Assessing the Feasibility of

Removing Pest Animals from Kawau Island

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Reviewers: Auckland Council, Predator Free NZ 2050 Ltd, Department of Conservation (including their Island Eradication Advisory Group), Wallaby Technical Advisory Group, Ngāti Manuhiri Settlement Trust, Pohutukawa Trust.

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PURPOSE STATEMENT

The purpose of this report is to provide information regarding feasibility of eradicating mammalian pests from Kawau Island. The release of this report marks an interim step in an ongoing assessment of feasibility which will have further review points prior to a decision to proceed to eradication.

EXECUTIVE SUMMARY

As evidenced by the formation of the Pōhutukawa Trust in 1992, the idea of Kawau being free of rats, stoats, possums and wallabies has been around for a long time. However, only in the past decade has the eradication of species such as rats on inhabited islands been proven possible. Amidst a growing number of precedents worldwide and increasing local support for the removal of invasive species, inspired by the work of the Pōhutukawa Trust and New Zealand's Predator Free 2050 Vision, the concept was included as a proposed objective in Auckland Council's Regional Pest Management Plan 2020 – 2030 (RPMP). The idea received significant positive feedback, resulting in its incorporation into the approved RPMP.

In recognition of the ambitious nature of the project and the high level of buy in required from the community, Auckland Council commissioned the Non-Governmental Organisation Island Conservation to assess the project's feasibility. Kawau is predominantly privately owned, and the project's success is intrinsically dependent on support from the community. Eradication of rats for example is contingent on the cooperation of all land holders on the island and to prevent reinvasion, stakeholders and partners must be willing to support ongoing biosecurity measures. To fully determine the project's social acceptability, Island Conservation discussed the project one on one with landowners and directly affected stakeholders and asked for feedback. To ensure stakeholder feedback was well informed, the benefits of the project were clearly outlined along with the project's potential risks and impacts. A picture of what would be involved if the eradication operation was to proceed was also provided.

What is to be gained from the removal of rats, stoats, possums and wallabies from Kawau

Removing rats, stoats, possums and wallabies from Kawau would lead to significant gains for biodiversity, contribute to the recovery of several threatened species and ecosystems, improve living conditions for residents and landowners, ultimately reduce the risk of fire, and potentially create new economic opportunities. Strategically, the project is also of critical importance to New Zealand's predator free vision, paving the way to other inhabited islands within the Hauraki Gulf and elsewhere. The proposed project also presents a number of risks and costs. Potential impacts to the island's weka and pāteke (brown teal) populations would require mitigation and the removal of wallabies from the island is a contentious issue and could lead to the loss of community cohesion. Nevertheless, relative to the project's benefits, most risks and costs associated with the project are limited in scope, short-lived or can be mitigated and on balance, the project's benefits are considered to outweigh its costs. This view is supported by most landowners and stakeholders.

Is it acceptable?

Based on the feedback received, iwi are generally supportive of the proposed concept and Ngāti Manuhiri Settlement Trust, who are mandated to represent Ngāti Manuhiri as mana whenua of this rohe, have committed to being a project partner. Discussions with the Kawau community confirmed strong support for the project with 93% of landowners supporting rat, possum and stoat eradication and 82% in favour of the removal of wallabies. A small percentage of the 347 landowners spoken to (42) were opposed to the removal of wallabies and a similar number had concerns about the use of rodent bait or property access. Further engagement with stakeholders will be necessary for the project to succeed.

Is it achievable?

The eradication of rats, stoats, possums and wallabies on Kawau is considered technically feasible based on precedents established elsewhere. Rats have been removed from more than 650 islands worldwide including both inhabited islands and islands larger and more complex than Kawau. Possums and stoats have been removed from islands and mainland fenced sanctuaries up to 3,875 ha in size and precedent also exists for wallaby eradication in the form of Rangitoto and Motutapu where brush-tailed rock wallabies were removed in the 1990's.

A provisional operational strategy has been developed that outlines how the eradication could be achieved. Constraints imposed by the social unacceptability of certain tools (i.e. the aerial application of 1080 to target wallabies) and the need to use ground-based methods to target rats within residential areas to avoid contaminating water supplies are considered surmountable. However, the project's success, particularly for rats, is contingent on the application of rodent bait across 100% of properties on the island. Even the smallest property on Kawau could provide a refuge for rats and lead to eradication failure. Further work with landowners currently unsure about proposed methods or opposed to the project is required to meet this condition.

Preventing rats and stoats re-establishing on Kawau requires dedicated ongoing resourcing and will undoubtedly be a challenge. However, landowners appear willing to take the extra care that will be required and precedents within the Hauraki Gulf and elsewhere suggest the project's outcomes can be sustained. As evidenced through its work elsewhere in the Hauraki Gulf, Auckland Council has the legal mandate, resources and necessary skills and expertise to support the implementation and maintenance of biosecurity for Kawau.

Capacity to support the project's implementation in terms of personnel, pest detection dogs, accommodation, and other resources, appears to be available within New Zealand and the provisional operational strategy is consistent with legal requirements suggesting the project can meet its statutory obligations. The overall cost of the project, estimated to be ~$6,500,000 for the eradication with ongoing annual costs of ~$375.000 to prevent reinvasion and reestablishment, is considered attainable.

Conclusion and recommended next steps

In conclusion, while the Kawau project is undoubtedly ambitious and contingent on a number of dependencies, the project is considered provisionally feasible. Discussion to date has highlighted the need for community representation within the proposed project. Progress can only be made with the support and input of the community, and consideration of how the community would like to be represented is central to this and will be gathered in response to this report. If a decision is made to progress to operational planning, this phase would encompass amongst other things, the development of an operational plan, confirmation of the delivery model (and leadership), liaison with landowners to develop individual property agreements and securing the funding required to support the project's implementation.

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1. KEY CONCEPTS

Concept	Description
Biodiversity	The variety of living organisms on the earth, including the variability within and between species and within and between ecosystems.
Biosecurity	Preventing the spread of invasive species across international or internal borders.
Control	Reducing the population of an invasive species (numbers and distribution).
Ecosystem	Plants, animals and other organisms and the physical environment in which they live and interact with each other. Types of ecosystems with distinct characteristics include lagoons, forests, and grasslands.
Ecosystem services	All the benefits to people provided by the natural environment and from healthy ecosystems. Some of the benefits of healthy ecosystem function include natural pollination of crops, clean air and water, nutrient cycling, and food productivity. Ecosystem services are usually referred to within four categories: regulating, provisioning, cultural and supporting services.
Endemic species	A native species that naturally occurs confined to a single specific country or area. Indigenous (native) species occur naturally in one or more places.
Eradication	The removal of every individual of an invasive species from a specific place. Eradication is only successful if every individual is removed.
Feasibility	The possibility that something can be done or achieved, or is reasonable.
Introduced species	Plants, animals, and other organisms taken beyond their natural range by people, deliberately or unintentionally.
Invasive species	Introduced species that become destructive to the environment or human interests; can also include some native species that proliferate and become destructive following environmental changes caused by human activities.
Monitoring	Programmes to detect change, e.g., in the distribution of invasive species, the success of management projects etc.
Native species	Plants, animals, and other organisms that occur naturally on an island or in a specified area, having either evolved there or arrived without human intervention.
Non-native species	Non-native species are those species that have been introduced by people, and include both harmful (i.e., invasive) and beneficial species.
Pest	A pest is an animal or plant that harms the environment directly or human interests in an environment (agriculture, people's health) - whether it is native or introduced. Any animal that is harmful, unwanted, or annoying.
Surveillance	Monitoring to detect the arrival of new invasive species.
Threatened species	General term for species ranked by IUCN as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU).

2. INTRODUCTION

In 2018, Auckland Council reached out to the people of Auckland for feedback on a draft Regional Pest Management Plan (RPMP) for the region (Auckland_Council 2020). One of the recommendations in the plan was the concept of a predator free Kawau or, in other words, a Kawau free of rats (*Rattus rattus* and *R. norvegicus*), stoats (*Mustela erminea*), possums (*Trichosurus vulpecula*) and wallabies (*Macropus eugenii, Macropus parma, Petrogale penicillata* and *Wallabia bicolour*). The proposal received a lot of positive feedback suggesting the removal of invasive vertebrates from the island might be socially acceptable and the concept was mandated in the finalised RPMP 2020 – 2030 (Auckland_Council 2020).

There is no doubt that removing this suite of species from Kawau is ambitious. If successful, Kawau would overtake Rakino to become the largest permanently inhabited island within the Hauraki Gulf to be pest free. The island is also a significant milestone in New Zealand's bid to be predator free by 2050, would pave the way for other inhabited and privately owned islands within the Hauraki Gulf to become pest free, and provide an important benchmark for other projects such as Rakiura/Stewart Island (DOC 2020).

Kawau is a step up in terms of complexity. Any eradication asks a lot of an island community. For example, access to private land is required and the community has to buy in to measures designed to maximise the chances of project success and put in place ongoing precautions to reduce the risk of reinvasion (Pearson et al. 2019). Accordingly, an extremely high level of community buy is required for the Kawau eradication project to be successful.

This report documents the findings of a study to assess the feasibility of removing rats, stoats, possums and wallabies from Kawau. As it is structured, the first part of the report identifies its audience, defines the scope of the feasibility assessment and sets out the methods used to determine feasibility. It also provides detailed information about Kawau, and the species targeted for eradication as well as outlining a strategy for how eradication would be achieved if the project were to go ahead.

The second part of the report focuses on evaluating the project's feasibility against commonly accepted eradication principles beginning with an assessment of the costs, risks and benefits associated with the project. These are identified and weighed against each other to highlight the relative value of the project. The report then evaluates feedback from mana whenua, landowners and stakeholders to assess the project's social acceptability before assessing the project's technical feasibility. Finally, the report defines how the project would conform to legal and statutory obligations and secure and deploy the necessary resources. These individual components are then brought together in the third part of the report to form a conclusion on the project's feasibility.

It is important the benefits, costs and risks associated with the proposed project are understood before making a decision to proceed to full operational planning. Community representation within the project is yet to be resolved but is considered integral to the project's success.

This document is intended to provide the background to assist with decision making. Auckland Council commissioned Island Conservation to complete this study.

3. PURPOSE AND SCOPE

3.1. Purpose

The purpose of this document is to facilitate an informed decision on whether or not to proceed to the full operational planning phase for the eradication of rats, stoats, possums and wallabies on Kawau Island. This would include further discussions with landowners, completing operational, monitoring, mitigation and safety plans, developing individual property agreements and securing funding.

3.2. Scope

The report's scope is the evaluation of feasibility for a proposed project to eradicate rats, stoats, possums and wallabies on Kawau Island. Eradication is defined as the permanent removal of an invasive species; thus the scope incorporates an assessment of whether the target species can be prevented from re-establishing on the island. Outside the scope of the report is the removal of other introduced species from Kawau and an evaluation of other options for pest management although these subjects are discussed.[1]

4. KAWAU ISLAND

4.1. Location

Kawau Island or Te Kawau Tūmārō o Toi (the sentinel cormorant of Toi) (35.42°S, 174.85°E) is located in the Hauraki Gulf, north of Auckland and east of Warkworth (Fig. 1). The nearest point on the mainland is the Tāwharanui Regional Park predator free sanctuary, 1.4km to the north and the nearest settlements are Campbell and Baddeleys Beach, Snells Beach, Algies Bay and Sandspit.

4.2. Physical Landscape

At 2058 ha, Kawau is one of the largest islands of the Gulf. The island has a generally rolling topography rising to 185m in height from an irregular coastline (46km in length) indented by three large inlets known as Bon Accord Harbour, North Cove and South Cove (Kim 2020). The island's exposed eastern coastline is dominated by steep cliffs up to 60m in height whereas the island's more protected western shore has a gentler topography. Although Kawau has been intensively modified since human arrival, most of the island (~90%) is covered in regenerating native forest (Baber et al. 2008). Several permanent and semi-permanent streams feed small wetlands and/or artificial ponds (Sutherland and Woolly 2019).

[1] If there is sufficient community support for the removal of feral cats, the scope of the project going forward may be changed to include this species. With regard to mice, the proposed operational strategy has been designed to accommodate the potential presence of this species.

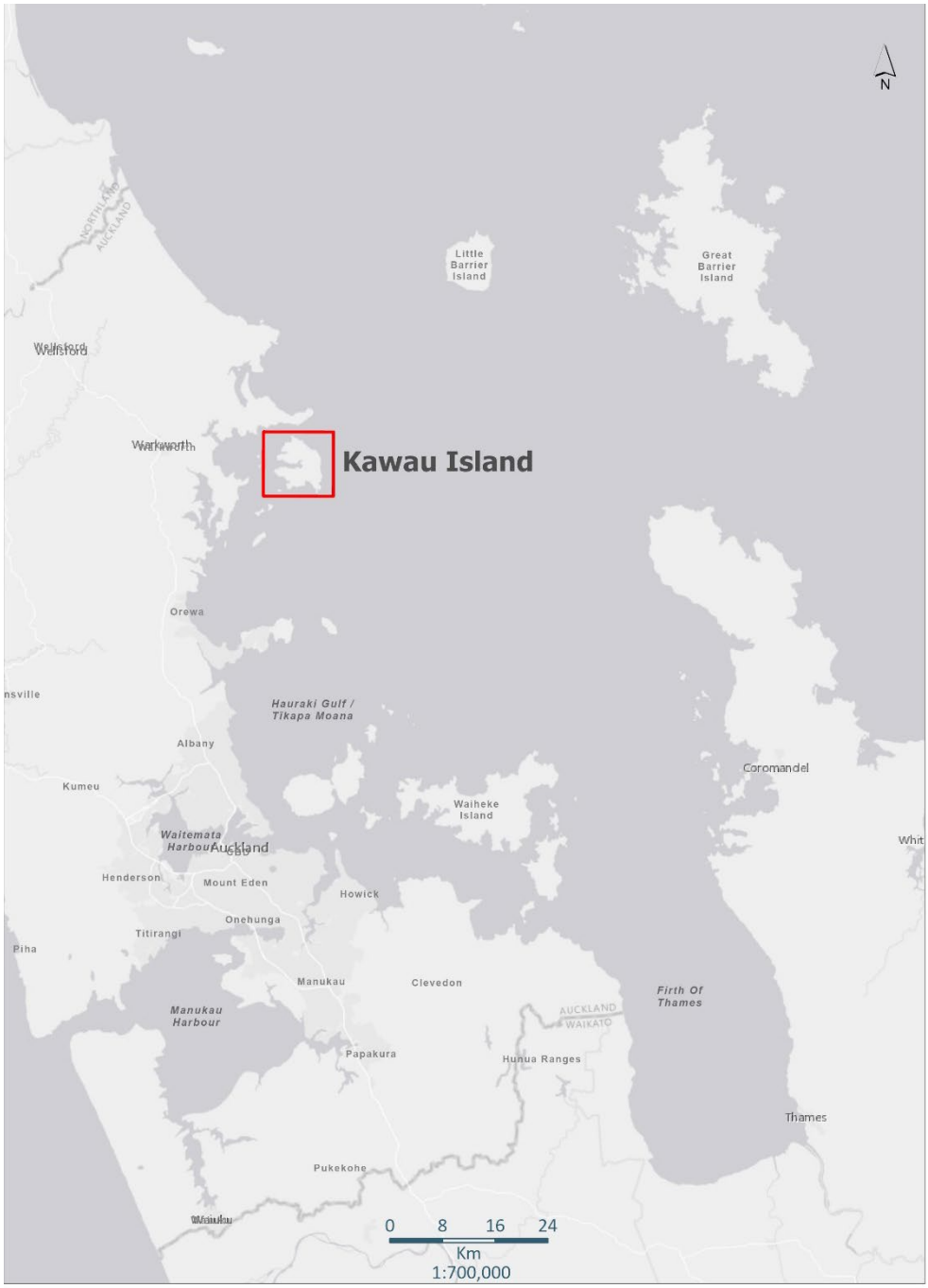

Fig 1. Location of Kawau

4.3. History

Kawau is reputed to have been first settled by descendants of Toi te Huatahi from whom its traditional name 'Te Kawau Tūmārō o Toi' arose. Descendants of the Arawa and Tainui canoes subsequently arrived and for three centuries the island was occupied by the people known as Ngāti

Tai who were later defeated by the Te Kawerau iwi, specifically Ngāti Manuhiri (Auckland_Council 2014). During the 18th century there was continuing conflict between the resident Kawerau and the Marutūahu confederation of tribes from the Hauraki area over access to the island's shark fishing grounds. Kawau was later abandoned after the musket war raids in the 1820's by Ngapuhi, and remained unoccupied until the 1830's. In this period the Ngāti Manuhiri hapū of Te Kawerau and Ngātiwai returned to the adjoining area where they remain to this day (Auckland_Council 2014).

After a protracted debate over ownership, Kawau was sold in the 1840's to W.T. Fairburn of the North British Australasian Loan and Investment Company. According to reports, Mr W.T. Fairburn, an agent of Mr Henry Tayler, and local Māori made arrangements in good faith on 11 January 1840 and Mr Fairburn paid an initial deposit. Henry Taylor then completed arrangements for Mr James Forbes Beattie who was acting for the North British Australian Loan and Investment Company. Beattie had arrived in New South Wales at the end of 1839 with £50,000 for investment in Australia and New Zealand. The remainder of the agreed amount to settle the transaction was made on 3 March The transaction was confirmed in a Crown Grant dated 15 July 1844 (Herschel 1844).

The discovery of copper in 1844 led to the development of a major mining and processing industry. In 1862, a new phase in the history of Kawau began, when the island was purchased by Sir George Grey, then Governor of New Zealand. Between 1862 and 1888, Grey developed an estate based around the former mine manager's house in Mansion House Bay. He introduced many plants and animals from around the world, and his legacy can still be seen in the diversity of plants and trees that remain (Auckland_Council 2014).

In 1888, Grey sold the island on which he had spent most of his fortune. The island then passed through a number of hands until in 1910 the island was subdivided (Auckland_Council 2014). Many of the plants, birds and animals imported by Grey have since disappeared. Species such as zebras never acclimatised whereas the monkeys did so well, they had to be exterminated. Wallabies and possums also flourished and although controlled, were never eliminated.

4.4. Land Tenure

Today around 88% of Kawau is privately owned with 455 land titles held by approximately 365 landowners (Auckland Council 2022). Land holdings range in size from 0.08 to 866 ha with most of the island owned by three large landowners. The balance of the island ~12% including Mansion House, the adjoining valley and the Coppermine is public land most of which is managed by the Department of Conservation.

