DRAFT
LORD HOWE ISLAND RODENT ERADICATION PLAN

Lord Howe Island Board

October 2009

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This Plan should be cited as follows:

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Foreword

Having completed a feasibility study in 2001, the Lord Howe Island Board has been considering the possibility of eradicating rats and mice from the Lord Howe Island Group for a number of years as part of its responsibility to protect the islands' ecosystems, the kentia palm and tourism industries, and the health and wellbeing of residents and visitors. Introduced ship rats and house mice are having a significant negative impact on the islands' unique flora and flora, many of which are found nowhere else in the world.

The *Draft Lord Howe Island Rodent Eradication Plan* has been prepared to guide the planning and implementation of a programme to eradicate rats and mice from the Lord Howe Island Group of islands.

The Plan presents an opportunity to define a new future for the Lord Howe Island Group – one in which the unique biodiversity of the place can flourish alongside the community and its visitors. This opportunity is an exciting but challenging one. From the information gathered so far – much of it based on more than 300 successful eradication programmes on other islands around the world – the proposed programme is complex but achievable using proven methods.

In this Plan, the significant benefits of eradicating rats and mice from the Lord Howe Island Group are set against manageable and controllable risks. Implementation of this Plan will only proceed once these risks have been fully investigated and addressed. Meanwhile, the current programme to control rats on the island will continue.

The Plan has been prepared using published information, experience obtained from successful eradications on other islands in New South Wales, extensive advice and guidance from overseas experts in the field, local knowledge, community feedback and peer review. It will continue to be updated and refined to incorporate the most recent findings from scientific research undertaken on the island, along with any new developments in eradication methodology from around the world. The Plan will also be amended as a result of ongoing community consultation, peer review, funding availability and the statutory approval processes.

The success of the operation is dependent on the participation and commitment of the whole community, and a shared responsibility to protect the islands' ecosystems and ensure its economic sustainability by making the island free of pests that have been impacting the island for more than 90 years.

We ask that you consider this draft Plan and draw on your knowledge and experience to provide comments, ideas and suggestions on what is arguably one of the most significant management actions that can be undertaken for biodiversity and threatened species conservation in Australia.

We look forward to your active involvement in creating a brighter future for the Lord Howe Island Group and safeguarding the islands' World Heritage listing.

Alistair Henchman

Chair Lord Howe Island Board

Invitation to contribute

Members of the public, whether as individuals or as members of community interest groups, are invited to comment on the *Draft Lord Howe Island Rodent Eradication Plan*. Submissions should be in writing and be as detailed and specific as possible. However any comments, no matter how brief, are welcome.

To make your submission as effective as possible, please:

- refer to the section or part of the Plan you wish to address or discuss
- briefly explain the reasons for your comments, providing source information or examples where possible
- provide your name and address to enable receipt of your submission to be acknowledged.

Submissions may be made as letters or other documents and sent to:

The Lord Howe Island Board
PO Box 5
Lord Howe Island NSW 2898

administration@lhib.nsw.gov.au

The Board will consider all submissions to the Plan received during the exhibition period between 30 October 2009 and 27 November 2009.

The closing date for comments on the plan is 27 November 2009.

All submissions will be a matter of public record and will be made available for public inspection upon request. Your comments on this draft Plan may contain information that is defined as 'personal information' under the NSW *Privacy and Personal Information Protection Act 1998*. The submission of personal information with your comments is voluntary.

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Acknowledgments

Planning the eradication of rodents from the Lord Howe Island Group has progressed to this stage with financial support from the Australian Government's *Natural Heritage Trust* and *Caring for our Country* programmes, the NSW Government, and the Foundation for National Parks and Wildlife. Assistance has been provided by the Endangered Species Recovery Council, Worldwide Fund for Nature; Department of Environment, Climate Change and Water NSW; New Zealand Department of Conservation; and the residents of Lord Howe Island.

This Plan is substantially based on a report prepared by Dr Ian Wilkinson and Dr David Priddel (both Department of Environment, Climate Change and Water NSW). The original report was peer reviewed by: the Island Eradication Advisory Group of the New Zealand Department of Conservation; the Invasive Species Specialist Group of the Species Survival Commission of the World Conservation Union; the Worldwide Fund for Nature, Australia; Birds Australia; Landcare Research, New Zealand and Professor Tim Flannery. The comments and suggestions made by these reviewers have been incorporated into the draft Plan.

Summary

The *Draft Lord Howe Island Rodent Eradication Plan* ('the Plan') provides an overview of the proposed eradication programme of house mouse (*Mus musculus*) and ship rat (*Rattus rattus*) from the Lord Howe Island (LHI) Group of islands. The operation proposed in this Plan aims to eradicate all ship rats and house mice from the LHI Group while minimising any adverse impacts on the environment, non-target species, humans, livestock and pets. This will be achieved in a single 100-day baiting operation.

The Plan has been prepared by the LHI Board and funded by the Australian Government, NSW Government and the Foundation for National Parks and Wildlife. The LHI Group, situated 760 km north-east of Sydney, is a World Heritage Area with global environmental significance.

The impact of house mice and ship rats on the LHI Group

Populations of house mouse and ship rat were accidentally introduced to LHI. They probably arrived around 1860 and 1918 respectively. Both species have had, and continue to have, significant adverse impacts on the biodiversity of the island.

Ship rats are implicated in the extinction of at least five endemic birds and at least 13 invertebrates. They are also a recognised threat to at least 13 other bird species, 2 reptiles, 51 plant species, 12 vegetation communities and numerous threatened invertebrates.

The impact of house mice on the biodiversity of LHI is not as well understood, however, evidence elsewhere shows they eat eggs of small birds, reduce seedling recruitment of some plants, and compete with native seed-eating fauna. On other islands, mice have been implicated in declines of invertebrates, and in some cases this has greatly affected nutrient recycling processes.

From a human perspective, both rats and mice are a major domestic pest. They infest residences, destroying foodstuffs and contaminating homes with excrement. They are also a known health risk to humans as they harbour and transmit diseases and parasites. From an economic perspective, rats cause considerable economic loss to the island's kentia palm industry. Tourism, the LHI Group's other main industry, is based on the islands' unique biodiversity and World Heritage values, and the visitor experience offered by the islands, all of which are being eroded by introduced ship rats and house mice.

Current control programme

Since ship rats and house mice arrived on LHI, the Lord Howe community has invested considerable resources in trying to keep the populations of both species under control.

Control is quite distinct from eradication. Control aims to keep the negative effects within acceptable limits, but its ongoing nature brings with it a constant financial burden. It also brings an increased potential for negative impacts caused by the constant presence of poison in the environment.

Currently the LHI Board's ongoing control programme costs around $65 000 per year. The cost of control incurred by the community is unknown. Two poisons have been used: warfarin and brodifacoum, the former in by far the largest quantities. The prolonged use of warfarin has led to house mice becoming resistant to this poison.

Unmitigated use of rodent poisons, as part of ongoing control, increases the chance of rats developing resistance to the poison. Resistance to currently available poisons will make eradication impossible. It also presents a major risk to non-target species, humans, pets and livestock. As such, the effectiveness and long-term sustainability of the existing localised control programme, or an expanded programme, is highly questionable.

The case for eradication

Eradication eliminates all target individuals through a concentrated effort within a short period of time, thereby eliminating potential long-term negative impacts. Obviously a successful eradication programme would also mean no ongoing control-related costs. In 2001, the LHI Board commissioned a study to examine the feasibility of eradicating both species. The study indicated that such a goal was achievable.

The many successful rodent eradication programmes undertaken on islands around the world have shown that the benefits to humans and native plants and animals are both significant and immediate. The benefits specifically relating to an eradication programme on the LHI Group include:

- a marked increase in plants, birds, reptiles and insects – this boost in diversity enriching the experience of both living on the island and visiting as a tourist
- removal of the economic and environmental burden of the ongoing control currently in place, eliminating the need for the ongoing use of rodent poisons in the environment and their associated long-term risks to native species, pets, livestock and people
- an increase in productivity in the island's kentia palm industry and returns to the local community
- the ability to return species long absent due to the predation of rats and mice, such as the LH gerygone, grey fantail and LHI phasmid
- elimination of significant health risks caused by rodents, including a range of viruses, bacteria, internal parasites (such as intestinal worms) and external parasites (such as fleas, mites and lice), many of which can spread disease to humans
- elimination of the inconvenience currently experienced by residents caused by spoiled foodstuffs and rodent excrement – currently, keeping rodents out of dwellings is an ongoing task for the island's residents.

The proposed eradication programme

LHI will be the largest, permanently populated island on which the eradication of exotic rodents has been attempted. The evidence shows that the best long-term solution is to eradicate both rats and mice from the LHI Group in a single eradication operation. However, given the island's permanent human population, its highly developed tourism industry and its endemic and threatened species, considerable planning needs to be carried out before this can occur.

Many methods have been carefully investigated in order to identify the method most suited to the LHI Group, including a number of different toxins and different means of delivering them, as well as undeveloped and unproven viral methods.

Based on data from over 300 successful eradication programmes on islands around the world, the proven and most effective method will be to distribute poison baits to all parts of the island group, except Balls Pyramid and its associated islets, by aerial and hand broadcasting. The bait, Pestoff 20R®, contains brodifacoum and is highly palatable to both ship rats and house mice. The operation will require 42 tonnes of the bait pellets, containing 840 g of brodifacoum poison.

Concerns about the method of delivery, interaction with soil and water, impact on the marine environment, impact on non-target species and efficacy are addressed in this Plan. A detailed risk assessment is presented which determines the risks to the environment (including wildlife, freshwater and marine habitats), humans, livestock and pets. Measures to ameliorate any adverse impacts are also detailed. These include the establishment of captive populations of a number of species: LH woodhen, LH pied currawong, LHI golden whistler, LHI silvereye and emerald ground-dove. A detailed research and monitoring programme is also presented which details work to be undertaken before, during and after the eradication operation.

Community consultation and involvement

The people of LHI are deeply connected to the island and its history. They play an integral part in the way in which the island is managed. The LHI community will have an important role in planning and implementing a rodent eradication programme to ensure its success. Residents will need to be involved in detailed operational planning for their properties and some may take an active role in the operation itself. The LHI community have been consulted extensively in the preparation of this draft Plan and it is now made available for the community and other interested parties to provide comment. These comments will be considered and incorporated into the final Plan.

Ongoing consultation and dissemination of information about the eradication programme to multiple stakeholders, both on and off LHI, will be essential. This Plan recognises that each stakeholder group has particular needs and different communication methods are proposed for the various phases of the programme.

Timeframe and cost of the proposed programme

The eradication will involve a number of stages which will occur concurrently over a four-year period. The eradication will be conducted in winter, at the start of the third year of the proposal. Tasks to be undertaken during the first two years include: finalise detailed planning and all necessary risk assessments, obtain required permits and approvals, update and finalise operational details, continue community consultation, develop and implement a revised biosecurity strategy, prepare tenders and contracts and establish monitoring programmes. Tasks in the third year include the baiting operation, captive management of birds, environmental monitoring, importation of replacement livestock when bait breakdown is complete, and monitoring of fauna species to provide preliminary information on biodiversity benefits. In the fourth year, monitoring will be continued with a final decision on the success of the eradication made two years after the eradication is conducted.

The cost of the programme is estimated to be approximately $8 million over a four-year period. Funding for the programme has not been secured and will need to be sourced from grants such as those available under the Australian Government's *Caring for our Country* programme.

Conclusion

The proposed eradication technique has proven to be safe and effective and is supported by previous case studies, the advice and support of international experts, and comprehensive site research. It is arguably one of the most significant management actions that can be undertaken for biodiversity and threatened species conservation in Australia, and will safeguard the LHI Group's World Heritage listing well into the future.

1 Introduction

1.1 The Lord Howe Island Group

The Lord Howe Island (LHI) Group is located 760 km north-east of Sydney. It comprises the main island (LHI which is 1455 ha) and 28 smaller islets and rocks (see Figure 1). The most significant of the outer islets are the Admiralty Islands (1 km to the north of LHI) and Balls Pyramid (23 km to the south-east).

First permanently settled in 1833, the resident population is now around 350, spread across some 150 households. LHI is the only island within the LHI Group on which settlement has occurred. The settlement is restricted to the central lowlands and covers about 15% of the island. Islanders hold perpetual leases on blocks of up to 2 ha for residential purposes, and short-term leases on larger tracts for agricultural and pastoral activities. Today, there are approximately 1000 buildings or structures on the island.

Tourism is one of the island's major sources of income. There is an airstrip on the island and daily (or thereabouts) commercial air services to Sydney and Brisbane. About 16 000 tourists visit the island each year. Numbers are regulated, with a maximum of 400 allowed on the island at any one time. The export of kentia palm (*Howea forsteriana*) seedlings is the other major source of income for the island. The Lord Howe Island Board (LHI Board) operates a nursery that produces and exports 2–3 million palm seedlings each year. The seed is harvested from plantations and natural palm forests.

Fish are harvested and sold locally, but not exported. Numbers of livestock fluctuate, however, there are currently around 100 beef cattle on the island and a small dairy herd of 14 cows provides milk for local consumption. There are also approximately 3 horses, 12 goats, 48 pet dogs and 300 domesticated chickens kept by island residents. Cats and pigs are prohibited.

The main island is 12 km long, 1–2 km wide, and formed in the shape of a crescent with a coral reef enclosing a lagoon on the western side (see Figure 1). Mount Gower (875 m), Mount Lidgbird (777 m) and Intermediate Hill (250 m) form the southern two-thirds of the island, which is extremely rugged. The central part of the island is low-lying, rising gradually to the north to about 200 m where sheer sea cliffs fringe the island.

The climate is moderated by oceanic air currents and mild sea temperatures. The climate is mild with warm humid summers and temperate winters. Average winter daily temperatures range from 13–18°C. Mean annual rainfall on the lowlands is 1650 mm, with most falling in winter. Rainfall in the mountains is higher due to orographic cloud and other influences. Humidity is high throughout the year.

More than half the main island is covered in closed forest. Of this forest, 54% is rainforest, 19% is megaphyllous (large-leaved) broad sclerophyll forest (mainly palms), and 2% is gnarled mossy forest. The remaining natural vegetation is scrub, herbfields, grasslands and vegetation on exposed cliffs and littoral terrains (Pickard 1983 in DECC 2007). Around 13% of the island has been cleared.

The LHI Group falls under the jurisdiction of the New South Wales (NSW) Government. The LHI Board is responsible for the care, control and management of the LHI Group in accordance with the *Lord Howe Island Act 1953*. Approximately 75% of the main island, plus all outlying islets and rocks within the LHI Group, are protected under the Permanent Park Preserve, which has similar status to that of a national park.

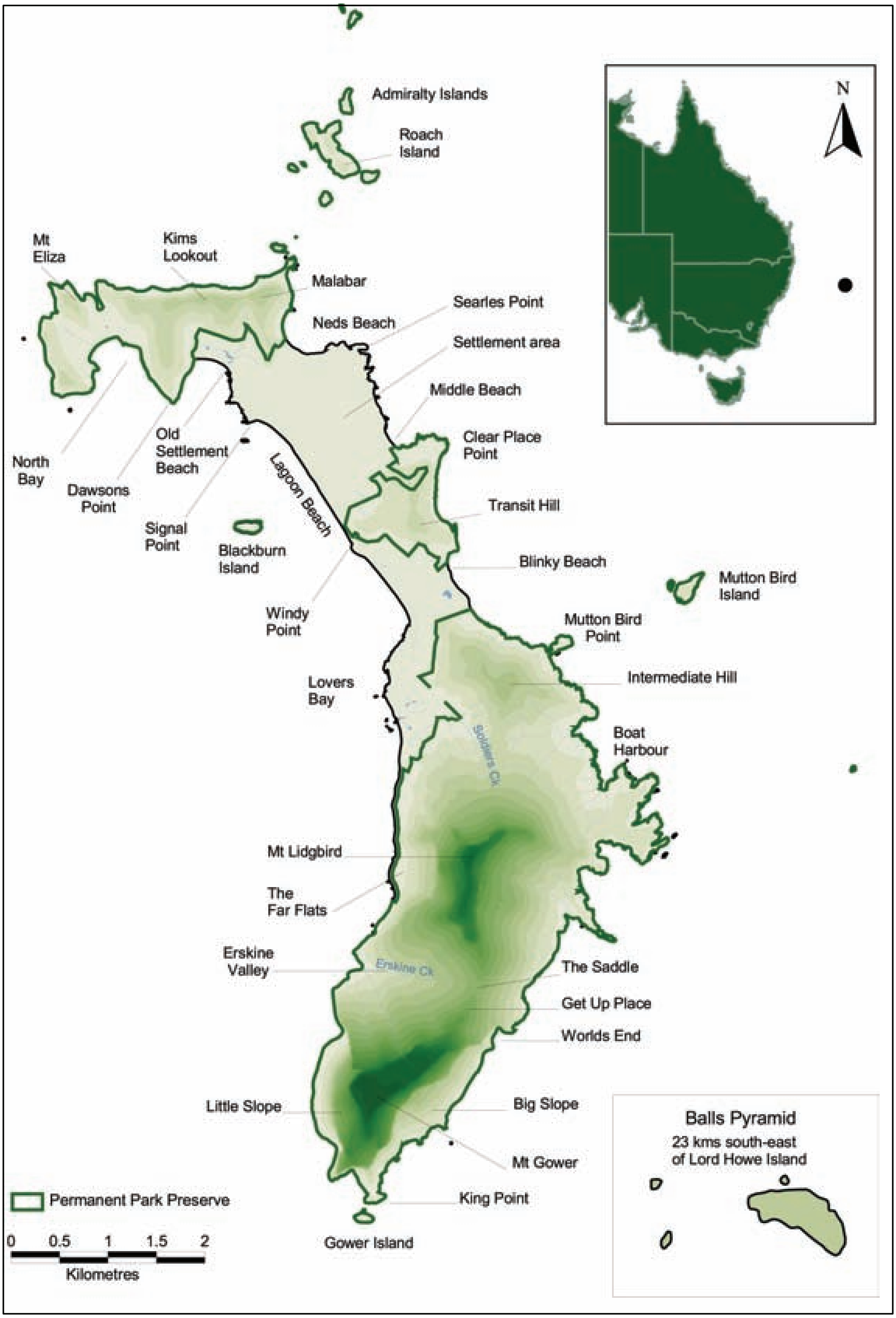

Figure 1. Lord Howe Island Group

The LHI Marine Park is a marine protected area extending from the islands out to a distance of 12 nautical miles. The area out to 3 nautical miles covers approximately 46 000 ha and is managed under the NSW *Marine Parks Act 1997*. The area from 3 to 12 nautical miles covers approximately 300 500 ha and is managed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The outstanding natural phenomena, biodiversity values, threatened species and exceptional natural beauty of the LHI Group were recognised when it was listed as a World Heritage Area in 1982. The LHI Group is also listed on the NSW Government's Heritage Register and the Australian Government's Register of National Estate in recognition of its outstanding landscapes, flora, fauna and geology.

The LHI Group is home to a unique array of plants and animals, many of which are endemic. For example, 44% of the islands' native plants and more than 50% of its native invertebrates are found nowhere else in the world (Recher & Clark 1974; Green 1994). Many of these endemic species are threatened with extinction.

There are 21 species of fauna, 8 species of flora and 2 ecological communities listed as threatened under the NSW *Threatened Species Conservation Act 1995* (TSC Act). At a Commonwealth level, there are 15 fauna species and 2 flora species listed as threatened under the EPBC Act. Other migratory fauna species that visit the islands are listed under various international agreements.

Two species of exotic rodents – the ship rat (*Rattus rattus*) and the house mouse (*Mus musculus*) – were accidentally introduced to LHI around 1918 and 1860 respectively. Ship rats were widespread on the island by 1920, when the Island Board of Control (a forerunner of the current LHI Board) encouraged rat control. Despite various efforts to reduce their numbers, rats remain widespread and abundant across the island; with densities of up to 94 per hectare being reported (Miller & Mullette 1985). Today, rodents are only known on the main island but rats are competent swimmers and so could potentially occur on other islands within the LHI Group.

Evidence from around the world demonstrates that these invasive pests have severe adverse impacts on island biodiversity (Towns et al. 2006) and they are known to be adversely impacting the biodiversity values of the LHI Group. Rodents feed on food crops and infest buildings and residences where they are a social nuisance and a threat to human health. Rodents also adversely impact the economy through ongoing costs of control and lost palm seed.

1.2 Putting the Plan in context

1.2.1 Scope of the Plan

The proposed eradication operation set out in the *Draft Lord Howe Island Rodent Eradication Plan* (the Plan) relates to the LHI Group of islands as shown in Figure 1. Ship rats and house mice are only known to occur on the main island, however, the proposal is to bait all islands and islets in the LHI Group, except Balls Pyramid and its associated islets (Observatory Rock and Wheatsheaf Islet) (see Section 5.2.2).

Research has commenced, in conjunction with the rodent eradication planning process, to assess the feasibility of eradicating masked owl (*Tyto novaehollandiae*) from the LHI Group. Masked owls were deliberately introduced to the island in a failed attempt to control rats and are now considered a pest on the island as they prey on a range of native fauna (see Section 3). Any owl eradication programme will run coincidentally with the rodent eradication operation and will be addressed in a separate plan.

1.2.2 The aims of the proposed rodent eradication programme

The proposed operation aims to eradicate (see box) all ship rats and house mice from the LHI Group while minimising any adverse impacts on the environment, non-target species, humans, livestock and pets. This will be achieved in a single 100-day baiting operation.

Eradicate = the intentional total extermination of a species or population
Control = to regulate, restrain, or hold in check

1.2.3 The planning process

LHI will be the largest, permanently inhabited island on which the eradication of ship rats and house mice has been attempted. Planning for the proposed operation is particularly challenging due to:

- the complexities of targeting two pest species (rather than just one)
- the existence of highly vulnerable endemic species that are susceptible to the poison, in particular LH woodhen (*Gallirallus sylvestris*) and LH pied currawong (*Strepera graculina crissalis*) (see Section 6)
- the presence of a large resident population, a well-developed tourist industry, domestic animals and livestock.

The residents of the island are crucial to the success of the proposed eradication programme. Their input, cooperation and participation will determine the success of the operation. Residents will be part of the decision-making process, in particular in relation to decisions concerning their own properties. The planning process seeks to inform residents because they are an integral part of the process.

Unlike control, eradication succeeds only if every single individual of the targeted species is eliminated. Consequently, it is critical that any eradication programme is carefully planned, implemented and adequately funded. A successful eradication on the scale of the LHI Group is a multi-year operation (a minimum of four years), with significant lead-in times required to ensure that everything is ready for implementation.

There are five stages in planning and implementing the eradication of rodents from the LHI Group, as outlined below. The first has been completed. The second stage is partly addressed by this Plan and Stage 3 has commenced.

Stage 1: Feasibility

In 2001, the LHI Board commissioned a study to examine the feasibility of eradicating ship rats and house mice from the LHI Group (see Saunders & Brown 2001). The study considered eradication to be feasible, but recommended that the risks would need to be appropriately managed.

In 2003, the LHI Board commissioned a further report to review the risks and constraints involved in managing ship rats and house mice and assess the various costs and benefits involved (see Parkes et al. 2003). The report noted the benefits of reduced rodent control costs and increased production of kentia palm seed. It also noted that the eradication of both species would likely have significant biodiversity benefits, although these benefits would be difficult to determine in monetary terms. As such, the eradication operation would provide an overall benefit above the current ongoing control programme.

These two reports identify the major issues and risks, and were used as scoping documents for the next planning stage. Both reports also contain extensive background material that is not repeated in this Plan.

Stage 2: Methodology, consultation and costing

Stage 2 of the planning process has focussed on preparation of this Plan which will be subject to further peer review, public consultation and updating prior to implementation.

A number of research programmes have been and are being undertaken to establish that the rodents will consume the proposed bait and to assess the likely impacts on non-target species. These programmes are outlined in Appendix 1 and the findings to date have been incorporated into this Plan and will be useful during the preparation of the species and other impact assessments (see Stage 3).

A budget (including contingencies) has been prepared for all subsequent stages of the eradication operation including planning, implementation, and the first three years of monitoring. As planning and implementation timeframes for the proposed operation are spread over a number of years, it is important to ensure that funding arrangements account for this and provide for the effective implementation of the remaining stages of the operation.

Stage 3: Approvals and preparations

Stage 3 of the planning process will take a further two years. During this time, the Plan will be further refined, updated and finalised. In addition, the operational procedures will be fully developed in line with current best practice, new research findings, peer review, approval conditions and community feedback.

Individual consultation with each household to develop baiting plans (property action plans) for each lease will take place early in Stage 3 (see Section 5.1.5). The feasibility of the eradication operation will be reassessed after this consultation phase, and further changes to the Plan may be necessary to minimise the risk of failure.

A number of regulatory requirements will need to be fulfilled in seeking approval for the proposed operation (see Section 5.1.1) including a species impact assessment under Section 91 of the NSW TSC Act and a referral under the Commonwealth EPBC Act. These documents will address statutory requirements and will include a comprehensive assessment of the impacts of the eradication programme. The documents will also outline the significance of any potential risks and how these risks will be managed to ensure that adverse effects are avoided, remedied or mitigated.

Other approvals that will be required include:

- Animal Care and Ethics approval to undertake many of the research and monitoring components of the Plan
- approval from the Australian Pesticides and Veterinary Medicines Authority to use the proposed bait – Pestoff® 20R
- permissions to aerially bait within 150 m of dwellings and public places required under the NSW *Pesticides Act 1999*.

Stage 4: Implementation

This phase is centred on the actual eradication baiting operation as well as the on-ground actions that precede it (see Section 5.2).

Stage 5: Monitoring, evaluation, reporting and improvement

Long-term monitoring of this Plan will be undertaken to assess and document the biodiversity benefits of eradicating rats and mice from the LHI Group (see Appendix 1). Demonstrating the outcomes of the investment in this conservation initiative is essential. The information gained will progress the science of island eradications, particularly those on islands with large human populations.

Research and monitoring will commence two years prior to the actual eradication operation to allow time to collect baseline, pre-eradication environmental data. The research and monitoring programme should continue for at least three years after the eradication to assess the benefits of the operation.

2 The Impacts of Rodents

2.1 Impacts on biodiversity

The devastating impacts of introduced rodents on offshore islands around the world are well documented. The presence of exotic rodents on islands is one of the greatest causes of species extinction in the world (Groombridge 1992). Ship rats alone are responsible for the severe decline or extinction of at least 60 vertebrate species (Towns et al. 2006), and currently endanger more than 70 species of seabird worldwide (Jones et al. 2008). They suppress plants and are associated with the declines or extinctions of flightless invertebrates, ground-dwelling reptiles, land birds and burrowing seabirds (Towns et al. 2006).

Rats and mice prey heavily on birds, bats, reptiles, snails, insects and other invertebrates. The ship rat is known to eat seeds and other plant material, fungi, invertebrates, small vertebrates and eggs (NSW Scientific Committee 2000 in DECC 2007). Rats prey on the eggs and chicks of land birds and seabirds, and can cause major declines in these species (Merton et al. 2002). Mice eat the eggs and chicks of small bird species such as storm-petrels, but are capable of killing birds as large as albatross. Disease transmission by rats and mice is thought to have caused mass mortality of seals and other mammals.

Rats and mice consume vast quantities of seeds, flowers, fruits, foliage, bark and seedlings. This severely reduces seedling recruitment which changes the characteristics of native vegetation communities (Rance 2001; Shaw et al. 2005; Brown et al. 2006). The impact that rats have on the regeneration of plants on islands is often not fully appreciated. After rats were removed from the Chetwode Islands, New Zealand, there was a twenty-fold increase in seedling numbers and a seven-fold increase in the diversity of plant species (Brown 1997a).

One of the indirect impacts of rats is the loss of nutrients. Rats kill seabirds and this leads to a reduction in the amount of nutrients available from droppings, regurgitations, failed eggs and corpses. These losses can profoundly affect the health and condition of forest ecosystems (Holdaway et al. 2007), as has happened on Norfolk Island after the loss of the providence petrel (*Pterodroma solandri*).

Ship rats are implicated in the extinction of at least five endemic birds and at least 13 invertebrates on LHI. They are also a recognised threat to at least 13 other bird species, 2 reptiles, 51 plant species, 12 vegetation communities and numerous threatened invertebrates.

The damage caused to the biodiversity of LHI by rats was noticeable very soon after their arrival in 1918. While many extinctions occurred within only a few years of rats arriving on the island, the negative impacts on the island's plants and animals is ongoing. These impacts were clearly evident to Islanders and early naturalists (see box).

'*One can scarcely imagine a greater calamity in the bird world than this tragedy which has overtaken the avifauna of Lord Howe Island*' (McCulloch 1921)

'*People wouldn't believe you now, if you told them how many birds there were before the rats got here*' (L. Wilson in Hutton 1991)

Appendix 2 lists the species on the LHI Group that are negatively impacted by rats and mice. Rats are implicated in a number of species' extinctions and these species are identified in the appendix.

2.1.1 Impacts of rats on birds and reptiles

Rats are implicated in the extinction of five birds[1] on LHI (Hindwood 1940). Rodents also pose an ongoing threat to at least 13 other bird species (DECC 2007).

Two seabirds – white-bellied storm-petrel (*Fregetta grallaria*) and Kermadec petrel (*Pterodroma neglecta*) – that once bred on the main island are now restricted to breeding on smaller, rat-free islands within the LHI Group. They were last recorded breeding on the main island by Roy Bell in 1913-1915, just prior to the introduction of rats. These species nest above ground, where they are highly vulnerable to rat predation.

Rats' consumption of seeds and invertebrates reduces the amount of food available to the islands' seed-eating and insectivorous birds. This competition for food resources is likely to be reducing the abundance of remaining bird populations.

Rats prey heavily on reptiles and have severely reduced the abundance and distribution of the LHI skink (*Cyclodina lichenigera*) and LHI gecko (*Christinus guentheri*) on the main island (Cogger 1971). These species are more abundant on the rat-free outer islets (DECC 2007).

2.1.2 Impacts of rats on invertebrate fauna

Rats are voracious predators of invertebrates. The loss of invertebrates is particularly significant because invertebrates play an important role in maintaining ecological functions, for example, nutrient cycling, pollination, pest control and decomposition.

