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Pacific Regional Invasive Species Management Support Service

RESTORING ISLAND RESILIENCE

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MINISTRY OF AGRICULTURE
COOK ISLANDS

TE IPUKAREA SOCIETY
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Feasibility assessment of the eradication of ship rats (*R.rattus*) and kiore (*R.exulans*) from Palmerston Atoll, Cook Islands

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Version History

Version	Reason for change	Date
1.1	Feedback from IEAG considered and addressed	10/3/23
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Contents

1. Executive Summary

This report assesses the feasibility of eradicating rats from Palmerston Atoll – a small inhabited Atoll located in the Southern Cook Island group. The project was originally requested by the community so has social acceptance and political support. The project is being funded by the New Zealand Ministry of Foreign Affairs and Trade through the Managing Invasive Species for Climate Change Adaptation in the Pacific project. The Department of Conservation are leading the operational planning and delivery of the project, in collaboration with multiple Cook Island partner agencies and the Palmerston Island community.

The feasibility study reviews why the eradication is being done; whether it is achievable; sustainable and acceptable; and identifies what the key issues and dependencies are; and proposes the next steps if the project is to proceed.

Rats are present on two islands within the Atoll, over a total operational area of 71 hectares. Ship rats and kiore and present on the inhabited island (Palmerston/Home Island), while only kiore are present on Cooks motu. Rats have a significant impact of the livelihoods of the residents on the Atoll, and the elimination of these impacts, in addition to the biodiversity gains eradicating rats will bring, is the driver for the proposed project.

The eradication is technically feasible, with precedent being set by a number of other tropic island rat eradications that have similar environmental contexts and used a similar proposed methodology of hand application of 2nd generation anticoagulant bait in combination with open bait tray baiting in buildings. Initial bait rates have been based on availability studies conducted in November 2022. Bait rates and number of applications may be adjusted from further bait monitoring during the eradication. The proposed delivery of the baiting operation is likely to take 4-5 weeks on the Atoll, with a field team of 12 from collaborating agencies and the community and led by DOC staff.

Significant operational risks have been identified, and are mostly associated with non-target consumption which may decrease bait availability; and human produced alternative food sources for rats that may decrease bait palatability. Unmanaged, these risks are likely to increase the risk of the eradication failing– but reasonable and realistic management actions have been identified and agreed on by the community to enable the elimination or mitigation of these issues.

Logistics to the island are difficult, with very limited availability and confidence of security of transport operators between Rarotonga and the Atoll. Resourcing the scoping and security of sea transport has been identified as an important component to resource if the project commences.

A successful eradication operation is deemed feasible, however, there are some key dependencies identified in the feasibility study that need to be addressed if the operation is to proceed – these are summarised in **Table 10** on page 40.

Pending approval of the project to move into operational planning, the next steps are:

1. determining and securing the best transport arrangements for freight and passengers from Rarotonga to Palmerston;
2. detailed operational planning including peer review; and
3. working with the Palmerston Working Group and Palmerston Island Community to ensure agreed mitigation actions on the Atoll are carried out between before April to ensure the best conditions for successfully eradicating rats from the Atoll in July/August 2023.
4. Identifying pragmatic biosecurity improvements that can be made sustainably to improve on the current systems in practice; to furthermore reduce the risk of rodents immigrating to the Atoll.

2. Introduction

The Department of Conservation (DOC) National Eradication Team (NET) have engaged with Cook Islands partners to undertake a feasibility study for the eradication of ship rats (*Rattus rattus*) and pacific rats (*Rattus exulans*) from Palmerston Atoll in the Southern Cook Island group.

The purpose of this feasibility study is to evaluate the feasibility of eradicating pacific and ship rats from Palmerston Atoll by answering three key questions:
1). Why do it?
2). Can it be done?
3). What will it take?

The main body of this report will set out the context, benefits, risks, and constraints – and decide whether the risks and constraints need to be further resolved before an attempted eradication proceeds. This will enable the decision to proceed, taking into account the key issues and risks requiring specific management in order to optimise the likelihood of eradication success.

Should the eradication of rats from Palmerston Atoll be assessed as feasible, the next steps are to address any issues identified, develop an Operational Plan detailing resources and logistics for delivering the operation, delivering the eradication operation, and a post-operational phase to assess what was done and the consequences.

Project background

In 2018 the Palmerston Island Council made a request through the NGO Te Ipukarea Society (TIS) for a rat eradication project following the recommendations of a seabird survey (TIS 2018), coconut crab survey (Kora and Munro 2020), and a Natural Resource Management Plan (TIS 2020) for the Atoll. Opportunity arose for funding of the project through the New Zealand Ministry of Foreign Affairs and Trade (MFAT) through the Managing Invasive Species for Climate Change Adaptation in the Pacific (MISCCAP) project. This is a partnership between MFAT, the Secretariat of the Pacific Regional Environment Programme (SPREP), Manaaki Whenua - Landcare Research (MWLR) and DOC to support the newly established Pacific Regional Invasive Species Management Support Service (PRISMSS).

The project is being led by the New Zealand Department of Conservation (DOC) in partnership with the Palmerston Atoll community, the Cook Islands National Environment Service (NES), Cook Islands Ministry of Agriculture (MOA), and the Non-Governmental Organisation Te Ipukarea society (TIS).

Initial project scoping workshops were conducted in July 2022 in Rarotonga, co-led by the NES and DOC, to collect information from stakeholders and the community around the scope and context of the project. Feasibility fieldwork and a site visit to Palmerston Atoll occurred in November 2022 to gain information required to complete the feasibility study (see DOC-7241702).

This fieldwork identified rats being present on only two of the islands (motu) within the Atoll, with kiore (*Rattus* exulans) and ship rats (*Rattus* rattus) present on Home Island, and just kiore present on Cooks motu. As a result, the focus of the project is on the eradication of rats from these two motu, while ensuring rat populations are not established on others in the Atoll in the meantime.

3. Site and target pest description

3.1 Location and physical environment

Palmerston Atoll **Figure 1** lies in the middle of the Pacific Ocean, being the Northern most of the Pa Enua (outer islands) within the Southern Group of the Cook Islands (see **Figure 1**). Palmerston Atoll is traditionally known as "*Ava Rau"*, meaning 200 channels in Cook Islands Maori.

Figure 1: Palmerston Atoll and the wider Cook Islands

Its nearest neighbours are Suwarrow Atoll 500km to the north, Aitutaki 367km to the southeast and Rarotonga, the country's capital, 500km south. The island country of Niue is 700km to the west. The Atoll consist of six vegetated islands (referred to as motu) ranging from 12 to 42ha, with a number of <1ha sandbanks that are unvegetated (see **Figure 2**). The distance between each of the islets varies from 900m to 7km. The Atoll's lagoon is approximately 11km across, covering approximately 5700 ha, with total land area of the motu covering approximately 183ha.

Home Island, also known as Palmerston Island, is the only inhabited islet in the Atoll, and holds the highest point of land in the atoll at 5mabsl. It has a total land area of 40 hectares, and is over 2100m distance to the next closest motu (Cooks motu to the south-east).

Cooks motu consists of several motu and sandbanks that have been fragmented by significant storm events (see **Figure 3**). It consists of the Dicky Boy Sandbanks, and Calcutta and Aparanuta motu; with a total area of 32 hectares. The next closest motu is Toms, which is approximately 850m away to the east-south-east.

Figure 2: Palmerston Atoll and associated motu and sandbanks

Figure 3: Cooks motu group (from left to right consisting of Aparanuta, Calcutta, and the two Dicky Boy Sandbanks), and Home Island in the distant right. These are the islets/motu with rats present and therefore the scope of the eradication project.

3.2 Climate

Common to most tropical islands, Palmerston experiences distinct wet and dry seasons; "Wet" from November through to April which coincides with the cyclone season (when tropical cyclones are more likely, restricting access) "Dry" from May to October. Although this is the general trend, significant isolated rain events can occur anytime through the year, and feedback from the community has been that weather patterns in recent years have been less predictable than in the past.

An automatic weather station was installed on the island in 2020, and specific climate data for Palmerston exist only for the 2021 year (see **Figure 4**). From this data, temperature is relative constant year-round (mean annual temperature is 28 degrees Celsius), and total annual rainfall was 2038mm. The next closest proxy for climate data is Rarotonga, with receives an average of 1600mm of precipitation annually (see **Figure 5**).

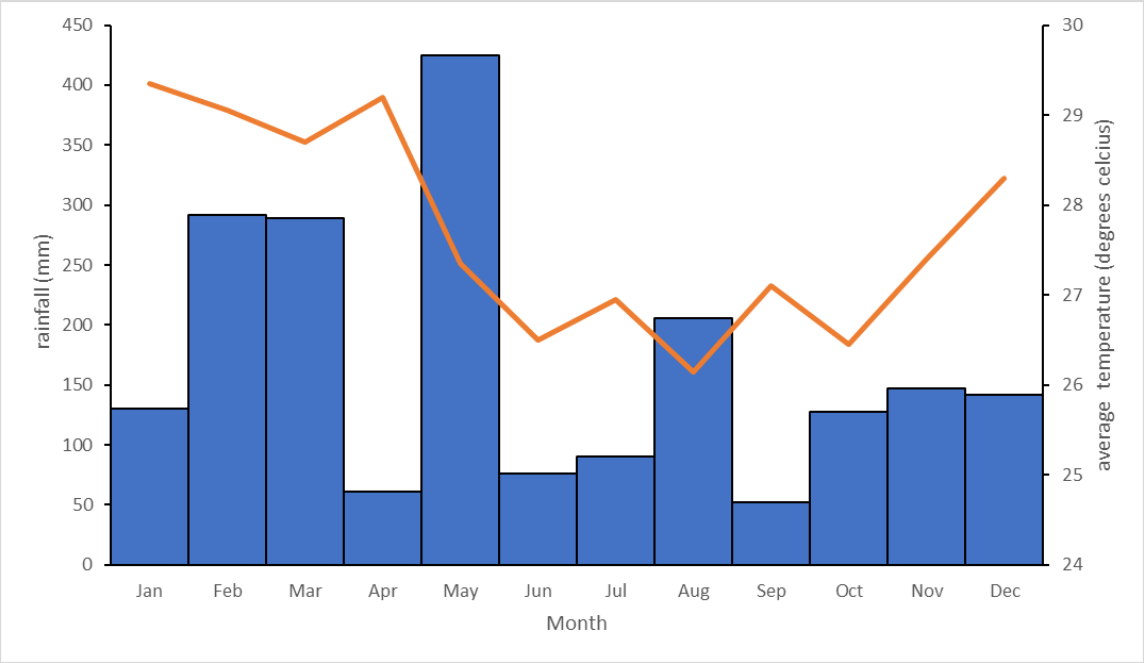

Figure 4: Palmerston Atoll AWS data for 2021

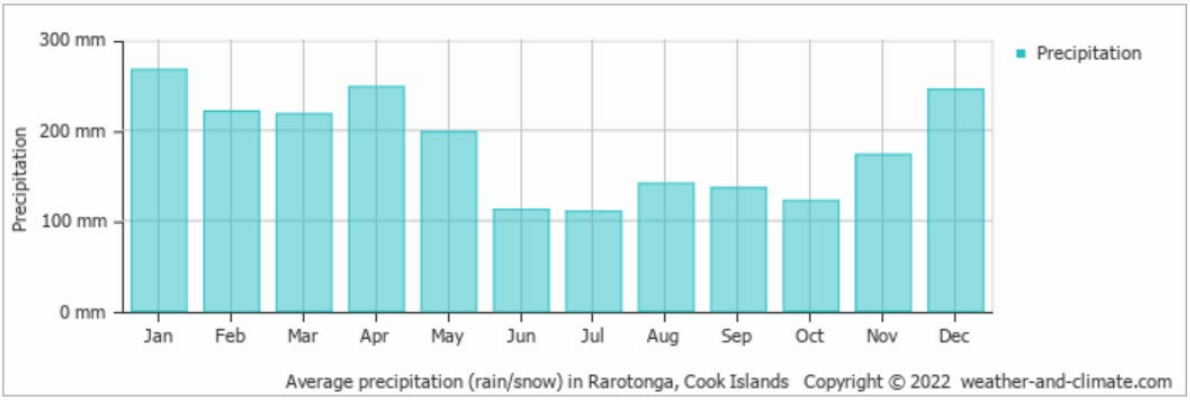

Figure 5: Average precipitation in Rarotonga, Cook Islands

3.3 Biodiversity values

Palmerston Atoll is part of the Polynesia-Micronesia Biodiversity Hotspot, one of 34 regions in the world where extraordinary levels of biodiversity and endemism are coupled with extremely high levels of threat (Mittermeier et al. 2004).

Flora

Much of Home Island has been heavily modified due to the presence of residential use, infrastructure, agriculture, and livestock (see **Figure 6**). There are still tracts of wooded canopy trees, but the canopy is generally less diverse than the uninhabited motus, dominated by coconut (*Cocos nucifera*) and Pacific Mahogony (*Calophyllum inophyllum*).

Figure 6: Oblique aerial photo of Home island, showing the dominance of coconut trees as canopy species, and significant vegetation gaps

The other motu (including Cooks) have had significantly less vegetation clearance, and generally consist of larger trees located centrally and protected from constant salt spray and periodic inundation from the ocean. These include coconut (*Cocos nucifera*), Pacific Mahogany/Tamanu (*Calophyllum inophyllum*), Pukatea *(Pisonia grandis)*, ‘Ano (*Guettarda speciosa*), ‘Ara (*Pandanus tectorius)*, Tou *(Cordia subcordata)*, Tutu *(Colubrina asiatica),* the Lantern Tree (Puka or *Hernandia nymphaeifolia),* and occasionally Toa *(Casuarina equisetifolia)*. Understory vegetation is dominated by saplings, ferns, and Indian Mulberry *(Morinda citrifolia)*. Salt-tolerant plants common to most Pacific Islands in the tropic zone surround the taller, centralised wooded vegetation. These include Ngangie Raupunupunu *(Pemphis acidula)*, Beach Heliotrope *(Messerschmidia argentea),* Rakau pakari (*Timonius polygamus*) and *Scaevola taccada*. Occasionally the strand shrub Ngangie Moe (*Suriana maritima*) can be observed.

Figure 7: Oblique aerial photo of Cooks motu showing the transition in canopy vegetation sequence from inner island trees to more salt tolerant shrubs on the exterior

Fauna

Palmerston has been known for several decades as one of the most important sea turtle nesting sites in the Cook Islands (TIS 2020). This includes the Green turtle (*Chelonia mydas*) and Hawksbill turtle (*Eretmochelys imbricata*), listed as endangered and critically endangered respectively. Harvesting of turtle eggs and commercial harvest of

turtles was once common but has largely ceased, although the community have mentioned some individuals succumbing to the commercial demand for turtle meat in Rarotonga on occasions. Cooks motu is a key turtle nesting site, with 24 nest (4 times more than any other motu) found there in 2018 (TIS 2020).

