledges and lower slopes. Additional stations will be placed along stone walls, ruins, World War bunkers and other structures.

Special care needs to be given to archaeological areas and sites during the eradication. All significant sites should be identified by HES. Whenever possible, bait stations should be placed outside of any recognisable structure and if this is not possible, the required stations should be placed in areas that would minimise disturbance or damage to the site. Access to all archaeological sites would be limited to work purposes only.

In all areas, marker poles and/or flagging tape will aid the location of lines and stations. Each station will be individually numbered, have its position recorded using GPS and added into a GIS-linked database. Maps will be produced of the bait station grid for all phases of the operation. Any gaps in the grid can be detected and corrected prior to the poisoning phase.

It will be important to have a number of spare bait stations and a contingency supply of bait on hand to fill any gaps and cover any damage or losses due to weather.

Once all the bait stations are in position on Inchcolm, they shall be left for one week or more (without toxin in them) so the rats become accustomed to them and accept them as part of the terrain.

7.6 Eradication Phase

The plan shall be to check bait stations a minimum of every two days, where safe access is available; replacing bait as rats consume it. Partially eaten bait will be replaced with a new block. Old or partially eaten bait will be disposed of at a registered landfill or incineration facility as recommended by the safety data sheets. Where sea conditions and weather forecasts suggest safe access to a location will not be available, larger quantities of bait may be used and/or a greater number of bait stations thereby ensuring bait is still available during periods of no attendance.

Checking bait stations enables constant monitoring of bait take and the resulting die-off of rats. The success of the eradication and any problems, which need to be overcome during the programme, require the detail of accurate recording.

Bait take shall be accurately recorded into GIS-linked database apps in the field for ongoing analysis. Refinements to the eradication phase can be made from this real time data. Hot spots can be identified quickly and targeted throughout the programme.

Baiting should begin in November and continue through to March (overlapping with the early intensive monitoring phase of the programme). Any surviving rats or problem areas should be obvious by the end of December and could be treated with an alternative poison or techniques.

7.7 Intensive monitoring phase

After about six weeks, bait take should be reduced to nil, with all the rats on Inchcolm having been poisoned. During the following three months it is vital to establish an intensive monitoring programme to detect any rats which may have escaped poisoning. A grid of rat-attractive food items (flavoured wax, soap, chocolate, candles, and apple etc.) as well as chew cards should be pegged out as monitoring tools. Tracking tunnels and trail cameras should also be used. Beach surveys for footprints in the sand should also occur.

The coverage of the monitoring grid extends beyond that of the bait stations; one monitoring point at the station and one in-between two stations. Each monitoring site shall be checked every two days to detect rat sign (usually teeth marks or footprints or footage on camera). If any rat sign is detected, an intensive targeting programme (e.g., alternative bait, reduced spacing in the bait station grid, trapping etc.) is started until rat sign in the area ceases.

All intensive monitoring points will be recorded on GPS, entered into the GIS-linked database, and mapped to ensure coverage of the island.

It is expected that the monitoring phase of the programme would begin from mid-December. The bait station grid can be removed once the intensive monitoring phase has been completed and rat sign is absent.

If rats are detected at the end of winter (i.e., February and/or March) a second baiting (i.e., during the following winter) and continued monitoring operation would have to be completed to finish the eradication.

7.8 Long-term monitoring phase

Following international best practice, long-term monitoring for surviving (or reinvading) rats continues for two years between the end of the eradication phase before declaring the island rat-free. This is based on the average life expectancy of a wild adult rat (c. 18 months).

The two-year long-term monitoring programme should be continued for at least every four weeks throughout the year to confirm the success of the eradication phase (i.e., to detect any surviving (or possible invasion) of rats). Permanent monitoring stations will be placed around the island (i.e., within known seabird areas, optimum rat habitat and in high-risk areas) to aid with detecting any surviving rats or intercepting invading rats.

All long-term monitoring points should be recorded on GPS, entered into the GIS-linked database, and mapped to ensure coverage of the islands. Any sign or indication of rodents should be photographed and if possible, collected or sampled for expert opinions on identification.

This long-term monitoring for the presence of rodents after an eradication operation is done as part of the biosecurity programme. It is important to monitor using a range of detection devices (such as flavoured and plain wax, chew cards, traps, rodent motels, trail cameras and indicator dogs) and have a regular search effort. Low numbers of rats may take longer to detect than realised. It may also be possible to use the recovery of vulnerable species (such as puffin) or establishment of prospecting species (such as arctic tern or storm petrel) to indicate that rats have been successfully eradicated.

Once the two-year monitoring phase has been completed and no rats have been detected, one further intensive island-wide monitoring check is completed. This involves putting a range of monitoring devices over the entire island and checking every two days for six weeks. Once this check is completed and no rats have been detected the island can be declared rat-free.

7.9 Terrain and accessibility

There are no serious problems with accessibility on the majority of Inchcolm. The main issue for accessibility will be reaching any of the islets around Inchcolm which cannot be safely accessed by land. If these islets are only accessible in certain sea conditions this will limit the number of days on which they can be visited. Staff will have to be able to respond quickly to make the most of periods of good weather. Working relationships and safe work procedures will need to be made with a safety and competency approved local boat operator to explore how boat access arrangements would work.

There are a few physical features of Inchcolm that pose challenges for an eradication operation, particularly the coastal cliffs. Sections of the coastal areas may only be accessed by boat or rope. Coastal cliff sections will need specialised rope work to access these areas and suitably qualified and experienced team members will make up part of the project personnel. Access to the offshore islets will require boat transport and safe egress and operating and emergency response procedures to be developed and implemented for staff working on these more remote and challenging locations. Overall, no topographical characteristics are unsurpassable and should not inhibit the success of an eradication programme.

All hazards and mitigation to avoid significant risks will be documented in a series of project specific Risk Assessments and Method Statements (RAMS) with accompanying Safe Work Procedures (SWPs).

7.10 Pre-operational requirements

A number of pre-operational aspects need to be completed prior to the proposed eradication phase including amongst others, obtaining permits and approvals, key species monitoring programmes in place, engagement of an experienced eradication operator, biosecurity plan, onsite preparations complete, Health and Safety plan, sites of archaeological significance plan, waste management procedures and purchase of project equipment.

7.11 Summary of technical feasibility

Table 6 summarises the technical feasibility criteria. Colour coding represents Green as Criteria met; Amber as Criteria requires further study or consultation and Red as Criteria not met (fail).

Table 6. Summary of the technical feasibility criteria for the proposed black rat eradication on Inchcolm Island.

Feasibility criteria	Summary	Outcome
Technically feasible	Ground-based bait station operation. Registered rodenticide. Range of bait station designs. Potential none target impacts managed 25 x 25 m grid. Winter operation safely delivered. Intensive monitoring period. Rope and boat access requirement.	Pass.

8.0 SUSTAINABILITY FEASIBILITY

8.1 REINVASION POTENTIAL

There are a number of ways a rat can reach an island; these include swimming from neighbouring islands or the mainland, accidental transport in visiting vessels, accidental transport by visitors (in luggage and supplies) or intentional release.

8.1.1 Swimming

Inchcolm lies approximately 1 km from the Scottish mainland, although there are two long piers at Braefoot Bay on the Fife mainland which reduces the distance to just over 0.7 km.

Figure 12 provides an aerial photograph that shades the presence of the black rats recorded on Inchcolm and the known presence of brown rats on the mainland of Fife.

Brown rats are known to be better swimmers than black rats[5]. Figure 12 includes two envelopes around Inchcolm that shade the recorded known swimming distances of 500 m for brown rats and 250 m for black rats, Thomas *et al*., 2017. Figure 13 adds the maximum potential swimming distances of 2 km for brown rats and 750 m for black rats; Russell & Clout, 2005; Russell *et al*., 2008.

These illustrated swimming distances are provided as a guide to previous invasion sources at non-Scotland locations and are indicators only of the possible reinvasion risks for Inchcolm. The maximum recorded swimming distances for rats may be considered extremely rare events and studies have shown that the probability of rats occurring on islands greater than 1 km from a source population was low (Tabak *et al*., 2015; Sjodin *et al*., 2020). Furthermore, currents, water temperature and marine predators reduce the chances of rats surviving long distance swims (Ershoft, 1954; Evans *et al*., 1978; Duncan *et al*., 2008; Russell *et al*., 2008; Harris *et al*., 2012).

In practice Inchcolm is surrounded by strong currents, cold waters and frequent adverse weather which means a rat would have to be very determined and extremely hardy to attempt this swim. Because there are a wide range of habitats and food sources on the mainland, it is also reasonable to hypothesis there is little pressure for rats to leave the mainland by swimming. Supporting this position, the field studies (Appendix A) have shown brown rats are not present on Inchcolm which substantiates the invasion risk by swimming is negligible. Not only are brown rats better swimmers than black rats, but they are also larger and if they had previously swum to Inchcolm, they would have outcompeted the black rats and be the dominant rat species on the island today which they are not.

This said, since Inchcolm lies within 1 km of mainland Scotland, the island should be considered slightly vulnerable to reinvasion by swimming. A robust biosecurity strategy shall be maintained on Inchcolm

[5] https://biosecurityforlife.org.uk/resources/detail/uk-rodent-eradication-best-practice-toolkit

following an eradication operation to ensure any incursions are quickly detected and immediate management action can be taken.

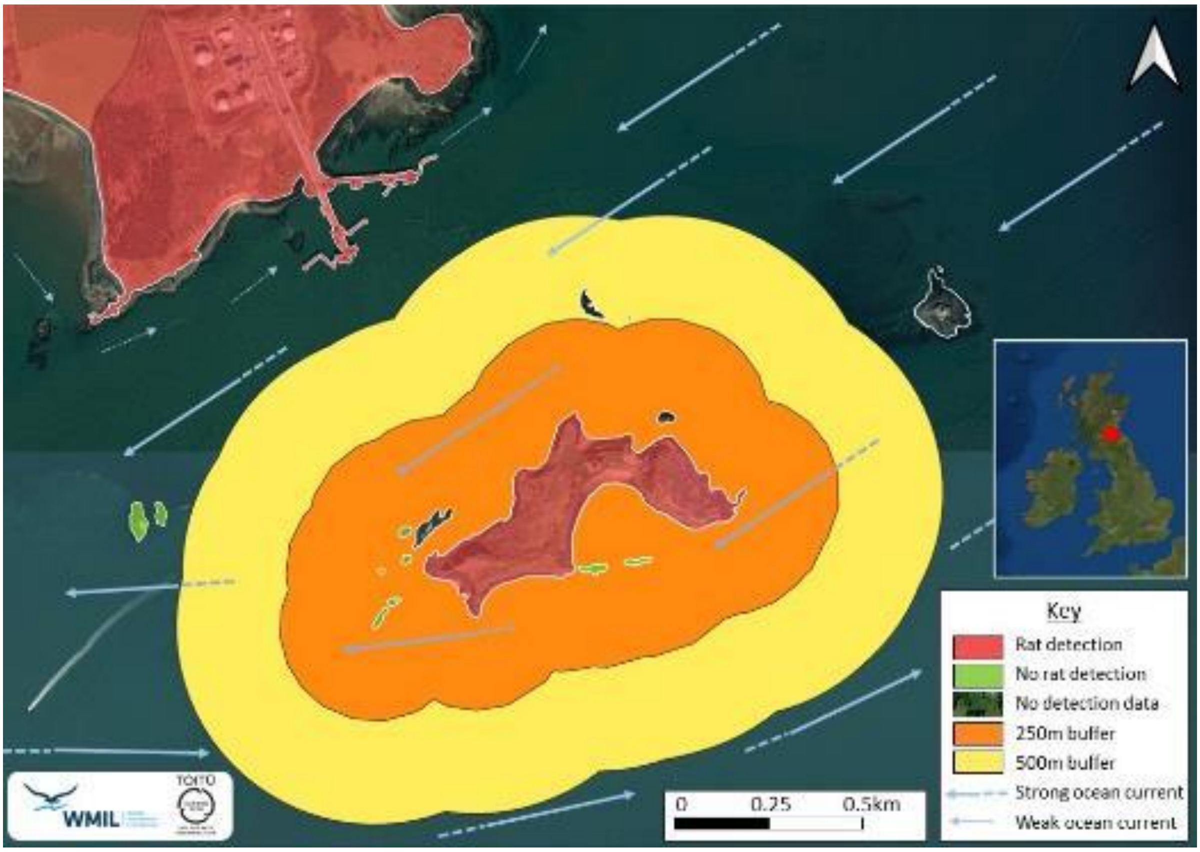

Figure 12. 'Known' swimming distances for black and brown rats around Inchcolmn.

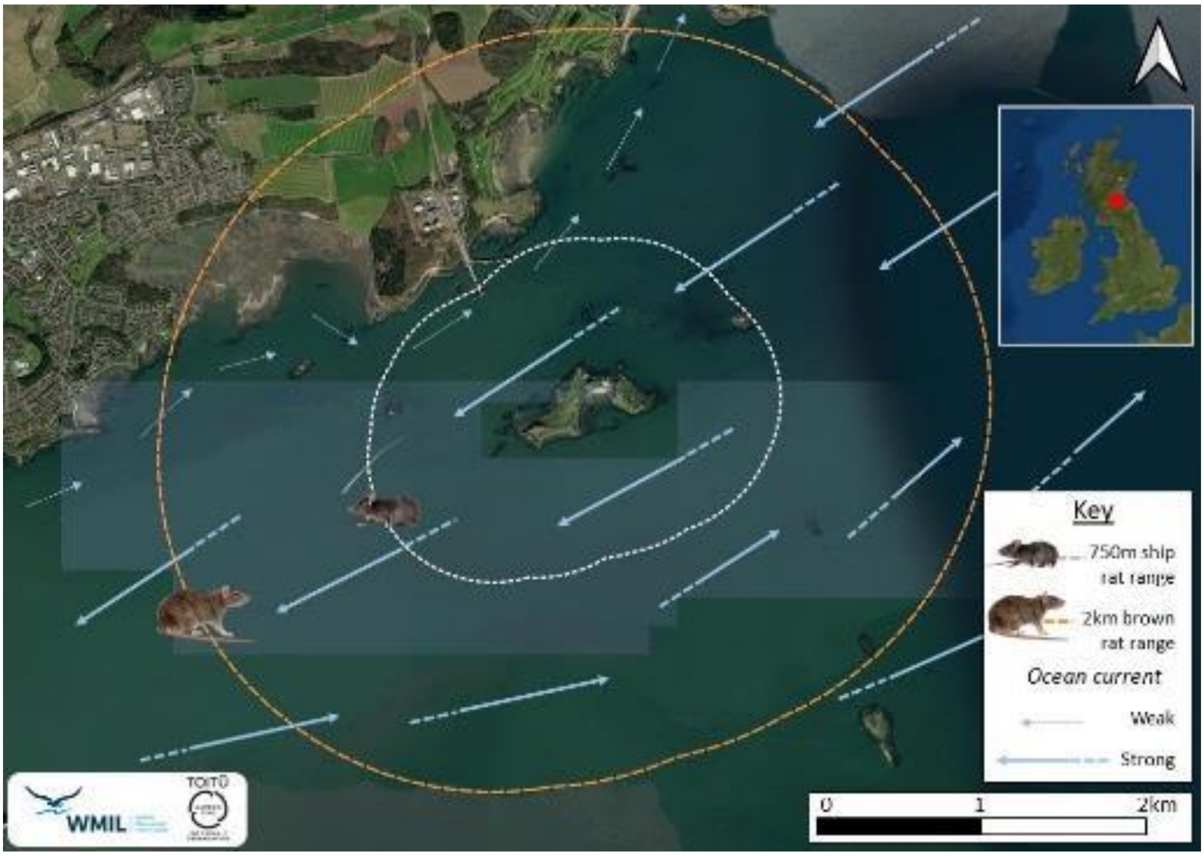

Figure 13. Maximum potential swimming distances for black and brown rats around Inchcolm.

8.1.2 Vessels and visitors

Inchcolm has a regular intake of visitors during the summer months, but access to the island in winter is restricted. Information about the eradication should be available on the island during the winter operation in case people reach the island (i.e., information panel on shore).

It is important that an information campaign (such as links to websites, programme leaflets and posters) regarding the eradication programme will be provided to any visitor. Information could be included on the HES website and provided to all charter boat operators. Given tourists visit Inchcolm to view the Abbey, World War bunkers, and birds, the proposed eradication is unlikely to impact on tourism. The eradication of rats and subsequent recovery of seabirds and island ecosystems could have a positive result for the tourism industry; tourists present on Lundy Island during the black and brown rat eradication were supportive of the project and the enhancement of the island and species there (along with a new branding and marketing programme) resulted in increased visitor numbers to over 20,000 per year (Khamis, 2011).

As all these visiting boats constitute a risk for the re-introduction of rodents (however small), it is important that the eradication programme is discussed with boat operators as well as many regular visitors as possible. An information campaign (such as programme leaflets and posters) regarding the proposed eradication programme could outline the best practices for preventing re-invasion. Biosecurity stations would be established on Inchcolm as part of the biosecurity procedures.

After the successful completion of the proposed eradication, leaflets could raise awareness of the rodent-free status of Inchcolm, outline best practices for preventing rodent re-invasion and detail how members of the public can assist. Examples of information leaflets produced following similar eradication projects could be obtained from the relevant agencies (e.g., RSPB for Lundy Island and St Agnes & Gugh and the Biosecurity for Life project, and National Trust of Scotland for Isle of Canna).

8.1.3 Intentional release

Although there is always a possibility that an intentional release (i.e., to deliberately sabotage the eradication) may occur, it is unlikely if the landowner, local community, and relevant agencies support the programme. It is important to continue to include and consult with the landowner and stakeholders in all stages of the project to ensure that everyone takes ownership of the project and sees the benefits for the conservation and ecosystem of Inchcolm.

8.2 Biosecurity

Once the black rats have been successfully eradicated from Inchcolm, the priority is to ensure that they or brown rats do not become re-established on the island. An effective biosecurity plan needs to be developed and fully implemented prior to the eradication phase of the programme.

A biosecurity plan would provide details to minimise the risk of accidental liberation of rodents, and what measures should be taken if a rodent is sighted on the island.

It is important to be able to distinguish between the failure of the eradication and a biosecurity failure should rodents be detected during the long-term monitoring. DNA samples of black rats from Inchcolm and other locations across the UK, and brown rats from nearby islands and the mainland should be collected and stored.

As Inchcolm is within the maximum potential swimming range of brown rats, biosecurity needs to be maintained over the long term. It will be important to train local HES staff or any other relevant agencies and stakeholders as well as the landowner to ensure that the biosecurity can be undertaken by these groups in the long-term. Data collection and management is important (particularly if incursions are detected and subsequently eradicated); all sightings and other rodent-related observations should be recorded and investigated.

The early interception of incursions is vital, and it is recommended that surveillance (using rodent motels, traps, tracking tunnels, etc.) is undertaken every month. Any rodent caught in a trap should be sent for DNA sampling for comparison against the baseline to determine provenance (i.e. failure of eradication programme or incursion from the mainland). Protocols can be established during the eradication and training given to local agency staff, landowners, and the community to undertake this work long-term.

Periodic audits and on-going monitoring of these biosecurity measures should be completed to ensure compliance and support as it is common for people and agencies to become complacent and have standards drop. It is important that all involved realise that biosecurity is a long-term ongoing commitment.

It will be important to focus on advocacy and education regarding biosecurity protocols and methods as this will engage the stakeholder groups to take ownership of keeping the Inchcolm rat-free.

8.3 Summary of Sustainable Feasibility

Table 7 summarises the sustainable feasibility criteria. Colour coding represents Green as Criteria met; Amber as Criteria requires further study or consultation and Red as Criteria not met (fail).

Table 7. Summary of the sustainable feasibility criteria for the proposed black rat eradication on Inchcolm Island.

Feasibility criteria	Summary	Outcome
Sustainable	Within the maximum potential swimming distance of brown rats from mainland Scotland. Assessed as slightly vulnerable to reinvasion by swimming. High numbers of visitors throughout the year. Private and charter vessels and operating year-round but peaking in the summer months. Commitment for comprehensive biosecurity programme required from key stakeholders including HES, local communities, tourists, visitors and boat operators.	There has been positive engagement with key stakeholders to date. No reason at present to consider that commitment to a robust biosecurity plan would not be forthcoming. A clarification note shall be provided once consultation has been completed.

9.0 Legal and Political Acceptability

9.1 Legal and political framework

A number of legal requirements will need to be assessed prior to the operational phase of the proposed eradication. These include, but are not limited to landowner and HES permissions, NatureScot permissions and confirmation the implementation plan is valid under Health and Safety at Work and legislation controlling pesticides and pest control.

Additional consultation will be undertaken to provide relevant context of the black rat population on a Scotland, UK, European and global perspective. Compensation strategies such as a capture population held by a zoo or wildlife park may be a strategy to enable the loss of black rats on Inchcolm to be mitigated.

Similar projects in the UK have met with no significant political or legal issues that would prevent their delivery.

9.2 Summary of legal and political feasibility

Table 8 summarises the legal and political feasibility criteria. Colour coding represents Green as Criteria met; Amber as Criteria requires further study or consultation and Red as Criteria not met (fail).

Table 8. Summary of feasibility criteria for the proposed black rat eradication on Inchcolm Island.

Feasibility criteria	Summary	Outcome
Politically acceptable	Clarification recommended on views of regulatory stakeholders including Local Council, HES, NatureScot and other key stakeholder views and how this impacts upon political support for a black rat eradication.	Further consultation required. No reason at present to believe that eradication would not be politically acceptable.
Legally acceptable	Registered rodenticide use in bait stations as per relevant UK or local regulations. Working under current health, safety and welfare law and regulations.	Pass.

10.0 SOCIAL ACCEPTABILITY

10.1 INTRODUCTION

Social acceptability is unlikely to be a significant problem for the proposed project. There is a strong case for the environmental benefits likely to follow any proposed rat eradication, particularly in relation to the likely benefits to seabirds. The support of the islands' owners and the island's manager (HES) will be essential. But individual residents on the mainland, although they should be kept informed and involved wherever possible, need not give their consent for the project to proceed. The project will, however, need to build and maintain a considerable level of local and regional community support and goodwill to operate effectively.,

Gaining social acceptability therefore depends upon:

- Communicating that risks to island residents and visitors, particularly children, will be extremely low.
- Communicating how risks to non-target wildlife can be managed to an acceptably low level.

These issues have all been raised on other rat eradication project on inhabited islands e.g. Lundy, Canna and St Agnes & Gugh and were all mitigated successfully during those projects.

10.2 SCOPE OF WORK

A key stakeholder was defined by the consultants carrying out the stakeholder engagement as an organisation or person who has invested interests (culturally, business or other) in the island. Prior to engagement commencing, expert support was given by an environmental social scientist at the Centre for Geography and Environmental Science at Exeter University, to develop and finalise the stakeholder engagement process (Appendix A). Through telephone conversations and email correspondence with stakeholders were informed this current phase of work was a feasibility study which necessitated gathering their opinions on whether they would support a plan for an eradication of rats on Inchcolm.

Official stakeholder engagement began on 21 July 2022 and continued through to the end of August 2022. Three key methods were used to engage with key stakeholders:

i. A bespoke stakeholder questionnaire was emailed to specific individuals with a target stakeholder group. The respondent/s filled out the questionnaire and the responses were saved and then qualitatively summarised.
ii. Ad hoc email correspondence to specific groups or persons.
iii. Face-to-face online Microsoft Teams meetings throughout the project.

Table 9 summarises the names of the key stakeholders who were contacted for the study and it describes the methods of communication that were adopted.

Table 9. Summary of key stakeholders and communication method for engagement regarding the proposed black rat eradication.

Group	Contact	Communication method
Historic Environment Scotland (HES)	Senior Management	Online meetings. Email correspondence.
NatureScot	Mammal Advisor	Email correspondence and questionnaire.
Mammal Society	Vice Chair	
Scottish Seabird Centre	CEO	
Scottish Wildlife Trust	Reserves Manager	
Forth Heritage Group	Chair	
Forth Seabird Group (FSG)	Chair	
Forth Yacht Clubs Association (FYCA)	Vice Chair	
Forth Ports	Chief Harbour Master	
RSPB	Senior Conservation Planner	
Maid of Forth Ltd.	Head Skipper	
SPCA	Chief Superintendent	

10.3 Results

A range of key stakeholders completed the questionnaire regarding the proposed eradication of black rats from Inchcolm, and a summary of the main findings are given in Table 10. (N.B. Two stakeholders (FSG, FYCA) gave a summary of their opinions on an eradication by email response only and did not complete a questionnaire and these results are not included in Table 10 but are documented in Table 14).

Table 10. Questionnaire results from key stakeholders.

Questions	Response		
Number of responses	9		
Have you noticed, or are you aware of, the presence of rats on Inchcolm Island?	Yes 78%	No 22%	No response 0%
Do you know what type (species) of rats are present on Inchcolm Island?	Yes 78%	No 22%	No response 0%
Do you have any concerns about the presence of rats on Inchcolm Island?	Yes 56%	No 44%	No response 0%
Have you, or your organisation, been affected by any problems with rats on Inchcolm Island in the past five years?	Yes 0%	No 100%	No response 0%
What do you think could benefit from a successful rat eradication project?			
Wildlife	89%		
Local community	44%		
Public health	44%		
Economy (Tourism)	44%		
Animal health	44%		
What do you think could challenge a successful rat eradication project?			
Gaining agency support	44%		
Access to private land	22%		
Island terrain	56%		
Avoiding harm to other wildlife	89%		
Avoiding harm to visiting domestic animals	56%		
Adequate funding	78%		
Avoiding rats returning	78%		
Waste management	67%		
Ecological effects of removing rats	56%		
Do you believe the black rat (*Rattus rattus*) to have any important cultural, ecological, or historical significance?	Yes 56%	No 33%	No response

Questions	Response		
			11%

The headline findings from the stakeholder engagement are summarised in Table 11. Supporting detail is included in Appendix A.

Table 11. Summary of key stakeholders' findings and comments regarding the proposed black rat eradication.

Group	Key findings
Historic Environment Scotland	• Do not object to an eradication of rats on Inchcolm if it has the support of NatureScot and the Scottish Government.
NatureScot	• . • Black rats are listed as a priority for conservation action on the NatureScot Scottish Biodiversity List.[6] • Recognise the benefits of an eradication of black rats. • Do not object to the concept of an eradication Decision dependant on further consultation inclusive of Scottish Government representation.
Mammal Society	• Regard the black rat as an invasive alien species. • Support an eradication on Inchcolm.
Scottish Seabird Centre	• Supportive of an eradication of black rats on Inchcolm. • Recognise with appropriate specialist input it will be possible to eradicate black rats on Inchcolm and it should be done sooner rather than later. • Believe it is very important to have a biosecurity plan in place, inclusive of detection and controls in place to respond to renewed activity.
Scottish Wildlife Trust	• Recognise black rats may be detrimental to breeding seabirds on Inchcolm. • Would like to see further consultation around the historical significance of the local black rat population.

[6]https://www.nature.scot/scotlands-biodiversity/scottish-biodiversity-strategy-and-cop15/scottish-biodiversity-list.

Group	Key findings
Forth Heritage Group	• Has been sympathetic to black rat presence historically, but now recognise the wider wildlife benefits their eradication would bring.
Forth Seabird Group	• Do not support an eradication without being provided with additional supporting information on the benefits it would bring.
Forth Yacht Clubs Association	• Recognises black rats were introduced to Inchcolm by man, so removing them is not disruptive to the natural ecosystem. • Supportive of an eradication for the benefits it would bring to the recovery of breeding seabirds.
Forth Ports Plc	• Does not see the black rat as historically significant. • Recognises that black rats will be impacting breeding bird populations if abundant. • Would not object to an eradication on Inchcolm.
RSPB	• Would not object in principle to an eradication on Inchcolm but would welcome further consultation on the opportunities and benefits to breeding seabirds.
Maid of Forth Ltd.	• Does not support an eradication due to a perception that black rats may be limiting the numbers of aggressive gulls thereby benefitting the 'tourist experience'.
SPCA	• Does not generally support animal culls/eradications unless for public health and safety. • Does however recognise breeding seabirds may be more successful following an eradication. • Where animals must be culled, the most humane methods should be used.