Rats are implicated in the extinction of at least 13 invertebrates, including two endemic land snails (Ponder 1997) – *Epiglypta howinsulae* and *Placostylus bivaricosus* sub. sp. – and 11 beetles. These beetles, that were present on LHI prior to the introduction of rats, have not been recorded since. This is despite significant effort including a systematic invertebrate survey by the Australian Museum between 2002 and 2004 (C. Reid unpublished data).

The LHI phasmid (*Dryococelus australis*), a stick-insect, has also disappeared from the main island. The only remaining population of phasmid occurs on rat-free Balls Pyramid (Priddel et al. 2003). Likewise, LHI wood-feeding cockroach (*Panesthia lata*) is now restricted to rat-free outer islets.

2.1.3 Impacts of rats on flora

Rats are believed to have caused the extinction of the bridal flower (*Solanum bauerianum*) and native cucumber (*Sicyos australis*) from LHI. The *LHI Biodiversity Management Plan* (DECC 2007) identifies rodents as a threat to 51 plant species and 12 vegetation communities.

Rat predation on seeds and seedlings also severely reduces or stops recruitment of the little mountain palm (*Lepidorrhachis mooreana*) and big mountain palm (*Hedyscepe canterburyana*) (Moore Jr 1966; T. Auld unpublished data). It is thought that seed and seedling predation by rats is hindering the regeneration of the palm stand on Little Slope (Pickard 1982).

Rats consume the seeds of many other plant species including: blue plum (*Chionanthus quadristamineus*), green plum (*Atractocarpus stipularis*), pandanus (*Pandanus forsteri*) and tamana (*Elaeodendron curtipendulum*) (Harden personal observations).

Rats damage the vegetative parts of a number of plant species, including all four species of palms on the island. Rats commonly chew through the rachis, completely detaching the frond from the tree (Pickard 1983; Harden personal observations).

[1] Avian taxonomy in the Plan follows Christidis and Boles (2008).

Rats damage the bark on the trunk and limbs of a number of tree species, including Sally wood (*Lagunaria patersonia*), tamana and island apple (*Dysoxylum pachyphyllum*). In severe cases this can result in the death of the tree (Harden personal observations).

Other indirect effects that rats have on vegetation include the reduction of habitat of some invertebrates and the removal of some fauna food resources.

2.1.4 Impacts of house mice

House mice have probably been present on LHI since about 1860. They are widespread across the island but are most commonly encountered in the settlement area. Mice can occur in high densities (up to 200 per hectare) in areas where rat control programmes are in place (Billing & Harden 2000). This is because the mice have developed resistance to the poison in the rat bait and are using the bait (which is wheat-based) as a source of food.

While the impacts of house mice on the LHI Group may not be as significant or as well understood as those of ship rats, they are likely to be similar to those demonstrated on other islands (see Newman 1994; Jones et al. 2003). For example, evidence on subantarctic Gough Island has identified mice as being responsible for increased mortality of several species of seabird fledglings (Cuthbert & Hilton 2004), including the Tristan albatross (*Diomedea dabbenena*). This albatross is a similar size to the masked booby (*Sula dactylatra*) which is the largest seabird breeding in the LHI Group. New Zealand studies have found that mice prey on reptiles and their eggs and can severely deplete populations (Towns & Broome 2003).

The negative impacts of house mice include:

- mice eat seeds, competing with native seed-eating fauna for food resources
- mice can severely reduce seedling recruitment which in turn changes vegetation communities
- mice eat the eggs and chicks of small bird species, such as storm-petrels
- it is likely that mice have adversely affected populations of the LHI skink and LHI gecko
- mice prey on invertebrate fauna and can cause the extinction of some species, as has occurred on Antipodes Island in New Zealand (Marris 2000)
- mice have been found to detrimentally affect island nutrient recycling systems by reducing the abundance and diversity of soil invertebrates (Smith & Skeenkamp 1990).

2.2 Impacts of rodents on the social and economic wellbeing of island residents

2.2.1 The impacts on the kentia palm and tourism industries

Rat predation on seed of the kentia palm severely reduces seed production (Pickard 1983; Billing 1999) resulting in considerable economic loss. Seed and seedling predation is thought to be sufficient to inhibit regeneration of the palm stand on Little Slope (Pickard 1982).

Evidence from LHI and other islands around the world (Towns et al. 2006) shows that the ongoing impacts of rodents on native fauna and flora erodes the biodiversity and World Heritage values, and the visitor experience offered by the island – the basis of its tourism industry. In other locations the impact of invasive rodents on tourism has been acknowledged and is a primary consideration in decisions to eradicate rodents. In the Seychelles, which is a global biodiversity hotspot, the importance of rat eradication to tourism has been recognised (Nevill 2004). Tourism operators on privately owned islands funded eradications with the primary goal of facilitating the reintroduction of endangered bird species that would enhance their existing tourism operations. Despite a reinvasion on one island, private tourist operators on other islands have continued to embrace the eradication concept. This enthusiasm reflects the realisation that ecotourism is the fastest growing niche market in the tourism industry; and providing pristine tropical island getaways allows the Seychelles to target the exclusive top-end tourist market. A survey of island managements that have undertaken rat eradications showed that ecotourism was the (or one of the) primary motivation(s) behind the activity along with philanthropy and direct commercial issues. Resort owners noted that 'exclusive 5 star tourism and rats don’t mix' (Nevill 2004).

On Ulva Island in New Zealand, an eradication of rodents was undertaken in 1996. The success of the eradication, and subsequent reintroduction of species lost from the island as a consequence of rat predation, have resulted in the island becoming a premier tourist location. Tourist numbers increased from around 10 000 to 30 000 per year in the decade after rat eradication. This boost in tourism resulting from ecosystem recovery sustains 17 new businesses (A. Roberts, Department of Conservation pers. comm.).

2.2.2 The impacts on local residents

Rodents present significant health risks including a range of viruses, bacteria, internal parasites (such as intestinal worms) and external parasites (such as fleas, mites and lice), many of which can spread disease to humans. Currently, keeping rodents out of dwellings is an ongoing task for the island’s residents. They are a major inconvenience; spoiling foodstuffs and contaminating homes with excrement. In addition, the poisons that residents use to control rodents on their properties pose an ongoing risk to small children and family pets, requiring a level of vigilance that would be unnecessary if rodents were eradicated. The ongoing purchase of rodent poisons also imposes financial costs on residents.

3 Past and Present Rodent Control Efforts on LHI

Attempts to control rats began soon after they arrived on the island. From about 1920 until at least 1935, a bounty of a few pence was paid on rat tails by the then Board of Control (Clark 1935). Between 1927 and 1930, approximately 63 000 rats were killed by island residents using sticks and dogs (Hindwood 1940). Other early methods included subsidised shotguns and ammunition.

Between 1920 and 1930, around 100 owls were introduced; primarily masked owl and barn owl (*T. javanica* and *T. furcata*) (Hindwood 1940). This attempt at biological control failed. The owls took some rats but they also caused the extinction of the endemic southern boobook (*Ninox novaeseelandiae albaria*) and inflicted a heavy toll on other birds. The barn owl has disappeared but the masked owl survives and continues to prey on a range of species, including the LH woodhen, LH pied currawong, black-winged petrel (*Pterodroma nigripennis*), brown noddy (*Anous stolidus*), providence petrel, sooty tern (*Sterna fuscata*) and white tern (*Gygis alba*). Masked owls are now considered a pest on LHI and are periodically controlled by shooting.

Control of rats using the poison barium chloride was also tried in the past, but discontinued because it caused the death of many non-target birds (Hutton 1991).

Since 1986, approximately 124 tonnes of bait containing 84 kg of poison has been distributed on LHI, concentrated largely in 140 ha of palm forest and 54 ha of settlement area (see Table 2). The vast majority of this (approximately 110 tonnes) was warfarin impregnated Ratsak® bait (containing 76 kg of warfarin).

Over each hectare of palm forest, approximately 786 kg of bait containing 546 g of poison have been distributed. Over each hectare in the settlement area, approximately 261 kg of bait containing 140 g of poison have been distributed.

Based on figures for 2000–2009, the total amount of bait currently being distributed annually on LHI is approximately 2.1 tonnes, containing approximately 1.3 kg of poison (Table 2).

The current LHI Board rat control programme covers just 10% of the island and costs around $65 000 per annum. Significantly, mice are not controlled at all because they have become resistant to the poison used.

Rat poisons

Rat poisons are generally classified into two types:

1. non-anticoagulant acute poisons
2. anticoagulants.

Non-anticoagulant acute poisons:

- are typically single-dose poisons that act rapidly
- can produce symptoms within one hour and death within a few hours when a lethal dose is eaten
- rarely result in 100% mortality of the target species
- are non-selective (i.e. they don't just kill one species)
- use declined dramatically in the 1950s after the introduction of anticoagulant poisons
- examples include zinc phosphide, cholecalciferol, strychnine, sodium monofluoacetate (sold as 1080).

Anticoagulants

- are substances that stop blood from clotting
- are either single-dose or multiple-dose poisons that act slowly
- usually produce symptoms a few days after being eaten
- are extremely effective because rodents don't link eating the bait to getting ill – by the time symptoms start they have already eaten a lethal dose
- are separated into first-generation and second-generation types

First-generation anticoagulants were developed between 1940 and 1960. They include warfarin, diphacinone, pindone and coumatetralyl. They are generally low toxicity but need a high concentration and several feeds over a number of days to kill their target.

Second-generation anticoagulants were developed in the 1970s and 1980s. They include brodifacoum. They were developed partly because rodents became resistant to first-generation types. They are more toxic so require lower concentrations and only a single feed to kill rodents.

(Sources: Eason & Ogilvie 2009; Hone and Mulligan 1982: Putman undated)

3.1 Control in the palm forest

During the 1950s and early 1960s, the increasing rat damage to kentia palms – which were then the island's prime source of revenue – led to trials with newly developed anticoagulant poisons (see Box: Rat poisons), including diphacinone and warfarin. The use of diphacinone was discontinued because of concerns around the risk to non-target birds (Harden & Leary 1992).

In 1980, a more systematic control programme using warfarin began in an effort to protect the kentia palm forests.

The current control programme in the palm forests, undertaken by the LHI Board, remains largely unchanged since 1986. Approximately 1000 permanent bait stations are dispersed among 33 separate locations in the palm forest, covering approximately 140 ha. The bait used is loose, crushed wheat impregnated with warfarin.

Bait was available continuously early in the programme, however, the mice developed resistance to warfarin (Billing 2000) and were actually feeding on the bait. This resulted in ever-increasing quantities of bait having to be placed in the bait stations. To address this, the frequency of baiting was reduced so that bait was available intermittently, not continuously.

In the current palm forest programme, around 200 g of bait is placed in each station and this is replenished five times per annum (approximately every 10 weeks). While changes have been made to the frequency of baiting, the locations targeted for control have remained essentially the same. The baiting is largely focussed on protecting the kentia palm seed crop from rat damage; however, there is some overlap and extension into identified habitats of *Placostylus* snails.

3.2 Control in the palm nursery

In addition to the rat control undertaken in palm forests, control is also undertaken at the LHI Board's palm nursery and waste management facility using brodifacoum-based baits. At the nursery the aim is to reduce the impacts that rodents (especially mice) have on seeds and seedlings. The nursery uses about 100 kg of Talon® per annum which has brodifacoum as its active ingredient.

3.3 Control in the settlement area

Local residents also control rats in the settlement area using warfarin supplied by the LHI Board. The amount of warfarin bait provided to residents is estimated at approximately 380 kg per annum (Saunders & Brown 2001). This equates to 9.1 tonnes during the 24-year period between 1986 and 2009 (see Table 2).

Residents also purchase brodifacoum and other anticoagulant baits on the island and the mainland to control mice. The quantity of commercial rodenticide used by residents each year on the island is estimated at approximately 400 kg The residential area baited by the community is approximately 54 ha thus the average baiting rate equates to 7.4 kg/ha each year. If the less toxic Pestoff® 20R baits to be used in the eradication were used it would require 18.5 kg/ha/year. Consequently, the proposed coverage during a one-off eradication of 20 kg/ha would amount to the quantity of bait currently used every 13 months by the community over the comparable area.

3.4 Summary of control efforts

Although the current LHI Board rat control programme, which costs around $65 000 per annum, results in some environmental and financial gains, overall the programme is not an effective long-term solution. Significantly, mice are not controlled at all because they have become resistant to the poison used.

There have been few attempts to quantify the effectiveness or biodiversity benefits of the current control programme. Notwithstanding, only 10% of the island is baited; across the other 90% no measures are undertaken to mitigate the impact of exotic rodents.

Table 1 Type and amount of bait used to control rodents on LHI, 1986–2009

(Based on information in Harden & Leary 1992; Saunders & Brown 2001)

Timeframe *Area baited*	Poison	Concentration of poison (parts per million)	Approximate quantity of bait used per year (tonnes)	Total bait used over period (tonnes)	Total active ingredient used over period (g)
Palm forest					
1986–1988	Warfarin	250	7	21	5 250
1989–1999	Warfarin	800	7	77	61 600
2000–2009	Warfarin	800	1.2	12	9 600
			Subtotal	110	76 450
Nursery					
2000–2009	Brodifacoum	50	0.1	1.0	50
Settlement					
1986–2009	Warfarin	800	0.38	9.1	7 296
2000–2009	Brodifacoum	50	0.4	4.0	200
			Subtotal	14.1	7546
			Total	124.1	83 996

4 Options for the Future - the Case for Eradication

4.1 The ‘do nothing’ option

Realistically, this is not an option because failure to eradicate rodents from the LHI Group would:

- compromise the protection and recovery of numerous threatened species listed under State and Commonwealth legislation, and potentially lead to further extinctions
- fail to mitigate a number of key threatening processes listed under State and Commonwealth legislation
- fail to restore, as far as possible, the natural ecological processes on the island
- further degrade World Heritage values
- result in ongoing negative financial impacts on the kentia palm and tourism industries, and island residents
- result in ever-increasing use of poisons to control rodents, with resistance becoming more and more likely
- result in ongoing human health risks associated with diseases that can be transmitted from rodents to residents and tourists, including serious diseases such as leptospirosis, choriomeningitis and salmonellosis
- result in ongoing requirement for the use of rodenticides on LHI to control rodents.

Failure to control or eradicate rodents would also mean that a number of objectives in key strategic planning documents would not be fulfilled (see Section 4.3).

4.2 Continue the current rat control programme

There have been few attempts to quantify the effectiveness or biodiversity benefits of the current control programme. Mice still consume large quantities of the bait, thereby reducing the efficiency of the control programme for rats. Using warfarin baits also provides mice with a supplementary food resource that may enable them to sustain higher population numbers than they otherwise would.

The greatest failing of the current control programme is that benefits to biodiversity are limited to the palm forests included in the control programme, which cover just 10% of the island. A temporary reduction in ship rat numbers is achieved in these areas and this does provide benefits to the local palm seed industry, however, broader biodiversity benefits are minor. Any benefits are short-lived because rats rapidly reinvade baited areas, and there are ongoing risks to non-target species. Control efforts in the settlement area are not likely to provide significant benefits to biodiversity. The large area and rugged terrain of LHI makes widespread control of rodent populations impractical because it would be difficult and cost-prohibitive to access and service the large number of bait stations required. As such, the effectiveness and long-term sustainability of the existing localised control programme is highly questionable.

There is also real concern that, like the mice, rats could become resistant to the poison currently being used. If resistance to a second-generation anticoagulant develops, the option to eradicate rats and mice from LHI using this type of poison will be lost. This could potentially result in a situation where there was no effective way to control rodents on the island, resulting in reduced yields for the palm industry, irreparable consequences for biodiversity, and flow on effects for the tourism industry.

The ongoing and unmitigated use of bait to reduce rat numbers results in the constant presence of poisons in the environment, with ongoing associated risks to non-target native species, pets, livestock and people. The effects of highly concentrated brodifacoum baits (50 parts per million) in the settlement area poses a high risk to wildlife, particularly LH woodhen.

Blue coloured faeces have been seen when handling some birds, indicating they had been consuming dyed, wax bait blocks (Harden 2001). The long-term impacts of poisons on non-target species are unknown.

4.3 Implement an eradication programme

The biodiversity benefits of removing rodents from islands are well recognised, and eradications are now being attempted on increasingly larger and more complex islands, including those with human populations. Eradication has become a powerful tool to prevent species extinctions and to restore damaged or degraded ecosystems (Towns & Broome 2003).

The enormous ecological benefits of removing exotic rodents from islands have been well demonstrated and are well documented (see review in Towns et al. 2006). They include:

- significant increases of seeds and seedlings of numerous plant species on islands after the eradication of various rat species
- rapid increases in the number of ground lizards (e.g. geckos, skinks) following removal of rats – including a 30-fold increase in one case
- dramatic increases in the numbers of breeding seabirds and fledging success
- rapid increases in forest birds.

Rodents have caused the extinction of numerous species within the LHI Group and led to the decline of many others. It is essential that rodents are eradicated so that no more species become extinct. Past extinctions on LHI caused by rats and mice make it clear that rodents are a real threat to the island's biodiversity and they are known to have particularly significant impacts on its birds, reptiles, invertebrates and native vegetation. Any future attempts to reintroduce locally extinct fauna can only be attempted once rodents have been eradicated.

The eradication of rodents would have enormous benefits to a range of species currently known to be adversely impacted by rats and mice including a number of endangered endemic species and others listed in Appendix 2. The eradication of rodents provides the only practicable means of recovering a number of threatened species, restoring natural ecosystem functions, and maintaining the biodiversity and World Heritage values of the LHI Group. In particular, eradicating rats and mice from the LHI Group would provide a range of biodiversity benefits including the following:

- marked increases in the abundance of land birds and seabirds
- the re-establishment on the main island of nesting colonies of white-bellied storm-petrel and Kermadec petrel, both of which are highly vulnerable to predation by rats
- marked increases in the distribution and abundance of the LHI gecko and the LHI skink
- marked increases in the abundance of land snails and other invertebrates
- increase in the abundance of seeds and seedlings, thereby enhancing the process of forest regeneration
- reduced risk of extinction of numerous threatened species, thereby safeguarding the LHI Group's World Heritage status
- allow for the safe return of fauna that have been extirpated by rats and mice, such as the LH gerygone (*Gerygone insularis*), grey fantail (*Rhipidura fuliginosa*) and LHI phasmid.

Given the potential for rodents to develop resistance to poisons used to control them, as has occurred with mice on LHI, the best long-term option to mitigate the detrimental impacts of rodents on the biodiversity of LHI is to eradicate both species. The proposed eradication operation specifically targets both house mice and ship rats.

Due to developments in eradication techniques during the past 20 years, particularly the refinement of aerial baiting methods, the eradication of both rats and mice on the LHI Group in a single operation is now feasible.

The eradication techniques proposed for LHI are neither novel nor experimental. They are the culmination of more than 20 years of development and implementation involving more than 300 successful eradications worldwide (Howald et al. 2007) (see below).

The proposed eradication operation is also supported by a range of international, national and State laws, policies and strategic planning documents, including:

- *Lord Howe Island Permanent Park Preserve Draft Plan of Management* (DECC 2009)
- *Lord Howe Island Group, World Heritage Property and Strategic Plan of Management 2000–2005* (LHI Board 2000), including objectives to:
    - minimise threatening processes including pest animal proliferation
    - eradicate or control unwanted introduced animal and plant species
- *Lord Howe Island Biodiversity Management Plan* (DECC 2007), including objectives to eradicate introduced rodents
- *Lord Howe Island Permanent Park Preserve Plan of Management* (NPWS 1986), including objectives relating to the management of introduced plants and animals, such as:
    - to eliminate, as far as possible, all introduced plants and animals from the preserve ecosystem
    - to maintain undisturbed ecological conditions within the preserve which least promote invasion by introduced species
- *Recovery Plan for the Lord Howe Placostylus* (NPWS 2001)
- *Interim Recovery Actions for the Lord Howe Island Phasmid* (Priddel et al. 2001)
- *Threat Abatement Plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100 000 hectares* (DEWHA 2009)
- *Australian Pest Animal Strategy – A national strategy for the management of vertebrate pest animals in Australia* (NRMMC 2007)
- *Australia's Biodiversity Conservation Strategy 2010–2020* (NBSRRTG 2009).

Predation by exotic rats on LHI is also listed as a key threatening process under the Commonwealth EPBC Act and the NSW TSC Act.

Apart from the benefits to biodiversity, the proposed eradication operation is considered the most appropriate course of action for a range of social, health and financial reasons. The current control programme could be discontinued which would remove the constant presence of rodent poisons in the environment which risks the health of people, pets and livestock.

4.3.1 Eradication operations – past experience

Systematic techniques for eradicating rodents from islands were first developed in New Zealand in the 1980s (Moors 1985; Taylor & Thomas 1989; Taylor & Thomas 1993). Since then techniques have improved significantly, and larger, more complex eradications have been achieved. Worldwide, more than 300 successful rodent eradications have been undertaken (Howald et al. 2007).

Rodents have been eradicated from at least 284 islands (see review by Howald et al. 2007). Of the 387 invasive rodent campaigns, 332 (or 86%) were reported as successful, 35 (or 9%) failed, and 20 did not have a reported outcome. Islands where rodents have been successfully eradicated that have a similar topography, geology and vegetation cover to LHI include Raoul Island in the Kermadecs; and Little Barrier, Codfish and Kapiti islands in New Zealand.

Of the 174 reported attempts to eradicate ship rats, 92% were successful (Howald et al. 2007). The largest island where ship rats have been successfully eradicated is Hermite Island (1022 ha) in Western Australia (Burbidge 2004).

Of the 37 attempts to eradicate mice, 81% were successful (Howald et al. 2007). Another review of mouse eradication attempts (MacKay et al. 2007) calculated a lower success rate: 62% (28 successes from 47 attempts). Since these reviews were written there has been at least eight more successful mice eradication operations. The largest island where mice have been successfully eradicated is Enderby Island (710 ha) in the New Zealand subantarctic region (Torr 2002).

Eradication failures are thought to result from a number of identified issues including technical issues (e.g. inadequate or insufficient bait deployment), failure to follow established protocols, observed or suspected non-target poisoning issues that halted the campaign, lack of funding and public support, and bait competition by terrestrial crabs (Howald et al. 2007; MacKay et al*.* 2007).

The reasons for the lower success rate of house mouse eradications are unclear, but in many cases operations were undertaken with the primary aim being to eradicate rats, so mice were not specifically targeted. For example, some eradication operations have used bait stations at spacings suitable for rats, but too large for mice. In other cases where baits were broadcast, inadequate bait densities were used (Howald et al. 2007; MacKay et al*.* 2007).

Early eradications of rodents from islands typically used traps and bait stations. Due to the time involved in checking and replenishing the stations, these operations were very costly and time consuming for anything other than small islands (less than about 100 ha). Target animals can also be excluded from bait stations by inter- and intra-specific dominance issues (i.e. both mice and rats can be prevented from entering bait stations by dominant individuals, or rats may exclude mice from entering bait stations). This type of behaviour can put eradication operations at risk by violating a fundamental requirement that *all* target animals are exposed to the poison. Although bait stations have been used successfully in some eradications, their use is now generally restricted to small, easily accessible islands.

Hand broadcasting of bait is another technique that has been used; however, it too is extremely resource-intensive and has a greater risk of leaving gaps in bait distribution. When hand broadcasting is unavoidable, it is used over the minimum area possible to maximise cost-efficiency and minimise the risk of failure.

Aerial broadcasting of bait using helicopters has become the standard method used in eradications, particularly those on large islands (Towns & Broome 2003). This method has proven to be a more reliable and more cost-effective option. Depending on the nature of the area to be baited, aerial baiting has been combined with hand broadcasting of bait, particularly around areas of human habitation. The use of new tracking and mapping technologies such as differential global positioning systems and geographic information (computer mapping) systems has increased the efficacy of aerial-based eradication programmes (Lavoie et al. 2007).

The majority of successful eradications on large islands have used aerial baiting with brodifacoum in cereal pellets. The largest island successfully treated this way was Campbell Island (11 300 ha) in the New Zealand subantarctic, where Norway rats (*Rattus norvegicus*) were successfully eradicated.

Similar operations to that proposed for the LHI Group, either completed or planned, include the eradication of:

- ship rats, house mice and rabbits (*Oryctolagus cuniculus*) from Macquarie Island (12 870 ha) in 2010
- nine species including ship rats and house mice from Rangitoto Island, New Zealand (~4 000 ha) in 2009
- four species of rodents, including house mice and ship rats, from several islands in the Bay of Islands, New Zealand (605 ha) in 2009.

These operations offer opportunities to share information on techniques and planning. Not only are the target species similar, Rangitoto Island has a small number of residents and livestock, and the Bay of Islands includes several permanent residents, a full-time tourism operation and numerous day visitors. Macquarie Island, about nine times the size of LHI, will be the largest island from which house mice and ship rats have been eradicated, either individually or in combination. Close collaboration with these programme teams will continue to assist planning for the eradication on the LHI Group.

5 The Proposed LHI Group Rodent Eradication Programme

To minimise the risk of failure it is vital to use techniques that have proven to be successful in a range of environments. Use of published information, previous experience on other islands, on-site research, close collaboration with international experts, and peer review has ensured that planning for the eradication of rodents on the LHI Group is based on current best practice.

The large number of past case studies provides a sound basis for planning the eradication of rodents from the LHI Group. A few consistent themes have emerged as being necessary for an eradication to be successful, including:

- strong public and managerial support and belief in the programme's merit and success
- meticulous planning
- sufficient funding to ensure all stages of the programme are undertaken
- the use of highly skilled helicopter pilots who have previously been involved in eradication operations
- highly motivated and experienced staff with a strong commitment to the task they are undertaking
- access to each property and approval to place baits within each dwelling, and all other buildings.

The planning process for the proposed eradication is outlined in Section 1.2 of this Plan, and comprises 5 distinct phases. The operational component is comprised of the latter three stages which are discussed here:

Stage 3: approvals and preparations

Stage 4: implementation – pre-operational activities and bait distribution

Stage 5: monitoring, evaluation, reporting and improvement

5.1 Approvals and preparations

This part of the proposal focuses on:

- what statutory approvals are necessary for the operation
- when the actual baiting operation should be conducted
- the choice of bait to be used (after considering a range of options)
- the choice of bait distribution methods
- the preparation of property action plans in consultation with island residents
- the pre-operational monitoring and research work detailed in Appendix 1.

5.1.1 Statutory approvals

A number of regulatory requirements will need to be fulfilled in seeking approval for the proposed operation, including a species impact assessment under Section 91 of the NSW TSC Act and a referral under the Commonwealth EPBC Act. These documents will address statutory requirements and will include a comprehensive assessment of the impacts of the eradication programme. The documents will also outline the significance of any potential risks and how these risks will be managed to ensure that adverse effects are avoided, remedied or mitigated.

Other approvals that will be required include:

- Animal Care and Ethics approval to undertake many of the research and monitoring components of the plan
- approval from the Australian Pesticides and Veterinary Medicines Authority to use the proposed bait – Pestoff® 20R
- permissions to aerially bait within 150 m of dwellings and public places required under the NSW *Pesticides Act 1999*.

5.1.2 Timing of the baiting operation

The proposal is to undertake the baiting operation in August. Winter is the best time to distribute bait because at this time of year:

- there is less natural food available for rodents so they will take the baits more readily and the baits will be more effective
- there are generally less rodents because of lower breeding rates and higher mortality rates
- many of the non-target species that are likely to be disturbed or otherwise impacted by the operation will be absent from the island.

As there are minimal numbers of tourists on the island in August, the impacts on the tourism industry can be minimised, and there are more opportunities for accommodating off-island personnel needed for the operation.

5.1.3 Choice of bait

There are three key issues that have to be considered when selecting a bait: the poison, the bait that carries the poison, and the size of the bait pellets.

The poison

A critical component in any eradication is the choice of poison. There is a range of poisons available which could potentially be used in an eradication operation on the LHI Group. An 'ideal bait' (as described by Howald et al. 2007) is one that is:

- palatable and lethal to the target species after a single feed
- persistent in the environment long enough for the target species to be exposed to it, but short enough to minimise impacts on non-target species
- unlikely to lead to bait shyness
- non-toxic or unpalatable to non-target species.

These characteristics guided the selection of the bait for the proposed rodent eradication operation on the LHI Group. Details of the various baits that were considered for use in the proposed operation are provided in Appendix 3 and summarised here.

Non-anticoagulant acute poisons

Non-anticoagulant acute poisons have immediate ill effects on the target species. This immediacy can, however, lead to the pest becoming averse to the bait, eating less of it and not getting a lethal dose. Therefore, acute poisons are generally less effective in operations where complete eradication of the target species (i.e. 100 per cent mortality) is the aim. Regardless of this, all possible options (including a number of acute poisons) were considered for use in the proposed operation.

First-generation anticoagulant poisons

Anticoagulant poisons come in two forms, first and second generation. First-generation anticoagulants are generally low toxicity, need to be at high concentrations in baits, and need to be eaten several times over a number of days to kill their target (Hone & Mulligan 1982). The need for rodents to eat large quantities of these types of baits to obtain a lethal dose of the poison increases the risk of failure in eradication operations. First-generation anticoagulants are better suited to ongoing, repeat application control operations due to their low toxicity and lower risks of secondary poisoning of non-target species.

Second-generation anticoagulant poisons

All second-generation anticoagulants are more toxic than the first-generation anticoagulants. Consequently they have a greater potential to kill non-target species that consume bait. Also, second-generation anticoagulants persist longer in the tissues of those animals that eat the bait and, therefore, there is a greater risk of secondary poisoning. Although generally not toxic to invertebrates, anticoagulants can be ingested by some invertebrates (Spurr & Drew 1999) which may then be eaten by non-target species. Thus, the use of second-generation anticoagulants generally poses more risks than first-generation anticoagulants.

However, the effectiveness of these poisons in eradication operations tends to outweigh the risks.

Brodifacoum

Brodifacoum is a well-known, second-generation anticoagulant poison that is primarily used to kill rodents in and around buildings. It is a very potent anticoagulant that effectively kills rats and mice, including some that are resistant to warfarin. Death is caused by internal haemorrhaging; typically within 3–10 days of ingesting the poison (Hadler & Shadbolt 1975). As it is highly toxic in minute quantities, a lethal dose can be consumed in a single feed thus avoiding the consumption of sub-lethal doses. Although toxic to livestock, pets and humans if accidentally consumed, an antidote is readily available.

Ship rats and house mice are highly susceptible to brodifacoum, and when the poison is contained in Pestoff® 20R bait formulation (see below) it is highly palatable to both species. This has been confirmed by field trials on LHI. Being palatable to both target species greatly simplifies logistics and maximises cost-effectiveness of the proposed programme on the LHI Group.