Two species of hermit crabs (*Coenobita brevimanus* and one other *Coenobita spp.*), at least one species of land crab (*Cardisoma carnifex*), and coconut crabs (*Birgus latro*) are present on the Atoll. The latter is listed as 'vulnerable' on the IUCN Red List, but have healthy numbers on Toms, Primrose, Bird, and North Atolls. Land crabs and coconut crabs are absent from Home Island but present in relatively low numbers on Cooks. Low numbers/absence of coconut crabs on Cooks and Home is likely due to harvesting pressures of humans and possible due to predation of young by rodents.

The atoll acts as a layover site for migratory seabirds such as the wandering tattler (*Tringa incana*), pacific golden plover (*Pruvialis fulva*), ruddy turnstone (*Arenaria interpres*), and the bristle thighed curlew (*Numenius tahitensis*). The latter is listed as 'vulnerable' on the IUCN Red List. Palmerston also acts as a nesting site for other seabirds such as the red-tailed tropic bird (*Phaethon rubricauda*), brown and black noddy (*Anous stolidus* and *A.minutus*), brown booby (*Suia leucogaster*), greater and lesser frigate bird (*Fregata minor* and *F.ariel*), white tern (*Gygis alba*) and red footed booby (*Suia suia*). The Pacific pigeon (*Ducula pacific*) is the only land bird.

Rat predation on fauna may not be the only factor limiting the presence/recovery of fauna on Home Island and Cooks motu. There has been a history of harvesting turtle eggs and meat, coconut crabs (which continues on Cooks), and seabirds on the island for both residential consumption and commercial markets in Rarotonga. To see these species recover to sustainable levels may require additional human management measures in addition to the eradication of rodents.

3.4 Human history and governance

Remnants of stone tools and graves were found by James Cook who visited the uninhabited Atoll in 1777 (Gill 1885), providing evidence of early Polynesian visitation or settlement that was subsequently abandoned.

The current population on Palmerston Atoll are mixed Polynesian and English descent, and link back to the first recorded attempted settlement by William Marsters (an Englishman) who settled on the island in 1863 with his three Penrhynese wives. The residents of Palmerston ultimately trace back to these three Matriarchal family lines - the Akakaingaro, Tepou Tinioi, and Matauia families.

In recent decades, the permanent population on Palmerston has slowly declined. During COVID lockdowns, some residents were unable to get back from visiting Rarotonga, and have ended up not returning. The current population on the Atoll is 39. The current population is spread between 12 households.

Palmerston has its own island government, established under the Island Government Act 2012-13. It consists of the Mayor, elected from any of the individual heads of the three families, three other representatives of the three families, and the Member of Parliament who resides in Rarotonga. Members of the Council are elected according to the island customs. An Executive Officer is also appointed by the Island Government, after approval by the Public Service Commissioner, and is the senior public servant on the island. Under the Island Government Act 2012-13, the Island Council can make by-laws for the licensing and regulation of any activities or matters affecting the island.

3.5 Land use and tenure

Land on all of the motu are divided between the three family branches who hold customary land legal status **(Figure 8** shows demarcation of family land boundaries on Home Island). Some islets such as Primrose are divided between two families. The head of the family gives the rights of access to their family areas/sections on the motus. Individual residential sections on Home Island are considered private property, with ownership belonging to the homeowner. For other open spaces within a common family boundary, the Family Head is in charge. For the purposes of the eradication, the Family Heads have given their support for the project to be carried out where needed.

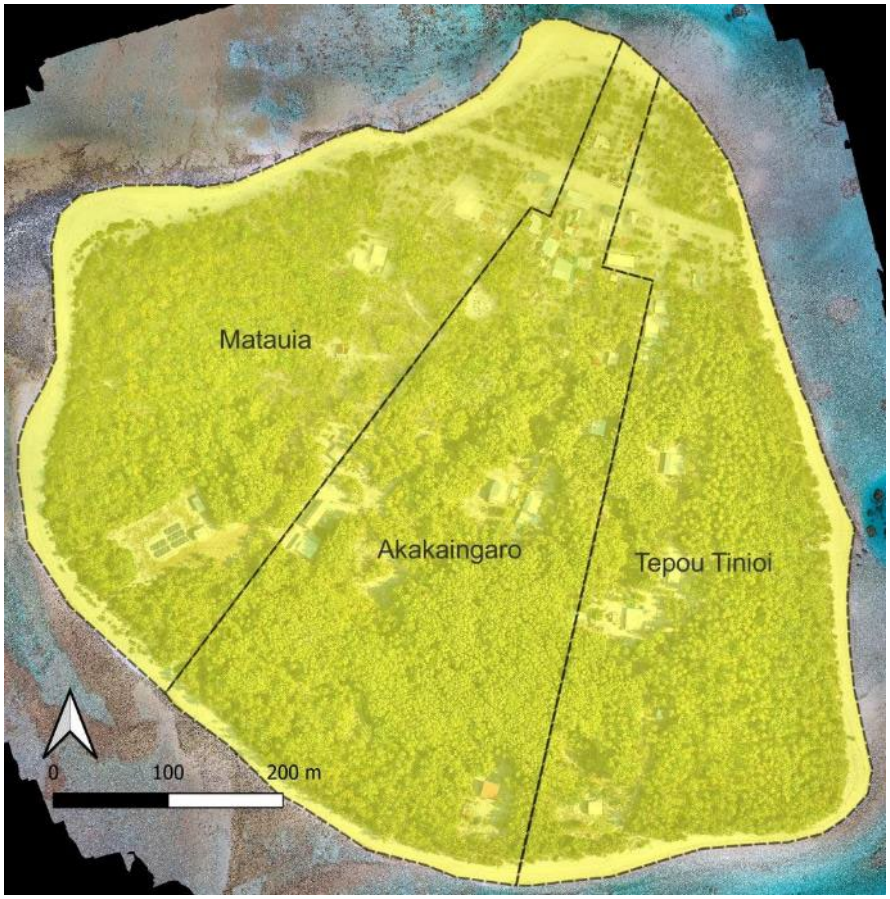

Figure 8: Demarcation of family land on Home Island

Land use on Home Island is a mixture of residential and non-residential buildings, some small-scale agriculture and fruit trees, and for small scale semi-domesticated livestock (pigs and chickens). It is also the base for small dinghy operations that are at work most days for the purpose of commercial and subsistence fishing. The Palmerston community rely heavily on a partially-subsistence livelihood, with a focus on marine resources such as parrot fish for subsistence and commercial export to Rarotonga. Palmerston has the highest fish consumption per capita in the world (Pinca et al., 2009); which is supplemented by fruits and vegetables grown on the island. A hydroponics shed with planters produces tomato, cabbage, lettuce, cucumbers, bok choy, and beans. Other locally grown food sources include coconut, banana, mango, pawpaw, lime, pūraka (swamp taro), sugarcane, breadfruit, bamboo, kumara, dragonfruit, arambola (rapa), nenu (nono, noni), tuava (wild guava) and arrowroot.

DEPENDENCY 1:
Agriculture and produce grown on Home Island presents a significant alternate food source for rodents which may reduce the likelihood of rats consuming bait if preferred alternate foods are present.
The community have come up with solutions to manage these alternate food sources with the project team, and have agreed to implement them prior and during the eradication effort (see appendices 4 and 5 of DOC-7241702).
Proceeding with the operation is dependent on these alternative food sources being managed and operational planning will need to incorporate dedicated effort and resource to manage and monitor the agreed management of alternative food sources.

Land use on the motu outside of Home Island is generally low. Shelters/campsites are present on Toms, Primrose, and Karakarake – which are used infrequently by the community (during school holidays to overnight camp, or for day visits). Toms motu contains several small plots of puraka amongst the forest. The outer motu are also used for the harvest of coconut crabs and land crabs year-round, and during a limited period of the year (September/October) bosun birds (red tail tropic birds). Cooks, Toms, and Primrose are more likely to be visited due to the closer proximity (and therefore less fuel use) than the Bird/Karakarake and North motus. The lagoon and reef is used more actively than the outer motus by the community, who fish daily.

Other locally harvested food sources include brown and red-footed boobies, frigate bird, pacific pigeon, and eggs (birds and turtles).

Pigs are kept as domesticated livestock. Several hundred wild chickens exist over Home Island. Wild chickens are occasionally harvested for meat, but not relied on. 'Semi-domesticated' chickens also exist, which are fed at common points close to residential buildings but roam freely. Eggs are sometimes found opportunistically for consumption, but like meat, are not relied on. Wild and semi-domesticated chickens pose a risk to the eradication on Home Island through non-target consumption of bait, therefore reducing bait availability to the target species. As an added precaution, baiting rates on Home Island are likely to be inflated to account for non-target consumption from chickens.

DEPENDENCY 2:
Significant reductions in roaming chicken populations will be required to reduce the risk of eradication failure due to poor bait availability caused by non-target consumption. Semi-domesticated/fed chickens need to be removed from Home Island (either culled or penned elsewhere), and effort needs to be dedicated to significantly reducing the wild population as much as possible. The community have agreed to do this and the operation should not proceed unless it has been done.
Operational planning should state the effort and targets required, and have contingency resourcing for the issue if field teams show up and chickens are still present. Operational planning should also clarify whether semi-domesticated chickens are penned on another island during the eradication, or if all chickens are culled and replacements are brought in post-eradication.
During the preceding months, PIA should update the Palmerston Working Group as to how the culling of wild chickens in progressing, so that if work is needed during the field phase of the eradication prior to baiting, this can be planned for.

Fifteen pigs in total are kept between all households on Home Island. Some pigs are penned in simple pens constructed from coconut trunks; some are tethered by rope, and some walk freely but do not range out of residential lots.

DEPENDENCY 3:
Livestock on Home Island (chickens and pigs) will consume bait and potentially present a secondary or tertiary poisoning pathway to humans if consumed. Pigs and chickens (or the consumption of) will need to be removed from Home Island so this does not occur.
The operational planning will need to identify the actions, resources and delegations required for managing stock during the eradication. The community have said they will resource this but this will need to be checked and enforced by the project team in PWG meetings, and on the initial arrival of field-teams. All stock will need to be removed from Home Island during and the baiting period, and the community are deciding whether to cull and replace, or temporarily house some stock on Primrose Island (which will require significant resourcing in terms of pen construction, daily watering and feeding, and increase biosecurity risks).

3.6 Existing infrastructure

There are 18 residential/residential accessory buildings, and a total of 66 non-residential buildings (storage, facilities, infrastructure, and dilapidated) dotted across Home Island. Some of these buildings include the administration building, school, government building, Christian church, cyclone shelter, fuel depot, hydroponics shed, Vodafone satellite station and solar power station. The settlement has been fully solar powered since 2015 but also uses a 36kwh generator in addition to solar generation and battery storage. Refrigeration and freezers are present, which support the small fish export market to Rarotonga.

Water supply is from rainwater collected household and accessory building roofs, and stored in tanks. There are also formed wells that are covered, dotted throughout Home Island that are seldom used (not for drinking). There are 3 graveyards on Home Island and one in the yard of a house. Many homes have flush toilet systems and grey water septic systems that lead to an underground septic tank, however some buildings and homes utilise long drop toilets, and greywater from kitchens runs into uncovered pits.

PLANNING ISSUE 1:

The issue is that open black and grey water systems can act as an alternate food source for rats, potentially reducing bait palatability leading to eradication failure. Open black and grey water systems should be treated as alternative food sources and managed so this risk is eliminated during the operational phase of the eradication.

The issue can be resolved by ensuring pre-operation activities address this issue, and the project supporting these actions through provisioning of materials and logistics support from Rarotonga partner agencies. The community have agreed to seal and contain black and grey water by building septic tanks for the relevant households prior to the project team arriving for the delivery phase of the eradication. Progress and updates of this will be provided by the PIA in monthly PWG meetings. Sink sieves can be brought by the eradication team and used in households to empty smaller solid food wastes from drains, to sealed food waste buckets as an additional measure.

A community medical room is present that provides a basic level of pre-hospital care and stabilisation, including a defibrillator. A trained nurse is present in the community. Patients are required to be evacuated by vessel for hospital level care, which is likely to take several days due to finding an available vessel and the travel time to Rarotonga from the atoll.

Cellular phone (Vodafone), a 'fixed' telephone to Rarotonga, and satellite internet are all present to a limited extent on Home Island. VHF communications to vessels take place on VHF Channel 16.
There is a working excavator, quad bike, tractor, and trailer for unloading supplies as well as three heavy machines which are not currently operational.

There are several small passages through the reef for small boats, however there is no safe entry for large ships. The Atoll is out of range to service by helicopter, and has no infrastructure to accommodate fixed wing aircraft landings. Thus the residents rely on inter-island shipping for transportation and food supply. Supplies come once every 3-4 months on average via a freight boat that travels between the Pa Enua, but these have been less frequent since the 2020 COVID pandemic. Pre-COVID, small cruise ships and yachts visited the island, creating additional revenue for locals. In 2016 a total of 64 yachts visited the atoll (TIS 2020). All yachts visiting are required to have a health and agriculture/quarantine clearance, which is authorised by the Executive Officer on Home Island. Crews must remain onboard until the required checks and clearance is complete.

3.7 Target species ecology and impacts

Ship rats (*Rattus rattus)* and kiore (*Rattus exulans*) are both present on Home Island, and kiore are present on Cooks motu. Significant rodent detection effort took place on the Atoll in November 2022 to provide a high level of confidence that rodents are absent from all other motu (see DOC 2022). This is reinforced by the 2018 baited coconut crab surveys across vegetated motu that also observed rodents only on Home and Cooks (Kora and Munro 2020).

Origins

Based on observations of 'small brown rats' from Captain Cooks visit in 1777 (Beaglehole 1967), kiore were likely brought to Palmerston by early Polynesian voyagers. The period in which ship rats arrived is unconfirmed, but common anecdote amongst the residents of the Atoll is that the larger rats (ship rats) came from a copra transport schooner known as the Taipi, which wrecked inside the Atoll in 1948. Ship rats are often distinguished as 'taipi rats' by the community as a result.

Home range, preferred habitat, and known distribution

The smallest home range size reported in literature is 0.015 ha in area for kiore, which have smaller home ranges compared to ship rats (Wirtz 1972; King and Forsyth 2021). The size of the home range of breeding adults is not affected by density fluctuations or reproductive activity (Wirtz 1972), but it is likely that some individuals will not be actively foraging at any point in time e.g. pups and breeding females. Weaning times reported for *R. exulans* (Wirtz 1972; Tobin, 2005) and *R. rattus* (Cowan, 1981) range from 21 to 28 days.

