



Pacific Invasive Species Battler Series

REMOVING RODENTS FROM SMALL TROPICAL ISLANDS WITH SUCCESS



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Our vision: A resilient Pacific environment sustaining our livelihoods and natural heritage in harmony with our cultures

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Cover photo: Carlo Iacovino, SPREP

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Dear Invasive Species Battler,

We are a diverse bunch of people in the Pacific region, which spans a third of the earth's surface and encompasses about half of the global sea surface. We have ~2,000 different languages and ~30,000 islands. Pacific ecosystems are one of the world's biodiversity hotspots, with a large number of species found only in the Pacific and nowhere else. In fact, there are 2,189 single-country endemic species recorded to date. Of these species, 5.8 per cent are already extinct or exist only in captivity. A further 45 per cent are at risk of extinction. We face some of the highest extinction rates in the world.

The largest cause of extinction of single-country endemic species in the Pacific is the impact of invasive species. Invasives also severely impact our economies, ability to trade, sustainable development, health, ecosystem services, and the resilience of our ecosystems to respond to natural disasters. Fortunately, we can do something about it.

Even in our diverse region, we share many things in common. We are island people, we are self-reliant, and we rely heavily on our environment to support our livelihoods. We also share many common invasive species issues as we are ultimately connected. Sharing what we learn regionally benefits us and our families economically, culturally, and in our daily lives. The "Invasive Species Battler" series has been developed to share what we have learned about common invasive species issues in the region, with information and case studies that can assist you to make a decision about what to do next or where to go for further information.

The SPREP Invasive Species Programme aims to provide technical, institutional, and financial support to regional invasive species programmes in coordination with other regional bodies. We coordinate the Pacific Invasive Learning Network (PILN), a network of practitioners battling invasive species, and the Pacific Invasives Partnership (PIP), the umbrella regional coordinating body for agencies working on invasive species in more than one Pacific country.

For knowledge resources, outreach tools, and more information on SPREP, the Invasive Species Programme, PILN, and PIP, please visit the SPREP website: www.sprep.org

Thank you for your efforts,
SPREP Invasive Species Team



About This Guide

While eradication projects on large islands require substantial funding and a high level of technical and logistical support, projects on small islands are much simpler and can achieve success with much less funding and outside assistance. The Pacific has thousands of such islands that can contribute to significant biodiversity outcomes. The purpose of this guide is to assist the practitioner in removing invasive rodents from small islands (less than 20 hectares) where access to all parts of the island is possible. These guidelines are designed to be used in conjunction with the resource 'Use anticoagulant rodent bait safely'.

Thanks to our partner Island Conservation, who drafted this guide following the successful removal of rodents on Motutapu and Malinoa islands in the Kingdom of Tonga.



Why should we manage rat populations?

Some species of rats are particularly destructive invasive animals on Pacific islands. Invasive species are non-native plants, animals, or other organisms that have been intentionally or unintentionally introduced by people and that are destructive to the environment or human interests.

In their home ranges, these species are controlled by predation, parasitism, and disease. When introduced to a new environment free from such controls, they may adversely impact the environment by competing with, and in some cases replacing, native species and by causing complex changes in ecosystem structure and function.

Invasive rats are particularly harmful for native bird populations, in addition to causing economic damage and affecting human communities in many ways.



Did you know?

Rodent baits containing second-generation anticoagulants are a highly effective tool for removing rodents from islands. However, the use of any poison or toxicant presents risks that must be carefully considered and understood prior to proceeding.

For an eradication project to be successful, it must also meet a number of criteria. These criteria need to be addressed for every project before proceeding with project implementation.

See the Battler booklet "Use anticoagulant rodent bait safely" for more information.



Photo: Carlo Iacovino, SPREP

What is the difference between eradication and control?

A control operation reduces the impacts of an invasive species by reducing its abundance. A control operation does not have to ensure that the last individual within the population is removed. In contrast, an eradication operation must target every individual within the population. Consequently, a different mind-set is required. The project manager and project team must clearly understand this difference if the project is to be successful. If successful, and reinvasion is prevented, an eradication operation permanently eliminates the impacts of an invasive species.



Eradication Criteria

To be successful, a rodent eradication must meet a number of criteria. Practitioners must ensure that these have been met prior to proceeding with a rodent eradication.