Brodifacoum does not dissolve in water and binds strongly to soil particles. This prevents it contaminating or leaching into waterways, and consequently run-off into the marine environment is negligible. Brodifacoum is also less likely than other poisons to accumulate in either aquatic systems or plant material (Brown 1994; Ogilvie et al. 1997). The half-life of brodifacoum in the soil is reasonably short (12–25 weeks depending on soil type and conditions) so there is no long-term contamination of soils.

Brodifacoum has proven to be successful in 226 eradications in Australia and around the world, including all 14 eradications on islands greater than 500 ha in size. It has also proven to be successful in a variety of climatic conditions including those similar to the LHI Group. The Department of Environment, Climate Change and Water NSW has used brodifacoum to eradicate rabbits from Cabbage Tree Island (Priddel et al. 2000); ship rats from Brush Island; rabbits and house mice from Montague Island; and rabbits and ship rats from the Broughton Island Group.

Although there are significant benefits in using brodifacoum, there are some risks. Common to other second-generation anticoagulants, the poison persists in the liver for long periods (over nine months), so there is a high risk of secondary poisoning of non-target species. Overall though, the effects on non-target species are well enough understood to enable planning to minimise impacts on susceptible non-target species. Species in the LHI Group that are at risk of primary or secondary poisoning by brodifacoum are identified in Appendix 2. The risk to each species was assessed based on diet, palatability of baits to invertebrate prey, findings of previous studies and observations made during previous eradications using anticoagulants. Only two species of conservation concern were found to be at significant risk from poisoning: LH woodhen and LH pied currawong. The risk assessment (see Section 6 below and Appendix 4) that was undertaken as part of the preparation of this Plan details the risks involved.

Brodifacoum has proved effective and is recommended by Eason and Ogilvie (2009) for one-off use in eradication programmes. They consider the benefits significantly outweigh the negative effects on non-target species. The Island Eradication Advisory Group for the Department of Conservation in New Zealand is of the opinion that '*there is no other alternative rodenticide on the market anywhere in the world with which we would have the same level of confidence in using to eradicate ship rats and mice from an island such as Lord Howe*'.

In summary, brodifacoum is the preferred poison for the LHI Group eradication because it has a high probability of killing all individuals of both target species and has been well tested and proven in numerous successful rodent eradication projects throughout the world.

The bait

There are two companies that currently manufacture brodifacoum bait for aerial distribution to eradicate rodents: one in New Zealand and the other in the United States of America. Due to its more extensive use and proven efficacy in numerous eradications globally, along with lower transport costs, the proposal is to purchase the bait from Animal Control Products in New Zealand.

The bait will be packaged in specially designed weatherproof pods each capable of holding approximately 600 kg. These pods will be shipped individually from Port Macquarie to LHI. The pods can be easily handled by facilities on LHI, and can be stored in the open within a designated loading zone at the airport until needed.

The brodifacoum bait, Pestoff® 20R, is a cereal-based pellet, dyed emerald green to reduce its attractiveness to birds (Brown et al. 2006). Pestoff® 20R is produced to rigorous specifications and is hard enough to withstand being applied through a mechanical spreader. The hardness of the product also means there will be minimal dust residue.

The cereal seed used as the base in the bait is ground to flour, screened to 1.5 mm (smaller than cereal seed) and heated. This 'denatures' the proteins required for germination so there is no risk of the cereal becoming a weed problem. The amount of brodifacoum proposed to be in each bait is 20 parts per million (0.002%), much less than that present in commercially available Talon® (50 parts per million).

Trials using non-toxic bait pellets were undertaken on LHI during August 2007, and they confirmed that the baits were highly palatable to both rats and mice and were readily eaten by both species, a critical prerequisite for eradication. Most birds did not eat the bait pellets, however, the LH woodhen and hybrid mallard/black ducks did eat the baits.

Trials on LHI found that the Pestoff® 20R bait pellets disintegrated completely after approximately 100 days.

As a precaution against ingestion by humans, some commercial rodenticides contain a compound known as bitrex which is extremely bitter and highly distasteful to humans. There are indications that this additive may cause bait aversion in some rodents and this may have contributed to the failure of at least one operation targeting mice. Consequently, bitrex will not be incorporated into baits used in the eradication on LHI.

The use of Pestoff® 20R requires approval from the Australian Pesticides and Veterinary Medicines Authority. Approval has previously been granted to use Pestoff 20R® on several islands in NSW, Western Australia and Tasmania.

The size of the bait

Typically, 10 mm diameter bait pellets are used for eradications targeting rats. The most appropriate size bait to target mice is less certain.

Mice typically have smaller home ranges than rats and are less likely to be exposed to bait when it is broadcast relatively sparsely. This is thought to have been the reason for some mice eradications failing. For operations involving bait stations, a solution is to put the stations as close as 10 m apart. For aerial operations, a possible solution is to use smaller bait that provides a greater number of pellets per unit area. (On average, each 5.5 mm bait pellet weighs approximately half a gram, and each 10 mm pellet weighs approximately two grams. Therefore, when smaller bait pellets are applied at the same number of kilograms per hectare, there is four times the number of pellets on the ground compared to when 10 mm baits are used. This provides a greater number of pellets per unit area and increases the chances of mice coming across the bait, thus improving the chances of all individuals having access to the bait.)

In light of these uncertainties, tests were conducted on LHI to determine the efficacy of both 10 mm and 5.5 mm diameter bait for eradicating mice. Each size bait was applied to different sections of the island and the trials showed that all rats and mice readily consumed baits of both sizes. A recent successful eradication operation on Montague Island, NSW, also demonstrated that both sizes are capable of eradicating mice, provided that there are no gaps in the distribution of bait.

Given that the most difficult component of the eradication will be removing mice from the settlement area, where alternative foods may be more readily available, a high bait encounter rate is preferable. On the other hand, the practical advantages of 10 mm baits over 5.5 mm baits include:

- they have been used successfully in aerial sowing buckets in large quantities
- the pilot can see baits as they are being spread which can be an advantage when distributing baits next to exclusion zones or sensitive boundaries
- it is feasible to retrieve baits accidentally over-sown into exclusion zones during aerial baiting operations.

Given the advantages and disadvantages of each bait size, it is proposed to use 10 mm baits for all aerial operations, and 5.5 mm baits for all hand-baiting operations. The benefits of using two bait sizes justify the added complexity of the operation.

5.1.4 Choice of bait distribution technique

Bait distribution methods that are currently available include bait stations, hand broadcasting and aerial broadcasting (Howald et al. 2007).

Bait stations containing rodenticide are the oldest technique used. Stations are laid out across the landscape in a grid pattern, spaced 25–100 m apart depending on the target species (Howald et al. 2007). Some advantages of using bait stations include: minimal exposure of non-target animals to bait, and reduction in the amount of toxin delivered to the environment. However, there are a number of disadvantages. The use of bait stations is very labour-intensive with regular visits required to top up bait levels, a process that can disturb sensitive species and spread weeds. They are potentially very expensive to use over large areas, given the numbers of bait stations and manpower required to service them. Recent research on mice has shown that their highly restricted movements indicate the need for a 10 m bait grid, which on LHI would mean that 210 000 bait stations would need to be deployed over the 2100 ha surface area of the island. It would also be necessary to cut an extensive network of tracks to allow the bait stations to be accessed on a regular basis. Notwithstanding the above, it is impossible to use bait stations on islands that have steep cliffs (Howald et al. 2007).

Hand broadcasting has proven to be more cost-effective than bait stations and this led to the development of aerial baiting using helicopters (McFadden 1992 in Howald et al. 2007). Eradication operations started using helicopters to broadcast bait in the early 1990s. Since then, aerial broadcasting has generally been used on larger islands and hand broadcasting on smaller islands (Howald et al. 2007).

The benefits of aerial baiting include the ability to broadcast baits on islands with steep and inaccessible cliffs – a significant benefit on LHI. The use of geographic positioning systems and geographic information systems has increased the effectiveness and efficiency of eradiation operations (Lavoie et al. 2007). Another benefit of aerial broadcasting is that these operations are much shorter in duration than bait station eradications which can last up to two years. This means that non-target species are at risk for a significantly shorter period (Howald et al. 2007).

The eradication of rats and mice from the LHI Group requires that every individual of both species is killed in a single eradication operation. To ensure that this happens, it is absolutely critical that every single rat and mouse is exposed to bait during the operation. As the boundaries between the settlement area and natural areas on LHI are not distinct, there is no clear separation of rodent populations into settlement populations and field populations such as may occur in more urbanised towns and cities. However, to ensure that all rodents come in contact with the bait, methods designed for both settlement and field populations of rodents are proposed.

To achieve eradication success, a combination of aerial baiting, hand broadcasting, bait trays (see Section 5.2.2) and bait stations will be used. Due to its efficacy, aerial baiting will be used wherever possible. Hand-broadcasting of bait and use of bait stations/trays will be used over a limited area where aerial distribution is not appropriate.

5.1.5 Preparation of property action plans

As discussed, the input and participation of all island residents and organisations (including the LHI Board) is crucial to the success of any rodent eradication programme. Residents' input is currently being sought and will continue to be sought throughout the life of the programme. Part of this will involve the development of individual 'property action plans'. These action plans will be agreements between the LHI Board and individual leaseholders on how the programme will be undertaken on each leasehold.

Property action plans will be developed to ensure the programme is effective and safe, and will be used to detail a range of things, including:

- existing baiting methods, including the number of bait stations currently in use
- the best ways for residents to control rodents in the lead up to the eradication baiting operation
- during the eradication baiting period, how and where the bait will be placed on each property (including residences, outbuildings, gardens, and pens/enclosures of cattle, horses, goats, pet birds, dogs and other pets)
- how pets will be managed during the baiting period
- how to ensure the health and safety of all family members and pets during the baiting period
- how to deal with food waste, compost and waste disposal in the lead up to, and during the baiting period
- other actions to contribute to the success of the eradication operation.

The eradication of rodents from the LHI Group has a much greater chance of success if access to alternative non-natural food sources is reduced during the baiting operation. Ways in which residents can help include:

- cleaning up poultry pens and taking waste to the vertical composter
- stopping composting prior to the operation and burying all partially composted material in the garden
- removing food scraps from areas used by domestic animals
- storing feed for domestic animals in rodent-proof containers and cleaning up after any spills
- sending all food scraps to the vertical composter
- taking care in waste disposal
- storing edible dry goods in rodent-proof containers
- storing linen and excess bedding in rodent-proof containers or cupboards
- keeping doors and cupboards closed when they are not in use.

Island residents will be asked to play a vital role in monitoring rodent activity during the 100-day baiting period. Monitoring will include: checking for evidence of bait take from bait trays and bait stations; cleaning up all rodent droppings carefully so that any fresh droppings will be easily seen; checking for signs of rodent activity regularly and reporting any findings to the project team.

The LHI Board will also prepare property action plans for lands it manages within the settlement area. In the year leading up to the eradication, the LHI Board will need to clean up any accumulated organic waste that could provide alternative food sources, particularly at places such as the waste disposal plant.

Between June and December in the year of the eradication all food scraps and other edible material will have to be directed to the island's vertical composter, an industrial sized apparatus that transforms putrescible waste into usable compost. The LHI Board will need to ensure that the composter is in good working order and that material produced by the composter does not provide a palatable food source for rodents. If the vertical composter fails, some material may need to be shipped off the island.

The feasibility study conducted in 2001 recommended that the ongoing use of brodifacoum baits be stopped to avoid the potential for resistance to develop in the rodent population. Consultation with island residents and retailers will assess appropriate alternatives. Alternative rat control measures could form part of the property action plans.

5.1.6 Improve existing quarantine measures

A biosecurity strategy (Landos 2003) is currently in operation on LHI. A new strategy will be developed to eliminate, as far as possible, the chances of rats and mice reinvading after the eradication operation.

Given that LHI is approximately 500 km from the closest point on mainland Australia, natural reinvasion is impossible. However, rodents could possibly be transported to LHI by any of the following:

- fortnightly cargo shipments from the mainland (Port Macquarie)
- daily scheduled Qantas flights from Brisbane and Sydney
- flights by a local aviation company to the mainland, mainly to collect fresh produce
- other private or military aircraft
- private yachts visiting the island.

Rodent control is already in place on the cargo ship, the *Island Trader*, that delivers goods to LHI.

Some additional measures will be needed to ensure rodents are not reintroduced once they have been eradicated. Where possible these measures will be introduced prior to the eradication operation. These measures include improved checks of cargo before departure from the mainland, in-transit checks of sea freight, pre-landing inspections of the cargo vessel and private yachts, and arrival inspections of all aircraft and passengers.

It is proposed that most of these inspections will be conducted using trained detector dogs. The costs associated with acquiring and training such dogs are included in the budget which has been prepared as part of Stage 2 of the planning process. It is recommended that the ongoing costs, including salaries for the handler and maintenance of the dogs, be met by the environmental levy imposed by the LHI Board. This is justified on the basis that improved quarantine has broad biodiversity benefits.

These additional quarantine measures will assist in preventing other exotic flora and fauna from invading LHI. This has been identified as one of the major ongoing threats to the biodiversity of the LHI Group and its prevention is a high priority (DECC 2007). The introduction of highly undesirable species such as cane toads (*Bufo marinus*), crazy ants (*Anoplolepis gracilipes*) or snakes would have devastating consequences for residents and the local tourist industry, as has occurred elsewhere. For example, the brown tree snake (*Boiga irregularis*) was transported from the Philippines to Guam, where it killed almost the entire native bird population on this previously snake-free island. The snake has no natural predators on the island, and consequently Guam now has one of the highest snake densities in the world (an estimated 2000 snakes per square kilometre).

5.2 Implementation: the baiting period

This phase of the proposed eradication programme involves the actual distribution of bait and the monitoring of its impact. It will last approximately 100 days – or as long as the aerially and hand-broadcast baits persist in the environment. However, this period is weather-dependent and the actual period of risk will be determined by the measured rate of bait disintegration.

5.2.1 Pre-operational activities

A number of pre-operational activities need to be completed prior to bait distribution, including:

- purchasing bait and materials
- contracting appropriate helicopter support, aviculturist and veterinarian
- constructing aviaries and on-island captive trials
- mapping of flight lines
- improving quarantine procedures
- preparing contracts/agreements for all aspects of the eradication including the removal of stock
- establishing all monitoring programmes.

All procurement procedures will follow relevant NSW Government guidelines and policies.

5.2.2 Bait distribution

The bait will be distributed at a nominal dose rate of 20 kg of bait (or 0.4 g of poison) per hectare. At this rate, 42 tonnes of bait (containing 840 g of brodifacoum) will be required to cover the total island surface area of 2100 ha.

The following sections outline the general intended methods for baiting the islands; however, the details of baiting on settlement and leasehold properties will be in the individual property action plans (see Section 5.1.5).

Area to be baited

Rats and mice occur throughout LHI, including the settled areas. LHI is the only island in the LHI Group that is known to contain rats. However, ship rats are able to swim over 500 m and are difficult to detect at low densities. It is therefore possible that they occur on offshore islets close to the main island. To minimise the risks of operational failure, the main island and all islands and islets, other than Balls Pyramid and its associated islets, will be baited. The 23 km distance between Balls Pyramid and the main island renders the chances of invasion by rodents very low.

Number of bait drops

The proposal is for aerial and hand baiting to be carried out twice: once at the commencement of the baiting period, and again about 14 days later (depending on the weather). This will maximise the exposure of rodents to the bait.

The nominal application rate for the first bait drop will be 12 kg of bait per hectare, and 8 kg per hectare for the second drop. These application rates relate to the actual surface area of the islands.

Most rodents will be killed by bait from the first bait drop. However, it is beneficial to carry out a second bait drop to eliminate the likelihood of any gaps in the distribution of baits and to target:

- individuals that may have been denied access to bait distributed in the first application (by more dominant individuals that will now be dead)
- any surviving young that have recently emerged from the nest.

Bait drops will be timed to avoid periods of predicted heavy rainfall. Weather forecasts of rainfall and wind speeds will be obtained from the Bureau of Meteorology station on LHI from late July onwards. A forecast of less than 15 knots and four fine days (three fine nights) without significant rainfall (less than 6 mm daily) is preferred for each drop.

Aerial baiting

Aerial baiting will be conducted throughout the LHI Permanent Park Preserve, including Admiralty Islands, Blackburn Island, Muttonbird Island and other areas of the main island excluding the settlement area and identified buffer zones. In all areas baited aerially, 10 mm baits will be broadcast at a nominal density of at least one bait every two square metres.

In line with current best practice, cliffs and steep slopes (particularly around Mt Gower and Mt Lidgbird) will be flown more than once during each baiting operation. Actual ground cover in these areas will be calculated to ensure adequate bait coverage.

The bait will be dispersed using a spreader bucket slung below a helicopter. A rotating disc throws the bait up to 40 m sideways, enabling a swathe of up to 80 m to be baited in a single pass. Overlapping each swathe will ensure that there are no gaps in the distribution of baits. The dose rate, bait direction and swathe width can all be controlled within set limits. This combination of techniques will enable all terrains on the LHI Group to be effectively baited. The exact method of distributing bait aerially on LHI will be finalised in consultation with the helicopter contractors. Additional precautions will be taken to ensure that spillage of bait into the marine environment is minimised.

A 30 m buffer zone will be established around all dwellings and containment areas for livestock. In these buffer zones bait will either be applied aerially using specialised equipment that limits the spread of bait, or will be broadcast by hand. The bait will be distributed at a rate 50% higher than elsewhere around livestock containment areas.

Differential GPS will be used to guide the helicopter along a set of pre-determined paths designed to ensure that all areas are adequately baited. Computer-generated plots of the actual path flown will be inspected after the flight to confirm that this has been done. Any identified gaps will be re-flown.

Although some bait will inevitably get caught in the forest canopy, the vast majority will fall through to the forest floor where it will be available to rats and mice. Aerial baiting trials conducted on LHI in August 2007 confirmed this. Wind will dislodge the bulk of the bait held in the canopy but baits that remain lodged in trees will still be available to ship rats because they spend considerable time in the forest canopy, as evidenced from the damage they do to palm seeds. Notwithstanding, the amount of bait to be dropped has been determined knowing that a small proportion of it may not be available to the rodents.

Hand broadcasting of bait

Hand broadcasting of bait will be conducted concurrently with aerial baiting. It will be undertaken throughout the settlement area and in buffer zones. In the settlement area, 5.5 mm baits will be hand-broadcast at a nominal density of at least one bait every half square metre. Provisional areas to be hand-baited are shown in Figure 2.

Trained personnel will move through such areas and apply bait at the designated rate. All personnel will carry a GPS unit capable of continuously tracking their path. Computer-generated plots of their paths will be used to check bait coverage. The aim will be to distribute baits in garden beds and other areas of vegetation around dwellings, rather than broadcast on lawns. These details will be contained in the individual property action plans.

It is essential that all hand-broadcast bait be out in the open so it is subject to degradation by weathering. No bait will be hand-broadcast directly in or under buildings where it will not be subject to weathering.

Bait stations

Bait stations will be used where aerial or hand broadcasting cannot be undertaken.

Where practicable, and with the agreement of householders, small amounts of bait in open containers (‘bait trays') similar to commercial products currently available will be placed within buildings. Where possible, bait trays will also be put in any accessible roof cavities and under-floor cavities. Additionally, bait stations will be placed within all areas containing livestock (cattle, horses and goats). These bait stations will need to be able to withstand interference and trampling by stock and so will be designed specifically for this eradication operation.

All bait trays and bait stations will be monitored regularly and bait replenished as necessary for 100 days after the second baiting (or longer if surviving rats or mice are detected). Bait take will provide an indication of rodent activity. Bait in these locations will not be exposed to weathering, and so any remaining bait will be removed 100 days after mice or rats are no longer detected.

When using bait stations or trays it is important that they are set close enough together that individual rats and mice come across at least one station during their daily movements. Rats are wide-ranging and can be eradicated using a grid spacing of 25 m. Mice, however, are not as wide-ranging, and require a grid spacing as close as 10 m.

Figure 2. Areas proposed to be hand-baited (shaded areas)

5.3 Post-operation

5.3.1 Release of captive held animals

Once the period of risk has passed, all captive animals will be released back into the wild (see Sections 6.3.1 and 6.3.3).

Where livestock have been removed from the island, they will be replaced in accordance with agreements between the LHI Board and individual leaseholders.

5.4 Cost of the proposed programme

The cost of the programme is estimated at approximately $8 million over a four-year period. Funding for the programme has not been secured and will need to be sourced from grants such as those available under the Australian Government's *Caring for our Country* programme.

5.5 Monitoring, evaluation, reporting and improvement (MERI)

The eradication will be declared a success if rodents are not detected for a period of two years.

An eradication such as the one proposed in this Plan can provide valuable information on the mechanism of ecosystem restoration and the biodiversity benefits that result from such action. Monitoring the benefits of eradicating rodents from the LHI Group is likely to be a requirement of any funding body. The information gained can also feed into the reporting requirements for the LHI Board, Department of Environment, Climate Change and Water NSW, and the NSW State Plan.

Knowledge of the ecosystem impacts of removing rats and mice from the LHI Group can be used by others planning similar operations, and by ecologists attempting to understand the impact of invasive species on ecosystem function. Consequently, monitoring will be undertaken to determine the changes in the distribution and abundance of key taxa. To provide the necessary baseline information, monitoring needs to commence prior to the eradication and continue for at least three years after the eradication. Continued monitoring beyond this period is highly desirable, not only for its own intrinsic value and to demonstrate the benefits of this investment, but also for its contribution to both the NSW and Commonwealth monitoring programmes for fauna and threatened species (MER and MERI respectively). However, funding for long-term monitoring of the outcomes of conservation initiatives is, as always, problematic. Sources of long-term funding for monitoring have yet to be identified.

Appendix 1 details the types of monitoring and research that are proposed before, during and after the baiting operation.

6 Managing Risks Associated with the Eradication Programme

A detail risk assessment has been undertaken for all aspects of the eradication programme including: legislative and regulatory, environmental, human health, tourism, pets, financial, operational, capability (of people), biosecurity, resource, stakeholders and political. The risk matrix and a detailed discussion of the various risks are provided in Appendix 4.

During the statutory approval process a more detailed risk analysis will be done, and appropriate amendments to other documents and the programme's scope will be made as required.

Risk is defined as negative factors which may seriously delay or compromise the implementation of the plan (i.e. timeframe or techniques) and may affect the outcomes of the operation. Risks may be external or internal to the project. Internal risks are those associated with the consequences of decisions made while managing or implementing aspects of the operation. External risks are normally outside the influence or control of project management.

The overall risk is expressed in terms of the likelihood of occurrence and the consequence of occurrence using a general risk assessment matrix (see Appendix 4).

In summary, any potential negative consequences are far outweighed by the benefits of the proposed eradication operation. Non-target impacts are expected, but these will affect some individuals only and will be sustainable at the population level. No significant or irreversible impacts are expected for any non-target species.

A number of additional actions have been proposed to manage identified risks to humans, the tourism industry, non-target species, the environment, livestock and pets. These are outlined below and discussed in more detail in Appendix 4.

6.1 Human health

Brodifacoum at the low concentrations specified for this operation is of low toxicity to humans and an antidote is readily available. In NSW in 2008–09, the Poisons Centre (J. Kirby NSW Poisons Centre pers. comm.) reported that incidents of human exposure are confined to small children through accidental poisoning and people intent on self-harm. In no cases did children require treatment, and all adults were successfully treated. These same risks already exist on LHI for current rodenticides and similar risks exist for a range of cleaning products and other household chemicals stored in the home.

Of the four possible pathways for humans to be affected by brodifacoum, direct ingestion of baits is the only one that poses a potentially significant health risk. The group of residents most at risk are small children, and parents will need to be vigilant to ensure that children do not ingest baits for the period that the pellets are present (they will have disintegrated after 100 days and no longer be available to be ingested).

The antidote for brodifacoum poisoning is vitamin K. Brodifacoum is slow acting and several days are available for treatment. In the unlikely event that a person or child ingests bait, medical advice and aid will be provided on the island. There is a hospital on LHI and diagnostic and treatment procedures will be discussed with the island's medical doctor as part of the operational planning process.

A detailed information sheet outlining the hazards associated with brodifacoum will be prepared for residents prior to the operation. Talks will also be given at the island's school to inform children of the operation and how they should behave around the toxic baits.

Residents will be informed of the date of baiting well in advance, and will be issued with reminders closer to the date. Residents will be kept informed of progress and will be notified when baits have disintegrated and there is no further risk of poisoning.

In line with standard occupational health and safety procedures, personnel distributing baits will wear protective gloves and face masks to eliminate the minimal risk posed by inhaling or absorbing the toxicant through the skin.

6.2 Tourism

The most popular time to visit the LHI Group is between September and June. The baiting programme is scheduled to take place during the month of August which is traditionally in the 'off-peak season'. As such, the timing of the baiting operation is unlikely to impact tourism.

Between 1998 and 2009, tourists in August comprised 3.1–5.0% of the annual visitor totals. Tourist numbers ranged between 392 and 779 which, based on an average stay of 6.4 days and a maximum 400 bed capacity per night, indicates bed occupancy rates of between 20% and 40% for August in these years. The presence of an estimated 40 project staff during this period will require 10% of the available beds on the island, providing a significant boost to the island economy during the low season. These staff will also contribute to the economy through the purchase of food and meals from local shops and restaurants.

Despite the limited impact on visitation, it is important that an 'interim' tourism strategy be prepared to ensure that visitors are informed of the date of baiting well in advance. The interim strategy will be prepared in consultation with the LHI Tourism Association, tourism operators on the island and Tourism NSW. Visitors who choose to visit during this period will be issued with detailed information outlining the proposed operation. The strategy will also consider promotional strategies for the LHI Group following completion of the eradication programme.

6.3 Environmental

6.3.1 Birds

Non-toxic bait trials conducted in 2007 confirmed that LH woodhen will ingest baits in amounts that would be fatal. Research also shows that LH pied currawongs consume rodents and so would be susceptible to secondary poisoning. To minimise the impact on these two threatened species, a substantial proportion of each population will be taken into captivity on LHI and will remain there for the duration of the operation – until the baits have disintegrated and pose no further risk. In accordance with best practice captive management, a small population of LH woodhen will also be held in captive management on the Australian mainland.

In addition, although operational risks are low, prudence requires that small numbers of LHI golden whistler, LHI silvereye (both endemic species) and emerald ground-doves be held in captivity during the eradication (see Appendix 4).

Captive facilities to temporarily house these birds will be built on LHI. All captive management (including aviary design) will be overseen by acknowledged leaders in avian husbandry. A specialist aviculturist will be present on the island during the period of captivity. A veterinarian will be present during the capture and will be on call throughout the period of captivity.

Providence petrels (*Pterodroma solandri*) are ashore breeding in August, but at this time of the year they have chicks in the burrow and by day are generally foraging at sea, usually not returning to the island before mid-afternoon. To minimise the risk of bird strike, as far as practicable, all helicopter operations near the summits of the southern mountains will be conducted during the morning.

Masked booby will be breeding during the operation, and some will have eggs and possibly chicks in the nest. Grey ternlets (*Procelsterna cerulea*) may also have begun nesting. These two species nest above ground, so care will need to be taken to minimise disturbance and avoid bird strikes while flying helicopters over these colonies. Preparations will include briefing helicopter pilots of this risk.

6.3.2 Reptiles

There are two species of native reptiles on LHI: LHI skink and LHI gecko. Both species occur on the main island and on many offshore islets around LHI as well as on Norfolk Island. These species are considered to be at low risk of poisoning, and are likely to substantially increase in abundance following the removal of rodents. Research on LHI's reptiles is commencing in summer 2009 as part of the pre-operational preparations.

6.3.3 LH placostylus

Brodifacoum is not expected to have significant effects on invertebrates as they have different blood clotting systems compared with mammals and birds. However, research will be conducted on the vulnerability of the LH placostylus to brodifacoum baits, and if significant mortality occurs provision will be made to collect and house animals in captivity for the duration of the eradication operation. Techniques for captive breeding of this species are currently being investigated.

6.3.4 Fresh water bodies

Any baits entering streams or other water bodies on LHI will sink and disintegrate, usually within a few hours depending on turbulence and rate of flow. The minute amount of brodifacoum in the bait (20 parts per million) settles in the sediment where it binds to organic material and breaks down. Although it has been shown that brodifacoum will not contaminate water bodies (Morgan & Wright 1996, Ogilvie et al. 1997), tests will be undertaken on designated fresh water bodies to assess and monitor brodifacoum levels after the bait drop. Prior to the operation, residents and tourists will be advised not to drink from streams until the water has been tested and verified to not contain detectable traces of brodifacoum. During the few days it will take to collect and analyse the water samples, drinking water will be positioned at several locations along the track to Mt Gower.

6.3.5 Marine environment

While every effort will be made to ensure that bait is directed onto land, it is inevitable that a small amount of bait will enter the marine environment, particularly where cliffs come right to the shoreline. Most of this bait will fall within a few metres of the shoreline and will be subjected to the mechanical effects of wave action, resulting in disintegration within a few minutes (Empson & Miskelly 1999). This, together with the high dilution factor, and the insolubility of brodifacoum in salt water, means that the potential risk to marine organisms is negligible. The amount of brodifacoum assimilated into the marine environment will be many orders of magnitude lower than the concentrations known to be toxic to fish (Empson 1996).

In the lagoon, where wave action is not as great as the open ocean, disintegration of the bait pellets will take longer. Consequently, additional care will be taken to prevent bait entering the lagoon. This will be done by aerial baiting with specialised equipment that limits the spread of bait, or by hand-broadcasting of bait along the shoreline of the lagoon. Also, divers will be present to remove any bait that falls into the water.

Outside of the lagoon some marine organisms may feed on the residual particles and some fish may feed on the bait before it disintegrates. However, there are very few recorded instances of fish mortality due to ingestion of brodifacoum. Even an accidental spillage of 18 tonnes of bait at Kaikoura, New Zealand, resulted in no known fish deaths (Primus et al. 2005). A study of marine fish undertaken during the operation to eradicate rats on Kapiti Island found no evidence that their population densities were adversely affected (Cole & Singleton 1996). Notwithstanding, brodifacoum is toxic to fish so it is possible that a small number of fish may be killed. However, no species or population will be put at risk.