From fieldwork undertaken in November 2022, kiore were found across all broad habitats surveyed on Home Island and Cooks motu. Catch rates for kiore did not appear to significantly differ between broad habitat types on Home Island (see **Figure 9**).

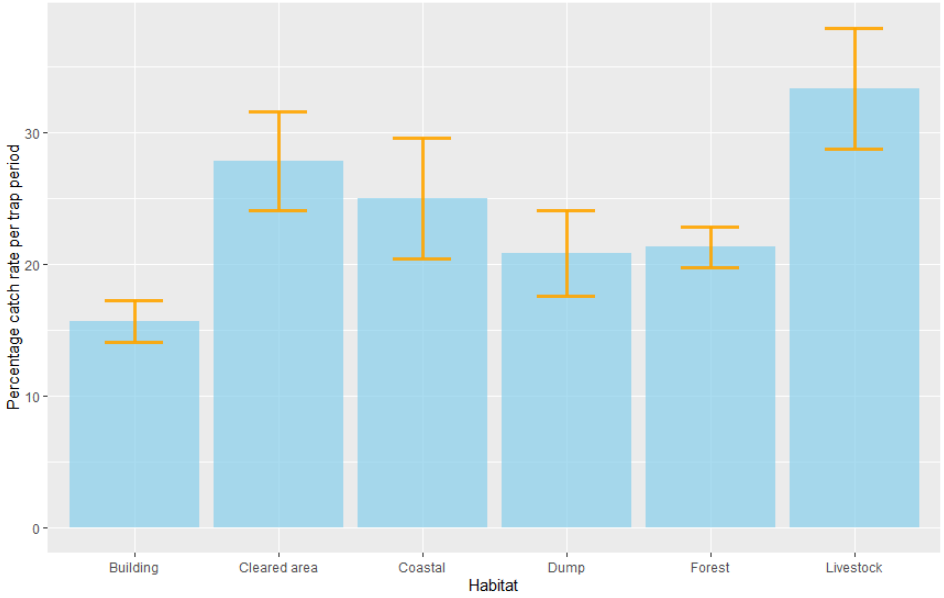

Figure 9: Catch rates per trap period on Home Island for kiore across different habitat

Condition of Kiore (**Figure 10**) was found to be significantly better on Cooks compared to Home (body size larger and heavier), which may correlate to food availability on the relevant motu.

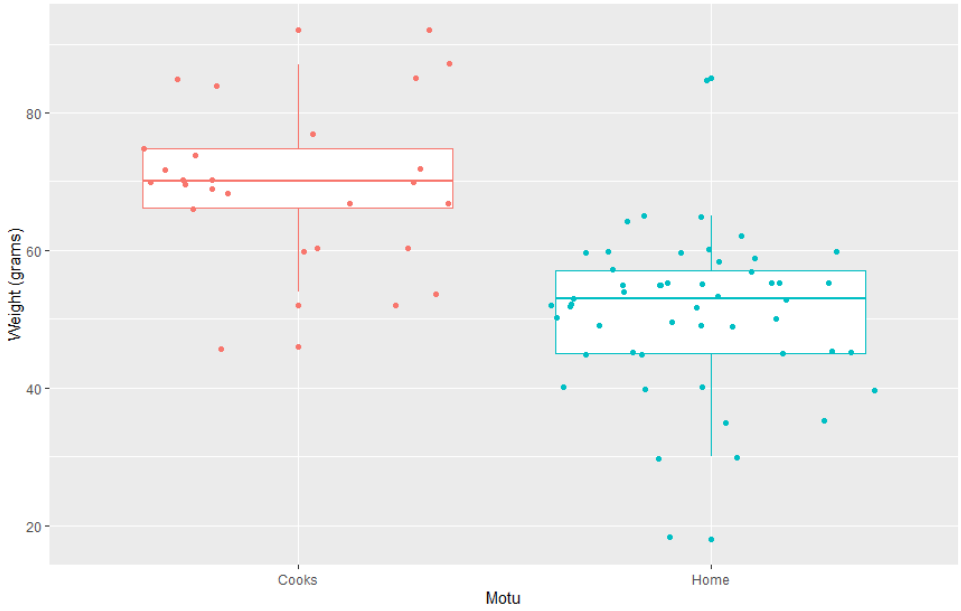

Figure 10: Comparison of distribution of weight of individual kiore between Cooks and Home motu.

Results from fieldwork gave the perception that kiore were dominant over ship rats, with only one ship rat being caught for every ten kiore caught. The five ship rats caught were all caught in one particular area on a single transect, rather than from traps across the island. This potential finding of kiore dominance is inverse to the normal relationship in which ship rats are the dominant species and are known to successfully displace kiore from most environmental niches and largely outcompete kiore over much of its global range where the two species overlap (Spennemann 1997; Atkinson 1985; Long 2003; Varnham 2010).

PLANNING ISSUE 2:

The issue is that there is uncertainty about the relationship between kiore and ship rats on Home Island. From the limited observations and data available, kiore are widespread and appear dominant over ship rats. Ship rats have only been detected around resident buildings, often coming from neighbouring coconut palm canopies. If ship rats spend aa lot of time in the canopy, or are submissive to kiore – it is important that bait is available over a long period to ensure that when kiore have eaten bait and died after the first bait application period, or when ship rats come down from the canopy, there is bait present for them to consume.

This issue can be best addressed by ensuring bait quantity is sufficient, and that applications are spaced sufficiently that kiore would have eaten bait and died before a 2nd application, and bait is almost continuously present between the 1st and 2nd application.

The presence of ship rats on Palmerston Atoll increases the chances of self-establishing populations on the outer motu due to the swimming ability of ship rats compared to kiore. Ship rats are probably capable of swimming up to 800m (Jacques 2021.) in cooler temperate waters in New Zealand, and this distance could potentially increase in the warmer tropic waters of the Palmerston Atoll lagoon. Kiore on the other hand are relatively poor swimmers, with many examples in the tropics where parts of atolls have remained uninvaded by kiore when existing <50m from source populations (Richard Griffiths Pers comms.).

Impacts

The eradication of rodents from Palmerston will have significant benefits for both biodiversity and the livelihoods of people living on Home Island.

The impacts of introduced rats on biodiversity and island ecosystems is well documented. Introduced rats have a significant impact on island ecosystems and have been one of the leading causes for species extinctions of mammals, birds, invertebrates, and reptiles (Atkinson 1985; Towns et al. 2006, Hutton et al. 2007; Duncan and Blackburn 2007). Rodents have significant impacts on seabirds, preying upon eggs, chicks, and adults and causing population declines, with the most severe impacts on burrow-nesting seabirds (Atkinson 1985; Jones et al. 2008; Towns et al. 2006). In addition to the predation of fauna, rodents feed opportunistically on plants, and alter the floral communities of island ecosystems (Campbell and Atkinson 2002); in some cases degrading the quality of habitat for fauna that depend on the vegetation (Wegmann 2009, Young et al. 2010).

On Palmerston Atoll, there is a noticeable absence of seabirds present on Home and Cooks Island relative to the other vegetated motu which are rat-free. Both kiore and ship rats are likely to have a negative impact on bird species that breed on these islands, especially the smaller ground-nesting species, due to direct predation of eggs, chicks and nest disturbance.

Rats have been acknowledged as a possible predator of young coconut crabs, which could be particularly vulnerable due to their smaller size and soft shells at earlier life stages (Harper & Bunbury 2015, Samaniego et al. 2019). Rats are also known predators of turtle eggs and hatchlings, which is of particular concern for Cooks motu which has been identified as a relative stronghold breeding area for turtles.

The effects of rats on the livelihoods of the Palmerston community are obvious. All food and stores must be kept in sealed containers, otherwise they are prone to being consumed or contaminated by rats. Agricultural yields are diminished as rats consume crops such as cucumbers, coconuts, mangos, and guava. Where infrastructure exists, rodents feed, chew holes, urinate, and defecate – often ruining household items and clothing. There is a potential increased risk of diseases such as leptospirosis and salmonellosis due to the presence of rodents in commensal areas. As such the eradication of rats will lead to increased food security, reduction of stress, reduce the risk of illness; and make time available for other activities.

Control history

Sporadic attempts of rat control take place on Home Island, with snap traps placed in homes, and rodenticide blocks also used in several households. Rodenticide blocks which have historically and are currently being used are ‘Rentokil rat blocks’ - 20g blocks containing the active second generation anticoagulant bromadiolone (0.05g/kg). Blocks are often left open around households, or in open cans that are attached to trees.

PLANNING ISSUE 3:

Current use of rodenticides by the community should cease in anticipation of toxic baiting during an eradication. Although bait avoidance or potential resistance to anticoagulants is unlikely, this reduces the risk. The PIA should cease supplying baits immediately and ensure households cease using baits by March 2023. Snap traps can be used in households as an alternative.

An inexperienced field attempt to remove rats from Cooks by the community has occurred in the past, using rodenticides in bait stations made from icecream containers with entrances cut in them. Density, intensity, and distribution of bait stations during this attempt was far less than required to succeed..

3.8 Other pests

A number of stray and domestic cats exist on Home Island. Cats are classified as stray as they do not seem to be truly wild, with most living/hiding around human residential areas, but obviously wary of humans. In general, stray cats appear in poor condition, and are likely to survive through scavenging household rubbish, and hunting lizards, chickens, and rats.

Two households keep domesticated cats. One household has a single cat that is neutered, while the other household has three cats – which are more akin to stray cats which are fed rather than domesticated inside cats. With the exception of these two households, the remaining ten households in the community had no issue with the incidental poisoning of cats which is likely to occur via secondary poisoning with consumption of rats that have been poisoned during a toxic baiting operation. Based on operational experience, it is unlikely a coincidental eradication of cats will occur from secondary poisoning, so if the community wishes to eradicate cats – a clear decision will need to be made and relevant planning and actions identified and resourced.

PLANNING ISSUE 4:

There is an opportunity to eradicate stray/feral cats from the atoll through secondary poisoning via rats during the eradication, however the community need to agree and set rules around compulsory neutering if new cats are to be brought to Home Island from Rarotonga. The planning issues are that:

- The community need to decide if they want cats to stay or go

- If they are to go, a cat eradication project needs to be planned

- Preventing new cats being brought in has to be firmly established in island policy

Management of the domestic cat population during the eradication will need to include confinement of identified individual cats, until the risk of secondary poisoning through carcasses is absent. This will require carcass degradation monitoring to be established. If the community wishes to eliminate stray cats and the possibility of cat populations establishing in the future, any domestic cats on the island should be neutered.

A logistically simpler alternative would be for a new neutered cat/s to be brought in from Rarotonga to replace domestic cats that are not neutered, if this solution is acceptable to the relevant household.

In either case, the eradication of cats is outside the scope of this project, but it is acknowledged that should the community want it, it is a good opportunity for the community to eradicate cats from Home Island following the rat eradication.

4. Why do it?

4.1 What is the goal?

The goal of the project is to eradicate rats from Palmerston Atoll, with confirmation of success by April 2024.

4.2 Is eradication the most appropriate pest management tactic?

Eradication is the most appropriate management tactic (as opposed to sustained control or containment). Eradication of rats on Palmerston will allow the best outcomes for human livelihoods and biodiversity outcomes, and eliminate the risk of rat populations establishing on additional motu in the Atoll. Sustained control was not considered as it is unclear what densities to which rats would need to be suppressed to meet the project outcomes; it would be problematic to sustain; and is regarded as substantially less cost-effective than eradication (Pascal et al. 2008).

4.3 What are the objectives, outputs, and desired outcomes?

Table 1: Project objectives, outputs, and desired outcomes

Area	Objective	Output	Outcome
Biodiversity	• Rats are eradicated from Home and Cooks motu	Implementation of the eradication project and subsequent report	The Atoll is rodent free and remains so
	• All islands on Palmerston Atoll remain free of rodents	Implementation of biosecurity and ongoing reporting	Rats are prevented from impacting ecosystems on the other motu in the Atoll, and Home and Cooks motu ecosystems are improved and maintained in a healthy and functioning state.
		Monitoring and reporting of outcomes	Long term, seabird numbers increase on Cooks motu.
Community/ Livelihoods	• Community is supportive of eradication and ongoing biosecurity	Community attitudes are reported	The local community benefits from the eradication
	• Increased food security for the Palmerston community	Measurable increase in agricultural yields reported by the community	An increase resilience of the community through more secure food production
Partnerships	• Work collaboratively to achieve conservation outcomes with NES, TIS, MOA, and the Palmerston community	The success of partnerships is reported on	Capacity and understanding of rodent eradications, island biosecurity and project management is built amongst partners
Knowledge	• Increased knowledge and capacity of in-country organisations and communities with invasive species management	Individuals from partner organisations and the community are involved in delivering the eradication	Organisations and individuals have the capacity to provide experience to future invasive management projects. Feedback received from partner agencies.
		Project documented	Capacity and knowledge are increased and shared

4.4 What are the potential ecological consequences of eradication?

Based on results from other island rodent eradication efforts around the world, it is likely that the eradication of rats from Cooks Motu and from Home Island will see significant ecological benefits.
Particularly on Cooks, where cats and wild chickens are absent, the removal or rats should see a recovery/increase in the abundance, and potentially diversity, of fauna. This includes seabirds known to the Atoll and surrounding motu,

invertebrate and herpetofauna species, and potentially an increase in the survival of turtle hatchlings and juvenile coconut crabs. All of which would result in increased population sizes for these species, which would increase the resilience of these populations to withstand environmental pressures such as climate change.
Coconut crabs and seabirds on non-rat occupied motu have been noted as relatively abundant compared to Home and Cooks (TIS 2018; TIS 2020), and therefore provide a proxy to what recovery may look like on Cooks if human harvest is managed sustainably.

Habitat disturbance and harvesting of birds/crabs/turtles are activities which occur regularly by residents of Palmerston. For recovery of these harvested species to occur after the eradication of rats on both Cooks and Home Islands, management of harvests will need to occur in a way that allows the relevant species to recover to a level that will allow sustainable harvesting. This is outside of the rat eradication project scope, but worth noting.

Wild chickens and feral cats are also present on Home Island, and while these are not in scope of the eradication, numbers of both are likely to be significantly affected through primary and secondary poisoning during a toxic baiting operation. Recovery of these populations will negatively affect the recovery of invertebrates, lizards, crabs, and birds on Home Island. Wild chickens may become more prolific in the absence of rodents, due to potential food resources increasing. The eradication provides an opportunity and resources for the community to remove both wild chickens and feral cats from the island.

The eradication of rats is also likely to result in markedly increased seed and seedling survival which were previously eaten by rats. This can lead to an increase in density of the understorey and an increase of diversity in forest canopy longer term (Harper 2020). The same response may be seen in invasive weed species if noxious weed species are present and being suppressed by rats (this has not been observed on Palmerston Atoll).