10.3 Concerns and Mitigation

An overarching concern raised by HES and NatureScot is the historical significance of black rats on Inchcolm, and the possibility that Inchcolm may be home to the last remaining island population of black rats in Scotland and possibly the UK. NatureScot has also asked for further consultation over the evidence that black rats are adversely impacting the breeding success of seabirds on Inchcolm.

Table 12 summarises the range of concerns expressed by stakeholders and provides recommendations as to how these concerns can be addressed.

Table 12. Stakeholder concerns, mitigation recommendations and feasibility.

Theme of concern	Description	Mitigation	Are mitigation measures feasible?
Safe and secure use of rodenticide.	Stakeholders requested that any bait stations in public areas be secure and unavailable to members of the public and their pets.	All bait stations shall be locked. Eradication phase will be delivered during the winter when tourist footfall is very low. Bait stations shall be serviced regularly, and old bait retrieved and disposed of off-site.	Yes
Avoidance of harm to non-target species of wildlife.	Concerns for rodenticide to be ingested by none-target species and accumulated through the food web.	A 'Non-target Species Management Plan' shall be developed as part of pre-eradication Operational Plan. Rodenticide formulation will be selected and applied to reduce the likelihood consumption by non-target species.	Yes
Information and communication.	Consultation process should continue with further information to keep key stakeholders informed through all stages of the design and implementation of the eradication project.	Recommend developing a robust 'Communication and Engagement Strategy', inclusive of a register of Frequently Asked Questions (FAQ) with answers.	Yes
Impact and ethics assessment of eradicating black rats.	Some stakeholders have requested additional supporting information to evidence the adverse impact that the black	Share the findings of the feasibility study with interested stakeholders including local and global evidence of the behaviour and impact black rats have on	Yes

Theme of concern	Description	Mitigation	Are mitigation measures feasible?
	rats may be having on the breeding success of seabirds.	island communities of breeding seabirds. Support this with case studies from Lundy Island and the Shiant Isles. Consider carrying out additional monitoring (camera traps) of rat activity and behaviour around target species nest sites during the pre-eradication planning phase.	
Historical significance of possibly the last island population of black rats in the UK. Black rats are listed as a priority for conservation action on the NatureScot Scottish Biodiversity List.	Some stakeholders are concerned about the status and significance of the Inchcolm black rat population, whilst also recognising the adverse impact the black rats will be having on the breeding success of seabirds.	Black rats are listed as a naturalised, non-native species in Red List for British Mammals. Black rats are abundant in the Channel Isles (Sark and Alderney), continental Europe and globally. Further isolated populations are believed to exist on mainland UK. Historical records indicate black rats may have arrived on Inchcolm as recently as the start of the 20th century (post 1899). An option for the live capture of a subsample of the Inchcolm black rat population for rehousing within a zoo and/or wildlife park can be investigated.	Yes

Theme of concern	Description	Mitigation	Are mitigation measures feasible?
		Further consultation with key stakeholders and evidence gathering shall be carried out during the pre-eradication planning phase.	
Large seasonal numbers of breeding gulls (Herring and lesser black backed)	Some stakeholders have asked if there is information available that explores the impact that 'predatory' gulls might be having on the success of the breeding seabirds. One stakeholder has asked if rats are also known to be predating on gull eggs and chicks. A stakeholder has also highlighted the adverse impact that the grass mowing regime by HES is having on the success of some gull eggs and chicks and has asked if this mowing is also adversely impacting on the success of the target seabird nests. Other stakeholders have highlighted gulls are highly aggressive to visitors and might benefit from being controlled.	The study has confirmed the target seabird species are at high risk of predation from gulls (and at moderate risk to predation by a pair of resident nesting peregrine falcons). (Section 5.2). A sample number of nest sites shall be monitored (camera traps) during the pre-eradication field studies to assess this impact. The field studies conducted so far have found target seabird species are not competing with gulls for nest sites on the main 'plateau' and central parts of Inchcolm. They prefer to nest on the steep cliffs and vegetated slopes. This preferred habitat reduces their risk of predation by gulls and ensures they are also nesting well away from areas of grass mowing. Further, as numbers of target seabirds start to grow the benefits of 'safety in numbers' will be accrued. Adult gulls will not be at risk of predation by black rats. Gull eggs and hatchlings may be slightly to moderately	Yes

Theme of concern	Description	Mitigation	Are mitigation measures feasible?
		vulnerable to predation by black rats. Gulls will aggressively defend their nest sites from attack by black rats, and black rats themselves will be vulnerable to predation by the adult gulls. A sample number of gull nest sites shall be monitored during the pre-eradication field studies to assess this impact. The study does not recommend controlling the numbers of nesting gulls to improve the visitor experience.	
Impact that shrubs, grasses, and tree mallow may have on the breeding success of target seabirds	Some stakeholders consider that tree mallow may reduce the attractiveness of Inchcolm to burrow nesting puffins	During the pre-eradication planning phase, studies shall be undertaken to assess and recommend a package of measures that can improve the island habitat to encourage additional numbers of target seabirds to nest on Inchcolm; including management of tree mallow on the priority slopes to improve access to burrow nesting puffins (Section 5.3.2). Further consultation with key stakeholders shall be carried out during the pre-eradication planning phase.	Yes
Rats may be helping to remove detritus	Stakeholders have asked for more information on what	Natural decomposition and scavenging processes shall continue in the absence of	Yes

Theme of concern	Description	Mitigation	Are mitigation measures feasible?
and corpses of dead seabirds.	natural processes will be available after an eradication of rats to help decompose carcasses and other detritus	rats. Include the answer to this query in the 'FAQ' part of Communication and Engagement Strategy.	
Use of non-lethal rat controls.	If stakeholder does not understand the methods and health and safety measures, they will not support the proposed eradication.	Include the answer to this query in the 'FAQ' part of Communication and Engagement Strategy. See section 7.2.	Yes
Use of a contraception bait programme to control the breeding success of rats.	If stakeholder does not understand the methods and health and safety measures, they will not support the proposed eradication.	Include the answer to this query in the 'FAQ' part of Communication and Engagement Strategy. See section 7.2.	Yes
What steps will be deployed for the removal of dead rats?	If stakeholder does not understand the methods and health and safety measures, they will not support the proposed eradication.	Include the answer to this query in the 'FAQ' part of Communication and Engagement Strategy. See section 7.4.	Yes
Steps to ensure rats are not reintroduced to Inchcolm?	If stakeholder does not understand the methods and biosecurity measures, they will not support the proposed eradication.	A detailed and effective Biosecurity Plan to be developed and implemented during the pre-eradication planning phase. Recommend 'Case studies from Lundy and the Shiant Isles to be developed and	Yes

Theme of concern	Description	Mitigation	Are mitigation measures feasible?
		passed onto stakeholders' as part of Communication and Engagement Strategy.	

Key stakeholders should be informed about all aspects and stages of the programme and kept regularly informed and involved throughout the planning, implementation, and monitoring stages of the project. Success is also dependent on the support of local agencies and all stakeholder groups.

An eradication project is complex, and it is important to recognise that stakeholder viewpoints are dynamic and are likely to change throughout the project. As such, the feasibility of 'stakeholder support' is a snapshot in time and the proposed Inchcolm project will need a robust Communication and Engagement Strategy.

Although Inchcolm is closed to scheduled visitors over the winter period, it is important that locals be fully informed about the eradication programme. Information boards and notices should be erected on Inchcolm to notify people of the programme and provide warnings and risk information regarding the bait stations and the presence of rodenticides.

Key stakeholders should be kept informed throughout all phases of the eradication programme though meetings, briefings, update and/or progress reports and through information available on the relevant websites. Targeted media should be briefed on the project's progress at appropriate times or as and when media interest in the project occurs.

Site visits for stakeholders will provide information on rats, eradication procedures and progress, and results outcomes. These visits could be extended to media and representatives of funding bodies.

A Communication and Engagement Strategy should be developed to guide ongoing consultation media liaison, coordinate the dissemination of information, raise awareness of the proposed eradication to multiple stakeholders and promote the long-term goals and benefits of the proposed eradication project. This will be particularly important due to the likely interest in the black rat (as a recognised rare naturalised, non-native British mammal).

10.4 Summary of Social Feasibility

Table 13 summarises the social acceptability feasibility criteria. Colour coding represents Green as Criteria met; Amber as Criteria requires further study or consultation and Red as Criteria not met (fail).

Table 13. Summary of social acceptability feasibility criteria for the proposed black rat eradication on Inchcolm Island.

Feasibility criteria	Summary	Outcome
Socially acceptable	Support from the majority of stakeholders. Clarification required on certain issues (i.e., risk, mitigation for non-target species, etc.). Clarification on significance, current range, and status of black rat. Clarification on impacts of black rats on seabirds on Inchcolm. Mitigation strategy options. Biosecurity strategy raised. Issues with gulls and tree mallow.	Stakeholder consultation and engagement shall continue throughout the pre eradication operational planning activities. No reason to consider that local communities, residents and majority of other stakeholders would not be supportive.

11.0 Environment, health and safety acceptability

The eradication of rats is likely to have a strong positive impact on the wildlife of Inchcolm. Predation on seabirds, as well as many other native plant and animal species will be reduced, allowing populations of these species to recover and expand. A summary of the likely risks to non-target species, and the measures that should be taken to minimise these risks is discussed in this section,

11.1 Rodenticide use

Environmental contamination by coumatetralyl and/or bromadiolone can be minimised by the use of well-constructed bait stations and wiring the bait into the stations. In most cases, traces of poison are only recorded at the entrances of the bait stations. Bait stations should not be placed directly next to water sources or dropped into the sea.

Both coumatetralyl and bromadiolone are unlikely to be found in water as they are not very soluble in water and as such, does not migrate through the soil (Eason & Wickstrom, 2001). Where baits disintegrate, they would most likely remain in the soil, where they may persist for up to a year before being degraded by soil micro-organisms (Eason & Wickstrom, 2001). Relatively persistent in the systems of animals and humans, bromadiolone (170-250 days) and slightly persistent coumatetralyl (55 days) are both slowly excreted in urine (Eason & Wickstrom, 2001). Bait remnants must be disposed at a registered landfill or incineration.

11.2 Non-target species

Any eradication project has an associated risk that non-target species will be accidentally poisoned or affected by the eradication programme. This may be through direct consumption of bait, or secondary poisoning by eating poisoned animals, or indirect effects (such as trampling and disturbance). Programme planning must identify species at risk and establish preventative measures to minimise risk.

There is also the potential for unintended ecological consequences of rat removal, as their loss will affect species which predate upon them, species which are predated upon by them, and species which compete with them for resources. At first consideration, there are no species on Inchcolm which would be negatively impacted by the loss of invasive rodents. The most likely visible impact is an increase in the numbers of birds and their species diversity. The risks to non-target species will need to be assessed fully as part of the eradication planning process but it appears at this stage that the main risks are likely to be to wintering gulls, birds of prey and scavenging corvids.

On Inchcolm, a range of species are potentially at risk from primary and secondary poisoning and the details of risk and mitigation are outlined in Table 14. Each species (or group) is considered below. The principal preventative action for primary poisoning (i.e., direct consumption of bait) is the design of bait station which excludes larger non-target species.

Table 14. Risk assessment for non-target species during the proposed black rat eradication on Inchcolm.

Species	Effect	Preventative action	Risk
Plants and fungi	Trampling.	Identification and map locations of rare plants.	Low
Invertebrates	Direct poisoning. Secondary poisoning by eating other invertebrates.	Bait does not affect invertebrates. Bait station design. Bait formulation.	Nil
Marine life (e.g. fish, etc.)	Direct poisoning. Secondary poisoning.	Care to prevent bait falling into sea. Bait only placed in bait stations. Carcasses collected.	Very low
Raptors	Secondary poisoning by eating poisoned rats.	Bait type. Bait station design. Carcasses collected. Timing of eradication.	Medium to Low
Gulls	Direct poisoning. Secondary poisoning by eating poisoned rats.	Bait type. Bait station design. Bait formulation. Bait wired into stations. Carcasses collected.	Low
Crows	Direct poisoning. Secondary poisoning by eating poisoned rats or invertebrates.	Bait type. Bait station design. Bait formulation. Bait wired into stations. Carcasses collected.	Low
Land birds (passerines)	Direct poisoning. Secondary poisoning by eating invertebrates which have consumed bait.	Bait type. Bait station design. Bait wired into station. Carcasses collected.	Low

Species	Effect	Preventative action	Risk
Seabirds	Disturbance.	Majority of seabirds not present. Timing of eradication.	Nil
Bats	Disturbance. Secondary poisoning by eating invertebrates which have consumed bait.	Bait type. Bait station design. Bait wired into station. Carcasses collected.	Low
Dogs	Direct poisoning. Secondary poisoning.	Not present on island (limited numbers visiting island). Bait station design. Bait formulation. Antidote available.	Low

The risk of secondary poisoning through eating poisoned rats is low, as most rats die underground or under vegetation in their nests and burrows. Less than five rats were found on the surface in each of the other UK operations on Lundy, Isle of Canna, St Agnes & Gugh and the Shiants (Bell *et al*., 2011; Bell, 2019; Bell *et al*., 2019; Main *et al*., 2019). Searches for carcasses would be undertaken as part of the bait and monitoring station checks as well as along stone walls throughout the eradication project. Any carcasses found on the surface will be collected, necropsied to assess poisoning symptoms, and disposed of safely (either by deep burial or incineration).

The timing of the eradication, use of bait stations, crow clips, selection of bait type and formulation, and wiring the bait into position reduced the potential risk to non-target species in other UK eradication operations completed on behalf of Natural England, RSPB, NatureScot and The National Trust for Scotland (E. Bell 2019). It is expected that using these same measures, and other adaptions as the operation proceeds, will minimise the potential risk to those non-target species present on Inchcolm.

Despite all preventative methods, it is possible that some incidental loss to non-target species might occur. However, this should be balanced against the long-term benefits to native species and ecosystem recovery.

Through a partnership of agencies, the Campaign for Responsible Rodenticide Use (CRRU) have developed a good practice leaflet on the use of rat poison and the threats to wildlife (CRRU 2021). This leaflet outlines methods to prevent rodent infestations, methods to control rats, information on trapping, rodenticides and resistance and the dangers to wildlife (particularly raptors and other birds of prey) for the general public.

11.2.1 Plants and fungi

Any important plants or fungi should be identified and mapped. These locations should be avoided as much as possible.

11.2.2 Invertebrates

The recommended bait will not affect invertebrates (Booth *et al*., 2001). Centipedes, slugs, beetles, and smaller insects have been recorded eating bait on a number of eradication programmes with no loss. It is more likely that invertebrates that have eaten bait would cause secondary poisoning in other animals which eat them. Following the eradication of black rats, the populations of large invertebrates are likely to increase with the removal of a major predator, although this increase will be counterbalanced to some extent by rising land bird populations.

11.2.3 Marine life

It is unlikely that the recommended bait will affect crabs. Pain *et al*., (2000) who tested the effects of brodifacoum on land crabs on Ascension Island found although crabs readily ate the bait, none were killed by the toxin. Low residues were recorded in body flesh, but these were excreted within a month (Pain *et al*., 2000). Similar research by Buckelew *et al*. (2005) and Wegmann *et al*. (2011) during the Palmyra Atoll rat eradication also reported that crabs did not appear to be detrimentally affected by brodifacoum exposure through the consumption of bait. The main problem is that consumption of bait by crabs can affect the availability of bait to rats (Wegmann *et al.*, 2011; Keitt *et al*., 2015).

It is also unlikely that the recommended bait will affect other marine species. As shown by an accident in New Zealand in 2001 when significant amounts of brodifacoum bait fell into the sea, residues were detected in shellfish at the 100 m^2 site immediately but this dropped to nothing after several weeks (Primus *et al.*, 2005). No observable effects of brodifacoum on marine ecosystems after aerial bait drops using pellet bait have been recorded in New Zealand and fish did not appear to show any interest in the bait (Empson & Miskelly, 1999, Fisher *et al*., 2011). As the bait will be contained in bait stations, it is very unlikely that any bait will make it into the sea. Rat carcasses will be collected.

11.2.4 Raptors

Raptors are at risk from secondary poisoning (from scavenging dead rats or targeting slower sick rats). There are very few resident raptors (peregrines and possibly buzzards *Buteo buteo*) on Inchcolm. The risk of secondary poisoning through eating poisoned rats is low, as most rats die underground or under vegetation in their nests or burrows. Few rats were found on the surface during other UK eradications (Bell, 2019).

Searches for carcasses should be undertaken throughout the eradication programme. Any carcasses found on the surface will be collected and disposed of safely.

11.2.5 Crows and gulls

Having some fat/ wax content to the formulation, crows (*Corvus* spp.) and gulls (*Larus* spp.) have been recorded eating rodenticide baits during other eradications in the UK (Bell *et al*., 2011; Bell *et al*., 2019;

Bell, 2019, Main *et al.*, 2019). Crows and gulls may also interfere with the bait stations. Experience on Ramsey Island, Lundy Island and the Isle of Canna has developed an alternative bait station design; a longer bait station, wired entrances and a crow clip were added (Bell, 2019). This made the stations more secure in the wind and stopped the crows and gulls removing the lids (Bell, 2019). Further adaptations can be made throughout the eradication programme if necessary. Consideration will also be given to the use of lockable traditional bait boxes for higher risk areas (see also Section 7.5).

Another risk to gulls and crows is from eating dead or dying rats. Many gulls may not be present on Inchcolm during winter, but as with raptors, this risk is low due to rats dying underground or under vegetation, and the studies preference to use a first generation rodenticide formulation that can be metabolised quickly by the rats leaving minimal rodenticide residues.

Adaptations to the bait stations or bait grid can be made throughout the eradication if interference by gulls is noted.

11.2.6 Land birds (Passerines)

Grain based baits will not be used for the eradication operation. Fat/ wax based formulations will be less attractive to passerines. Furthermore, the bait will only be delivered in bait stations and most passerine species will not enter a bait station due to fear of predation. The risk to passerines is reduced further by the bait station design (increased length and additional wires) and the fact that the bait is wired into the stations. If passerines are noted interfering with the bait and/or stations throughout the eradication programme, further adaptations can be made as necessary, including changing over to a lockable traditional bait box design.

11.2.7 Bats

Pipistrelle bats (*Pipistrellus pipistrellus*) have been recorded on Inchcolm. These species are primarily invertebrate foragers. As such it is likely that these bats would be at risk from secondary poisoning only via eating invertebrates.

Like many other species there is limited data on the impact of anticoagulant poisons to bats (and no data on the recommended rodenticides coumatetralyl or bromadiolone), but there have been no deaths reported from previous eradication operations in the UK, and bats did not show any interest in pellet or block bait formulations reported on by others (Lloyd, 1994; Eason & Spurr, 1995; Sedgeley & Anderson, 2000; O'Donnell *et al*., 2011).

11.2.8 Dogs

Although there are no dogs on Inchcolm and the island has restricted access during winter, dogs may be brought ashore by visitors during the eradication. Domestic dogs are at risk from both primary and secondary poisoning. The risk of primary poisoning is very low as the bait is in wax-block form and in bait stations. There is a higher risk of secondary poisoning from eating dead or dying rats, however a 10 kg dog would have to eat over 50 dead rats (and consume the entire carcass, particularly the liver and stomach where the active ingredient accumulates) to obtain a lethal dose. Information on the symptoms of anti-coagulant poisoning should be available to all stakeholders.

The local veterinarians should have all the relevant information on the poison used, symptoms and treatment prior to the eradication. Vitamin K1 is the antidote to difenacoum, and it is available in injection or tablet form (requiring 1-5 mg/kg once a day for 1-4 weeks depending on amount of bait consumed). Any dogs accidentally poisoned can be effectively treated either by the veterinarian or trained project personnel.

11.3 Alternative natural food

The eradication plan will schedule the work to take place over the winter period when the natural food supply is most scarce for rats. The rat diet at this time of the year will primarily comprise scavenging vegetation, insects, marine crustaceans, animal and seabird carcasses and human derived waste products. Any animal or seabird carcasses will have to be monitored closely to check for rat activity and removed for disposal.

Guidance will be provided to HES on measures that can be adopted to contain food waste to minimise the availability of these wastes to scavenging rats.

11.4 Key species monitoring

Key species monitoring (rats, seabirds and other island species) should be undertaken prior to, during and after the proposed eradication.

Monitoring should commence in the spring and summer ahead of a winter eradication to enable baseline information to be collected. This monitoring should continue for two years after the eradiation phase. A detailed Key Species Monitoring Plan should be prepared to ensure relevant, robust, and accurate data collection procedures, data storage and analysis.

11.5 Human health

Direct ingestion of baits or inhalation of bait dust poses a potential health risk with young children being most at risk from ingestion should they obtain access to the bait. This risk shall be mitigated by only dispensing bait using enclosed, locked and secured boxes. Furthermore, the recommended baits for the eradication, Romax Rat CP and Contrac Blocks™ have Bitrex™ added (as per UK regulations). Bitrex™ is a bittering agent to make the bait unattractive to children and adults.

As rodenticide blocks have been recommended, the risk of dust inhalation is reduced. Clear warning signs (detailing the eradication, bait station design and danger from bait) should be placed on Inchcolm at all public access points and suitable landing sites (quay, beaches, noticeboards, etc.). Warning labels will be placed on all bait stations advising visitors not to touch the stations or bait.

The antidote for anticoagulant poisoning is Vitamin K1. Difenacoum is relatively slow-acting and several days are available for treatment. In the unlikely event that a person ingests bait, medical advice and aid should be provided. Diagnostic and treatment procedures should be discussed with a local medical doctor as part of the operational planning process.

A detailed information sheet outlining the hazards associated with coumatetralyl and bromadiolone should be prepared for the eradication team as part of the Health and Safety plan prior to the operation.

Rats are known carriers of a number of diseases (including leptospirosis, toxoplasmosis, salmonella, and cryptosporidium) and parasites (including mites and fleas). Generally, most people catch leptospirosis from drinking contaminated water or handling wet vegetation or soil (that had the bacteria present after being spread in rat urine) and then transmitted via the hands to the mouth (by eating or smoking) rather than handling rats. The risk from leptospirosis is highest in warm, moist environments. The bacterium dies almost immediately when it dries out. Most people are at minimal risk from this disease. As there are no reports of leptospirosis (Weil's disease) on Inchcolm and few (less than 5 per year[7]) in Scotland, the risk is low.

As part of the project Health and Safety procedures, to remove any minor risks from handling bait, animal carcasses, or working with and around rats, all eradication team members should be wearing protective gloves and protective clothing (i.e., overalls, boots etc.). Any cuts or abrasions should be covered. It is very important to wash and thoroughly dry hands before eating, drinking, and smoking after handling bait or carcasses. All rats (and other carcasses) should be handled using gloves.

11.6 Health and Safety

The health and safety of the project team is of primary concern. A detailed Health and Safety plan should be prepared for the project. This must be approved by the project-chartered safety practitioner and relevant organisations prior to the eradication operation. This plan must detail all hazards and mitigation to avoid these issues. The team should be trained in comprehensive outdoor first aid or Pre-Hospital Emergency Care. A member of the team should be designated as the Safety Officer and be responsible for addressing any safety issue that arises during the project. No unsafe practises will be allowed to continue.

The physical features of Inchcolm pose few challenges for an eradication operation. Sections of the coastal areas will only be accessed by boat or rope. The western cliffs will need rope work to access some of the ledges. This will require suitably qualified and experienced team members as part of the project personnel. Bait stations with difficult access could have more bait placed inside during each check to enable enough bait to be available to rats in these areas.

Any offshore islets will require bait stations and regular checks, which will require boat transport. This will have to be available to ensure adequate bait coverage and monitoring of these sites.

Overall, no topographical characteristics on Inchcolm are unsurpassable and should not inhibit the success of an eradication programme.

[7] https://www.hps.scot.nhs.uk/a-to-z-of-topics/leptospirosis/

11.7 WASTE MANAGEMENT

It is important that the availability of alternative food for rats is minimised during the eradication programme. Waste management arrangements will be discussed and arranged through the local council, HES, SEPA and local businesses.

Waste bait, rat carcasses and used monitoring tools should be disposed of at a registered landfill or incineration facility as per regulations.

The eradication project shall also generate its own waste streams including:

Non-hazardous Wastes e.g:

- Packaging waste.
- Used personal protection equipment, gloves, masks, ropes etc.
- Paper waste.
- Food wastes etc.

Hazardous wastes e.g:

- Spent rodenticide bait.
- Contaminated rat carcasses etc.

A project waste management plan (PWMP) shall be developed to identify and document the types of waste that will be produced and describe how they will be handled, from generation to recycle to reuse and/or to disposal, and in accordance with the guidance and standards laid down by the local council and SEPA.

11.8 ARCHAEOLOGY

Special care needs to be given to archaeological areas and sites. There are a number of important archaeological sites on Inchcolm, and HES should be consulted on the proposed project and the bait and monitoring station network.

Rats can have a negative impact on archaeological structures; much of this is due to digging burrows underneath. Evidence of rats burrowing around the abbey on Inchcolm was observed during site visits in June 2022.

Whenever practicable, bait stations should be placed outside of any recognisable structure and if this is not practicable, the required stations should be placed in areas that would minimise disturbance or damage to the site. At no time should archaeological structures be dismantled or excavated for bait station placement. Very important archaeological sites would be identified by HES on field maps for the eradication team. Access to all archaeological sites would be limited to work purposes only.

The Abbey, military bunkers and other archaeological structures may increase the number of bait stations required, but this is unlikely to affect the proposed programme in any way. The presence of these structures may reduce the home range of black rats within these areas, but additional monitoring should be able to detect this, and action can be taken to target these locations during the eradication.

11.9 Likely outcomes (Cost/Benefit) following the black rat eradication on Inchcolm

There are a number of outcomes that could result following the eradication of black rats from Inchcolm; some which can be predicted. Owing to the number of eradication projects that have occurred around the world, responses of a number of species (i.e., plants, invertebrates, mammals, reptiles, and birds) have been monitored (Towns *et al*., 2006; Witmer *et al.,* 2007; Varnham, 2010). Most species have benefited following the eradication of rats, but there have been some unforeseen and negative impacts recorded too (Courchamp *et al*., 2003; Towns *et al*., 2006).

The cost of controlling rats or the damage that rats cause is on-going and as a result, where feasible, it is recommended that rats are eradicated rather than controlled.

A number of outcomes can be predicted for the Inchcolm eradication project (It is expected that following a rat eradication the following could occur on Inchcolm: (i) guillemot, razorbill, puffins, kittiwake, fulmar, eider duck and other seabird species present on Inchcolm will have enhanced breeding success, (ii) prospecting storm petrels and terns may establish new breeding colonies. Establishment techniques, such as playback attraction, burrow provision and translocation, have been used successfully elsewhere, and would greatly improve the prospects of breeding colonies for these species post-eradication (Miskelly *et al.,* 2009), (iii) regeneration of vegetation (such as heather) susceptible to suppression by rats, (iv) enhanced breeding success of land birds such as snipe, pipits, skylarks and twite, and (v) reappearance of rarely seen or unknown invertebrates.

It is recommended that pre- and post-eradication monitoring is included in the project. This will help quantify impact on or changes to the status and productivity of other island species following the eradication.

It is expected that following a rat eradication the following could occur on Inchcolm: (i) guillemot, razorbill, puffins, kittiwake, fulmar, eider duck and other seabird species present on Inchcolm will have enhanced breeding success, (ii) prospecting storm petrels and terns may establish new breeding colonies. Establishment techniques, such as playback attraction, burrow provision and translocation, have been used successfully elsewhere, and would greatly improve the prospects of breeding colonies for these species post-eradication (Miskelly *et al.,* 2009), (iii) regeneration of vegetation (such as heather) susceptible to suppression by rats, (iv) enhanced breeding success of land birds such as snipe, pipits, skylarks and twite, and (v) reappearance of rarely seen or unknown invertebrates.