4.5. Access

Almost every property on the Island relies on direct access to the sea. There are few roads on the island, most of which are found in Schoolhouse Bay and South Cove. These two bays along with Mansion House Valley have the island's only public wharves. Most landowners outside of these two locations have their own or share ownership of a private wharf or slipway. A ferry and water taxi service operates out of Sandspit servicing all parts of the island, but many landowners also have their own boat which are either moored, tied up at a jetty or brought ashore on the island. Two commercial barge companies operate out of Sandspit offering transport for vehicles, building materials and landscaping supplies. Transport providers from the wider Auckland region also service Kawau on demand.

4.6. Infrastructure

In contrast to most other islands in the Hauraki Gulf, Kawau is connected via undersea cables to an electricity supply and telephone connection. Internet is accessed either from the existing copper

connection, a cellular, satellite or HF radio and is good enough so that a number of people now work from home on the island. There is no reticulated water supply or centralised waste treatment system on Kawau, so the majority of properties rely on tank water for their domestic supply and most Kawau properties have their own septic tanks or treatment systems. Disposal of domestic waste is the responsibility of the landowner and waste is generally taken off the island by landowners on an as needed basis; landowners have access to a skip bin service at Sandspit (KIRRA 2018).

4.7. The Kawau Community

The isolation that living on Kawau brings has inspired a sense of community and many residents and landowners share a strong sense of self-reliance together with their fellow islanders. This community spirit is illustrated and reinforced through involvement in local initiatives such as the Kawau Island Residents and Ratepayers Association (KIRRA), Kawau Book Club, Kawau Boating Club, volunteer fire brigade, Pohutukawa Trust, North Harbour Custodians and attendance of various community events that are hosted during the year. It's worth noting that the community has developed a well organised and professional emergency response group, who manage medical, civil defence, weather and fire events (KIRRA 2018).

It is also fair to say that the Kawau community is physically divided into a number of smaller communities, an outcome of the convoluted nature of the island's coastline with no connecting roads. Most landholdings on Kawau are clustered into smaller bays or harbours that are connected only by sea. Further distinctions can also be made between permanent and semi-permanent residents (80-90) and those who visit irregularly. These characteristics are reflected in the values shared by neighbours living in close vicinity. There is also a small community of people living permanently on boats moored at Kawau for extensive periods of time. These people interact with residents and form a part of the Kawau Island community. Many properties on Kawau have multiple owners and landholdings have been retained by some families for generations. Consequently, some landholdings are inhabited by or utilised by multiple branches of a single family.

Many residents and landowners are retired or semi-retired but there is an increasing number of people living and working on the island. Island occupancy increases significantly over the summer months and during holiday periods. Over these periods the island receives many visitors, some of whom travel to the island by ferry and some on their own boats. The island's harbours become extremely busy with several hundred boats from the very large to the very small anchoring or mooring in the sheltered bays and harbours of the island.

4.8. Domestic Animals

Approximately 45% of landowners have either a cat or a dog and several keep chickens. Two goats are kept as pets on the island along with several alpacas and ducks. Contrasting opinions about pet ownership exist and incidents of weka and kiwi killed by dogs generates concern within the community about how pets should be managed. Kawau residents have access to a free service subsidized by Auckland Council for microchipping and desexing cats. Of the island's cat owners, all but one, who is a professional breeder, confirmed their cats to be desexed.

4.9. Commercial Activity

There are a number of commercial enterprises operating on or in association with Kawau. These include transport (Kawau Cruises & Water Taxis, Stanaway Marine Services, Hallett Enterprises and Skywork Helicopters), accommodation and hospitality (Kawau Lodge, Moana Cove Lodge, the Beach House, Kawau Boating Club/Bon Accord bar & Bistro, Mansion House café, Parohe Retreat, Stillwaters Retreat Centre, AirBnB and Bookabach options). Construction and landscape providers are mostly Rodney based but there are permanent residents on Kawau who provide commercial building, earthworks and general maintenance services.

4.10. Non-commercial Activity

An outdoor education camp at Camp Bentzon operates as a charitable organisation catering for schools and other groups (Camp Bentzon 2022). The New Zealand Department of Conservation manages Mansion House and Mansion House Valley as a visitor destination and for its historic heritage. Walking tracks from Mansion House Bay are open to the public and provide access to School House Bay and the Coppermine. The Royal New Zealand Yacht Squadron have the historic Lidgard House in Smelting House Bay that is popular with RNZYS members. A number of community-based organisations operate on the island including the Kawau Voluntary Fire Brigade, Pōhutukawa Trust and North Harbour Custodians.

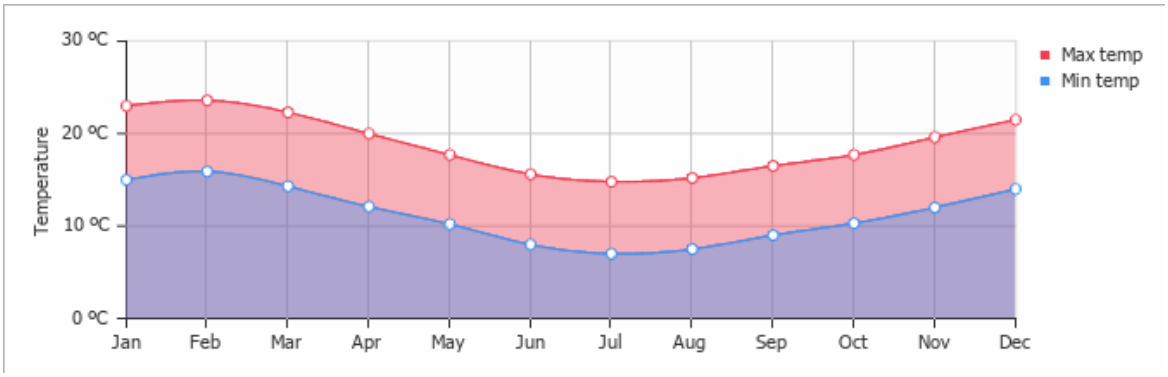

Fig 2. Average monthly temperatures for Kawau.

4.11. Weather and Sea Conditions

Kawau has a relatively mild climate with few extreme conditions except for heavy rain and high wind events, most commonly associated with ex-tropical cyclones or mid-latitude storms. Mean monthly temperatures range from about 15°C in July to 24°C in February. Annual rainfall is around 1210 mm with monthly rainfall averaging between 65mm over the summer and 144mm in winter. The island's eastern coast is exposed to easterly and north easterly swells making landing there difficult at times whereas the island's west coast is very protected due to its proximity to the mainland. Nevertheless transport between the mainland and Kawau can be obstructed by strong and sustained winds from the west that generate wave heights difficult for boating.

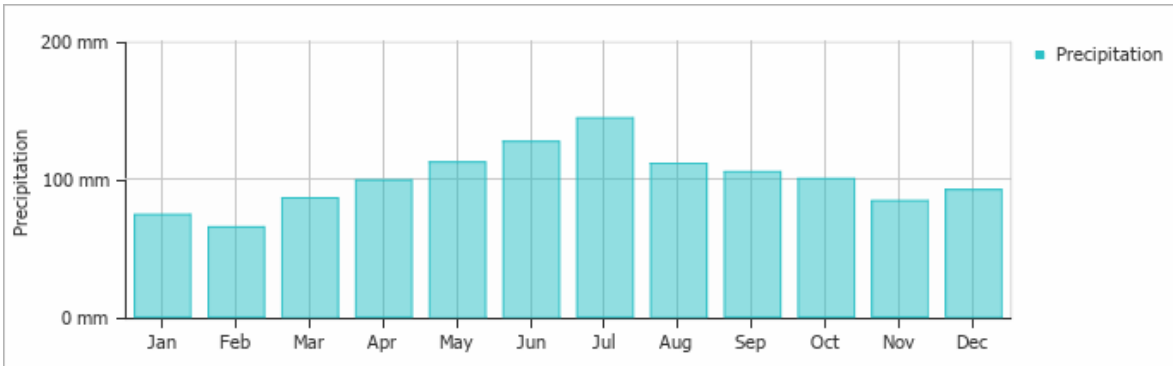

Fig 3. Average monthly rainfall for Kawau

4.12. Flora

At least nine indigenous ecosystem types are found on Kawau. These are listed by Singers et al. (2017). All are regionally threatened except for mangrove forest and kānuka scrub/forest. The island's vegetation is dominated by kānuka (*Kunzea robusta*). Large areas of the island's kānuka forest are even-aged and have regenerated since farming ceased in the 1920's-30's (Wilcox et al. 2004). On ridges and drier slopes kānuka forms a monoculture although mānuka (*Leptospermum scoparium)* is occasionally present (Wilcox et al. 2004). Where wallabies are present, the understorey is open as a result of browsing and in the past when possums have been abundant heavy damage has been noted to the forest canopy. Less palatable species are present in the understorey including māpou (*Myrsine australis*), soft mingimingi (*Leucopogon fasciculatus)*, prickly mingimingi (*Leptecophylla juniperina*), cutty grass (*Gahnia lacera*), akepiro (*Olearia furfuracea*) and silver fern (*Cyathea dealbata*). Intense browsing pressure from wallabies has also induced unique and diverse cryptogamic grazing lawns to develop in some areas. These are carpets of mosses, liverworts and lichens (Wilcox et al. 2004).

There are remnants of more mature native forest on the island, including pockets of kauri-podocarp-broadleaved forest in some areas. Canopy species within forest remnants include kauri (*Agathis australis*), pūriri (*Vitex lucens*), taraire (*Beilschmiedia tarairi*), nīkau (*Rhopalostylis sapida*), karaka (*Corynocarpus laevigatus*) tōwai (*Weinmannia silvicola*), rewarewa (*Knightia excelsa*), white maire (*Nestegis lanceolata*), pōhutukawa (*Metrosideros excelsa*), tawaroa (*Beilschmiedia tawaroa*), tawāpou (*Planchonella costata*), hīnau (*Elaeocarpus dentatus*) and pigeonwood (*Hedycarya arborea*) (Wilcox et al. 2004), with hard beech (*Fuscospora truncata*) in some locations.

There are some wetland areas in the lower reaches and floodplains of streams, which drain into the bays on the western side of the island (Wilcox et al. 2004). Common native species in the wetlands include cabbage tree (*Cordyline australis*), raupō (*Typha orientalis*), jointed twig rush (*Machaerina articulata*) and pūkio (*Carex virgata*). Saltmarsh vegetation and mangroves (*Avicennia marina* subsp. *australasica*) are present in the upper reaches of a number of sheltered inlets.

Exotic forest is also present on the island and is largely concentrated at the south-western end near Mansion House. Weeds are common across the island and particularly where wind-thrown kānuka has created large canopy gaps. The most widespread and prolific weeds are boneseed (*Chrysanthemoides monilifera* subsp. *monilifera*), pampas (*Cortaderia* spp.) and arum lily (*Zantedeschia aethiopica*) (Wilcox et al. 2004). Other locally-common weeds are Australian sedge

(*Carex longebrachiata*), agapanthus (*Agapanthus praecox*), sweet pea shrub (*Polygala myrtifolia*), Mauritius hemp (*Fucraea foetida*), pines (*Pinus* spp.) and brush cherry (*Syzygium australe*) (Wildlands Consultants 2009).

A number of nationally and regionally threatened plant species are present on Kawau including the Nationally Critical sneezeweed (*Centipeda minima* subsp. *minima*). Kauri has a threat status of nationally vulnerable due to the threat of kauri dieback caused by *Phytophthora agathidicida*, and myrtle species e.g. mānuka, kānuka, pōhutukawa and rātā (*Metrosideros spp.*) are considered threatened due to myrtle rust (*Austropuccinia psidii*). Comprehensive botanical surveys of the whole island have not been undertaken, so it is possible other threatened species may be present (Baber et al. 2008). The Mansion House valley hosts a number of exotic trees that are heritage listed.

4.13. Native Fauna

A number of threatened species are present on Kawau (Table 5). Some of these are resident and breed there, and some are occasional visitors. Kawau is a nationally important site for North Island weka with an estimated population between 2100 – 5000 birds stemming from a reintroduction to the island in 1976 (Beauchamp and Chambers 2000, Shaw and Pierce 2002, Miskelly and Powlesland 2013). However, the island's weka population fluctuates and DOC expect the population to have declined over recent years due to summer drought conditions in 2021 and 2022. There are also populations of North Island brown kiwi and pāteke. Kiwi were reintroduced in the 1860's and the pāteke likely arrived after their release and establishment at Tāwharanui Regional Park (Shaw and Pierce 2002, Colbourne 2005, Miskelly and Powlesland 2013).

Common native forest birds on Kawau include kererū (*Hemiphaga novaeseelandiae*), tūī (*Prosthemadera novaeseelandiae*), grey warbler (*Gerygone igata*), fantail (*Rhipidura fuliginosa*), silvereye (*Zosterops lateralis*), morepork (*Ninox novaeseelandiae*), kingfisher (*Todiramphus sanctus*) and shining cuckoo (*Chrysococcyx lucidus*). Kākā (*Nestor meridionalis)* are increasingly commonly seen as the regional population slowly expands and bellbird (*Anthornis melanura)* and kākāriki (*Cyanoramphus novaezelandiae)* are occasional visitors to the island likely arriving from Tāwharanui Regional Park (Sutherland and Woolly 2019).

Many marine and shorebird species have been documented on or around Kawau (see Appendix 1), including little blue penguin (*Eudyptula minor*), various petrel and shearwaters (*Puffinus* and *Pterodroma spp*.), Australasian gannet (*Morus serrator*), several shag species (*Phalacrocorax* spp.), several species of gulls and terns, variable oystercatcher (*Haematopus unicolor*) and northern New Zealand dotterel (*Charadrius obscurus*). Little blue penguin have been observed coming ashore and probably nest on Kawau. Grey-faced petrels (*Pterodroma macroptera*) breed on Challenger Island (Little Kawau) (Cameron et al. 2011), and it is possible they may also be nesting or attempting to nest on Kawau itself.

Juvenile New Zealand fur seals (*Arctocephalus forsteri*) or kekeno appear around Kawau over the winter months (Sutherland and Woolly 2019). A number of freshwater fish have been recorded on Kawau including banded kokopu, red finned bully and long finned eel. Freshwater mussels and shrimps have also been observed. Tree wētā, cave wētā and giant earthworms were noted as present by Baber *et al*. (2008), but there is no information on surveys for invertebrates or for bats on Kawau.

No formal herpetofauna surveys have been undertaken on Kawau, although Pacific gecko (*Dactylocnemis pacificus*), ornate skink (*Oligosoma ornatum*) and moko skink (*Oligosoma moco*) are described as present by Baber *et al*. (2008). It is possible that other native lizard species are present but have been overlooked, such as Auckland green gecko (*Naultinus elegans*). Other native gecko species could also be present, such as raukawa gecko (*Woodworthia maculata*), which were not detected on nearby Tiritiri Matangi Island until a number of years after mammalian pests had been eradicated (Baling et al. 2013).

4.14. Non-Native Fauna

Many introduced bird species are present on the island. These are listed in Appendix 1. Of note peafowl (*Pavo cristatus*) and the laughing kookaburra (*Dacelo novaeguineae*) originally introduced by Governor Gray both remain. No domestic stock are kept on the island other than the goats, chickens and alpacas mentioned above. Other introduced and invasive species include rats (ship rat and Norway rat), stoats, possums, four wallaby species and feral cats. More information on these species are included in following sections. Argentine ants have previously been eradicated from Schoolhouse Bay and a large area of Vivian Bay, but a small population in Little Vivian Bay is still being targeted for eradication by Auckland Council (P. Brown pers. comm). There is uncertainty over the presence or absence of the plague skink (*Lampropholis delicata*). A survey in 2010 failed to detect the species but anecdotal reports of their presence have been communicated to Auckland Council (Wairepo 2012).

5. SPECIES TARGETED FOR ERADICATION

Target species for eradication include rats (ship rat and Norway rat), stoats, possums, and the four wallaby species. No recent records exist for both mice (*Mus musculus*) and kiore (*R. exulans*) and as such they are not listed as eradication targets, but the presence of either species cannot be ruled out. It is unlikely that mice never arrived, instead, it is more likely they haven't established due to the presence of rats and possibly weka. Although their presence has not been confirmed, the operational strategy has been designed to target mice and kiore if also present. Weasels (*M. nivalis*) and ferrets (*M. furo*) have not been reported from the island but like mice, if determined to be present, would influence the operational strategy. Feral cats are present on the island but are not commonly seen. They are also not listed as a target species for eradication, but could be included with sufficient community support.

5.1. Rodents

Species present

The ship rat is the most abundant rat species on Kawau and is the species most commonly trapped and poisoned. Norway rats are also documented but are less commonly seen (Cameron et al. 2011).

Arrival

The first mammalian species to be introduced to Kawau was likely kiore, although dogs or kuri (*Canis familiaris*) may also have accompanied Kawau's first visitors. Travelling with people across the Pacific and to New Zealand with early Polynesian voyagers, kiore are likely to have arrived on Kawau early

during the period of New Zealand's settlement that began around 1200AD. Norway rats were the first rat species to arrive following European contact and may have established prior to 1800. Norway rats were the most common rat species carried on ships visiting New Zealand in the late eighteenth and early nineteenth centuries. During the second half of the nineteenth century this changed, with ship rats becoming the most common species on board European ships (Atkinson 1973). Consequently, ship rats may not have become widespread through the North Island until after 1860 and the species' arrival on Kawau may not have been until the late nineteenth century.

Upon their arrival Norway rats replaced kiore as the dominant rat species and it is likely that the species was extirpated following the arrival of ship rats. Ship rats out compete both species in forested habitats (Innes 2001).

Population density

The ship rat is the most abundant rat species on Kawau and as seen elsewhere, its density varies both within and across years largely driven by resource availability. Population densities ranging from less than 10 individuals per ha in late winter to more than 30 per ha in late summer are expected (Innes 2001). Norway rats are much less common and densities likely up to 13 rats per ha are likely similar to the Auckland region (Innes 2001). As with ship rats, densities fluctuate during the year peaking during late summer, early autumn.

Distribution

Ship rats are widespread on Kawau and are found in all habitat types, although they are likely most abundant within the island's forest. Norway rats are more likely associated with the island's coastline and wetland areas. Ship rats are commonly encountered around dwellings and outbuildings during late autumn as individuals search for shelter to see through the winter.

Home Range

For ship rats, home ranges sizes within New Zealand span a range of 0.8ha to nearly 10 ha although Harper (Harper and Rutherford 2016) found females inhabiting home ranges as small as 0.06 ha during a breeding season on Taukihepa Island. Norway rats, although fewer studies have been undertaken, have much larger home ranges (Innes 2001).