To confirm the risk to fish, observational studies using local divers will be undertaken to determine which fish species consume baits dropped into the ocean. Fish species that readily consume baits will undergo laboratory studies to determine their susceptibility to brodifacoum and to measure the uptake of toxicant into body tissues. The risk to these species will then be reassessed.

6.3.6 Livestock and pets

Livestock

Having livestock present during the eradication poses a substantial risk to the success of the operation. Consequently, the proposal is to as far as possible de-stock the island prior to the eradication. Stock feed provides an ideal harbour and food source for rodents. If rodents have access to this feed or any spillage they may not take baits. There is also a risk that livestock may consume baits.

De-stocking of beef cattle prior to the eradication will be done largely through orderly culling and butchering. Replacement breeding stock will then be brought to the island when the breakdown of bait in paddocks is complete. Most stock-owners on the island have indicated their willingness to cooperate in this process, subject to satisfactory compensatory arrangements being put in place.

With the proposed mitigation measures in place there is little likelihood of brodifacoum entering the human food chain via milk from the dairy herd. As such, it will be safe for the dairy herd (approximately 14 animals) to remain on the island throughout the operation, if requested by the owners. Animals will be confined to a small paddock and will receive supplementary feed during the period that bait is present (approximately 100 days). Baiting within the holding paddock will use cattle-proof bait stations. Although brodifacoum is unlikely to be excreted in milk, as a precaution the milk will be tested to ensure that it does not contain traces of poison. It is recommended that milk should not be consumed immediately after each bait drop until testing is complete. Testing is expected to take 3–5 days.

Similar arrangements will be made for goats (approximately 12) and horses (approximately three) confined during the risk period. All confined livestock will be fed with fresh-cut grass from unused paddocks, alleviating the need to store food which may provide an alternative food source for rodents.

Poultry will be exposed to the risk of primary poisoning from baits spread around the settlement area. More significantly, the presence of poultry poses a major risk to the success of the operation as the presence of large amounts of feed grain has the potential to distract rodents from consuming the bait. All poultry will be removed from the island or culled at least one month prior to the eradication. Once all bait has disintegrated and no longer poses a threat, disease-free day-old chicks will be brought to the island to replace those birds removed.

Dogs

Dogs are at risk from both primary and secondary poisoning from brodifacoum. Owners will need to be vigilant to prevent animals from eating baits or consuming dead or dying rodents. Residents are already familiar with the risk and, as far as is known, there have been no reported incidences of anticoagulant poisoning from current control operations. To assess the risk to each dog, owners will be provided with a sample of non-toxic bait many months prior to the operation. Any dogs that have a propensity to eat baits may need to be muzzled and/or kept on a leash during the period that bait is present on the ground.

The option of removing dogs from the island for the duration of the risk period and housing them in boarding kennels on the mainland will be available to any concerned residents, at no cost. In the unlikely event of poisoning, the affected dog will be treated with a course of vitamin K injections administered under veterinarian supervision.

6.3.7 Potential adverse effects of removing rodents

Notwithstanding the enormous benefits of removing rodents from offshore islands, there have been unintended negative consequences in some instances. For example, some exotic species have been reported to increase after rodents have been removed. On LHI, exotic species that could potentially increase after rodent removal include: masked owl, grass skink (*Lampropholis delicata*), bleating tree frog (*Litoria dentata*), several introduced bird species and some species of weeds.

The grass skink is probably subject to predation by rodents and its numbers may increase after rodents are removed. However, this species established in the presence of rodents and is already widely distributed and abundant across the island, suggesting that its numbers are not greatly controlled by rodents. The native LHI skink is adversely affected by rodents, and is expected to flourish following rodent eradication. It is possible that the larger LHI skink will compete with the smaller introduced skink, reducing its abundance. Baseline monitoring of the grass skink will measure population densities pre- and post-eradication.

The bleating tree frog is also a recent introduction to LHI and has also established in the presence of rodents, again suggesting that it may not be significantly controlled by rodents. Notwithstanding, this frog is an unwelcome exotic species with unknown consequences on the LHI ecosystem. Research will be conducted to collect baseline population densities and investigate what options are available to control or eradicate this frog.

Some weeds whose seeds are destroyed by rats and mice may be kept at low densities by rodents. However, many weeds are also spread by rodents when they cache fruit and seed. The rodent eradication may result in native plants out-competing some weed species. The LHI Board currently has a systematic weed eradication programme in place and is reducing weed density extensively. This programme will continue beyond the proposed rodent eradication. In addition, a rapid response and detection protocol for the introduction of new weeds and exotic fauna is currently being prepared as part of the implementation of the *LHI Biodiversity Management Plan* (DECC 2007).

If rats are eradicated but not mice, it is possible that the numbers of mice on LHI could increase. This Plan specifically targets both rats and mice. Considerable additional effort has been included to target mice specifically to maximise the chances of eradicating both species.

7 Consultation and Communication

The eradication of ship rats and house mice from the LHI Group will generate substantial interest on the island, within NSW, across Australia and around the world.

To ensure the eradication operation is a success, it is essential that the residents of the island are willing and able to fully participate. To achieve this, the community will be engaged in all aspects of the operation, and residents may play active roles. Success is also dependent on the support of government agencies and all stakeholder groups.

A Communications Strategy (LHI Board 2008) has been developed to guide ongoing consultation, coordinate the dissemination of information, raise awareness of the eradication to multiple stakeholders both on and off LHI, and promote the long-term goals and benefits of the proposed operation. The Communication Strategy focuses on several stakeholder groups both on and off the island. The groups broadly consist of residents, government agencies, members of parliament, non-government organisations, media, and specialist groups such as philanthropists and scientists. The Strategy recognises that each group has particular needs and different communication methods are proposed for the various phases of the operation.

7.1 Consulting and communicating with residents

The Strategy emphasises the essential role that the local community will play in the operation, and details ways to inform and consult with them. Consultation with residents has already commenced and the results of these exchanges have been incorporated into this Plan. This process will continue and residents will continue to be consulted throughout the planning, operation, monitoring and evaluation stages of the eradication programme through the following ways:

- Community meetings to inform residents about the eradication programme and address any questions or concerns they may have. Additional meetings will be held with livestock owners, chicken owners, dog owners, tourism operators and residents who live outside the settlement area.
- One-on-one meetings with island residents will discuss eradication plans for individual lease areas and provide residents with the opportunity to give feedback to staff about the programme as it progresses. This will include the development of individual 'property action plans' (Section 5.1.5). These action plans will be agreements between the LHI Board and individual leaseholders on how the programme will be undertaken on each property.
- Phone calls to residents (particularly livestock and chicken owners, residents outside the settlement area and tourism operators) to alert them to critical phases of the programme.
- Fact sheets will outline key aspects and address community concerns relating to the eradication.
- Letters targeting island residents will notify them of critical stages in the programme (e.g. first and second bait drops, and end of the risk period).
- Editorials in *The Signal*, the local LHI newspaper, will inform local residents of activities associated with the programme, along with updates on research findings, and progress.
- Information notices will be erected at multiple points around the island to notify people of the commencement of the programme, closures during the risk period and warnings to avoid contact with poison baits.
- Escorted site visits for LHI school children and interested residents will provide insight to rodent issues, progress with the project and successful outcomes. This will also be extended to media representatives, politicians, agency executives, non-government organisations and representatives of funding bodies visiting the island.

- Engagement with the LHI school to raise awareness of the impacts of rodents on island biodiversity, plans for eradication, protection of endemic species and the benefits of eradication.

7.2 Communicating with visitors

Visitors to the island will be informed throughout the planning, operation and monitoring stages of the eradication programme. The eradication operation will be undertaken in the off-peak season and is likely to have minimal impact on tourism to the island. Despite the limited impact on visitation, it is important that an 'interim' tourism strategy be prepared in consultation with the LHI Tourism Association, tourism operators on the island and Tourism NSW to cover the period of the eradication operation.

The strategy will establish the most effective way to distribute information about the eradication programme to visitors who are planning to visit the island. It will also include information for visitors present during the baiting operation. The strategy will also consider options for 'value-adding' during the period of baiting for visitors who choose to visit the island during the operation.

The strategy will also consider promotional strategies for the LHI Group after the completion of the eradication programme.

7.3 Communicating with other stakeholders

Other key stakeholders will be informed throughout the planning, operation and monitoring stages of the eradication programme though briefings, reports and through information available on the LHI and Department of Environment, Climate Change and Water NSW websites. Targeted media will be briefed on the proposal at appropriate times.

During the preparation of this Plan there has been extensive consultation and communication with the scientific community, including overseas eradication experts. Considerable technical assistance has already been provided by the New Zealand Department of Conservation who are the world leaders in rodent eradication on islands and this Plan has been peer reviewed by Australian and international experts (see Appendix 5 for a summary of the peer review). This consultation will continue throughout the duration of the project.

Glossary

target species	species that the poison is aimed at killing – in this case ship rats and house mice
non-target species	species that the poison is not aimed at killing
lethal dose	the amount of poison required to be ingest in order to kill the animal
sub-lethal dose	an amount less than the lethal dose
resistant / resistance	an animal (e.g. rat or mouse) that is not affected by the poison
orographic	orographic clouds are clouds formed when air passes over a mountain or ridge
primary poisoning	poisoning resulting in the ingestion of a poison bait
secondary poisoning	poisoning resulting from an animal ingesting an animal that has eaten a poison bait
control	to regulate, restrain or hold in check
eradicate / eradication	the intentional total extermination of a species or population
rachis	on a palm frond, the stalk that the leaflets are attached to
taxa	a number of species or broader taxonomic groups

Acronyms and abbreviations

EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
LHI	Lord Howe Island
LHI Board	Lord Howe Island Board
NSW	New South Wales
TSC Act	*Threatened Species Conservation Act 1995*

References

Billing, J. (1999). The management of introduced rodents on Lord Howe Island. Unpublished report. Lord Howe Island Board, Lord Howe Island.

Billing, J. (2000). The control of introduced *Rattus rattus* L. on Lord Howe Island. II. The status of warfarin resistance in rats and mice. *Wildlife Research* **27**, 659-661.

Billing, J. and Harden, B. (2000). Control of introduced *Rattus rattus* L. on Lord Howe Island. I. The response of mouse populations to warfarin bait used to control rats. *Wildlife Research* **27**, 655-658.

Booth, L. H., Eason, C. T. and Spur, E. B. (2001). Literature review of the acute toxicity and persistence of brodifacoum to invertebrates. In 'Department of Conservation 2001: Literature Review of the Acute Toxicity and Persistence of Brodifacoum to Invertebrates and Studies of Residue Risks to Wildlife and People'. Eds J. Jasperse and L. Clelland. pp. 1-9. (Department of Conservation: Wellington.)

Booth, L. H., Fisher, P., Heppelthwaite, V. and Eason, C. T. (2003). Toxicity and residues of brodifacoum in snails and earthworms. DOC Science Internal Series, No. 143. Department of Conservation, Wellington, New Zealand.

Bowie, M. H. and Ross, J. G. (2006). Identification of weta foraging on brodifacoum bait and the risk of secondary poisoning for birds on Quail Island, Canterbury, New Zealand. *New Zealand Journal of Ecology* **30**, 219-228.

Brown, D., Wylie, M. and McClelland, P. (2006). Assessment of environmental effects for the eradication of: Ship rats (*Rattus rattus*) from Taukihepa, Pukeweka and Solomon (Rerewhakaupoko) Islands; and Kiore (*Rattus exulans*) from Big Moggy (Mokonui) Island. Unpublished Report. Department of Conservation, New Zealand.

Brown, D. A. (1997a). Chetwode Island kiore and weka eradication project. *Ecological Management* **5**, 11-20.

Brown, K. P. (1997b). Impact of brodifacoum poisoning operations on South Island robins *Petroica australis australis* in a New Zealand *Nothofagus* forest. *Bird Conservation International* **7**, 399-407.

Brown, R. A. (1994). Assessing the environmental impact of rodenticides. In 'Rodent Pest and Their Control'. Eds A. P. Buckle and R. H. Smith. pp. 363-380. (CAB International: Wallingford, Oxfordshire.)

Burbidge, A. A. (2004). Montebello Renewal: Western Shield Review-February 2003. *Conservation Science Western Australia* **5**, 194-201.

Christidis, L. and Boles, W. E. (2008). Systematics and taxonomy of Australian birds. CSIRO Publishing, Collingwood.

Clark, H. L. (1935). The paradise of the Tasman. *National Geographic* **68**, 115-136.

Cogger, H. G. (1971). The reptiles of Lord Howe Island. *Proceedings of the Linnean Society of New South Wales* **96**, 23-38.

Cole, R. G. and Singleton, R. J. (1996). Monitoring of reef fish populations at Kapiti Island during aerial poisoning for rats 1996. Unpublished report prepared for Wellington Conservancy, Department of Conservation, Wellington. National Institute of Water and Atmospheric Research, Nelson, New Zealand.

Colman, P. (1974). Appendix E. Terrestrial molluscan survey. In 'Environmental Survey of Lord Howe Island'. Eds H. F. Recher and S. S. Clark. pp. 47-54. (New South Wales Government Printer: Sydney.)

Craddock, P. (2004). Environmental breakdown of Pest-Off poison bait (20ppm brodifacoum) at Täwharanui Regional Park, North of Auckland. Unpublished report prepared for Northern Regional Parks, Auckland Regional Council. Entomologica Consulting, Auckland.

Cuthbert, R. and Hilton, G. (2004). Introduced house mice *Mus musculus*: a significant predator of threatened and endemic birds on Gough Island, South Atlantic Ocean? *Biological Conservation* **117**, 483-489.

DECC – *see* Department of Environment and Climate Change.

DEWHA – *see* Department of Environment, Water, Heritage and the Arts.

Department of Environment and Climate Change (2009). *DRAFT Lord Howe Island Permanent Park Preserve Plan of Management*. DECC, Hurstville.

Department of Environment and Climate Change (2007) *Lord Howe Island Biodiversity Management Plan*. DECC, Hurstville.

Department of Environment, Water, Heritage and the Arts (2009). *Threat Abatement Plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100 000 hectares.* DEWHA, Canberra.

Department of Environment, Water, Heritage and the Arts (2009). Threatened species and ecological communities. http://www.environment.gov.au/biodiversity/threatened/index.html. Date accessed: 20/01/2009.

Dowding, J. E., Lovegrove, T. G., Ritchie, J., Kast, S. N. and Puckett, M. (2006). Mortality of northern New Zealand dotterels (*Charadrius obscurus aquilonius*) following an aerial poisoning operation. *Notornis* **53**, 235-259.

Eason, C. T., Hix, S., MacMorran, D. and Murphy, E. C. (2009). The first stage of preliminary screening of candidate MtHb inducers as potential rodenticides including PAPP and sodium nitrite by oral gavage and in bait. Unpublished Connovation Contract Report. Landcare Research, New Zealand.

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

Eason, C. T. and Spurr, E. B. (1995). Review of the toxicity and impacts of brodifacoum on non-target wildlife in New Zealand. *New Zealand Journal of Zoology* **23**, 371-379.

Empson, R. A. (1996). Application for resource consent application of anticoagulant toxic baits for rat eradication (Kapiti Island): Background information and assessment of effects. Unpublished report. Department of Conservation, Wellington, New Zealand.

Empson, R. A. and 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.

Fisher, P. (2005). Review of house mouse (*Mus musculus*) susceptibility to anticoagulant poisons. *DOC Science Internal Series* **198**, 1-18.

Gerlach, J. and Florens, V. (2000). Considering molluscs in rodent eradication projects. *Tentacle - The Newsletter of the IUCN/SSC Mollusc Specialist Group* **9**, 7-8.

Godfrey, M. E. R. (1985). Non-target and secondary poisoning hazards of "second-generation" anticoagulants. *Acta Zoologica Fennica* **173**, 209-212.

Graham, M. F. and Veitch, C. R (2001). Changes in bird numbers on Tiritiri Matangi Island over the period of rat removal. Paper presented at the "Eradication of island invasives: practical actions and results achieved" conference. University of Auckland.

Greaves, M. (1993). Anticoagulants in pregnancy . *Pharmacology and Therapeutics* **59**, 311-327.

Green, P. S. (1994). `Flora of Australia. Vol. 49. Oceanic Islands 1.' (Australian Government Publishing Service: Canberra.)

Groombridge, B. (1992). Global biodiversity: status of the earth's living resources: a report. Report prepared for the World Conservation Monitoring Centre, British Museum (Natural History), and International Union for Conservation of Nature and Natural Resources. Chapman and Hall, London.

Hadler, M. R. and Shadbolt, R. S. (1975). Nivel 4-hydroxycoumarin anticoagulants active against resistant rats. *Nature* **253**, 277-282.

Harden, B. (2001). Recent trends in the number of woodhen recorded during surveys. Unpublished report to the Lord Howe Island Board. NSW National Parks and Wildlife Service, Armidale.

Harden, R. H. and Leary, C. (1992). The Lord Howe Island Board rat control programme: report to the Lord Howe Island Board. Unpublished report to the Lord Howe Island Board, Lord Howe Island. NSW National Parks and Wildlife Service, Armidale.

Hindwood, K. A. (1940). The birds of Lord Howe Island. *Emu* **40**, 1-86.

Holdaway, R. N., Hawke, D. J., Hyatt, O. M. and Wood, G. C. (2007). Stable isotopic (δ^{15}N, δ^{13}C) analysis of wood in trees growing in past and present colonies of burrow-nesting seabirds in New Zealand. I. δ^{15}N in two species of conifer (Podocarpaceae) from a mainland colony of Westland petrels (*Procellaria westlandica*), Punakaiki, South Island. *Journal of the Royal Society of New Zealand* **37**, 75-84.

Hone, J. and Mulligan, H. (1982). Vertebrate pesticides. *Science Bulletin 89*. New South Wales Department of Agriculture, Orange.

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. and Tershy, B. (2007). Invasive rodent eradication on islands. *Conservation Biology* **21**, 1258-1268.

Hutton, I. (1991). `Birds of Lord Howe Island: Past and Present.' (Ian Hutton: Coffs Harbour.)

Hutton, I. (1998). `The Australian Geographic Book of Lord Howe Island.' (Australian Geographic: Terrey Hills.)

Jones, A. G., Chown, S. L., Ryan, P. G., Gremmen, N. J. M. and Gaston, K. J. (2003). A review of conservation threats on Gough Island: a case study for terrestrial conservation in the Southern Oceans. *Biological Conservation* **113**, 75-87.

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

Landos, J. (2003). Quarantine Strategy for Lord Howe Island. Unpublihed report for the Lord Howe Island Board. Quarantine and Inspection Resources Pty Ltd, Griffith, ACT.

Lavoie, C., Donlan, C. J., Campbell, K., Cruz, F. and Carrion, V. G. (2007). Geographic tools for eradication programmes of insular non-native mammals. *Biological Invasions* **9**, 139-148.

LHI Board - *see* Lord Howe Island Board

Lord Howe Island Board (2000). Lord Howe Island Group, World Heritage Property and Strategic Plan of Management 2000–2005. LHI Board, Lord Howe Island.

Lord Howe Island Board (2008). Lord Howe Island Rodent Eradication Communication Strategy. LHI Board.

Lourie-Fraser, G. (1985). Successful woodhen project - a brief overview. *Australian Aviculture* **November**, 255-271.

MacKay, J. W. B., Russell, J. C. and Murphy, E. C. (2007). Eradicating house mice from islands: successes, failures and the way forward. In 'Managing Vertebrate Invasive Species: Proceedings of an International Symposium '. Eds G. W. Witmer, W. C. Pitt and K. A. Fagerstone. pp. 64-66. (USDA/Aphis/WS, National Wildlife Research Center: Fort Collins.)

Marris, J. W. M. (2000). The beetle (Coleoptera) fauna of the Antipodes Islands, with comments on the impact of mice: and an annotated checklist of the insect and arachnid fauna. *Journal of the Royal Society of New Zealand* **30**, 169-195.

McCulloch, A. R. (1921). Lord Howe Island: a naturalist's paradise. *Australian Museum Magazine* **1**, 31-47.

Merton, D., Climo, G., Laboudallon, V., Robert, S. and Mander, C. (2002). Alien mammal eradication and quarantine on inhabited islands in the Seychelles. In 'Turning the Tide: the Eradication of Invasive Species'. Eds C. R. Veitch and M. N. Clout. pp. 182-198. (IUCN: Gland, Switzerland.)

Micol, T. and Jouventin, P. (2002). Eradication of rats and rabbits from St Paul Islands, French southern territories. In 'Turning the Tide: the Eradication of Invasive Species'. Eds C. R. Veitch and M. N. Clout. pp. 199-205. (IUCN SSC Invasive Species Specialist Group, IUCN: Gland, Switzerland and Cambridge, UK.)

Miller, B. and Mullette, K. J. (1985). Rehabilitation of an endangered Australian bird: the Lord Howe Island woodhen (Sclater). *Biological Conservation* **34**, 55-95.

Moore Jr, H. E. (1966). Palm hunting around the world. IV Lord Howe Island. *Principes* **10**, 12-21.

Moors, P. J. (1985). Eradication campaign against *Rattus norvegicus* on the Noises Islands, New Zealand, using brodifacoum and 1080. In ' Conservation of Island Birds: Case Studies for the Management of Threatened Island Species. Technical Publication No. 3'. pp. 143-155. (International Council for Bird Preservation: Cambridge.)

Morgan, D. R. (1993). Lab report to the Department of Conservation on assays of samples from Coppermine and Red Mercury islands. Unpublished report. Landcare Research, Hamilton.

Morgan, D. R. and Wright, G. R. (1996). Environmental effects of rodent Talon® baiting. Part 1: Monitoring for toxic residues. Science for Conservation: 38. Dept. of Conservation, Wellington, New Zealand.

Morgan, D. R., Wright, G. R., Ogilvie, S. C., Pierce, R. and Thompson, P. (1996). Assessment of the environmental impact of brodifacoum during rodent eradication operations in New Zealand. In 'Proceedings of the Seventeenth Vertebrate Pest Control Conference'. Eds R. M. Timm and A. C. Crabb. pp. 213-218. (Davis: California.)

Morriss, G. (2007). Susceptibility of Rangitoto and Motutapu island house mice to 20R brodifacoum baits. Landcare Research Contract Report: LC0607/155. Landcare Research, Lincoln, New Zealand.

National Biodiversity Strategy Review Task Group (2009). Australia’s Biodiversity Conservation Strategy 2010-2020. Consultation Draft. Australian Government, Department of the Environment, Water, Heritage and the Arts, Canberra.

National Parks and Wildlife Service (1986). *Lord Howe Island Permanent Park Preserve Plan of Management*. NSW National Parks and Wildlife Service, Hurstville.

National Parks and Wildlife Service (2001). *Lord Howe Island Placostylus Placostylus bivaricosus (Gaskoin, 1855) recovery plan*. NSW National Parks and Wildlife Service, Hurstville.

Natural Resource Management Ministerial Council (2007). *Australian Pest Animal Strategy – A national strategy for the management of vertebrate pest animals in Australia*. Commonwealth Government of Australia, Department of the Environment and Water Resources, Canberra.

NBSRRTG – *see* National Biodiversity Strategy Review Task Group

Nevill, J. (2004). Eco-tourism as a source of funding to control invasive species: The case of the Seychelles. International Journal of Island Affairs. February, 99 – 102.

Newman, D. G. (1994). Effects of a mouse, *Mus musculus,* eradication programme and habitat change on a lizard population on Mana Island, New Zealand, with special reference to McGregor's skink, C*yclodina macgregori*. *New Zealand Journal of Zoology* **21**, 443-456.

NPWS – *see* National Parks and Wildlife Service

NRMMC – *see* Natural Resource Management Ministerial Council

Ogilvie, S. C., Pierce, R. J., Wright, G. R. G., Booth, L. H. and Eason, C. T. (1997). Brodifacoum residue analysis in water, soil, invertebrates, and birds after rat eradication on Lady Alice Island. *New Zealand Journal of Ecology* **21**, 195-197.

Parkes, J., Ruscoe, W., Fisher, P. and Thomas, B. (2003). Benefits, constraints, risks and costs of rodent control options on Lord Howe Island. Unpublished report to the Lord Howe Island Board. Landcare Research, Lincoln, New Zealand.

Parrish, G. R. and Pierce, R. J. (1993). Reptiles of Motuopao Island, Northland, New Zealand. *Tane* **34**, 53-58.

Pickard, J. (1982). Catastrophic disturbance and vegetation on Little Slope, Lord Howe Island. *Australian Journal of Ecology* **7**, 161-170.

Pickard, J. (1983). Vegetation of Lord Howe Island. *Cunninghamii* **1**, 133-265.

Ponder, W. F. (1997). Conservation status, threats and habitat requirements of Australian terrestrial and freshwater mollusca. *Memoirs of the Museum of Victoria* **56**, 421-430.

Priddel, D., Carlile, N., Humphrey, M., Fellenberg, S. and Hiscox, D. (2001). Interim Recovery Actions: The Lord Howe Island Phasmid *Dryococelus australis*. Unpublished report. National Parks and Wildlife Service, Hurstville.

Priddel, D., Carlile, N., Humphrey, M., Fellenberg, S. and Hiscox, D. (2003). Rediscovery of the 'extinct' Lord Howe Island stick-insect (*Dryococelus australis* (Montrouzier)) (Phasmatodea) and recommendations for its conservation. *Biodiversity and Conservation* **12**, 1391-1403.

Priddel, D., Carlile, N. and Wheeler, R. (2000). Eradication of European rabbits (*Oryctolagus cuniculus*) from Cabbage Tree Island, NSW, Australia, to protect the breeding habitat of Gould's petrel (*Pterodroma leucoptera leucoptera*). *Biological Conservation* **94**, 115-125.

Primus, T., Wright, G. and 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.

Rance, B. (2001). Titi Islands expedition, March 2001. Unpublished Report RI 6418. Department of Conservation, Invercargill.

Recher, H. F. and Clark, S. S. (1974). A biological survey of Lord Howe Island with recommendations for the conservation of the island's wildlife. *Biological Conservation* **6**, 263-273.

Saunders, A. and Brown, D. (2001). An assessment of the feasibility of eradicating rodents from the Lord Howe Island Group. A report to the Lord Howe Island Board. Endangered Species Recovery Council, Hamilton.

Shaw, J. D., Hovenden, M. and Bergstrom, D. M. (2005). The impact of introduced ship rats (*Rattus rattus*) on seedling recruitment and distribution of a subantarctic megaherb (*Pleurophyllum hookeri*). *Austral Ecology* **30**, 118-125.

Shirer, M. (1992). In poison's defence. *Terra Nova* **17**, 3.

Smith, V. R. and Steenkamp, M. (1990). Climatic change and its ecological implications at a subantarctic island. *Oecologia* **85**, 1424.

Spurr, E. B. and Drew, K. W. (1999). Invertebrates feeding on baits used for vertebrate pest control in New Zealand. *New Zealand Journal of Ecology* **23**, 167-173.

Taylor, R. H. and Thomas, B. W. (1989). Eradication of Norway rats (*Rattus norvegicus*) from Hawea Island, Fiordland, using brodifacoum. *New Zealand Journal of Ecology* **12**, 23-32.

Taylor, R. H. and Thomas, B. W. (1993). Rats eradicated from rugged Breaksea Island (170 ha), Fiordland, New Zealand. *Biological Conservation* **65**, 191-198.

Torr, N. (2002). Eradication of rabbits and mice from subantartic Enderby and Rose islands. In 'Turning the Tide: the Eradication of Invasive Species '. Eds C. R. Veitch and M. N. Clout. pp. 319-328. (IUCN SSC Invasive Species Specialist Group. IUCN: Gland, Switzerland and Cambridge, UK.)

Towns, D., McFadden, I. and Lovegrove, T. (1993). Offshore islands co-operative conservation project with ICI Crop Care Division: Phase one (Stanley Island). Science and Research Internal Report 138. Department of Conservation, Wellington.

Towns, D. R. (1991). Response of lizard assemblages in the Mercury Islands, New Zealand, to removal of an introduced rodent: the kiore (*Rattus exulans*). *Journal of the Royal Society of New Zealand* **21**, 119-136.

Towns, D. R. (1994). The role of ecological restoration in the conservation of Whitaker's skink (*Cyclodina whitakeri*), a rare New Zealand lizard (Lacertilia: Scincidae). *New Zealand Journal of Zoology* **21**, 457-471.

Towns, D. R. and 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. and Daugherty, C. H. (2006). Have the harmful effects of introduced rats on islands been exaggerated? *Biological Invasions* **8**, 863-891.

World Health Organisation (1995). Anticoagulant rodenticides. International Programme on Chemical Safety. Environmental Health Criteria 175. World Health Organisation, Geneva.

APPENDIX 1: Research and Monitoring Programs

Research and monitoring has been undertaken in conjunction with the planning of the proposed rodent eradication operation to inform operational details and also to further the science of rodent eradications. Research and monitoring, post-operation, will also be important in evaluating the benefits of eradicating rodents from the LHI Group.

The various research and monitoring programs have been classified (broadly) into research and monitoring of: brodifacoum, Pestoff® 20R, rodents, and non-target species.

Brodifacoum

Resistance of rodents to brodifacoum

Warfarin has been used on LHI to control ship rats and house mice for almost 90 years. In this time the house mice have become resistant to warfarin.

The continued use of brodifacoum by island residents to control mice in and around the settlement could likewise lead to rats or mice developing a resistance to this poison also. Such resistance would remove the possibility of conducting an eradication using a second-generation anticoagulant poison, currently the most effective and widely used class of poisons for eradication operations.

Proposed pre-operational monitoring: Standard laboratory-based mortality trials of both rats and mice will be carried out to test for possible resistance.

Impact of brodifacoum on LHI placostylus

Land snails are generally unaffected by brodifacoum baits. However, there is a single incidence of mortality of snails occurring as result of brodifacoum poisoning (Gerlach & Florens 2000). It is therefore prudent to assess the impact of brodifacoum on the threatened LHI placostylus.

Proposed pre-operational monitoring: Research will be conducted on the vulnerability of this species to brodifacoum baits. Animals will be taken into captivity and allowed to feed on brodifacoum baits. If a significant level of mortality occurs, techniques will be developed to collect and house animals in captivity for the duration of the eradication operation. A program to investigate and refine methods for captive breeding, as well as the establishment of captive pens is currently being undertaken as part of the implementation of the *LHI Biodiversity Management Plan* (DECC 2007).

Brodifacoum uptake by plants

Brodifacoum binds strongly to soil particles and is highly insoluble in water, therefore, it is not likely to be transported through soils and into plant tissues. Many island residents have fruit and vegetable gardens so there is concern about the impacts of brodifacoum on these crops.