There have been unforeseen and unintended negative consequences following eradication projects around the world, particularly other exotic species (usually plants) have increased (Towns *et al*., 2006). It is possible that the following negative impacts could result following the eradication of rats from Inchcolm: (i) changes and spread of exotic and problem plant species, (ii) fluctuations in the abundance of invasive invertebrates which could compete with or affect native plant and invertebrate species, (iii) increased populations of invertebrates, bees, and land birds that result in high mortality as natural food sources level out, and (iv) prey switching by other native or non-native predators (i.e. raptors).

Monitoring should be conducted during the pre-eradication phase of work to collect baseline information on likely problem species, particularly weeds and invertebrates. It is possible that weed species whose seeds are eaten by rats, may currently be kept at low densities which may cause a problem if weed species spread into vulnerable or important areas. However, many weeds are also spread by rats when they cache fruit and seed. Interestingly the eradication of rats may result in native plants outcompeting some weed species.

Information on the ecology and seabird populations of Inchcolm has been collected for a long period by the Forth Seabird Group, Forth Heritage Group, and various individuals. This project will provide the opportunity to measure the rate of recovery after the eradication of black rats. The opportunity for seabird restoration on Inchcolm post-eradication is good; current seabirds (such as puffins, razorbills, and guillemots) could expand range and density and prospecting species could establish on the island.

It is important to assess the level of native predators (i.e., raptors and gulls) on Inchcolm to determine what affect these species may have on the recovery and spread of seabirds on the island. There are few native predators on Inchcolm, although gulls and raptors are known to predate other bird species. Gull numbers are unlikely to change due to rats being eradicated from the island, as they are not significantly affected by rat predation.

11.10 Summary of Environmental Feasibility

Table 15 summarises the environmental feasibility criteria. Colour coding represents Green as Criteria met; Amber as Criteria requires further study or consultation and Red as Criteria not met (fail).

Table 15. Summary of environmental feasibility criteria for the proposed black rat eradication on Inchcolm.

Feasibility criteria	Summary	Outcome
Environmentally acceptable	Rodenticide contained in bait stations. Working to strict H&S protocols. Compliant waste management protocols. Key species monitoring to ensure no negative affect from eradication operation. Archaeology mapped to ensure no impact from eradication operation.	Pass.

Feasibility criteria	Summary	Outcome
	Mitigation strategies for non-target species to prevent impact during eradication operation.	

12.0 CAPACITY

12.1 ORGANISATION, LOGISTICS AND RESOURCING PLAN

For any eradication programme on Inchcolm to be successful it must involve experienced operators. Four experienced eradication field staff would have overall responsibility for the planning and execution of the eradication programme. This will enable the grid to be established in the recommended timeframe, as well as ensuring that Inchcolm can be baited, monitored, and checked every two days as required. Two of these field team members would have to be qualified rope access technicians (to complete work on the cliffs areas). This field team would be supported by a mainland-based management and communications team to help plan, coordinate, direct staff and maintain effective communication with the landowner, HES personnel, interested parties and stakeholders.

The team would need to be involved in all stages of the preparation and implementation of the eradication programme, including attending project planning meetings, maintaining communication between the landowner and stakeholder agencies, obtaining equipment, and coordinating field activities. The team would have to be involved throughout the lead-in time (6-12 months prior) as well as the six-month eradication operation.

Boat transport would be required. This could be via a charter operator or purchasing a project boat with a qualified and experienced boat operator as part of the team. The eradication on Inchcolm is reliant on boat transport to the island as well as the offshore islets and some cliff or coastal areas. Boat transport could be affected by adverse weather or availability of a suitable vessel. It will be vital that a boat is confirmed for the duration of the project.

In addition to the experienced eradication operators, it is recommended that wherever possible, local, or regional agency staff (i.e., HES, RSPB, NatureScot, Forth Seabird Group, Forth Heritage Group, etc.) will be trained to enable the long-term monitoring to be undertaken by these people or agencies.

12.2 SUMMARY OF CAPACITY FEASIBILITY

Table 16 summarises the capacity feasibility criteria. Colour coding represents Green as Criteria met; Amber as Criteria requires further study or consultation and Red as Criteria not met (fail).

Table 16. Summary of capacity feasibility criteria for the proposed black rat eradication on Inchcolm.

Feasibility criteria	Summary	Outcome
Capacity	Project leadership, direction and health and safety. 4-person eradication team (including rope access personnel). Boat transport to islands. Operational base in Edinburgh for project team. Agency support for ongoing biosecurity.	Pass.

13.0 FINANCIAL VIABILITY

13.1 BUDGET FORECAST

Costs are being developed to deliver the eradication project, carry out the monitoring and establish the long term biosecurity programme for the life span of the Berwick Bank Wind Farm.

A contingency sum shall be built into the budget to allow for the possibility of rats being detected at the end of the eradication phase or aspects of the project go over the allocated time. This allows for a second baiting operation (i.e., during the following winter as it is more difficult to target rats successfully during spring and summer when natural food is widely available) to complete the eradication programme. Although, based on similar eradication projects in the UK this should not be necessary, it is important to plan for every outcome.

If required, a mitigation option to retain a sample of black rats from Inchcolm would include a partnership with a zoo or wildlife park.

13.2 SUMMARY OF FINANCIAL FEASIBILITY

Table 17 summarises the financial feasibility criteria. Colour coding represents Green as Criteria met; Amber as Criteria requires further study or consultation and Red as Criteria not met (fail).

Table 17. Summary of financial feasibility criteria for the proposed black rat eradication on Inchcolm.

Feasibility criteria	Summary	Outcome
Affordable	Two-year eradication operation. Biosecurity and adaptive management and stakeholder engagement would continue.	Pass

14.0 Conclusions

Berwick Bank identified an opportunity to eradicate mammalian predators on Inchcolm as part of the suite of compensation measures if required. Inchcolm was chosen based on delivery and connectivity of the seabird populations within a wider geographical network within the area. Inchcolm has previously been recognised as a priority island for restoration by the RSPB

The feasibility report has found the eradication of black rats (*Rattus rattus*) from Inchcolm island and its islets, its islets and sea stacks intensive followed by on-going biosecurity monitoring and control is feasible. A comprehensive, rat eradication and biosecurity operation that follows international best practice (Clout & Williams, 2009; Thomas *et al*., 2017) should be adopted, with clear strategies in place to deal with risk and technical requirements to maximise the likelihood of success. Unobtrusive biosecurity measures will help reduce re-introduction risk. There would be significant benefits to the seabirds including kittiwake, guillemot, razorbill and puffin following rat eradication.

The outcomes of the study against the 7 internationally recognised feasibility criteria described in the UK Rodent Eradication Best Practice Toolkit (Thomas *et al*., 2017) are provided in Table 18. Colour coding represents Green as Criteria met; Amber as Criteria requires further study or consultation and Red as Criteria not met (fail).

Table 18. Summary of feasibility assessment outcomes.

Feasibility criteria	Summary	Outcome
Technically feasible	Ground-based bait station operation. Registered rodenticide. Range of bait station designs. Potential none target impacts managed 25 x 25 m grid. Winter operation safely delivered. Intensive monitoring period. Rope and boat access requirement.	Pass.
Sustainable	Within the maximum potential swimming distance of brown rats from mainland Scotland. Assessed as slightly vulnerable to reinvasion by swimming. High numbers of visitors throughout the year.	There has been positive engagement with key stakeholders to date. No reason at present to consider that commitment to a robust biosecurity plan would not be forthcoming.

Feasibility criteria	Summary	Outcome
	Private and charter vessels and operating year-round but peaking in the summer months. Commitment for comprehensive biosecurity programme required from key stakeholders including HES, local communities, tourists, visitors and boat operators.	A clarification note shall be provided once consultation has been completed.
Politically acceptable	Clarification recommended on views of regulatory stakeholders including Local Council, HES, NatureScot and other key stakeholder views and how this impacts upon political support for a black rat eradication.	Further consultation required. No reason at present to believe that eradication would not be politically acceptable.
Legally acceptable	Registered rodenticide uses in bait stations as per UK regulations. Working under current health, safety and welfare law and regulations.	Pass.
Socially acceptable	Support from the majority of stakeholders. Clarification required on certain issues (i.e., risk, mitigation for non-target species, etc.). Clarification on significance, current range, and status of black rat. Clarification on impacts of black rats on seabirds on Inchcolm. Mitigation strategy options. Biosecurity strategy raised. Issues with gulls and tree mallow assessed and managed.	Further consultation required. No reason to consider that local communities, residents and majority of other stakeholders would not be supportive.

Feasibility criteria	Summary	Outcome
Environmentally acceptable	Rodenticide contained in bait stations. Working to strict H&S protocols. Compliant waste management protocols. Key species monitoring to ensure no negative affect from eradication operation. Archaeology mapped to ensure no impact from eradication operation. Mitigation strategies for non-target species to prevent impact during eradication operation.	Pass.
Capacity	Project leadership, direction and health and safety. 4-person eradication team (including rope access personnel). Boat transport to islands. Operational base in Edinburgh for project team. Agency support for ongoing biosecurity.	Pass.
Affordable	Two-year eradication operation. Biosecurity and adaptive management and stakeholder engagement would continue.	Pass

15.0 REFERENCES

Auld, T.D.; Hutton, I.; Ooi, M.K. & Denham, A.J. (2010). Disruption of recruitment in two endemic palms on Lord Howe Island by invasive rats. *Biological Invasions* 12(9): 3351-3361.

Appleton, D.; Booker, H.; Bullock, D.J.; Cordrey, L. & Sampson, B. (2006). The Seabird Recovery Project: Lundy Island. *Atlantic Seabirds* 8(1&2): 51-59.

Atkinson, I.A.E. (1985). The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. Pages 35-81 in: Moors, P.J. (ed.). *Conservation of island birds*. ICBP Technical Publication No. 3.

Baig, M.; Farah, S.; Atkulwar, A. & Searle, J.B. (2022). Genomic analysis reveals subdivision of black rats (*Rattus rattus*) in India, origin of the worldwide species spread. *Genes* 13(2); 267 (https://doi.org/10.3390/genes13020267).

Bailey, C.I. & Eason, C.T. (2000). Anticoagulant Resistance in Rodents. *Conservation Advisory Science Notes No. 297.* Department of Conservation, Wellington, New Zealand.

Baxter, J.M.; Boyd, I.L.; Cox, M.; Donald, A.E.; Malcolm, S.J.; Miles, H.; Miller, B. & Moffat, C.F. (eds.) (2011). *Scotland's Marine Atlas: Information for the national marine plan.* Marine Scotland, Edinburgh.

Bell, E.; Bell, M.; Morgan, G. & Morgan, L. (2019). The recovery of seabird populations on Ramsey Island, Pembrokeshire, Wales, following the 1999/2000 rat eradication. Pages 539-544 in C.R. Veitch, M.N. Clout, A.R Martin, J.C Russell & C.J. West (eds.). *Island invasives: scaling up to meet the challenge*. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

Bell, E.; Boyle, D.; Floyd, K.; Garner-Richards, P.; Swann, B.; Luxmoore, R.; Patterson, A. & Thomas, R. (2011). The ground-based eradication of Norway rats (*Rattus norvegicus*) from the Isle of Canna, Inner Hebrides, Scotland. Pages 269-274 in Veitch, C.R.; Clout, M.N.; Towns, D.R. (Eds.). *Island Invasives: Eradication and Management*. IUCN, Gland, Switzerland.

Bell, E.; Floyd, K.; Boyle, D.; Pearson, J.; St Pierre, P.; Lock, L.; Mason, S.; McCarthy, R. & Garratt, W. (2019). The Isles of Scilly seabird restoration project: the eradication of brown rats (*Rattus norvegicus)* from the inhabited islands of St Agnes and Gugh, Isles of Scilly. Pages 88-94 in C.R. Veitch, M.N. Clout, A.R. Martin, J.C. Russell & C.J. West (eds.). *Island invasives: scaling up to meet the challenge*. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

Bell, E.A. (2019). It's not all up in the air: the development and use of ground-based rat eradication techniques in the UK. Pages 79-87 in C.R. Veitch, M.N. Clout, A.R. Martin, J.C. Russell & C.J. West (eds.). *Island invasives: scaling up to meet the challenge*. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

Bell, E.A.; Bell, B.D. & Merton, D.V. (2016). The legacy of Big South Cape: rat irruption to rat eradication. *New Zealand Journal of Ecology* 40(2): 212-218.

Bellingham, P.J.; Towns, D.R.; Cameron, E.K.; Davis, J.J.; Wardle, D.A.; Wilmshurst, J.M. & Mulder, C.P.H. (2010). New Zealand Island restoration: seabirds, predators, and the importance of history. *New Zealand Journal of Ecology* 34(1): 115-136.

Booker, H & Price, D. (2014). Manx shearwater recovery on Lundy: Population and distribution change from 2001 to 2013. *Journal of the Lundy Field Society* 4: 105-116.

Booker, H.; Slader, P.; Price, D., Bellamy, A.J. & Frayling, T. (2018). Cliff nesting seabirds on Lundy: Population trends from 1981 to 2017. *Journal of the Lundy Field Society* 6: 65-76.

Booth, L.H., Eason, C.T. & Spurr, E.B. (2001) Literature review of the acute toxicity and persistence of brodifacoum to invertebrates. *Science for Conservation 177.* Department of Conservation, Wellington, New Zealand.

Brooke, M. de L.; Bonnaud, E.; Dilley B.J.; Flint, E.N.; Holmes, N.D.; Jones, H.P.; Provost, P.; Rocamora, G.; Ryan, P.G.; Surman, C.& Buxton, R.T. (2018). Seabird population changes following mammal eradications on islands. *Animal Conservation* 21(1): 3-12.

Buckelew, S.; Howald G.R.; Wegmann A.; Sheppard J.; Curl J.; McClelland P.; Tershy B.; Swift K.; Campbell E. & Flint B. (2005). *Progress in Palmyra Atoll restoration: rat eradication trial, 2005*. Island Conservation, Santa Cruz, California.

Buckle, A.P.; Prescott, C.V. & Ward, K.J. 1994. Resistance to the first- and second-generation anticoagulant rodenticides - a new perspective. *Proceedings of the 16th Vertebrate Pest Conference 1994*: 138-144.

Bull, J.O. (1976). Laboratory and field investigations with difenacoum, a promising new rodenticide. *Proceedings of the 7th Vertebrate Pest Conference* 1976: 72-84.

Buxton, R.; Taylor, G.; Jones, C.; Lyver, P. O'B. Moller, H.; Cree, A. & Towns, D. (2016). Spatio-temporal changes in density and distribution of burrow-nesting seabird colonies after rat eradication. *New Zealand Journal of Ecology* 40(1): 88-99.

Cain, I. (2022a). INCHCOLM Field Study Report: Tasks 1 and 2: SSER Berwick Bank Wind Farm: Predator Eradication Feasibility Study. Contract report prepared for SSE Renewables.

Cain, I. (2022b). INCHCOLM Breeding Seabird Survey and Habitat Assessment Report: Tasks 3 and 4: SSER Berwick Bank Wind Farm: Predator Eradication Feasibility Study. Contract report prepared for SSE Renewables.

Campbell, E.W. (1991) The effect of introduced roof rats on bird diversity of Antillean cays. *Journal of Field Ornithology* 62: 343-348.

Capizzi, D.; Baccetti, N. & Sposimo, P. (2016). Fifteen years of rat eradication on Italian Islands. Pages 205-227 in Angelici, F (ed.). *Problematic Wildlife*. Springer International Publishing, Switzerland.

CABI (2022). *Rattus: Black rat*. In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc.

Chua, C.; Humaidi, M.; Neves, E.S.; Mailepessov, D.; Ng, L.C. & Aik, J. (2022). VKORC1 mutations in rodent populations of a tropical city-state as an indicator of anticoagulant rodenticide resistance. *Scientific reports* 12(1): 1-8.

Clout, M.N. & Williams, P.A. (Eds.). 2009. Invasive species management: a handbook of principles and techniques. Oxford University Press. Oxford, United Kingdom.

Courchamp, F.; Chapius, J.-L. & Pascal, M. (2003). Mammal invaders on islands: impacts, control, and control impact. *Biological Review* 78: 347-383.

CRRU – Campaign for Responsible Rodenticide Use (2021). *CRRU UK Code of Best Practice: Best Practice and Guidance for Rodent Control and the Safe Use of Rodenticides*. CRRU UK, Killgerm Group, UK. https://www.thinkwildlife.org/download/crru-uk-code-of-best-practice-2021/?wpdmdl=18095&masterkey=60de99c7ba058

Croxall, J.P.; Butchart, S.H.M.; Lascelles, B.; Stattersfield, A.J.; Sullivan, B.; Symes, A. & Taylor, P. (2012). Seabird conservation status, threats and priority actions: a global assessment. *Bird Conservation International* 22: 1–34.

Cunningham, D.M. & Moors, P.J. (1996). A guide to the identification and collection of New Zealand rodents: 3rd Edition. *Occasional Publication No. 4.* New Zealand Wildlife Service, Department of Internal Affairs, Wellington. New Zealand.

Daltry, J.C., James, K.J., Otto, A. & Ross, T.N. (2010). Evidence that eradicating black rats (*Rattus rattus*) has boosted the recovery of rare reptiles and sea birds on Antiguan islands. *Island Biodiversity: Flora, Fauna and Humans in the Lesser Antilles, 6-8 November.* Martinique, France.

Daniel, M.J. (1972). Bionomics of the ship rat (*Rattus r. rattus*) in a New Zealand indigenous forest. *New Zealand Journal of Science* 15: 313-41.

Dawson, J.; Oppel, S.; Cuthbert, R.J.; Holmes, N.; Bird, J.P.; Butchart, S.H.M.; Spatz, D.R. & Tershy, B. (2015). Prioritizing islands for the eradication of invasive vertebrates in the United Kingdom overseas territories. *Conservation Biology* 29(1): 143-153.

Dennis, G.C. & Gartrell, B.D. (2015). Non-target mortality of New Zealand lesser short-tailed bats (*Mystacina tuberculata*) caused by diphacinone. Journal of Wildlife Disease 51(1): 177-186.

DIISE (2018). *The Database of Island Invasive Species Eradications*. Island Conservation, Coastal Conservation Action Laboratory UCSC, IUCN SSC Invasive Species Specialist Group, University of Auckland and Landcare Research New Zealand. http://diise.islandconservation.org.

Duncan, M.J., Hughey, K.F.D., Cochrane, C.H. & Bind, J. (2008) River modelling to better manage mammalian predator access to islands in braided rivers. *British Hydrological Society 10th National Hydrology Symposium*, pp. 487-492. British Hydrological Society, London, UK.

Dunlop, J.N.; Rippey, E.; Bradshaw, L.E. & Burbidge, A.A. (2015). Recovery of seabird colonies on Rat Island (Houtman Abrolhos) following the eradication of introduced predators. *Journal of the Royal Society of Western Australia* 98: 29-36.

Dyke, P.P.G. (1987). Water circulation in the Firth of Forth, Scotland. *Proceedings of the Royal Society of Edinburgh* 93B (3-4): 273-284.

Eason, C.T. & Ogilvie, S. (2009). A re-evaluation of potential rodenticides for aerial control of rodents. *DOC Research & Development Series 312*. Department of Conservation, Wellington. 33 p.

Eason, C.T. & Wickstrom, M. (2001). Vertebrate Pesticide Toxicology Manual (poisons). *Department of Conservation Technical Series 23*. Wellington, New Zealand.

Eason, C.T. & Spurr, E.B. (1995). The toxicity and sub-lethal effects of brodifacoum in birds and bats: a literature review. *Science for Conservation 6*. Department of Conservation, Wellington, New Zealand.

Elliott, A.J. & Neill, S.P. (2007). The tidal flux in the Firth of Forth. *Proceedings of the Institution of Civil Engineers: Maritime Engineering* 160: 25-32.

Empson, R.A. & Miskelly, C.M. (1999). The risks, costs and benefits of using brodifacoum to eradicate rats from Kapiti Island, New Zealand. *New Zealand Journal of Ecology* 23: 241-254.

Ershoft, B.H. (1954) Beneficial effect of low-fat diets on the swimming performance of rats and mice in cold water. *Journal of Nutrition* 1954: 439-449.

Evans, R.L., Katz, E.M., Olson, N.L. & Dewberry, D.A. (1978). A comparative study of swimming behaviour in eight species of muroid rodents. *Bulletin of the Psychonomic Society* 11: 168-170.

Fisher, P.; Eason, C.T.; O'Connor, C.E.; Lee, C.H.; Smith, G.B. & Endepols, S. (2003). Coumatetralyl residues in rodents and secondary poisoning hazard to barn owls. In: Singleton, G.R.; Hinds, L.A.; Krebs, C.J.; Spratt, D.M. (Eds), *Rats, Mice and People: Rodent Biology and Management.* Monograph No 96, Australian Centre for International Agricultural Research, Canberra, pp. 457–460.

Fisher, P.; Griffiths, R.; Speedy, C. & Broome, K. (2011). Environmental monitoring for brodifacoum residues after aerial application of baits for rodent eradication. Pages 300-304 in Veitch, C.R.; Clout, M.N.; Towns, D.R. (Eds.). *Island Invasives: Eradication and Management*. IUCN, Gland, Switzerland.

Greaves, J.H.; Shepherd, D.S. & Gill, J.E. (1982). An investigation of difenacoum resistance in Norway rat populations in Hampshire. *Annals of Applied Biology* 100(3): 581-587.

Harris, D.B. (2009). Review of negative effects of introduced rodents on small mammals on islands. *Biological invasions* 11: 1611-1630.

Harris, D.B.; Gregory, S.D.; Bull, L.S. & Courchamp, F. (2012). Island prioritization for invasive rodent eradications with an emphasis on reinvasion risk. *Biological Invasions* 14(6): 1251-1263.

Hilton, G.M. & Cuthbert, R.J. (2010). The catastrophic impact of invasive mammalian predators on birds of the UK Overseas Territories: a review and synthesis. *Ibis* 152: 443-458.

Howald, G.; Donlan, C.J.; Galvan, J.P.; Russell, J.C.; Parkes, J.; Samaniego, A.; Wang, Y.; Veitch, D.; Genovesi, P.; Pascal, M.; Saunders, A. & Tershey, B. (2007). Invasive rodent eradication on islands. *Conservation Biology* 21: 1258-1268.

Humane Vertebrate Pest Control Working Group. (2004). *A National Approach Towards Humane Vertebrate Pest Control*. An unpublished discussion paper arising from the proceedings of an RSPCA Australia/AWC/VPC joint workshop, August 4-5, Melbourne. RSPCA Australia, Canberra, Australia.

ISSG – Invasive Species Specialist Group. (2010). *Rattus*: Global Invasive Species Database. IUCN/ISSG Invasive Species Specialist Group. Auckland, New Zealand. http://www.issg.org/database/species/ecology.asp?si=19&fr=1&sts=sss&lang=EN

Jones, H.P.; Tershy, B.R.; Zavaleta, E.S.; Croll, D.A.; Keitt, B.S.; Finkelstein, M.E. & Howald, G.R. (2008). Review of the global severity of the effects of invasive rats on seabirds. *Conservation Biology* 22: 16-26.

Keitt, B.; Griffiths, R.; Boudjelas, S.; Broome, K.; Cranwell, S.; Millett, J.; Pitt, W. & Samaniego-Herrera, A. (2015). Best practice guidelines for rat eradication on tropical islands. Biological Conservation 185: 17–26.

Khamis, S. (2011). Lundy's hard work: branding, biodiversity and a "unique island experience." *Shima: The International Journal of Research into Island Cultures,* 5, 1-23.

King, C.M. & Forsyth, D.M. (eds.) (2021). *The Handbook of New Zealand Mammals (3rd Ed).* Oxford University Press. Auckland, New Zealand and CSIRO Publishing, Australia. 576 p.

Lloyd, B.D. (1994). Evaluating the potential hazard of aerial 1080 poison operations to short-tailed bat populations. *Conservation Science Advisory Notes* 108. Wellington, Department of Conservation. 12 p.

Lock, J. (2006). Eradication of brown rats *Rattus norvegicus* and black rats *Rattus* to restore breeding seabird populations on Lundy Island, Devon, England. *Conservation Evidence* 3: 111-113.

Lowe, S.J.; Browne, M. & Boudielas, S. (2000). *100 of the World's Worst Invasive Alien Species.* IUCN/SSC Invasive Species Specialist Group (ISSG), Auckland, New Zealand.

Lund, M. (1984). Resistance to the second-generation anticoagulant rodenticides. *Proceedings of the Eleventh Vertebrate Pest Conference* 1984: 89-94.

Martin, A.R. & Richardson, M.G. (2019). Rodent eradication scaled up: Clearing rats and mice from South Georgia. *Oryx* 53(1): 27–35.

Martin, J.L.; Thibault, J.C. & Bretagnolle, V. (2000). Black rats, island characteristics, and colonial nesting birds in the Mediterranean: consequences of an ancient introduction. *Conservation Biology* 14(5): 1452-1466.

Mason, G.M. & Littin, K.E. (2003). The humaneness of rodent pest control. ***Animal Welfare*** 12: 1-37.

Matheson, C. (1939). A survey of the status of *Rattus* and its subspecies in the seaports of Great Britain and Ireland. *Journal of Animal Ecology* 8(1): 76-93.

Mathews, F. & Harrower, C. (2020). *Red List for Britain's Terrestrial Mammals.* The Mammal Society. Natural England, Peterborough, UK. (https://www.mammal.org.uk/science-research/red-list/).

McClelland, P. (2002). Eradication of Pacific rat (*Rattus exulans*) from Whenua Hou Nature Reserve (Codfish Island), Putahinu and Rarotoka Islands, New Zealand. Pages 173-181 in Veitch, C.R.; Clout, M.N. (Eds.). *Turning the Tide: The Eradication of Invasive Species*. IUCN SSC Invasive Species Specialist Group, Gland, Switzerland.

McCormick, M. (2003). Rats, communications, and Plague: Towards an ecological history. *Journal of Interdisciplinary History* 35(1): 1-25.

McDonald, R.A.; Hutchings, M.R. & Keeling, J.G.M. (1997). The status of ship rats *Rattus* on the Shiant Islands, Outer Hebrides, Scotland. *Biological Conservation* 82:113–117.

Miskelly, C.M.; Taylor, G.A.; Gummer, H. & Williams, R. (2009). Translocations of eight species of burrow-nesting seabirds (genera *Pterodroma, Pelecanoides, Pachyptila* and *Puffinus*: Family Procellariidae. *Biological conservation 142*: 1965-1980.

Moors, P.J. & Atkinson, I.A.E. (1984). Predation on seabirds by introduced animals and factors affecting its severity. Pages 667-690 in J.P. Croxall, P.G.H. Evans & R.W. Schreiber (eds.). *Status and Conservation of the World's Seabirds.* ICBP Technical Publication 2. Cambridge, UK: International Council for Bird Preservation (ICBP).

Moors, P.J. (1985). Norway rats (*Rattus norvegicus*) on the Noises and Motukawo Islands, Hauraki Gulf, New Zealand. *New Zealand Journal of Ecology* 8: 37-54.

Mulder, C.P.H.; Grant-Hoffman, M.N.; Towns, D.R.; Bellingham, P.J.; Wardle, D.A.; Durrett, M.S.; Fukami, T. & Bonner, K.I. (2009). Direct and indirect effects of rats: does rat eradication restore ecosystem functioning of New Zealand seabird islands? *Biological Invasions* 11: 1671-1688.

Newton, K.M.; McKown, M.; Wolf, C.; Gellerman, H.; Coonan, T.; Richards, D.; Harvey, A.L.; Holmes, N.; Howald, G.; Faulkner, K.; Tershy, B.R. & Croll, D.A. (2016). Response of native species 10 years after rat eradication on Anacapa Island, California. *Journal of Fish and Wildlife Management* 7(1): 72-85.