Diet

Both ship rats and Norway rats are omnivorous and although their diet is dominated by invertebrates, seed and plant material (Miller and Miller 1995), they are both known predators of reptiles, birds and other vertebrates (Innes 2001). Rodent bait is highly palatable to both species (Morriss et al. 2008).

Lifecycle

The life span of rats is around a year to two years, during which time, a female will typically breed up to six times, with the average litter being seven or eight. In warmer parts of New Zealand, both ship and Norway rats can breed throughout the year but breeding generally peaks over the late spring to early autumn period. Gestation for both species is between 20-22 days and weaning happens between 21-28 days. Individuals become sexually mature at 3-4 months and may breed up to six times before death (Innes 2001).

History of control

Rat control on Kawau has been ongoing by the community for many years. Widespread control of rats has been implemented using rodent bait containing anticoagulants deployed in bait stations across large areas of the island and most residents and landowners (~87%) undertake ongoing control around dwellings on the island. More recently residents have started trapping rats using a variety of trap types including Victor Professional Rat traps housed in a wooden tunnel, Goodnature A24's and D-RAT PRO.

5.2. Mustelids

Species present

Of the three mustelid species present in the Auckland Region only the stoat has been documented on Kawau(Sutherland and Woolly 2019).

Arrival

There are no records of stoats being released on Kawau and it is probable that stoats arrived under their own steam. Kawau is separated from the adjoining mainland to the north by just 1.4 km at its closest point (Fig. 4), a distance well within the known maximum swimming distance recorded for stoats (Veale et al. 2012). Stepping stone islands also shorten the distance bringing Kawau within swimming range of other points on the mainland. Stoats may have arrived soon after their establishment in the Auckland Region in the early 1900's (King 2017). A stoat caught on nearby Rabbit Island in 2021 (Fig. 2) highlights the dispersal ability of this species.

Population density

No density estimates for stoats on Kawau are available but the population density on Kawau as evidenced by sightings and the few reports of individuals ever being trapped, appears to be extremely low (C. Weaver pers. comm.). Resource scarcity, especially during dry summers, may explain the low numbers but competition with feral and domestic cats may also be a factor. The removal of invasive vertebrates from the island would provide for the recovery of the island's forest bird, seabird, reptile and invertebrate communities potentially improving conditions for stoats and the island's carrying capacity could change over time.

Distribution

Stoats utilise a range of different habitats but given the size of the island could potentially be found anywhere. Trapping on Waiheke indicates a preference for coastal and wetland habitats that might be more productive (F. Lepera pers. comm.).

Home Range

Home ranges for stoats in New Zealand range from just a few hectares to over 200 ha (King 1990). Trapping densities as low as 1 trap per 7 ha have been used successfully to remove stoats from islands up to 1130 ha (Elliott et al. 2010) but attempts to eradicate stoats from larger islands (e.g. Secretary, and Resolution) through trapping alone have not succeeded and an eradication attempt from Waiheke is still underway.

Diet

Stoats are carnivores and in New Zealand their diet consists primarily of rodents, rabbits, invertebrates, birds, possums and reptiles (King 1990). On Kawau, rats, invertebrates and birds are the most likely food groups targeted.

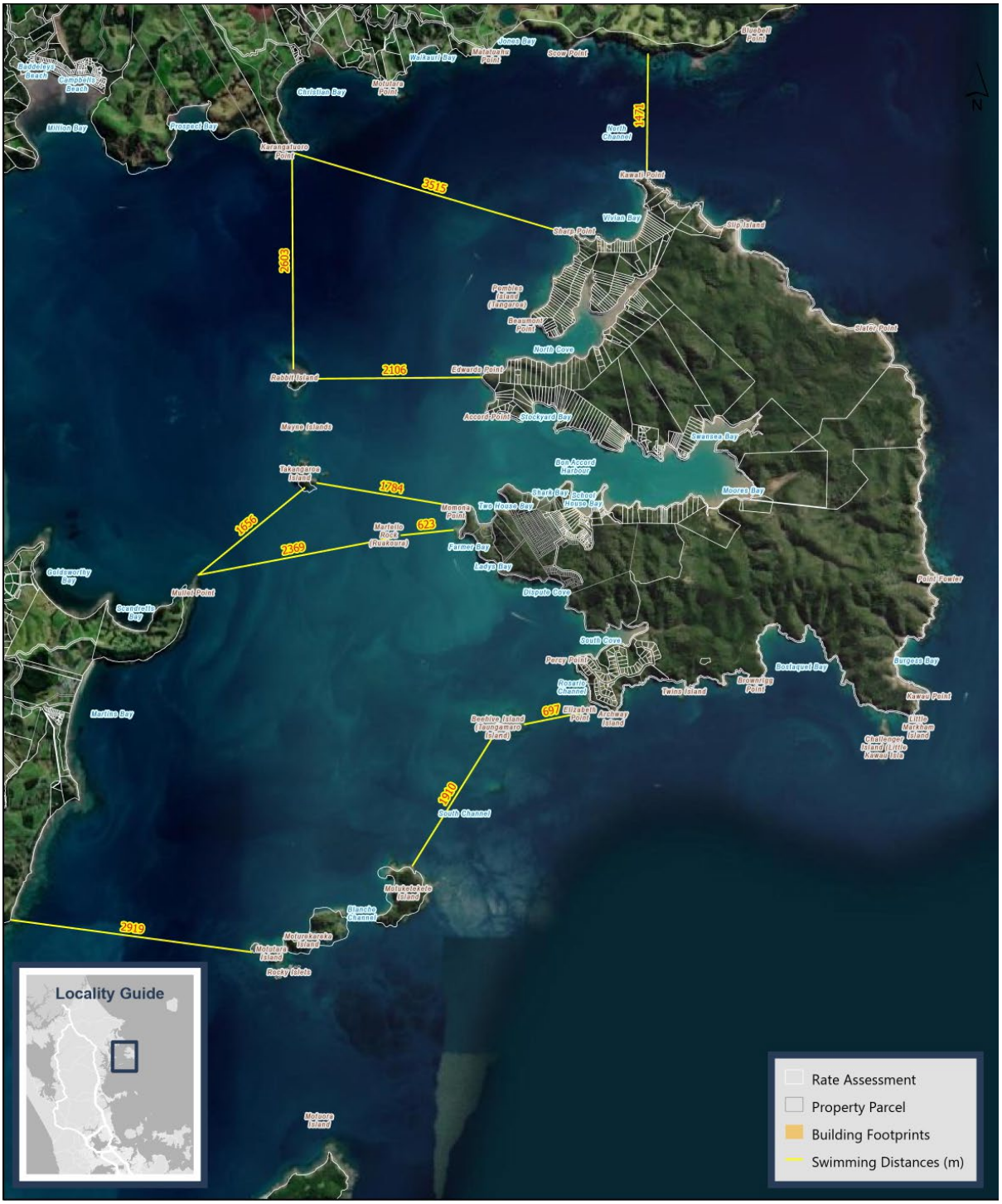

Fig. 4. Kawau Island with swimming distances from the closest potential source populations of stoats.

Lifecycle

Stoats typically live for up to two years in New Zealand, but individuals can survive longer. Females typically give birth just once a year, but litters can be up to eight or nine. Juvenile stoats are independent from before 12 weeks and female kits are sexually mature and generally impregnated before they leave the den. Female stoats undergo a process called embryonic diapause, which means fertilised eggs don't immediately implant in the uterus. Instead, they are held in a state of stable hibernation following fertilisation for up to 300 days. After this period, they are implanted in the uterus and undergo gestation for 3 to 4 weeks before being born. These adaptations allow stoat populations to rapidly respond to periods of resource scarcity or abundance (King 1990).

History of control

No systematic control of stoats has been undertaken on Kawau although stoats may have been impacted by secondary poisoning as a consequence of control operations targeting rats, possums and wallabies.

5.3. Possums

Arrival

Brush-tailed possums were introduced to Kawau by Governor Grey in 1868-1869. From genetic analysis it appears that like several other North Island populations, they were introduced directly from the Australian mainland (Taylor et al. 2004).

Population density

Following their release, possum numbers on Kawau likely exploded. The damage possums inflicted on the island's native vegetation was illustrated most visibly by the near total defoliation of the island's pōhutukawa trees (Weaver 1999). Thanks to control efforts possums are now in low densities on Kawau and appear to be absent from some areas altogether.

Distribution

Control efforts, in addition to reducing possum abundance on Kawau may have also reduced their distribution. Although still widespread, they are potentially at very low density or even absent from some areas of the island such as South Cove, Pembles and Vivian Bay where they have not been reported for several years (Carl Weaver pers. comm.). There appears to be an association with pine forest and individuals are regularly trapped in School House Bay and Mansion House Valley.

Home Range

Possum home ranges vary with habitat and population density. Home ranges recorded by Whyte et al. (2013) ranged from 1.2 ha to 12 ha.

Diet

Possums are principally herbivorous feeding on the leaves, fruit and seeds from a variety of tree species, but they also feed on fungi, invertebrates and vertebrates (Fitzgerald and Gibb 2001). Preferred tree species on Kawau likely include puriri, kohekohe, tawapou and pōhutukawa but they also do well in pine forest.

Lifecycle

Young are typically weaned by about 6 months and disperse anytime between 8 and 18 months. Females can reproduce by about 12 months of age, and males typically reach sexual maturity by age 2. Possums have an average life span of 7 years in the wild (King and Forsyth 2021).

History of control

Possum control operations (primarily the use of bait containing brodifacoum in bait stations but also hunting during wallaby culls) have been undertaken on Kawau since the early 1990's resulting in a significant decline in their abundance across the island, so much so that, as mentioned above, possums are rarely encountered in some parts of the island.

5.4. Wallabies

Species present

Four species of wallaby remain on Kawau. These are the dama or tammar wallaby (*Macropus eugenii*), the parma wallaby (*Macropus parma*), the brush tailed rock wallaby (*Petrogale penicillata*) and the swamp wallaby (*Wallabia bicolour*). The black striped wallaby (*Macropus dorsalis*) is no longer present (Shaw and Pierce 2002). The four species of wallaby remaining on Kawau are predominantly nocturnal, emerging to feed in the late evening and sheltering amongst vegetation during the day.

Conservation status

The dama wallaby is listed by the International Union for the Conservation of Nature (IUCN) as a species of Least Concern and has been delisted in Australia following conservation efforts to reintroduce the species to South Australia where it once disappeared. Some of the individuals reintroduced came from Kawau (Woinarski et al. 1996). The species was once split into three sub-species with the Kangaroo Island and Kawau populations considered genetically distinct. However, this has since been revised and the species is now recognised as one grouping (TSSC 2019).

The parma wallaby is considered Near Threatened by the IUCN but a recent Australian based reassessment classified the species as Vulnerable (DCCEEW 2022). The species' status does not warrant the preparation of a recovery plan, but recent advice does not identify the repatriation of further individuals from Kawau as a conservation need (DCCEEW 2022). Past translocations have not been overly successful. Twenty-four parma wallabies from Kawau were introduced to Pulbah Island in New South Wales in 1972 along with 12 individuals from the Taronga Park Zoo's captive population (which incidentally also originated from Kawau), but these individuals failed to establish. A captive population within a predator fenced private property at Mt Wilson in NSW was founded from 30 individuals sourced from Kawau but individuals later taken from this population to Robertson did not survive due to predation by foxes (*Vulpes vulpes*) (Short et al. 1992).

Brush-tailed rock wallabies are listed as Vulnerable by the IUCN and Australia, under the Commonwealth *Environment Protection and Biodiversity Conservation Act*. Individuals from Kawau have in the past been used to develop a captive breeding program in Australia (Menkhorst and Hynes 2010). Australian authorities now consider that Kawau genes are appropriately represented within Australia and that resources would be better spent supporting and preserving the diversity present

within wild Australian populations which have been less represented in comparison (Mark Eldridge pers comm.).

Swamp wallabies are not considered at risk and are listed by the IUCN as Least Concern.

Arrival

The five species of wallaby mentioned above were released on Kawau by George Grey in about 1870 (Sadleir and Warburton 2001).

Population density

Eradication efforts by the Pōhutukawa Trust have greatly reduced wallaby numbers across the island. Dama and parma are still the most numerous with smaller numbers of brush-tailed rock wallaby and swamp wallaby (C. Weaver pers. comm.).

Distribution

Although their numbers have been reduced, swamp, dama and parma wallabies are still widely distributed across the island, whereas rock wallabies are generally considered confined to the northern and eastern cliffs.

Home Range

A study on tammar wallabies in Rotorua, which were originally sourced from Kawau documented ranges of between 10 and 39 ha (Lentle et al. 1999). Lentle et al. (1999) calculated the mean home range size for Parma wallabies on Kawau Island, New Zealand. Using 80 percent external convex polygons, the mean home range was estimated as 5.24 hectares (± 0.5 hectares). Brush tailed rock wallabies have the smallest recorded home ranges for the four extant species as small as 2ha (King and Forsyth 2021). Information from local residents also suggests there is movement within the island at times of the year e.g. during summer months when more people are present on the island, wallaby movement to the less populated eastern side has been noted.

Diet

All four species feed on grasses but will also browse on seedlings and leaf litter (King and Forsyth 2021). Most broadleaf native forest species on Kawau are clearly highly palatable given the near complete absence of an understorey.

Lifecycle

Characteristics vary between the four species but on Kawau all species generally have on average one young a year. Most young are born early in the year but all species except for the dama wallaby likely breed throughout the year if conditions are suitable. Due to the current lower abundance of wallabies as a consequence of hunting pressure by the Pohutukawa Trust, breeding is likely to more opportunistic. Wallaby species can use diapause and put embryos on hold for up to 11 months. Young spend between 7-9 months in the pouch. Sexual maturity is reached at 9 months for dama females but longer in the other species. Lifespan may be up to 10 years for some species (King and Forsyth 2021).

History of control

Control of wallabies began in 1923 and was undertaken erratically up until 1973 when farming was abandoned. Over this period, most wallabies were shot, although poison (cyanide) was also used (Warburton 1986). The parma wallaby was protected in 1969 but shooting of the other three wallaby species on the island continued. In 1984, protection for the parma was removed but it wasn't until the Pōhutukawa Trust was formed in 1992, that concerted efforts to reduce the number of possums and wallabies across Kawau began (Shaw and Pierce 2002). Since 1992, under the leadership of Pōhutukawa Trust, wallabies have been reduced in number across large parts of Kawau through hunting and as a non-target casualty of the application of cereal bait containing brodifacoum in bait stations to target possums. Over the last seven years, teams of hunters using thermal detection and spotlighting have undertaken 3-4 'culls' per year (C. Weaver pers. comm.). These culls cover much of the island but focus predominantly on the largest landholdings and conservation land.

6. METHODOLOGY USED TO ASSESS PROJECT FEASIBILITY

To assess the project's feasibility, we adopted the following approach. First, we drafted a provisional eradication strategy to identify the likely methods, sequence and timing of an operation to remove wallabies, possums, stoats and rats from Kawau. This strategy was informed by a horizon scan of evolving tools and technology to pinpoint methods that would meet eradication principles but at the same time be respectful of community values, reduce costs, minimise risk to human health and the environment, and increase the likelihood of success (Griffiths 2022). We also compiled a provisional set of risks, costs and benefits for the project.

This information was then used as part of one on one discussions to provide landowners, mana whenua and other stakeholders with a clear picture of what an eradication project on Kawau would look like and an understanding of the anticipated impacts. Feedback from stakeholders fully informed through the engagement process was then fed back into a revised version of both the operational strategy (see Section 7) and cost benefit analysis (see section 8) against which the feasibility of the project was assessed. The seven eradication principles originally identified by Parkes (1990) and Bomford & O'Brien (1995) and outlined below must be satisfied if an eradication is to be considered feasible.

1. The benefits of the project outweigh the costs.
2. The project is socially acceptable to the community involved.
3. All individuals of the target species can be put at risk by the eradication technique(s).
4. Target species populations can be removed at a rate exceeding their rate of increase at all densities.
5. The probability of target pests re-establishing is manageable to near zero.
6. The project meets all legal and statutory requirements.
7. The necessary resources to complete the project are available and can be deployed.

The first principle was evaluated by weighing both the short and long-term benefits of the project against its risks and costs. Benefits, risks and costs were broken into several categories (economic, social and cultural, environmental and human health and safety). Benefits and costs were quantified

wherever possible, although only a few could be accurately estimated. Where quantification was not possible, feedback received from community discussions was used to calibrate relative consequence.

Principle 2, the project's social acceptability, was assessed through an engagement process. Mana whenua were engaged as part of a separate process described below. In line with a strategy developed in 2021 (Island_Conservation 2021), stakeholders were identified as individuals and organisations directly affected by the project and are listed in Table 1 below. Over a period of 12 months, stakeholders were contacted confidentially on a one-on-one basis to ensure they received a clear picture of what an eradication operation on Kawau would likely involve, how they would be personally affected, and ensure their personal views on the project were accurately recorded. Along with clearly communicating the benefits of the project, conversations were explicit and transparent about the project's costs and risks. Eradication concepts were communicated in plain language, so they could be easily understood and follow up conversations were held with several individuals to address outstanding questions. All information recorded was treated confidentially.

Table 1. Stakeholders contacted to inform the feasibility of rat, stoat, possum and wallaby eradication on Kawau Island as of June 2023.

Stakeholder Type	**Stakeholder**	**Number Contacted**
Landowners	Residents and landowners	347
Community based organisations	Pōhutukawa Trust, North Harbour Custodians, Camp Bentzon, Royal New Zealand Yacht Squadron, Kawau Boating Club, Kawau Island Residents and Ratepayers Association, Kawau Volunteer Fire Brigade, Mansion House Foundation.	8
Commercial Organisations	Kawau Cruises and Water Taxis, Stanaway Marine Services, Hallett Enterprises, Mansion House Cafe, Parohe Retreat, Kawau Lodge, The Beach House/Fernz Lodge, AirBnB providers.	10
Government Departments	Department of Conservation, Ministry of Primary Industries, Heritage New Zealand	3
Local Government	Auckland Council, Rodney Local Board	2
National and local government representatives	Councillors and MP's	5

Kawau O Tumaro (Kawau Island) is located within the eastern boundaries of Ngāti Manuhiri who are mana whenua of this rohe. As a project partner, Ngāti Manuhiri Settlement Trust, as the mandated authority, has been kept apprised of progress and a commitment has been made to undertake a cultural impact assessment for the project as well as employ a kaitiaki to assist with planning and delivery, including cultural monitoring. If delivery is given approval to proceed, kaumatua will undertake a formal blessing immediately prior to work commencing in the field.