Proposed pre-operational monitoring: A range of edible plants will be grown in soil that has been dosed with bait. Samples of these plants will then be collected and analysed.

Water sampling

Post-baiting monitoring: Tests will be undertaken on water bodies on the island to monitor brodifacoum levels after the bait drop. These will be repeated at various intervals after the bait drop.

All tests will be conducted at an accredited analytical laboratory.

Soil sampling

Proposed pre-bait period monitoring: Testing on island to assess breakdown in soil.

Post-bait period monitoring: Soil samples will be collected to monitor residues of brodifacoum in the soil after a simulated bait drop. Samples will be collected directly below toxic baits and at control sites where no bait occurs.

All tests will be conducted at an accredited analytical laboratory.

Pestoff® 20R

Bait disintegration

The length of time that the poison bait pellets persist in the environment after distribution is fundamental to the proposed operation. It provides a guide for the expected duration of risk in relation to captive animals, pets, people and livestock. While the baits persist, there is a risk of non-target species being poisoned and accidental poisoning of people and pets. Knowing the length of time that baits persist allows us to make informed decisions relating to captive animals and livestock.

Completed pre-operational monitoring: Research was conducted on LHI during 2007 to find out how long it takes bait pellets to disintegrate in the LHI environment. To do this, both 5 mm and 10 mm baits were placed in rodent proof containers in open, full canopy and partial canopy areas, and monitored weekly, noting disintegration on a 6 point scale. Baits of both sizes and in all areas had disintegrated after 100 days, and no longer posed a primary poisoning threat.

Proposed bait period monitoring: During the proposed baiting operation, the actual period of risk will be determined by measuring the rate of bait breakdown occurring at that time.

Bait palatability trials

Completed pre-operational monitoring: In trials conducted on LHI with non-toxic baits, all mice and rats consumed the bait. This is a critical precursor for a successful eradication.

Marine studies

Proposed pre-operational monitoring: Observational studies by divers will be undertaken to determine which, if any, fish species consume baits dropped into the ocean. Fish species that readily consume baits will undergo laboratory studies to determine their susceptibility to brodifacoum and to measure the uptake of poison into body tissues. This work will be contracted to a university or other research body, several of which already work on LHI.

Rodents

Genetics of rats and mice

Genetic testing allows the genetic characteristics of individuals of a particular population to be mapped. Genetic testing of rodents from major source points of reinvasion (e.g. Port Macquarie) is critical to enable the identification of the source of rodents should they be found on LHI after the eradication operation has been completed.

By testing any animals discovered on the island after the eradication operation, it is possible to determine either that the operation failed (if they fit the genetic identity of the island population), or that LHI has been re-invaded (if they have a genetic identity distinct from those on LHI). Collection of genetic material will be conducted prior to the eradication. Analysis of this material, along with samples from surviving rodents, will be conducted only if the operation fails.

Elimination of survivors

Proposed bait period and post-operational monitoring: The settlement area will be monitored for the presence of rodents throughout the 100-day period of the baiting operation. Detection of surviving rodents will be evidenced by bait take from bait trays and bait stations and observations of droppings or rodent activity. Residents will be asked to report any such evidence to the project team.

In addition, trained detector dogs will be deployed throughout the settlement area to find and locate any surviving rodents. In the unlikely event that rodents are detected action will be taken to eliminate them.

Rodents

Monitoring of the rodent-free status of LHI following the eradication of rats and mice will be achieved by monitoring rodent activity at bait stations and tracking tunnels strategically placed at stratified locations across the island. This will form part of the island's permanent rodent detection and prevention system initiated as an integral part of the island's biosecurity program.

Non-target impacts

It is important to quantify the level of non-target species mortality, both for the purpose of understanding the impacts of this operation and also to increase our knowledge for future operations. The risk assessment found that the expected level of non-target mortality is low, and restricted to a small number of species.

Proposed bait period monitoring: Any non-target animals found dead during the four months after the second bait drop will be collected and autopsied to determine the cause of death. If internal haemorrhaging is not obvious, liver samples will be taken and tested for the presence of brodifacoum.

LH pied currawong

Those individual LHI currawong that are not taken into captivity will be at risk, and some are likely to succumb to the effects of brodifacoum.

Proposed bait period monitoring: To assess the survival rate of those currawongs not held in captivity, marked individuals will be monitored during the period of risk. Also, unmarked animals will be caught, banded and monitored. This will enable an assessment of the impacts of brodifacoum baits on this species.

Ongoing monitoring: The annual surveys of LH currawong abundance will continue in their current form. Birds have been individually marked with coloured leg bands. Birds are attracted to designated locations across the island with food, and then observed and the band combinations recorded. Any unbanded birds are caught, banded and released. Population size is estimated by mark-recapture analysis. Data will be available to compare the survival of (i) birds left in the wild during the period of risk, (ii) birds held captive during the period of risk; and (iii) the population prior to disturbance.

LH woodhen

Ongoing monitoring: The annual surveys of woodhen will continue in their current form. A large number of birds have been individually marked with coloured leg bands. Each November most of the accessible areas where the birds are known to breed are visited. The birds are then observed and the band combinations recorded. Unbanded birds are caught in hand nets, then banded and released. The number of birds caught or sighted provides an index of population size. More complex, computer modelling of the data is currently being undertaken.

Kentia palm seed

Ongoing monitoring: There is good evidence that rats severely reduce the seed yield of palms. The annual quantity of kentia palm seed harvested provides a coarse index of seed availability. Monitoring of rat damage to palm seed will also be undertaken. A sample of trees will be assessed for seed damage before and after the eradication.

Big and little mountain palms

Rats severely reduce seedling recruitment of the little mountain palm and big mountain palm.

Ongoing monitoring: Fruiting and seedling establishment in both these species has been measured over a number of years, with almost no seedling establishment evident. Continued monitoring of these species is likely to demonstrate a marked change in seedling recruitment.

Other plants

Tree species which are likely to suffer significant seed or seedling predation by rats include the blue plum, green plum, pandanus and tamana.

Proposed post-operational monitoring: Fruiting and seedling establishment in these species will be measured. A marked change in seedling recruitment is expected. Also, seedling establishment could be measured in plots sited in various plant communities to compare seedling survival and recruitment before and after the eradication.

Land birds

Proposed post-operational monitoring: Surveys of the distribution and abundance of land birds will be undertaken annually from late spring to early summer. Replicated sampling will be undertaken at randomly selected points from a grid covering all accessible parts of the island. At each sampling point, standard 10-minute counts of bird abundance will be recorded.

This monitoring program will be developed in cooperation with, and undertaken by interested members of the local community and a mainland ornithologist association such as Birds Australia and the Canberra Ornithologists Group. In addition, other visiting bird-watchers, and interested residents could go to designated sites and collect the same information. Such opportunistic sampling could be arranged through a non-government organisation such as Birds Australia.

Seabirds

Proposed post-operational monitoring: Monitoring of seabirds will focus on those species most vulnerable to rat predation: white tern; grey ternlet, common noddy, black noddy, black-winged petrel and little shearwater. For each of these species, the distribution and abundance of nests or burrows will be monitored annually to obtain an estimate of population size and extent of the colony. A sample of nests will be monitored (immediately after egg laying and shortly prior to fledging) to determine breeding success (the proportion of eggs that produce fledglings).

In addition, searches will be made to determine if white-bellied storm-petrel resume nesting on the main island. Storm-petrels used to breed on LHI in tens of thousands but were extirpated from the main island by rats. They are likely to return once rats have been removed as has recently occurred on Brush Island off the coast of NSW.

The possibility of involvement from interested residents on LHI and collaboration with community bird groups such as Birds Australia will be explored.

Reptiles and Frogs

Proposed pre-operational monitoring: Research on LHI's reptiles is commencing in summer 2009. This research will provide important baseline population densities and will investigate what options are available for control or eradication of the bleating tree frog.

Proposed post-operational monitoring: Surveys of the two native reptile species plus the recently introduced (c. 1995) grass skink will be undertaken annually in summer. Permanent survey plots will be established in representative habitats. Nocturnal searches of each plot will be undertaken to detect geckos and diurnal searches will be conducted for skinks. Where possible, animals will be captured, measured and marked. Each plot will be surveyed on consecutive days. Population size will be estimated from mark recapture data. Population size and body size will be compared over time.

Land snails

Proposed post-operational monitoring: Surveys of the LH placostylus will be undertaken on nights after rain. Permanent survey plots will be established in representative habitats, focussing on those areas where snails have been recorded previously. Nocturnal searches of each plot will be undertaken to detect snails foraging on the surface. All animals will be measured and marked. 'Dead' shells will also be counted. Each plot will be surveyed on multiple nights. Population size will be estimated from mark-recapture data. Population number and body size (of both live and dead animals) will be compared over time. Given that this work can only be undertaken after rain, it will need to be undertaken by people resident on the island.

The possibility of undertaking annual surveys of the other listed threatened land snails will be investigated. These species include: Masters' charopid land snail*,* Mount Lidgbird charopid land snail, Whitelegge's land snail, and *Gudeoconcha sophiae magnifica* (a land snail).

Other threatened invertebrates

Proposed post-operational monitoring: The possibility of undertaking annual surveys of the other listed threatened invertebrates will be investigated. These species include: the LHI wood-feeding cockroach (*Panesthia lata*) and the LHI earthworm (*Pericryptodrilus nanus*).

Masked owls

Masked owls are considered a pest on LHI because they prey on several species of threatened birds, including the woodhen and the self-introduced white tern. The reduction in availability of rodent prey after the eradication will result in increased predation pressure on native birds. However, masked owls also prey on rats and mice so they are vulnerable to secondary poisoning during the eradication. Although some individual owls may succumb to brodifacoum poisoning, it is unlikely that the entire population will be killed.

A study to examine the feasibility of eradicating masked owls from LHI is being undertaken in 2009 using funding provided by the Australian Government. Information collected during this project, which will be completed in 2009–10, will be used to determine if eradication of owls is possible and, if so, devise an eradication plan to remove owls from the island. Any owl eradication program will be run coincidentally with the rodent eradication

APPENDIX 2: Impact of rodents and brodifacoum on LHI Group biodiversity

Endemic: En = endemic species or subspecies

Impacted by rodents: Ex = rodents are implicated in the extinction of these species, ~ = regular migratory visitor.

TSC Act (NSW *Threatened Species Conservation Act 1995*) and EPBC Act (Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*): PEx = presumed extinct, CE = critically endangered, E = endangered, V = vulnerable, M = migratory.

Common name	**Scientific Name**	**Endemic**	**TSC Act**	**EPBC Act**	**Impacted by rodents?**	**Impact of brodifacoum**		**Proposed operational response**
						Primary	**Secondary**	
BIRDS								
Australian kestrel	*Falco cenchroides*	-	-	-	No	Low	Low	Nil
Bar-tailed godwit	*Limosa lapponica* ~	-	-	M	No	Low	Low	Nil
Black noddy	*Anous minutus*	-	-	-	No	Low	Low	Nil
Black-winged petrel	*Pterodroma nigripennis*	-	V	-	Yes	Low	Low	Nil
Brown noddy	*Anous stolidus*	-	-	M	Yes	Low	Low	Nil
Buff-banded rail	*Gallirallus philippensis*	-	-	-	No	High	Low	Nil
Cattle egret	*Ardea ibis* ~	-	-	M	No	Low	Low	Nil
Double-banded plover	*Charadrius bicinctus* ~	-	-	-	No	Low	Low	Nil
Eastern curlew	*Numenius madagascariensis* ~	-	-	M	No	Low	Low	Nil
Emerald ground-dove	*Chalcophaps indica*	-	-	-	Yes	Medium	Low	Some individuals to be held in captivity during the baiting period
Flesh-footed Shearwater	*Puffinus carneipes*	-	V	M	Yes	Low	Low	Nil
Grey fantail (Lord Howe Island subsp.)	*Rhipidura fuliginosa cervina*	En	PEx	PEx	Ex	-	-	
Grey ternlet	*Procelsterna cerulea*	-	V	-	Yes	Low	Low	Nil

Common name	Scientific Name	Endemic	TSC Act	EPBC Act	Impacted by rodents?	Impact of brodifacoum		Proposed operational response
						Primary	Secondary	
Grey-tailed tattler	*Tringa brevipes ~*	-	-	M	No	Low	Low	Nil
Island thrush (Lord Howe Island subsp.)	*Turdus poliocephalus vinitinctus*	En	PEx	PEx	Ex	-	-	
Japanese snipe	*Gallinago hardwickii ~*	-	-	M	No	Low	Low	Nil
Kermadec petrel	*Pterodroma neglecta*	-	V	-	Yes	Low	Low	Nil
Little shearwater	*Puffinus assimilis*	-	V	-	Yes	Low	Low	Nil
Lord Howe gerygone	*Gerygone insularis*	En	PEx	PEx	Ex	-	-	
Lord Howe Island golden whistler	*Pachycephala pectoralis contempta*	En	V	-	No	Low	Low	Some individuals to be held in captivity during the baiting period
Lord Howe Island silvereye	*Zosterops lateralis tephropleura*	En	V	-	No	Low	Low	Some individuals to be held in captivity during the baiting period
Lord Howe pied currawong	*Strepera graculina crissalis*	En	V	V	No	Medium.	High	Most individuals to be held in captivity during the baiting period
Lord Howe woodhen	*Gallirallus sylvestris*	En	E	V	Yes	High	Medium	Most individuals to be held in captivity during the baiting period
Magpie lark	*Grallina cyanoleuca*	-	-	-	No	Low	Low	Nil
Masked booby	*Sula dactylatra*	-	V	M	Yes	Low	Low	Nil
Masked lapwing	*Vanellus miles*	-	-	M	No	Low	Low	Nil
Nankeen kestrel	*Falco cenchroides*	-	-	-	No	Low	Medium	Nil
Pacific black duck	*Anas superciliosa*	-	-	-	No	Medium	Low	Nil
Pacific golden plover	*Pluvialis fulva ~*	-	-	M	No	Low	Low	Nil
Providence petrel	*Pterodroma solandri*	-	V	M	Yes	Low	Low	Nil
Purple swamphen	*Porphyrio porphyrio*	-	-	-	No	High	Low	Nil
Red-tailed tropicbird	*Phaethon rubricauda*	-	V	-	No	Low	Low	Nil

Common name	Scientific Name	Endemic	TSC Act	EPBC Act	Impacted by rodents?	Impact of brodifacoum Primary	Secondary	Proposed operational response
Red-crowned parakeet (Lord Howe Island subsp.)	*Cyanoramphus novaezelandiae subflavescens*	En	PEx	PEx	No	-	-	
Red knot	*Calidris canutus* ~	-	-	M	No	Low	Low	Nil
Red-necked stint	*Calidris ruficollis* ~	-	-	M	No	Low	Low	Nil
Robust white-eye	*Zosterops strenuus*	En	PEx	PEx	Ex	-	-	
Ruddy turnstone	*Arenaria interpres* ~	-	-	M	No	Low	Low	Nil
Sacred kingfisher	*Todiramphus sanctus*	-	-		No	Low	Medium	Nil
Sharp-tailed sandpiper	*Calidris acuminata* ~	-	-	M	No	Low	Low	Nil
Sooty tern	*Sterna fuscata*	-	V	-	Yes	Low	Low	Nil
Southern boobook (Lord Howe Island subsp.)	*Ninox novaeseelandiae albaria*	En	PEx	PEx	Ex	-	-	
Tasman starling (Lord Howe Island subsp.)	*Aplonis fusca hullianus*	En	PEx	PEx	Ex	-	-	
Wandering tattler	*Tringa incana* ~	-	-	M	No	Low	Low	Nil
Wedge-tailed shearwater	*Puffinus assimilis*	-	-	M	Yes	Low	Low	Nil
Welcome swallow	*Hirundo neoxena*	-	-	-	No	Low	Low	Nil
Whimbrel	*Numenius phaeopus* ~	-	-	M	No	Low	Low	Nil
White-bellied storm petrel	*Fregetta grallaria*	-	V	V	Yes	Low	Low	Nil
White-faced heron	*Ardea novaehollandiae*	-	-	-	No	Low	Medium	Nil
White gallinule	*Porphyrio albus*	En	PEx	PEx	No	-	-	Nil
White tern	*Gygis alba*	-	V	-	No	Low	Low	Nil

Common name	Scientific Name	Endemic	TSC Act	EPBC Act	Impacted by rodents?	Impact of brodifacoum		Proposed operational response
						Primary	Secondary	
White-throated pigeon (Lord Howe Island subsp.)	*Columba vitiensis godmanae*	En	PEx	PEx	No	-	-	Nil
INTRODUCED OR EXOTIC SPECIES								
Common blackbird	*Turdus merula*	-	-	-	No	High	Low	Nil
Feral chicken	*Gallus gallus*	-	-	-	No	High	Low	Nil
Song thrush	*Turdus philomelos*	-	-	-	No	High	Low	Nil
Common starling	*Sturnus vulgaris*	-	-	-	No	Low	Low	Nil
Masked owl (Tasmanian subspecies)	*Tyto novaehollandiae*	-	V	-	No	Low	High	Plan to eradicate species coincident with rodents
Rock dove / feral pigeon	*Columba livia*	-	-	-	No	High	Low	Nil
Pacific black duck-mallard hybrids	*Anas superciliosa* x *A. platyrhynchos*	-	-	-	No	High	Low	Nil
REPTILES								
Lord Howe Island gecko	*Christinus guentheri*	-	V	V	Yes	Low	Low	Nil
Lord Howe Island skink	*Oligosoma lichenigera*	-	V	V	Yes	Low	Low	Nil
INVERTEBRATES								
Lord Howe Island ground weevil	*Hybomorphus melanosomus*	-	PEx	-	No	-	-	Nil
Lord Howe Island phasmid	*Dryococelus australis*	En	E	CE	Yes	Nil	Nil	Nil
Lord Howe Island wood-eating cockroach	*Panesthia lata*	En	E	-	Yes	Low	Low	Nil

Common name	Scientific Name	Endemic	TSC Act	EPBC Act	Impacted by rodents?	Impact of brodifacoum		Proposed operational response
						Primary	Secondary	
Lord Howe placostylus	*Placostylus bivaricosus*	En	E	E	Yes	Low	Low	Pre-operational monitoring to assess impact
Lord Howe earthworm	*Pericryptodrilus nanus*	En	E	-	Yes	Low	Low	Nil
Whitelegge's land snail	*Pseudocharopa whiteleggei*	En	-	CE	Yes	Low	Low	Nil
Masters' charopid land snail	*Mystivagor mastersi*	En	-	CE	Yes	Low	Low	Nil
Mt Lidgbird charopid land snail	*Pseudocharopa lidgbirdi*	En	-	CE	Yes	Low	Low	Nil
A helicarionid land snail	*Gudeoconcha sophiae magnifica*	En	-	CE	Yes	Low	Low	Nil
FLORA								
Christmas bush	*Alyxia lindii*	-	-	-	Yes	Nil	Nil	Nil
	Alyxia squamulosa	En	-	-	Yes	Nil	Nil	Nil
	Asplenium milnei	En	-	-	Yes	Nil	Nil	Nil
	Asplenium pteridoides	En	-	-				
Green plum	*Atractocarpus stipularis*	En	-	-	Yes	Nil	Nil	Nil
	Boehmeria calophleba	En	-	-				
LHI broom	*Carmichaelia exsul*	En	E	-	Yes	Nil	Nil	Nil
	Cassinia tenuifolia	En	-	-				
Blue plum	*Chionanthus quadristamineus*	En	-	-	Yes	Nil	Nil	Nil
	Corokia carpodetoides	En	-	-	Yes	Nil	Nil	Nil
Blackbutt	*Cryptocarya gregsonii*	En	-	-	Yes	Nil	Nil	Nil

Common name	Scientific Name	Endemic	TSC Act	EPBC Act	Impacted by rodents?	Impact of brodifacoum		Proposed operational response
						Primary	Secondary	
Bush orchid	*Dendrobium macropus ssp. howeanum*	En	-	-	Yes	Nil	Nil	Nil
Moorei orchid	*Dendrobium moorei*	En	-	-	Yes	Nil	Nil	Nil
Wedding lily	*Dietes robinsoniana*	En	-	-	Yes	Nil	Nil	Nil
Greybark	*Drypetes deplanchei subsp. affinis*	En	-	-	Yes	Nil	Nil	Nil
Island apple	*Dysoxylum pachyphyllum*	En	-	-	Yes	Nil	Nil	Nil
	Elaeocarpus costatus	En	-	-	Yes	Nil	Nil	Nil
	Elymus multiflorus var. *kingianus*	-	-	CE	Yes	Nil	Nil	Nil
	Exocarpus homalocladus	-	-	-	Yes	Nil	Nil	Nil
Banyan	*Ficus macrophylla ssp. Columnaris*	En	-	-	Yes	Nil	Nil	Nil
	Geniostoma petiolosum	En	-	-	Yes	Nil	Nil	Nil
Island cedar	*Guoia coriacea*	En	-	-	Yes	Nil	Nil	Nil
Big mountain palm	*Hedescepe canterburyana*	En	-	-	Yes	Nil	Nil	Nil
Curly palm	*Howea belmoreana*	En	-	-	Yes	Nil	Nil	Nil
Kentia palm	*Howea forsteriana*	En	-	-	Yes	Nil	Nil	Nil
	Korthalsella emersa	-	-	-	Yes	Nil	Nil	Nil
Sallywood	*Lagunaria patersonia*	En	-	-	Yes	Nil	Nil	Nil
Little mountain palm	*Lepidorrhachis mooreana*	En	-	-	Yes	Nil	Nil	Nil

Common name	Scientific Name	Endemic	TSC Act	EPBC Act	Impacted by rodents?	Impact of brodifacoum		Proposed operational response
						Primary	Secondary	
Tea tree	*Leptospermum polygalifolium ssp. howense*	En	-	-				
Cava	*Macropiper hooglandii*	En	-	-				
	Marattia howeana	En	-	-				
	Melicope contermina	En	-	-	Yes	Nil	Nil	Nil
	Melicope polybotrya	En	-	-	Yes	Nil	Nil	Nil
	Melicytus novae-zelandieae subsp. centurionis	En	-	-	Yes	Nil	Nil	Nil
Pumpkin tree	*Negria rhabdothamnoides*	En	-	-				
Forked tree	*Pandanus forsteri*	En	-	-	Yes	Nil	Nil	Nil
	Passiflora herbertiana ssp.insula-howei	En	-	-	Yes	Nil	Nil	Nil
	Phymatosorus pustulatus subsp. howensis	En	-	-	Yes	Nil	Nil	Nil
	Pittosporum erioloma	En	-	-	Yes	Nil	Nil	Nil
	Plectorrhiza erecta	En	-	-				
Black grape	*Psychotria carronis*	En	-	-	Yes	Nil	Nil	Nil
	Rapanea mccomishii	En	-	-	Yes	Nil	Nil	Nil
	Rapanea myrtillina	En	-	-	Yes	Nil	Nil	Nil
	Rapanea platystigma	En	-	-	Yes	Nil	Nil	Nil
Snake vine	*Stephania japonica var timoriensis*	-	-	-	Yes	Nil	Nil	Nil

Common name	Scientific Name	Endemic	TSC Act	EPBC Act	Impacted by rodents?	Impact of brodifacoum		Proposed operational response
						Primary	Secondary	
	Symplocos candelabrum	En	-	-	Yes	Nil	Nil	Nil
Scaly bark	*Syzygium fullargarii (syn. Cleistocalyx fullargarii)*	En	-	-	Yes	Nil	Nil	Nil
Burny vine	*Trophis scandens subsp. megacarpa*	-	-	-	Yes	Nil	Nil	Nil
	Xylosma maidenii	En	-	-	Yes	Nil	Nil	Nil
	Xylosma parvifolium	En	E	-				
Hotbark	*Xygogynum howeanum*	En	-	-				
VEGETATION COMMUNITIES								
	Chionanthus quadristamineus	En	-	-	Yes	Nil	Nil	Nil
	Chionanthus quadristamineus-Howea belmoreana	En	-	-	Yes	Nil	Nil	Nil
	Drypetes deplanchei-Cryptocarya triplinervis (calcarenite variant)	En	-	-	Yes	Nil	Nil	Nil
	Drypetes deplanchei-Cryptocarya triplinervis (exposed variant)	En	-	-	Yes	Nil	Nil	Nil
	Drypetes deplanchei-Cryptocarya triplinervis on coral	En		-	Yes	Nil	Nil	Nil

Common name	Scientific Name	Endemic	TSC Act	EPBC Act	Impacted by rodents?	Impact of brodifacoum		Proposed operational response
						Primary	Secondary	
	Drypetes deplanchei-Cryptocarya triplinervis on volcanics	En	-	-	Yes	Nil	Nil	Nil
	Howea belmoreana	En	-	-	Yes	Nil	Nil	Nil
	Howea forsteriana on coral	En	-	-	Yes	Nil	Nil	Nil
	Howea forsteriana on volcanics	En	-	-	Yes	Nil	Nil	Nil
	Howea forsteriana - Chionanthus quadristamineus	En	-	-	Yes	Nil	Nil	Nil
	Howea forsteriana - Howea belmoreana	En	-	-	Yes	Nil	Nil	Nil
	Lowland mixed forest	En	-	-	Yes	Nil	Nil	Nil

APPENDIX 3: Poisons and other mortality agents considered for the operation

Unless otherwise stated, information in this section comes from Eason and Ogilvie (2009).

A critical component in any eradication is the choice of poison. There is a range of poisons available which could potentially be used in an eradication operation on the Lord Howe Group. An ‘ideal bait’ (as described by Howald et al. 2007) is one that is:

- palatable and lethal to the target species after a single feed
- persistent in the environment long enough for the target species to be exposed to it, but short enough to minimise impacts on non-target species
- unlikely to lead to bait shyness
- non-toxic or unpalatable to non-target species.

These characteristics drove the selection of the bait for the proposed rodent eradication operation on the LHI Group. A summary is presented in Table 1.

Non-anticoagulant acute poisons

Non-anticoagulant acute poisons have immediate ill effects on the target species. This immediacy can, however, lead to the pest becoming averse to the bait, eating less of it and not getting a lethal dose. Therefore, acute poisons are generally less effective in operations where complete eradication of the target species (i.e. 100% mortality) is the aim. Regardless of this, all possible options including a number of acute poisons were considered for use in the Lord Howe operation.

Cholecalciferol

Cholecalciferol is a form of vitamin D. It is marketed as Feracol® and usually contains 0.8% cholecalciferol in rodent baits. In rodents its mode of action appears to be heart failure. This bait has been especially useful in controlling house mice (Eason & Ogilvie 2009).

Eason and Ogilvie (2009) state that cholecalciferol is worth considering for aerial control of rodents. It is an effective rodent poison, is more toxic to mammals than birds, and has a low risk of causing secondary poisoning of non-target species. In aerial baiting it would be a lower risk to non-target bird species than either zinc phosphide or 1080. It is also less toxic to birds than brodifacoum. However, poisoning of non-target species would need to be avoided and the treatment of accidentally poisoned pets is complex.

Cholecalciferol has been used in at least three eradications, but all involved small islands and in each case baiting was supplemented with anticoagulants. The use of cholecalciferol in conjunction with an anticoagulant has all the non-target risks that are involved with the use of an anticoagulant alone, and so provides no additional benefit.

More importantly, there is evidence that mice can detect the poison in baits and will avoid it. This bait avoidance, while not critical in a control operation, would place an eradication program at risk of failure.

Sodium monofluoroacetate (1080)

Sodium monofluoroacetate, commonly known as 1080, is a naturally occurring compound produced by many species of Australian plant. It was first synthesised in Europe in 1896 and developed in the USA as a rodenticide during the 1940s. It is now widely used in Australia and New Zealand to control mammalian pests such as rabbits, foxes and possums. It is an acute poison which is prone to promoting bait shyness making it unsuitable for eradication. There is also no known antidote.

Zinc phosphide

Zinc phosphide was the most widely used rodent poison in the world prior to the introduction of anticoagulant poisons. It is used in Australia for field control of rodents because of the comparatively low risk of secondary poisoning compared to strychnine or 1080. Death is caused by a combination of cardiac failure and respiratory failure.

Zinc phosphide is more toxic to birds than it is to rodents and there is no available antidote. It is therefore not recommended for use in the LHI rodent eradication operation.

Rat-specific toxin

Research has been conducted by Landcare Research in New Zealand into a rat-specific poison for possible use in island eradications. However, the project failed to develop a suitable product. Apart from problems with the bait, the chemical they were investigating was a rapid action acute poison to which rats developed a rapid aversion, preventing them from ingesting a fatal dose. Research to develop this product has now been abandoned, consequently this poison is both unsuitable and unavailable for use in eradication operations.

Other poisons/agents

Cellulose compound

There is a cellulose compound named Eradibait® that works by blocking water absorption in the gut of rats and mice leading to eventual death. The bait contains no poison, so there are no secondary poisoning issues. Unfortunately, while the product has been used for control on farms it has never been used in an eradication program. Recent research conducted in New Zealand indicates that the bait has low palatability to rodents, and they will only consume it when no other food source is available. This makes it unsuitable for use in the proposed Lord Howe eradication, where every animal must consume a lethal dose.

PAPP

Para-aminopropiophenone (PAPP) is currently being developed for the control of feral cats, foxes and wild dogs. The need to encapsulate the poison has added considerably to the task. Trials show that PAPP does not kill rodents. It is possible that an analogue of PAPP could be developed as a rodenticide sometime in the future (Eason et al. 2009), but its potential non-target impacts and its suitability for eradication are all unknown.

Mouse-specific virus

Long-term research to develop a mouse-specific mortality agent has been abandoned both in Australia and overseas. Work over the past two decades focussed on the development of a contraceptive agent which would be transmitted between mice using a virus. The virus would make females sterile. To be effective, this type of agent needs to be readily transmitted between individuals, which proved not to be the case with this agent as transfer rate slowed as it spread in the population. This reduction in the transfer rate or attenuation of the virus ultimately halts the spread of the virus among the population. Researchers were unable to resolve this problem when the virus was spreading among wild mice. While developing an eradication tool capable of killing 100% of individuals was never a goal of the research program, even broadscale control is now considered unlikely. This conclusion led to the program being abandoned.