Nowak, R.M. (1999). *Walker's Mammals of the World: Volume II.* The Johns Hopkin University Press, London, United Kingdom.

O'Connor, C.E.; Eason, C.T. & Endepols, S. (2003). Evaluation of secondary poisoning hazards to ferret and weka from the rodenticide coumatetralyl. *Wildlife Research* 30: 143–146.

O'Donnell, C.F.J.; Edmonds, H. & Hoare, J.M. (2011). Survival of PIT-tagged lesser short-tailed bats (*Mystacina tuberculata*) through a pest control operation using the toxin pindone in bait stations. *New Zealand Journal of Ecology* 35(3): 291-295.

Pain, D.J.; Brooke, M.D.; Finnie, J.K. & Jackson, A. (2000). Effects of brodifacoum on the land crabs of Ascension Island. *Journal of Wildlife Management* 64: 380-387.

Pelz, H-J.; Rost, S.; Hunerberg, M.; Fregin, A.; Heiberg, A-C.; Baert, K.; MacNicoll, A.D.; Prescott, C.V.; Walker, A-S.; Oldenburg, J. & Muller, C.R. (2005). The genetic basis of resistance to anticoagulants in rodents. *Genetics* 170: 1839-1847.

Pender, R.J.; Shiels, A.B.; Bialic-Murphy, L. & Mosher, S.M. (2013). Large-scale rodent control reduces pre-and post-dispersal seed predation of the endangered Hawaiian lobeliad, *Cyanea superba* subsp. *superba* (Campanulaceae). *Biological invasions* 15(1): 213-223.

Primus, T.; Wright, G. & Fisher, P. (2005). Accidental discharge of brodifacoum baits in a tidal marine environment: a case study. *Bulletin of Environmental Contamination and Toxicology* 74: 913-919.

PSD - Pesticide Safety Directorate. (1997). *Assessment of the Humaneness of Vertebrate Control Agents*. York, UK.

Puckett, E.E.; Orton, D. & Munchi-South, J. (2020). Commensal Rats and Humans: Integrating Rodent Phylogeography and Zooarchaeology to Highlight Connections between Human Societies. *BioEssays* 42 (https://onlinelibrary.wiley.com/doi/pdfdirect/10.1002/bies.201900160)

Quy, R.J.; Cowan, D.P. & Swinney, T. (1993). Tracking as an activity index to measure gross changes in Norway rat populations. *Wildlife Society Bulletin* 21: 122-127.

Quy, R.J.; Shepherd, D.S.; Inglis, I.R. (1992). Bait avoidance and effectiveness of anticoagulant rodenticides against warfarin and difenacoum resistant populations of Norway rats (*Rattus norvegicus*). *Crop Protection* 11: 14-20.

Ratcliffe, N.; Mitchell, I.; Varnham, K.; Verboven, N.; Higson, P. (2009). How to prioritize rat management for the benefit of petrels: a case study of the UK, Channel Islands and Isle of Man. *Ibis* 151(4)**:** 699–708.

Rielly, K. (2010). The black rat. Pages 134-145 in O'Connor, T. & Sykes, N. (eds.), *Extinctions and Invasions: A Social History of British Fauna*. Oxford: Windgather Press.

Royal Society for the Protection of Birds – RSPB (2018). *Layman's Report: Shiant Isles Recovery Project - Increasing the resilience of seabird populations.* Unpublished report to EU Life by RSPB Scotland.

Russell, J.C. & Clout, M.N. (2005). Rodent incursions on New Zealand islands. *Proceedings of the 13th Australasian Vertebrate Pest Conference*, pp. 324-330. Landcare Research, Wellington, New Zealand.

Russell, J.C., Towns, D.R. & Clout, M.N. (2008) Review of Rat Invasion Biology: Implications for Island Biosecurity. *Science for Conservation 286.* Department of Conservation, Wellington, New Zealand.

Russell, J.C., Towns, D.R., Anderson, S.H. & Clout, M.N. (2005). Intercepting the first rat ashore. *Nature*, 437: 1107.

Schmidt, K.M. & Badger, D.D. (1979). Some social and economic aspects in controlling vampire bats. *Proceedings of the Oklahoma Academy of Science* 59: 112−114.

Sedgeley, J. & Anderson, M. (2000). *Capture and captive maintenance of short-tailed bats on Codfish Island and monitoring of wild bats during the kiore eradication programme, winter 1998*. Invercargill, Department of Conservation Southland Conservancy. 64 p.

Seebens, H.; Blackburn, T.M.; Dyer, E.E.; Genovesi, P.; Hulme, P.E.; Jeschke, J.M.; Pagad, S.; Pyšek, P.; Winter, M.; Arianoutsou, M.; Bacher, S.; Blasius, B.; Brundu, G.; Capinha, C.; Celesti-Grapow, L.; Dawson, W.; Dullinger, S.; Fuentes, N.; Jäger, H.; Kartesz, J.; Kenis, M.; Kreft, H.; Kühn, I.; Lenzner, B.; Liebhold, A. & Mosena, A. (2017). No saturation in the accumulation of alien species worldwide. *Nature Communications* 8(2): 14435. http://www.nature.com/articles/ncomms14435

Shiels, A.B. & Drake, D.R. (2011). Are introduced rats (*Rattus rattus*) both seed predators and dispersers in Hawaii? *Biological Invasions* 13(4): 883-894.

Shiels, A.B.; Pitt, W.C.; Sugihara, R.T. & Witmer, G.W. (2014). Biology and Impacts of Pacific Island Invasive Species. 11. *Rattus*, the Black Rat (Rodentia: Muridae). *Pacific Science* 68(2): 145-184.

Sjodin, B.M.F.; Irvine, R.L.; Ford, A.T.; Howald, G.R. & Russello, M.A. (2020). *Rattus* population genomics across the Haida Gwaii archipelago provides a framework for guiding invasive species management. *Evolutionary Applications* 13(5): 889-904.

Spatz, D.R.; Newton, K.M.; Heinz, R.; Tershy, B.; Holmes, N.D.; Butchart, S.H.M. & Croll, D.A. (2014). The biogeography of globally threatened seabirds and island conservation opportunities. *Conservation Biology* 28: 1282–1290.

Stapp, P. (2002). Stable isotopes reveal evidence of predation by ship rats on sea birds on the Shiant Islands, Scotland. *Journal of Applied Ecology* 39: 831–840.

Tabak, M.A.; Poncet, S.; Passfield, K. & Martinez del Rio, C.C. (2015). Modelling the distribution of Norway rats (*Rattus norvegicus*) on offshore islands in the Falkland Islands. *NeoBiota* 24:33–48.

Takeda, K.; Ikenaka, Y.; Fourches, D.; Tanaka, K.D.; Nakayama, S.M.; Triki, D.; Li, X.; Igarashi, M.; Tanikawa, T. & Ishizuka, M. (2021). The VKORC1 ER-luminal loop mutation (Leu76Pro) leads to a significant resistance to warfarin in black rats (*Rattus rattus*). *Pesticide biochemistry and physiology* 173: 104774.

Takeda, K.; Ikenaka, Y.; Tanaka, K.D.; Nakayama, S.M.; Tanikawa, T.; Mizukawa, H. & Ishizuka, M. (2018). Investigation of hepatic warfarin metabolism activity in rodenticide-resistant black rats (*Rattus rattus*) in Tokyo by in situ liver perfusion. *Pesticide biochemistry and physiology* 148: 42-49.

Thomson, V.A.; Wiewel, A.S.; Palmer, R.; Hamilton, N.; Algar, D.; Pink, C.; Mills, H.; Aplin, K.P.; Clark, G.; Anderson, A.; Herrera, M.B.; Myers, S.; Bertozzi, T.; Piper, P.J.; Suzuki, H. & Donnellan, S. (2022). Genetic Insights Into the Introduction History of Black Rats Into the Eastern Indian Ocean. Frontiers in Ecology and Evolution (9). https://www.frontiersin.org/articles/10.3389/fevo.2021.786510

Towns, D.R. & Broome, K.G. (2003). From small Maria to massive Campbell: forty years of rat eradications from New Zealand islands. *New Zealand Journal of Zoology* 30: 377-398.

Towns, R.T.; Atkinson, I.A.E. & Daugherty, C.H. (2006). Have the harmful effects of introduced rats on islands been exaggerated? *Biological Invasions* 8: 863-891.

Varnham, K. (2010) *Invasive Rats on Tropical Islands: Their History, Ecology, Impacts and Eradication*. RSPB Research Report No. 41. Royal Society for the Protection of Birds, Sandy, United Kingdom.

Veitch, C. R. (2002). Eradication of Pacific rats (*Rattus exulans*) from Fanal Island, New Zealand. In Veitch, C. R. and Clout, M. N. (Eds.). *Turning the tide: the eradication of invasive species*, pp. 357-359. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, United Kingdom.

Wegmann, A.; Buckelew, S. Howald, G.; Helm, J. & Swinnerton, K. (2011). Rat eradication campaigns on tropical islands: novel challenges and possible solutions. Pages 239-243 n Veitch, C.R.; Clout, M.N.; Towns, D.R. (Eds.). Island Invasives: eradication and management. IUCN, Gland, Switzerland.

Witmer, G.W.; Boyd, F. & Hillis-Starr, Z. (2007). The successful eradication of introduced roof rats (*Rattus rattus*) from Buck Island using diphacinone, followed by an eruption of house mice (*Mus musculus*). *Wildlife Research* 34: 108–115.

Zhelev, G.; Lyutskanov, M.; Petrov, V.; Michaylov, G.; Marutsov, P.; Koev, K. & Tsvetanov, T. (2013). Efficacy of a cellulose-based rodenticide for control of warfarin-resistant black rats (*Rattus rattus*). *Bulgarian Journal of Veterinary Medicine* 16(1): 134-140.

Zonfrillo, B. (2001). *Wildlife Conservation on Ailsa Craig.* The Thomas Duncan Memorial Lectures. Friends of the McKechnie Institute, Scotland, United Kingdom.

Zonfrillo, B. (2002). Puffins return to Ailsa Craig. *Scottish Bird News* 66: 1-2.

Document Title	**Appendix A Field Study Report: Tasks 1 and 2**
Document Number	ICEM/SSER - 002
Location	Inchcolm Island
Client	SSER Berwick Bank Wind Farm
Project Title	**Assessment of the Feasibility for the Eradication of Black Rats (*Rattus rattus)* from Inchcolm Island, Firth of Forth, Scotland.**

	Signature	**Name**	**Date**
Prepared	Ian M Cain	Ian Cain	08/08/22
Verified		Elizabeth Bell	08/08/22
Approved	Ian M Cain	Ian Cain	14/07/23

Document Issue/ Amendment Sheet:

Issue No.	**Date**	**Description of changes**
1.0	08/08/22	Original draft report
2.0	14/07/23	Addressed comments from SSER plus consistency check with feasibility report

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1.0 INTRODUCTION

Berwick Bank Wind Farm Limited (The Applicant) is proposing to develop the Berwick Bank Wind Farm. Berwick Bank comprises of up to 307 wind turbines and will be located in the outer Firth of Forth and Firth of Tay Figure 1, within the former Round 3 Firth of Forth Zone.

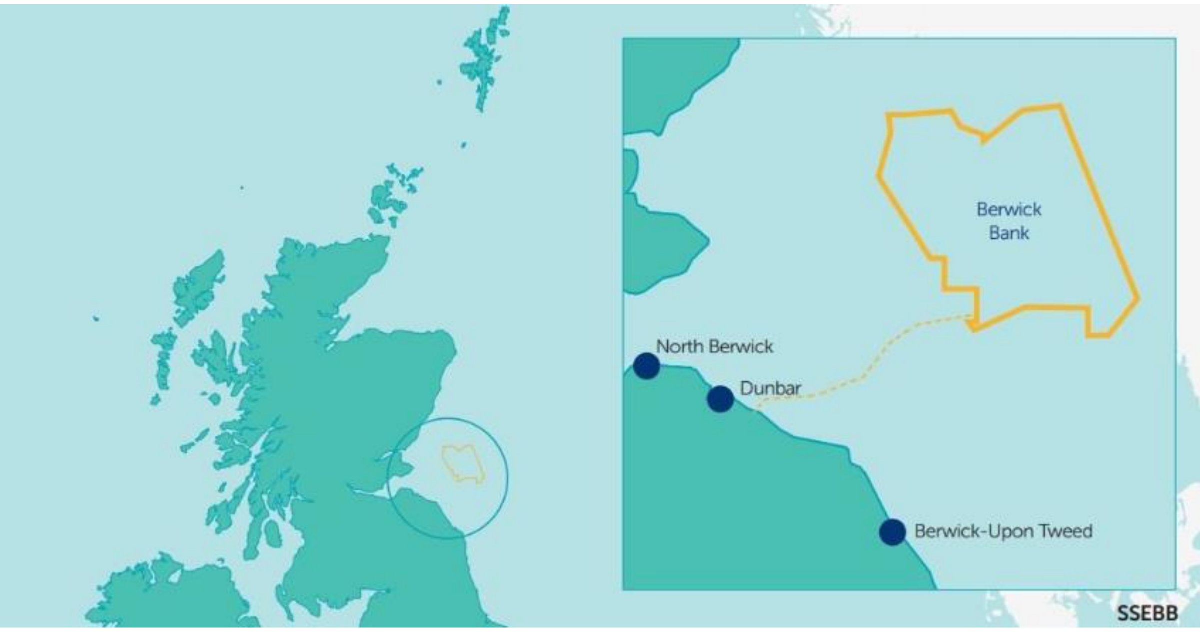

Figure 1. Location of the proposed Berwick Bank Wind Farm (map downloaded from https://www.berwickbank.com/project).

Berwick Bank will include both offshore and onshore infrastructure including the array, offshore export cables to landfall and onshore transmission cables leading to an onshore substation with electrical balancing infrastructure, with subsequent connection to the electricity transmission network. The Scottish Ministers are the primary Regulatory Authority in respect of the necessary consents and licences required for the construction and operation of an Offshore Wind Farm project in Scotland. To allow the Scottish Ministers to properly consider the development proposals, Berwick Bank is required to provide information which demonstrates compliance with the relevant legislation and allows adequate understanding of the material considerations.

The applicants Report to Inform Appropriate Assessment (RIAA) concluded that an adverse effect on site integrity could not be ruled out for Black-legged Kittiwake (hereafter Kittiwake) *Rissa tridactyla*, Common Guillemot (hereafter Guillemot) *Uria aalge*, Razorbill *Alca torda*, and Atlantic Puffin (hereafter Puffin) *Fratercula arctica*. These are collectively referred to as the 'key species'.

Several colony-based measures are proposed as compensatory measures for the proposed development[1]. This document concerns the proposed compensation measure for rat eradication and

[1] EOR0766_Berwick Bank Wind Farm Application - 4. Derogation Case - Colony Compensatory Measures Evidence Report

biosecurity to benefit kittiwake, guillemot, razorbill and puffin nesting at Inchcolm, an island in the Firth of Forth.

The scope of work for the feasibility study on Inchcolm comprises the following 4 tasks:

Task 1: Field studies in June 2022 (This report) to:

- Determine the presence and abundance of mammalian predators.
- Gather evidence of predation pressure.
- Assess early stakeholder opinion.

Task 2: Field studies in June 2022 (Appendix B) to:

- Collate seabird census data for Inchcolm and the other islands in the Firth of Forth.
- Assess the availability of potentially suitable nesting habitat that are currently unoccupied which may indicate that rats are preventing nesting by key species in these locations.

Task 3: Assessment against the following seven key feasibility criteria described in the UK Rodent Eradication Best Practice Toolkit (Thomas, Varnham, & Havery, 2017):

- Technically feasible
- Sustainable
- Socially acceptable
- Politically and legally acceptable
- Environmentally acceptable
- Have Capacity, and be
- Affordable.

Task 4: Feasibility Study Report shall document the results of the site visit and desk study and will report the findings against the seven feasibility criteria. Based on these answers the project benefits, costs and uncertainties have been considered and recommendations made on whether eradication is feasible or not. Where additional data is required to support a pre eradication phase of work these has been described.

2.0 Environmental Setting

Inchcolm lies in the Firth of Forth, 1 km off the south coast of Fife opposite Braefoot Bay (separated from the Fife mainland by a stretch of water known as Mortimer's Deep), 6 km east of the Forth Road Bridges and 9 km northwest of the City of Edinburgh (Figure 2, Figure 3 and Figure 4).

Figure 2. Location of Inchcolm, Firth of Forth, Scotland (Google Earth).

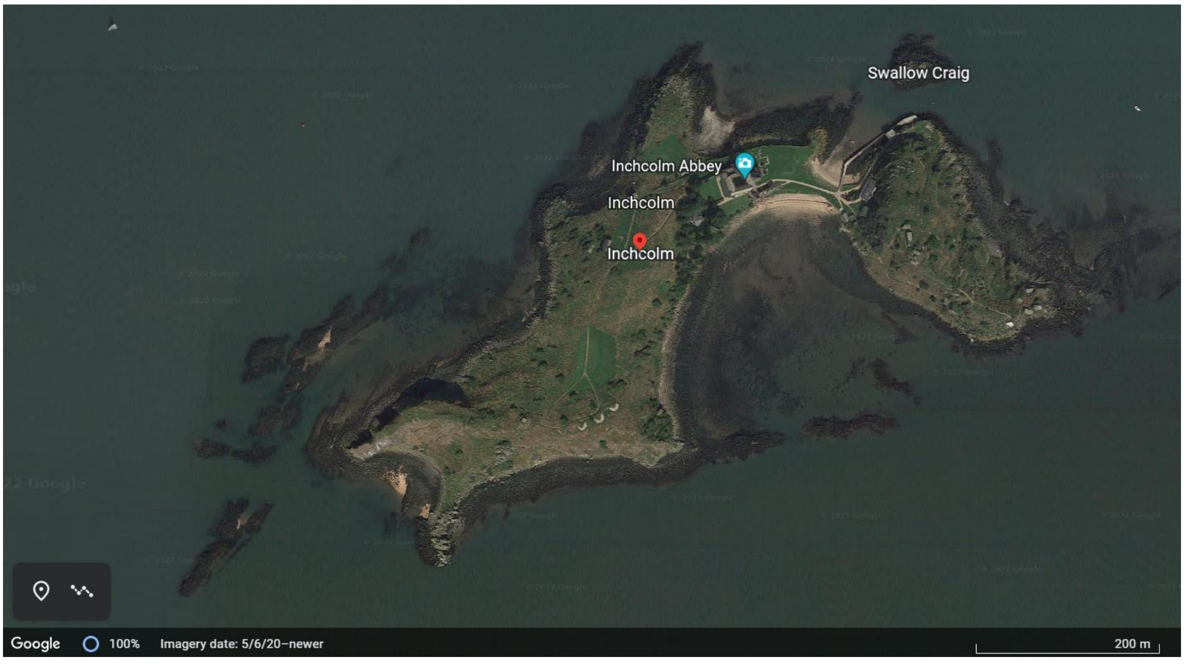

Figure 3. Inchcolm, Firth of Forth (Google Earth).

Figure 4. Aerial photograph Inchcolm Island.

Inchcolm is 10.5 hectares (ha) in area and 34 m high at its highest point. The island comprises two segments (east and west) which are linked by a narrow isthmus. The east section rises to 30 metres above sea level. The west section is flatter but rises to 30 m cliffs at the western extreme of the island.

The island is privately owned and uninhabited. It is managed by Historic Environment Scotland (HES) with at least four HES stewards based on the island during the day. These staff maintain the island and run the shop for the high numbers of seasonal summer (April to October) visitors. Inchcolm is famous for the 12th century Augustinian Abbey which is in the middle of the island and World War I and II military fortifications.

The grounds of the Abbey and central part of the island are landscaped lawns, ornamental shrubs, and few trees. The rest of the island is dominated by coastal grassland with small shrubs and trees.

The island is recognised for breeding seabirds including the northern fulmar (*Fulmarus glacialis*), common eider duck (*Somateria mollissima*), herring gull (*Larus argentatus*) and lesser black-backed gull (*Larus fuscus*). Inchcolm also has smaller populations of puffin, razorbill, black-legged kittiwake, and European shag (*Gulosus aristotelis*).

Small numbers of grey seal (*Halichoerus grypus*) drop their pups on the shore of Inchcolm each autumn and the common or harbour seal (*Phoca vitulina*) has been known to use the island for pupping during the summer months. The only other mammal recorded on Inchcolm is the black rat.

There are two small barren rocky islets, Carr Craig (to the east) and Haystack (to the west), approximately 500 metres offshore from Inchcolm. Both islets have been important breeding grounds for several species of tern in the past, and in more recent years have hosted important colonies of great cormorant *Phalacrocorax carbo* and European shag.

3.0 PRESENCE OF INVASIVE MAMMALIAN PREDATORS

3.1 FIELD STUDY DESCRIPTION

A field survey team was deployed between the period of 13 – 23 June 2022 to assess and confirm the presence/absence of mammalian predators across Inchcolm Island. All permissions and approvals were granted from Historic Environment Scotland (HES). The team gained safe access to the island on a daily schedule using the services of a 7.4m RIB chartered from The Port Edgar Marine Academy.

3.2 METHODOLOGY

The field survey was undertaken in accordance with international best practice described in the UK Rodent Eradication Best Practice Toolkit (UK Biosecurity for Life) (Thomas et al, 2017).

Multiple tools including index trapping, tracking tunnels, wax blocks, and trail cameras were used to assess the presence and distribution of rodents and other potential predators of seabirds and their chicks and eggs across Inchcolm Island. Further details relating to these various techniques are described below.

3.2.1 Index trapping

Index trapping helps assess the density and distribution of rodents over the island, which in turn can inform operational planning (e.g. grid density in different parts of the island). It can also be used to compare populations between years. The methodology described in Annex 2 of the UK Rodent Eradication Best Practice Toolkit was developed from Cunningham & Moors and now listed in adopted for this study (Thomas et al, 2017). It is important to recognise that lower abundance does not equate to 'easier to eradicate'. The implementation study recognises abundance (or rat density) as:

- Low (< 10%)
- Moderate (between 11-25%)
- High (between 26-50%)
- Very High (> 50%)

Break back (or kill) traps were used to carry out this task. The kill traps were enclosed within protective tunnels (Figure 5 and Figure 6) to restrict entry by larger species. The same type of 'Trapper T-Rex' trap, baited with a variety of attractants including peanut butter, sweet potato and chocolate were used for index-trap lines. Traps were spaced approximately 30 metres apart with two traps placed back-to-back at each station. Traps were placed in level sites where there was natural cover and rats were likely to be active (i.e. rat runs, bases of large rocks, etc).

Figure 5. Photograph showing deployment of lethal traps enclosed within a protective tunnel.

Figure 6. Photograph showing lethal traps within the protective tunnel.

Where island size and safety allowed, one index line would normally be placed per 50 ha. Adjustments to this standard length of index line and spacing between stations were applied to the smaller 10.5 hectare Inchcolm Island where space and terrain was limited and a determination of a suitable and representative number of traps was determined following field survey observations. Index lines were not extended to include steep or unsafe cliffs or other difficult to access locations.

Index trap lines were set for a minimum four consecutive nights. The traps were checked daily. Records were taken of each survey date, location, trap number, capture, sprung trap (i.e. set off, but no capture) and still set traps. Traps were set overnight, then left unset during the day and reset at dusk. Each line was mapped using GPS and locations plotted on Google Earth satellite imagery.

The results were input to a formula (see Section 3.3.1) to calculate the index of abundance (IoA; rats per 100 trap nights) for each habitat area on each accessible target location. This formula makes an allowance of traps which have been set off, but not caught a rat (i.e. corrected trap night; a corrected trap night is assumed to have been set for half the night and set off for the other half of the night (i.e. subtract half a night).

3.2.2 Necropsy

The majority (86%) of rats caught in the kill-traps were photographed, measured, and necropsied. Rat species (black *Rattus* vs brown *Rattus norvegicus*) was identified, and the following measurements were taken:

- Head;
- Body length; and
- Tail length, nose to ear, right ear, and right hind foot with claw.

In addition, weight, colour, age (juvenile or adult), sex, body condition, stomach contents (to provide information on diet) and breeding status were recorded.

3.2.3 DNA analysis

Tissue samples (rat tails) were taken from each trapped rat and a subsample was submitted for DNA analysis. The findings of which are being used to answer the following questions:

i. Is eradication sustainable or are rats likely to reinvade quickly? Where rats are found to be present, a genetic comparison can be made between the rats on different islands, islets and stacks. This involved taking representative DNA samples from each population and testing for genetic comparison. The findings from these analyses will also provide information on the location specific rat populations as a basis for genetic comparison if rodents are discovered and collected on one or more of the islands after an eradication programme has been completed. This will gauge whether there was a reinvasion, or the eradication had failed.
ii. Is eradication technically feasible or are rats showing rodenticide resistance? This will be vitally important to deciding which rodenticide formulations will be most effective in any subsequent eradication project. Resistance to a number of rodenticides is known, particularly for brown rats *Rattus norvegicus*.

In addition tissue samples were submitted for stable isotope analysis to assist the study to infer information on whether the rodents have been predating on seabird eggs, nestlings, or adults.

Two specialist laboratories were selected, with each possessing their own unique strengths, thereby providing the implementation study with a comprehensive service capability:

i. School of Applied Sciences, University of Huddersfield, Queensgate, Huddersfield, HD1 3DH

ii. School of Biological Sciences, University of Aberdeen, AB24 2TZ

3.2.4 Tracking tunnels and wax blocks

Tracking tunnels (with ink plates) were deployed to obtain additional presence/absence and activity information on rodents and other predators (Figure 7 and Figure 8). Tunnels were held in place by pegs and a card with ink spread in its centre was placed inside the tunnel and baited with peanut butter. Tunnels were also placed 30 m apart, with 10 tunnels per line. 1 tracking tunnel line was placed on Inchcolm Island.

Tunnels were placed level and in locations where rodents were considered likely to be active. Each line was mapped using GPS and plotted on satellite imagery.

Figure 7. Photograph showing deployment of ink plates enclosed within a protective tunnel.

Figure 8. Photograph showing rodent footprints on ink plate.

Tracking tunnels were typically left in place for a minimum 4 days and the tunnels and cards collected, and tracks identified, counted, photographed, and recorded daily. The number of cards that had rodent tracks present was used to estimate the tracking index.

Chocolate flavoured wax chew blocks were made up and positioned and secured on metal wires in a location close to each tracking tunnel (Figure 9). These were checked daily and left in place over a minimum 4 day period. These blocks provided additional qualitative information on the presence of potential predators. By inspecting the teeth marks it is possible to determine the presence of different species of rodents.

Figure 9. Photograph showing use of wax chew blocks.

A network of trail cameras (Figure 10) was deployed targeting locations of suspected moderate to high bird and /or predator activity. These cameras provided both still and video footage to further confirm the presence of rats and other potential predators plus valuable additional insight into the behaviour of these animals and birds.

Figure 10. Photograph of the deployment of a trail camera.

3.3 STATION DEPLOYMENT

Access was gained to all parts of Inchcolm Island allowing the deployment of the planned monitoring equipment and the completion of an average of five trapping nights at each location. A tabulated summary of the deployment of the monitoring stations is presented in Table 1. The locations of these stations were recorded as GPX waypoints and uploaded to satellite mapping imagery (Google Earth) and illustrated on Figure 11

Table 1. Summary of the deployment of rodent monitoring stations deployed across the Inchcolm Island.