Correspondence with Kawerau ā Maki, Ngāti Paoa, Ngāi Tai ki Tāmaki, Ngāti Maru, Ngaati Whanaunga, Ngāti Wai, Te Rūnanga o Ngāti Whātua, Ngāti Whātua o Kaipara was also undertaken to provide information and opportunities to engage on the project.

Deciding on the threshold of support for a project to be deemed socially acceptable is a difficult task. To do this for the Kawau project, we evaluated what impact the level of support for the project might have on eradication principles 3-5 for each of the target species. For instance, access to all private property is needed to satisfy eradication principles 3 and 4.

Principles 3-5 were assessed taking into account community feedback and by drawing on precedents established from other eradication projects completed on both uninhabited and inhabited islands. Advice was also incorporated from technical experts working in the eradication field. The project's ability to meet Principle 6, was evaluated by reviewing regulations that might constrain the proposed eradication strategy. Legislation specific to aviation, hunting and the use of vertebrate toxic agents was reviewed. Principle 7, if the required resources to realise the project can be acquired and put in place to ensure eradication success was evaluated, first by identifying potential sources of funding that could address the current funding shortfall and second, by talking to other organisations, operators and individuals working in the pest management field to assess capacity and availability of human and other resources.

7. PROPOSED ERADICATION STRATEGY

The removal of wallabies, possums, rats and stoats from Kawau will require a range of eradication tools and techniques. Although a comprehensive operational strategy has not yet been developed, if the project was to proceed, wallabies would need to be removed first. This means that the most humane methods for control (shooting, trapping and localised toxin use) can be implemented via a split-treatment approach, avoiding the risk of consumption of large quantities of rodent bait, intended for other target species. Wallabies could consume significant quantities of rodent bait creating gaps in bait distribution within which some rats might survive. Bait consumption by non-target consumers has led to eradication failure in other operations (Holmes et al. 2015). The application of cereal bait containing brodifacoum is also not registered for use targeting wallabies. Once wallabies have been removed, the focus would then shift to rats, possums and stoats. An operation targeting these species would take place over the winter period when rats are hungry and breeding rates are reduced. Specific methods proposed are set out below.

7.1. Wallabies

Planning and preparation

Further discussions with those landowners who currently do not support the removal of wallabies will be required. As for the other species targeted, the eradication operation for wallabies will stand the greatest chance of success if access can be gained to all parts of the island. Sufficient capacity to implement the eradication will also need to be found. It is envisaged that a team of at least 12 hunters, four of whom are wallaby detection dog handlers, would be required to execute the project efficiently. This team could be broken into two, with six staff on the island at all times, allowing consistent pressure to be placed on wallaby populations and leeway for having more hunters on the ground when required.

Greater efficiencies might also be gained if the island can be divided into two using a fence extending from the head of Bon Accord Harbour to the island's east coast. Barriers to wallaby movement have been used elsewhere with success (Statham et al. 2010). This option has yet to be explored with landowners so at this stage remains a concept only. It will likely also make sense to divide the island virtually into blocks for hunting and monitoring purposes.

A trail camera network would be deployed across the island to document progress. A network of static cameras that remain in place for the duration of the operation would be coupled with population modelling to provide confidence in absence. An additional set of floating cameras that are moved around the island would be used to pinpoint the location of surviving animals. To reduce processing time, artificial intelligence will be used to complete the initial analysis for all footage captured.

Population knock down

The aerial application of 1080 was the method used on Rangitoto to reduce the wallaby population and is currently used elsewhere to control wallaby numbers. However this method was ruled out for use on Kawau based on community feedback. Instead, it is envisaged that a rolling front approach would be employed to progressively eliminate wallabies starting north of North Cove (where wallabies have been greatly reduced in number) and ending at Kawau Point. As the operation progresses, residential areas will be prioritised for completion first so that individuals do not take refuge in these areas. Areas to be targeted will be surveyed first and pre-feeding conducted. If groups of wallabies are being encountered, trapping and the localized use of toxins or a combination of these methods will be employed to reduce numbers before hunting is employed. The rationale for this strategy is to avoid as far as possible the risk of wallabies learning to avoid hunters. The effectiveness of hunting needs to be preserved as the key method that will be needed to remove the last few individuals.

Toxins registered for use in New Zealand against wallaby include cyanide (Feratox), 1080 cereal carrot bait, and 1080 gel. If toxins are used, baits will be hand laid or placed in bait stations outside of residential areas. Competition by rats and possums will need to be carefully managed as possums out compete wallabies at bait stations and for this stage of the operation, rats will be unwanted bait consumers. Ideas about bait station design and placement for wallabies are evolving as wallaby eradication/control efforts advance in other parts of the country and these ideas will be taken into account in the development of an operational plan. Traps to be considered include large enclosure style traps, drop nets as well as hard jawed Victor No 3 and 4's. However, exemption to use Victor No 3's ad 4's will be required and the non-target impacts to kiwi and weka need further consideration.

Once wallabies have been reduced to the point where solitary individuals are being encountered, then hunting using thermal detection as is being done currently will be rolled out. Team hunting methods may be used to drive individuals out of specific areas and into areas where they can be targeted. For those properties where hunting is not possible, dogs may also be used for this purpose. Cliff faces will be surveyed using thermal detection equipment either from suitable vantage points or by drone or helicopter. Aerial hunting over non-residential areas may be considered if some wallabies prove inaccessible to ground hunting.

Detecting and removal of survivors

Drones/helicopters with thermal cameras, trail cameras and dogs will be used to detect surviving individuals. Detection effort using thermal technology will be undertaken shortly after areas have been hunted. However, systematic sweeps of areas by dogs and dog handlers may need to wait until fresh sign has largely disappeared. Any detections will be immediately followed up by the targeted use of trapping, hunting or toxins.

Confirmation

The static camera network, dogs and public sightings will be used to confirm the presence or absence of the four wallaby species on Kawau. Thresholds for declaring eradication success will be developed.

7.2. Rodents

To remove rats and mice from Kawau, the only available method capable of achieving a high likelihood of success, is to place rodent bait into every territory on the island. Rodent territories can be small, so it is very much a 'no stone left unturned' approach.

Planning and preparation

To ensure rodent eradication on Kawau is successful, access to every property on the island will be required. The nature of this access will need to be determined through individual property agreements and this is expected to take a dedicated team at least a year to complete. Further dialogue with those landowners who are currently opposed to the use of rodent bait on their properties will also be required. A six-month minimum moratorium on the use of toxins on Kawau prior to eradication (to reduce the risk of bait shy rodents) was discussed with landowners with the majority supportive of this measure although assistance with trapping and other forms of rodent control may need to be provided to mitigate impacts.

To eliminate alternative food sources during the eradication, project staff will need to work closely with landowners to ensure food waste management and composting systems are secure. Significant support for these measures was documented during discussions with landowners. Many permanent residents have vegetable gardens and some have fruit and nut trees that could provide alternative sources of food for rats during an operation. Although, from the engagement process and visits to many of these properties, the risks are considered low, the project team will need to work with residents to ensure no highly palatable species are being grown in gardens during the operation. Ripe citrus fruit, fruiting palms and macadamias will need to be harvested prior to the operation as these tree species could offer an alternative source of food to rats during the eradication operation.

Although risks are low, measures to protect domestic pets and livestock such as muzzles, enclosures or taking pets off the island during the operation will also need to be in place. General acceptance for these measures was received from landowners along with a number of good ideas that need further consideration.

Sufficient capacity to implement the eradication will also need to be found. It is envisaged that a team of at least 20 staff for a period of 4-5 months will be required to establish the grid network, set up bait stations and undertake the ground-based component of the operation and a team of 12 for the aerial

operation. At least two dog handlers will also be required for follow-up surveillance. Identified accommodation and transport options will also need to be solidified.

The application of rodent bait (both aerially or by hand) to non-stocked islands is an exempt activity and resource consent for its use on Kawau is not required if specific conditions are met and followed (Resource Management (Exemption) Regulations 2017). Medical Officer of Health (MOH) approval is also not a requirement. However, it is recommended that the MOH is advised and that local vet clinics are notified in case of accidental poisoning of domestic pets. Ongoing dialogue with the community about the management of pets will be necessary and a supply of Vitamin K will need to be sourced and stored on the island in case of accidental consumption.

Implementation

Although the risks to human health are low, it is proposed that ground-based methods are used within and around residential areas. The preferred methodology would entail the creation of a 20m x 20m grid where bait Pestoff 20R™ containing brodifacoum at 20ppm would later be spread by hand. Bait would also need to be placed in bait stations under houses and outbuildings and ideally within roof spaces as well. Access to unoccupied homes would need to be worked out through the formation of property agreements. Alternative methodology, for example, bait stations may be used as the treatment method for a small number of residential properties to minimise perceived risk to domestic animals and young children. The use of bait stations over hand broadcast to deploy bait outside of buildings would add risk to the ultimate success of the operation and extend the duration of the operational period so the aim would be to keep the number of properties where this method is used to a minimum. Pestoff 20R™ would also be used in bait stations.

Because of the size of Kawau and the steep and inaccessible nature of some parts of the island, a helicopter would be required to apply rodent bait (Pestoff 20R™) outside of residential areas. A buffer zone would be established between helicopter flight paths and any building or roof water catchment to exclude any possibility of bait entering water supplies. The extent of the buffer zone has not yet been decided but will be between 50-100m from any building. Ground and aerial methods will overlap to minimise the risk of gaps in bait distribution and any hand spreading will be completed after aerial bait application so aerial spread can be ground truthed. Two to three island wide applications of bait would be required.

Ground based treatment of an area of this size to (i.e. up to 400ha) is not without precedent. However, it is still a significant area which includes some challenging terrain and quality controls will need to be employed to ensure the area is comprehensively treated.

Confirmation

Standard practice in New Zealand is to wait two years before confirming the outcome of a rat eradication. However, for Kawau, ongoing biosecurity surveillance would be in place prior to the eradication starting and be an ongoing task. Trail cameras, tracking tunnels, indicator dogs and observations by the community would all be used to confirm the presence absence of rats. Success could be declared following two years of no detections.

7.3. Possums

Planning and preparation

As demonstrated by other eradication projects such as Maungatautari and Tāwharanui, the application of rodent bait is expected to eliminate possums, but at least two dogs and dog handlers will be retained to locate and remove individuals if Kawau proves the exception.

Implementation

After bait application, follow up monitoring using dogs, trail cameras and thermal detection from ground and air will be undertaken to detect surviving possums. Targeted leg-hold and kill trapping, supplemental bait application and hunting would be used if survivors are detected.

Confirmation

Although the effort required has not yet been quantified, a year of no detections with trail cameras, dogs and sweeps of the island using drones or helicopters with a thermal camera will likely be used as the threshold for confirming successful eradication of possums.

7.4. Stoats

Planning and preparation

As demonstrated by other eradication projects such as Rangitoto and Motutapu, the application of rodent bait is expected to eliminate stoats through secondary poisoning caused by stoats eating poisoned rodents. Follow up trapping and at least two dogs and dog handlers will be retained to locate and remove individuals if Kawau proves the exception. Dog and dog handler capacity will also be retained to manage incursions on an ongoing basis.

Implementation

In anticipation of an irregular but ongoing rate of incursions by stoats, a permanent surveillance network would be established on the island prior to the eradication being undertaken. Once established, trail cameras would be activated and detection effort with dogs undertaken to establish baseline data on presence/absence. Further detail on the surveillance network is provided in a draft biosecurity strategy commissioned by Auckland Council but consists of a number of DOC 200 traps (in wooden tunnels) and trail cameras set in strategic locations and the periodic use of indicator dogs. After bait application, traps established for ongoing surveillance would be activated and along with indicator dogs and trail cameras, used to detect and remove surviving stoats. Stoats that are detected but not trapped will be targeted by more intensive trapping and the use of a stoat specific bait although it is noted that baits for stoats are still in development.

Confirmation

Although the amount of effort required has not yet been quantified, two years of no detections with trail cameras, dogs and trapping will be used as the threshold for confirming successful eradication of stoats. Monitoring effort will be sustained as part of the biosecurity surveillance in perpetuity.

7.5. Preventing Reinvasion

Current levels of biosecurity protection for Kawau are insufficient to prevent population reestablishment by both rats and stoats. However, the island is within the Hauraki Gulf Controlled Area Notice providing a basis for biosecurity requirements following eradication. A biosecurity plan

for the island is in development and it is anticipated that both the plan and its outlined measures would be in place and audited prior to rats and stoats being targeted.

Advocacy

The success of the project is contingent on changing the behaviour of landowners and visitors alike so that everyone travelling to the islands takes sufficient steps to prevent pest introduction. If the project goes ahead, Auckland Council have committed to resourcing and spearheading a campaign to ensure all landowners and visitors understand the risks and how they can be addressed. Some stakeholders such as the RNZYS already convey biosecurity messaging to members and can reinforce campaign messaging. All commercial vessels visiting Kawau are required to have a Pest Free Warrant from Auckland Council and this requires them to advocate to their customers.

Prevention

Most biosecurity measures to prevent reinvasion of the target species prescribed for Kawau will be voluntary, as the island is largely privately owned and is openly accessible to visitors. Consequently, advocacy efforts to ensure island users understand the risks and are motivated to do something about them will be the key mechanism for preventing reinvasion. All commercial transport operators servicing Kawau are required to be part of the Pest Free Warrant scheme. These operators undergo extra auditing prior to the eradication proceeding and any departure from standards addressed. High risk shipments are not currently checked prior to shipping to Kawau but Auckland Council has committed to enforcing Pest Free Warrant standards and supporting these additional measures for high-risk shipments.

Surveillance

Ongoing surveillance for the presence or absence of mice, rats and stoats will be critical to maintaining the pest free status of Kawau. Incursions by swimming stoats are inevitable due to the proximity of mainland and stepping stone islands, though it is uncertain how regularly this would occur, particularly given there is stoat control on land closest to Kawau. There is also a risk that both mice and rats could arrive via human mediated sources, such as vessels. However, the rate of incursions on other islands in the Hauraki Gulf suggest this may only happen every few years.

Techniques for detecting and responding to rodent incursions are constantly evolving but surveillance on Kawau will apply best practice. Current plans are that surveillance would incorporate a comprehensive network of trail cameras and traps complemented by periodic checks using dog teams. Permanent and semi-permanent residents will also be the island's eyes and ears and a system for reporting incursions will be established.

Response

Resources will be required to respond to incursions as they occur, and contingency funding must be readily available. Development of the response plan together with the Kawau community, that already has a well organised and professional emergency response group, would increase the likelihood of buy in. Ongoing access arrangements to respond adequately to an incursion is also required.

8. DO THE BENEFITS OF REMOVING WALLABIES, RATS, STOATS AND POSSUMS FROM KAWAU OUTWEIGH THE COSTS?

The proposed removal of wallabies, rats, possums and stoats from Kawau presents many benefits for both people and the environment. The project also presents a number of risks and these need to be weighed carefully against the benefits before any decision is taken to proceed. The following costs, benefits and risks were identified and refined over the course of engagement with Kawau landowners and stakeholders and from lessons learnt on other eradication projects completed on both inhabited and uninhabited islands. This section concludes with an analysis of the cumulative costs and benefits of the project to provide an overall cost/benefit equation for the project.

8.1. Benefits

8.1.1. Economic Benefits

Tourism

A pest free Kawau is likely to provide some stimulus to Kawau's visitor economy that is already reliant on both local and international tourism. Opportunities for overnight accommodation in a location where native wildlife can be experienced (including the chance of seeing kiwi, weka, kaka and other iconic bird species) in a predator free environment are currently rare in New Zealand. However, this experience would be readily attainable on Kawau with current levels of infrastructure. It's worth noting that prior to the pandemic, pest free islands such as Tiritiri Matangi were among Auckland's top 10 visitor destinations on Trip Advisor.

Infrastructure

Rats can cause significant damage to property, chewing wiring, plumbing and other critical infrastructure. On Ahuahu (Great Mercury Island) damage by rats to property, food and infrastructure coupled with the extra work created was estimated to cost up to $40,000 annually. A significant benefit of the project is that these impacts would be permanently alleviated.

Property values

A pest free Kawau has the potential to influence property values, and it could certainly be a selling point used by Real Estate Agents. Living in a pest free environment would be considered desirable to many New Zealanders.

Food production and storage

With the removal of wallabies, possums and rats, gardens and fruit and nut trees on the island would be better protected from damage. Fencing to exclude weka would still be required but most residents already have some form of fencing in place.

Accommodation

The proposed project would require short term accommodation to house field staff. This could provide a short term (2-3 year) boost to the local island economy or at the very least offset lost income associated with the project's implementation. The impact this might have on the local economy has not yet been quantified but ~$320,000 has been earmarked in the indicative budget for on island accommodation.

Local employment

The proposed project offers both short term and longer-term local employment opportunities associated with the eradication, ongoing surveillance, biosecurity and species reintroductions. It is estimated that this could inject up to $400,000 into Kawau's economy over the course of the operation and potentially as much as $200,000 in ongoing annual income into the future.

Pest control

In the absence of pests, there would no longer be a need for residents to undertake ongoing control of wallabies and possums nor purchase rodent bait or traps saving both time and resources. Most landowners spoken to use rodent bait and/or traps to control rats and the larger landowners contribute significant funding annually to control rats, possums and wallabies. Based on an average investment of $50 per annum per landowner and $100,000 per annum invested by the Pōhutukawa Trust and the island's large landowners, the eradication would represent ongoing annual savings of ~$120,000 to the island's economy.

Reduced fire risk

The regeneration of more broadleaved species that would accrue from the proposed project is expected to gradually reduce the fire risk that currently exists on Kawau, both in terms of the risk of fires starting and of how quickly or far they would spread. While ongoing annual investments in both capacity and response will still be required, the number of incidents may reduce over time resulting in reduced costs to emergency services and reduced risk of damage to property.

Reduced biosecurity risk

The spectre of wallabies establishing in the Auckland and Northland regions would be significantly diminished with their removal from Kawau. Individuals potentially from Kawau have been sighted in the past on the adjacent mainland and on Aotea suggested animals have been moved in the past. The economic impact of wallabies in New Zealand is predicted to reach $84M by 2025 (MPI 2023) and the cost of their potential establishment in the Auckland and Northland regions is not included in this estimate.

8.1.2. Social and Cultural Benefits

As described in the Section 4 above, the social and cultural benefits associated with the project were identified over the course of discussions with the community and from other projects.