Although the long-term potential ecological consequences of the eradication will be positive, short-term potential negative ecological consequences could include short-term impacts to non-target species due to direct or indirect poisoning from the use of rodenticides; and the short-term fluctuations in the abundance of resident species, for example the removal of rats could lead to an increase in invertebrate species that could in turn lead to short term impacts to plant life.

4.5 What are the potential social consequences of eradication?

Positive social consequences anticipated from the eradication of rats from Palmerston Atoll include:

- Increased local food security in the long-term from the likely increase in agricultural crop yields from locally grown produce such as coconuts, mangos, pawpaw, breadfruit, cucumbers, capsicums, bananas, and sugar cane.
- Increase biosecurity awareness and pragmatic biosecurity processes instigated by the community, which may help prevent other unwanted invasive organisms arriving and impacting on the community. Increased biosecurity awareness and procedures of external stakeholders in Rarotonga (ports and shipping companies) will benefit invasive species prevention on other Pa Enua communities in the Cook Islands.
- Improved hygiene and sanitation in living and cooking areas due to the absence of rats, and eliminate potential contamination of water sources
- Increase food security from eliminating rodent consumption and spoiling of stored dry goods and food products.
- Improvement in mental and physical health from the absence of rodents – through increasing time availability from not having to clean the mess of rats daily, and the time spent storing and securing food stores from rats.
- Reducing long term use of rodenticides for rat control that have been used continuously in the past and may be present in local food sources (pigs/chickens etc).

- Long-term increase native species populations that could be sustainably harvested with appropriate management
- Upskilling of local community members, particularly members of the Palmerston Island Administration, in rodent ecology, monitoring, and biosecurity.
- Upskilling collaborating partner organisations (NES, MOA, TIS) in invasive species management and project management.
- Strengthening New Zealand and Cook Islands relations
- Community seen as national leaders in eradicating rodents and other Pa Enua (outer islands) in the Cook Islands may follow the example.

Possible negative social consequences of eradicating rats from Palmerston Atoll are generally short-term and could include:

- The time and resources spent leading up to and during the operation to ensure the eradication has the best chance of succeeding. This includes changing lifestyles, prioritising waste management, clearing agricultural crops that may act as an alternative food source to rats during the eradication period, and other actions that may be inconveniences – all to ensure alternative food sources and habitat are reduced as much as possible during the operational phase of the eradication.
- Livestock either culled or temporarily moved until withholding period has ceased on Home Island. Penned livestock will be located on another motu and require daily commutes to feed.
- All eradication operations carry the risk of failure. If this were to occur, a loss of support from the community for future efforts and projects could occur.
- Long term rahui on eating wild chicken that were present during baiting on Home Island due to the possibility of long-term presence of toxin in flesh
- Short term (6 month) rahui on harvesting coconut crabs from Cooks motu. Other sources of coconut crabs exist on the surrounding motu.
- Extra vigilance and ultimately time spent on biosecurity and transport of goods to the Atoll to avoid a rodent population re-establishing. Not only by the community, but to externals such as shipping companies in Rarotonga

4.6 Is the proposed eradication consistent with other planning documents?

The Palmerston community developed an Island Strategic Plan which sets the community's goals and aspirations under the vision "committed to building a better future together". The plan outlines how the Island Council and island government will improve the welfare of the island through improved and sustainable management of natural resources and the island's assets. Following this, in 2018, the Palmerston Island Council made a request through Te Ipukarea Society (TIS) to the Ridge to Reef project for a rat eradication project which did not proceed due to lack of funds. Eradication of rats is also supported by recommendations in the Palmerston Island Coconut Crab Assessment 2020 that was conducted in 2018 (Kora and Munro 2020) and Palmerston Island Natural Resource Management Plan 2020 (Tis 2020) which is intended to help guide sustainable development.

Alignment of the proposed eradication with other national legislation and planning documents is outlined in **Table 2** below.

Table 2: Alignment between national priorities and the proposed rat eradication

Legislation/planning document	Relevance of documents to project

National Sustainable Development Agenda (2020) (NSDA 2020)	- Goal 10 – Agriculture and Food Security
	  o Indicator 10.3 Minimise the impact of a biosecurity outbreaks
	- Goal 11 – Our Biodiversity and Natural Resources
	  o Indicator 11.6 Biodiversity Index
	- Reduction of the adverse impact of invasive species on indigenous and agricultural species and ecosystems
	  o No rats on the Islands of Palmerston

NES Environment Act 2003	- Protect, conserve, and manage wildlife in the Cook Islands, particular protected species.
MOA Biosecurity Act 2008	- Management of border control and quarantine and regulation of the movement of animal and plant pests and diseases and of animals and plants.
National Biodiversity and Action Plan (NBSAP)	- Invasive species management was one of eight themes in the initial NBSAP, with goals to reduce the adverse impacts of invasive species on indigenous species and ecosystems and on agricultural species and ecosystems, including preventing new invasions.
National Invasive Species Strategy and Action Plan (NISSAP)	- Conduct a feasibility and cost-benefit of eradicating rats from Palmerston, - Implement a plan for rat management on inter-island shipping - Assess opportunities for Island councils to introduce by-laws to reduce risks posed by invasive species

5. Is it achievable?

5.1 What control tools will be used?

The proposed method for eradicating rodents from Home and Cooks motu is the use of 2nd generation anticoagulants combined with a highly palatable cereal bait, distributed across every rat territory in a methodical and comprehensive manner. This method has been developed and refined over many years and in many different eradication projects, in a range of different ecozones, including islands in the tropic zone. Anticoagulants cause death in rats by preventing blood clotting, causing internal haemorrhaging. The effects of the anticoagulants are not felt by the rats until a few days after consumption, meaning bait avoidance or shyness is unlikely before receiving a lethal dose. 2nd generation anticoagulants are more potent and more persistent than 1st generation anticoagulants, but do not require multiple feeds and a lethal dose can be attained through a single feed of bait. This is a characteristic suited to tropical rodent eradications where competition for bait from non-target consumers (such as crabs and invertebrates) is usually high, and natural food availability is high year-round.

Trapping is not considered an option for eradication of rodents on islands larger than 5ha, and operational area aside, trapping almost invariably results in a small percentage of rodents escaping or becoming wary of traps so does not achieve the eradication principle of exposing every individual.

Pestoff 20R bait is the proposed bait product to be used for the eradication. Pestoff 20R is a cereal bait containing 0.02 g/kg of the 2nd generation anticoagulant brodifacoum. Of the second generation anticoagulants available, brodifacoum is the most commonly used anticoagulant in rodent eradications (Howald *et al*. 2007, Parkes *et al*. 2011). Brodificoum has been used as a rodenticide in the Cook Islands in eradication attempts on Suwarrow, and as a rodent control bait in the Takitimu Conseration Area in Rarotonga.

The proposed application method of toxic bait is using hand broadcast. Bait broadcast application by hand has been chosen over bait stations as broadcasting provides increased bait availability to target species through better coverage, does not require targets to enter a foreign object to feed, and is less resource intensive; all of which will reduce the chances of the eradication failing. Whilst best practice baiting guidelines for tropic rat island eradications recommend forested islands over 30ha use aerial broadcast (PII 2022), aerial broadcast of bait by helicopter is not an option due to the remote location of Palmerston Atoll being out of flight range of the nearest commercially available helicopters, and the cost of logistics in shipping helicopters and buckets is prohibitive for the project.

Unmanned Aerial Vehicle (UAV) treatment was considered but would take 5 days per operational block and was over 30% more costly than hand broadcast. Recent review of UAV aerial baiting operations has also identified reliability issues (see DOC-7058623).

Hand broadcast should be manageable on Cooks and Home Islands given the flat terrain, but good training and operational management will be required to ensure adequate and even bait spread. Hand broadcasting has been used to eradicate rats in the tropics successfully elsewhere on islands up to 300ha (PII 2022).

On Home Island, where a number of buildings and residential houses are present (86) – paper bait trays containing Pestoff 20R will be used inside of buildings and roof-spaces, in combination with hand broadcast of bait in outside areas. This is to eliminate the persistence of toxic baits in areas where they will not be exposed to environmental processes (precipitation and microbiological activity in the soil) that are needed to break them down.

5.2 What is the eradication design?

Timing of bait application phase is proposed to be in July/August, which sits within the dry season (June – October) of the Atoll. This period has been targeted as it likely the time of natural food scarcity meaning lower numbers of rodents, less breeding/young, and coincides with the timing of lowest crab (non-target consumers) activity due to less rainfall in this period. Lower rainfall means bait will be present and palatable for longer as it will not lose form and breakdown as fast as when rainfall is present.

A 20 metre by 20 metre grid will be cut and marked across both motu. Flagging tape on wooden sticks or flagged pegs in open areas will demark 20x20m grid points where bait will be hand broadcast from. For Home Island this will consist of approximately 34 transect lines, consisting of 5 – 40 baiting points per line, as per indicate in **Figure 11**. This methodology has been trialled on both Home and Cooks motu in November 2022 during the bait availability

work with non-toxic bait, cutting 20x20m grids over a 3.5ha and 2.5ha respectively. This experience provides confidence for using this method.

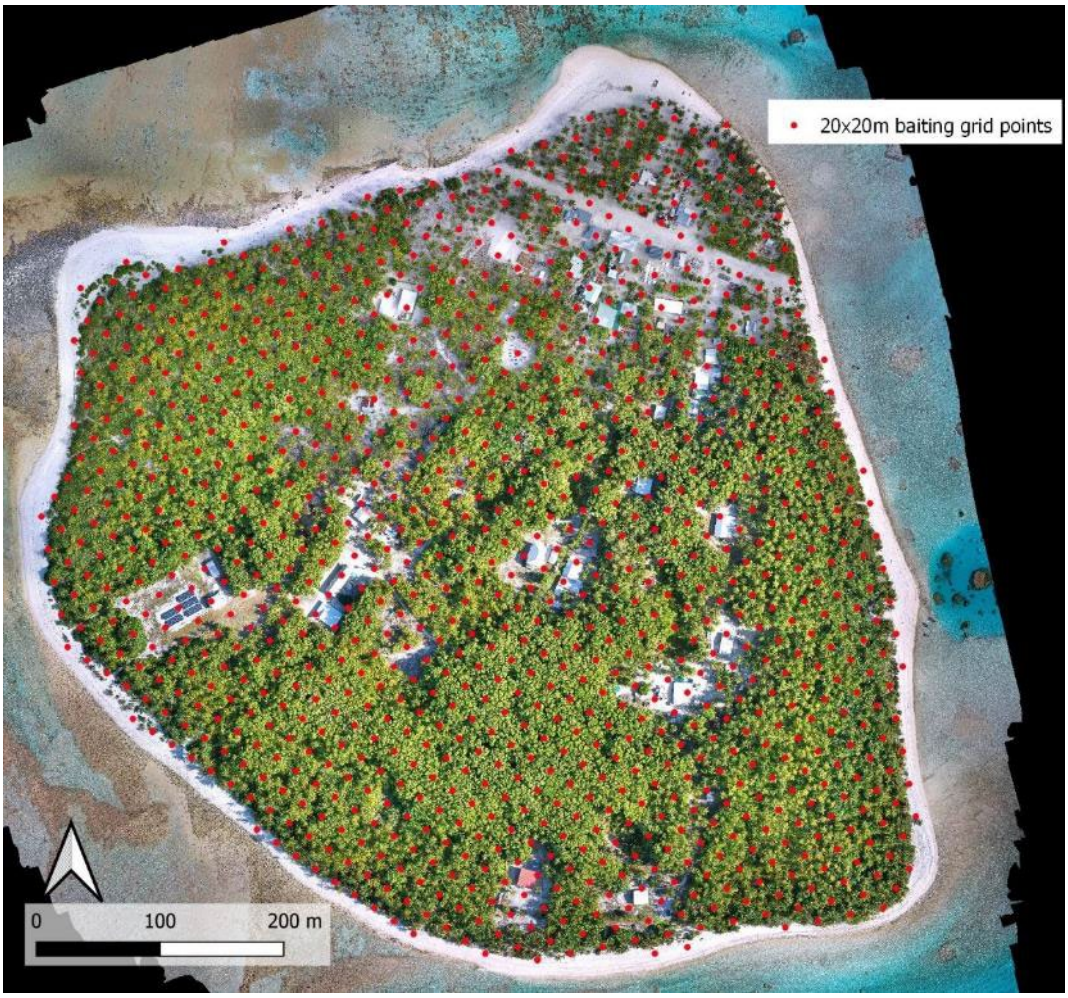

Figure 11: Example of 20m x 20m baiting grid layout on Home Island.

In addition to the 20x20m grid broadcast application across each island, each application will include additional perimeter baiting at 20m intervals around the island perimeter at the same prescribed broadcast application rate used for the grid.

Two hand broadcast applications will occur on each motu, with the 1st and 2nd applications on each motu being spaced atleast 10 days apart. Bait applications for each motu will be completed in a single day. Two applications of bait help counteract unforeseen bait loses (e.g. from weather); allows young rats emerging from nests after the first application to be exposed to fresh bait in the second application; and a second application may help target a sub-dominant species where two rat species are present (as is the case on Home Island).

Broadcast bait application rates for the first application will be 20kg per hectare on Home Island, and 30kg per hectare on Cooks motu. These rates are based on how much bait was needed to be available for four nights based on bait availability studies carried out in November 2022, with contingency added for confidence. Bait availability monitoring at each motu will occur during the first and second application over the first four nights. If bait availability is high after the fourth night, and crab activity/conditions appear low, a reduction in bait application rates for the second application may be considered; however enough bait will be on hand to apply the same amount of bait in the 2nd application.

Bait trays inside of buildings will be placed with 20 pellets per tray on the same day broadcast application is occurring. Each bait tray will be monitored daily and replenished, with a record of bait take kept. Bait trays will be checked daily until 3 consecutive days of no bait take has occurred, then will be checked weekly for a fortnight.

In addition to buildings on Home Island, other areas that have been identified as requiring special baiting are outside kitchen areas that are often under tarpaulins areas; in old rubbish burning pits; and any piles of material that might act as three-dimensional habitat for rats; long drop toilets (which will stopped being used prior to the eradication); and around domestic vegetable gardens and hydroponics areas.

Approximate bait calculations for the proposed methodology can be found in **Appendix 1**.

PLANNING ISSUE 5:

Proposed baiting applications rates are based on bait availability studies conducted in November 2022, with 'fat' added in to provide confidence that bait will be present for rats for four nights whilst accounting for rat density and non-target consumption.

The issue is that it is possible that during the eradication operation environmental variables are different and result in non-targets consuming more bait than anticipated, meaning all rats do not have access to bait.