No Rat Trap Lines (Yellow Marker)	No. Rodent Ink Tunnel and Wax Block Lines (Blue Marker)	No. Mice Boxes (Purple Marker)	No. Nontoxic Block Boxes	No. Cameras (White Marker)	Mean No. Trap Nights
3 lines/ 80 traps including ad hoc locations	1 line/ 10 tunnels/ 10 blocks	6	4	9	4

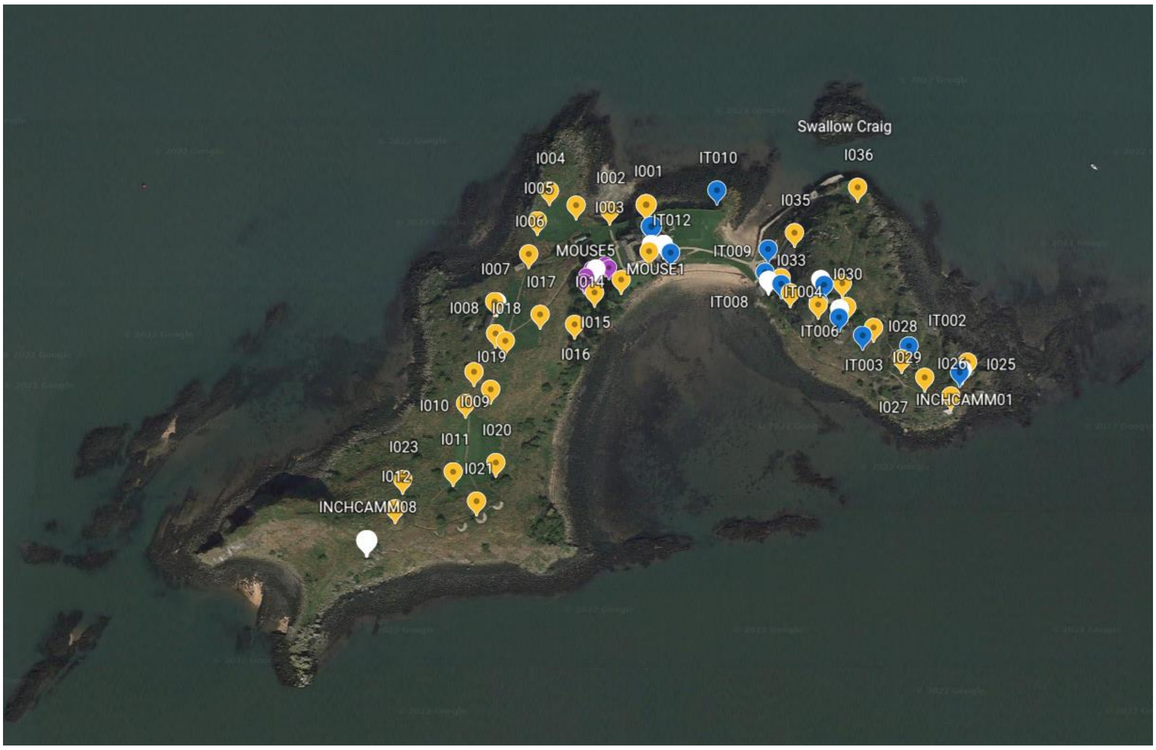

Figure 11. Google earth satellite image showing the deployment of the rodent monitoring stations.

3.4 Field Survey Results

3.4.1 Density and abundance of rats and other potential predators

The full set of results for the trapping conducted in June 2022, with an accompanying set of field photographs and video still images can be provided upon request. Table 2 and Table 3 below provide a summary of the results and abundance calculations for rats.

Table 2. Density and abundance results: index trapping.

Inchcolm Island	
No. Traps	80
Mean no. trap nights	5
Total trap nights TTN - no. traps x no. of nights	376
No. Black Rat captures	28
No. Brown Rat Captures	0
No. Mice captures	0
Total captures	28
No. Sprung but empty traps	4
Lost Trap Nights LTN 0.5x (captures+sprung empty traps)	16
Corrected trap nights CTN =TTN-LTN	360
Index of Rat Abundance (IOA) = captures x 100/CTN %	**8**

Table 3. Density and abundance results: tracking tunnels.

Inchcolm Island	
No. ink tunnels	12
Mean no. ink tunnel nights	4
Total no. ink tunnel nights TTN - no. ink tunnels x no. of nights	48
No. ink plates with rat footprints	13
Index of Rat Abundance (IOA) = No. ink plates with footprints x **100/CTN %**	**27**

The field study has shown black rats are widely active across Inchcolm Island. The locations of trapped rats are shown as red markers on Figure 12.

Figure 12. 'Hot spots' of rat activity on Inchcolm Island.

3.4.2 Rat Species identification and measurements:

All rats trapped and observed were black rats (*Rattus rattus*). A summary of the results for sex and vital measurements is provided in Table 4

Table 4. Summary of measurements recorded for adult black rats caught on Inchcolm Island.

Measurement	Female	Male
Total number adults	10	10
Total number Juveniles	1	2
Body Condition	Good	Good
Weight g	Average 209/ Std Dev 22	Average 187/ Std Dev 17
Head- Body length mm	Average 181/ Std Dev 10	Average 164/ Std Dev 28
Tail length mm	Average 198/ Std Dev 69	Average 201/ Std Dev 71
Nose to ear length mm	Average 45/ Std Dev 3	Average 43/ Std Dev 2
Right ear mm	Average 20/ Std Dev 2	Average 21/ Std Dev 2
Right hind foot with claw mm	Average 34/ Std Dev 4	Average 36/ Std Dev 4
Right hind foot without claw mm	Average 32/ Std Dev 4	Average 34/ Std Dev 4
Stomach contents	Partially digested vegetation, meat, some minor fragments of shell and hair.	
Breeding status	1x pregnant	n/a

These measurements show:

- A total number of 28 rats were trapped on Inchcolm Island producing an abundance calculation of 8%.
- Only black rats (*Rattus rattus*) were found to be present.
- Of 24 rats necropsied 13r rats were male, and 11 rats were female.
- 88% of rats trapped were adults.
- The physical condition of the rats was good, but with some evidence of tail damage on the majority of rats is indicative of fighting between rats and/or amputation by defensive gulls.
- One female rat was pregnant.
- Generally female adult rats were heavier (10% heavier on average) than adult male rats.
- Most females had slightly longer head- body lengths (10% longer). Males and females did not differ in other body measurements.
- The stomach contents were primarily composed of digested food, inclusive of fragments of meat, vegetation and **significantly suspected egg shell** (Figure 13).

Figure 13. Washed stomach contents of rat sample AD005 showing suspected egg shell fragments.

3.4.3 Tissue samples for DNA analysis

Tissue samples (rat tails) were taken and stored frozen for all rats trapped and necropsied. Table 5 records the subsample of tails sent for laboratory analysis.

Table 5. Inchcolm Island rat tail samples sent for DNA analysis.

Laboratory	No. samples sent for VKORC1 Rodenticide resistance testing	No. Samples sent for DNA profiling	No. of samples sent for stable isotope analysis
School of Applied Sciences University of Huddersfield, UK	14	14	-
School of Biological Sciences, University of Aberdeen, AB24 2TZ	-	-	14

The laboratory analytical reports are available on request.

VKORC1 rodenticide resistance genotyping indicated that all rat samples were rodenticide sensitive as they did not display any of the known rodenticide resistance polymorphisms found in these species. This suggests that they should be able to be controlled/ eradicated using first generation or second generation anticoagulant rodenticides (FGARs or SGARs).

The **DNA profiling** has revealed the Inchcolm rats represent a novel genotype that has not yet been found in populations sampled elsewhere in the UK or worldwide. The rats fall into 3 groups:

- Six animals are *Rr-D1-Inchcolm-A1*
- Two animals are *Rr-D1-Inchcolm-A2*
- Six animals are heterozygotes which display both genotypes *Rr-D1-Inchcolm-A1/A2* which could be derived from mating of A1 and A2 animals or A1/A2 animals. Mating of A1/A2 animals can also give rise to all three haplotypes.

Stable isotope analysis of whiskers taken from a sample of the Inchcolm rats shows the rat's diet does comprise a marine high trophic level signature, which could be indicative of a seabird predation. However, without taking samples of the target seabirds, this test was unable differentiate between a seabird food source and another high trophic source such as a dead seal.

4.0 Projected Impacts of Black Rats on Breeding Seabirds

Black rats (*Rattus rattus*) are one of the most widespread invasive species, occurring on 80% of the world's islands (Atkinson 1973, Atkinson 1985, Jones et al. 2008, Spatz et al. 2014, Dawson et al. 2015). Rats have had devastating impacts on islands through predation, competition, and habitat modification (Bell 1978; Imber 1985, Campbell 1991, Stapp 2002, Towns et al. 2006; Jones et al. 2008, Mulder et al. 2009, Croxall et al. 2012, Bell et al. 2016, King & Forsyth 2021), but have been successfully removed from islands ranging in size from 1 to 36,000 hectares (Towns & Broome 2003, Howald et al. 2007, Bell 2019, Martin & Richardson 2019). Black rats are recognised to have greater impacts on seabirds, especially burrow-nesting species, compared to other *Rattus* species (Moors & Atkinson 1984, Towns et al. 2006, Jones et al. 2008, King & Forsyth 2021).

Following the successful eradication of black rats from islands, native species, particularly seabirds, have increased in density and range and often diversity (Bellingham et al. 2010, Daltry et al. 2010, Varnham 2010, Buxton et al. 2016, Newton et al. 2016, Booker et al. 2018, Brooke et al. 2018, King & Forsyth 2021). Native plant biomass on islands has also increased often within 10 years of removing rats (Towns et al. 2006, Daltry et al. 2010).

Both cliff nesting and burrowing seabird species have shown significant increases following the eradication of black rats from islands within the UK and around the globe (Dunlop et al. 2015, Capizzi et al. 2016, Booker et al. 2018). On Lundy Island guillemot (*Uria aalge*), razorbill (*Alca torda*), kittiwake (*Rissa tridactyla*) and puffin (*Fratercula arctica*) have all increased in number and distribution across the island since 1981 with the most significant increases following the 2002 rat eradication (Booker et al. 2018). Similar trends for Manx shearwater (*Puffinus puffinus*) and European storm petrels (*Hydrobates pelagicus*) have been recorded on Lundy Island (Booker & Price 2014, Booker et al. 2018) and after the brown rat (*Rattus norvegicus)* eradication on Ramsey Island (Bell et al. 2019).

Black rats are likely to be having effects on the Inchcolm ecosystem (including reduced regeneration of plants and predation of invertebrates and birds). There are a number of seabird species present on Inchcolm that are vulnerable to predation by black rats including puffin, razorbill, guillemot, and kittiwake. Seabird count data is presented and discussed Appendix B.

5.0 Community and Key Stakeholder Surveys

5.1 Introduction

Social acceptability is unlikely to be a significant problem for the proposed project. There is a strong case for the environmental benefits likely to follow any proposed rat eradication, particularly in relation to the likely benefits to seabirds. The support of the islands' owners and the island's manager (HES) will be essential. But individual residents on the mainland, although they should be kept informed and involved wherever possible, need not give their consent for the project to proceed. The project will, however, need to build and maintain a considerable level of local and regional community support and goodwill to operate effectively.,

Gaining social acceptability therefore depends upon:

- Communicating that risks to island residents and visitors, particularly children, will be extremely low.
- Communicating how risks to non-target wildlife can be managed to an acceptably low level.

5.2 Scope of work

A key stakeholder was defined as an organisation or person who has invested interests (culturally, business or other) in the island. Prior to engagement commencing, expert support was given by an environmental social scientist at the Centre for Geography and Environmental Science at Exeter University, to develop and finalise the stakeholder engagement process (Appendix A). Through telephone conversations and email correspondence with stakeholders it was made clear that this was not an eradication project, and no rodenticides were being used. Stakeholders were informed this was a feasibility study which necessitated gathering their opinions on whether they would support a plan for an eradication of rats on Inchcolm.

Official stakeholder engagement began on 21 July 2022 and continued through to the end of August 2022. Three key methods were used to engage with key stakeholders:

i. A bespoke stakeholder questionnaire was emailed to specific individuals with a target stakeholder group. The respondent/s filled out the questionnaire and the responses were saved and then qualitatively summarised.
ii. Ad hoc email correspondence to specific groups or persons.
iii. Face-to-face online Microsoft Teams meetings throughout the project.

Table 6 summarises the names of the key stakeholders who were contacted for the study and it describes the methods of communication that were adopted.

Table 6. Summary of key stakeholders and communication method for engagement regarding the proposed black rat eradication.

Group	Contact	Communication method
Historic Environment Scotland (HES)	Senior Management	Online meetings. Email correspondence.
NatureScot	Mammal Advisor	Email correspondence and questionnaire.
Mammal Society	Vice Chair	
Scottish Seabird Centre	CEO	
Scottish Wildlife Trust	Reserves Manager	
Forth Heritage Group	Chair	
Forth Seabird Group (FSG)	Chair	
Forth Yacht Clubs Association (FYCA)	Vice Chair	
Forth Ports	Chief Harbour Master	
RSPB	Senior Conservation Planner	
Maid of Forth Ltd.	Head Skipper	
SPCA	Chief Superintendent	

5.3 Results

A range of key stakeholders completed the questionnaire regarding the proposed eradication of black rats from Inchcolm, and a summary of the main findings are given in Table 7. (N.B. Two stakeholders (FSG, FYCA) gave a summary of their opinions on an eradication by email response only and did not complete a questionnaire and these results are not included in Table 7 but are documented in Table 7.

Table 7. Questionnaire results from key stakeholders.

Questions	**Response**		
Number of responses	9		
Have you noticed, or are you aware of, the presence of rats on Inchcolm Island?	Yes 78%	No 22%	No response 0%
Do you know what type (species) of rats are present on Inchcolm Island?	Yes 78%	No 22%	No response 0%
Do you have any concerns about the presence of rats on Inchcolm Island?	Yes 56%	No 44%	No response 0%
Have you, or your organisation, been affected by any problems with rats on Inchcolm Island in the past five years?	Yes 0%	No 100%	No response 0%
What do you think could benefit from a successful rat eradication project?			
Wildlife	89%		
Local community	44%		
Public health	44%		
Economy (Tourism)	44%		
Animal health	44%		
What do you think could challenge a successful rat eradication project?			
Gaining agency support	44%		
Access to private land	22%		
Island terrain	56%		
Avoiding harm to other wildlife	89%		
Avoiding harm to visiting domestic animals	56%		
Adequate funding	78%		
Avoiding rats returning	78%		
Waste management	67%		
Ecological effects of removing rats	56%		
Do you believe the black rat (*Rattus rattus*) to have any important cultural, ecological, or historical significance?	Yes	No	No response

Questions	Response		
	56%	33%	11%

The headline findings from the stakeholder engagement are summarised Table 8.

Table 8. Summary of key stakeholders' findings and comments regarding the proposed black rat eradication.

Group	Key findings
Historic Environment Scotland	• Do not object to an eradication of rats on Inchcolm if it has the support of NatureScot and the Scottish Government.
NatureScot	• Recognise the benefits of an eradication of black rats. • Do not object to the concept of an eradication. • Decision dependant on further consultation inclusive of Scottish Government representation.
Mammal Society	• Regard the black rat as an invasive alien species. • Support an eradication on Inchcolm.
Scottish Seabird Centre	• Supportive of an eradication of black rats on Inchcolm. • Recognise with appropriate specialist input it will be possible to eradicate black rats on Inchcolm and it should be done sooner rather than later. • Believe it is very important to have a biosecurity plan in place, inclusive of detection and controls in place to respond to renewed activity.
Scottish Wildlife Trust	• Recognise black rats may be detrimental to breeding seabirds on Inchcolm. • Would like to see further consultation around the historical significance of the local black rat population.
Forth Heritage Group	• Has been sympathetic to black rat presence historically, but now recognise the wider wildlife benefits their eradication would bring.
Forth Seabird Group	• Do not support an eradication without being provided with additional supporting information on the benefits it would bring.

Group	Key findings
Forth Yacht Clubs Association	• Recognises black rats were introduced to Inchcolm by man, so removing them is not disruptive to the natural ecosystem. • Supportive of an eradication for the benefits it would bring to the recovery of breeding seabirds.
Forth Ports Plc	• Does not see the black rat as historically significant. • Recognises that black rats will be impacting breeding bird populations if abundant. • Would not object to an eradication on Inchcolm.
RSPB	• Would not object in principle to an eradication on Inchcolm but would welcome further consultation on the opportunities and benefits to breeding seabirds.
Maid of Forth Ltd.	• Does not support an eradication due to a perception that black rats may be limiting the numbers of aggressive gulls thereby benefitting the 'tourist experience'.
SPCA	• Does not generally support animal culls/eradications unless for public health and safety. • Does however recognise breeding seabirds may be more successful following an eradication. • Where animals must be culled, the most humane methods should be used.

An overarching concern raised by HES and NatureScot is the historical significance of black rats on Inchcolm, and the possibility that Inchcolm may be home to the last remaining island population of black rats in Scotland and possibly the UK. NatureScot has also asked for further consultation over the evidence that black rats are adversely impacting the breeding success of seabirds on Inchcolm.

It is likely that there will be a high level of public, and key stakeholder support as well as some opposition to the proposed eradication project on Inchcolm and there will need to be an excellent advocacy programme explaining the rationale for the project if it proceeds.

6.0 Conclusions

The key conclusions drawn from the Tasks 1 and 2 Field studies are summarised below. These findings are explored further through the feasibility assessment process and its report.

- The trapping data indicate rat abundance across Inchcolm Island is low to moderate at 8%. The abundance calculations for the ink tunnels suggest a higher level of abundance at 27%. The disparity is probably attributed to the rat trapping taking place in June when alternate sources of food (incl. food wastes deposited by tourist activity, vegetation, seabird eggs and chicks etc) is abundant and rats will be less attracted to the bait offered in the lethal traps; indicating rat activity across the island is moderate to high.
- At these levels of abundance rat activity is likely to have an adverse impact on bird populations. (King et al, 2021) (Moors et al, 1984).
- Camera traps provide video evidence that rats share habitat with nesting birds.
- Discussions with Historic Environment Scotland and a review of the pest control folder left at the visitor centre revealed rodenticides are being used in moderate quantities in and around Inchcolm Abbey, and the island accommodation and visitor buildings. This may be suppressing rat activity, but not eradicating it.
- The stomach contents of the trapped rats were observed to be primarily composed of partially digested food, inclusive of fragments of meat, vegetation and significantly some suspected egg shell.
- Stable isotope analysis of whiskers shows the rat's diet does comprise a marine high trophic level signature, which could be indicative of a seabird predation. However, further analysis is required to differentiate between a seabird food source and another high trophic source such as a dead seal.
- The DNA analysis of tissue samples taken from the Inchcolm rats show a novel genotype that has not yet been recorded elsewhere in the world. To add context, the Global DNA library for island populations of black rats is not comprehensive. The consultants are aware only of two black rat populations, namely the population that previously existed on Lundy prior to eradication, and the population on Sark that have been subject to this type of genetic analysis.
- The DNA analytical results show there were no rodenticide resistance genotypes in the black rats trapped on Inchcolm Island. This suggests that rats should be able to be controlled / eradicated using first generation or second generation anticoagulant rodenticides (FGARs or SGARs). Rodenticides such as coumatetralyl or bromadiolone could be used to control / eradicate these populations rather than utilising the more toxic brodifacoum or flocoumafen required for resistant populations.

- It is likely that there will be a high level of public, and key stakeholder support as well as some opposition to the proposed eradication project on Inchcolm and there will need to be an excellent advocacy programme explaining the rationale for the project if it proceeds. A key concern raised by HES and NatureScot is the historical significance of black rats on Inchcolm, and the possibility that Inchcolm may be home to the last remaining island population of black rats in Scotland and possibly the UK.

REFERENCES

(n.d.). *'UK Rodent Eradication Best Practice Toolkit: Annex 2 Rodent Trapping and DNA Sampling Annex 2' .*

King et al. (2021). *King, C.M & Forsyth, D.M 2021. The handbook of NZ mammals. 3rd. Otago University Press and CSIRO Publishing. .*

Lambert et al. (2021). *Unexpected involvement of a second rodent species makes impact of introduced rats more difficult to detect, breeding success of Manx Shearwaters, Isle of Rum, Lambert, Cain et al.*

Moors et al. (1984). *Moors, P.J. & Atkinson, I.A.E. 1984. Predation on seabirds by introduced animals and factors affecting its severity. In Status and Conservation of the World's seabirds (Eds. J.P. Croxall, P.G.H. Evans and R.W. Schreiber). pp 667-690. ICBP, Cambridge.*

Thomas et al. (2017). *Current Recommended Procedures for UK (bait station) Rodent Eradication Projects, Royal Society for the Protection of Birds.*

Thomas et al. (2017). *Current Recommended Procedures for UK (bait station) rodent eradication projects: Annex 2: Rodent Treapping and DNA Sampling. Royal Society for the Protection of Birds.*

Atkinson, I.A.E. (1985). The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. Pages 35-81 in: Moors, P.J. (ed.). *Conservation of island birds*. ICBP Technical Publication No. 3.

Baxter, J.M.; Boyd, I.L.; Cox, M.; Donald, A.E.; Malcolm, S.J.; Miles, H.; Miller, B. & Moffat, C.F. (eds.) (2011). *Scotland's Marine Atlas: Information for the national marine plan.* Marine Scotland, Edinburgh.

Bell, E.A. (2019). It's not all up in the air: the development and use of ground-based rat eradication techniques in the UK. Pages 79-87 in C.R. Veitch, M.N. Clout, A.R. Martin, J.C. Russell & C.J. West (eds.). *Island invasives: scaling up to meet the challenge*. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

Bell, E.A.; Bell, B.D. & Merton, D.V. (2016). The legacy of Big South Cape: rat irruption to rat eradication. *New Zealand Journal of Ecology* 40(2): 212-218.

Bell, E.; Bell, M.; Morgan, G. & Morgan, L. (2019). The recovery of seabird populations on Ramsey Island, Pembrokeshire, Wales, following the 1999/2000 rat eradication. Pages 539-544 in C.R. Veitch, M.N. Clout, A.R Martin, J.C Russell & C.J. West (eds.). *Island invasives: scaling up to meet the challenge*. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

Bellingham, P.J.; Towns, D.R.; Cameron, E.K.; Davis, J.J.; Wardle, D.A.; Wilmshurst, J.M. & Mulder, C.P.H. (2010). New Zealand island restoration: seabirds, predators, and the importance of history. *New Zealand Journal of Ecology* 34(1): 115-136.

Booker, H.; Slader, P.; Price, D., Bellamy, A.J. & Frayling, T. (2018). Cliff nesting seabirds on Lundy: Population trends from 1981 to 2017. *Journal of the Lundy Field Society* 6: 65-76.

Booker, H & Price, D. (2014). Manx shearwater recovery on Lundy: Population and distribution change from 2001 to 2013. *Journal of the Lundy Field Society* 4: 105-116.

Brooke, M. de L.; Bonnaud, E.; Dilley B.J.; Flint, E.N.; Holmes, N.D.; Jones, H.P.; Provost, P.; Rocamora, G.; Ryan, P.G.; Surman, C.& Buxton, R.T. (2018). Seabird population changes following mammal eradications on islands. *Animal Conservation* 21(1): 3-12.

Buxton, R.; Taylor, G.; Jones, C.; Lyver, P.O'B. Moller, H.; Cree, A. & Towns, D. (2016). Spatio-temporal changes in density and distribution of burrow-nesting seabird colonies after rat eradication. *New Zealand Journal of Ecology* 40(1): 88-99.

Capizzi, D.; Baccetti, N. & Sposimo, P. (2016). Fifteen years of rat eradication on Italian Islands. Pages 205-227 in Angelici, F (ed.). *Problematic Wildlife*. Springer International Publishing, Switzerland.

Campbell, E.W. (1991) The effect of introduced roof rats on bird diversity of Antillean cays. *Journal of Field Ornithology* 62: 343-348.

Croxall, J.P.; Butchart, S.H.M.; Lascelles, B.; Stattersfield, A.J.; Sullivan, B.; Symes, A. & Taylor, P. (2012). Seabird conservation status, threats and priority actions: a global assessment. *Bird Conservation International* 22: 1–34.

Daltry, J.C., James, K.J., Otto, A. & Ross, T.N. (2010). Evidence that eradicating black rats (*Rattus rattus*) has boosted the recovery of rare reptiles and sea birds on Antiguan islands. *Island Biodiversity: Flora, Fauna and Humans in the Lesser Antilles, 6-8 November.* Martinique, France.

Dawson, J.; Oppel, S.; Cuthbert, R.J.; Holmes, N.; Bird, J.P.; Butchart, S.H.M.; Spatz, D.R. & Tershy, B. (2015). Prioritizing islands for the eradication of invasive vertebrates in the United Kingdom overseas territories. *Conservation Biology* 29(1): 143-153.

Dunlop, J.N.; Rippey, E.; Bradshaw, L.E. & Burbidge, A.A. (2015). Recovery of seabird colonies on Rat Island (Houtman Abrolhos) following the eradication of introduced predators. *Journal of the Royal Society of western Australia* 98: 29-36.

Duncan, M.J., Hughey, K.F.D., Cochrane, C.H. & Bind, J. (2008) River modelling to better manage mammalian predator access to islands in braided rivers. *British Hydrological Society 10th National Hydrology Symposium*, pp. 487-492. British Hydrological Society, London, UK.

Dyke, P.P.G. (1987). Water circulation in the Firth of Forth, Scotland. *Proceedings of the Royal Society of Edinburgh* 93B(3-4): 273-284.

Elliott, A.J. & Neill, S.P. (2007). The tidal flux in the Firth of Forth. *Proceedings of the Institution of Civil Engineers: Maritime Engineering* 160: 25-32.

Ershoft, B.H. (1954) Beneficial effect of low-fat diets on the swimming performance of rats and mice in cold water. *Journal of Nutrition* 1954: 439-449.

Evans, R.L., Katz, E.M., Olson, N.L. & Dewberry, D.A. (1978). A comparative study of swimming behaviour in eight species of muroid rodents. *Bulletin of the Psychonomic Society* 11: 168-170.

Harris, D.B.; Gregory, S.D.; Bull, L.S. & Courchamp, F. (2012). Island prioritization for invasive rodent eradications with an emphasis on reinvasion risk. *Biological Invasions* 14(6): 1251-1263.

Howald, G.; Donlan, C.J.; Galvan, J.P.; Russell, J.C.; Parkes, J.; Samaniego, A.; Wang, Y.; Veitch, D.; Genovesi, P.; Pascal, M.; Saunders, A. & Tershey, B. (2007). Invasive rodent eradication on islands. *Conservation Biology* 21: 1258-1268.

Jones, H.P.; Tershy, B.R.; Zavaleta, E.S.; Croll, D.A.; Keitt, B.S.; Finkelstein, M.E. & Howald, G.R. (2008). Review of the global severity of the effects of invasive rats on seabirds. *Conservation Biology* 22: 16-26.

King, C.M. & Forsyth, D.M. (eds.) (2021). *The Handbook of New Zealand Mammals (3rd Ed).* Oxford University Press. Auckland, New Zealand and CSIRO Publishing, Australia. 576 p.

Martin, A.R. & Richardson, M.G. (2019). Rodent eradication scaled up: Clearing rats and mice from South Georgia. *Oryx* 53(1): 27–35.

Moors, P.J. & Atkinson, I.A.E. (1984). Predation on seabirds by introduced animals and factors affecting its severity. Pages 667-690 in J.P. Croxall, P.G.H. Evans & R.W. Schreiber (eds.). *Status and Conservation of the World's Seabirds.* ICBP Technical Publication 2. Cambridge, UK: International Council for Bird Preservation (ICBP).

Mulder, C.P.H.; Grant-Hoffman, M.N.; Towns, D.R.; Bellingham, P.J.; Wardle, D.A.; Durrett, M.S.; Fukami, T. & Bonner, K.I. (2009). Direct and indirect effects of rats: does rat eradication restore ecosystem functioning of New Zealand seabird islands? *Biological Invasions* 11: 1671-1688.

Newton, K.M.; McKown, M.; Wolf, C.; Gellerman, H.; Coonan, T.; Richards, D.; Harvey, A.L.; Holmes, N.; Howald, G.; Faulkner, K.; Tershy, B.R. & Croll, D.A. (2016). Response of native species 10 years after rat eradication on Anacapa Island, California. *Journal of Fish and Wildlife Management* 7(1): 72-85.