Community spirit

Although the proposed project poses a risk of creating community division, it also offers the opportunity to bolster community cohesion and spirit. Existing community initiatives on Kawau tackling amongst other things rats and weeds, already clearly demonstrate this. If the eradication were to move forward, efforts to support the eradication, prevent reinvasion, educate visitors, re-establish native species on the island and manage habitats would require residents to, in effect, become the island's guardians and many Kawau islanders already see themselves in this role. This common cause has brought other communities together (e.g. Bell et al. 2019) and could serve to unite the Kawau community and bring it closer together.

Māori cultural impacts

As described above, a cultural impact assessment is underway but has not yet been completed. However, it is worth noting that the proposed project present opportunities for Māori to reengage in the management of Kawau and retain some determination over its future. Training and employment opportunities are also possible. Other positive impacts of the project on Māori culture have not yet been evaluated, partly due to mana whenua capacity to complete the cultural impact assessment, but Ngāti Manuhiri are leading this work. It is expected though that removal of invasive species and restoration of indigenous biodiversity values would have positive impacts on the mauri of the island.

Native species recovery

Pest eradication on Kawau will result in the recovery of native bird and reptile species with some populations significantly increasing in size and prevalence. This is likely to increase appreciation for the island by many within the Kawau community.

Wallabies

Although there are some that see the loss of wallabies as a negative outcome due to heritage values, many landowners see wallabies in the same way as possums, as an introduced species from Australia and view them as a direct threat to Kawau's natural landscapes and heritage. Within this group, appreciation of the island's natural values is expected to only increase over time.

8.1.3. Environmental Benefits

Native species recovery

Significant recovery within Kawau's native species populations is anticipated as a consequence of less predation and competition and improved habitat with some native species such as grey faced petrel, kākā and Pacific gecko expected to increase significantly in abundance. Other species such as bellbird and kākāriki, already occasional visitors to the island, would establish and become widespread in short order.

Species reintroductions

In the absence of pests, re-introduction of many native species that likely previously existed on Kawau would be possible. A suite of native bird, reptile and invertebrate species would be potential candidates some examples of which include whitehead, saddleback, New Zealand robin, kākāriki, Duvaucel's gecko. Eventually, Kawau could become a source for re-establishing native species elsewhere.

Forest recovery and regeneration

With the exception of the island's novel cryptogamic communities that have been induced by wallaby grazing, removal of wallabies, possums and rats would have an immediate and long-lasting beneficial impact on Kawau's forest and floral communities. Rates of pollination, seed dispersal and decomposition are all expected to improve along with seedling survival and recruitment. Forest regeneration on Kawau will over time lead to the re-establishment of a diverse coastal kauri-podocarp-broadleaf forest ecosystem mixed with beech in some places.

Recovery of ecosystem processes

Invasive species such as wallabies, stoats, rats and possums impact ecosystem processes and this is certainly evident on Kawau. Ecosystem processes on Kawau such as primary production, energy and nutrient cycles are all likely beneficiaries of the proposed project. The potential recolonisation of the island by seabirds for example would re-establish a key pathway for the transfer of marine nutrients from the ocean to terrestrial areas. These nutrients in turn have a beneficial effect on coastal ecosystem stimulating the productivity of reef and nearshore ecosystems.

Carbon sequestration and resilience to climate change

The removal of wallabies, rats and possums and the re-establishment of a forest understory and over time a thriving coastal broadleaf forest ecosystem will increase the island's ability to sequester carbon. Figures are not currently available but the amount of carbon that could be sequestered is likely to be significant. Biodiversity recovery and the re-establishment of ecosystem process are expected to result in a more resilient ecosystem that can better withstand future climate change impacts.

Supporting regional conservation efforts

The removal of possums, stoats and rats from Kawau is a key stepping stone for New Zealand's Predator Free movement. The removal of invasive vertebrates from the island would provide an important benchmark for predator-free initiatives on other inhabited Hauraki Gulf islands such as Aotea and Waiheke and would inform other projects such as Rakiura and Rekohu. Other regional conservation initiatives such as Northwest Wildlink, Forest Bridge Trust, Restore Rodney East and Tāwharanui Regional Park also stand to benefit.

Should the project proceed, technologies and skills developed, as well as lessons learned will contribute to future projects, as this project will build on past eradication efforts from within New Zealand, and abroad. The outcomes of this project are expected to be widely disseminated through reports, scientific publications and conference proceedings, thereby providing maximal benefits for other pest eradication programmes. It is expected that the project will build knowledge, skills and confidence that can be taken forward into future pest management ventures.

Reduced fire risk

The proposed project is expected to reduce current fire risk levels for the island. Many of the native species currently missing from Kawau's forest understory are fire resistant. As these species establish and the island slowly reverts to a coastal broadleaf forest, the island's vegetation will be less able to support the spread of a wildfire. Humidity and soil moisture levels will also increase, reducing the risk of ignition.

Reduced erosion

Intensive grazing by wallabies has removed much of Kawau's understory and resulted in areas with little to no vegetation. These areas are subject to gullying and rilling leading to sediment run off. A more natural forest structure, increasing leaf litter and improved soil structure will all contribute to reduced erosion over time.

Pest management

With no introduced mammalian predators on Kawau there would no longer be a need for ongoing pest control, freeing up resources currently expended by the community to be invested in other conservation activities on the island. Significant progress could be made on the island's weed issues with greater investment and community involvement. This will benefit the surrounding marine environment as well as on-island values.

Reduced use of toxins

Currently the use of toxins for pest control on Kawau is widespread and ongoing and possibly sub-optimal, creating the potential for residues to accumulate within wildlife. The proposed project would utilise pesticides but as it would lead to the eradication of pests, there would be little need for toxins to be used again on Kawau in the future. The only situation where rodenticides would be needed would be during a response to an incursion.

8.1.4. Human Health and Safety Benefits

Fewer zoonotic diseases and improved water quality

The proposed project would reduce the risk of residents and visitors being exposed to a number of zoonotic diseases. Rats in New Zealand are known to carry a number of diseases including toxoplasmosis, lymphocytic choriomeningitis, salmonellosis, mycoplasma, leptospirosis, Weil's disease, streptobacillus and dysentery. Possums, also carry a number of these diseases as well as others such as *Mycobacterium ulcerans* and tuberculosis. The majority of Kawau landowners collect water from their roof and this is then stored in large tanks. Stream and bore water collections systems are also in use on the island. This water can be contaminated if rats and possums have access to roof catchments or storage systems.

Reduced reliance on toxins

The current ongoing use of toxins for pest control creates the potential for residues to accumulate in the human food chain. The proposed project would greatly reduce this risk.

8.2. Risks and Costs

8.2.1. Economic Costs

Direct costs

The estimated direct cost of implementing the proposed operation to eradicate wallabies, possums, rats and stoats on Kawau, is $6,500,000. This estimate includes the cost of mitigating risks to domestic animals and addressing population level risks to non-target species but does not include the cost of mitigating the expected short-term increase in the abundance, distribution and diversity of some weed species. Establishment costs for biosecurity, surveillance and response will cost an additional $237,000 over two years and the ongoing maintenance of biosecurity measures is estimated to cost $375,000 per annum although increasing automation of surveillance tools may bring this cost down.

Indirect costs

Indirect costs include the potential for temporarily reduced visitation/tourism to the island. However, most of the intensive phases of the eradication operation would take place over the winter months

when tourism activity on Kawau and at Mansion House is limited. Families with young children may reconsider visiting the island over the period the eradication is underway but other groups are likely to be less sensitive or will have greater flexibility. Therefore, in the absence of any survey of prospective visitors to Kawau, it is reasonable to expect that there will be minimal financial impact as a consequence of the eradication. The accommodation needs of the eradication team will also likely offset any revenue lost from a reduction in bed nights.

Wallabies are considered by some as one of the attractions of the island and some stakeholders suggest there is a risk of a decline in visitor numbers if they were removed. However, recent research completed by Kim (2020) found most visitors to Kawau came to the island because of its historic history and native wildlife. Any negative impact on visitor number from the project is therefore expected to be minimal but opportunities for dialogue with those who feel differently need to be made.

The organisations most affected by the proposed project are Camp Bentzon (a charitable outdoor education facility for school groups) and Kawau Cruises and Water Taxi's that service Camp Bentzon. Based on the experience from Motutapu Outdoor Education Camp during a similar rat eradication undertaken in 2009, Camp Bentzon would need to suspend school visits over the period that rat bait is present on the ground; up to four months. Flow on economic impacts are also possible as there is a risk that some schools directed elsewhere do not return. Some but not all of these impacts, could be offset by the accommodation and transport needs of the eradication project team who will need to be based on the island for extended periods.

For some island residents, the loss of wallabies may lead to the need for more vegetation management on their properties such as more lawnmowing and track clearing. The increased cost of this activity has not been quantified.

Opportunity costs

Inescapably, an investment of the nature of the proposed project presents an opportunity cost. Is there another investment that could be made in the Auckland Region that would have a greater return on investment for people and the environment? This is a difficult question to answer but there are many reasons why the Kawau project deserves to be prioritised. Core to these reasons is that Kawau, because of its size, proximity to other pest free islands and sanctuaries and small community, is the logical next step within the Auckland Region for advancing New Zealand's Predator Free 2050 vision.

The project, if successful would lead to permanent and significant biodiversity recovery but it would pave the way for realising the predator free status of other inhabited islands within the Hauraki Gulf such as Great Barrier Island/Aotea and Waiheke. It must also be noted that the funding that has already been and could potentially be allocated to the Kawau project has been earmarked for predator free initiatives e.g. NETR and PFNZ 2050 Ltd funds. Thus, opportunity costs are considered to be low.

8.2.2. Social and Cultural Costs

Social and cultural risks and impacts were identified during discussion with landowners and stakeholders about the proposed pest eradication and drawing on experience from other projects. Quantifying social and cultural risks and impacts is extraordinarily difficult as impacts both real and

perceived are subjective and value driven. However, acknowledging their existence is important in the cost/benefit analysis of the proposed project. At the time of writing, a cultural impact assessment evaluating the impact of the proposed project on Māori culture and wāhi tapu sites has not yet been prepared. This is an obvious gap.

Wallabies

The loss of wallabies from Kawau will emotionally impact some landowners and island visitors. Some individuals view wallabies as an important part of the island's historic heritage and an element of Governor Grey's legacy that should be retained. A subset of landowners also sees wallabies as contributing to Kawau's uniqueness because wallabies are not present on any other Hauraki Gulf island. Possums, also introduced by Governor Grey, are not viewed in the same light.

Landscape changes

Should the proposed project be completed, Kawau's native forest communities will recover, and the forest will slowly transition from kānuka, mānuka shrubland to a mixed coastal broadleaf forest. This transition will change the character of some of the island's landscapes. Although this impact was not raised by stakeholders during discussions, it could be experienced as a negative impact by some.

Native species recovery

The proposed project will result in the recovery of native plant and bird species some of which will significantly increase in number and prevalence. The increased volume and intensity of bird song may be less well received by some landowners. Damage to fruit trees and gardens by species such as kākāriki and kākā may also be incurred adding to the existing impacts of weka.

Community spirit

Exploration of the project's feasibility has already generated tensions within the Kawau community. Opinions are principally divided over the fate of wallabies, although there is also some disagreement over proposed eradication methods. Thus, any decision to move forward is likely to be contentious in some parts of the community. However, it is anticipated, based on other examples such as the rodent eradication on Lord Howe Island (LHI), that these impacts will be short term and that the cohesivity of the community will recover over time. Opportunities for further feedback and dialogue to minimise these impacts would need to be provided should the project proceed.

Ongoing biosecurity

Efforts to prevent reinvasion will require residents and island visitors alike to take more care when departing the mainland for Kawau. Proposed measures are not onerous and impose no financial cost on landowners or transport providers, but behaviour and attitudinal changes will be required such as more forethought and preparation before travel. Discussion with the Kawau community indicates strong support for biosecurity measures but some in the community see biosecurity as a burden and others remain sceptical that rats can be prevented from re-establishing on the island.

Domestic pets

Domestic pets and livestock are at potential risk from the proposed project and mitigation measures to reduce this risk will require greater restraints on animal behaviour and movement during the operation. Pets may need to be walked on a lead, muzzled, contained, kept indoors or temporarily

removed from the island. This will have a temporary impact on some residents. Poultry and other livestock may also need to be temporarily removed from the island or housed in rodent proof facilities to eliminate the availability of alternative foods for rats.

Access to private property

Access to private property will be required to complete the proposed project imposing short term impacts on the privacy of landowners. Access arrangements that minimise impacts will need to be worked through with landowners on a property by property basis. Most landowners spoken to are supportive of access provided adequate notice is given and access arrangements can be tailored to the landholder. Some are not supportive of access and, although opposition will likely decrease through further dialogue, it is likely that a small number of landowners will remain opposed. Access to all properties is a necessary condition to ensure the successful eradication of rats from Kawau. Consequently, if no suitable alternative can be found, it may be that as a last resort powers under the Biosecurity Act (1993) are utilised to gain access.

Mice

There is a chance that mice are present on Kawau but are currently at undetectable levels. If present and if the operation fails to eliminate them, mice could populate the island and replace rats as a source of impact on stored food and infrastructure.

Cats

Both domestic pet cats and unowned cats are present on Kawau. It is possible that unowned cats could be eliminated through secondary poisoning from the rat eradication operation but as evidenced by other operations some individuals are expected to survive. These individuals could repopulate the island and have a greater impact on native species than currently. This risk could be minimised by trapping any surviving unowned cats and continuing ongoing efforts to ensure all pet cats on the island are desexed. Island residents are already eligible for free desexing and microchipping, but this could be more proactively promoted, and may require assistance to get animals to mainland vets, as there is no on-island vet. Ongoing dialogue with community members will be required to inform decision-making if the project goes ahead.

Odour

At stages during the proposed project, there may be periods (2-4 weeks) where the smells of dead and decaying carcasses are annoying to some. However, as evidenced by other projects, these impacts will be short-lived and localised. This risk was minimised on other projects by trapping within and around homes prior to eradication.

8.2.3. Environmental Risks

An eradication operation poses a variety of environmental risks such as fire or the introduction of a new invasive species. However, the following assessment is restricted to the potential impacts of toxins, trapping and hunting on native species. For each species, where risk was identified, risk was assessed on three levels: to the individual, the island's population, and to the species as a whole. The consequence level was derived from the potential outcome that could occur i.e. loss of individuals, a population, or species extinction. Because the island has no species endemic just to Kawau, the consequences were considered 'moderate' if there was a significant risk of eliminating the island's

population. However, the consequence were judged to be 'high' if there was a possibility of impacting the species' global population.

While the project poses a risk of losing individuals of several species, with the exception of weka and pāteke, for which mitigation would be a necessary part of the project, the analysis indicates there is a very low risk of impacts at the species level. The list of species present on Kawau and on which this risk assessment was based, was compiled based on survey reports for the island and is presented in Appendix 1. In short, few species present on Kawau are at risk from the operation and for all native species present, any short-term impacts will be negligible and far outweighed by the long-term benefits anticipated from the project. No genetic analysis was completed to inform this risk assessment.

Hunting

Hunting poses a low risk to non-target species present on Kawau. Positive target identification by hunters will eliminate the risk of native species being shot and bird aversion training for all working dogs used on Kawau will minimise the risk of disturbance. Low levels of disturbance are expected as much of the island will need to be searched. However, such disturbance is unlikely to lead to mortality and no native species is considered at risk at either the individual or local population level as a consequence of hunting.

Trapping

Trapping may be required to target the last wallabies, possums and stoats on Kawau. A range of trap types may be used ranging from live traps for wallabies to leg hold and kill traps for possums and stoats. A cautious and adaptive approach coupled with careful siting and housing of traps will minimise risks to non-target species such as weka and kiwi, but it is expected that some risk to individuals will still exist. Surveillance as part of ongoing biosecurity will also necessitate trapping. However, no native species is expected to be at risk at the local population level because of trapping.

Wallabies

Contrary to some opinions, the extirpation of wallabies from Kawau poses minimal risk to the long-term security of the species in Australia. Of the four species, only parma wallabies are considered vulnerable. Individuals of this species have already been repatriated from Kawau to Australia and the genetics of the Kawau population are well represented in captive facilities there. Dialogue with Australian conservation agencies about the conservation importance of Kawau's four wallaby species is ongoing but it is unlikely that further individuals will be repatriated.

Toxins

The risk of the use of cyanide, 1080 and brodifacoum to birds, reptiles, invertebrates and marine organisms on Kawau is evaluated in Appendix 1 along with the consequences of any potential impact. Cyanide, if used, would be utilised on a localised basis outside of waterways and residential areas. The commercial product that would most likely be used for possums and wallabies is Feratox that contains encapsulated pellets of potassium cyanide. Feratox poses minimal risk to native birds although weka have been previously poisoned. Potassium cyanide, the active ingredient breaks down on contact with air, leaving no residues in soil or water.

If 1080 were to be used, it would be applied on a very localised basis outside of waterways and residential areas and away from the coast. Cereal baits containing 1.5 or 2 g/kg sodium fluoroacetate, carrot coated in a solution of 1.5 g/kg and gel at concentrations up to 100 g/kg are all registered products that could be used on Kawau to target possums and wallabies. These products, if used, would be deployed in bait stations or distributed by hand within small areas. Regardless of the product used, the application of 1080 would pose some risk to non-target native species on Kawau. Birds may be killed by eating baits directly and predatory birds, such as weka and ruru, could be killed if they eat an animal that has eaten poisoned bait. However, while individual mortality of weka and ruru is possible, the localized use of these methods would ensure no populations on Kawau are at risk.

Conditions for the breakdown of 1080 in soil on Kawau are expected to be favourable (i.e. a soil temperature between 11^{o}C and 23^{o}C and soil moisture between 8 and 15 percent) (PCE 2011). Based on studies, in these conditions, 1080 will be significantly broken down in one to two weeks. Such favourable conditions are expected to be present on Kawau for much of the year except for the drier summer months. Concentrations of 1080 in soil and leaf litter are also expected to be extremely low based on field studies elsewhere and far below the concentrations required to kill native insects such as ants and wētā (PCE 2011).

Plants can take up 1080 from the soil through their roots, and 1080 has been recorded in very low concentrations in some New Zealand plants (PCE 2011). However, the localised use of 1080 on Kawau would limit opportunities for plant uptake and any 1080 taken up will be broken down by plants so that it is undetectable within one to two months, as evidenced elsewhere (PCE 2011).