To counter this, it is proposed that bait availability plots are established and measured for 4 successive nights after each bait application.

In the event that the highest bait availability plot consumption on an island shows significant levels of bait still available by the fourth night, an appropriate reduction of the application rate may be made for that island for the 2nd application.

If bait availability plots indicate plots running out of bait by or before the fourth night after the 1st application, there is adequate contingency bait planned for to allow up to double the application rate on the 2nd application.

5.3 Can all individuals be placed at risk?

The proposed eradication design (timing, spatial distribution, and intensity) should reasonably put all individuals at risk. Bait availability studies were conducted in November 2022 (see DOC 2022) on both Home and Cooks motu to determine appropriate baiting densities that would provide bait availability for rats for a minimum of 4 nights (as suggested for best practice in Keitt *et al* 2015). The suggested baiting rates in the proposed methodology are based on these, providing confidence that the amount of bait being used is enough to account for non-target consumers and the density of rats present on the motu. The bait availability study was run in November, generally a time of year with more rainfall than the July/August period targeted, meaning it is likely rodent densities will be less and crab activity (non-target consumers) may also be less. Full details of the bait availability methodology and results can be found in DOC-7241702, and four night bait availability results can be found in **Appendix 2**.

The most recent published best practice for tropical rat eradications (Keitt et al. 2015) recommends a 10-21 day spacing between bait applications to allow for the maximum period for when a young rat emerges from a nest. In the nine years since this best practice was written, many tropic island rodent eradications at similar latitudes to Palmerston with similar vegetation and non-target bait consumers, have successfully eradicated rodents with a period of less than seven days between bait applications.

For Palmerston, it is proposed the spacing between the first and second bait applications on each motu is at least 10 days apart. The proposed bait rates and application spaces are in line with recent successful 'dry' tropic island eradications that have used lower bait rates and a shorter period between first and second bait applications (17kg ha in Arrecife Alacranes as per Samaniego et al 2018; and 16kg per ha in Reiono Island as per Samaniego et al 2020). As previously discussed, contingency bait will be available to deliver as much as double the planned application rate for the 2nd application if bait availability monitoring does not provide confidence that all rodents have or will have access to bait.

Other non-target consumers (domestic chickens, domestic pigs, and wild chickens on Home Island) will be managed to ensure bait is available for target species. Domestic pigs and chickens on Home Island will be culled, as decided on by the community – with the project bringing in new stock from Rarotonga after risk of primary and secondary

poisoning has subsided. Wild chickens on Home Island present more of a management challenge. It is estimated one to two hundred wild chickens are present. When bait softens (through humidity or rainfall) cereal baits become extremely palatable to chickens, and groups of wild chickens present a significant risk to bait availability. In general, chickens are only found in groups where they are fed by residents, and wild chickens tend to stay as individuals or with their young. The community have agreed to significantly reduce the wild chicken population several months prior to the operational phase of the rat eradication.

The 20x20m grid proposed is more intensive that the minimum requirements (25x25m) suggested for best practice for eradication of kiore, providing confidence and a larger margin for error in regards to for bait coverage to ensure every individual has access to bait.

Landowner permission and access to every building has been granted and reassured by the island council, and all residents in the community have agreed to the principle of bait being openly broadcast on the islands, and open bait trays being used inside all rooms in all buildings, and in roof spaces where roof spaces are present.

DEPENDENCY 4:

There are a number of buildings present where the occupier is not present on the island. Access to these buildings are needed to ensure baiting occurs within them and every rodent has access to bait. Some of these buildings are used as unorganised storage and potential act as significant rodent habitat.

For the operation to occur, the Island Council and community must ensure the baiting team has access to every building for baiting for the delivery phase. The Island Council and PIA have ensured this will be the case, and that the heads of families will have access to every building for the purpose of baiting during the eradication, and for clearing rubbish and clutter prior to the operational period.

One of the significant risks associated with the eradication is the presence of alternate food sources. Presence of alternate food may decrease the likelihood of rats consuming toxic baits. As part of previous fieldwork, potential alternate food sources that needed (and could pragmatically) be managed were identified, and management solutions have been proposed and agreed upon by the Palmerston community, Island council, and project team. These are listed in **Table 3**.

Table 3: Identified alternative food sources for rats, and agreed management measures.

Source	Issue/description	Management required
Wastewater (grey water)	A number of household kitchens currently drain into open holes rather than closed tanks. Rats could potentially survive on fat and food scraps from sink waste.	Community will construct underground septic tanks at the identified eight households by April 2023. Project will also provide sink plug sieves to catch food waste which can be emptied into sealable food waste buckets.
Household rubbish	Household rubbish, particularly food packaging, can be a food source to rats. Household rubbish is often not cleaned well and thrown in open pits to be burnt at a later time.	A waste management system will be in place prior and during the operational period, where household rubbish is cleaned, sorted into plastics, glass, burnables, and foodwaste, and placed in sealed buckets. These buckets will be collected and replaced daily by Island Administration, and stored centrally. Food waste will be taken off-island to feed penned livestock, or disposed of by boat outside of the reef.
Food waste	Discarded food from meal preparations, to discarded coconuts, are a food source to rats. Current practice is to discard in the bush, burn, or feed to stock.	Household food waste will be part of the household rubbish system described above. Pictorial educational materials have been created to remind people to dispose of food scraps appropriately.
Livestock excrement/scraps	Livestock pens containing chickens or pigs provide a source of food from scraps fed to stock, or from animal excrement.	Sub-population of stock to be penned on rodent free motu (most likely Primrose) and the remaining livestock culled for food prior to the operational phase of the operation. Penned stock will be fed and watered

		daily via boat immediately prior, during, and several weeks post baiting period.
Wild chicken eggs/chicks	Wild chickens present a food source for rats in the form of eggs and young chicks.	Community to instigate significant effort in wild chicken culling to reduce the risk of alternate food and non-target bait consumption.
Human food	Human food stores can be a source of food for rats.	Community store all food in rat proof materials (already done). Storing fresh fruit and vegetables in rodent proof containers is challenging in such humid and hot environments, and as a result the community have sought to remove fresh fruit and produce immediately prior, during, and the weeks after the baiting phase – using dry goods, frozen goods, and canned goods only.
Rubbish holes	Given rubbish burning holes often house rubbish that can act as food for rats, most rubbish holes were observed to have a significant number of rat (kiore) burrows on their side walls. At present each household has atleast one rubbish hole it uses.	Several weeks prior to the baiting, all rubbish holes will be burnt off as hot as possible. From this point, household rubbish will be collected by the Island Administration and all burnables from Home Island will be burnt in a single delegated burning drum administered by the Island administration, and household rubbish holes are not to be used. During the baiting phase, bait will be specifically broadcast in rubbish holes to ensure rat access to bait.
Fish cleanings	Fishing occurs daily and catch is brought back to Home Island for cleaning/gutting on land. Entrails/cleanings are usually discarded in the lagoon immediately adjacent to land. Remnant cleanings in the fish processing area can act as a food source for rats.	Extreme vigilance is required in the cleanup of fish gutting/cleaning. Processing areas should be on a hard, wipeable surface, so that scraps can be easily recovered and stored in sealable containers, if not disposed of at sea. Current practice of disposing fish cleanings in the lagoon is acceptable, but this should be centralised so all families are disposing daily far enough out in the lagoon, where black tipped reef sharks aggressively feed on the scraps, and there is no risk of remnants washing to shore.
Agricultural produce	Sugar cane, banana, carambola, guava, breadfruit, and sweet nuts are all grown and may fruit/ripen during the operational period.	Families have agreed to pull sugar cane crops out and seek new cuttings from Rarotonga after the eradication period. Guava, banana, breadfruit, and carambola will be harvested/pruned/cut back during the June/July period. Known sweet nut trees will be picked/rowed and cleaned off by the community before the baiting application.
Domestic garden produce	Domestic gardens and the school gardens/hydroponics produce capsicum, cucumbers, greens, and other food sources for rats.	These gardens will be harvested a week before bait application by the community.
Long drops	Some houses (and school) utilise long drops. These longdrops are not sealed and human excrement can act as a food source to rats.	Long drops will be sealed off and not used for two weeks before the arrival of the field team for the operational phase. All residents will have access to a flush toilet during the eradication period.
Coconuts	Coconut husk piles are common, and husks can sometimes contain remnant coconut meat that can act as a food source to rats	All husk piles to be burnt prior to the operational phase. More husk will inevitably be created as they are consumed daily, but should be managed as household food waste as per above and be stored in sealed containers that are collected daily to be either feed to livestock or discarded outside the reef.

DEPENDENCY 5 and PLANNING ISSUE 6:

There are a high number of potential alternative food sources (as identified in Table 3 and previously identified dependencies) that have the potential to lower the attractiveness and therefore palatability of bait to rats. The number of alternative food sources and the management of them adds a level of complexity to the operation. This will require a detailed plan, resources, and personnel allocated to managed these risks adequately in the operational plan).

Carrying out the eradication will be dependent on the establishment of management systems to the risks identified as per Table 3.

Coconut palms are present and are a dominant canopy species on both Home Island and Cooks motu. Observations from the field team and community are that rats utilise the canopy of coconut palms frequently, and many of the community are concerned that rats nest and live in the palms and may not come to the ground during the period bait remains readily available there (a minimum of 4 days). A review of operational and research from tropic island eradications in the past decade, as well as communication with practitioners (R Griffiths, A Samaniego Pers comms.) have shown that it is unlikely that rats are truly arboreal in these scenarios. Rats that live in the canopy will come to ground to feed, as will rats that live on the ground will access the tree canopy. Operations in similar environments, where coconut palms are dominant in the canopy, have successfully eradicated rats with ground based bait applications without the need for baiting tree canopies, but as previously mentioned, if bait is available over a longer period – this will ensure bait is available for rats that potentially visit the ground infrequently.

5.4 Can the target pest be detected at low abundance?

There are a range of tools available for the detection of rats, and combined with intensity and time, there is a high level of confidence in the ability to detect both kiore and ship rats in low abundance based on significant operational experience on both temperate and tropical islands.

During the feasibility study carried out in November 2022, a combination of victor snap traps baited with high oleic content peanut butter and icing sugar, peanut butter infused waxtags, and motolures dispensing 1ml of high oleic content peanut butter one hour after sunset and one hour before sunrise – paired with a motion activated trail camera recording 10 second video clips; all proved to detect rats in the presence of potential non-target interference (crabs and ants). It is suggested that motolures paired with trail cameras; and transect trapping with victor traps are employed post-eradication. A suggested time frame of at least 6 months after the 2nd bait application is suggested as the fecundity of surviving rats in this environment should be suffice that a rat population would be expected to have a reasonable distribution and therefore reasonable detection probability by this stage.

5.5 Can pests be killed faster than they breed?

Kiore are able to exceed population densities of over 200 rats per ha on tropical islands, and ship rats 119 per ha (Harper and Bunbury 2015). Mean litter size for kiore in tropical islands is 3.5 and 4.5 for ship rats (Harper and Bunbury 2015). Young can breed towards the end of their first season of birth – with ship rats more likely to reach sexual maturity earlier. Even given the maximums of breeding capacity, enough bait will be applied to kill all individuals in a population faster than they can breed. The expected latent period between bait ingestion and death is likely to be approximately 5 days on average (DOC 2022).

5.6 Can immigration of the target pest be managed?

At present, rats are only present on Home Island and Cooks motu. Kiore have potentially been present on these islands for centuries, while ship rats are likely to have arrived on Home Island about 80 years ago. In this time, they have not managed to immigrate to any other motu in the Atoll.

Tom's motu is 2100m and 850m away from Home and Cooks motu respectively. 850m is well outside the swimming range of kiore, and similarly 2100m for ship rats. The most likely path of immigration between motu within the Atoll is through human assistance with small dinghies travelling between the motu and in stores they are carrying.

Fortunately, the small dinghies use on the Atoll are open and do not have points where rats could stowaway unseen, which reduces the risk of this happening. The project team have discussed the risk of inner-atoll immigration to the community and boat operators have agreed to be vigilant with boat checks and stores before landing on the surrounding motu.

PLANNING ISSUE 7:

There is always a risk present, with low likelihood, that a rodent population could establish on another motu between now and when the baiting operations take place on Home and Cooks.

In order to avoid failing to eradicate rats from the entire Atoll, baited trail cameras will be established on North, Karakarake, Primrose, and Toms in the months of May/June by the Palmerston Island Administration to ensure their rodent free status before the baiting operations on Cooks and Home occur.

Immigration from outside the Atoll is covered under section 7.6 in biosecurity needs.

5.7 Can dispersal be managed?

Containment of the operational areas naturally occurs given the operational blocks are islands. The Cooks motu operational blocks consist of two islands and two vegetated sandbanks, but all will have bait applied on the same day, eliminating the risk of rodents present not being exposed to bait.

6. Is it acceptable?

6.1 Do local island families support eradication?

The Palmerston community are completely supportive of the eradication, and the original request for the eradication came from the community and Island Council. The feasibility field trip conducted in November allowed dialogue and presentations to inform the community what an eradication would require of the community, and the impacts it would bring to their day to day lives prior, during, and after broadcasting toxic bait. The two main concerns the community had were around toxic baits and children, and the perception that poisoned rats would seek out residential water tanks to die in, and therefore contaminate drinking water. The actual risks and pathways around the realities of these concerns were discussed with the community by the project team and concerns were largely resolved.

A number of issues were identified by the eradication project planning team in regards to issues present that increase the risk of failure of an eradication. These issues were presented to the community, and the community and Island council identified management actions that would be put in place to eliminate or mitigate these issues (see appendices 4 and 5 in DOC-7241702).

6.2 Do key stakeholders support eradication?

Key stakeholders (government and NGOs) and the community support the eradication of rats on the atoll, and eliminating the impacts they have on peoples livelihoods on Home Island, and the potential impacts they have on biodiversity values.

There are likely differences between individuals in the community around the vision of natural resource preservation/restoration in the medium and long term. This relates to both marine and terrestrial resources, but is more obvious with marine resources which are currently used as a commercial export and income earner. An example of this would be the preservation/conservation of coconut crabs on Cooks motu. In a recent coconut crab survey (Kora and Munro 2020), Cooks motu was identified as having the lowest population of coconut crabs out of the uninhabited motu on the Atoll. Rats were identified by the community as having potential impacts on the coconut crab population on Cooks; yet the community were observed harvesting adult coconut crabs on this motu whenever they were encountered during the November fieldtrip.

While this tension in the community around natural resource use is not perceived to affect the support or success of a rat eradication, it is an issue the community will need to resolve in order to achieve management outcomes they set for their natural resources and biodiversity.

6.3 Does the project have institutional support?

The project has institutional support from multiple organisations, who's roles are identified in **Table 4** below.