First generation anticoagulant poisons

First generation anticoagulants are generally low toxicity, need to be at high concentrations in baits, and need to be eaten several times over a number of days to kill their target (Hone & Mulligan 1982). The need for rodents to eat large quantities of these types of baits to obtain a lethal dose of the poison increases the risk of failure in eradication operations. First generation anticoagulants are better suited to ongoing, repeat application control operations due to their low toxicity and lower risks of secondary poisoning of non-target species.

Pindone

Pindone has been used worldwide to control rodents, however, its use in controlling rats has decreased since the introduction of the more potent anticoagulants like diphacinone (see below). It has never been used in aerial eradication of rodents, and is therefore untested and not a suitable poison for use on the LHI Group.

Diphacinone

Diphacinone is more toxic to most rats and mice than either warfarin or pindone. Rats are able to survive relatively high single doses of this poison, but are not able to survive when eaten over five days. Mice require a much higher dose of diphacinone than rats.

Like pindone, diphacinone is rapidly eliminated from the liver of target species and so these poisons are less likely to cause secondary poisoning, compared to brodifacoum or other second generation anticoagulants.

Diphacinone is a safer alternative to brodifacoum if repeat aerial applications are planned. However, its limited (<10 operations) use in eradications make it a poor choice for LHI given the lack of information on efficacy, and impacts on non-target species. It is also preferred over coumatetralyl (see below) because it is less persistent even though they have similar potencies.

Coumatetralyl

Coumatetralyl is marketed as Racumin®. Little research has been carried out on the effects of coumatetralyl on non-target species, however, death of pets that have gained access to the baits have been reported. Eason and Ogilvie (2009) consider that this poison has potential in aerial rodent control programs and is a safer alternative to brodifacoum. However, in common with other first generation anticoagulants, coumatetralyl needs to be eaten in large quantities to be effective and this poses risks to a successful eradication operation. It is also largely untested in eradication operations, being used only once in an operation that failed.

Second-generation anticoagulant poisons

All second-generation anticoagulants are more toxic than the first-generation anticoagulants. Consequently they have a greater potential to kill non-target species that consume bait. Also, second-generation anticoagulants persist longer in the tissues of those animals that eat the bait and, therefore, there is a greater risk of secondary poisoning. Although generally not toxic to invertebrates, anticoagulants can be ingested by some invertebrates (Spurr & Drew 1999) which may then be eaten by non-target species. Thus, the use of second-generation anticoagulants generally poses more risks than first-generation anticoagulants.

However, the effectiveness of these poisons in eradication operations tends to outweigh the risks.

Flocoumafen and bromodiolone

Flocoumafen and bromodiolone have both been used in eradications, but there is a relative lack of information on the environmental effects of these poisons or how effective they are. There appear to be no great advantages in using these poisons in place of brodifacoum which has been used in many successful eradications and whose effects are understood more thoroughly.

Table 1 Suitability of potential mortality agents for the eradication of rats and mice

Na = not applicable.

Poison / Mortality agent	Palatability	Probability of killing all targeted individuals	Availability of manufactured formulations	Target specificity	Environmental persistence	Likelihood to induce aversion	Antidote available	Number of successful eradications
Non-anticoagulant acute poisons								
Cholecalciferol	High	Low	High	High	Low	High	Yes	Low
Sodium monofluoroacetate	High	Low	High	Low	Low	High	No	Low
Zinc phosphide	High	Low	High	Low	Low	High	No	None
Rat-specific toxin	Na	Low	Not available	High	Low	Low	Na	None
Cellulose compound	Low	Low	High	High	Low	High	Na	None
PAPP	Low	Low	Not available	?	?	?	Yes	None
First generation anticoagulant poisons								
Diphacinone	High	Low	High	Low	Low	Low	Yes	Low
Pindone	High	Low	Low	Low	Low	Low	Yes	Low
Coumatetralyl	High	Low	Low	Low	Low	Low	Yes	Low
Second generation anticoagulant poisons								
Flocoumafen	High	High	Low	Low	High	Low	Yes	Low
Bromodiolone	High	High	Low	Low	High	Low	Yes	Low
Brodifacoum	High	High	High	Low	High	Low	Yes	High
Other mortality agents								
Mouse-specific virus	Na	Low	Not available	High	Low	Low	Na	None

APPENDIX 4: Risk Assessment

Analysis of risks

In this section general risks and mitigation strategies are identified. During the approval process a more detailed analysis will be done, and appropriate amendments to other documents and the project's scope may be made.

Risk is defined as negative factors, which may seriously delay or compromise the implementation of the plan (i.e. timeframe or techniques) and may affect the project outcomes. Risks may be external or internal to the project. All risks are assessed as inherent, without any prior mitigation.

Internal risks are those associated with the consequences of decisions made while managing or implementing aspects of the project. External risks are normally outside the influence or control of project management.

Overall risk is expressed in terms of the product of likelihood of occurrence and the consequence of occurrence. A general risk assessment matrix (below) is used to determine the risk. For each identified risk we have assessed the:

- **Consequence of the risk** - either
    - insignificant
    - minor
    - moderate
    - major
    - catastrophic, and the
- **Likelihood of risk occurring** - either
    - almost certain
    - likely
    - possible
    - unlikely
    - very unlikely

The Overall risk is determined in the **absence** of any mitigation using the matrix below. For example, a minor consequence that has a possible likelihood of occurring is a low risk. A **response** is then given which describes possible mitigation/contingency, and finally a measure of overall risk after mitigation.

General Risk Assessment Matrix

Likelihood	Consequences				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Low	Medium	High	Very High	Extreme
Likely	Low	Medium	High	Very High	Very High
Possible	Low	Low	Medium	High	High
Unlikely	Minimal	Minimal	Low	Medium	High
Very Unlikely	Minimal	Minimal	Low	Low	Medium

Legislative and regulatory risks

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Legislation doesn’t allow required activities	**Major:** may compromise planned eradication techniques or progress	**Possible**	**High**	Change strategies to suit legislation (pre-emptive).	**Low**
Approvals delayed or denied	**Major**: may prevent sequential contract or tender negotiations	**Possible**	**High**	Seek approvals before time (pre-emptive). Negotiate acceptable approval timelines ahead of requirements (pre-emptive).	**Medium**

Environmental risks

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Adverse population level impacts on endemic species	**Major:** adverse population level impact on any endemic species is unacceptable	**Likely** only in species that ingest baits or large numbers of contaminated prey	**Very high**	Assess each species and hold species at risk in captivity for the duration of risk.	**Low**
Adverse population level impacts on non-endemic, native, non-pest species through primary or secondary poisoning	**Moderate**: impacts are undesirable	**Likely** only in species that ingest baits or large numbers of contaminated prey	**High**	Assess each species and hold species at risk in captivity for the duration of risk or monitor and re-introduce if necessary.	**Low**
Adverse population level impacts on introduced or pest species through primary or secondary poisoning	**Insignificant:** impacts may be desirable	**Likely** only in species that ingest baits or large numbers of contaminated prey	**Low**	Explore possibilities of eradicating undesirable pest species.	**Low**

Adverse population level impacts on the marine environment	**Minor**: Information from other eradications indicate that no risk posed to marine species at a population level.	**Unlikely**	**Low**	Research conducted at LHI to examine possible effects on fish species. Protocols implemented to minimise bait entry to marine environment.	**Low**
Contamination of residential tank drinking water supplies	**Minor**: Given the low baiting density, low toxin levels and high insolubility of brodifacoum in water.	**Almost certain**: Inevitable that baits would enter rain water storage tanks if aerial baiting was conducted throughout the settlement.	**Medium**	Eliminate risk of contamination of tank water by hand baiting in the settlement area, and in proximity to residential buildings.	**Minimal**
Contamination of fresh water bodies	**Insignificant**: Given the low baiting density, low toxin levels and high insolubility of brodifacoum in water. Numerous studies of eradications show that water bodies are not contaminated by brodifacoum	**Almost certain**: Blanket aerial coverage of the island would mean that It would be inevitable that baits would enter water bodies.	**Low**	No mitigation required	**Low**
Contamination of soil	**Insignificant**: Toxin binds to soil particles and degrades to non-toxic components.	**Almost certain**: Blanket aerial coverage of the island would mean that It would be inevitable that baits will occur on soil.	**Low**	No mitigation required	**Minimal**

Community perception of risk to non-target species	**Major:** Residents will perceive a risk to non-targets that will influence support of the proposal	**Likely:** Significant proportion of community will assume that the operation will affect non-target species	**Very High**	Conduct research to allay fears of community, and provide information on previous eradications and impacts, and show that the benefits to populations after rodent removal far exceed any impacts of eradication.	**Low** – unlikely to resolve issue in all community that the loss of some non-targets is acceptable if eradication benefits the species as a whole.
Community perception of risk to environment	**Major**: Loss or reduction of community or sponsor support.	**Likely**	**Very High**	Provision of evidence to the community that there is no risk of soil and water contamination.	**Low**
Community perception of risk to marine environment	**Major**: Loss or reduction of community or sponsor support.	**Likely**	**Very High**	Promotion of factual information on lack of evidence for marine impacts of toxin, measures to minimise entry of bait into ocean, and targeted research at LHI.	**Low**

Human health risks

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Residents/visitors poisoned by toxic baits	**Minor**: May require medical treatment in the event of sufficient bait being consumed. Has not occurred during history of toxin use on LHI. **Catastrophic** in cases of adults intent on self harm	**Very Unlikely** in all cases other than small unsupervised children (**Possible**)	**Minimal** for all groups other than small children **(Low**)	Implement public awareness campaign to ensure baits not ingested, including at LHI school. Parents to supervise small (1-3 yo) children during the at risk period. Utilise baits of low toxic loading to ensure that large quantities would need to be ingested to result in poisoning. Ensure sufficient supplies of vitamin K at island hospital in the event that treatment is required.	**Low**
Consumption of contaminated food products	**Moderate**: In extreme cases of consumption may result in need for medical treatment	**Likely**: In residents, visitors that consume local eggs, poultry, beef and fish	**High**	Removal of beef cattle and poultry prior to eradication. Appropriate mitigation to prevent milk contamination, and laboratory testing of milk and fish after baiting to ensure no contamination.	**Low**

Community perception of risk of consumption of contaminated crops	**Moderate**: Loss or reduction of community or sponsor support	**Likely**: due to lack of understanding of fact that toxin not taken up by plants	**High**	Provision of information on the lack of threat posed by toxin to crops. Conduct trials to confirm lack of uptake by plants of brodifacoum on LHI.	**Low**

Tourism

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Publicity around the presence of rodents on Lord Howe Island will negatively impacts tourism	**Moderate**: Minor reduction in tourism revenue, loss of community support for eradication	**Possible**: Some tourists may choose to not visit due to presence of rodents	**Medium**	Provide advice that perceived downturns will be offset by personnel required for the operation. Undertake targeted marketing to engage niche ecotourists. Promote the benefits of eradication to the islands environment, a positive action by the Board to conserve World Heritage values.	**Low**

Eradication operation limits access to tourists	**Minor**: Reduction in Island tourism revenue	**Very unlikely** – operation being conducted during winter low season and will boost revenue for lodges and restaurants that will house and feed project personnel	**Minimal**	Inform tourism association of numbers of project personnel likely to be on island during eradication and note the period of operation is during winter low season and this will actually boost numbers. Undertake targeted marketing to engage niche ecotourists.	**Minimal**
Negative publicity associated with residents concerns about operation will negatively impact tourism	**Moderate**: Lack of support by community to remove rodents may be perceived by tourists as a lack of will by the community to protect the environment	**Possible**: Many visitors are environmentally aware and may resent the actions of residents to hinder ecosystem recovery	**Medium**	Inform community of eradication benefits and encourage them to support rather than oppose operation.	**Low**
Community perception of risk to World Heritage values of LHI posed by eradication	**Moderate**: Loss or reduction of community or sponsor support	**Likely:** members of community assume that the operation will affect World Heritage values	**High**	Inform community of benefits of eradication, and that the operation will halt the current degradation of World Heritage values.	**Low**

Pets

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Ingestion of toxin by dogs	**Minor:** Dogs vulnerable to ingestion of either bait or contaminated rodents. May require Vitamin K treatment for poisoning	**Unlikely** given the lack of reports on the island despite the extensive use of brodifacoum in the settlement	**Minimal**	Inform community of risks to dogs. Provide all dog owners with muzzles to prevent their animals ingesting baits or rodents. Where requested, move dogs off the island for the duration of the at-risk period.	**Minimal**

Financial

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Funding allocated is less than requested budget	**Major**: Inability to conduct all work required in the plan	**Possible**: Funding bodies may not be prepared to support all components of plan – e.g. monitoring	**High**	Ensure funding bodies/agencies are aware of the need for full funding of project components to ensure success. Redesign program to exclude components not critical to success . Decline funding if insufficient to achieve eradication	**Low**

Tenders and purchased supplies cost more than budget estimates.	**Moderate**: Essential components cost more, increased pressure on budget	**Likely**	**High**	Inclusion of budget contingency sum. Reprioritise existing budget.	**Low**
Currency fluctuations.	**Minor** to **Major**: Depending on level of fluctuation - Variation in cost of internationally-purchased supplies	**Likely** (may impact positively or negatively on budget).	**Medium** to **very high**	Inclusion of budget contingency sum. Reprioritise existing budget.	**Minimal to Low**
Additional requirements needed to implement project that are not provided for in budget.	**Major:** Increasing overall cost, or compromising existing components to allow for unforeseen items. Inability to complete project. Project failure.	**Possible**	**High**	Inclusion of budget contingency sum. Ongoing budget monitoring to pick up variances. Reprioritise existing budget. Seek additional funds.	**Low**
Costs at time of implementation exceed original estimates	**Major:** Budgetary pressure. Inability to complete project within budget. Project failure.	**Likely**	**Very high**	Commitments register. Ongoing financial monitoring of actual vs. budgeted expenditure. Inclusion of budget contingency sum. Inclusion of CPI factor in staffing and major component costings. Reprioritise existing budget. Seek additional funds.	**Low**

Operational

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Failure to successfully eradicate rodents due to operational failure	**Major:** Loss of political and community support, tarnished organisational image, impediment to future requests to repeat eradication attempt, need to continue current control program indefinitely	**Possible:** Technically challenging project given issues relating to threatened endemics and presence of human population	**High**	Meticulous planning for all aspects of the operation. Use of current world's best practice techniques. High level of peer review. Ongoing enhancement of capacity of project team through participation in other rodent eradication operations. Deliver targeted training to all staff involved	**Low**
Aerial baiting operation delayed after scheduled start due to extended unsuitable weather, or delayed during aerial operation due to weather	**Moderate**: Delay to aerial baiting operation commencement. Requirement to repeat baiting with implications for contingency bait and fuel availability and additional helicopter costs.	**Possible**	**Medium**	Weather forecasting (pre-emptive) and generous operational timeframe (contingent). Thorough operational planning to ensure work completed during available weather. Re-baiting areas already treated (contingent). Inclusion of contingency on budget to cover extra costs	**Low**

Poor aerial baiting application	**Major**: Bait not available to all individuals of target species, likely failure of eradication attempt	**Possible**: Likelihood increases with lack of experience of aircraft operators in aerial eradication	**High**	Engage Helicopter contractor experienced in rodent eradication. A tender process will be conducted to engage the contractor with both the equipment and experienced personnel required to complete the operation. Use of GPS technology to guide flight lines to ensure full coverage.	**Low**
Failure to secure services of qualified helicopter company to aerially distribute bait	**Major**: Failure to adequately cover the entire island with toxic baits, increased risk of eradication failure	**Unlikely**: Given that several operators are known to have experience in this technique	**Medium**	Conduct tender process at least 12 months prior to the proposed bait drop to ensure unencumbered availability of operators.	**Low**
Equipment failure	**Minor to Major**: Assessed against specific equipment. Risk likely to increase with complexity of technology e.g. helicopters, GPS, spreader buckets	**Possible**	**Low** to **High** depending on specific equipment	Testing before deployment to island; provision of required spares (contingent).	**Minimal** to **Low**

Baits are ineffectual	**Major**: Failure to cause mortality in rodents. Failure of eradication.	**Very Unlikely**: Baits have been shown to be palatable to both target species	**Low**	Prior trials using recommended bait to confirm suitability (conducted 2007). Assay bait for toxin levels at manufacture to ensure meet requirements. Confirm susceptibility to toxin in resistance trials	**Minimal**
Failure to stop use of brodifacoum as a control agent prior to eradication	**Moderate**: Increased potential for the development of resistance among target populations to brodifacoum. Will compromise eradication	**Likely** if community not clearly informed of the need to cease use, and if no suitable alternative is available to control mice	**High**	Provide information to community on need to cease use of brodifacoum. Stop use as soon as Board give green light for eradication LHIB to source alternative rodenticide for use prior to eradication.	**Low**
Sabotage – live rodents held and released after bait breakdown	**Major:** Will totally undermine success of eradication	**Possible**: If individuals do not support the goals of eradication and lack community responsibility	**High**	Promotion of benefits of eradication among community and wider public in general. Use of rodent detector dogs during and after baiting operation to detect live rodents.	**Low**

Residents refuse access to properties during eradication	**Major**: Potential to compromise eradication	**Likely** that there will be some residents that will not allow access to their properties	**Very high**	Provide information to community on benefits of eradication for LHI. Develop property baiting plans in conjunction with residents.	**Low**

Capability (people)

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Inability to (or difficult to) recruit project staff or contractors	**Major**: Compromise implementation of plan.	**Unlikely**	**Medium**	Secure staff well in advance of operation. Train existing staff (pre-emptive and contingent). Standby agreements with alternative suppliers (for critical). Revise staffing requirements.	**Low**
Staff and staff employment contract conditions	**Major:** Required numbers of technical and field staff may be difficult to recruit for the proposed field deployment duration. Staff employment award conditions may impose constraints on field outputs.	**Possible**	**High**	Targeted advertising to recruit suitable staff. Recruit well in advance of operation. Consideration of employment awards in context of LHI field work.	**Low**

Loss of key people (from project)	**Major**: Loss of knowledge, experience and momentum. Delays to critical component implementation.	**Possible**	**High**	Knowledge sharing within teams (job rotation / share / briefing / mentoring / shadowing). Good staff management skills and organisational culture.	**Low**

Biosecurity

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Potential reinvasion by rodents.	**Major:** Undermine success of eradication, loss of financial investment, loss of support for any future attempt	**Possible**. Clearly defined pathways for reintroduction, known locations and times of potential reintroduction	**High**	Revise LHI quarantine strategy to incorporate measures to prevent transport of rodents to the island by air or sea, and establish a capability (using detector dogs) to detect and deal with any rodents that might arrive at the island.	**Low**
Increased biosecurity costs	**Moderate**: Loss of support from local community	**Likely**. Removal of rodents will require an upgrade of biosecurity to ensure no re-invasion	**High**	Promote importance of biosecurity to LHI's world Heritage values and thus tourism and economic base. Alert community that increased vigilance is not for rodents only but all invasives.	**Low**

Resource

Risk	***Potential Consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Lack of suitable accommodation (Lord Howe Island) for protect personnel	**Major**: Reduction in field team size, reducing project capability or additional cost to project.	**Very unlikely**: Operation to be undertaken during low season so sufficient tourist accommodation available	**Low**	Advance negotiation with tourism operators on Island to ensure availability of beds during operation. Book beds 1 yr in advance	**Low**
Insufficient interest from helicopter companies with eradication experience to undertake work	**Major**: Failure to contract helicopters would compromise aerial baiting phase and thus entire project. Mechanical breakdown or crash during project may compromise project continuing or may delay schedule.	**Possible**	**High**	Standby agreements with alternative suppliers.	**Low**
Insufficient supplies of fuel (helicopter and station)	**Major**: Prevent continuation of project field operations.	**Very Unlikely**: Well established, reliable fuel supply on island	**Low**	Detailed prior planning to estimate requirements. Contract fuel supply 12 months in advance of operation	**Low**

Stakeholders

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Failure of community to support eradication	**Major**: Potential to compromise eradication Possibility of injunctions or legal challenges delaying planning and operations.	**Possible**: due to lack of knowledge of program benefits and mechanics	**High**	Provide information to community on benefits of eradication for LHI Communication plan (pre-emptive and contingent). Respond to issues to build support.	**Low**
Lobbying seeks to adversely change the project's scope or cause effort/resources to be withdrawn or diverted from essential tasks	**Moderate**: Distraction from project focus.	**Likely**: If community concerns not addressed	**High**	Communication plan (pre-emptive and contingent).	**Low**

Political

Risk	***Potential consequences***	***Likelihood***	***Overall risk***	***Response***	***Overall risk after mitigation***
Loss of support for project (including funding)	**Major:** Difficulty in implementing the project.	**Unlikely** if progress is satisfactory. **Likely** if community objections are not adequately addressed	**Medium** to **Very High**	Briefing ministers periodically. Implementation of communications plan. Steering Committee advocacy.	**Low**

Potential human and environmental impacts

Overview

A range of actual or potential environmental impacts and issues associated with the eradication of rats and mice from LHI have been identified, including:

- ingestion of bait by residents, tourists, livestock and pets
- poisoning of non-target species through direct ingestion of brodifacoum baits (primary poisoning)
- poisoning of non-target species through preying or scavenging upon target species (secondary poisoning)
- contamination of soils
- pollution of potable water supplies
- pollution of freshwater bodies (pools and streams)
- pollution of marine ecosystems and potential effects on marine organisms.

This Plan considers each of these potential adverse impacts and identifies actions to be undertaken to avoid, alleviate or mitigate these risks. Prior to receiving legislative approval for the eradication operation, the actual and potential impacts of such an operation will be addressed in a comprehensive species impact statement. This statement will outline the range and significance of any potential adverse effects and the means by which these risks will be managed to ensure that all potential adverse effects are avoided, remedied or mitigated.

Risks to humans

Anticoagulants such as brodifacoum and warfarin, if consumed in sufficient quantity, are harmful to humans. The antidote for brodifacoum poisoning is vitamin K. Brodifacoum is slow acting and several days are available for treatment. In the unlikely event that a person or child ingests bait, medical advice and aid will be provided on the island. There is a hospital on LHI and diagnostic and treatment procedures will be discussed with the island medical doctor as part of the operational planning process.

There are four possible pathways for humans to be affected by brodifacoum: (i) direct ingestion of brodifacoum baits, (ii) ingestion of contaminated food, (iii) inhalation of brodifacoum laden dust, and (iv) absorption of brodifacoum through the skin.

In the proposed operation to eradicate exotic rodents from LHI the only one of these pathways that poses a significant health risk is the direct ingestion of brodifacoum baits. The group of residents most at risk are small children, and parents will need to be vigilant to ensure that children do not ingest baits for the period that the pellets are available (approximately 100 days).

In NSW in 2008/09 the Poisons Centre (J. Kirby NSW Poisons Centre pers. comm.) reported that incidents of human exposure are confined to small children where householders have improperly stored or used the product, and people intent on self-harm. These same risks already exist on LHI for current rodenticides and for a range of cleaning products and other household chemicals stored in the home. Brodifacoum products at 2.5 times the concentration proposed are sold over the counter in many countries and are currently being sold and used on LHI. The risks to human health from disease and contamination passed on by rodents must be balanced against the risk to residents and visitors posed by this operation.

Many island residents are already familiar with brodifacoum baits, as these are currently in widespread use within the settlement area. Additionally, large quantities of warfarin bait, which has been used extensively for many decades, occur at bait stations, many of which are readily accessible, and currently pose a risk to humans, particularly children. As such, residents are already familiar with the risks of consuming and handling rodenticides, and there would be little additional risk posed by the proposed eradication operation. In fact, if the eradication is successful, the current use of rodenticides will be discontinued.

A detailed information sheet outlining the hazards associated with brodifacoum will be prepared for residents prior to the operation. Talks will also be given at the island's school to inform children of the operation and how they should behave around the toxic baits.

Residents will be informed of the date of baiting well in advance of it occurring, and will be issued with reminders closer to the date. Residents will be kept informed of progress and will be notified when baits have disintegrated and there is no further risk of poisoning.

In relation to the risk of inhaling dust, Pestoff® 20R is manufactured to stringent specifications to contain little or no dust. On average it contains less than 0.6% of fine particles (less than 2 mm in diameter). Studies indicate that when Pestoff® 20R is aerially distributed through a spreader bucket the amount of fine particles increases, but does not exceed 2% (range: 0.78–1.92%). Risks associated with inhalation of the toxicant will be negligible for residents given the pelletised nature of baits and the low levels of dust associated with this particular product. In line with standard OH&S procedures, personnel distributing baits will wear protective gloves and face masks to eliminate the minimal risk posed by inhaling or absorbing the toxicant through the skin.

Brodifacoum baits have been used successfully numerous times without incident in many parts of the world. Brodifacoum at the low concentrations specified for this operation is of low toxicity to humans and an antidote is readily available.

Risks to wildlife

Most eradications using brodifacoum have resulted in mortality of some non-target species. However, any mortality in the short-term has been far outweighed by the improved survival once populations are free of rodent predation.

Numerous studies have examined how broadscale baiting with brodifacoum affects various non-target animals, including species similar to those on LHI. Planning for the eradication of exotic rodents on LHI has drawn heavily on these studies. Additional studies have also been undertaken locally. Although the operation may result in some non-target deaths, these losses will be minimal and are not expected to have any significant long-term impact on the non-target populations. The majority of species will be unaffected. With the rats and mice gone, many native species will flourish, increasing in abundance to levels not seen since before the invasion of rats. Although the possibility of secondary poisoning cannot be excluded, it is expected that about 90% of rodents will die underground and thus not be available to scavenging birds.

Eradications of rats from Codfish, Korapuki, Marotere, Tiritiri Matangi and St Paul islands (Towns 1991; Parrish & Pierce 1993; Graham & Veitch 2001; Micol & Jouventin 2002), have all demonstrated the overwhelming benefits of rodent eradication and the net positive effect for non-target species.

Omnivorous, herbivorous and granivorous birds are most at risk from primary poisoning. In New Zealand, brodifacoum baiting is known to have caused deaths in 33 bird species. In most cases, the number of birds killed was few, often just one or two individuals. The only species for which large numbers of deaths have been recorded are purple swamphen

(*Porphyrio porphyrio)*, weka (*Gallirallus australis*, a rail similar to the woodhen), paradise shelduck (*Tadorna variegata*) and New Zealand dotterel (*Charadrius obscurus*). In all cases, however, these populations recovered rapidly following the eradication of rats. For example, up to 90% of swamphens suffered mortality through primary poisoning but the population recovered to pre-eradication levels within two years. Small birds such as silvereyes, sparrows and blackbirds are considered more resistant to brodifacoum than some larger birds such as gulls and geese. Some large birds such as swamp harrier (*Circus approximans*) are also considered to be relatively resistant.

Birds

LH woodhen and LH pied currawong

Non-toxic bait trials conducted in 2007 confirmed that the endemic LH woodhen will ingest baits in amounts that would be fatal. The LH pied currawong, also endemic, is known to consume rodents, and therefore would be susceptible to secondary poisoning. Both the woodhen and currawong are listed as vulnerable species under the *Environment Protection and Biodiversity Conservation Act 1999* and endangered and vulnerable respectively under the *Threatened Species Conservation Act 1995*. To minimise the impact on woodhens and currawongs, a substantial proportion of each population will be taken into captivity on LHI and will remain there for the duration of risk. In the case of species vulnerable primary poisoning this will be until the baits have disintegrated and pose no further risk. Birds at risk of secondary poisoning may be able to be released earlier, depending on the survival rate of those individuals that are not taken into captivity. In accordance with best practice, a small population of woodhen will be transferred to a captive facility on the Australian mainland during the period of captivity.

Captive facilities to temporarily house these birds will be built on LHI. All captive management (including aviary design) will be overseen by acknowledged leaders in avian husbandry, and a specialist aviculturist will be present on the island during the period of captivity. A veterinarian will be present during the capture and will be on call throughout the period of captivity. Woodhen have already been held in captivity both on the island and on the mainland. The on-island facility was extremely successful, producing about 80 birds for reintroduction to various locations in the southern mountains (Miller & Mullette 1985; Lourie-Fraser 1985). The mainland colony consisted of two juveniles taken from the settlement area to Taronga Zoo in December 1989. The female died after one year in captivity when it became eggbound; the male survived until August 1995 when it died, seemingly from colliding with an obstacle. Survival of the animals held in Taronga Zoo was comparable to their wild counterparts on LHI. A comprehensive husbandry manual produced by Taronga Zoo is available.

Other native birds

The LH golden whistler (*Pachycephala pectoralis contempta*) is considered to be at low risk given that they eat mainly insects. Trials conducted in 2007 found no evidence that this species consumed baits, and secondary poisoning through eating insects is considered unlikely. Laboratory studies show that invertebrates are unlikely to accumulate brodifacoum as it is eliminated quickly through metabolism and excretion (Morgan et al. 1996). In addition, the concentration of brodifacoum found in invertebrates collected after poison operations has been low, indicating that very large numbers of contaminated invertebrates would need to be consumed in a relatively short period to cause mortality (Morgan & Wright 1996). No invertebrates were found to have traces of brodifacoum following baiting operations on Stanley Island and Red Mercury Island (Towns et al. 1993; Morgan & Wright 1996). The chances of secondary poisoning are further reduced by the operation being carried out in winter when invertebrate activity is low. Notwithstanding, given that golden whistlers are an irreplaceable endemic species, as a precaution, a small number will be taken into captivity during the eradication.

The LH silvereye (*Zosterops lateralis tephropleurus*) is considered to be at low risk given that they eat mainly insects and fruit. Trials conducted in 2007 found no evidence that this species consumed baits. It is possible that a few individuals may succumb to the effects of brodifacoum, as has occurred with silvereyes in New Zealand operations (Brown 1997b). However, any losses of individuals are unlikely to be significant or long-term. Any initial decline is likely to be quickly followed by marked population increases following the removal of rodents and subsequent increase in invertebrate and fruit food supplies. Notwithstanding, given that silvereyes are an irreplaceable endemic species, as a precaution, a small number of will be taken into captivity during the eradication.

Non-toxic bait trials found no evidence that the emerald ground dove (*Chalcophaps indica*) consumed bait. Although this species is not endemic, it is less wary than the same species on the mainland, and so is considered unique. Consequently, as a precaution, a small number will be taken into captivity during the eradication.

Other native birds considered to be at risk include buff-banded rail (*Gallirallus philippensis*) and purple swamphen (*Porphyrio porphyrio*). These species are not endemic and if lost are likely to recolonise. There is unverified concern that these species may be adversely affecting some endemic species and that they should be regarded as pests. No action will be taken to mitigate the potential effects of baiting on these species.