Russell, J.C. & Clout, M.N. (2005). Rodent incursions on New Zealand islands. *Proceedings of the 13th Australasian Vertebrate Pest Conference*, pp. 324-330. Landcare Research, Wellington, New Zealand.

Russell, J.C., Towns, D.R., Anderson, S.H. & Clout, M.N. (2005). Intercepting the first rat ashore. *Nature*, 437: 1107.

Russell, J.C., Towns, D.R. & Clout, M.N. (2008) *Review of Rat Invasion Biology: Implications for Island Biosecurity.* Science for Conservation 286. Department of Conservation, Wellington, New Zealand.

Sjodin, B.M.F.; Irvine, R.L.; Ford, A.T.; Howald, G.R. & Russello, M.A. (2020). *Rattus* population genomics across the Haida Gwaii archipelago provides a framework for guiding invasive species management. *Evolutionary Applications* 13(5): 889-904.

Stapp, P. (2002). Stable isotopes reveal evidence of predation by ship rats on sea birds on the Shiant Islands, Scotland. *Journal of Applied Ecology* 39: 831–840.

Spatz, D.R.; Newton, K.M.; Heinz, R.; Tershy, B.; Holmes, N.D.; Butchart, S.H.M. & Croll, D.A. (2014). The biogeography of globally threatened seabirds and island conservation opportunities. *Conservation Biology* 28: 1282–1290.

Tabak, M.A.; Poncet, S.; Passfield, K. & Martinez del Rio, C.C. (2015). Modelling the distribution of Norway rats (*Rattus norvegicus*) on offshore islands in the Falkland Islands. *NeoBiota* 24:33–48.

Towns, D.R. & Broome, K.G. (2003). From small Maria to massive Campbell: forty years of rat eradications from New Zealand islands. *New Zealand Journal of Zoology* 30: 377-398.

Towns, R.T.; Atkinson, I.A.E. & Daugherty, C.H. (2006). Have the harmful effects of introduced rats on islands been exaggerated? *Biological Invasions* 8: 863-891.

Varnham, K. (2010) *Invasive Rats on Tropical Islands: Their History, Ecology, Impacts and Eradication*. RSPB Research Report No. 41. Royal Society for the Protection of Birds, Sandy, United Kingdom.

Document Title	**Appendix B Field Study Report: Tasks and 4**
Document Number	ICEM/SSER - 002
Location	Inchcolm Island
Client	SSER Berwick Bank Wind Farm
Project Title	**Assessment of the Feasibility for the Eradication of Black Rats (*Rattus rattus)* from Inchcolm Island, Firth of Forth, Scotland.**

	Signature	Name	Date
Prepared	Ian M Cain	Ian Cain	17/08/22
Verified		Elizabeth Bell	17/08/22
Approved	Ian M Cain	Ian Cain	14/07/23

Document Issue/ Amendment Sheet:

Issue No.	Date	Description of changes
1.0	17/08/22	
2.0	28/10/22	Updated nesting projections and document reformatted as Appendix to feasibility report.
3.0	14/07/23	Addressed comments from SSER plus consistency check with feasibility report.

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1.0 INTRODUCTION

Berwick Bank Wind Farm Limited (The Applicant) is proposing to develop the Berwick Bank Wind Farm. Berwick Bank comprises of up to 307 wind turbines and will be located in the outer Firth of Forth and Firth of Tay Figure 1, within the former Round 3 Firth of Forth Zone.

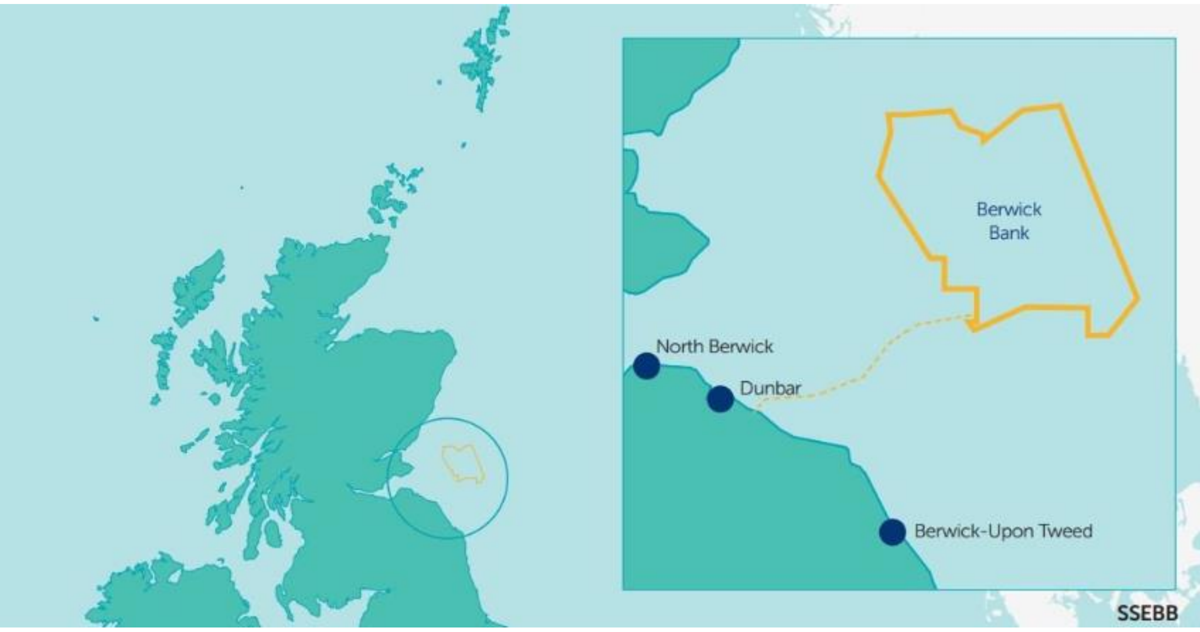


Figure 1. Location of the proposed Berwick Bank Wind Farm (map downloaded from https://www.berwickbank.com/project).

Berwick Bank will include both offshore and onshore infrastructure including the array, offshore export cables to landfall and onshore transmission cables leading to an onshore substation with electrical balancing infrastructure, with subsequent connection to the electricity transmission network. The Scottish Ministers are the primary Regulatory Authority in respect of the necessary consents and licences required for the construction and operation of an Offshore Wind Farm project in Scotland. To allow the Scottish Ministers to properly consider the development proposals, Berwick Bank is required to provide information which demonstrates compliance with the relevant legislation and allows adequate understanding of the material considerations.

The applicants Report to Inform Appropriate Assessment (RIAA) concluded that an adverse effect on site integrity could not be ruled out for Black-legged Kittiwake (hereafter Kittiwake) *Rissa tridactyla*, Common Guillemot (hereafter Guillemot) *Uria aalge*, Razorbill *Alca torda*, and Atlantic Puffin (hereafter Puffin) *Fratercula arctica*. These are collectively referred to as the 'key species'.

Several colony-based measures are proposed as compensatory measures for the proposed development[1]. This document concerns the proposed compensation measure for rat eradication and

[1] EOR0766_Berwick Bank Wind Farm Application - 4. Derogation Case - Colony Compensatory Measures Evidence Report

biosecurity to benefit kittiwake, guillemot, razorbill and puffin nesting at Inchcolm, an island in the Firth of Forth.

The scope of work for the feasibility study on Inchcolm comprises the following 4 tasks:

Task 1: Field studies in May 2022 (Appendix A) to:

- Determine the presence and abundance of mammalian predators.
- Gather evidence of predation pressure.
- Assess early stakeholder opinion.

Task 2: Field studies in June 2022 (This report) to:

- Collate seabird census data for Inchcolm and the other islands in the Firth of Forth.
- Assess the availability of potentially suitable nesting habitat that are currently unoccupied which may indicate that rats are preventing nesting by key species in these locations.

Task 3: Assessment against the following seven key feasibility criteria described in the UK Rodent Eradication Best Practice Toolkit (Thomas, Varnham, & Havery, 2017):

- Technically feasible
- Sustainable
- Socially acceptable
- Politically and legally acceptable
- Environmentally acceptable
- Have Capacity, and be
- Affordable.

Task 4: The Feasibility Study Report shall document the results of the site visit and desk study and will report the findings against the seven feasibility criteria. Based on these answers the project benefits, costs and uncertainties have been considered and recommendations made on whether eradication is feasible or not. Where additional data is required to support a pre eradication phase of work these has been described.

2.0 ENVIRONMENTAL SETTING

Inchcolm lies in the Firth of Forth, 1 km off the south coast of Fife opposite Braefoot Bay (separated from the Fife mainland by a stretch of water known as Mortimer's Deep), 6 km east of the Forth Road Bridges and 9 km northwest of the City of Edinburgh (Figure 2, Figure 3 and Figure 4).

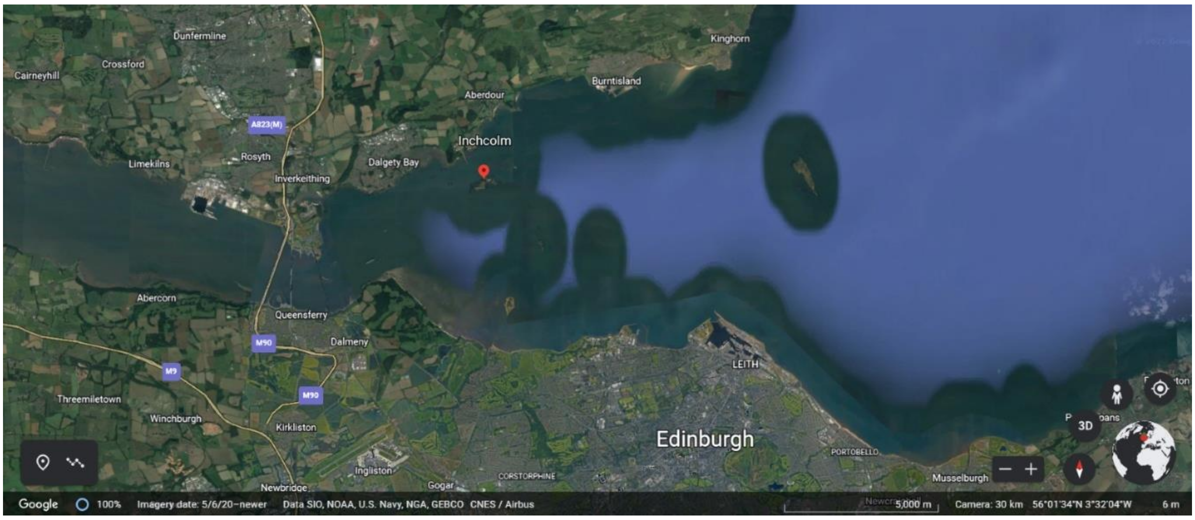


Figure 2. Location of Inchcolm, Firth of Forth, Scotland (Google Earth).

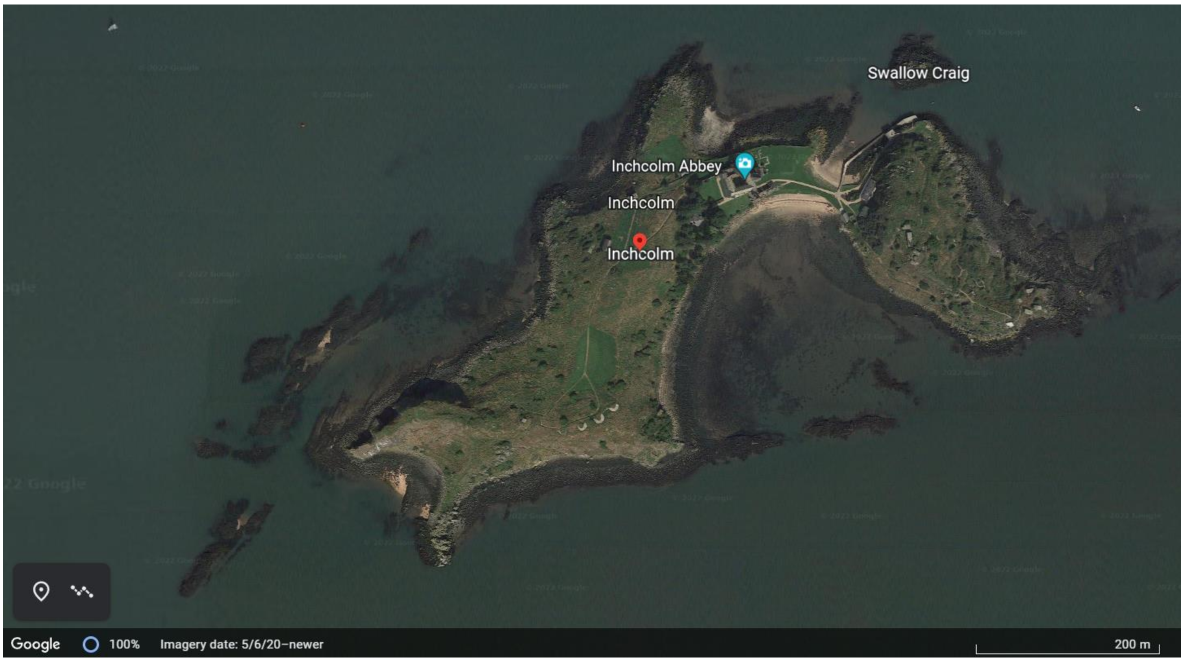


Figure 3. Inchcolm, Firth of Forth (Google Earth).

Figure 4. Aerial photograph Inchcolm Island.

Inchcolm is 10.5 hectares (ha) in area and 34 m high at its highest point. The island comprises two segments (east and west) which are linked by a narrow isthmus. The east section rises to 30 metres above sea level. The west section is flatter but rises to 30 m cliffs at the western extreme of the island.

The island is privately owned and uninhabited. It is managed by Historic Environment Scotland (HES) with at least four HES stewards based on the island during the day. These staff maintain the island and run the shop for the high numbers of seasonal summer (April to October) visitors. Inchcolm is famous for the 12th century Augustinian Abbey which is in the middle of the island and World War I and II military fortifications.

The grounds of the Abbey and central part of the island are landscaped lawns, ornamental shrubs, and few trees. The rest of the island is dominated by coastal grassland with small shrubs and trees.

The island is recognised for breeding seabirds including the northern fulmar (*Fulmarus glacialis*), common eider duck (*Somateria mollissima*), herring gull (*Larus argentatus*) and lesser black-backed gull (*Larus fuscus*). Inchcolm also has smaller populations of puffin, razorbill, black-legged kittiwake, and European shag (*Gulosus aristotelis*).

Small numbers of grey seal (*Halichoerus grypus*) drop their pups on the shore of Inchcolm each autumn and the common or harbour seal (*Phoca vitulina*) has been known to use the island for pupping during the summer months. The only other mammal recorded on Inchcolm is the black rat.

There are two small barren rocky islets, Carr Craig (to the east) and Haystack (to the west), approximately 500 metres offshore from Inchcolm. Both islets have been important breeding grounds for several species of tern in the past, and in more recent years have hosted important colonies of great cormorant *Phalacrocorax carbo* and European shag.

3.0 HABITAT REQUIREMENTS AND BREEDING BEHAVIOUR FOR TARGET SEABIRDS

This section summarises habitat type preferred by the target seabird species and presents a description of their breeding behaviour.

3.1 GUILLEMOT AND RAZORBILL

Guillemot and razorbill nest in broadly similar habitat types and share colony space (Harris and Wanless, 1987), although razorbill show a preference for nesting in cavities and crevices as well as nesting on ledges (Plumb, 1965; Hipfner and Dussureault, 2001).

The **guillemot** is a colonial, sea-cliff nesting species found in the North Atlantic and Pacific (Harris and Birkhead, 1985). The species is widespread along the British and Irish coasts (Balmer *et al*., 2013).

Guillemot breed at varying, often high, densities on ledges, in cliff niches, among boulders or on rock platforms (Harris *et al*., 1996). Densities as high as 46 pairs/m2 have been reported (Harris and Wanless, 1987). In the book "The Atlantic Alcidae", Harris and Birkhead (1985) state that guillemot breed at densities of around 20 pairs/m2.

Guillemots nest from the top of cliffs down to two meters above wave height at high tide and appear to show a preference for sites further away from cliff tops, sites that slope inwards and sites that have walls (Harris *et al*., 1997).

They can nest on ledges that are substantially sloped, with slopes recorded to vary "*from +50° (sloping down, outwards) to -30° (sloping inwards)",* but generally place their eggs on spots that are almost completely level (+5° to -5°) (Harris *et al*., 1997).

Birds show a preference for breeding next to cospecies, and new breeders join existing colonies (Birkhead, 1977; Harris *et al*., 1997).

On seabird islands, Heaney and St Pierre (2017) noted that guillemot were also found to nest under boulders and on ledges in cavities, potentially related to high predation pressure and/or the absence of preferred ledges.

After remaining relatively stable from 1986 to 2002, UK guillemot productivity declined steeply until 2007, by which time a mean of just 0.23 chicks per pair were fledged. Productivity has increased since then, although values recorded between 2009 and 2019 are still lower than those recorded prior to 2002. In 2019, productivity was estimated at 0.62 chicks fledged per pair[2].

Productivity of black guillemots on the east coast of Scotland, derived from monitored colonies located on the Isle of May between 2009 and 2019, recorded an average of 0.57 and 0.58 chicks per site respectively (Mike & Chen, 2019) (Merne & Mitchell, 2019)

[2] https://jncc.gov.uk/our-work/guillemot-uria-aalge/, adapted from (Harris M, 2019)

Razorbills breed mainly on small ledges or in cracks of rocky cliffs and in associated scree, and on boulder-fields. Razorbills are usually associated with colonies of other seabirds, with small numbers scattered among the larger concentrations of common guillemots on the Herm island group. Razorbill 'nest' sites are often hidden from view, but the presence of a colony is clearly indicated by the attendance of off-duty birds standing close by. Smaller niches and short sections of ledge are available and abundant across the Herm islands group, and these provide additional and preferred nesting habitat for **razorbill**. The preference for nesting in cavities and crevices makes a generic nesting density assumption difficult for razorbill. Such sites can be identified as part of on-site visits during follow-up work and could result in an increased nest habitat availability calculation.

Razorbill productivity[3] in the UK was relatively stable from 1986 to 2001 but then declined to a low point in 2008, when only 0.38 chicks were fledged per pair. Between 2010 and 2017, however, there was a steep upward trend to 0.65 chicks fledged per pair. In 2019, an average of 0.63 razorbill chicks were fledged per pair.

When making the projections for the numbers of additional pairs of target seabirds that could be supported following an eradication of mammalian predators, this study assumes razorbill will share colony space with guillemot on short sections of ledges. **The study adopts a conservative 20 breeding pair / sq. m nesting density for a mixed guillemot/ razorbill colony, and a productivity of 0.58 chicks per nest site.**

3.2 Black-legged kittiwake

The black-legged kittiwake *(Rissa tridactyla)* is a colonial, sea-cliff nesting species found in the North Atlantic It favours steep cliffs with horizontal ledges for nesting; often sharing these with other seabirds, particularly guillemot and razorbill. Nests are built up on grassy knolls in crevices and on ledges using a mix of grasses and seaweeds. A crude estimate suggests a kittiwake nesting density of 3 nests per linear metre of suitable ledge is achievable for a healthy colony (derived from (Massaro,M: Chardine, J; Jones, I, 2001) .

Kittiwake will breed on cliffs building small circular nest structures out of things like mud, grass and seaweed. The nest is built on rock shelves or ledges and is added to year on year. Kittiwake will lay between one and three eggs a year, much more commonly two. Black-legged kittiwakes breeding in Scotland underwent a sustained decline in productivity from 1986, culminating in a very poor breeding season in 2008 when, on average, only one chick fledged per five pairs. Productivity between 2009 and 2019 was higher than it had been for several years, possibly due to increased availability of sandeel prey. In 2019, average productivity on the Isle of May was 0.89 chicks fledged per pair (Heubeck, Martin, 2019).

[3] https://jncc.gov.uk/our-work/razorbill-alca-torda/ adapted from (Merne & Mitchell, 2019)

3.3 Atlantic puffin

The atlantic puffin (*Fratercula arctica*) is a colonial cliff top and grassy slope nesting species digging a burrow in which a single egg is laid.

Where possible, the birds excavate a nesting burrow into the soil. Where burrowing is not possible, the birds' nest under boulders or in cracks and cavities in cliffs. Puffins lay a single egg, in late April or early May. The fledging period is very variable, ranging from 34 to 60 days, depending on the area and year. The young birds leave their nest burrow and make their way to the sea, normally under cover of darkness to avoid predators.

Puffin burrow density has been shown to be negatively correlated with distance from the cliff edge and positively correlated with angle of slope. These correlations are biologically significant in that close to the cliff edge, where the angle of slope was steep, breeding success was significantly higher than on adjacent level habitat (Nettleship 1972). On St Kilda burrow densities averaging approximately 0.5 burrows per m2 have been reported (Harris and Rothery, 1988).

Productivity of puffins in Scotland derived from monitored colonies in 2018 and 2019, recorded an average of 0.74 and 0.69 chicks per site respectively (Harris, Mike; Wanless, Sarah, 2019)

Of interest to the habitat assessment, puffins, on the Isle of May, located 45 km to the east of Inchcolm, recorded only five pairs of puffins were breeding in 1958, while 20 years later, 10,000 pairs were present (Boag et al, 1995).

3.4 Northern gannet

The northern gannet (*Morus bassanus*) is native to the coasts of the Atlantic Ocean. The world's largest breeding colony comprising an estimated 75,000 pairs is on the Bass Rock in the Firth of Forth, located some 40km east of Inchcolm.

Gannets normally nest in large colonies on cliffs overlooking the ocean or on small rocky islands. The preferred nesting sites are on coastal hillsides or cliffs. If these are not available gannets will nest in groups on islands or flat surfaces. Nests are always built close together and otherwise ideal nesting sites will not be used if they are some distance from a colony. On average 2.3 nests per square metre (Nelson 2005) have been reported. The consultants project it is unlikely that gannets will readily colonise Inchcolm island following an eradication of black rats given i. gannets are not currently nesting on Inchcolm or on the other islands of the Inner Forth, ii. Inchcolm is relatively small and low lying, and iii. their most favourable habitat type is currently occupied by large numbers of herring and lesser black-back gulls.

3.5 Estimating nest site availability

This report provides estimates for the potential nest site availability for the target seabirds. These estimates are crude and have been made from preliminary observation made of the island coastal habitat from a boat and supported with photographs. All observations were made in June during the peak of the seabird breeding season. More precise measurements would require additional physical and intrusive study during the none breeding season to collate such additional information as dimensions of individual rock crevices for puffin and razorbill, depth and type of superficial soils for burrow nesting species etc.

4.0 SEABIRD CENSUS

The study obtained data on seabird numbers and breeding success from three primary sources:

i. Forth Heritage Group Method: Single day counts

ii. Forth Seabird Group Method: Single day counts[4].

iii. Observations made by the consultants during the Task 3 field work June 2022.

The most recent census data provided by FHG for 2021 and 2022 are available on request and summarised for Inchcolm and selected neighbouring islands in Table 1 and Table 2. The data for Inchcolm, Inchkeith, Inchgarvie, Carr Craig and Haystacks are reported below for single day counts carried out on May 31st 2021 by the volunteer groups FHG and FSG. The data for Inchmickery and the Isle of May were sourced by the FHG from the RSPB and NatureScot respectively.

Table 1.Summary seabird counts Inchcolm Island 2021-2022.

Inchcolm Island seabird cencus: Source Forth Heritage Group, June 2022					
Island	**Bird species**	**Count Unit**	**31st May 2021**	**2022 31st May 2022**	**Additional observations made by the consultants June 2022**
Inchcolm Island	**Guillemot**				No nesting guillemot
	Razorbill	AOS	12	24	Approx 12 breeding pairs
	Puffin	AOB	10 (On water)	22	Approx 5 occupied burrows northwest
	Kittiwake	AON	63	77	
	Fulmar	AOS	174	259	
	Common Tern				
	Arctic Tern				No nesting terns
	Oyster Catcher	AON	5	5	
	Eider	AON	122	c.134 nests	Moderate eider duck breeding activity; less than 20 nests June 2022
	LBBG	AOT	1789	1930	
	Herring Gull	AOT	1847	2054	
	GBBG	AON	5	7	
	Shag	AON	27	42	
	Cormorant				
	Peregrine		1 nest observed	2	No nesting observed June 2022 - suspect chicks had fledged.
	Mallard	AON	1		

[4] http://www.forthseabirdgroup.org.uk/pages/wcount-tables.htm).

Table 2. Summary Seabird counts other local islands 2021.

	Other Local islands seabird cencus: Source Forth Heritage Group, June 2022 (expressed as AON/ AON/ AOT/ or AOB)						
Other Significant Forth Island Counts 2022		Inchkeith	Inchmickery (Supplied by RSPB)	Inchgarvie	Carr Craig	Haystack	Isle of May (Supplied by NatureScot)
		May-21	May-21	May-21	May-21	May-21	May-21
	Guillemot (Pairs)	213	0	0	0	0	26134
	Razorbill (Pairs)	131	0	0	0	0	6184
	Puffin (AOB)	2178	29	0	0	0	Not available
	Kittiwake (AON)	502	0	0	0	0	5193
	Fulmar (AOS)	283	34	176	1	0	321
	Common Tern (AOS/ AON)	0	0	0	0	0	23
	Arctic Tern (AOS/ AON)	0	0	0	0	0	382
	Oyster Catcher (AOS/ AON)	Not available	Not available	Not available	Not available	Not available	Not available
	Eider (AON)	568	25	19	Not available	Not available	Not available
	Shelduck	Not available	Not available	Not available	Not available	Not available	Not available
	LBBG (AOT)	Not available	117	33	16	6	1739
	GBBG (AOT)	26	4	6	1	1	124
	Herring Gull (AOT)	Not available	217	236	54	17	5168
	Shag (AON)	276	23	0	15	0	491
	Cormorant (AON)	128	0	0	90	0	14
	Notes	Estimated 1899 apparently occupied Puffin burrows 2022 vs 2178 AOBs in 2021					

Significant findings for the target species are discussed below.

4.1 Razorbill

The razorbill was first observed in the waters around Inchcolm on June 1st 1993, when a group of 20-25 birds were seen (Morris R, 2003). Razorbills have continued to be present in relatively small numbers during the spring and summer months. Between two and four pairs bred on the island over the period 1996-1999. Eleven nest sites were counted in 2000 and 2002. These small numbers of birds appear to have stabilised with twelve nest sites counted in 2022.

4.2 Atlantic puffin

From the late 1980s up until 1991, small numbers of Atlantic puffin were seen frequenting the waters around Inchcolm during their breeding season, but no birds were seen ashore. Four nest sites were observed on Inchcolm in 1993. Breeding has been observed at low levels each year since. The puffin colony originally established itself in the boulder slopes of the south side of Inchcolm' s eastern part, but some birds spread to the grassy slopes of the northwest of the island and in more recent years the whole colony relocated to this area. It has been speculated that this movement may have been influenced by rat predation amongst the more accessible boulder fields of the south east. In 1995, 89 birds were counted on and offshore, in 2002 58 birds were counted on and offshore. In 2022 the numbers of occupied burrows has been estimated to be a maximum of 11.

4.3 Black-legged kittiwake

Kittiwake breeding was first recorded in 1991 when about 20 pairs were observed nesting at the northwest cliffs. Numbers built up at the colony over the following years reaching a recoded peak of 190 nests in 1995. But in the following years the breeding population declined with only 42 pairs observed to be nesting in 2001. A slight recovery may have started to take place in more recent years with 63 nest sites observed in 2021 and 77 in 2022.

4.4 Other species

No breeding guillemot or species of terns have been observed on Inchcolm in recent years despite the abundance of suitable breeding habitat.

Fulmars appear to be breeding successfully in moderate numbers on Inchcolm's steep rocky cliffs, with approximately 259 birds counted in May 2022.