Table 4: Institutional support and roles for the project

Institution	Type	Key contact	Role
NZ Ministry of Foreign Affairs and Trade (MFAT)	NZ government	Via Souad Boudjelas	• Funding
NZ Department of Conservation (DOC)	NZ government	Souad Boudjelas (MISCCAP project manager)	• Project lead • Operational planning • Provide field staff • Technical expertise to provide capacity building • Part of Project Working Group

Palmerston Island Administration (PIA)	Cook Islands government	Arthur Neale (Executive Officer)	• Local knowledge and expertise • Arrange local logistics and infrastructure • Provide local staff • Liaison to the community and Island Council • Part of Project Working Group
National Enviironment Standard (NES)	Cook Islands government	Elizabeth Munro (Manager, Environmental Stewardship Department)	• Governance • Liaison with Palmerston Island Council and the community • Lead community engagement • Part of Project Working Group • Advice around local legislation and regulations • Provide field staff
TIS	Cooks Islands NGO	Alanna Smith (Director)	• Lead on awareness raising • Part of Project Working Group • Provide field staff • Support with in-country logistics
MOA	Cook Islands government	Ngatoko Ngatoko (Director, Biosecurity Division)	• Lead on creation and implementation of biosecurity plan for Palmerston • Part of Project Working Group • Provide field staff
Birdlife International	INGO	Steve Cranwell (Programme Manager, Pacific)	• Part of Project Working Group • Provide technical advice based on operational experience

6.4 Is there political opposition or support?

The community and political components of the community (Island Council, heads of families) all vocally support the eradication of rats on the Atoll. Given the community is small, on-island politics and tensions are to be expected.

PLANNING ISSUE 8:

From a project management perspective, one of key issues to be aware of in terms of politics is around the perception of equity between individuals and the three families present on the island. This applies to aspects of the project that may see individuals from the community receive renumeration for – such as field work, provision of food and accommodation for field staff, the use of small boats for transport etc. The Executive Officer from the Island Administration has been asked to manage the allocation of these tasks in a way that is equitable amongst the community, and that the plan for these tasks is transparent and planned in advance with the community and Island Council to avoid any perception of favouritism or unfairness.

6.5 What environmental impacts are likely?

Non-target species

The benefits brought about to avifauna, herpetofauna, and invertebrate populations on Cooks and Home motu from the eradication of rats is likely to result in increased populations of most species where habitat is suitable.

There are several species on Home and Cooks where poisoning of individuals could occur through eating bait directy (primary poisoning) or secondary poisoning (consuming something, including a carcass, that has eaten bait). There are several species of waders/seabirds on the Atoll that could be affected as they are known crustacean consumers, but it is not expected they would be impacted at a population level. Lizard species similarly could be affected through primary or secondary poisoning (through invertebrates) but the fecundity of the lizard species present and the risk of poisoning means population level impacts are not anticipated. A full list of potentially susceptible species on the Atoll are shown in **Table 5**. For many bird species identified to be potentially at risk through secondary poisoning via crustaceans, this risk is further mitigated by their feeding grounds being in the intertidal or low tide area, where baits will not be applied. Risks to migratory species identified is further decreased as adults are likely to be absent during the proposed operational period.

Invertebrates (including crustaceans) have a different blood clotting system to mammals, so are not susceptible to anticoagulant poisons.

Table 5: Fauna potentially susceptible to poisoning on Palmerston Atoll. Seabird presence based on Smith 2018; and Lizards on Gill 1998)

Species	Common name	Risk pathway	Present on Home?	Present on Cooks?	Present on other motu?	Migratory?	Risk rating
Tringa incana	Wandering tattler	Secondary consumer (crustaceans)	No	Yes (few)	Yes	Yes	Low
Pluvialia fulva	Pacific golden plover	Secondary consumer (crustaceans and invertebrates)	Yes (few)	No	Yes	Yes	Low
Arenaria interpres	Ruddy turnstone	Secondary consumer (crustaceans, invertebrates, carrion)	No	No	Yes	Yes	Low
Numenius tahitiensis	Bristle thighed curlew	Secondary consumer (crustaceans)	No	Yes (few)	Yes	Yes	Low
Gygis alba	White tern	Secondary consumer (crustaceans)	No	Yes	Yes	No	Low
Egretta sacra	Pacific reef-herons	Secondary consumer (crustaceans)	No	Yes	Yes	No	Low
Gallus Gallus	Chickens	Primary consumer, and secondary (invertebrates)	Yes	No	No	No	High
Gehyra oceanica	Pacific Dtella	Secondary poisoning (invertebrates)	Unknown	Unknown	Yes	No	Low
Lepidodactylus lugubris	Mourning gecko	Secondary poisoning (invertebrates)	Unknown	Unknown	Yes	No	Low
Emoia cyanura	Copper tailed skink	Secondary poisoning (invertebrates)	Yes	Yes	Yes	No	Low

The issue and management of chickens has been discussed in previous sections, but it is anticipated that any remaining wild chickens may succumb to primary poisoning.

Other environmental impacts

Further unpredictable and potentially unwelcome short-term effects may include:

- Chaotic short-term fluctuations in abundance of resident species, for example explosive production of invertebrates leading to defoliation of native plants. There are no species known that are expected to do this but is more a precautionary thought.
- Increase in invasive plants that may have been suppressed by rats consuming seeds. There are no species known that are expected to do this but is more a precautionary thought.
- High mortality of other species that 'overshoot' food supplies as the population limitation that rats imposed is removed.
- Track cutting/vegetation removal in the understory associated with the 20 x 20m grid creation. This is low impact and vegetation is likely to recover within a season.

Such short-term effects are unlikely to result in long-term negative effects to the populations.

7. What will it take?

7.1 What is needed to effectively manage the project?

The project organisation and governance structure are outlined in **Figure 12** below and described in **Table 6**.

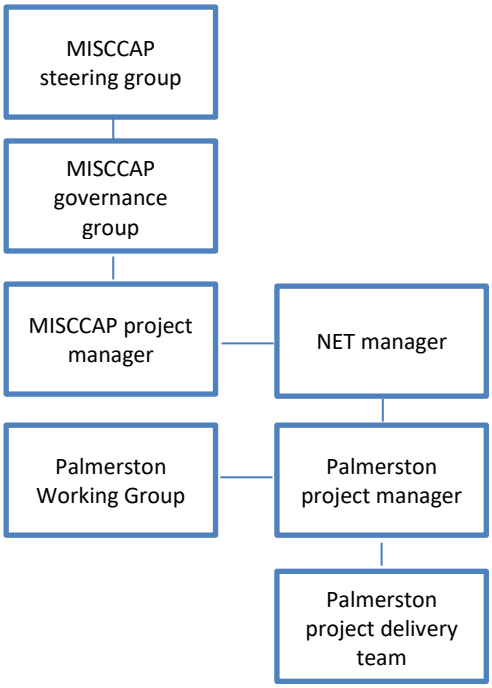

Figure 12: Project organisation and governance structure

Table 6: Description of roles of different organisational components

	Role	Organisation/s involved
MISCCAP steering group	• Provides strategic guidance and guidance for the three implementing Partners of MISCCAP	MFAT, SPREP, DOC, LCR
MISCCAP Governance Group	• Provides guidance and support to ensure business objectives are being adequately addressed • Ensures the project remains viable and aligned to DOC's strategic principles • Reports to MISCCAP steering group	DOC
MISCCAP project manager	• Facilitator between DOC MISCCAP project operations and governance group	DOC
NET manager	• Manages staff who are delivering MISCCAP projects on behalf of DOC	DOC
NET Palmerston project manager	• Leads the operational planning and delivery of the Palmerston project. • Reports to the NET manager • Consults with the Palmerston Working group • Manages the project delivery team • Reports to NET manager	DOC
Palmerston Working Group	• Guides and support the Palmerston project manager in the planning of the feasibility study and the rat eradication	DOC, PIA, NES, MOA, TIS, Birdlife International
Project field team	• Carry out the planning, logistics, and operations as specified by the operational plan and the project manager • Reports to project manager	DOC, PIA, NES, MOA, TIS

The eradication project team will consist of collaborating agencies – the National Environment Service, Te Ipukarea Society, the Ministry of Agriculture, and the Palmerston Atoll community. DOC will lead the operational planning and delivery through the project manager, who will coordinate the field team who will deliver the field component of the rat eradication. The field team will comprise of staff from DOC, NES, MOA, TIS, and the Palmerston Atoll community and administration.

Provided the eradication proceeds following the feasibility study, an operational plan will be produced which will help guide the logistics and task specifications to the detail required to ensure the eradication has the best chance of success.

7.2 What is the capacity and capability need?

The project requires a full-time operational lead to oversee the planning and delivery of the operational phase of the project. This includes writing an operational plan and related task specifications, GIS work, seeking technical input where required, communicating with project partners, and fulfilling reporting required by internal and external agencies for the project. An assistant staff (DOC) is also anticipated to help scope and organise logistical arrangements for the operational phase of the project.

For the delivery of the baiting phase, a field team of 12 people will be required to achieve the creation of a 20x20m baiting grid on both motu; ensuring identified issues relating to alternative food are managed adequately; two broadcast applications of bait over the operational area; special baiting of buildings and infrastructure; and bait availability monitoring; and deconstruction of the grids. The delivery phase of the baiting operation is predicted to take 4 to 5 weeks, not including travel to the Atoll.

A debrief of the operation will occur and be included in a post-operational report that records the baiting phase of the project. Post-eradication monitoring to determine success of the eradication take place approximately 6 months after baiting operations have been completed.

For the baiting phase of the project, attention to detail is critical to allow the project to achieve the two most important underlying principles for achieving the eradication of rats (every rat has access to bait and every rat eats bait). The project field team will consist of several DOC staff with experience and working ethos of invasive animal eradication; along with members of the community and partner organisations for which this will be the first time they have taken part in animal control operations in general. This presents an element of risk in that any level of complacency or misunderstanding in regards to key tasks could lead to a cause of failure. In order to mitigate this, experienced DOC staff will lead and oversee critical components of the field delivery, supported by collaborating partners. The proposed field delivery structure and key roles are outlined in **Figure 13**. This model ensures best chance of success while building the capacity of partner organisations. An approximate timeline for planning and delivery of operational components is shown in **Figure 14**.

In addition to these roles, the Palmerston Island Administration and community will have delegated the daily cleaning, collection, and consolidation of household waste during the eradication period.

DEPENDENCY 6:

The successful eradication of rats from Palmerston will be dependent on having a high enough ratio of experienced staff with the appropriate eradication mindset and pest control experience to ensure high enough quality control to ensure every rodent has access to bait and will eat a bait. Staff capability from the community and partner organisations is limited when coming to animal control and eradication operations. Project management, planning, and technical expertise relies soley on DOC staff. To ensure enough redundancy, ability to increase capacity of partner organisations through training, and to ensure key operational tasks are done to the required standard to avoid failure; the operational and planning team from DOC must be staffed sufficiently.

The project manager must ensure the delivery phase is resourced with enough skilled staff to lead and deliver the relevant components of the operation – particularly the creation of the baiting grid, special baiting, and bait

application. Staff without experience can be involved but must either be partnered with a skilled operator or be assigned tasks that are not operation critical.

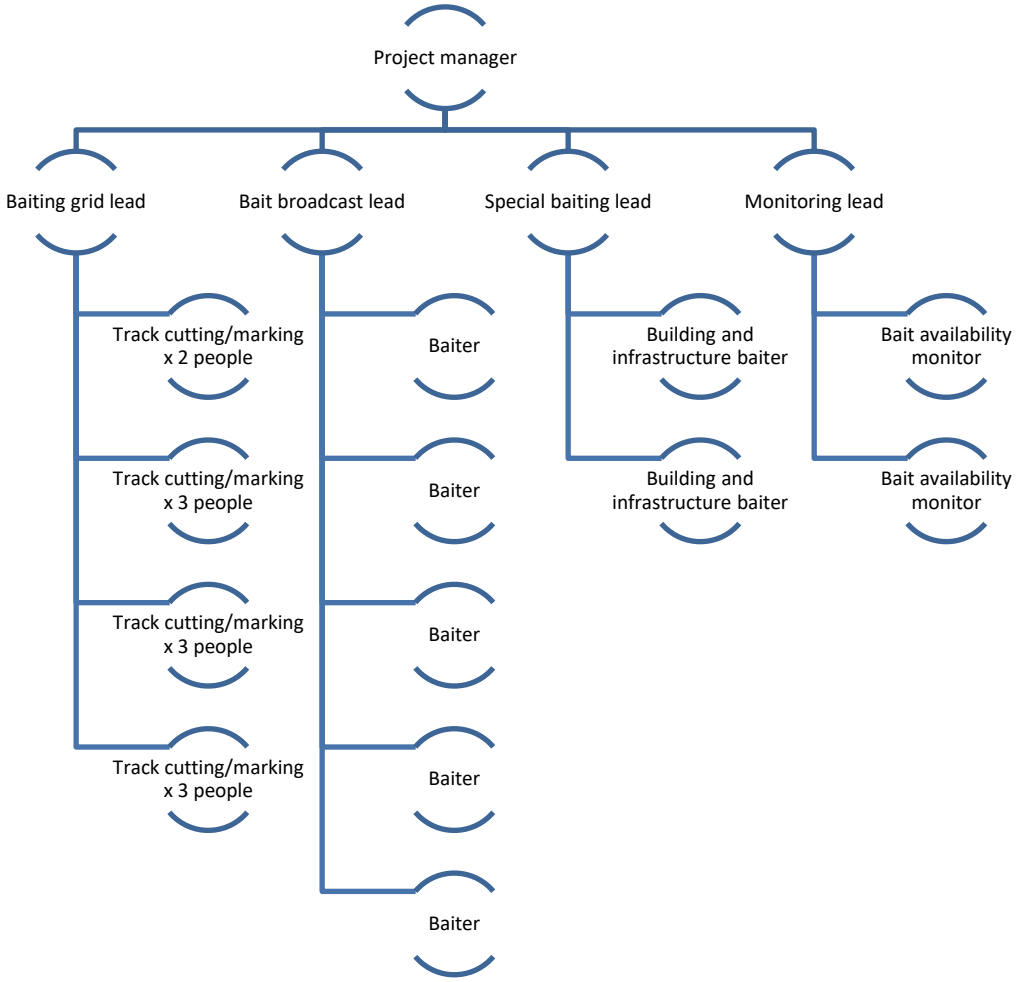

Figure 13: Field delivery team structure and roles (note that as the creation of the baiting grid and baiting are done sequentially, they will use the same staff)

	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24
Project manager	Feasibility study produced		Operation plan and task specifications produced			Prepare and familiarise with roles and task specifications	Field delivery - baiting operations		Post-op reporting							Monitoring to confirm eradication success (field team unconfirmed)
Project assistant		Scoping and securing transport logistics														
Field team member (DOC)																
Field team member (DOC)																
Field team member (TIS)				In-country logistical assistance												
Field team member (TIS)																
Field team member (MOA)																
Field team member (NES)																
Field team member (PIA)		Management activities identified to address reducing alternatie food sources for rats														
Field team member (PIA)																
Field team member (PIA)																
Field team member (PIA)																

Figure 14: Timeline of planning and operational phase of project and personnel required (yellow indicates pre-operation off-atoll preparation, green indicates on-site work, and purple indicates post-operation work)

7.3 Can all required permissions be secured?

Table 7 outlines the permissions required for the operation. Precedent for the import and use of PestOff 20R in the Cook Islands has been set by the use of it for cyclic control of rodents in the Takitimu Conservation Area (Rarotonga), and for several rat eradication attempts on Suwarrow.