The island wide use of cereal baits containing brodifacoum to target rats during the winter months is considered essential to the success of the project. Because of the comprehensive coverage required, this method also poses the greatest risk to non-target native species and the environment. Potential pathways for exposure to brodifacoum were identified and classified as either primary or secondary (Appendix 1). Based on monitoring at Tāwharanui Open Sanctuary and on other islands in the Hauraki Gulf, cereal bait is expected to disappear relatively rapidly because of consumption by invertebrates and degradation by rainfall (Craddock 2003). Encompassing the interval between bait applications, the risk of primary poisoning is expected to span a total period of up to 90 days. Brodifacoum is expected to persist for a longer period in soil and in organisms that have been sub-lethally exposed to either primary or secondary poisoning (Fisher et al. 2011). It is worth noting that brodifacoum use is already widespread by private property owners on Kawau, and therefore the risks associated with this toxin already exist to some extent on an on-going basis.

Most species present on Kawau are widespread elsewhere, not threatened and will not be significantly impacted as a result of individual mortality. Exceptions to this are weka and pāteke. Although North Island weka have persisted on all five islands where rat eradication has been undertaken (e.g. Empson and Miskelly 1999, Mossman 2003), individual rates of mortality for North Island weka on Kawau are likely to be high. Kawau supports the largest island population of North Island weka and is considered a stronghold for the species whose population fluctuates widely on the mainland (Beauchamp and Chambers 2000). Pāteke are the only other threatened species on Kawau considered at risk at the island population level. Pāteke populations have also persisted through aerial poisoning operations

e.g. Kapiti, Ahuahu and Rakitu but mortality has been recorded (Eason and Spurr 1995a). The pāteke population on Kawau is small and is therefore considered vulnerable at the population level.

For these reasons, if the project were to proceed, it would be contingent on mitigation being put in place to ensure the long-term persistence of both weka and pāteke on Kawau. Captive management has been used successfully as a mitigation measure multiple times for both species and this would serve to protect the integrity of both populations. Temporary translocation is another option and one that might be effective for pāteke with Tāwharanui a potential translocation site

Ruru, New Zealand dotterel, paradise shelduck, kiwi, pūkeko, banded rail and a number of introduced bird species are also at risk of individual mortality, as evidenced by past projects (e.g. Stephenson et al. 1999, Fisher et al. 2011), but at a lower risk compared to weka and pāteke due to their foraging behaviour. The number of individuals likely to be lost is low and the loss of these individuals will have no lasting impacts on the island's populations (Table 4). At Vivian Bay where New Zealand dotterel are present, the operation would be ground based, so there would be no bait in the coastal habitat where dotterel are feeding.

No negative effects on reptiles (geckos and skinks) have been reported as a result of rodent eradication operations on islands in New Zealand. In fact, all monitored reptile populations have thrived following removal of rodents (Towns 1991, Newman 1994, Towns et al. 1997). Invertebrates are generally not susceptible to anticoagulant poisoning (Eason and Spurr 1995b, Morgan and Wright 1996, Spurr 1996, Booth et al. 2001) and as such no species on Kawau is considered to be at risk. Long-tailed bats are believed to be present on Kawau but are not considered at risk at a population level from the proposed project. Long-tailed bats are aerial insectivores so no significant pathway for poisoning is present.

Because brodifacoum is practicably insoluble in water, the toxicant is most unlikely to be found in water even after aerial application of baits for rodent eradication (Fisher et al. 2011). Baits sown on land therefore pose a negligible risk to freshwater fauna (see Section A.1 for more detail). Baits that are sown directly into streams, are unlikely to attract much interest from the freshwater fish species present on Kawau. As listed in Appendix 1 short and long finned eel, banded kōkopu, inanga and common, giant and red finned bully are present in streams on Kawau. Galaxiids and bullies respond to movement cues for feeding and eels to olfactory cues. Native fish have not been threatened by similar aerial operations carried out in New Zealand. For instance galaxiids and eels survived an aerial brodifacoum operation (15kg/ha) on Red Mercury Island (T. Stephens pers. comm.). Similarly, banded kōkopu and long finned eel were still present in Karori Sanctuary following a similar aerial brodifacoum operation (L. Chadderton, pers. comm.).

Risks to marine life

To ensure that bait is available within all rat territories, it will be necessary to apply bait across the entire land area of Kawau right up to MHWS. Within residential areas, bait would be applied by hand posing little danger of bait entering the marine environment. However, where bait is to be spread by helicopter, directional spreader systems would be used to minimise the risk of bait going below MHWS, but the risk cannot be entirely eliminated. Pestoff 20R™ rodent bait sinks and breaks apart over a relatively short period (<24hrs) once wet and exposed to wave action (Empson and Miskelly

1999). In line with results obtained from studies both in New Zealand and overseas (e.g. Empson and Miskelly 1999, Primus et al. 2005, Fisher et al. 2011), the impact to the marine fauna of Kawau is expected to be low (Table 4). There is the possibility that some individual fish around the coast of Kawau might ingest bait, but no population level impacts, or health risks are anticipated, and moratoriums on fishing are not considered to be required.

Plants

With the exception of kauri (kauri dieback has not yet been detected on Kawau so the risk of its introduction will be a key implication for delivery of the proposed project), no other plant species is anticipated to be at risk from the operation itself. The removal of wallabies is expected to reduce the extent of moss-dominated communities in kānuka forest. Cryptogamic grazing lawns induced by wallaby grazing pressure (Wilcox et al. 2004), could also be lost or severely depleted in certain areas (Baber et al. 2008). Another potential impact of the proposed project is a decline in the distribution and abundance of threatened native herbs such as *Lagenifera lanata* and sneezeweed (*Centipeda minima* subsp. *minima*). These species are partially dependent on modified habitats within which wallabies suppress other naturalised plants and weeds. An adaptive management approach may be required for disturbance-dependent native herbs and for the cryptogamic grazing lawns. Monitoring before and after the eradication programme, will be necessary to identify if management of these plant communities is needed.

The proposed project poses no risk of contamination for vegetables and fruit grown on the island. Anticoagulant rodenticides that may be used as part of the proposed project are practicably insoluble in water and as such are not taken up by plants.

Water

With the exception of two stream sourced water supplies and two dams for which special provisions will be required, the operational strategy effectively isolates all other (roof) water catchments from any risk of contamination, and because of the insolubility of anticoagulants, ground water is not at risk. Anticoagulants do not dissolve well in water, so leaching from soil into water does not occur. Only the erosion of soil itself can result in anticoagulants such as brodifacoum reaching water. If soil containing brodifacoum reaches a waterway, the brodifacoum generally remains bound to organic material and settles out in sediments. Nevertheless mitigation measures will need to be enacted for the households that extract water from surface streams to alleviate any perceived risks.

Residues in fresh water are extremely rare. Only one positive result for the second generation anticoagulant brodifacoum has ever been recorded in New Zealand, and three others worldwide despite at least 324 samples analysed over 11 operations. The highest residue for brodifacoum recorded was 200 times less than the concentration of the baits used (Fisher et al. 2011).

Soil

Soils are not anticipated to be negatively impacted by the project. As baits disintegrate, anticoagulants that might be used as part of the proposed project are broken down in the top layers of the soil, where they are slowly degraded into inert (non-toxic) compounds over weeks to months by soil bacteria. Soil type, temperature, and the presence of soil micro-organisms capable of degrading anticoagulants all influence the time it takes to completely break down.

8.2.4. Risks to Human Health and Safety

Physical Hazards

The proposed project presents a number of hazards common to many field operations. These include, isolation, boat use, the use of helicopters, drones, firearms and mechanised equipment, access to private property (including potential conflict situations), dogs and travelling across difficult terrain. A safety plan will need to be prepared for the proposed project, but it is anticipated that any significant physical hazards can be managed appropriately to ensure the risk to human safety is low.

Use of toxins

Removal of some of the pest species present on Kawau will necessitate the use of toxins. The people most at risk of exposure will be those handling and applying the products and the safety plan prepared for the proposed project would need to address these risks. As evidenced by other operations, the proposed project will pose little risk to island residents and visitors. Nevertheless, a precautionary approach should be taken.

As mentioned above, there is a small risk that some coastal fish consume bait as evidenced by other operations, but residue levels are very unlikely to ever exceed thresholds whereby human health might be impacted.

8.3. Cost Benefit Analysis

Economically, the benefits of the project appear to outweigh the costs especially for the community as most of the funding is likely to come from sources external to the island. Eradication of pest species from Kawau will result in ongoing and sustained savings to landowners that will eventually exceed the one-off cost of the project. Visitor numbers and subsequently tourism revenues are unlikely to be negatively affected by the removal of wallabies, instead they could be positively influenced due to the increasing natural values of Kawau. And the predicted short-term loss of revenue by Camp Bentzon and Kawau Cruises will be short term in nature and could be offset by the transport and accommodation needs of the project.

The lion share of the cost of the project's implementation will fall on ratepayers and taxpayers as most of the project's funding will come from Auckland Council and government agencies. These organisations are legally mandated to address the threat of invasive species, would wear the costs if wallabies established in the Auckland and Northland Regions and eradication is generally favourable relative to long term control as the implementation costs of the project are one off. The ongoing costs of biosecurity will fall on the shoulders of the Auckland Council. However, there is a possibility that estimates will reduce over time with improvements in the automation of surveillance and these costs will have a defined term (<30 years) if New Zealand's predator free 2050 vision is realised.

Although the social costs of the project are acute, the long-term social benefits of the project are expected to outweigh the costs. Reasons for this include the significant majority of the community in favour of the project proceeding offering the opportunity to bring the community together far more than any other island-based initiative. The loss of wallabies will be painful to a number of landowners, but social divisions on this issue are already present and may heal over time. The risks posed by the

project to human health and safety are low and can be managed and the long-term benefits to the Kawau community as a consequence of reduced toxin use and zoonotic diseases exceeds any short-term risk.

Environmentally, the project's long-term benefits far outweigh the expected short-term costs and risks. Risks to the island's weka and pāteke populations can be managed and as evidenced by invasive species eradication projects completed on other Hauraki Gulf Islands, the benefits to native species recovery, ecosystems and ecosystem processes are expected to be significant and long lasting.

9. IS THE PROJECT SOCIALLY ACCEPTABLE TO THE COMMUNITY INVOLVED?

The importance of community to the success of the proposed eradication of wallabies, possums, rats and stoats on Kawau cannot be understated. To proceed with the project, it must be demonstrated that the vast majority of landowners are accepting of the project's anticipated impacts and risks and are committed to sustaining the project's outcomes. However, aspiring to 100% community support for the project is unrealistic as unanimous agreement within any community is a low probability. Few eradication projects have proceeded with unanimous support and for some, such as Lord Howe Island (LHI), a significant proportion of the community remained opposed despite a decision to proceed with its implementation. LHI was ultimately successful in removing rats and mice.

In 2018, Auckland Council reached out to the people of Auckland for feedback on the Regional Pest Management Plan (RPMP) for the region. One of the actions outlined in the plan was the concept of a predator free Kawau or in other words a Kawau free of rats, possums, wallabies and stoats. The RPMP received a lot of positive feedback suggesting the removal of invasive vertebrates from the island might be socially acceptable. Social research conducted by Aley (2016) and more recently by Kim (2020) supports this conclusion.

However, the RPMP consultation process and social research merely assessed support for the concept of pest eradication, not how it might be undertaken, nor the risks and costs that could impact stakeholders. Although all landowners were contacted by mail during the RPMP process, correspondence also likely did not reach all affected parties, and only a proportion of community members responded. From a survey of environmental and pest management attitudes on inhabited Hauraki Gulf Islands, the average response rate from the island communities of Waiheke, Great Barrier, Rakino and Kawau was between 28% - 40% (Russell et al. 2018) and Kim (2020) targeted only a sample of community members.

To fully explore whether the necessary level of trust and community buy is present for the proposed eradication to be successful and enduring, an in-depth one on one engagement process with all landowners, partners and stakeholders (as described in Section 4) was necessary.

9.1. Mana whenua

Ngāti Manuhiri as mana whenua will have a seat on the project's governance group and are in support of the proposed concept. Te Kawerau ā Maki, Ngāti Paoa, Ngāi Tai ki Tāmaki, Ngāti Maru, Ngaati Whanaunga, Ngāti Wai, Te Rūnanga o Ngāti Whātua, Ngāti Whātua o Kaipara were consulted about the project and no feedback opposing the project has been received. Further work on the project's

cultural and environmental impact by Ngāti Manuhiri Settlement Trust is required to reach a firm conclusion on the implementation of project deliverables.

9.2. Feedback received

Discussion with 347 of 365 landowners, completed between January 2022 and the present, revealed overwhelming support for the concept of removing rats, stoats and possums (324 of 347 landowners or 93%) from Kawau (see Fig. 5). A smaller but still significant majority (283 of 347 landowners or 82%) were supportive of the removal of wallabies (Fig. 6). Several landowners wanted to see rats, stoats and possums removed prior to wallabies despite explanations why, from an operational risk perspective, this would pose unacceptable risks to rat eradication. Nineteen of 347 (~5%) landowners were opposed to the use of toxins and another 20 (6%) were unsure or had concerns about methods. A few (18 of 347 or 5% of landowners) were opposed to the project's need to access their properties and some (20 of 347 or 6% of landowners) were unsure about this requirement. Several others were concerned about the risk to domestic animals and were opposed to the hand spreading of rodent bait around their properties but were open to the use of bait stations. Some residents (23 of 347 or ~6% of landowners) were opposed to the proposed aerial application of rodent bait on the island. Although the aerial application of 1080 was not proposed, the subject came up in a number of conversations with strong reservations expressed about this method.

Inevitably some landowners (~18) could not be contacted. Landowners with only a postal address were sent a letter to make initial contact. A further round of letters went out to landholders who had a mixture of email addresses and phone numbers, but at the time of writing, responses from 18 of 365 landowners still had not been received. No assumptions were made on the position of landowners we did not hear from, and communication channels remain open. Spam folders, outdated postal and email address and landline phone numbers may have been factors in some of the delayed responses received, and a small number of individuals did not see it as a pressing issue. To highlight the engagement process, articles were included in the local community magazine 'Kookaburra'. Attendance of KIRRA meetings also provided opportunities reminding landowners to engage. Within the Kawau community, emails and conversations have been shared to encourage neighbours to make contact.

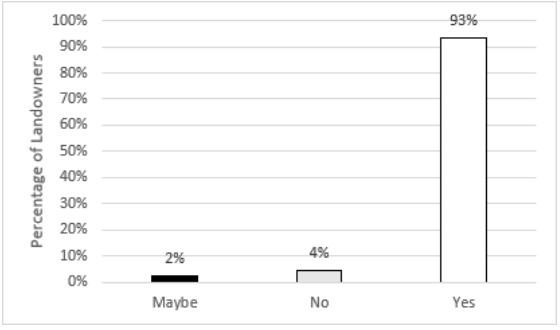

Fig 5. Percentage support by landowners for the removal of rats, stoats and possums from Kawau.

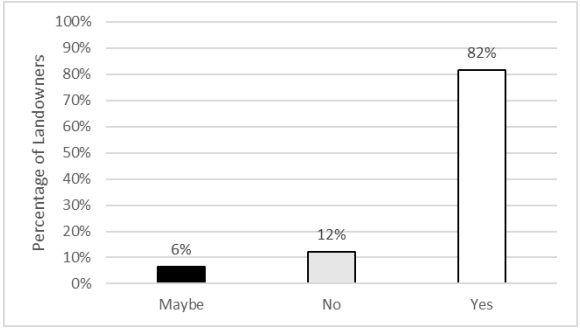

Fig 6. Percentage support by landowners for the removal of wallabies from Kawau.

Transport operators were supportive of the proposed project and, as all but one are already operating within or working towards the Pest Free Warrant Scheme, saw no significant issues in complying with ongoing biosecurity measures. There was a general sentiment that all commercial operators should be held to the same biosecurity standards to ensure fair competition. One commercial operator expressed concerns that the loss of wallabies might impact visitor numbers. No additional biosecurity costs would be imposed on operators or landowners which was an initial concern by some within the community.

Other stakeholders spoken to included transport and barge operators from the wider Hauraki Gulf area (e.g. Facilitator Barge hire), Rodney Local Board and MP's, Mansion House Foundation, Heritage New Zealand and Department of Conservation species recovery specialists.

As expected, the key concerns reflected by the community from discussions centred on the proposed methods namely the use of toxins, the risk to domestic animals and native species, property access and the risk of reinvasion. Some residents and one non-commercial entity raised concerns about the costs associated with complying with biosecurity measures. The removal of wallabies was seen by some as the loss of New Zealand's colonial history along with changing the identity of the island.

9.3. Wallabies

The proposed eradication of wallabies is contentious within the Kawau community, and the 42 landowners opposed to their removal have strongly held views. If a decision is made to proceed, it is expected that some individuals will try and influence the decision by targeting politicians or senior staff. A subset of this group has indicated they would accept removal of wallabies from Kawau if a publicly accessible captive population could be maintained on the island. DOC held wallaby in an enclosure under its 1995-2005 Conservation Management Strategy, but ceased the display in 2001 due to operational difficulties. The Department's position is still that it does not wish to hold wallabies in an enclosure. Other options, such as the periodic release of sterilized male wallabies onto the island are also being considered along with the possibility of establishing a population at Auckland Zoo or another captive facility.

9.4. Synopsis

The high levels of support documented for the project (93% for rat, stoat and possum eradication and 82% for wallaby removal) suggest the project is socially acceptable. These figures are higher than those for some other eradication projects that proceeded successfully. The LHI Board made a decision to proceed with rat and mouse eradication in spite of significant community opposition. Nevertheless, as discussed below, for rat eradication, rodent bait will need to be applied across all properties on Kawau. The 18 landowners currently opposed to access or the use of rodent bait on their properties represent 45 ha or less than 2.5% of the island's land area but even the smallest of these properties would undermine the project's ability to target all individuals weakening the case for the project being considered socially acceptable.

It is expected that some landowners currently in opposition or unsure, will change their position once apprised of the level of community support and although not desired, the project could rely on the Biosecurity Act (1993) to gain cooperation from some landowners. Thus, for rats and possums, the project's social acceptability is contingent on continuing dialogue with these last few landowners. For

wallabies, the picture is a little different. Although access to all properties is preferred as it would increase operational efficiency and speed up the eradication, it is probable that all eradication principles can be met even at current levels of support.

10. CAN ALL INDIVIDUALS OF THE TARGET SPECIES BE PUT AT RISK BY PROPOSED ERADICATION TECHNIQUES?

Judging from precedents set elsewhere, it is anticipated that all individuals of each target species can be put at risk by the techniques proposed (Section 7). An assessment for each species is presented below.