Exotic or introduced birds

Exotic or introduced bird species at risk include ducks, mostly hybrid black duck (*Anas superciliosa*) and mallard (*Anas platyrhynchos*), feral pigeon or rock dove (*Columba livia*), feral chicken (*Gallus gallus*), blackbird (*Turdus merula*) and masked owl (*Tyto novaehollandiae*). No action will be taken to mitigate the potential effects of poisoning on these pest species. In the case of masked owls, the reduction in availability of rodent prey after the eradication may result in increased predation pressure on other species. There is currently a research program assessing the feasibility of eradicating masked owls from the LHI Group. Any eradication of the owl will be run coincidentally with the rodent eradication.

Seabirds

Seabirds are not at risk as they do not feed when on land. By conducting the operation in August any potential impact on seabirds due to disturbance will be minimised as most species are absent from the island at this time.

- Providence petrels (*Pterodroma solandri*) are ashore breeding in August, but at this time of the year they have chicks in the burrow and by day are generally foraging at sea, usually not returning to the island before mid-afternoon.
- Another winter breeder - little shearwater (*Puffinus assimilis*) - will also have chicks, but these birds seldom emerge from their burrow during daylight.
- Masked boobies (*Sula dactylatra*) will be breeding, and some will have eggs and possibly chicks in the nest.
- Grey ternlets (*Procelsterna cerulea*) may also have begun nesting.

These last two species nest above ground, so care will need to be taken to minimise disturbance and avoid bird strikes while flying helicopters over these colonies. Helicopter pilots will be briefed on the potential risk of bird strikes prior to the operation and helicopter operations will be managed to minimise risk of bird strike.

Mammals

The only extant native mammal on LHI is the large forest bat (*Vespadelus darlingtoni*). This bat is insectivorous and eats flying insects, and is therefore considered to be at low risk of poisoning. While no specific research has been conducted to assess the impact of rodents on this species, it is expected that the removal of rodents will result in increased populations of bats.

Reptiles

No operations that have used brodifacoum baits to remove rodents have reported widespread deaths in reptile species. In many instances the removal of rodents has resulted in substantial increases in the abundance of reptiles (Towns 1991). For example, the number of skinks on Korapuki Island in New Zealand increased 30-fold within five years of rats being removed (Towns 1994). There are two species of native reptiles on LHI: the LHI skink (*Oligosoma lichenigera*) and the LHI gecko (*Christinus guentheri*). Both species occur on the offshore islets around LHI as well as on Norfolk Island. These species are considered to be at low risk of poisoning, and are likely to increase in abundance substantially following from the removal of rodents. Research on LHI's reptiles is commencing in summer 2009 as part of the pre-operational preparations.

Invertebrates

Brodifacoum is not expected to have significant effects on invertebrates as they have different blood clotting systems to mammals and birds.

While most studies of molluscs indicate a lack of impact of brodifacoum (Booth et al. 2003; Bowie & Ross 2006), a study conducted in Mauritius reported mortality in two snail species after reports of snails consuming toxic baits (Gerlach & Florens 2000).

Research will be conducted on the vulnerability of the endangered LH placostylus to brodifacoum baits, and if significant mortality occurs, provision will be made to collect and house animals in captivity for the duration of the eradication operation. Based on other eradications any incidental mortality that does occur will be more than offset by the benefits that accrue to invertebrate populations from the removal of predation pressure by rodents. Captive breeding of this species as a means of boosting recovery is currently being investigated.

There are also four species of critically endangered land snails on LHI: Masters' charopid land snail, Mount Lidgbird charopid land snail, Whitelegge's land snail and *Gudeoconcha sophiae magnifica* (a land snail). All these species are highly threatened by rat predation and it is likely that if rats are not removed these species will become extinct; some may already be extinct. The extreme rarity of these species precludes any testing of their susceptibility to brodifacoum, however, for these species the threats associated with not removing rodents exceed the potential risk associated with an eradication operation.

Captive studies with large-headed tree-weta (*Hemidenina crassidens*) and Ascension Island land-crab (*Gecarcinus lagostoma*) indicate that neither of these species are particularly susceptible to brodifacoum, with no brodifacoum residues being detected in weta four days after sub-lethal exposure and in land crabs one month after sub-lethal exposure.

Arthropods exposed to brodifacoum during captive trials were unaffected (Booth et al. 2001), and earthworms only showed toxic effects at extreme doses, several orders of magnitude higher than proposed in this eradication proposal (Booth et al. 2003).

Field evaluations following aerial application of brodifacoum at a number of sites in New Zealand indicates that few insect species are at risk of primary poisoning, and no deleterious effects on arthropod populations have been detected. Non-target insects and millipedes in the Seychelles Islands consumed brodifacoum bait with no apparent adverse effects.

Experimental work conducted on earthworms indicated that a soil concentration of 500 μg/g (micrograms of toxicant per gram of soil) is required to cause mortality, which is around 1000 times higher than the likely levels of brodifacoum that would be found in soil directly below the proposed bait.

Soil

There are a number of operations in New Zealand where soil has been tested extensively following the use of cereal-based brodifacoum baits. During the Little Barrier Island operation in 2004, soil samples were collected from directly under decaying Pestoff® 20R baits. Samples were taken 56 and 153 days after the aerial bait drop. Those in grassland areas had residues of 0.2 μg/g after 56 days, and 0.03 μg/g on day 153. In forested areas the figures were 0.9 μg/g on day 56 and 0.07 μg/g on day 153. These data indicate a rapid decline in brodifacoum content in soil, with around a 90% reduction in toxicant levels between days 56 and 153.

Brodifacoum soil residues were also tested in a baiting trial conducted at Tawharanui Regional Park, Auckland. Soil samples were collected from directly beneath disintegrating baits at 56, 84, 122 and 153 days after first exposure to the elements. These samples produced residues of between 0.02 and 0.2 μg/g, with all positive samples occurring within the first 84 days. In other words, in this situation, no brodifacoum was detectable in the soil immediately below baits after just 84 days (Craddock 2004).

Analysis of bait and soil samples from Kapiti Island following an aerial application (14 kg/ha), showed only 10–30% of original levels of brodifacoum in samples taken 3 months after the operation (Empson in Brown et al. 2006). Analysis of soil samples from Red Mercury and Coppermine islands following rat eradication using brodifacoum showed no residue in any samples, including samples taken only one month after the operation (Morgan 1993; Morgan and Wright 1996).

Additional tests on LHI will be conducted to test brodifacoum residues in soil.

Secondary poisoning

Although generally not toxic to invertebrates, anticoagulants can be ingested by some invertebrates (Spurr & Drew 1999) which may then be eaten by non-target species. Invertebrates, however, tend not to bio-accumulate brodifacoum; instead it passes through them reasonably quickly. Consequently, in those instances where ingestion occurs, affected birds tend to receive sub-lethal doses. Notwithstanding, occasional instances of secondary poisoning of birds have been reported in eradications using brodifacoum (Dowding et al. 2006). These have occurred when birds have fed exclusively on contaminated invertebrates.

During trials conducted on LHI, some ants, slugs, cockroaches and snails (not Placostylus) were observed feeding on baits. For each of these groups only a small proportion of individuals had consumed bait; consequently it is unlikely that any of the birds on LHI will consume contaminated invertebrates exclusively.

Risks to aquatic and marine environments

Brodifacoum is highly insoluble in water; consequently contamination of streams and other water bodies after the aerial application of bait is extremely unlikely. The insolubility of brodifacoum coupled with its propensity to bind strongly to soils means that it cannot easily be washed into the marine environment. Only the erosion of soil itself would see any brodifacoum reaching water, and even then brodifacoum would remain absorbed in organic material and settle out in the sediment.

In studies, less than 2% of brodifacoum added to soil leached more than 2 cm in any of the four soil types tested (World Health Organisation 1995). Where baits are dropped directly into fresh or salt water, the toxicant will bind to organic matter in the sediment with no effect on water quality.

Brodifacoum baits have been used on islands in three marine reserves (Tuhua, Kermadec and Kapiti) and a marine park (Hauraki Gulf) without any incidents or measurable effects (see Appendix 5 - IEAG peer review comment) . Studies with the Kapiti operation found that reef fish were not adversely affected (Empson & Miskelly 1999).

The most dramatic demonstration of the relatively benign effects of brodifacoum in the marine environment comes from an accidental discharge of 18 tonnes of brodifacoum bait from a truck accident in 2001. This represents almost half the total proposed to be applied to the whole of the LHI Group. This incident has been extensively researched and the measurable effects of this very high concentration of toxicant on the marine environment were small and extremely localised (Primus et al. 2005). The greatest exposure of marine invertebrates occurred within 100 m of the spill location, with only minor exposure being observed 100–300 m from the spill location.

Fresh water bodies

Any baits entering streams or other water bodies on LHI will sink and disintegrate, usually within a few hours, depending on turbulence or rate of flow. The minute amount of brodifacoum in the bait (20 parts per million) settles in the sediment where it binds to organic material and breaks down. Although it has been shown that brodifacoum will not contaminate water bodies (Morgan & Wright 1996, Ogilvie et al. 1997), tests will be undertaken on designated fresh water bodies to assess and monitor brodifacoum levels after the bait drop. Residents and tourists will be informed to not drink from streams until they have been tested and verified to not contain detectable traces of brodifacoum. During the few days it will take to collect and analyse the water samples, potable drinking water will be positioned at several locations along the track to Mt Gower.

Marine environments

While every effort will be made to ensure that bait is directed onto land, it is inevitable that a small amount of bait will enter the marine environment, particularly where cliffs come right to the shoreline. Most of this bait will fall within a few metres of the shoreline and will be subjected to the mechanical effects of wave action, resulting in disintegration within a few minutes (Empson & Miskelly 1999). This, together with the high dilution factor, and the insolubility of brodifacoum in salt water, means that the potential risk to marine organisms is negligible. The amount of brodifacoum assimilated into the marine environment will be many orders of magnitude lower than the concentrations known to be toxic to fish (Empson 1996).

In the lagoon, where wave action is not as great as the open ocean, disintegration of the bait pellets will take longer. Consequently, additional care will be taken to prevent bait entering the lagoon. This will be done by aerial baiting with specialised equipment that limits the spread of bait, or by hand-broadcasting of bait along the shoreline of the lagoon. Also, divers will remove any bait that falls into the water.

Outside of the lagoon, some marine organisms may feed on the residual particles and some fish may feed on the bait before it disintegrates. However, there are very few recorded instances of fish mortality due to ingestion of brodifacoum; even the accidental spillage of 18 tonnes of bait (described above) resulted in no known fish deaths (Primus et al. 2005). A study of marine fish undertaken during the operation to eradicate rats on Kapiti Island found no evidence that their population densities were adversely affected (Cole & Singleton 1996). Notwithstanding, brodifacoum is toxic to fish, so it is possible that a small number of fish may be killed. However, no species or population will be put at risk.

To confirm the risk to fish, observational studies using local divers will be undertaken to determine which fish species consume baits dropped into the ocean. Fish species that readily consume baits will undergo laboratory studies to determine their susceptibility to brodifacoum and to measure the uptake of toxicant into body tissues. The risk to these species will then be reassessed.

Risks to livestock

Having livestock present during the eradication poses a substantial risk to the success of the operation. Stock feed provides an ideal harbour and food source for rodents. If rodents have access to this feed or any spillage they may not take baits. Poultry sheds in particular provide a harbour from which rodents need not move out to feed. There is also a risk that livestock may consume baits. Consequently, the aim is to de-stock the island as much as possible prior to the eradication.

The presence of livestock on LHI poses technical challenges in the eradication operation. Approximately 75 hectares of land outside the settlement area is utilised for grazing livestock. Like the rest of the land on the island, these 75 hectares must be comprehensively baited to ensure all rodents are presented with toxic baits during the operation. The most effective way to bait such a large area is to incorporate it into the area that will be aerially baited. To do this it is necessary to remove livestock from the land for the duration of the eradication.

Although any ingestion of brodifacoum by cattle on LHI would be in sub-lethal doses, there is a potential human health risk associated from eating meat or milk from cattle which have ingested the toxicant. Mitigation measures will be taken to prevent the entry of brodifacoum into the human food chain. The island will be de-stocked of beef cattle during the year prior to the eradication. Replacement stock will then be brought to the island when the breakdown of bait in paddocks is complete. Most stock-owners on the island have indicated their willingness to co-operate in this process, subject to satisfactory compensatory arrangements being put in place.

The dairy herd (approximately 14 animals) to remain on the island throughout the operation, if requested by the owners. Animals will be confined to a small paddock and will receive supplementary feed during the period that bait is present (approximately 100 days). No aerial baiting using a spreader will be conducted within 30 m of the holding paddocks. Trickle baiting or hand-broadcasting of bait within this buffer zone will be conducted at a rate 50% higher than elsewhere. This will create a buffer around the holding paddocks to ensure any rats or mice leaving the paddock are exposed to the bait. Baiting within the holding paddock will use cattle-proof bait stations. Although brodifacoum is unlikely to be excreted in milk, as a precaution the milk will be tested to ensure that it does not contain traces of poison.

Similar arrangements will be made for goats (approximately 8) and horses (approximately 3) confined during the risk period. All confined livestock will be fed with fresh cut grass from unused paddocks, alleviating the need to store food which may provide an alternative food source for rodents.

Poultry will be exposed to the risk of primary poisoning from baits spread around the settlement area. More significantly, the presence of poultry poses a major risk to the success of the operation, as the presence of large amounts of feed grain has the potential to distract rodents from consuming the bait. All poultry will be removed from island or culled at least one month prior to the eradication. Once all bait has disintegrated and no longer poses a threat, disease-free, day-old chicks will be brought to the island to replace those birds removed.

Risks to dogs

Dogs are at risk from both primary and secondary poisoning from brodifacoum. Owners will need to be vigilant to prevent animals from eating baits or consuming dead or dying rodents. Again, however, residents are already familiar with the risk, and as far as we know there have been no reported incidences of anticoagulant poisoning from current control operations. To assess the risk to each dog, owners will be provided with a sample of non-toxic bait many months prior to the operation. Any dogs that have a propensity to eat baits may need to be muzzled and/or kept on a leash during the period that bait is present on the ground.

The option of removing dogs from the island for the duration of the risk period and housing them in boarding kennels on the mainland will be available to any concerned residents, at no cost. In the unlikely event of poisoning, the affected dog will be treated with a course of vitamin K injections administered under veterinarian supervision.

APPENDIX 5: Peer review summary

Draft Plan for the Eradication of Ship Rats (*Rattus rattus*) and House Mice (*Mus musculus*) on Lord Howe Island

Peer review: comments and responses

The Lord Howe Island Board invited the following organisations and individuals to review the *Draft Plan for the Eradication of Ship Rats (Rattus rattus) and House Mice (Mus musculus) on Lord Howe Island*: The Island Eradication Advisory Group of the New Zealand Department of Conservation (IEAG); The Invasive Species Specialist Group of the Species Survival Commission of the World Conservation Union (IUCN); Landcare Research, New Zealand (LCR); The Worldwide Fund for Nature, Australia (WWF); Birds Australia (BA); and Professor Tim Flannery (PTF).
Henceforth, each reviewer is identified by the abbreviations above.

The reviewers were asked to address the following questions, as well as provide any other comments they regarded as appropriate.

1. Does the plan demonstrate that there is a need to mitigate the detrimental impacts of exotic rodents on the biodiversity values of LHI?
2. Is the Lord Howe Island Board's position that rodent eradication is the best approach to mitigate these impacts adequately justified in the plan?
3. Does the plan provide adequate justification for the choice of toxin to be used in the proposed eradication?
4. Does the plan demonstrate that the approach, methods and risk mitigation measures proposed will enable the eradication of exotic rodents, while minimising adverse impacts on non-target species, residents and the environment?
5. Does the plan demonstrate that adequate attention has been given to the identification of potential environmental risks posed by brodifacoum and the methods to mitigate them?
6. Does the plan demonstrate that adequate measures have been proposed to mitigate the potential risks to wildlife by the presence of exotic rodents?
7. Are the proposed measures in the plan to ensure the safety of residents and visitors adequate?

The comments and suggestions made by all reviewers have been incorporated into the current amended version of the plan, strengthening it considerably. This document outlines all the issues raised by the reviewers, and in a brief response explains how each of these has been addressed in the revised plan. For full details see the eradication plan. Not all questions were addressed by all reviewers. No response is given where it is clear that none is required. The plan was sent to the reviewers in two parts; for simplicity these have now been combined into a single document.

In summary, the reviews were all highly supportive of the plan, and endorsed the aims and methods proposed. Many comments requested additional information to be added to the plan to explain more fully some complex issues and decisions; this has increased the size and scope of the plan. Changes to proposed procedures have not been extensive, being refinements rather than substantive modifications. Many comments offered suggestions for the next phase of the planning process, and these have been incorporated into this ongoing process.

Question 1. Does the plan demonstrate that there is a need to mitigate the detrimental impacts of exotic rodents on the biodiversity values of LHI?

Reviewer: IEAG. Yes. The evidence worldwide for the impacts of introduced rodents on island biodiversity is overwhelming. It has been identified as a key threatening process in Australia and the subject of a threat abatement plan which specifically mentions Lord Howe Island. In our opinion this question was satisfactorily answered by the feasibility study eight years ago and part one of the current plan provides ample justification by reiterating this. The impact of rodents on lizards is one omission we noted in the plan. Both rats and mice have been documented to have serious impacts on reptiles on other islands.

Response. *Information regarding the adverse impacts of rodents on lizards has been enhanced in the plan.*

Reviewer: IEAG. While it is true that few comprehensive studies have been carried out on LHI we do not believe there is any cause to question the need for managing the impacts of rodents to protect and enhance the island's biodiversity values. For further information on this issue we recommend a 2006 publication by Towns *et al* '*Have the harmful effects of introduced rodents on islands been exaggerated?*'

Response. *This publication will be made available to the residents of LHI.*

Reviewer: IEAG. The plan does not give much discussion to potential economic and human health benefits of rodent eradication on LHI. Presumably the economic side is well covered in the cost benefit analysis done in 2003. Although we did not read this document we would like to add that the Board does need to consider the long term sustainability of the current rat control programme if the eradication does not proceed.

Response. *The economic benefits are mentioned in the plan, but only cursorily; full details are contained in the cost benefit analysis. The plan now acknowledges that the efficacy of the current control program is not known.*

Reviewer: IUCN. The overview provides solid arguments on the need to carry out the eradication. The presence of introduced rodents represent a major threat to several endemic species of birds and other animals, and may have other detrimental effects not yet detected (e.g. the removal of rodents is likely to have significant positive effects on the endemic invertebrate fauna).

Response. *None required.*

Reviewer: LCR. No comment.

Response. *None required.*

Reviewer: WWF. The plan provides very convincing evidence of the need to mitigate the detrimental impacts of exotic rodents on the biodiversity values of LHI.

Response. *None required.*

Reviewer: BA. Birds Australia endorses the plan to eradicate rodents from the island. The plan is comprehensive and well-justified.

Response. *None required.*

Reviewer: PTF. There is no doubt in my mind whatever. The document demonstrates the need persuasively.

Response. *None required.*

Question 2. Is the Lord Howe Island Board's position that rodent eradication is the best approach to mitigate these impacts adequately justified in the plan?

Reviewer: IEAG. Yes. Once again this was quite adequately covered in the feasibility study and reiterated in part one of the plan. Eradication, as a strategic option, is justified over control in terms of cost, environmental impact, animal ethics, sustainability and biological outcome provided it is successful. There are risks associated with whatever strategic option is chosen. In our opinion, the opportunity to meet LHI Biodiversity Management Plan goals with least risk and maximum benefit lies with choosing the eradication option and implementing this option with good planning to minimise the risk of failure.

Response. *None required.*

Reviewer: IUCN. It is globally acknowledged that eradication of invasive alien species is a key management option for mitigating the impacts caused by biological invasions, and that this option is in general the best alternative to mitigate the impacts caused by invasive species. In this specific case, considering that the ongoing rodent control requires the use of tonnes of poison baits on the island, the eradication—if successful—will halt the significant impacts at present caused by the two alien rodents, at the same time reducing the presence of toxic substances in the environment. In my opinion it is therefore evident that the eradication is very solidly justified. I also agree that there is a risk that the permanent use of poison baits for control can bring to the insurgence of a resistance in the target rodents, with the possibility that eradication may become unfeasible in the future.

Response. *None required.*

Reviewer: LCR. No comment.

Response. *None required.*

Reviewer: WWF. The plan clearly demonstrates that rodent eradication is the best approach to mitigate these impacts.

Response. *None required.*

Reviewer: BA. Yes. The historical and ongoing impact of rats on the biodiversity values of LHI is well-documented, and the eradication approach is justified.

Response. *None required.*

Reviewer: PTF. Yes

Response. *None required.*

Question 3. Does the plan provide adequate justification for the choice of toxin to be used in the proposed eradication?

Reviewer: IEAG. Yes. There is substantial discussion of alternatives in the feasibility study and the plan provides ample justification for the choice of brodifacoum which is well tested in successful rodent eradication projects throughout the world. The use of any other toxicant in the context of LHI eradication at this time would be experimental. We see no compelling issue arising from the current plan which would lead the Board to consider any other alternative. We know of no other alternative vertebrate pesticides available on the market anywhere in the world with which we would have the same level of confidence in using to eradicate ship rats and mice from an island such as Lord Howe.

Response. *None required.*

Reviewer: IUCN. Second-generation anticoagulants, such as brodifacoum, have been successfully used in 226 eradication campaigns, and has proven to be particularly effective with the two target species. Furthermore, the characteristics of the toxin reduce the risk of environmental contamination. So I consider that the choice of the toxin is adequately justified.

Response. *None required.*

Reviewer: LCR. The rationale for selecting brodifacoum over other currently available (or in-development) rodenticides is not entirely clear; the main reason given in various parts of the plan seems to be that brodifacoum has a successful track record in previous island eradications. While this is a strong reason for its selection for LHI, I think the secondary poisoning risks of brodifacoum (i.e. persistence in liver, potential transfer in invertebrates) need to be more clearly stated and discussed in terms of balancing risks in the LHI context.

Response. *The sections of the plan outlining the choice of toxin and the risks associated with brodifacoum have been enhanced significantly. Brodifacoum has proven to be successful in 226 eradications including all 14 eradications on islands greater than 500 ha in size. Brodifacoum has proven to be successful in a variety of climatic conditions including those similar to LHI. Brodifacoum is highly toxic to rodents in minute quantities, allowing a lethal dose to be consumed in a single feed, thus avoiding the consumption of sub-lethal doses. Both target species are highly susceptible to brodifacoum, simplifying logistics and maximising cost-effectiveness. When contained in Pestoff® 20R bait formulation, brodifacoum is highly palatable to both species. Brodifacoum is highly insoluble in water; this combined with its propensity to bind to soil particles prevents it leaching into waterways or the marine environment. Brodifacoum is less likely than other poisons to accumulate in either aquatic systems or plant material. The half-life of brodifacoum in the soil is reasonably short: 12–25 weeks depending on soil type and conditions. Although toxic to livestock, pets and humans if consumed, an antidote is readily available. The non-target effects of brodifacoum (including the risks associated with secondary poisoning) are well understood, enabling planning to minimise any non-target impacts. Anticoagulants are extremely effective rodenticides because there is a delay (usually a few days) between ingestion and the onset of poisoning. Thus, rodents do not associate illness with ingestion of the bait, and by the time any ill effects are apparent, affected rodents have already ingested a lethal dose. This differs from acute (fast acting) poisons such as 1080 or zinc phosphide, where the* *onset of poisoning occurs on ingestion. The immediacy of acute toxicants can lead to bait aversion and animals obtaining sub-lethal doses. Consequently, anticoagulants are better suited to eradications than are acute toxicants. First-generation anticoagulants such as warfarin, diphacinone, pindone and coumatetralyl are generally of low toxicity but require a high concentration and several feeds over a number of days to be effective. The need for rodents to ingest large quantities of the bait to obtain a lethal dose of the toxicant increases the risk of failure in eradication. Second-generation anticoagulants are more toxic, require lower concentrations and only a single feed to kill rodents and are thus ideal for use in eradications. Although other second-generation anticoagulants such as floucoumafen and bromodiolone have been used successfully in rodent eradications, there is a relative lack of information on the environmental effects of these toxicants, making them a poor choice over the use of brodifacoum.*

Reviewer: LCR. The authors mention the potential for bait aversion to develop in relation to anticoagulant poisons; I don't think this is accurate. One of the reasons that anticoagulants are such effective rodenticides is their delayed onset of poisoning—rodents do not associate illness with bait ingestion with anticoagulants. This is an important reason why an anticoagulant, rather than a fast acting poison such as zinc phosphide, or 1080, would be a better choice for an eradication.

Response. *Agreed. This unintended error has been removed.*

Reviewer: LCR. It would be useful to tabulate rankings of alternative mortality agents or more simply rodenticides, against a set list of pros and cons, e.g. cost, availability of manufactured bait formulations, target specificity, environmental persistence, known to cause shyness or aversion, humaneness, track record in island rodent eradications. This would make the choice of brodifacoum more transparent but would also mean the authors also have to justify further why they would not nominate a less toxic, less persistent anticoagulant such as diphacinone (as they have chosen in Hawaii over brodifacoum).

Response. *A table outlining the advantages and disadvantages of each mortality agent has been added to the plan. The reasons for not using a first-generation anticoagulant such as diphacinone have been enhanced. Mice on LHI are resistant to warfarin so there is a risk that all first-generation anticoagulants such as diphacinone may be ineffective against mice. Second-generation anticoagulants were developed specifically for use in situations where rodents had developed resistance to first-generation anticoagulants. Moreover, first-generation anticoagulants are generally of low toxicity but require a high concentration and several feeds over a number of days to be effective. The need for rodents to ingest large quantities of the bait to obtain a lethal dose of the toxicant increases the risk of failure in eradication. Second-generation anticoagulants are more toxic, require lower concentrations and only a single feed to kill rodents and are thus ideal for use in eradications.*

Reviewer: LCR. Annual estimates of toxin use on LHI to date would be a useful contrast to support the case for eradication, i.e. *vs* the proposed amount of bait or toxin to be applied as a 'one-off' aerial application.

Response. *A comparison of the amount of toxin used in control versus eradication has been added to the plan. The current amount of bait distributed annually on LHI is approximately 2.1 tonnes, containing approximately 1.3 kg of toxicant. The eradication operation proposes to use approximately 42 tonnes of bait containing a total of 840 g of toxicant. This is less than the amount of toxicant currently used each* *year (1.3 kg), and approximately 1% of the total amount that has been used on LHI over the previous 24 years.*

Reviewer: LCR. There is evidence to suggest that mice are slightly less susceptible than rats to brodifacoum (although it is still highly toxic to mice) and mice can take a few days longer to succumb to poisoning. Factor both of these into sections about efficacy against mice and spacing of the two aerial applications and also how your proposed approach will cope with warfarin-resistant mice. This is where discussion of anticoagulant resistance could be most usefully summarised, especially viz the unique situation of already having known resistant mouse populations.

Response. *The interval between the two aerial applications is 14 days; this is adequate time for most mice to have succumbed before the second drop. The presence of mice that are resistant to a first-generation anticoagulant (warfarin) necessitates that a second generation anticoagulant (such as brodifacoum) is used. Second-generation anticoagulants were developed to control rodents that had developed resistance to first-generation anticoagulants. Tests are planned later in 2009 to confirm that rats and mice on LHI are susceptible to brodifacoum.*

Reviewer: WWF. The plan provides a detailed and convincing justification for the choice of toxin to be used.

Response. *None required.*

Reviewer: BA. No comment.

Response. *None required.*

Reviewer: PTF. Yes

Response. *None required.*

Question 4. Does the plan demonstrate that the approach, methods and risk mitigation measures proposed will enable the eradication of exotic rodents, while minimising adverse impacts on non-target species, residents and the environment?

Reviewer: IEAG. The plan as it stands is too conservative in mitigating perceived environmental risks which increases the risk of eradication failure. For example the plan to end aerial baiting flight lines 30 m inland and treat the coastal 30 m differently is not feasible in many parts of the island and opens the project up to huge risk of eradication failure for nil gain in environmental protection as the environmental risk of bait entering the marine environment is negligible.

Response. *Agreed. Although we have repeatedly stated that the risk associated with baits entering the marine environment is negligible, we attempted to address community concerns regarding perceived risks. As pointed out by the reviewer, this introduces an unacceptable and unnecessary risk of failure for no gain. The plan has been amended to focus more on potential rather than perceived environmental risks. Aerial baiting lines now end at the high water mark.*

Reviewer: IEAG. We recommend that the aerial baiting follow best practice on this issue which is to ensure parallel flight lines begin and end right at the coast (i.e. high water mark) and that these baiting lines are then overlaid with bait laid parallel with the coast. The only places where coastal exclusion zones are feasible (although undesirable) are the sandy beaches and relatively flat country facing the lagoon. It is possible to avoid baits entering the lagoon by adding to the complexity of the project.

Response. *See previous response. As recommended, parallel aerial baiting lines now end at the high water mark, and are overlaid with a line that runs parallel to the coast. Despite the absence of any identifiable risk to the marine environment, the following measures will be undertaken to prevent bait from entering the lagoon: (i) aerial trickle baiting or hand-broadcasting of bait along the shoreline of the lagoon; and (ii) having divers remove any bait that falls into the water. This action is being undertaken in response to community concerns rather than any substantive risk to the marine environment. Although this action adds to the complexity and cost of the project, we believe it can be done without significantly increasing the risk of failure.*

Reviewer: IEAG. The steep country (i.e. more than 50 degrees slope) should also be aerially baited twice on each application in keeping with best practice to reduce the chances of gaps in the bait coverage due to slope. This needs to be allowed for in the total bait required calculation and costings.

Response. *Agreed. The quantity of bait to be used has been calculated with this in mind. Bait quantity and distribution techniques will be confirmed following discussions with the helicopter company engaged for the project, as distribution methods will vary depending on the machinery available.*

Reviewer: IEAG. We support the baiting of all islands and rock stacks above high water as part of the project and agree with the exception of Balls Pyramid which is currently free of rodents and too far offshore to pose any risk. If a decision were taken to eliminate baits entering the lagoon, Blackburn Island is of a size and terrain that it could be baited by hand spreading.