Eider duck have been observed on Inchcolm in moderate numbers with some 134 nest sites recorded in May 2022. However, during the consultants Task 1 and 2 field work no more than 10 occupied eider nest sites were observed, suggesting fledging had largely completed and/or eggs and chicks had been predated and/or nests abandoned.

5.0 PROJECTED IMPACTS OF PREDATORS ON BREEDING SEABIRDS.

5.1 BLACK RAT IMPACT ON SEABIRDS

Black rats are one of the most widespread invasive species, occurring on 80% of the world's islands (Atkinson, 1973; Atkinson, 1985; Jones *et al*., 2008; Spatz *et al*., 2014; Dawson *et al*., 2015). Rats have had devastating impacts on islands through predation, competition, and habitat modification (Bell 1978; Imber, 1985; Campbell, 1991; Martin *et al*., 2000; Stapp, 2002; Towns *et al*., 2006; Jones *et al*., 2008; Harris, 2009; Mulder *et al*., 2009; Croxall *et al*., 2012; Shiels *et al*., 2014; Bell *et al*., 2016; King & Forsyth, 2021), but have been successfully removed from islands ranging in size from 1 to 36,000 hectares (Towns & Broome, 2003; Howald *et al*., 2007; Bell, 2019; Martin & Richardson, 2019). Black rats have been recognised to have greater impacts on seabirds, especially burrow-nesting species, compared to other *Rattus* species (Moors & Atkinson, 1984; Towns *et al*., 2006; Jones *et al*., 2008; King & Forsyth, 2021). They have also been implicated in the decline of other small mammals, including bats and wood mice (Harris, 2009; Bell *et al*., 2016). Seeds and fruit are particularly vulnerable to black rat predation and consumption (Auld *et al*., 2010; Shiels & Drake, 2011; Pender *et al*., 2013).

Black rats will be having an impact on the Inchcolm ecosystem (including reduced regeneration of plants and predation of invertebrates and birds). There are a number of seabird species present on Inchcolm that are vulnerable to predation by black rats including puffin, razorbill, guillemot, and kittiwake. Seabird count data from the Forth Seabird Group and the Forth Heritage group suggests that razorbill numbers have fluctuated in recent years between 1 and 15 pairs, puffin numbers have declined from a high of 65 pairs on the island in the mid-1990s to less than 10 pairs in 2022, kittiwake numbers have declined from a high of 190 pairs in 1995 to 77 pairs in 2022, and guillemot numbers are zero (http://www.forthseabirdgroup.org.uk/pages/wcount-tables.htm). Several species of highly vulnerable terns and guillemot that may have previously nested on Inchcolm, are likely to have suffered too from rat predation.

Stomach contents of black rats trapped on Inchcolm were primarily composed of digested food, including fragments of flesh, vegetation, and suspected eggshell (Appendix A, Section 3.3.2).

Stable isotope analysis of whiskers taken from a sample of the Inchcolm rats shows the rat's diet does comprise a marine high trophic level signature, which could be indicative of a seabird predation. However, without taking samples of the target seabirds, this test was unable differentiate between a seabird food source and another high trophic source such as a dead seal (Appendix A).

5.2 PREDATORY GULLS

The target seabird species on Inchcolm are also at high risk of predation from gulls (notably herring gull, lesser black back gull and to a lesser extent great black-backed gulls), and at moderate risk to a pair of resident nesting peregrine falcons (*Falco perigrinus*).

Gulls tend to attack a greater percentage of nest sites located at the upper sections of cliffs and grassy slopes than at lower sections. Successful foraging by gulls in calm conditions is largely constrained by ledge width (whereby nests on broad ledges are more likely to be attacked), whereas increased wind speed enables gulls to attack nests more successfully on both narrow and broad ledges.

5.3 Opportunity for seabird recovery following rat eradication

5.3.1 Global experience

The successful eradication of brown rats from Ailsa Craig, Scotland (100 ha; Zonfrillo, 2001; 2002), Ramsey Island, Wales (256 ha; Bell *et al.,* 2000; Bell *et al*., 2019), black and brown rats from Lundy Island, England (500 ha; Appleton *et al*., 2006; Lock, 2006; Bell, 2019), brown rats from Isle of Canna & Sanday (1314 ha; Bell *et al*., 2011), brown rats from St Agnes & Gugh, Isles of Scilly (142 ha; Bell *et al*., 2019) and the black rats from the Shiant Isles (143 ha; Main *et al*., 2019) further demonstrates how these techniques can be utilised on islands around the UK.

Following the successful eradication of black rats from islands, native species, particularly seabirds, have increased in density and range and often diversity (Bellingham *et al*., 2010; Daltry *et al*., 2010; Varnham 2010, Buxton *et al*., 2016; Newton *et al*., 2016; Booker *et al*., 2018; Brooke *et al*., 2018; King & Forsyth, 2021). Native plant biomass on islands has also increased often within 10 years of removing rats (Towns *et al*., 2006; Daltry *et al*., 2010).

Both cliff nesting and burrowing seabird species have shown significant increases following the eradication of black rats from islands within the UK and around the globe (Dunlop *et al*., 2015; Capizzi *et al*., 2016; Booker *et al*., 2018; RSPB, 2018). On Lundy Island, guillemot, razorbill, kittiwake, and puffin, have all increased in number and distribution across the island since 1981 with the most significant increases following the 2002 rat eradication (Booker *et al*., 2018). Similar trends for Manx shearwater (*Puffinus puffinus*) and European storm petrels (*Hydrobates pelagicus*) have been recorded on Lundy Island (Booker & Price, 2014; Booker *et al*., 2018) and after the brown rat eradication on Ramsey Island (Bell *et al*., 2019). The breeding success and productivity of puffin and razorbill increased on the Shiant Isles following the black rat eradication (RSPB, 2018). Storm petrels were also confirmed to be breeding on the Shiants and bred successfully in 2018 for the first time on record (RSPB, 2018).

6.0 Habitat Assessment

6.1 Methodology

During the field visit in June, a walkover survey of accessible aspects of Inchcolm was carried out. Care was taken not to disturb sensitive nesting seabirds. Coastal cliffs, slopes and boulder fields were avoided by foot, and observed from a survey vessel. Photographs of habitat of interest were taken and observations of seabird activity were recorded. Unoccupied areas of cliffs and slopes for nesting were noted and these areas were crudely measured with the aid of a laser rangefinder and reference to Ordnance Survey maps and Google Earth imagery. The high tide mark plus a 2m 'splash zone' was subtracted from the measured height of the 'unoccupied' island feature to provide an estimate of the total area of habitat available for additional nesting.

A photographs log documenting the key areas of habitat determined to be suitable for supporting the breeding of the target seabird species is available on request. Areas visually assessed to match known target species nesting preferences are marked on selected photographs.

N.B. It is important to recognise that only one species of seabird can occupy any one nest site, and this must be considered when making island wide multi species projections of available suitable nesting habitat. This will be considered further through the next stage of the assessment process.

6.1.1 Razorbill and guillemot estimates

For razorbill and guillemot, only horizontal rocky ledges clearly visible on the photographs were selected. This is a conservative estimate, as short ledges and small rocky crevices and other rocky features can also be used, and inclined ledges can be used if flat areas for egg placement or nest building are present. A crude estimate of the total length of the marked areas (total ledge length) was made.

Based on the topography of the cliffs and the width/depth of the ledges as observed during the preliminary site visits, a conservative estimate of an average 0.3m ledge depth was assumed. This width also aligns well with the published literature, with Birkhead (1977) recording a 0.29 m mean width for ledges occupied by guillemot. Where photographs showed large, flat rock areas (here referred to as platforms), depth was estimated as 0.6 m.

- A crude estimate of potential nesting space for a mixed colony of guillemot and/or razorbill (nr of pairs) on photograph = Total ledge length (m) x ledge depth (0.3 m) x bird density (20 pairs/m2).
- A crude estimate of guillemot and razorbill productivity derived from monitored colonies located on the Isle of May (Section 3.1) = average of 0.57 and 0.58 chicks per site respectively.

6.1.2 Kittiwake estimates

For kittiwake, only horizontal ledges, recesses and grassy knolls with an estimated depth equal to or greater than 0.3 m visible on the photographs were selected. A crude estimate of the total length of the marked areas (total ledge length) was made.

- A crude estimate of potential nesting space for kittiwake on photograph = Total ledge length (m) x ledge depth (0.3 m) x bird density (3 pairs/ m2).
- A crude estimate of kittiwake productivity derived from monitored colonies located on the Isle of May (Section 3.2) = average of 0.89 chicks per site.

6.1.3 Puffin estimates

For puffins only the areas of steep grassy banks at the top of cliffs or rocky outcrops have been used for the estimates. Again this is a conservative estimate as boulder fields and shallow inclines can also be used if vegetation is managed to improve access.

A crude estimate of potential nesting space for puffin on photograph = area of grassy bank on top of cliffs or rocky outcrop (m2) x bird density 0.5 pairs per m2.

- A crude estimate of puffin productivity derived from monitored colonies located in Scotland in 2019 (Section 3.3) = average of 0.69 chicks per burrow.

6.2 Nesting Space Estimates

Figure 5 illustrates those aspects of Inchcolm Island that were observed and assessed as providing the most suitable habitat to support the expansion of the target seabird species following a rat eradication.

Figure 5. Areas of Inchcolm Island assessed as most suitable for supporting the expansion of target seabird species.

Figures 6 through to 13 provides marked up copies of selected photographs to illustrate the key aspects of these projected suitable nesting locations for the target seabird species. **Yellow bounded areas** denote most suitable puffin habitat, **red lines** denote most suitable ledges for kittiwake and purple lines denote most suitable ledges for guillemot and/ or razorbill.

Figure 6. North (Central): Area A.

Figure 7. North (Central): Area B.

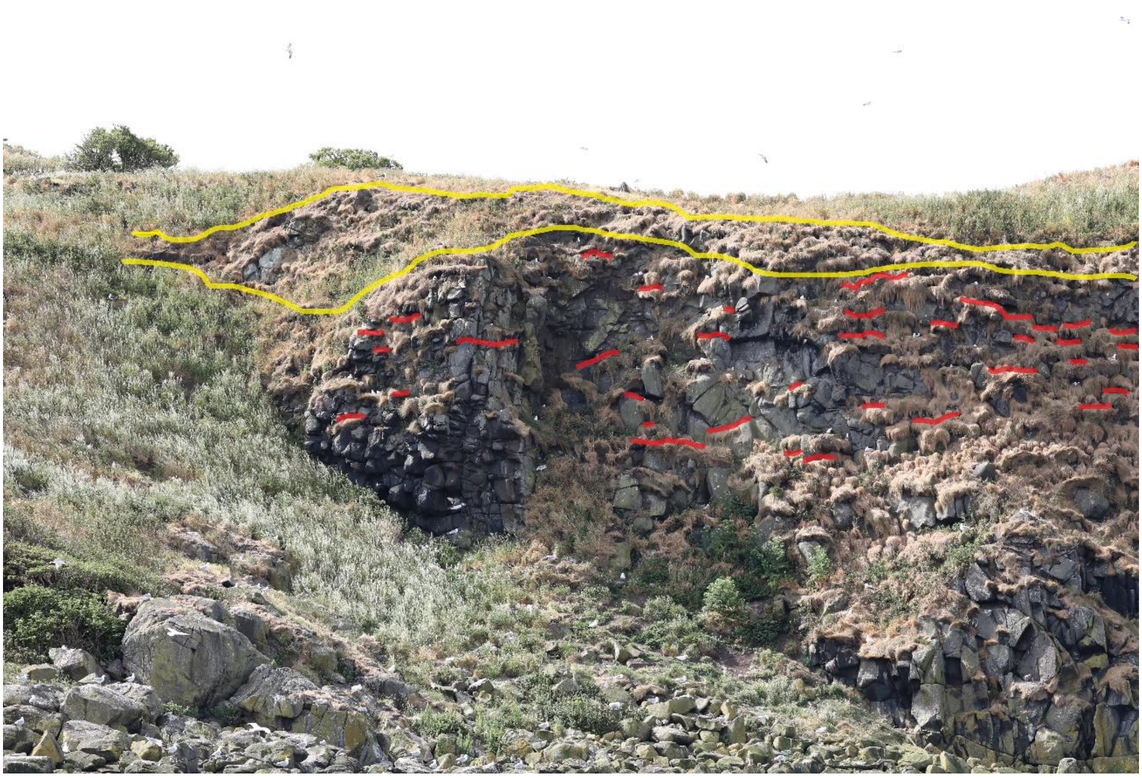
Figure 8. Northwest: Area C.

General view Area D

Puffin and herring gull nesting

Razorbill and kittiwake nesting

Kittiwake nesting



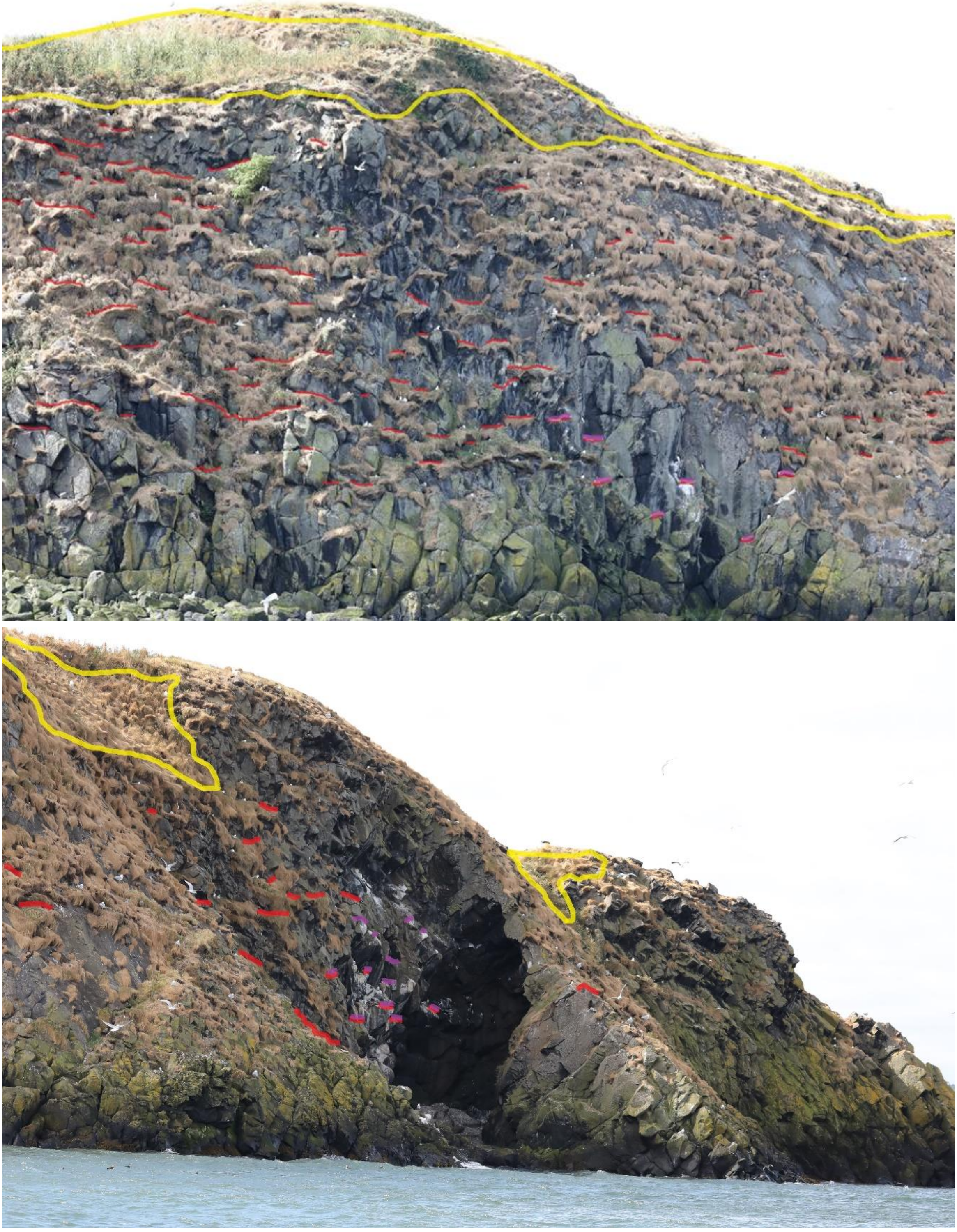


Figure 9. Northwest: Area D.

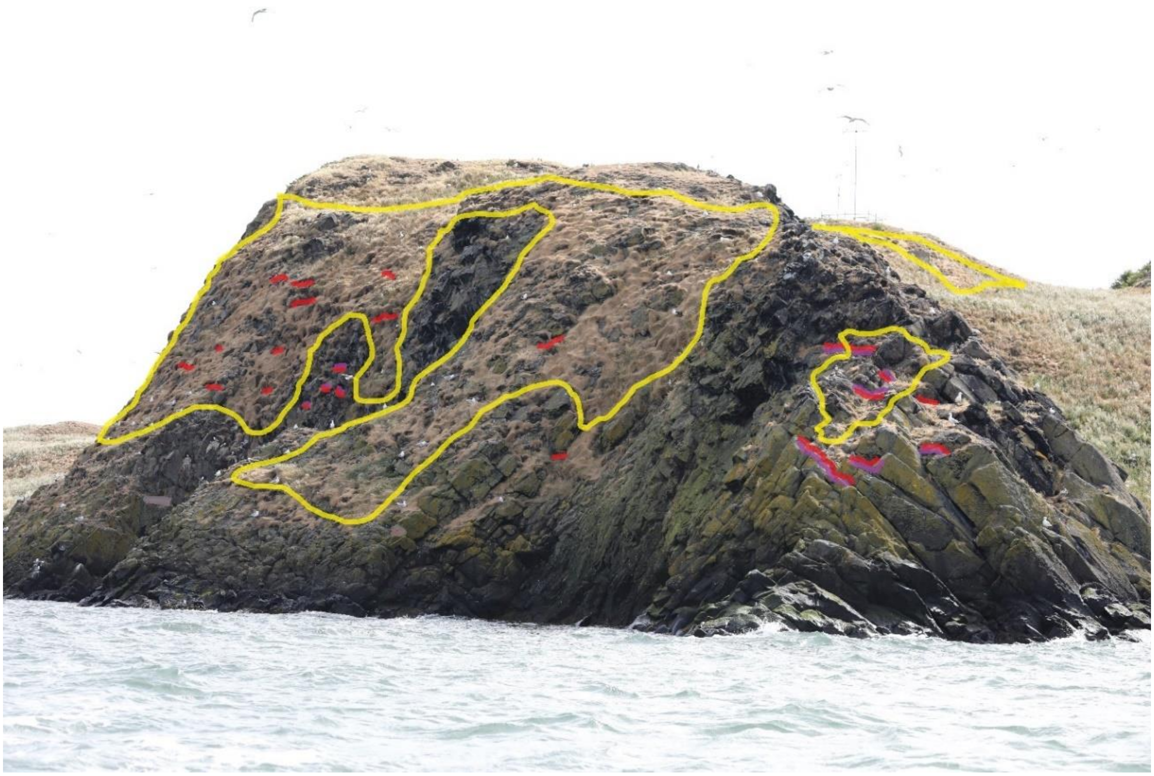


Figure 10. West: Area E.

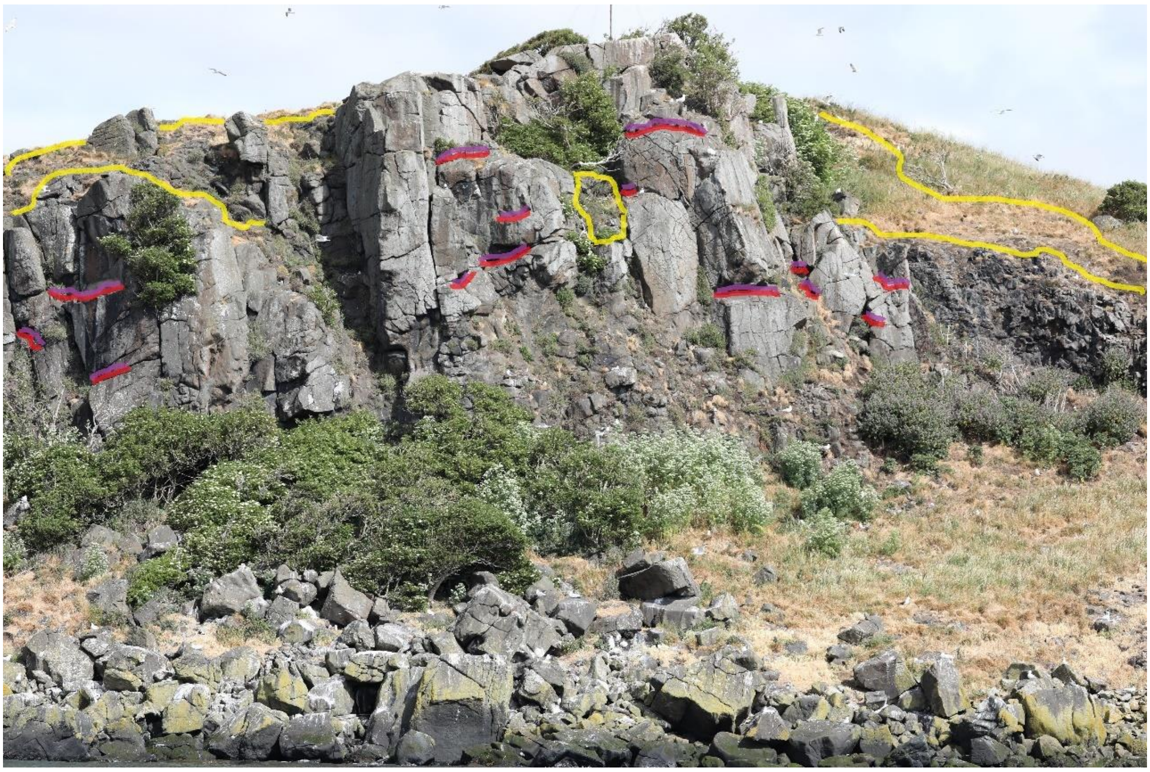


Figure 11. Southwest: Area F.

Figure 12. Southeast: Area G.

Figure 13. Northeast: Area H.

Table 3 describes each area and provides conservative estimates of potential additional unoccupied nesting space and numbers of additional seabirds that could be supported.

Table 3. Projections for target seabird species following a rat eradication (full resolution is available on request).

				Available Habitat						Additional target seabird projections				
Area	**Location/ aspect**	**Habitat Description**	**Approx. gradient**	**Approx. max height (m) above high tide minus 2m splash zone.**	**Approx. width (m)**	**Approx. area (sq. m)**	**Estimated length of unoccupied 'clean' ledges/ platforms (m) available for guillemot, and/or razorbill nesting**	**Estimated length of unoccupied ledges/ platforms (m) available for kittiwake nesting**	**Estimated area of unoccupied grassy bank (m2) available for puffin burrows.**	**Projection of numbers of pairs of guillemot and/or razorbill that could be supported by unoccupied ledge/ platform**	**Projection of numbers of pairs of kittiwake that could be supported by unoccupied ledge/ platform**	**Projection of numbers of pairs of puffin that could be supported by unoccupied grassy bank.**	**Current nesting Activity 2022** (ONS = Occupied Nest Site)	**Rating of the quality of the habitat to support additional nesting by target seabirds, following a rat eradication.**
Area A	North (Central)	Rock outcrop over grass and shrub bank.	45-60%	8	30	100	8	8	75	48	7	38	High activity species: - Herring Gull Moderate activity: - Lesser black back gull - Oyster catcher - Eider duck	**POOR** No target species currently nesting. Negligible new opportunities for target species due to abundance of gulls and tourist boat traffic..
Area B	North (Central)	Rock cliff with occasional grass and shrub	>90%	8	35	280	15	15	0	90	14	0	Moderate activity: - Fulmar (c.20 ONS's) Low activity -Herring gull	**GOOD** No target species currently nesting. Good number of unoccupied ledges for one or more of the following target species to establish nest sites: -Kittiwake -Razorbill -Guillemot
Area C	Northwest	Grassy bank	60-80%	7	30	210			60	0	0	30	Low activity species: - Gulls	**GOOD** Soft ground suitable for burrow nesting Puffins. Dense grassy vegetation may restrict access to some parts of bank.
Area D	Northwest	Grassy bank over rock cliff	80-90%	28	120	3360	20	180	220	120	162	110	Moderate activity species: - Kittiwake (c.70 ONS's) Low activity species -Razorbill (c. 12 ONS's) -Puffin (c. 5 ONS's) - Herring gull - Lesser black back gull	**GOOD** Steep cliffs with grassy knolls and bare rock suitable for expansion of kittiwake and razorbill colonies and introduction of guillemots. Extensive soft ground at top of cliffs suitable for expansion of burrow nesting puffins. Dense grassy vegetation may restrict access to some parts of bank.
Area E	West	Grassy bank over moderately rocky cliff	60-90%	15	127	1905	20	30	130	120	27	65	Moderate activity species: - Herring Gull - Lesser black back gull Low activity species: - Puffin - Oyster catcher - Eider duck	**MODERATE** One puffin burrow observed amongst moderate to high levels of nesting herring and lesser black gulls . Only moderate habitat opportunities for target species due to abundance of nesting gulls.
Area F	Southwest	Grassy bank over rock cliff over grass and boulder foreshore	45-90%	20	180	3600	35	35	220	210	32	110	Low activity species: - Herring Gull - Lesser black back gull - Kittiwake (c. 8 ONS's) - Fulmar (c. 2 ONS's) -Razorbill (c. 1 ONS) - Cormorant	**GOOD** Steep cliffs with grassy knolls and bare rock suitable for expansion of kittiwake and razorbill colonies and introduction of guillemots. Extensive soft ground at top of cliffs suitable for expansion of burrow nesting puffins. Dense grassy vegetation may restrict access to some parts of bank.
Area G	Southeast	Grassy bank, some rock outcrops and boulders.	60-80%	28	110	3080	0	0	320	0	0	160	High activity species: -Herring gull -Lesser black back gulls - Fulmar (cliff over concrete jetty)	**POOR** No target species currently nesting. Poor opportunities for target species due to abundance of nesting gulls and high tourist footfall.
Area H	Northeast	Grassy bank, some rock outcrops and boulders.	60-80%	15	110	1650	0	0	300	0	0	150	High activity species: -Herring gull -Lesser black back gulls	**POOR** No target species currently nesting. Poor opportunities for target species due to abundance of nesting gulls and high tourist footfall.
Totals 'Good Habitat'							**70**	**230**	**500**	**420**	**207**	**250**		
Total Scenario 1 where kittiwake out compete guillemot and razorbill for suitable shared 'Good Habitat'							**0**	**230**	**500**	**0**	**207**	**250**		
Total Scenario 2 where guillemot and/or razorbill out compete kittiwake for suitable shared 'Good Habitat'							**70**	**160**	**500**	**420**	**144**	**250**		

7.0 DISCUSSION

Key findings and recommendations are discussed below:

- The study has identified good opportunities for the target seabird species kittiwake, razorbill, guillemot and puffin to breed more successfully on Inchcolm island following an eradication of predatory rats.

Potential numbers of pairs of target seabirds that could be accommodated by unoccupied habitat following an eradication of rats:

- Conservative estimate of the additional number of pairs of target seabird species which could be accommodated by the island following predator eradication have been calculated and presented in Table 4.
- These estimates are based on observations made in May and June 2022, and adopt conservative assumptions on ledge length, width, and available nesting space from photographs taken from a vessel. (The dimensions of ledges, platforms and cliffs may be recorded with precision once seabird chicks have fledged, and nesting disturbance will not take place).
- Smaller niches and short sections of ledge, not clearly distinguishable on whole area images, are likely to be available and could provide additional nest habitat. Such sites can be identified as part of on-site visits during follow-up work and could result in an increased nest habitat availability calculation.
- These nesting estimates for Inchcolm are summarised in Table 4. The first estimates do not take potential competition between the target seabird species into consideration. Therefore two scenarios have been considered:

Scenario 1, presented in

  - Table 5, assumes kittiwake outcompete guillemot, razorbill and other none target seabird species to occupy available unoccupied 'clean' ledges.
  - Scenario 2, presented in Table 6, assumes guillemot and/or razorbill outcompete kittiwake to occupy the available unoccupied 'clean' ledges.