10.1. Rats

Globally rats have been removed from more than 600 islands, 20 greater than 1000ha in size, and the largest South Georgia at 39,000ha (DIISE 2022). Rats have also been removed from a number of inhabited islands, the nearest is Rakino, completed in 2000, but the largest and most complex is Lord Howe Island (LHI) in 2019 (Walsh et al. 2018). LHI is 1,445 ha, has a permanent resident population of around 382 individuals, and at the time of the operation had approximately 100 cattle, several horses, 48 dogs, four goats and 300 chickens (Walsh et al. 2018). Both mice and rats were removed from LHI using the same methodology as that proposed for Kawau i.e. bait deployed in bait stations or hand spread within residential areas and aerial application across uninhabited parts of the island (Harper et al. 2020).

Rat eradication on LHI was prolonged by a period of two years because some rats in the settlement area unexpectedly avoided bait stations, an outcome attributed to the unrestricted use of 1st generation anticoagulants on the island over many years (Harper et al. 2020). To reduce the risk of the same occurring on Kawau, residents would be asked to discontinue rodenticide use and use traps instead for at least six months prior to bait application, the area to be treated with bait stations will be minimised, strict measures to limit the availability of alternative foods will be implemented and follow up surveillance will be conducted within residential areas to detect survivors (Mackay 2011). In contrast to LHI, significant support for these measures exists within the Kawau community.

The proposed 20m x 20m grid over which bait would be hand broadcast exceeds best practice for rat eradications undertaken using bait stations or hand spreading in New Zealand (Broome and Brown 2010) and would also effectively target mice based on work done by Mackay et. al. (2011). Based on a minimum home range size of 0.8ha recorded for Norway rats (Bramley 1999), 0.06ha for female ship rats (Harper and Rutherford 2016) and 0.15 for mice (Mackay 2011), this grid intensity will ensure all individuals are targeted. The application rate to be used and number of applications will be designed to ensure that bait is available to all rodent species, even in the presence of other consumers such as possums.

The biggest risk to putting all individual rats at risk is the potential lack of access to each and every property on Kawau. Based on the conversation to date (347 of 365 landowners), just 18 landowners are opposed to access to complete rat eradication. This represents a total of 45 ha in total with the largest contiguous area being 37.8 ha. However, even the smallest of these properties at 0.8ha could

provide a refuge for rats spelling failure for the eradication effort. While it is anticipated that some of these landowners may become more receptive to the project access to all properties is fundamental to the success of rat eradication on Kawau.

If further dialogue with these landowners fails to secure access or a suitable compromise, the project would have to resort to using powers under the Biosecurity Act (1993) to apply control measures on residential premises. This avenue would only ever be pursued as a last resort if all other options fall through. The preference is to have landowner permission to manage access to land, dwellings and other buildings under a property agreement rather than exercise legal powers of access.

Given the small number of landowners currently opposed to rat eradication, it is cautiously concluded that the necessary conditions can be put in place to ensure each, and every rat can be targeted. In conclusion, while obvious challenges still exist, it is believed this eradication principle can be met.

10.2. Possums

Possums have been removed from a number of islands and fenced sanctuaries greater than 1000ha. Possums have also been eliminated through the application of rodent bait containing brodifacoum to target rats (Griffiths 2011). There is no reason to suspect that the same will not occur on Kawau. However, follow up work to detect survivors, as proposed, is warranted. And as for the rat eradication removing possums from Kawau faces the same challenges associated with property access.

10.3. Stoats

Stoats have been removed from a number of islands and fenced sanctuaries greater than 1000ha. Like possums, stoats have also been eliminated by the application of rodent bait containing brodifacoum to target rats, most likely as a consequence of secondary poisoning (Griffiths 2011). Although the same outcome is anticipated on Kawau, follow up work to detect and target survivors is proposed. Stoats have large home range so access to all properties across Kawau is not as critical for the removal of this species.

10.4. Wallabies

The only documented wallaby eradication to have been completed was undertaken on Rangitoto (2,311 ha) and Motutapu (1,509 ha) islands in the Hauraki Gulf. Brush-tailed rock wallabies were removed from both islands in an operation that spanned seven years (Mowbray 2002). The project used a combination of methods including 1080, cyanide paste, trapping and hunting. Lessons learnt from the Rangitoto and Motutapu project along with technological advances such as improvements in thermal imagery provide confidence that the same outcome can be realised on Kawau. Most of Kawau, except for the coastal cliffs is also far more accessible than the broken lava surface of Rangitoto providing some hope that eradication can be achieved within a significantly shorter period of time.

Three major challenges to ensuring all individuals can be put at risk are anticipated. First, wallabies have been hunted and controlled on Kawau for many years and there will be individuals within the population that are now extremely wary of people and vehicles. These individuals may have developed behaviours that make them extremely hard to detect. Second, some landowners (42) are against the removal of wallabies and are expected to oppose access. Deliberate obstruction of the operation or illegal release of wallabies following their removal also cannot be discounted. The third risk is presence

of possums and rats that could affect the ability to use Feratox and 1080 baits successfully if they exclude wallabies from bait stations or compete for bait. This could result in two issues: firstly, it will reduce/limit the tools available to eradicate wallabies, and secondly, it could have a knock-on impact on the effectiveness of the possum eradication if it generates bait/bait station shy possums as a result of the use of Feratox to remove groups of wallabies.

Nothing can be done to address the first challenge other than to ensure no further individuals are educated following the beginning of the eradication. The total area represented by landowners opposed to access, amounts to around 60 ha with the largest contiguous areas being 37.8ha, 4.69ha and 2.12ha. While it is hoped a number of these landowners will change their position, it is assumed that universal access to private property will not be gained. Based on home range estimates for the three wallaby species whose distribution overlaps with residential areas (parma, dama and swamp), the largest contiguous area the project could reasonably accept without taking on an unacceptable risk of failure would be ~10ha. Any area larger than this could offer a potential refuge for individual wallabies, at worst undermining the project's ability to meet eradication principles 3 and 4 or, at best, simply extending the duration of the operation. We are optimistic that with further dialogue this condition can be met without having to resort to the Biosecurity Act (1993), but this legislation remains an option to ensure all individuals can be targeted.

The consequences of the third risk will be evaluated before baits are deployed. Possum numbers across the island are low and it may be possible to confirm their absence prior to the use of baits. Mitigation options for rat interference at bait stations will be investigated.

11. CAN THE TARGET SPECIES BE REMOVED AT A RATE EXCEEDING THE POPULATION'S RATE OF INCREASE AT ALL DENSITIES?

Based on the proposed eradication strategy presented in Section 7, it is expected that this condition can be met for all target species, although a number of risks will need to be addressed. An assessment for each species is presented below.

11.1. Rats

The proposed operation will take place over the winter months, thereby targeting rats as they are undergoing population decline, and although the two rat species are capable of breeding during winter (Innes 2001), the chances of mortality being offset by breeding at that time of the year is low. Other operations have targeted these species at greatly varying densities, both within New Zealand and overseas, and have been successful. It can therefore be concluded that if the first principle is met, as is expected, then the second will be met accordingly. Because rat breeding begins in spring, to maximise the likelihood of success, bait application should be completed before the beginning of September.

The biggest risks of not meeting this condition are, as discussed above, the survival of some rats within residential areas due to some behavioural avoidance of baits or bait stations. In response to this, bait would be maintained in bait stations in and around structures for as long as is necessary and follow up surveillance and response work will be in place to target these individuals before they can breed.

11.2. Possums

Possums have a lower rate of reproduction than rats and this species is expected to be eliminated as a consequence of the rat eradication. Survivors, if they do appear, are expected to be picked up by proposed detection efforts allowing this principle to be met.

11.3. Stoats

Stoats are also expected to be eliminated as a consequence of rat eradication (Griffiths 2011). If individuals do survive some could produce offspring and this could extend the operation by a year or more. In the project's favour, stoats on Kawau have not previously been targeted so the population is expected to be naïve. Consequently, planned detection and trapping effort coupled with efforts to target survivors and the ongoing surveillance programme provides confidence that this eradication principle can be met.

11.4. Wallabies

The four wallaby species offer the biggest challenge for the project in meeting this principle. Hunting over many years has almost certainly generated an educated group of individuals that will be challenging to detect and remove. Although proposed methods (Section 7) are considered capable of preventing population recruitment, it will be important to avoid educating more individuals. The use of inappropriate trap types on Rangitoto and Motutapu, as an example, is attributed with extending the operation by two years. One of the last wallabies caught on Rangitoto had signs of being trapped at least three times previously. As discussed above, access and the cooperation of landowners will also be instrumental to meeting this principle.

12. CAN THE PROBABILITY OF THE TARGET PEST RE-ESTABLISHING BE MANAGED TO NEAR ZERO?

Meeting this principle is one of the key considerations of this feasibility assessment and the one that will ultimately determine the project's sustainability. Ensuring that Kawau is protected from reinvasion will be an enormous challenge because of the large number of landowners, the number of points of access to the island, the island's proximity to the mainland and its accessibility. In the project's favour, Kawau is beyond the swimming and dispersal range for all target pest species except stoats, all of the adjacent islands are rat free and rats and stoats are absent or at low densities along the closest points on the mainland. On the basis of discussions had, the Kawau community is also highly supportive of taking precautions to prevent reinvasion as well as being committed to ongoing surveillance.

12.1. The risk of pest reinvasion

The risk of reinvasion varies greatly between the pest species targeted for eradication, with rats the species most likely to return due to human activity and stoats, the only species capable of swimming to the island. Rats have an amazing ability to stow away on vessels or in stores and with no awareness or controls could quickly make their way back to the island. The distances that separate Kawau from potential sources of reinvasion are depicted in Fig 2. Although the closest stretch of coastline to the north presents less risk because of the presence of Tāwharanui Open Sanctuary, stoats could make their way back to the island via multiple different routes. A stoat caught on nearby Rabbit Island in 2021 emphasises this risk and it is expected that stoats will arrive on the island albeit irregularly.

Possums have stowed away on boats in the past but pose a low risk of reinvasion and, of the wallaby species, the only species on Kawau to be found elsewhere in New Zealand is the dama for which the nearest source population is the Bay of Plenty and Waikato. Both possums and wallabies are unlikely to be reintroduced unless by deliberate act of sabotage, an eventuality considered based on discussions with the community to be low risk.

12.2. Current protections

Several biosecurity provisions are already in place for Kawau. Commercial operators transporting passengers and freight to and from Kawau already operate under Auckland Council's Pest Free Warrant scheme. To comply with required measures, operators must maintain clean vessels, keep rodent detection devices on board and advise passengers of the risks. Other measures are yet to be implemented such as inspections of high-risk cargo. However, these measures are planned to come on stream ahead of an eradication if the project moves ahead. The Pest Free Warrant scheme has worked well for other islands in the Hauraki Gulf based on the low rate of incursions by rodents on islands serviced by commercial operators.

12.3. Precedent

Cause for optimism that this eradication principle can be met can be taken from other islands in the Hauraki Gulf that have remained rat free for many years. Of the over 30 pest free islands in the Hauraki Gulf many are privately owned or are open sanctuaries with high levels of visitation. In terms of land ownership, Rakino bears the greatest resemblance to Kawau with ~190 landowners and ~137 houses. The island, rat free since 2000, has 21 permanent residents but the population increases to more than 200 during the summer months. Like Kawau, Rakino is serviced by a regular ferry service although not as frequently and commercial barge operators are used to transport building and landscaping supplies. Landowners and visitors use both the ferry but also their own boats to access, and the island is a popular boating destination. Other pest free islands like Motuihe, Rangitoto and Motutapu receive volumes of private boating traffic that equal or exceed the levels travelling to Kawau providing further confidence that reinvasion can be managed to low levels.

12.4. Advocacy

Crucially all landowners and visitors to the islands must understand the need for preventing pest reinvasion. They must be aware of the risks and what they can do to minimise them. Conversations with residents and landowners suggests there is strong support for preventative measures. However, advocacy efforts as are proposed will be required to ensure all people travelling to Kawau understand what is required.

12.5. Surveillance needs

The risk of reinvasion cannot be eliminated for any island, but for Kawau, the risk for mice, rats and stoats is likely to remain higher than for other more remote and less intensively visited islands. An elevated level of surveillance and response readiness is proposed in response and this has been incorporated into draft biosecurity planning (See section 7), but further work on the specifics of surveillance is underway.

12.6. Response needs

Work is underway to refine the response to future incursions on Kawau but the following key elements would need to be in place to sustain project outcomes:

- A response kit maintained on the island that contains all of the resources necessary to respond to a rodent or stoat incursion.
- Dedicated capacity to put in place a rapid response.
- Ongoing engagement of the community that ensures landowner cooperation and swift access to private property.
- Up to date database of landowners contact details.
- Readily available transport and accommodation options.

Comparable resources are already in place on Kawau to respond to fire and other emergencies providing confidence that the same could be put in place for future pest incursions. The Kawau Voluntary Fire Brigade has dedicated facilities in each of the main bays of Kawau where critical resources are stored allowing them to rapidly respond to most events. Tapping into the experience of the Kawau Voluntary Fire Brigade would be well advised when developing a comparable system for incursion response.

If a decision was made to proceed with the project, Auckland Council would need to commit to providing the dedicated resources necessary to prevent population establishment.

12.7. Summary

Based on the above and on biosecurity planning currently underway, it is concluded that the proposed biosecurity measures and advocacy efforts can reduce the risk of reinvasion for Kawau to low levels. Plans for ongoing surveillance across the island coupled with the eyes and ears of residents are expected to provide a good chance of detecting an incursion soon after it occurs and the intention to develop and maintain a response capacity is considered essential to prevent population establishment.

The eradication of pests on Kawau should not proceed until it is clear that the probability of pests reinvading the island has been reduced to near zero. To allow a decision to be made whether or not to proceed before significant resources are committed, the systems outlined in the draft biosecurity plan must be in place and operational by 1 April in the year that rat eradication proceeds. These systems must be tested and reworked if they are not effective, and a final assessment made by 1 May. The assessment should be undertaken by staff experienced in island biosecurity.

13. CAN THE PROJECT MEET ALL OF IT'S LEGAL AND STATUTORY REQUIREMENTS?

The removal of rats, possums, stoats and wallabies from Kawau is mandated by the Auckland Regional Pest Management Plan 2020-2030. Nevertheless, the project will need to adhere to a variety of legislation, regulations, procedures and codes of practice, overseen by agencies including Civil Aviation Authority, WorkSafe, Auckland Council and Department of Conservation.

13.1. Legislation

A compliance register will be developed for the project and maintained but applicable legislation includes the Biosecurity Act (1993), the Hauraki Gulf Controlled Area Notice (2021), Wildlife Act 1953; the Wild Animal Control Act (1977); the Animal Welfare Act (1999), the Arms Act (1983), Health and Safety at Work Act (2015), Health and Safety at Work (Hazardous Substances) Regulations (2017),

Agricultural Compounds and Veterinary Medicines Act (1997), Civil Aviation Act (1990), Civil Aviation Rules and Heritage New Zealand Pouhere Taonga Act (2014).

13.2. Use of toxins

Resource Consent and Medical Officer of Health (MOH) approval is not required for the application of brodifacoum (Regulation 5, Resource Management (Exemption) Regulations 2017). However, MOH approval will be required for the local use of cyanide and 1080 baits. Secure storage for these toxins would also be required.

13.3. Firearms

Firearms will be needed for wallaby eradication. Hunting already occurs on Kawau setting precedence for the eradication, but additional steps may be required for hunting on private land and close to land boundaries. Secure firearms and ammunition storage will also be required on the island.

13.4. Traps

Exemptions from the Animal Welfare Act (1999) will be required for some of the traps identified in the provisional operational strategy wallaby eradication. Precedent exists for gaining these exemptions but for other species, so the effort this will require needs to be estimated.

13.5. Aviation

Helicopters and possibly drones will be utilised to complete the proposed eradication. For the proposed activities, compliance with civil aviation laws is well established for helicopters but the regulation of drones is still in development. The flexibility to use drones at night and beyond visual line of sight would be advantageous to the project and the regulations around these uses will need to be explored.

13.6. Biosecurity

The Hauraki Gulf Controlled Area Notice 2021 will support the eradication by reducing the risk of reinvasion.

13.7. Summary

Legal precedents have been established for all of the proposed project methods with the exception of some species uses for drones. Consequently, legislative and regulatory hurdles for the project are considered surmountable.

14. CAN THE NECESSARY RESOURCES TO COMPLETE THE PROJECT BE SECURED AND DEPLOYED?

14.1. Project cost

The project requires a significant one-off investment to achieve eradication and smaller but ongoing costs to sustain its outcomes. A breakdown of the proposed indicative eradication budget is presented in Appendix 2 but the overall cost to deliver the project is expected to be ~$6,500,000 for the eradication operation, ~$237,000 to establish systems for surveillance and response, and ~$375,000 per annum to support ongoing biosecurity costs associated with advocacy, surveillance and response. Ongoing surveillance costs may reduce over time as systems for detection become more automated.

It is not known what incursion response costs will be as they depend on so many factors, but based on other experiences in the Hauraki Gulf it is believed these will be manageable.

Securing the necessary funding for the project is believed to be feasible. Significant funding has already been committed, to the value of $2,700,000, and additional funding sources have been identified that could address the funding gap. Auckland Council has committed to funding the ongoing costs of biosecurity.

14.2. Personnel

Initial investigation into the availability and capacity within New Zealand's professional hunting community suggest there is sufficient capacity to put together a 12-person team for the period of time expected to complete wallaby eradication. The 12 staff required to set up the baiting grid and bait station network as well as the surveillance network will be a stretch. However, if some time is dedicated to training and upskilling individuals, then putting together such a team is considered feasible. Augmenting staff capacity at Auckland Council to sustain ongoing surveillance and biosecurity is a question that needs to be answered but it is believed that resources can be made available.

14.3. Helicopters and drones

Auckland has significant helicopter and pilot capacity that could complete the aerial application of rodent bait and support detection efforts. New Zealand is starting to develop its drone capacity and it is believed that sufficient capacity is available to meet operational needs.

14.4. Pest detection dogs and dog handlers

Dogs and dog handlers exist for all of the species targeted and it is believed that sufficient capacity exists to support the operation. However, competition for these resources is hard to predict and as such, the development of additional capacity to support the project is warranted. However, a two year lead time is required to get a dog to the necessary level of ability.

14.5. Transport and accommodation

Commercial transport options exist that could support the project's implementation although investing in dedicated boat capacity may be worth considering given the greater flexibility this option would provide. For accommodation, several options exist. Wallaby hunters currently working on the island are housed privately, commercial accommodation options exist, and the Department of Conservation has accommodation in the form of a bunkhouse that sleeps six. The operation could draw on all of these options if needed. Over the period of the rat, possums and stoat eradication, the significantly larger team required might be able to be accommodated by Camp Bentzon.