Response. *Agreed. The method of baiting Blackburn Island will be confirmed following discussions with the helicopter company engaged for the project. If aerial baiting cannot be done with minimal risk of baits entering the lagoon it will be baited by hand. Again, divers will remove any bait that falls into the lagoon.*

Reviewer: IEAG. Every attempt should be made to minimise the number and size of exclusion zones (i.e. areas which are not baited by helicopter). Exclusion zones increase the complexity of the project and complexity increases risk of failure. Alternative options for mitigating perceived water supply risk to householders which have been successfully used are:

- disconnect and cover intakes where roof water is collected, followed by collecting baits from roofs and reconnecting after rainfall; or
- covering roofs with plastic sheeting.

Response. *Agreed. Where landholders are agreeable, aerial baiting will be conducted over areas of low-density housing outside the main settlement area. In these areas, mitigation measures to stop contamination of rainwater tanks (such as disconnecting down pipes) will be implemented to protect all water storages.*

Reviewer: IEAG. The aircraft hire and personnel costs are based on a period of 35 days on the island. In New Zealand we would consider this to be too short a window to guarantee the required periods of fine weather (normally 3 months are allowed). We recommend that this be double checked. Are there other constraints on the timing not stated in the plan?

Response. *Aircraft hire and personnel costs have been extended to a period of 42 days. Weather on LHI is not as severe as islands at higher latitudes. Examination of August rainfall records for the period 1989–2008 found there to be no year during which the aerial operation could not have been completed within this timeframe.*

Reviewer: IEAG. Successful eradication of rats and mice from the settlement area will require access to all structures and a concerted effort to minimise rodent access to alternative food. We suggest that baiting in the settlement area be planned to coincide with aerial baiting and be sustained (i.e. bait continually replenished) for several weeks beyond the last indication of surviving rodents. Substantial further planning is required to develop sufficient mapping and baiting specifications for a team to implement this part of the project successfully. Where possible and safe, the bait should be hand spread or placed in open containers rather than bait stations. This will reduce the possibility of bait stations being dominated by rats to the exclusion of mice.

Response. *Agreed. All these suggestion, other than the proposed use of bait trays, were already planned. Open bait trays will now be used instead of enclosed bait stations wherever possible.*

Reviewer: IEAG. The size of the hand baiting task will require a substantial team to undertake. With each additional team member required the risk of failure increases because the risk that one team member will fail to undertake their allotted task to the quality standard necessary to achieve eradication. This risk can be mitigated in two ways:

- Make the total size of exclusion zones smaller and have fewer of them, thereby reducing the need for a larger team.

- Have fine scale planning, effective team selection, training and supervision; and effective audit and monitoring systems in place to ensure the quality of the work.

Response. *Agreed. All suggestions were already planned.*

Reviewer: IEAG. The IEAG discussed the risks of eradication failure posed by residents denying access to baiting buildings. While the inability to bait the sub-floor and roof cavities of any single structure increases risk of failure, it is impossible to judge when the level of risk from this cause becomes significant until specific circumstances are known (i.e. exactly what building and what is, or is not, permissible). For planning purposes the project should strive to have baits in and around every structure on the island for at least 3 months. This will take substantial cooperation by the residents who, after all, will be the main beneficiaries of the project.

Response. *Agreed. It was already planned to have viable bait in the settlement for at least 100 days. This will be supplemented by the use of detector dogs. Non-compliance by uncooperative residents remains the greatest risk of failure.*

Reviewer: IEAG. We recommend that information be provided to all households on what they can do as individuals to support the project through denying rodents access to food. Some examples of things to include are:

- Keep doors and cupboards closed when not in use.
- Store dry goods in rodent proof containers (plastic or tins).
- Store feed for domestic animals in rodent proof containers and clean up any spills.
- Take care in waste disposal.
- Store linen and unused bedding in rodent proof containers or cupboards.
- Check for rodent sign regularly and report any findings to the project team.
- Check for rodent presence in boats and engine compartments of cars.
- Clean up all rodent droppings carefully so that any fresh droppings will be quickly noticed.

Response. *Agreed. All suggestions were already planned, but have now been specifically included in the plan.*

Reviewer: IEAG. The plan mentions that Pestoff 20R is not registered for use in buildings in Australia and that Talon may be used for this purpose instead. Our understanding is that Talon baits all have bitrex additive which should be avoided for eradications. We recommend that registration for using Pestoff 20R in buildings be sought in parallel with other APVMA applications for this product.

Response. *Agreed. Talon was only to be used as a last resort. Approval will be sought to use Pestoff 20R in and around buildings.*

Reviewer: IEAG. The design of areas holding domestic animals and non-target native animals in captivity requires substantial further planning to ensure the welfare of the animals and to minimise the risk of these facilities providing refuge to rodents. Mouse proofing such a facility will require precision building to eliminate gaps bigger than 6 mm.

Response. *Agreed. Enclosures will be designed to be mouse proof. They will have mesh floors (buried) and no gap will exceed 6 mm. As an added precaution, rodent trapping will be conducted within each enclosure.*

Reviewer: IEAG. The feasibility study in 2001 recommended that the ongoing use of brodifacoum baits be stopped to avoid the potential for resistance in the rodent population to develop. This has yet to happen. It is precautionary but we suggest it be implemented now.

Response. *Agreed. This has been given greater prominence in the plan and should occur as soon as possible.*

Reviewer: IEAG. The current plan does not provide much detail on the structure and roles of the project team, the legislative requirements, procurement and contracting and other tasks leading up to the aerial baiting. We would expect further development in this area of the plan in the coming 12–18 months and would be happy to have further input if required. The team structure should be drawn up early to identify more clearly the size of the team required to manage all the tasks and to establish how reporting lines should operate. It is important that supervisors have the necessary span of control to manage the things they are responsible for without having too many people reporting to them.

Response. *Structure of the project team and roles are currently being developed.*

Reviewer: IEAG. The recent bait trials have not been written up which should be done as it will add to the knowledge base for the project.

Response. *The recent baiting trials have been analysed, and the results are currently being prepared for publication in a scientific journal.*

Reviewer: IEAG. We recommend that the eradication plan be further split to allow more focus on each topic. The captive animal husbandry requires its own document which should include the specification of the facilities to be built, the capture techniques and the release criteria as well as the feeding and husbandry aspects.

Response. *Agreed. Specifications of the captive facilities are currently being developed in collaboration with Taronga Zoo. A husbandry manual has already been prepared.*

Reviewer: IEAG. The environmental and non-target mitigation issues should be put into an Assessment of Environmental Effects. It is likely this document will be required anyway to apply for the regulatory consents. It will be important to ensure the mitigation measures proposed and the consent conditions resulting from this process do not compromise the success of the project. Any mitigation measures which cannot be implemented without significant increase in the risk of failure should be renegotiated or the project will have to be abandoned. When applying for consents get them to cover a 5 year period in case the operation is delayed. This will save you reapplying for consents that have expired.

Response. *Agreed. An Environmental Impact Statement is currently being prepared. Consent applications will have long timeframes.*

Reviewer: IEAG. The operational plan itself should focus on the eradication design and tasks required to achieve the eradication but the fine detail of individual tasks can be split out into 'task specifications', e.g. for the baiting of buildings or for the proper care of bait in storage. These task specifications become a valuable tool for planning and communicating or delegating the details of the work.

Response. *Agreed. Task specifications are currently being prepared.*

Reviewer: IEAG. The communication with all stakeholders requires a detailed plan stating what is to be done, when, for what audience, and who is responsible.

Response. *A Communications Strategy has already been prepared. This will be updated and amended as required.*

Reviewer: IEAG. Biosecurity for the island and for the project itself are two different things. A biosecurity plan for the island needs to be drawn up urgently and implemented well before the eradication takes place to manage the risk of rodents or other invasive species reaching LHI. Even if the project does not go ahead it will be worth improving LHI biosecurity to avoid further incursions which could devastate the island's fauna or tourist industry (e.g. tramp ants or snakes). We suggest that successful implementation of biosecurity requires a concerted ongoing effort to reach the required standard and this is best achieved by starting well ahead of time and using audits of biosecurity to identify gaps and areas for improvement. The biosecurity associated with the rodent eradication should focus on specific measures required to manage the risk of introducing unwanted organisms to LHI during the project. It should be compatible with the overall island biosecurity plan.

Response. *Agreed. Biosecurity remains one of the greatest threats to the flora and fauna of LHI as well as to the tourist industry. A Biosecurity Plan for LHI already exists. This will be updated as required. Detector dogs will be purchased and trained. Their use can extend beyond rodents. The quarantine section of the plan has been enhanced to reflect the planned improvements to biosecurity.*

Reviewer: IEAG. We suggest that the details of equipment to be used (aircraft, spreader buckets, GPS, loading equipment, etc) be left broadly described in the plan until an aerial contractor has been selected and known equipment can be specified. This allows the aerial contractor to become part of the eradication team to contribute their expertise to the final version of the operational plan. We recommend that prospective aerial contractors visit LHI before tendering or if this is not achievable, a pre-eradication planning visit be made a mandatory part of the contract.

Response. *Agreed. These conditions will be incorporated into the tendering process.*

Reviewer: IEAG. There are still plenty of logistical details to be worked out for this project. Our comments on what is currently there should not be considered adequate peer review of this aspect of the planning as further review will be required once the details have been worked out and documented.

Response. *Agreed. The IEAG will provide peer review throughout the project.*

Reviewer: IEAG. The bait transport from NZ is likely to be more efficient by shipping bait to Sydney in 25 kg paper walled sacks stacked on pallets and loaded into steel shipping containers. These could then be repackaged into purpose built storage pods and loaded aboard the Island Trader. This would give more control of the bait handling and quality, facilitate AQIS inspection and allow storage pods to be built optimum size in Australia. We suggest that the size of the pods be manipulated to allow them to:

- Store quantities of bait as multiples of helicopter loads (depending on helicopters chosen)
- Maximise efficiency of hold space in the Island Trader and the handling equipment on LHI

Response. *The program to eradicate rodents and rabbits from Macquarie Island has similar issues. A decision on how best to transport bait will be deferred until after the Macquarie operation.*

Reviewer: IEAG. Bait quantity calculations will need to allow for several extra passes over the highest cliffs to maximise the elimination of gaps in bait coverage. It will also have to allow for steep areas to be treated twice for each application. The plan describes the island area as 3-dimensional. We often find this unhelpful for calculating bait quantities and managing bait application rates. We prefer to use the planar area figures and supplement the cliff areas and steep areas with extra applications of bait.

Response. *Given the steep terrain, the quantity of bait to be used has been estimated from a nominal dose rate based on a 3-dimensional area. Bait quantity will be confirmed following discussions with the helicopter company engaged for the project and the delineation of all flight lines.*

Reviewer: IEAG. The size of bait most suitable for this project is an open question. The evidence for better performance against mice with smaller baits is, in our opinion, not convincing as we can point to several successful mouse eradication projects on islands using 10 mm or 12 mm baits. The practical advantages of the 10 mm baits (over 5.5 mm) are:

- They can withstand more rain before disintegrating.
- They have been used through aerial sowing buckets in large quantities without problems.
- The pilot can see baits being spread which can be an advantage sowing up to exclusion zones or sensitive boundaries.
- It is feasible to retrieve baits accidentally over-sown into exclusion zones.
- Their bulk storage and handling properties are well understood through previous experience.
- Their non-target acceptance and safety is well understood through experience.

Response. *After assessing the current information on the advantages and disadvantages of each bait size we have elected to use 10-mm bait to for all aerial operations, and 5.5-mm bait for all hand-baiting operations. In our view, the benefits of using two bait sizes justify the added complexity of the operation. A discussion of the advantages of using bait of various sizes has been added to the plan.*

Reviewer: IEAG. Bait monitoring post application to monitor bait breakdown should use rodent proof cages instead of marking baits with flags to eliminate the loss of monitored baits to rodents or other animals.

Response. *Agreed. Plan amended accordingly.*

Reviewer: IUCN. The proposed approach and methods appear to ensure adequate chances of success to the eradication attempt. However, such a large scale, multiple species eradication is indeed an ambitious program, and it is therefore crucial to plan contingency measures in case of unexpected problems with the completion of the eradication. Considering that the removal of the two target species requires a very widely distribution of the baits, and even the impossibility to access limited portions of private land or houses may limit the chances of success of the plan, in my opinion a further assessment of the program's feasibility should be carried on after the consultation phase is completed, on the basis of a better understanding of the public support to the eradication.

Response. *An individual baiting plan will be developed for each property in consultation with each property owner. The programme will be reassessed once these plans have been completed.*

Reviewer: IUCN. Regarding the potential adverse impacts, in my opinion the plan addresses very comprehensively and effectively all the risks for non-target species, residents and the environment. One potential undesired effect that in my opinion should be taken into account, is the risk that the removal of the two rodents may cause an increase of other alien species, at present controlled by the rats and mice. I refer for example to alien ants and weeds, that in a few cases have been reported to have increased after a rat eradication had been completed. Despite this potential undesired effect is very unlikely to happen, in my opinion the plan should include a specific monitoring effort to record such possible unexpected effects, and should allow the prompt implementation of contingency control actions, if needed.

Response. *A section dealing with potential adverse impacts has been added to the plan. Monitoring of biodiversity changes is a major component of the plan. A rapid response and detection protocol for new introductions of weeds and exotic fauna is currently being prepared as part of the implementation of the LHI Biodiversity Management Plan.*

Reviewer: LCR. That this attempted eradication will be one of the first on an island that is not remote (high profile in fact) and has permanent human habitation is not given sufficient emphasis in the plan. There are basically no case studies where well-established commensal rodent populations on islands have been successfully eradicated alongside field populations. Thus the LHI plan needs to outline far more detail as to why the approach proposed for commensal rodents (which I read as basically an extension of previously successful aerial application for field rodents to commensal habitats) is likely to be the best one. Bearing in mind that success on LHI will be the exemplar for future operations on inhabited islands there are some further considerations of potential habitat and behavioural differences between commensal and field rodent populations that need at least to be mentioned and discussed in terms of how they might contribute to a failure, e.g. field habitats are reinvaded by commensal rodents that survived.

Response. *A section dealing with commensal rodents has been added to the plan. Rats and mice occur throughout LHI, including the settled areas. One of the aesthetically pleasing aspects of LHI is that the residences and buildings are located in and amongst areas of native vegetation. The boundaries between the urban and natural areas have been deliberately blurred. As a consequence, there is not a clear separation of rodent populations into commensal and field populations such as that which may occur in more urbanised towns and cities. For this reason, rodents on LHI will be targeted using methods that have proven highly successful on less inhabited islands, i.e. broadscale distribution of brodifacoum baits. In addition, actions will be undertaken specifically to target rodents in and around buildings. These include: reducing and eliminating food sources in and around dwellings, placing baits inside and underneath all buildings where access is possible, and maintaining viable baits in the settlement area for the full period of risk (100 days). The settlement area will be monitored for the presence of rodents throughout the 100-day period. If rodents are detected, action will be taken to eliminate any survivors.*

Reviewer: LCR. It is already known that some commensal rodents on LHI have developed resistance to anticoagulants. The difference between physiological & behavioural resistance needs to be outlined, as does the likelihood of practical (affecting operational success) resistance to brodifacoum vs first-generation anticoagulants. As far as I know, there have been no other eradications planned where there are already known populations of mice with demonstrated anticoagulant resistance, so it needs to be very clear why you expect brodifacoum will still be successful (efficacy tests of Pestoff with actual LHI mice would be very important for this).

Response. *As discussed above there is no clear distinction between commensal and field populations on LHI, where all mice (commensal and field) have developed a resistance to warfarin. The presence of mice that are resistant to a first-generation anticoagulant (warfarin) necessitates that a second-generation anticoagulant (such as brodifacoum) is used. Tests are planned later in 2009 to ensure that both rats and mice are susceptible to brodifacoum. Second-generation anticoagulants were developed to control rodents that had developed resistance to first-generation anticoagulants.*

Reviewer: LCR. Do you expect that commensal rodents and field rodents will have the same foraging patterns and food availability as influences on the likelihood of bait encounter and acceptance? Are their population densities likely to be similar?

Response. *There is no clear distinction between commensal and field populations on LHI. There is no evidence to suggest that populations behave differently, and commensal populations of mice are currently susceptible to poisoning with brodifacoum. Measures will be undertaken within the settlement to reduce the availability of alternative food. Population densities vary markedly across the island, and adequate bait will be provided to remove all rodents.*

Reviewer: LCR. Given that commensal populations on LHI have a history of exposure to anticoagulant baiting, with subsequent development of physiological resistance in mice to warfarin, could you not also expect some behavioural traits that mean they are more likely to survive toxic baiting however palatable the bait, e.g. neophobia? Could baiting of commensal rodents be supplemented with other control techniques they have not yet encountered.

Response. *Again there is no clear distinction between commensal and field populations on LHI. Both commensal and field populations have been subjected to baiting. Rather than having developed behavioural traits to avoid bait, mice that are resistance to warfarin are known to feed freely on warfarin bait. Other control techniques will be used to eliminate any rodents that survive baiting in the settlement.*

Reviewer: LCR. Why would you not consider an earlier start on the commensal rodents through harbour removal, food reduction etc. ahead of the aerial application? Otherwise what would the contingency be if monitoring of commensal rodents showed there were survivors post-baiting e.g. would brodifacoum continue to be applied, bring in targeted hunting of individual survivors?

Response. *The removal of harbour and alternative food resources in the settlement area prior to the eradication is already included in the plan. Although there is no reason to believe that commensal rodents would survive a well-planned baiting programme on LHI, additional measures will be taken to detect and remove any survivors. The settlement area will be monitored for the presence of rodents throughout the 100-day period. Trained detector dogs will be deployed throughout* *the settlement area to find and locate any surviving commensal rodents. In the unlikely event that rodents are detected action will be taken to eliminate any survivors using a range of methods depending on circumstances, location, ease of use and public safety. Possible methods include trapping and fumigation.*

Reviewer: WWF. The plan provides a very thorough and convincing demonstration that the approach taken will enable the eradication of exotic rodents, while minimising adverse impacts.

Response. *None required.*

Reviewer: BA. We would like to note the need for a strong monitoring and maintenance plan during and following eradication. Resources need to be allocated to monitoring for and dealing with remnant populations of rats over several years post-eradication.

Response. *This comment emanates from a misconception about the current approach to rodent eradication, i.e. a single operation rather than a sustained process of control. In eradications conducted on non-inhabited islands it is now standard practice not to undertake any mopping up operations. If individuals of the target species were to survive the baiting operation they would be difficult to detect, so emphasis is placed on killing all animals during the baiting operation, primarily by ensuring there are no gaps in the distribution of bait. Although there is no reason to believe that commensal rodents would survive a well-planned baiting programme on LHI, additional measures will be taken to detect and remove any survivors. The settlement area will be monitored for the presence of rodents throughout the 100-day period.*

Reviewer: BA. The budget seems reasonable for the work involved over several years. However, the plan does not go beyond winter 2011/2012, so ongoing monitoring costs need to be factored into the budget.

Response*. Demonstration of the ecosystem benefits of removing rats and mice from LHI is essential. Monitoring to determine the changes in the distribution and abundance of key taxa will commence prior to the eradication and will need to continue for at least 3 years after the eradication. Continued monitoring after this period is highly desirable, not only for its own intrinsic value but also to demonstrate the benefits of this investment. However, funding for long-term monitoring of the outcomes of conservation initiatives is, as always, problematic. Sources of long-term funding for monitoring have yet to be identified.*

Reviewer: BA. A well thought out and enforced quarantine plan will be needed to prevent re-infestation. The likelihood of re-infestation and the possibly of prevent it should be discussed in the plan.

Response. *A Biosecurity Plan for LHI already exists. This will be amended as required. Detector dogs will be purchased and trained; their use can extend beyond rodents. The quarantine section of the plan has been enhanced to reflect the planned improvements to biosecurity.*

Reviewer: BA. The interaction between mice and rats is important. If rats were eliminated, but not mice, then mice could be expected to become more of a problem. This should be considered.

Response. *If rats are eradicated but not mice, it is possible (although far from certain) that the numbers of mice on LHI could increase. The eradication plan for LHI specifically targets both rats and mice. Considerable additional effort has been included to target mice specifically so as to maximise the chances of eradicating both species. For example, where used, bait trays and bait stations will be set at 10 m intervals. Although rats can be killed using bait stations placed at 25 m intervals, mice do not move as far, so the distance between baits cannot exceed 10 m. Also, the island will be de-stocked of poultry before the eradication because mice are likely to survive in poultry pens if these remain active. Although we expect all mice to be killed by the two applications of bait, additional actions will be undertaken to detect and, if necessary, eliminate any surviving commensal rodents.*

Reviewer: PTF. This is excellently covered. I can see no circumstances that the plan has not considered.

Response. *None required.*

Question 5. Does the plan demonstrate that adequate attention has been given to the identification of potential environmental risks posed by brodifacoum and the methods to mitigate them?

Reviewer: IEAG. Yes. The operational details of the current plan provide for substantial environmental protection. There will be further State and Federal legislative processes to go through which will also provide safeguards to the environment during this project. In our opinion the measures proposed to safeguard the marine environment are far more than is necessary based on current knowledge and experience of using brodifacoum in this way. It has been used on islands in three marine reserves (Tuhua, Kermadec, Kapiti) and a marine park (Hauraki Gulf) without any incidents or measurable effects. The accidental discharge from a truck accident in 2001 has been extensively researched and the measurable effects were extremely localised. The residue monitoring proposed will be expensive and we recommend it be given careful management to avoid any possibility of cross contamination of samples leading to a false positive.

Response. *Agreed. The measures proposed to safeguard the marine environment are expensive and are largely being undertaken to satisfy community concerns rather than to mitigate any real risk. Residue monitoring will be undertaken with a high level of scientific diligence.*

Reviewer: IEAG. If the monitoring currently proposed does end up being undertaken, IEAG recommends that the results be published and made available for other operations as soon as possible, to make best use of the effort and expense you have gone to.

Response. *Agreed. Results will be published in peer-reviewed scientific journals.*

Reviewer: IUCN. The plan addresses with adequate attention all the potential environmental impacts of the use of toxins, and the proposed framework of measures (selection of toxins, distribution methods, etc) indeed mitigates the potential environmental risks related to the use of the brodifacoum.

Response. *None required.*

Reviewer: LCR. Brodifacoum in water, soil and risks of human exposure through fish and milk have been well covered. Non-target risks of brodifacoum from a primary exposure perspective is also well covered, but the aspect of secondary exposure of non-targets to brodifacoum receives very little attention and deserves more in a justification of the pros and cons of using brodifacoum. The residual and persistent nature of brodifacoum in liver tissue is worth a mention re cumulative secondary exposure and possible sub-lethal effects on non-target birds, but the big omission is the potential for invertebrates that feed on bait to act as environmental vectors of brodifacoum to insectivores. Stating that “only small numbers” of invertebrates feed on bait is not enough; there is real potential for birds to be poisoned by feeding on contaminated invertebrates (see Dowding et al 2006) and this needs to be examined in the context of LHI species. Perhaps at least a trial with non-toxic baits to at least establish which LHI invertebrates find them palatable, and some ‘in theory’ risk assessments for birds?

Response. *The potential for secondary poisoning has been considered in depth, although the text may have been a little too concise. The Environmental Impact Statement will deal with this issue in detail. The relevant section in the plan has been expanded considerably. Numerous studies have examined how broadscale baiting with brodifacoum affects various non-target animals, including species similar to those on LHI. Planning for the eradication of exotic rodents on LHI has drawn heavily on these studies. Additional studies have been undertaken locally, including a trial with non-toxic baits. The risk for each bird species has been assessed (see Table 4 in the plan). Risk was assessed based on diet, palatability of baits to invertebrate prey, findings of previous studies and observations made during previous eradications using anticoagulants. Only two species were found to be at significant risk from poisoning—woodhen and currawong. Most eradications using brodifacoum, have resulted in mortality of some non-target species. However, any mortality in the short-term has been far outweighed by the improved survival once populations are free of rodent predation. Although the operation on LHI may result in some non-target deaths, these losses will be minimal and are not expected to have any significant long-term impact on the non-target populations. The majority of species will be unaffected. With the rats and mice gone, many native species will flourish, increasing in abundance to levels not seen since before the invasion of rats.*

Reviewer: WWF. The plan provides a detailed and convincing demonstration that adequate attention has been given to the identification of potential environmental risks posed by brodifacoum and their mitigation.

Response. *None required.*

Reviewer: BA. No comment.

Response. *None required.*

Reviewer: PTF. Yes

Response. *None required.*

Question 6. Does the plan demonstrate that adequate measures have been proposed to mitigate the potential risks to wildlife by the presence of exotic rodents?

Reviewer: IEAG. Providing the project is thoroughly planned to minimise the risk of eradication failure, that plan is put into action in a high quality way and adequate biosecurity measures are implemented, we see no reason why the risks to wildlife posed by rodents cannot be eliminated. Indeed we would suggest that the current risk to wildlife on LHI posed by rodents is not fully appreciated despite substantial scientific literature on this topic from studies carried out on other islands around the world. We would recommend to the Board that some of these papers be made available to LHI residents or, at a minimum, summaries of the key points in each paper.

Response. *Agreed. Information sheets currently being prepared for residents include one describing the adverse effects of rodents on islands. Relevant papers and websites will be made available to the LHI community.*

Reviewer: IUCN. The plan proposes an effective and adequate framework of measures to reduce the potential risks to other wildlife species. The commitment to capture and maintain in captivity an adequate stock of individuals of the non-target species most at risk, in order to allow a reintroduction into the wild in case significant impacts are recorded, minimises the risk of potential undesired effects at the population level of the non-target species.

Response. *None required.*

Reviewer: LCR. The rationale behind use or non-use of bait stations is confusing. Bait stations are a very obvious way to exclude non-targets, so it also needs to be mentioned why it is not an option for excluding at-risk birds from baits. I'm assuming that the use of bait stations, where it occurs, would only be for commensal rodents in and around buildings? If so, that needs to be made clear. See previous comments about having a clearly differentiated methodology and rationale for the commensal rodent population *vs*. field populations of rodents.

Response. *The earliest eradications utilised a network of bait stations, but this technique is very costly and time consuming for anything other than small islands (<100 ha). The use of bait stations to eradicate rats and mice on an island the size and ruggedness of LHI is impractical. Moreover, although bait stations have been used successfully in some eradications, their use is now generally avoided as this method has been shown to result in exclusion of target animals due to both inter- and intra-specific dominance issues, i.e. both mice and rats can be prevented from entering bait stations by dominant individuals. On LHI, where there are two target species, rats may exclude mice from entering bait stations. This type of behaviour can put eradication operations at risk by violating a fundamental pre-requisite that all target animals are exposed to the toxicant. Where unavoidable, the use of bait stations is generally kept to an absolute minimum.*

Reviewer: LCR. No detail of how post-operation monitoring will be applied to confirm non-target mortality, e.g. will any non-target carcasses found be tested for brodifacoum or just assumed to have been poisoned?

Response. *It is important to quantify the level of non-target species mortality, both for the purpose of understanding the impacts of this operation and also to increase our knowledge for future operations. Any non-target animals found dead will be collected and autopsied to determine the cause of death. If internal haemorrhaging is not obvious, liver samples will be taken and tested for the presence of brodifacoum. Collection and analysis of dead non-targets will continue for four months after the second bait drop.*

Reviewer: LCR. Are you proposing any sort of on-island sentinel system (not just inspections of boats) to look for rodent survivors or re-invaders?

Response. *Monitoring of the rodent-free status of LHI following the eradication of rats and mice will be achieved by monitoring activity at key bait stations placed near potential points of entry. This will form part of the island's permanent rodent detection and prevention system initiated as an integral part of the island's biosecurity programme. Tracking tunnels will also be set up at designated sites across the island. Should rodents be found on the island subsequent to the eradication operation, DNA samples will be taken. Comparison of these samples with those from rats and mice prior to the eradication will allow the provenance of the remaining individuals to be determined, i.e. whether they are survivors from the original population or from a subsequent re-invasion.*

Reviewer: LCR. What rules will you apply to declare eradication a success?

Response. *Trained detector dogs will search the entire settlement area at regular periods during the 100-day period and throughout the next two years. Outside the settlement area a system of tracking tunnels will be established at a number of locations to act as a surveillance measure for the presence of rodents. The eradication will be declared a success if rodents are not detected for a period of two years.*

Reviewer: WWF. The plan provides a detailed and convincing demonstration that adequate measures have been proposed to mitigate the potential risks to wildlife and that any residual risk is acceptable.

Response. *None required.*

Reviewer: BA. No comment.

Response. *None required.*

Reviewer: PTF. Yes.

Response. *None required.*

Question 7. Are the proposed measures in the plan to ensure the safety of residents and visitors adequate?

Reviewer: IEAG. Yes. The techniques planned for this project have been successfully used without incident several times in many parts of the world. Brodifacoum at the low concentrations used in rodent baits is low toxicity for humans and antidotes are readily available. Brodifacoum products at these concentrations are sold over the counter in many countries and are currently being sold on LHI. Incidents of human exposure are confined to small children where householders have improperly stored or used the product, and people intent on self harm. These same risks already exist on LHI for a range of cleaning products and other household chemicals stored in the home. The risks to human health from disease and contamination passed on by rodents would likely outweigh the risk to residents and visitors posed by this project as currently described.

Response. *None required.*

Reviewer: IUCN. The plan includes a very effective and advanced set of measures for excluding risks for residents and visitors. It should also be stressed that the eradication—if successful—will prevent the present risks of environmental contamination (and of inadvertent ingestion) due to the permanent use of warfarin for rodent control. So in my opinion the plan adequately ensures the safety of residents and visitors.

Response. *None required.*

Reviewer: LCR. Yes; very well covered.

Response. *None required.*

Reviewer: WWF. WWF cannot comment on the adequacy of the proposed measures in the plan to ensure the safety of residents and visitors as this is outside our area of expertise. However the measures proposed appear convincing in the light that toxic rodenticides are already freely used on LHI.

Response. *None required.*

Reviewer: BA. No comment.

Response. *None required.*

Reviewer: PTF. Yes

Response. *None required.*

Concluding comments

Reviewer: IEAG. This is a challenging project which is quite feasible technically and if successful will provide great benefit to LHI fauna and flora; its residents and visitors. Rodent eradications of this scale and complexity are being attempted throughout the world. The most challenging aspect in our opinion lies with the people on the island, success or failure is essentially in their hands.

Response. *Agreed. The residents of LHI will be major beneficiaries of this operation, and the operation will be conducted with little or no cost to the community. Yet, lack of cooperation from a few individuals poses the greatest risk of failure.*