Table 7: Regulatory permissions required for proposed eradication project

Consent/Permit required	Granted by	Received?
Formal community approval for access to motu and broadcasting bait	Mayor on behalf of Island Council and community	August 2022
Import of bait into the Cook Islands	MOA	TBC when bait ordered
Environmental Significance Declaration	NES	September 2022

7.4 What are the infrastructure needs?

In terms of infrastructure on the Atoll, it is well supplied with the infrastructure required to carry out the eradication. The feasibility field trip in November 2022 has allowed the testing of current infrastructure on the island to support and accommodate a field team of the proposed size. Members of the field team external to the Atoll (8 staff) will comfortably be accommodated at the Emergency Management Center (EMC – see **Figure 15**), and food will be prepared in turn by households on the island. The EMC has room and bedding to sleep 8 comfortably in a communal living/working space, a kitchen, toilets and showers, and two separate offices for smaller noise free meeting/working areas. It has power and internet available through a wifi extended satellite broadband connection.

The EMC has a covered outdoor area that is big enough to host meetings with the whole community attending, where the November field team gave several presentations using a supplied projector. The covered outdoor area is also a useful staging area for team meetings, gear preparation, and additional bait storage if needed.

Figure 15: Emergency Management Center where the field team operations will be based from, Home Island

The proposed site for bait storage is in an outside covered area on Home Island, on a raised concrete pad, sheltered from direct sun and with plenty of airflow (see **Figure 16**). Bait will be manufactured and stored in plastic pails so will not be prone to interference by rats or crabs.

A tractor and trailer, and quad bike and trailer are available on Home Island for the transport of bait and field gear around Home Island, and to the coast for transfer of gear to dinghies. A number of dinghies and skippers are available for transport to and from the outer motu for the purposes of the eradication.

Communication within the Atoll is primarily through simplex VHF channels, which work comfortably within the same Island, but require people to be on adjacent coasts for adequate clarity between Cooks and Home Island. In reach satellite communication devices will be taken and used by team leaders to address potential inter-island communication issues.

Figure 16: Proposed bait storage area below building on concrete pad

7.5 What are the logistical constraints?

The key logistical constraints relating to the project are primarily around the limited availability and range of transport options for passengers and freight between Rarotonga and Palmerston Atoll. Transport options are limited to boat, due to no fixed landing area present on the Atoll, and the Atoll being out of range from the nearest helicopter hanger.

Transport requirements for the baiting phase of the operation is the transport of 8 passengers, 6 tonne of bait, and associated field-gear and food. Transport of passengers and the relevant freight between New Zealand and Rarotonga is relatively uncomplicated and secure, however transport options between Rarotonga and Palmerston Atoll are limited, and some of the options which do exist are notoriously unreliable. The Kukupa II (Cook Islands police vessel) is the most reliable and fastest option and can comfortably fulfil freight requirements, but is limited to carrying 5 additional passengers per trip, and comes at a significant expense. For project planning purposes at this stage we are assuming a combination of using the Cook Islands General Transport Tanganui, the Cook Islands Police Kukupa II, and the Cook Island Voyaging Society sailing vaka to get field gear, bait, and passengers across to Palmerston Atoll.

DEPENDENCY 7:

Transport to the Atoll is extremely limited, with options confined to vessels. There are 4 potential vessels, 2 of which have passenger limits of 5 or less, and one of the other vessels would not be suffice to transport the volume of bait and cargo being taken. It is likely a combination of shipping options will be required, but it the operation will be dependent on the ability to charter particular vessels for the desired timeframes. An exercise scoping and securing the best potential transport options will be conducted in February/march to try and achieve an optimal solution

Constraints on bait production are that if Pestoff20R is to be used with an operational timing forecast of July, an order must be in confirmed with Orillion for April production. April production will also meet the timeframe for ensuring bait is shipped by May to Rarotonga, for it to arrive and clear customs for June.

7.6 What is the biosecurity need?

Biosecurity measures are currently in place in Palmerston, but work is in progress to identify possible practical improvements to the current measures. The highest risk likely comes from freight boats that visit 3-6 times per year, moving between Rarotonga and the other Pa Enua in the Cook Islands. Rarotonga and Penrhyn are the most likely sources of an unwanted organism, given they are the only places where freight boats can moor at a port.

The current status is that all incoming freight and passengers to Palmerston arrive by sea, in vessels that are too large to enter the reef system. As a result, all arriving passengers and freight are transferred from a larger vessel, to the islands small dinghies that are able to negotiate the shallow ~1m passages entries through the reef. Stores and items are able to be inspected on deck of the larger vessels, as well as by the small boat operators from Palmerston who receive the goods and transport them inside the reef to land at a single location on Home Island. Food and dry edible goods are often packed and stored in sealed [decommissioned] freezers on Rarotonga, then transported on cargo vessels and offloaded onto the smaller dinghies or Island Administration barge. These freezers act as suitable rodent-proof containers. Freight is all landed on a single beach where the community gather to receiver and transport goods.

Visiting vessels must communicate with the Executive Officer before arrival, and private vessels must have permits issued by the Executive Officer who comes onboard to inspect and issue these prior to people coming ashore.

A staff member of the Island Administration is also being trained as the on-island biosecurity officer (by the Ministry of Agriculture), and this person will be able to assist and oversee on-vessel checks of freight.

The MOA have been tasked and funded by the MISCCAP project to oversee the creation and implementation of a biosecurity plan for Palmerston Atoll in light of the rat eradication project. The plan will cover biosecurity procedures for Palmerston and other Pa Enua, given the rat eradication effort recently invested in Suwarrow also. The DOC MISCCAP project manager is leading this work.

DEPENDENCY 8:

The MOA have been tasked and funded by the MISCCAP project to oversee the creation and implementation of a biosecurity plan for Palmerston Atoll in light of the rat eradication project. The plan will cover biosecurity procedures for Palmerston and other Pa Enua, given the rat eradication effort recently invested in Suwarrow also. The DOC MISCCAP project manager is leading this work. The plan will need to identify pragmatic and low cost improvements in biosecurity for Palmerston in order for improved biosecurity to be engaged with and sustainable. An eradication should not proceed unless there can be confidence in preventing incursions of the target pest. Palmerston have some good safeguards in place, but there will be improvements that can be made to further reduce the risk of a future rodent incursion.

7.7 What monitoring will occur and how will eradication be validated?

Bait availability monitoring during the baiting phase will take place as described in section 5.1, in order to determine if application quantities are to be adjusted for the 2nd broadcast application.

Post-operation monitoring is proposed to take place in April 2024, at least 6 months post bait application, and outside of the cyclone season in the Cook Islands, which can significantly impact travel arrangements. Given April 2024 is approximately nine months after the proposed bait application period, it is quite likely that rat productivity in such a productive ecosystem over such a small area time period would mean residents of Palmerston may detect rats within that time period if the eradication was unsuccessful on Home Island. However, if rats have not been observed by April 2024 by the community, a series of baited trial cameras will be established on Home Island and Cooks motu over a week period, and footage will be reviewed to determine if the eradication was successful. Any informal non-target observations will be reported to the PIA and recorded/reported to the project manager.

In terms of outcome monitoring, agricultural yields, using cucumbers and mangos as indicators, will be recorded to demonstrate the impact the eradication of rats have had on food security for the Atoll.

Baseline outcome monitoring for biodiversity values has been recorded for seabirds (TIS 2018) and coconut crabs (Kora and Munro 2020). These studies could be repeated by the community and partner organisations after an appropriate recuperation period post-rat eradication to measure the anticipated recovery to relevant fauna provided by the removal of rats.

7.8 What are the information gaps?

Several information gaps exist regarding rat and non-target biology (see **Table 8**) but no more than have been common in other tropic island rat eradication operations. Institutional knowledge from other operations as well as best practice recommendations from Keitt 2015 and advice from relevant practitioners (A Samaniego, R Griffiths Pers. comms.) have been sought to plan proposed mitigation to the risks these unknowns may present.

Table 8: Information gaps for Palmerston rat eradication project

Information gap	Detail	Risk	Proposed mitigation
Limited knowledge on the natural peak and troughs of rodent breeding on Palmerston	To increase the chance of successfully eradicating rats, the period of less abundance/breeding/less food availability should be targeted. For Palmerston this is unknown as we only have one point of data (November 2022 field trip).	Rat population and breeding is at a high point when we conduct the operation, leading to increased risk of project failure.	The project is aiming for what should be the natural lowest period of food availability and therefore rat productivity. This is based of limited climate data specific to Palmerston, proxy climate data, and operational knowledge from proxy islands at similar latitudes. Maintaining a high amount of bait availability with a mix of application rate and period between applications. Monitoring bait availability and being prepared to significantly increase application rate on the second application if needed.
Non-target bait interference at the proposed time of year	Bait availability trials were conducted at a different time of year to the proposed time of the operation	Increased crab and invertebrate activity during the proposed operation period leading to reduced bait availability for the target species	Based on literature and previous operational knowledge, and available climate data and proxy climate data – crab activity should in theory be lower than the bait availability period due to anticipated cooler weather (relative to the field trial period). Maintaining a high amount of bait availability with a mix of application rate and period between applications. Monitoring bait availability and being prepared to significantly increase application rate on the second application if needed.
Effect of what appears to be sub-dominance of *R.rattus* to *R.exulans* on the eradication	The apparent sub-dominance of ship rats to kiore on Home Island is inverse to what is usually experienced.	Kiore dominate bait availability, reducing availability to ship rats – allowing them to survive.	Following best practice with two applications of bait, and being prepared to apply.

7.9 What are the planning issues?

Significant planning issues specific to the Palmerston project are summarised in **Table 9** below.

Table 9: Planning issues for Palmerston rat eradication project

Planning issue #	Description	Reference
1	Domestic greywater systems need to be contained and sealed. Planning needs to support the purchasing of resources and supporting logistics for the PIA	Section 3.6, page 14
2	Uncertainty about the dominance of kiore and ship rats, and habits of ship rats, and how this may affect bait uptake. As a result the project should try and ensure bait availability for a long period to ensure ship rats get access to bait.	Section 3.7, page 15-16
3	Current use of rodenticides to be ceased by the community effective immediately.	Section 3.7, page 16
4	The eradication of cats from the Atoll is outside the scope of this project, but the eradication of rats provides an opportunity to do if desired. The community needs to decide if this is what they want, and agree upon a pathway for this to happen.	Section 3.8, page 17
5	There is a risk that environmental variables may mean non-target bait uptake is more than when bait availability studies were done which were used to inform the eradication bait application rates. To ensure contingency, bait availability plots will run and enough contingency bait brought to allow up to double the application rates on the second application.	Section 5.2, page 24
6	There are a number of management issues in regards to managing alternate food sources that the community have agreed to address, but operational planning must take into account the resourcing and supporting of these actions to ensure they are adequately addressed	Section 5.3, Table 3, pages 26-27
7	It is possible rats could establish on motu that are currently rat free between now and when the operation takes place. Planning must incorporate pre-operation monitoring to confirm rat free status of the surrounding motu immediately before the baiting phase.	Section 5.6, pages 27-28
8	Politics exist around the perception of equity between individuals an the three families on the islands. Task delegation and payment for members of the community should be run through the Executive Officer to ensure allocation of tasks is equitable, and allocation should be transparent to the island council to avoid perceptions of favouritism or unfairness.	Section 6.4, page 30

7.10 What are the key dependencies?

Table 10 summarises the risks and dependencies identified with the Palmerston Rat eradication project. The management actions associated with these risks and dependencies need to be actioned/resolved otherwise the risk of failure is considered too high to proceed.

Table 10: Key dependencies for Palmerston rat eradication project

Risk	Dependency	Reference
Agricultural produce present on Home Island will decrease bait palatability to rats, thus causing eradication failure	Palmerston community eliminate/remove agricultural produce from Home Island prior to the bait phase of the eradication	Section 3.5, page 12
Wild and domesticated chickens on Home Island are likely to consume significant amounts of bait, leading to decreased bait availability for rats, resulting in the failure of the eradication	Domestic chickens must be removed from Home Island, and wild chickens must be significantly reduced – prior to the delivery phase of the eradication. This must be led by the community.	Section 3.5, page 13
Livestock (pigs and chickens) on Home Island will consume bait and also present alternative sources of food (manure and food scraps) for rats. Non-target bait consumption and alternate food sources are likely to lead to eradication failure.	Livestock must be removed from Home Island before the delivery phase of the eradication begins.	Section 3.5, page 13
Baiting team are unable to get access to all buildings resulting in some rats not being able to access bait	The Palmerston community are able to unlock and gain access to every building on Home Island, and the baiting team are able to bait all buildings and manoeuvre within buildings (meaning clutter may need to be reduced).	Section 5.3, page 25
There are a number of alternative food sources including household waste, greywater, livestock, rubbish piles, food waste that need to be managed/eliminated in order to ensure rats consume bait	The Palmerston community sufficiently carry out the agreed management actions as per Table 3. High priorities include rubbish burnoff, household rubbish and waste management systems, eliminating agricultural produce during the operation period, and removing livestock from Home Island	Section 5.3, Table 3, pages 26
Management of issues, grid construction, and/or baiting is done poorly/to a low standard, resulting in failure due to all rats not having access to bait or bait having low palatability.	For the operational phase, the project needs to ensure it has enough team members with animal pest control experience and an eradication mindset. This is likely to mean that 50% of the delivery team will consist of DOC/NZ staff. This will also increase the exposure of experience to partner agency staff for the benefit of capacity building.	Section 7.2, pages 35-36
Unable to get staff or freight to the Atoll; or transport of the delivery phases is delayed, pushing the operational phase into sub-optimal climatic conditions that increase the risk of failure.	Suitable transport vessel/s can be secured in the time periods required, that can take the number of passengers and freight volume required to and from the Atoll,	Section 7.5, pages 7

Appropriate biosecurity procedures are not in place, leading to a future rodent incursion on Palmerston after the eradication effort	Pragmatic biosecurity measures to implement are identified, and these are uptaken by the Palmerston Community at a minimum. Biosecurity of relevant vessels and the port in Rarotonga are reviewed and guidelines/actions identified and implemented.	Section 7.6, page 37

7.12 What are the estimated costs and timeline?

Estimated cost and timings of these costs are broadly categorised and outlined in the gantt chart in **Figure 17**. These figures do not include project contingency costs, and passenger and freight transport costs between Rarotonga and Palmerston ($130k) are a worst case scenario.