14.6. Supplies and materials

The supplies and materials needed to complete the operation are available although some resources (e.g. traps) will need to be ordered well ahead of the operation to ensure they are available in time.

15. CONCLUSION

When evaluated against eradication principles, the removal of rats, stoats, possums and wallabies from Kawau appears to be feasible. The cost benefit equation stacks up with the project expected to deliver significant benefits for the environment and net economic and social gains for the community. The project is strongly supported by the community with more than 90% of landowners behind the concept of pest eradication. This level of social acceptance compares favourably against other eradication projects such as Lord Howe Island where a decision was made to move forward on rat and mouse eradication with significantly less support (Walsh et al. 2019).

Based on the level of social acceptance for the proposed methods, the project also appears to be technically feasible with one caveat, that access to all properties can be gained for rat, possum and wallaby eradication and incursion response. Currently a small number of landowners do not support access, and some are opposed to the use of rodent bait on their land. Even the smallest properties where this support is lacking could lead to a failed rat eradication attempt. Consequently, further dialogue with these landowners is required to ensure these conditions are satisfied.

The $6,500,000 cost of the project is believed attainable as is the $375,000 pa of ongoing costs with sources identified that could fill the funding gap and the project is likely to meet all statutory and legal obligations. Thus, in conclusion, while the Kawau project is undoubtedly ambitious and contingent on a number of challenges being overcome, it is believed that all eradication principles can be met and that the project is feasible.

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APPENDIX 1. LIST OF SPECIES PRESENT ON KAWAU ISLAND AND LEVEL OF RISK POSED BY THE PROJECT

Scientific Name	Species	NZ Threat Status	Size of the island's population	Percentage of the global population	Global population (IUCN)	Diet	Exposure pathway (Primary or Secondary)	Feeding stratum	Risk of individual mortality	Risk to the island population	Risk to species	Consequence	Mitigation Planned
Native birds													
Anas chlorotis	pāteke/brown teal	Nationally Increasing	1-10	<1	~2000	Terrestrial, freshwater and marine invertebrates, vegetation, seeds	P/S	Ground, littoral zone	High	High	Low	Moderate	Yes
Anthornis melanura	korimako/bellbird	Not Threatened	1-10	<0.1%	~15,000	Nectar, fruits, invertebrates	S	Canopy	Low	Low	Low	Low	No
Anthus novaeseelandiae	Pīhoihoi/New Zealand pipit	Declining	1-10	<0.1%	Not quantified, described as stable	Omnivorous, invertebrates, grains, seeds	S	Canopy to ground	Moderate	Low	Low	Low	No
Apteryx mantelli	North Island brown kiwi	Not Threatened	10-100	<.5%	>20,000	Invertebrates, occasionally small fruits & leaves	S	Ground	Low	Low	Low	Low	No
Charadrius obscurus	tūturiwhatu/Northern New Zealand dotterel	Nationally Increasing	1-10	<1%	2500	Marine, littoral, and terrestrial invertebrates, sandhoppers	S	Ground, littoral zone	Moderate	Low	Low	Low	Yes
Chrysococcyx lucidus	pipiwharauroa/shining cuckoo	Not Threatened	10-100	<0.1%	Not quantified, described as locally common	Predominately invertebrates	S	Canopy	Low	Low	Low	Low	No
Circus approximans	kāhu/Australasian harrier	Not Threatened	10-100	<0.1	>100,000	Small to medium-sized birds, mammals, invertebrates lizards, carrion	S	Ground to canopy	Moderate	Low	Low	Low	No
Cyanoramphus novaezelandiae	kākāriki/red-crowned parakeet	Relict	1-10	<0.1	<35,300	Seeds, fruit, invertebrates	S	Canopy to on/near ground	Low	Low	Low	Low	No

Egretta novaehollandiae	matuku moana/white-faced heron	Not Threatened	10-100	-	Population trend unknown	Small fish, crabs, invertebrates, mice	S	Littoral zone, ground	Low	Low	Low	Low	No
Egretta sacra	matuku moana/reef heron	Nationally Endangered	1 – 10	<0.1	~1M	Fish, aquatic and terrestrial invertebrates	S	Littoral zone	Low	Low	Low	Low	No
Eudyptula minor	kororā/little penguin	Declining	10-100	<0.1%	<470,000	Fish, squid, crustacean species		At sea	Low	Low	Low	Low	No
Gallirallus australis greyi	North Island weka	Relict	1000-10000	20% (Kawau population estimated ~2000)	<10,000	Omnivorous, predate and scavenge	P/S	Ground	High	High	Low	Moderate	Yes
Gallirallus philippensis	moho-pererū/banded rail	Declining	1-10	-	Overall population trend is stable	Marine invertebrates, fish, seeds	P/S	Littoral zone, ground	Moderate	Low	Low	Low	No
Gerygone igata	riroriro/grey warbler	Not Threatened	10-100	-	Not quantified, described as common	Insectivorous	S	Canopy	Low	Low	Low	Low	No
Haematopus unicolor	tōrea pango/variable oystercatcher	Recovering	10-100	<2%	~4000	Littoral invertebrates, crustaceans	None	Littoral zone, ground	Low	Low	Low	Low	No
Hemiphaga novaeseelandiae	kererū/New Zealand pigeon	Not Threatened	10-100	<1%	>10,000	Buds, leaves, flowers & fruits	None	Canopy	Low	Low	Low	Low	No
Himantopus himantopus	poaka/pied stilt	Not Threatened	1-10	<0.1%	>150,000	Terrestrial and aquatic invertebrates	S	On or near the ground	Low	Low	Low	Low	No
Hirundo neoxena	waro/welcome swallow	Not Threatened	10-100	-	Population has not been quantified	Small invertebrates	None	Aerially	Low	Low	Low	Low	No
Hydroprogne caspia	taranui/caspian tern	Nationally Vulnerable	10-100	<0.1%	~29,000	Small surface-swimming fish	None	At sea	Low	Low	Low	Low	No
Larus dominicanus	karoro/black-backed gull	Not Threatened	10-100	<0.1%	>4M	Marine and terrestrial invertebrates, fish, small mammals, will scavenge	S	Ground, littoral, at sea	Moderate	Low	Low	Low	No
Larus novaehollandiae	tarāpunga/red-billed gull	Declining	10-100	-	Population trend increasing	Krill, small fish, invertebrates, will scavenge	S	Ground, littoral, at sea	Moderate	Low	Low	Low	No

Microcarbo melanoleucos	kawau paka/little shag	Declining	1-10	<0.1%	200,000	Small fish, eels, crustaceans	None	At sea, rivers, estuarine	Low	Low	Low	Low	No
Morus serrator	tākapu/Australasian gannet	Not Threatened	1-10	-	Unknown, population is suspected to be increasing	Fish, mainly pilchards, anchovies	None	At sea	Low	Low	Low	Low	No
Nestor meridionalis	kākā	Recovering	10-100	<.25%	<10,000	Fruit, nectar, sap, tree-dwelling invertebrates	P	Canopy	Low	Low	Low	Low	No
Ninox novaeseelandiae	ruru/morepork	Not Threatened	10-100	-	Population described as stable	Invertebrates, small birds, rodents	S	Canopy to ground	Moderate	Low	Low	Low	No
Phalacrocorax carbo	kawau/black shag	Relict	10-100	<0.1%	>2M	Fish, eels, aquatic invertebrates	None	At sea, rivers, estuarine	Low	Low	Low	Low	No
Phalacrocorax sulcirostris	kawau tui/little black shag	Naturally Uncommon	1-10	-	Population trend unknown	Small fish	None	At sea, rivers, estuarine	Low	Low	Low	Low	No
Phalacrocorax varius	kāruhiruhi/pied shag	Recovering	1-10	-	Population trend unknown	Small and medium-sized fish	None	At sea	Low	Low	Low	Low	No
Platalea regia	Kōtuku ngutupapa/Royal Spoonbill	Naturally Uncommon	1-10	<0.1%	Unknown, described as stable	Fish, crustaceans, aquatic invertebrates	None	Ground	Low	Low	Low	Low	No
Porphyrio melanotus	pūkeko/swamp hen	Not Threatened	10-100	<0.1%	>600,000	Vegetation, seeds, invertebrates	P	Ground	Moderate	Moderate	Low	Low	No
Prosthemadera novaeseelandiae	tūī	Not Threatened	10-100	<1%	<15,000	Primarily nectar, fruits	None	Canopy	Low	Low	Low	Low	No
Pterodroma gouldi	ōi/grey-faced petrel	Not Threatened	1-10	<0.1%	>900,000	Squid, crustaceans, fish	None	At sea	Low	Low	Low	Low	No
Rhipidura fuliginosa	pīwakawaka/fantail	Not Threatened	100-1000	-	Population size not quantified	Small invertebrates	S	Canopy, low to ground	Low	Low	Low	Low	No
Sterna striata	tara/white-fronted tern	Declining	1-10	<0.1%	<25,000	Small and larval fish	None	At sea	Low	Low	Low	Low	No
Tadorna variegata	pūtangitangi/paradise shelduck	Not Threatened	1-10	<0.1%	~700,000	Herbivorous, pasture grasses, leaves, seeds	P	Ground	Moderate	Moderate	Low	Low	No
Todiramphus sanctus	kōtare/kingfisher	Not Threatened	10-100	-	Population trend increasing	Terrestrial and aquatic invertebrates and vertebrates	S	Ground, estuarine, river	Low	Low	Low	Low	No

Vanellus miles	Spur-winger plover	Not Threatened	1-10	-	Population trend is increasing	Marine and terrestrial invertebrates	S	Ground	Low	Low	Low	Low	No
Zapornia tabuensis	pūweto/spotless crake	Declining	1-10	-	Population trend increasing	Omnivorous, seed, fruit, leaves, invertebrates	P/S	Ground, wetlands, mudflats	Low	Low	Low	Low	No
Zosterops lateralis	tauhou/silvereye	Not Threatened	100-1000	-	Unknown - population trend is increasing	Fruits, nectar, small invertebrates	None	Canopy and near ground	Low	Low	Low	Low	No
Non-native birds													
Acridotheres tristis	maina/common myna	Introduced	100-1000	<0.01%	Population not quantified but increasing	Omnivorous, invertebrates, fruit, nectar	P	Canopy to ground	Low	Low	Low	Low	No
Carduelis carduelis	kōurarini/european goldfinch	Introduced	10-100	<0.01%	<200m	Seeds particularly thistles, dandelion, grasses	P	Ground, near to ground	Moderate	Low	Low	Low	No
Dacelo novaeguineae	laughing kookaburra	Introduced	1-10	-	Population suspected to be in decline	Invertebrates, skinks, rodents	S	Canopy to ground	Low	Low	Low	Low	No
	mallard												
Emberiza citrinella	hurukōwhai/yellow hammer	Introduced	10-100	<0.1%	>60M	Seeds, small invertebrates	P	Ground or near to ground	Moderate	Low	Low	Low	No
Fringilla coelebs	pahirini/common chaffinch	Introduced	100-1000	<0.01%	>700M	Seeds, invertebrates	P	Canopy to ground	Moderate	Low	Low	Low	No
Passer domesticus	tiu/house sparrow	Introduced	100-1000	<0.01%	>540,000,000	Seeds, grain	P	Ground	Moderate	Low	Low	Low	No
Pavo cristatus	pīkao/Indian peafowl	Introduced	1-10?	<.1%	>10,0000	Invertebrates, vegetation, seeds, fruit	P	Ground	High	Moderate	Low	Low	Yes
Platycercus eximius	kākā uhi whero/eastern rosella	Introduced	10-100	-	Population not quantified	Seeds, fruit, nectar, buds, leaves	P	Canopy to ground	Moderate	Low	Low	Low	No
Sturnus vulgaris	tāringi/common starling	Introduced	10-100	<0.1%	>100M	Invertebrates and grains	P	Ground, near to ground	Moderate	Low	Low	Low	No
Turdus merula	manu pango/eurasian black bird	Introduced	100-1000	<0.01%	500M	Invertebrates	S	Ground	Moderate	Low	Low	Low	No

Turdus philomelos	manu-kai-hua-rakau/song thrush	Introduced	100-1000	<0.1%	>100M	Invertebrates	P	Ground	Low	Low	Low	Low	No
Native mammals													
Chalinolobus tuberculatus	pekapeka/long tailed bat	Nationally Critical	Present	<0.1%	~20000	Invertebrates,	S	Above ground	Low	Low	Low	Low	No
Arctocephalus forsteri	Kekeno/NZ fur seal	Not Threatened	Present	<0.1%	~20000	Marine	S	At sea	Low	Low	Low	Low	No
Domestic pets and animals													
Gallus gallus	Chicken	N/A	Present	<0.01%	Innumerable	Seeds, fruit, invertebrates,	P/S	Ground	Moderate	Low	Low	Low	Yes
Canis lupus familiaris	Dog	N/A	Present	<0.01%	Innumerable	Omnivorous	P/S	Ground	Moderate	Low	Low	Low	Yes
Felis catus	Cat	N/A	Present	<0.01%	Innumerable	Carnivore	P/S	Ground	Moderate	Low	Low	Low	Yes
Capra hircus	Goat	N/A	Present	<0.01%	Innumerable	Herbivore	P	Ground	Low	Low	Low	Low	Yes
Lama pacos	Alpaca	N/A	Present	<0.01%	Innumerable	Herbivore	P	Ground	Low	Low	Low	Low	Yes
Native reptiles													
Dactylocnemis pacificus	Pacific gecko	Not Threatened	Present	<0.1%	~20000	Invertebrates, honeydew, nectar	S	Ground	Low	Low	Low	Low	No
Oligosoma aeneum	Copper skink	Declining	Present	<0.1%	Described as stable	Invertebrates, spiders, small fruits	S	Ground	Low	Low	Low	Low	No
Oligosoma moco	Moko skink	Relict	Present	<0.1%	~20000	Insectivorous and frugivorous	S	Ground	Low	Low	Low	Low	No
Oligosoma ornatum	Ornate skink	Declining	Present	<0.1%	>100,000	Insectivorous and frugivorous	S	Ground	Low	Low	Low	Low	No
Freshwater fish													
Anguilla australis	Tuna hinahina/shortfin eel	Not Threatened	Present	<0.1%	>100,000	Insect larvae, invertebrates	None	Aquatic	Low	Low	Low	Low	No
Anguilla dieffenbachii	Tuna/longfin eel	Declining	Present	<0.1%	Unknown, area occupied >10000 ha	Insect larvae, worms, fish, snails	None	Aquatic	Low	Low	Low	Low	No
Galaxias fasciatus	banded kōkopu	Not Threatened	Present	<0.1%	Described as stable	Aquatic, terrestrial and benthic invertebrates	None	Aquatic	Low	Low	Low	Low	No

Galaxias maculatus	Inanga/common galaxias	Not Threatened	Present	<0.1%	Described as abundant in current range	Larvae, aquatic and terrestrial insects	None	Aquatic	Low	Low	Low	Low	No
Gobiomorphus cotidianus	Toitoi /common bully	Not Threatened	Present	<0.1%	Described as abundant, trend data not available	Benthic invertebrates, insect larvae	None	Aquatic	Low	Low	Low	Low	No
Gobiomorphus gobioides	Titarakura/giant bully	Naturally Uncommon	Present	<0.1%	Described as stable but population poorly surveyed	Benthic invertebrates	None	Aquatic	Low	Low	Low	Low	No
Gobiomorphus huttoni	Redfin bully	Not Threatened	Present	<0.1%	Population trend is decreasing	Opportunistic feeders, larvae, invertebrates, small crustaceans	None	Aquatic	Low	Low	Low	Low	No
Other species													
	Aquatic Invertebrates	N/A	N/A		Innumerable	Vegetation, algae, other invertebrates some vertebrates	P	Aquatic	Low	Low	Low	Low	Yes
	Marine fish	N/A	N/A		Innumerable	Marine	P/S	At sea	Low	Low	Low	Low	Yes
	Marine invertebrates	N/A	N/A		Innumerable	Marine	P	At sea	Low	Low	Low	Low	Yes
	Shellfish	N/A	N/A		Innumerable	Marine	P	At sea	Low	Low	Low	Low	Yes
	Terrestrial invertebrates	N/A	N/A		Innumerable	Organic matter, other invertebrates some vertebrates	P	Canopy to ground	Low	Low	Low	Low	No
	Terrestrial plants	N/A	N/A		Innumerable	N/A	None	N/A	Low	Low	Low	Low	No

APPENDIX 2. BUDGET BREAKDOWN FOR KAWAU MULTI SPECIES PEST ERADICATION AND ONGOING BIOSECURITY

Expense	Details	Amount (NZD)
Personnel	Project Management	$ 250,000
	Advisory Capacity	$ 120,000
	Community Liaison	$ 200,000
	Property management agreements	$ 240,000
	Wallaby team	$ 800,000
	Wallaby dog handlers	$ 400,000
	Non-target species mitigation	$ 440,000
	Team for set up for rat/stoat and possum eradication	$ 480,000
	Team for ground based rat eradication including	$ 320,000
	Team for aerial bait application	$ 120,000
	Team for follow up surveillance and demobilization	$ 200,000
	Dog handlers - rats, possums, stoats	$ 200,000
Travel	Transport to and from Kawau	$ 130,000
	Boat transport around Kawau	$ 64,800
	Food	$ 182,000
Shipping and storage	Transport of rodent bait	$ 49,500
	Shipping container hire	$ 27,500
	Transport for supplies and equipment	$ 6,000
Accommodation	Accommodation for team members on island	$ 319,200
Office supplies	Laptops, software, printers, white boards, office furniture	$ 16,000
Office costs	Phone, internet, office rental	$ 54,000
Field supplies and equipment	Handheld GPS units	$ 6,000
	Firearms	$ 16,800
	Ammunition	$ 12,000
	Bait and lure for wallaby eradication	$ 10,000
	VHF Radios	$ 10,800
	Trail cameras	$ 87,500
	Traps and trapping supplies	$ 36,000
	Wallaby fencing materials	$ 22,400
	PPE	$ 8,000
	Rodent bait	$ 320,000
	Bait stations	$ 36,800
	Consumables (Flagging tape, batteries, pin flags etc)	$ 54,000
	Tools for cutting and marking trails	$ 20,000
	Thermal scopes	$ 39,000
	Domestic animal risk management	$ 36,000

	Food waste management	$	22,000
Vehicle Expense	ATV purchase or hire	$	230,000
	Fuel	$	35,000
	Mechanical bait loading	$	44,000
Helicopter services	Rat eradication	$	220,000
	Detection	$	60,500
Drone servies	Detection	$	48,000
General and Adminstration (10%)		$	599,380
	Total	$	6,593,180