The reality is likely to be somewhere between these two scenarios. Both scenarios assume Puffin will not compete with guillemot, razorbill or kittiwake.

Table 4. Total estimated numbers of additional pairs of target breeding seabirds that could be supported by the unoccupied 'good' nesting habitat, together with an estimated number of additional fledged chicks per annum. N.B. These estimates do not take potential competition with other target seabirds into consideration.

Species	Estimated unoccupied ledge length (m)	Estimated unoccupied burrowing area (sq. m)	Estimated numbers of additional breeding seabirds (pairs)	Breeding productivity assumption (Chicks fledged per nest site)	Estimated numbers of additional fledged chicks per annum
Guillemot and/or razorbill	70	-	420	0.57	240
Kittiwake	230	-	207	0.89	184
Puffin	-	500	250	0.69	173

Table 5.Scenario 1 Total estimated numbers of additional pairs of target breeding seabirds that could be supported by the unoccupied 'good' nesting habitat, together with an estimated number of additional fledged chicks per annum. N.B. This scenario assumes kittiwake outcompete guillemot, razorbill and other none target seabird species to occupy available and suitable unoccupied 'clean' ledges.

Species	Estimated unoccupied ledge length (m)	Estimated unoccupied burrowing area (sq. m)	Estimated numbers of additional breeding seabirds (pairs)	Breeding productivity assumption (Chicks fledged per nest site)	Estimated numbers of additional fledged chicks per annum
Guillemot and/or razorbill	0	-	0	0.57	0
Kittiwake	230	-	207	0.89	184
Puffin	-	500	250	0.69	173

Table 6. Scenario 2 Total estimated numbers of additional pairs of target breeding seabirds that could be supported by the unoccupied 'good' nesting habitat, together with an estimated number of additional fledged chicks per annum. N.B. This scenario assumes guillemot and/or razorbill outcompete kittiwake and other none target seabird species to occupy available and suitable unoccupied 'clean' ledges.

Species	Estimated unoccupied ledge length (m)	Estimated unoccupied burrowing area (sq. m.)	Estimated numbers of additional breeding seabirds (pairs)	Breeding productivity assumption (Chicks fledged per nest site)	Estimated numbers of additional fledged chicks per annum
Guillemot and/or razorbill	70	-	420	0.57	240
Kittiwake	160	-	144	0.89	128
Puffin	-	500	250	0.69	173

- The removal of predatory rats will benefit the breeding numbers of target seabirds on Inchcolm. Once it has reached capacity, it is projected that the currently unoccupied habitat classified as 'good' could, support:
  - **Up to 420 additional pairs of breeding guillemot and/or razorbill, producing an estimated 240 fledged chicks per annum.**
  - **Between 144 and 207 additional pairs of breeding kittiwake, producing an estimated 128 to 184 fledged chicks per annum.**
  - **Up to 250 additional pairs of breeding puffin, producing an estimated 173 fledged chicks per annum.**
- The eradication of predatory rats is likely to also benefit other vulnerable species, notably several species of tern, eider duck and fulmar.
- There is unlikely to be a benefit to the northern gannet, which is considered unlikely to colonise Inchcolm Island.
- Gulls (primarily herring and lesser black-back) are firmly established across the island and will present an ongoing predatory threat to the target seabirds.

In practice, a wide range of factors may affect guillemot, razorbill, puffin and kittiwake recruitment and success following predator eradication. These factors are particularly relevant to guillemot, a target species that is currently not breeding on Inchcolm, but which is breeding successfully on the near islands of Inchkeith and Isle of May and from which recruitment could be reasonably expected to take place. Various techniques shall be explored as part of an eradication package of adaptive management to further improve conditions for recruitment and growth in the breeding numbers of target seabird species following a rat eradication, including:

- Artificial ground cover: Cliff ledge nests and burrows on steep slopes are susceptible to avian predation. In a study on a breeding colony of guillemots in California, Parrish and Paine (1996) showed that areas with artificial covers installed over the cliff tops produced nearly twice as many eggs. Artificial ground cover could thus be considered as an additional measure following predator eradication, to further increase breeding performance at potential cliff-top breeding sites.

- Decoys and playbacks: Social attraction methods, such as playbacks and decoys, can be used to increase the likelihood of recruitment, and has shown to be highly effective in a past study by Parker *et al*. (2007). Breeding guillemots were lost from a colony in California following an oil spill in 1986 and did not naturally recolonise over the following eight years. In January 1996, Parker *et al*. (2007) installed guillemot decoys, playbacks and mirrors to attempt to attract guillemot. No guillemot were observed before these social attraction techniques were installed. Following social attraction installation, birds were seen on all but two days (observations were carried out until the post-fledging period in August). Over 90% of 68,332 guillemot observations was in decoy plots vs. less than 10% in control plots and outside of study plots. Guillemot started breeding on the site during the 1996 breeding season, and numbers increased from 1996 (6 pairs) to 2004 (190 pairs) with continued but decreased use of the social attraction techniques (Parker *et al*. 2007).

- Vegetation management, comprising reduction in height and density of grasses and shrubs and loosening of soils on tops of steep slopes may be adopted prior to the start of the nesting season to optimise conditions and create space and access for target seabird species, notably burrow nesting puffin.

- In some seabird species, white paint has been used to simulate guano at potential breeding sites (Gummer, 2003; Sawyer and Fogle, 2013). This could be used for the auks, potentially alongside the use of vegetation management, decoys and playbacks, with the aim of increasing colonisation rates following rat eradication.

REFERENCES

Cain, I., Bell, E., & Balague, T. (2022). *Assessment of the Feasibility for the Eradication of Black Rats (Rattus rattus) from Inchcolm Island, Firth of Forth, Scotland.*

Harris, M. (2019). *https://jncc.gov.uk/our-work/guillemot-uria-aalge/*.

Harris, M., & Sarah, W. (2019). *https://jncc.gov.uk/our-work/atlantic-puffin-fratercula-arctica/#annual-abundance-and-productivity-by-geographical-area-scotland*.

Harris, M., & Wanless, S. (2019). Retrieved from https://jncc.gov.uk/our-work/atlantic-puffin-fratercula-arctica/#annual-abundance-and-productivity-by-geographical-area-scotland.

Harris, Mike; Wanless, Sarah. (2019). *https://jncc.gov.uk/our-work/atlantic-puffin-fratercula-arctica/#annual-abundance-and-productivity-by-geographical-area-scotland*.

Heubeck, Martin. (2019). *https://jncc.gov.uk/our-work/black-legged-kittiwake-rissa-tridactyla/#annual-abundance-and-productivity-by-geographical-area-scotland*.

King et al. (2021). *King, C.M & Forsyth, D.M 2021. The handbook of NZ mammals. 3rd. Otago University Press and CSIRO Publishing. .*

Lambert et al. (2021). *Unexpected involvement of a second rodent species makes impact of introduced rats more difficult to detect, breeding success of Manx Shearwaters, Isle of Rum, Lambert, Cain et al.*

Massaro,M: Chardine, J; Jones, I. (2001). *Relationships Between Black-Legged Kittiwake Nest-Site Characteristics and Susceptibility to Predation by Large Gulls.* American Ornithological Society.

Merne, O., & Mitchell, I. (2019). *https://jncc.gov.uk/our-work/razorbill-alca-torda/#annual-abundance-and-productivity-by-geographical-area-scotland*.

Mike, H., & Chen, J. (2019). *https://jncc.gov.uk/our-work/guillemot-uria-aalge/*.

Moors et al. (1984). *Moors, P.J. & Atkinson, I.A.E. 1984. Predation on seabirds by introduced animals and factors affecting its severity. In Status and Conservation of the World's seabirds (Eds. J.P. Croxall, P.G.H. Evans and R.W. Schreiber). pp 667-690. ICBP, Cambridge.*

Thomas et al. (2017). *Current Recommended Procedures for UK (bait station) Rodent Eradication Projects, Royal Society for the Protection of Birds.*

Thomas et al. (2017). *Current Recommended Procedures for UK (bait station) rodent eradication projects: Annex 2: Rodent Treapping and DNA Sampling. Royal Society for the Protection of Birds.*

Thomas, S., Varnham, K., & Havery, S. (2017). *(ref Thomas, S., Varnham, K. & Havery, S. 2017: Current Recommended Procedures for UK (bait station) rodent eradication projects (Version 4.0) .* Bedfordshire: Royal Society for the Protection of Birds.

Birkhead, T.R. (1977), 'The effect of habitat and density on breeding success in the Common Guillemot (Uria aalge) ', *Journal of Animal Ecology*, 46: 751-764.

Hipfner, J.M. and Dussureault, J., (2001), 'The occurrence, size, and composition of Razorbill Nest Structures', *The Wilson Bulletin, 113*: 445-448

Morris, Ron, (2003), The Wildlife of Inchcolm, a comprehensive record of the birds, mammals and plants associated with this Island in the Firth of Forth), *Hillside Press*

Parrish, J.K. and Paine, R.T., (1996), 'Ecological interactions and habitat modification in nesting Common Murres *Uria aalge'*, *Bird Conservation International, 6:* 261-269.

Parker, M.W., Kress, S.W., Golighty, R.T., Carter, H.R., Parsons, E.B., Schubel. S.E., Boyce, J.A., McChesney, G.J. and Wisely, S.M., (2007), 'Assessment of social attraction techniques used to restore a Common Murre colony in central California', Waterbirds: *The International Journal of Waterbird Biology, 30*:17-28.

Gummer, H., (2003), 'Chick translocation as a method of establishing new surface-nesting seabird colonies: a review', DOC Science Internal Series 150, Department of Conservation, Wellington.

Sawyer, S.L., (2013), 'Establishment of a new breeding colony of Australasian gannets (*Morus serrator*) at Young Nick's Head Peninsula', Notornis, 60: 180-182

Appendix C

The black rat *Rattus rattus* and its status in the World, UK, and Scotland: a contextual summary of its historical and current distributions.

Prepared by Tom Balague, NBC Environment, October 2022

Reviewed by Ian Cain, ICEM Ltd, Oct 2022

1.0 Black rat distribution: Global

The black rat (*Rattus rattus*) also referred to as the 'ship', 'roof', or 'house' rat, along with the house mouse (*Mus musculus*) and brown rat (Rattus *norvegicus*), have become globally distributed thanks to their proximate commensal association with humans (Alpin *et al*., 2011; Yu *et al*., 2022). The former being the most widely distributed of commensal rodents in the world and one of the most widespread and 100 worst, invasive species on earth (Alpin *et al*., 2011; Dawson *et al*., 2015; King and Forsyth, 2021; Lowe *et al*., 2000).

Believed to have originated from the India subcontinent, black rats were firstly introduced into Europe, specifically the eastern Mediterranean, by a suspected overland route from Southwest Asia (Figure 1.), but also a maritime route across the Indian Ocean and via the Red Sea has been hypothesised (Yu *et al*., 2022).

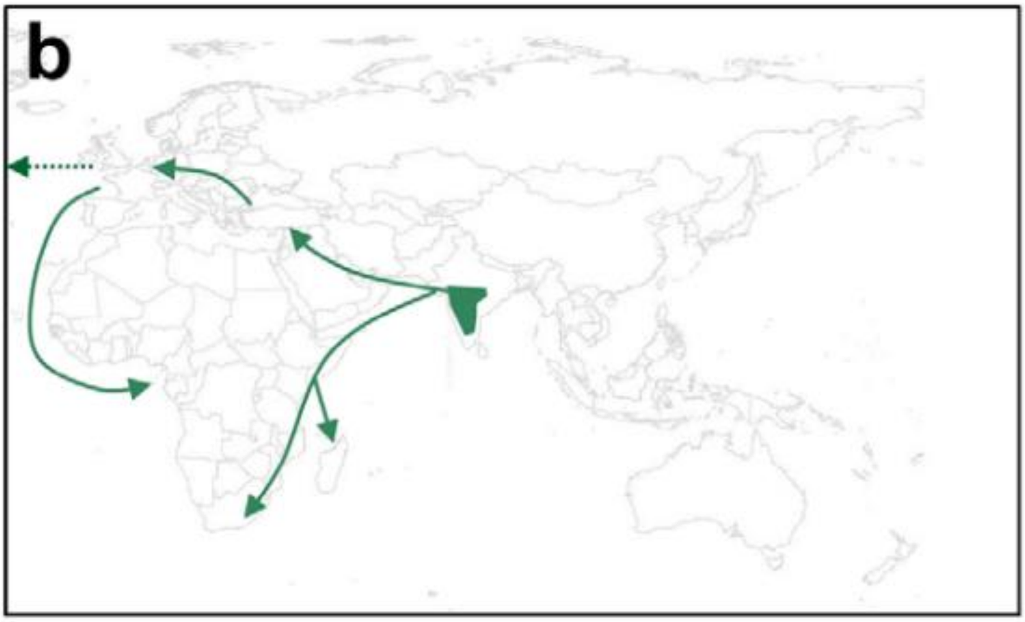


Figure 1. Global map showing range expansion routes for R. rattus. Figure sourced from: Puckett, E.E., Orton, D. and Munshi-South, J., 2020. Commensal rats and humans: integrating rodent phylogeography and zooarchaeology to highlight connections between human societies. Bioessays, 42(5).

From the Mediterranean they spread westward and northward, following the expansion of the Roman empires grain imports and trade movements during the first centuries (circa 3rd century) until they reached the United Kingdom (Puckett *et al*., 2020). Following the steady collapse of the Roman economic systems from the fifth century, black rats widely disappeared from Europe and the UK, only reappearing during the medieval period (circa 8th-11th centuries) mostly around Viking age trading hubs (Puckett *et al*., 2020; Yu *et al*., 2022). This highlights the two waves of rat introduction into temperate Europe. Figure 2 is a map of the UK showing Roman period archaeological sites where black rat bones were discovered. It gives a good impression of their likely extent and distribution within the UK following the first wave of introduction into Europe.

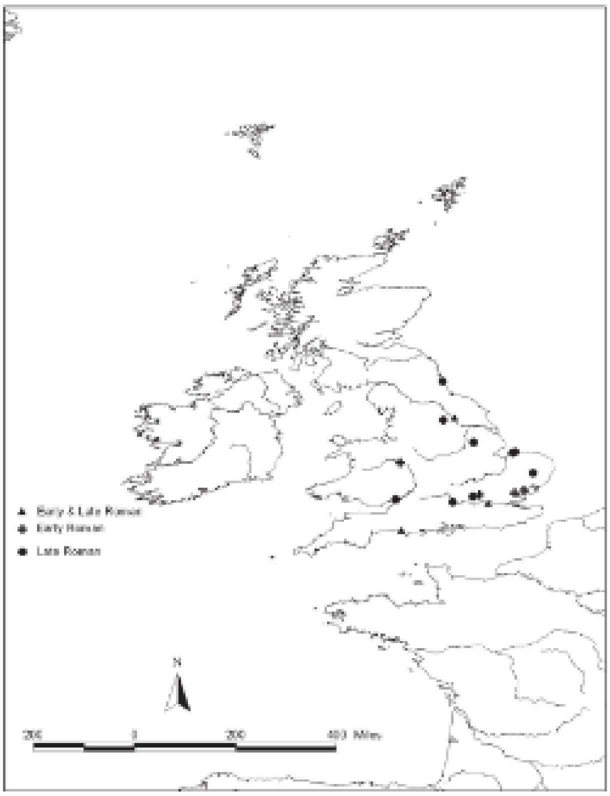


Figure 2. UK map showing distribution of Roman period sites where black rat bones were found. Sites include early and late Roman sites, early Roman sites, and late Roman sites. Source of figure: Rielly, K, 2010 The Black Rat, in T, O'Connor and N, Sykes (eds.), Extinctions and Invasions: A Social History of British Fauna, Oxford: Windgather Press, pp.134-14.

The ability of black rats to spread so efficiently demonstrates their commensal abilities. Black rats are sedentary by nature; thus, their range of active movement is limited (McCormick, 2003). Black rats seldom range beyond 200m when dispersing, however, there is some evidence to suggest that in the Mediterranean black rats move farther on average than black rats in the northern parts of Europe (McCormick, 2003). The fact that black rats are today more prevalent on mainland Europe, is probably because of the warmer climates and this apparent greater ability to disperse; as staying true to their warm origins, black rats live unprotected in the Mediterranean and are not as reliant on human dwellings and food sources (McCormack, 2003). This most likely would have allowed for a more unconstrained rat colonization around Europe. By contrast, in the colder climes, black rats were more reliant on human movement and the centrally heated Roman buildings to aid dispersal, so once the Roman trades began to collapse, black rats were unable to disperse effectively in colder regions and hence their apparent extirpation from the UK and much of Europe at the end of the Roman period (McCormack, 2003; Puckett *et al*., 2020).

Refugial populations of black rats (most likely residing in the Mediterranean) following the collapse of the Roman systems, probably formed the source populations of the second wave of introduction/colonisation into Europe/UK, however, this hypothesis requires much more phylogeographic analysis (Puckett *et al*., 2020). Figure 3 is a map of the UK showing medieval period archaeological sites where black rat bones were discovered. It highlights well that with passive transport methods re-emerging, black rats were able to spread to regions they had not previously inhabited, including Scotland.

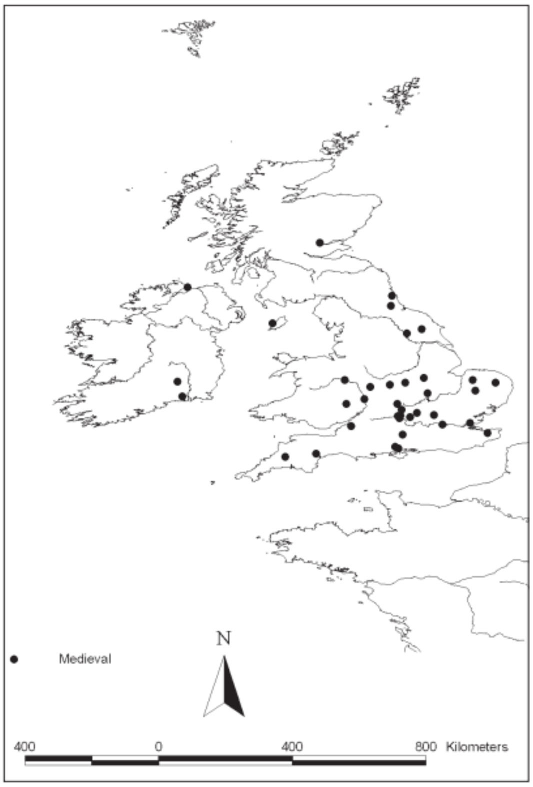


Figure 3 Figure 4. UK map showing distribution of Medieval period sites where black rat bones were found. Source of figure: Rielly, K, 2010 The Black Rat, in T, O'Connor and N, Sykes (eds.), Extinctions and Invasions: A Social History of British Fauna, Oxford: Windgather Press, pp.134-14

2.0 Blach rat distribution: UK and Channel Isles

Today scientific evidence on the distribution and prevalence of black rats in the UK is limited and evidenced studies are lacking, especially when compared with studies coming out of continental Europe (Pernick *et al*., 2022; Goulois *et al*., 2016). The Mammal Society list its UK classification as 'Not Assessed' (see Species – Black rat – The Mammal Society) meanwhile its Europe and global status on the IUCN's Red List of Endangered species is 'Least Concern' (see *Rattus rattus (black rat) (cabi.org)* for a detailed list of current known global distributions, including UK). An IUCN European scope of assessment on the black rat was last completed in 2006 (Amori, 2007) and a global scope of assessment was completed in 2016 (Kryštufek *et al*., 2021). The Mammal Society have not undertaken a comprehensive study in the UK since 2018, where they noted that black rats have not been observed in cities such as Glasgow, Manchester, and Liverpool since the end of the 20th century.

There are many misconceptions about black rats, some allude to the black rat as being possibly extinct in the UK, an endangered species, native, and if present in the UK, only so at ports and dockyards. However, very recent British Pest Control Association (BPCA 2022) data shows that black rats may be more common and widespread than prevailing opinions believe. Results from their survey have shown the extent of perceived black rat sightings in the UK in more recent years (see Appendix A for BPCA sightings data). Manchester, Southampton, Glasgow, Wakefield, Folkestone, London, and Norwich are but a few (S. Johnstone, BPCA, pers. comm.). Sightings include in domestic back gardens, along riverways and around retail centres. In addition to these, it is now known that there are also two large and healthy populations of black rats in the Channel Islands, on Sark and Alderney.

Furthermore, it is worthy to comment on the morphology of the species. Three distinct colour morphs of black rat have been described and all but one, are distinctly brown in appearance (King and Forsyth, 2021). The most common colour phase of the black rat is the '*frugivorous'* where pelage appears brown on the back rather than black, leaving identification by an untrained eye difficult. Therefore, and despite the decline of black rats following the 18th century invasion of brown rats into the UK (Puckett *et al*., 2020), it is suspected and hypothesised here for the first time, that there may be many more populations of black rat across the UK that simply go undetected due to their close resemblance to brown rats.

3.0 Black rat arrival: Inchcolm

The single example of black rat bones found in Scotland's medieval records (Figure 3) was from a deposit associated with a row of houses in medieval Perth (Rielly, 2010). From the evidence provided by literature, and as mentioned above, black rats began to re-establish themselves once again in the UK after the Viking trade had begun circa 8-11th centuries. There is no corroborative evidence historically or otherwise, to suggest that black rats were introduced to Scotland at, or prior, to the 13th century (Rielly, 2010). Therefore, it could be presumed, that black rat lineage present in Scotland today is only as old as the 14th century or the latter half of the 14th century, as the spread of the plague would indicate that black rats must have been more plentiful in certain areas of Scotland by that period (Rielly, 2010). The rat bones from Perth would have likely come from a population that was either originally introduced by boat across the North Sea, or by road up into Scotland from England. When looking at the distribution and spread of medieval bone deposits in Figure 3, one can assume the latter to be more probable.

The question of how and when black rats arrived on Inchcolm is relevant to this study. A literature review indicates:

- The historical records suggest that black rats were not present in Scotland prior to, or at the start of the 13th century, and from this we can conclude black rats were not present during the building and operation of Inchcolm Abbey in the 12th century.
- An account of Inchcolm and other islands in the Firth of Forth in 1899, by the author John Dickson, states: ''*Rabbits breed plentifully on Inchcolm; but there are no rats*''. The account was detailed in his book entitled *Emeralds chased in Gold; or, the Islands of the Forth: their story, ancient and modern* (Dickson, 1899, https://access.bl.uk/item/viewer/ark:/81055/vdc_000000058DB2#?c=0&m=0&s=0&cv=69&xywh=-1048%2C-128%2C4932%2C2558). This finding is potentially compelling when considering the age and historical significance of the black rats on Inchcolm.

- Interestingly there are now no rabbits on Inchcolm, and black rats are abundant. Assuming John Dickson's account is a accurate, this indicates black rats must have arrived on Inchcolm as recently as the 20th century, coinciding with a period that saw rabbits decline and eventually die out; possibly predated on by the rats, and/or hunted by island occupants. (Coincidentally, and probably unrelated, this time period also coincides with the first documented sighting of black rats on another Scottish island location; the Shetland Islands (*see* *Rattus rattus (black rat) (cabi.org)*) in 1904).
- Although there is no confirmed date as to when black rats were first sighted on Inchcolm, if none were present prior to 1900, the next significant period of human activity on the island was the building and operation of the in the time periods 1914-1918 and then again 1939-1945. These periods swelled the population of people living/ stationed on Inchcolm and significantly increased the movement of ships and materials to and from the island. Conditions that would have significantly enhanced conditions for a black rat incursion.

In conclusion it can be argued that the black rats on Inchcolm may have arrived as recently as the early 20th century, and therefore their presence may not be as significant in terms of their historical tenure, as that which has been communicated by some interested and concerned stakeholders.

The task 1 and 2 field included the taking of tissue samples for DNA analysis. The DNA profiling has revealed the Inchcolm black rats represent a novel genotype that has not yet been found in populations sampled elsewhere in the UK or worldwide. This result needs to be clarified against global databases of black rat DNA and should be taken in context that this population is the only one currently haplotyped in the UK. The testing rates for black rat populations globally is also low.

4.0 References

Aplin, K.P., Suzuki, H., Chinen, A.A., Chesser, R.T., Ten Have, J., Donnellan, S.C., Austin, J., Frost, A., Gonzalez, J.P., Herbreteau, V. and Catzeflis, F., 2011. *Multiple geographic origins of commensalism and complex dispersal history of black rats*. *PloS one*, *6*(11).

Cain, I. (2022a). INCHCOLM Field Study Report: Tasks 1 and 2: SSER Berwick Bank Wind Farm: Predator Eradication Feasibility Study. Contract report prepared for SSE Renewables.

Damin-Pernik, M., Hammed, A., Giraud, L., Goulois, J., Benoît, E. and Lattard, V., 2022. *Distribution of non-synonymous Vkorc1 mutations in roof rats (Rattus rattus) in France and in Spain-consequences for management*. *Pesticide Biochemistry and Physiology*, *183*.

Dawson, J., Oppel, S., Cuthbert, R.J., Holmes, N., Bird, J.P., Butchart, S.H., Spatz, D.R. and Tershy, B., 2015. *Prioritizing islands for the eradication of invasive vertebrates in the United Kingdom overseas territories*. *Conservation Biology*, *29*(1), pp.143-153.

Dickson, J., 1899. Emeralds Chased in Gold; or the Islands of the Forth: their story, ancient and modern. *The British Library*.

Giovanni, A., 2007. *Rattus*. *The IUCN Red List of Threatened Species* 2007.

Goulois, J., Chapuzet, A., Lambert, V., Chatron, N., Tchertanov, L., Legros, L., Benoît, E. and Lattard, V., 2016. *Evidence of a target resistance to antivitamin K rodenticides in the roof rat Rattus: identification and characterisation of a novel Y25F mutation in the Vkorc1 gene*. *Pest Management Science*, *72*(3), pp.544-550.

King, C.M. & Forsyth, D.M. (eds.) (2021). *The Handbook of New Zealand Mammals (3rd Ed).* Oxford University Press. Auckland, New Zealand and CSIRO Publishing, Australia. 576 p.

Kryštufek, B., Palomo, L., Hutterer, R., Mitsainas, G., Yigit, N., 2021. *Rattus* (amended version of 2016 assessment). *The IUCN Red List of Threatened Species* 2021.

Lowe, S.J., Browne, M., Boudjelas, S. and De Poorter, M., 2000. *100 of the world's worst invasive alien species*. IUCN/SSC Invasive Species Specialist Group, Auckland.

McCormick, M., 2003. *Rats, communications, and plague: toward an ecological history*. *Journal of Interdisciplinary History*, *34*(1), pp.1-25.

Puckett, E.E., Orton, D. and Munshi-South, J., 2020. *Commensal rats and humans: integrating rodent phylogeography and zooarchaeology to highlight connections between human societies*. *Bioessays*, *42*(5).

Rielly, K, 2010 The Black Rat, in T, O'Connor and N, Sykes (eds.), *Extinctions and Invasions: A Social History of British Fauna*, Oxford: Windgather Press, pp.134-14.

Johnstone, S., 2022. BPCA Lightning Survey, pers. BPCA.

Tree, T., 2018. Invasive Species Compendium. *Cabo*.

Yu, H., Jamieson, A., Hulme-Beaman, A., Conroy, C.J., Knight, B., Speller, C., Al-Jarah, H., Eager, H., Trinks, A., Adikari, G. and Baron, H., 2022. *Palaeogenomic analysis of black rat (Rattus rattus) reveals multiple European introductions associated with human economic history*. *Nature communications*, *13*(1), pp.1-13.