	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24
Management monitoring and logistics trip				$36,000												
Bait production				$27,000												
Bait and field gear freight (NZ to Raro)				$22,000												
Field gear & related supplies				$19,000												
On atoll materials required for management actions				$16,000												
Accommodation and passenger transport (NZ/Raro)							$66,500									
Passenger and freight transport Raro - Atoll							$130,000									
Project management				$80,000												
Field delivery team staffing costs						$130,000										
Post operation supplies for management on Palmerston									$12,500							
Eradication success monitoring																$40,000
Total expenditure	**$579,000**															

Figure 17: Gannt chart of project costs and expenditure timeline

8. Conclusion and recommended way forward

The eradication of kiore and ship rats from Home Island, and the eradication of kiore from Cooks motu, will achieve the eradication of rats from Palmerston Atoll. The successful eradication of rats from the Atoll will have significant benefits to the residents of Palmerston Atoll, ultimately resulting in improved livelihood outcomes.

Eradication of rats also has the potential for the restoration of biodiversity values for valued fauna such as seabirds, turtles, and coconut crabs. The caveat to this is that human impacts will also require management if the desired outcome of the community and Cook Islands is to see these population grow on these islands.

Planning for the project has benefited from pre-operational fieldwork to understand social and biological complexities of the project, and to test and quantify resourcing for delivery components such as baiting quantities, track cutting, organisational capacity, and logistics and infrastructure. Eradications on inhabited islands are inherently more difficult than uninhabited islands due to social complexities, but the situation on Palmerston Atoll is helped by unanimous support for the project by the community and relevant governing authorities.

The eradication methodology will use a 20 by 20 meter grid to apply at least two hand broadcast applications of PestOff 20R in conjunction with open bait trays in buildings. This methodology is considered technical feasible and has had proven success based on operational precedent set by successful tropic island eradication projects using the same methodology in similar environmental contexts.

The most significant risks and issues associated with the operation relate to bait availability (due to the consumption of bait by non-target consumers); the alternative food sources that need managing (mostly human produced); ensuring a high standard of operation delivery when some inexperienced staff are part of the delivery team; and the difficulty of logistics in availability and security of transport of freight and passengers between Rarotonga and the Atoll. All of these risks have proposed management actions that should eliminate or mitigate the issues and impacts they may have in increasing the risk of failure to the project.

The Atoll has relatively good and pragmatic biosecurity procedures in place given its resourcing, but a separate piece of work is being run through the MISCCAP project to identify and implement improvements for biosecurity on the outer islands in the Cook Islands, including Palmerston Atoll.

Project resourcing will require a project manager with some staff assistance for the operational and logistics planning between February and June 2023, and an inter-agency field delivery team consisting of 12 people from NZ and the Cook Islands will be engaged between June and August 2023 in order to conduct the delivery phase of the eradication on the Atoll in July – August 2023.

Pending approval of the feasibility study, the next steps are determining and securing the best transport arrangements for freight and passengers from Rarotonga to Palmerston; detailed operational planning including peer review for the delivery phase of the project; and working the Palmerston Working Group and Palmerston Island Community to ensure agreed management actions on the Atoll are carried out between now and April to ensure the best conditions for successfully eradicating rats from the Atoll in July/August 2023.

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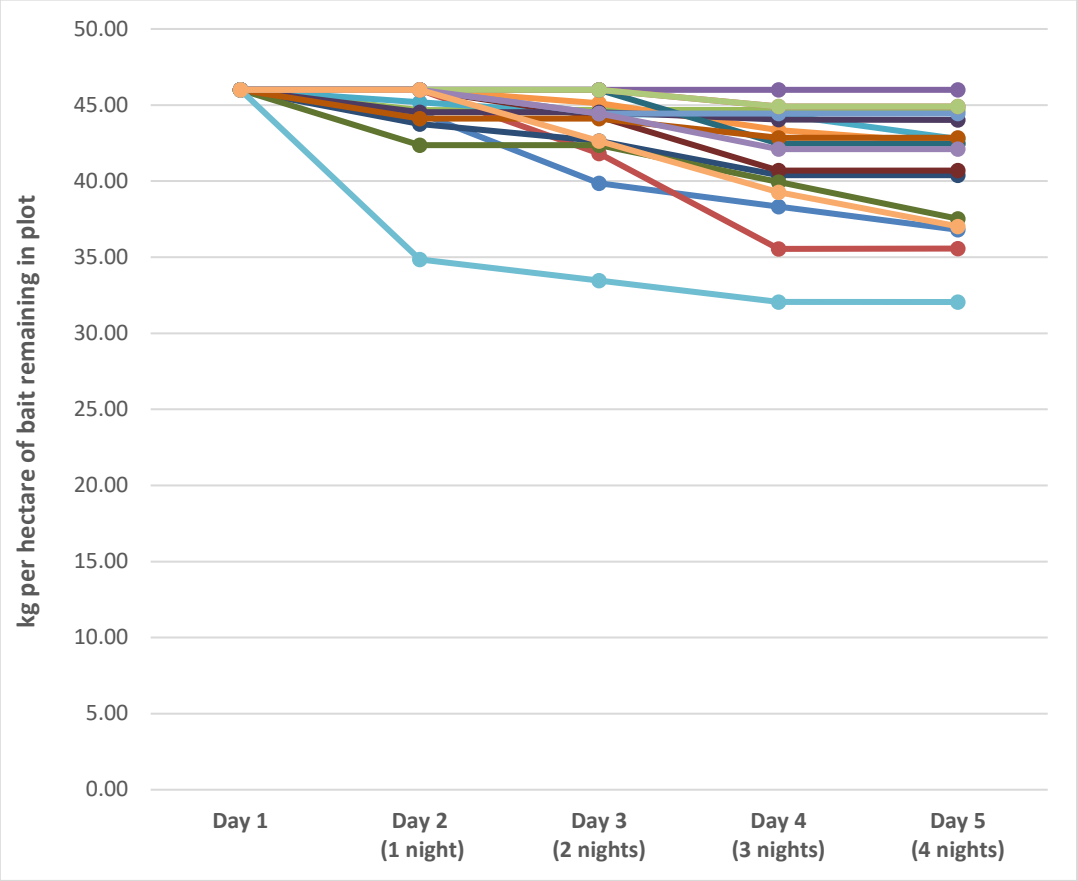
Appendix 1: Bait calculations

	Home	Cooks				Total
	Home	Dicky boy North	Dicky boy south	Calcutta	Aparanuta	
1st application rate (kg per ha)	20.00	30.00	30.00	30.00	30.00	
Area of block (ha)	39.90	0.29	0.31	13.84	17.40	**71.74**
Perimiter of block (meters)	2443.00	361.00	237.00	1896.00	1649.00	**6586.00**
Amount of bait needed for 1st broadcast application on 20m x 20m grid (36 baiting points per hectare)	798.00	8.70	9.30	415.20	522.00	**1753.20**
Plus additional perimeter baiting	67.86	15.04	9.88	79.00	68.71	**240.49**
Plus special baiting (bait trays in structures and areas of risk)	20.00					
Total for 1st application (kg)	**885.86**	**23.74**	**19.18**	**494.20**	**590.71**	**2013.69**
2nd application rate (kg per ha)	20.00	30.00	30.00	30.00	30.00	
Amount of bait needed for 2nd broadcast application on 20m x 20m grid (36 baiting points per hectare)	798.00	8.70	9.30	415.20	522.00	**1753.20**
Plus additional perimeter baiting	67.86	15.04	9.88	79.00	68.71	**240.49**
Plus special baiting (bait trays in structures and areas of risk)	20.00					
Total for 2nd application	**885.86**	**23.74**	**19.18**	**494.20**	**590.71**	**2013.69**
Total between both applications (kg)	**1771.72**	**47.48**	**38.35**	**988.40**	**1181.42**	**4027.37**
plus 20% contingency	**2126.07**	**56.98**	**46.02**	**1186.08**	**1417.70**	**4832.85**

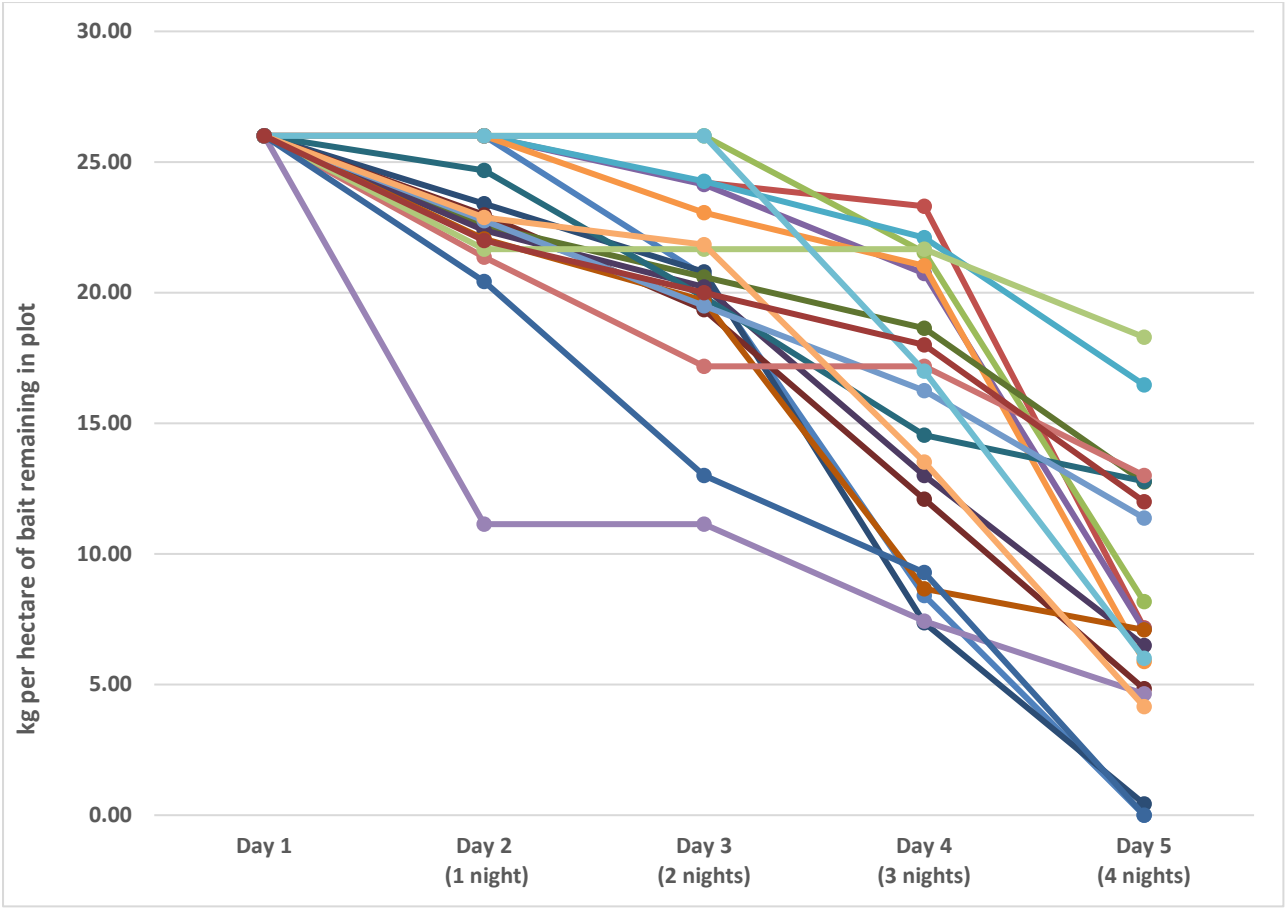
Appendix 2: Bait availability results from feasibility fieldwork, November 2022



Home Island bait availability results (n of plots = 18)

Table of Home Island bait availability results (kg per ha)

Plot	Day 1	Day 2 (1 night)	Day 3 (2 nights)	Day 4 (3 nights)	Day 5 (4 nights)
B2	46.00	44.47	39.87	38.33	36.80
B8	46.00	46.00	41.82	35.55	35.56
C2	46.00	44.67	44.69	44.69	44.69
D2	46.00	46.00	46.00	46.00	46.00
D4	46.00	45.19	44.39	44.39	42.77
D7	46.00	46.00	45.12	43.35	42.46
D8	46.00	43.76	42.63	40.39	40.39
E2	46.00	46.00	44.23	40.69	40.69
E5	46.00	42.37	42.37	39.95	37.53
E7	46.00	44.53	44.53	44.04	44.02
E8	46.00	46.00	46.00	42.46	42.46
F2	46.00	44.11	44.11	42.85	42.85
F4	46.00	46.00	44.44	44.44	44.44
F6	46.00	46.00	46.00	44.90	44.90
F8	46.00	46.00	46.00	44.90	44.90
G2	46.00	46.00	44.44	42.10	42.10
H2	46.00	34.85	33.45	32.06	32.06
H4	46.00	46.00	42.63	39.27	37.02



Cooks motu bait availability results (n of plots = 20)

Table of Cooks motu bait availability results (kg per ha)

Plot	Day 1	Day 2 (1 night)	Day 3 (2 nights)	Day 4 (3 nights)	Day 5 (4 nights)
B2	26.00	26.00	20.65	8.41	0.00
B4	26.00	26.00	24.21	23.31	7.17
B6	26.00	26.00	26.00	21.54	8.17
C2	26.00	26.00	24.14	20.74	7.12
C4	26.00	26.00	24.27	22.10	16.47
C6	26.00	26.00	23.06	21.03	5.88
C7	26.00	23.40	20.80	7.37	0.43
D2	26.00	22.98	19.35	12.09	4.84
D4	26.00	22.57	20.60	18.64	12.75
D6	26.00	22.39	20.22	13.00	6.50
E2	26.00	24.68	19.83	14.54	12.78
E4	26.00	22.06	19.70	8.67	7.09
E6	26.00	22.75	19.50	16.25	11.38
F2	26.00	21.36	17.18	17.18	13.00
F4	26.00	21.67	21.67	21.67	18.30
F6	26.00	11.14	11.14	7.43	4.64
F7	26.00	26.00	26.00	17.00	6.00
G2	26.00	22.88	21.84	13.52	4.16
G4	26.00	20.43	13.00	9.29	0.00
G6	26.00	22.00	20.00	18.00	12.00