- Re-invasion by the target species and future invasions of new invasive species can be prevented.
- Risks to human health and safety, non-target species, and the environment are acceptable or can be avoided, minimised, or mitigated (see 'Use anticoagulant rodent bait safely').
- The project and its methods have the support of the community and other key stakeholders.
- All necessary permits and consents have been secured.
- The skills, resources, and equipment necessary to complete the project are available.
- Funding to complete the project has been secured.

“Eradication operations may use the same techniques as control operations, but the goal and therefore the essential mind-set for everyone involved is different” – Cromarty et al. 2002.

This difference should be reflected in the planning undertaken for a rodent eradication operation.

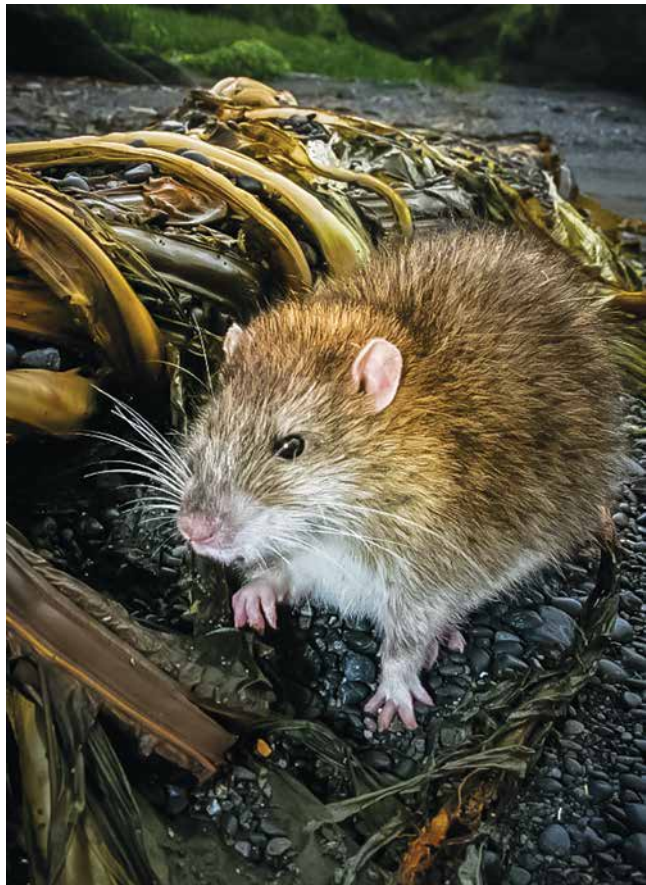
Methods of eradication

Two approaches are outlined within these guidelines: the hand spreading of rodent bait and the dispensing of rodent bait via bait stations.

These methods are used widely for removing rodents from islands. Both depend on all parts of an island being accessible.

For the sake of simplicity, both methods are described based on the use of rodent bait containing a second-generation anticoagulant at concentrations between 20 and 50 ppm.

Second-generation anticoagulant rodenticides, such as brodifacoum, have had the best record of successfully removing rodents from islands. However, it should be noted that both approaches have also been used successfully with first-generation anticoagulants.



Variations to the strategy outlined below may be required if rodent bait containing a first-generation anticoagulant is to be used. If in any doubt what these changes should be, seek expert advice.



How do I plan a rat eradication?

Operational Plan

It is strongly recommended that you create an operational plan for your project because this will ensure you have thought through the implementation of the project from beginning to end and it will maximise the likelihood that your project is successful. The operational plan should establish a timeline for the project, the resources that will be required, and how the project will take place. It should also provide detail on how risks to people and the environment will be managed (see 'Use anticoagulant rodent bait safely'). Seek expert advice when writing your operational plan.



Site Visit and Trials

Visiting the island prior to completing the planning for your project will allow you to find solutions to logistical challenges and quantify risks to the environment and human health.

Site-based trials may be necessary to inform the operational plan. For example, you will need to determine a bait application rate that maximises the likelihood of operational success but that does not pose an unacceptable risk to non-target native species.

To achieve success, sufficient bait must be applied so that it is accessible to every rat or mouse within the population. In temperate climates such as New Zealand, 8 kilograms per hectare is often enough to meet this need, but on tropical islands with higher rodent population densities or high numbers of land crabs, this quantity may be insufficient.

A site-based trial can be used to determine the most appropriate application rate. If a visit cannot be undertaken, consider using bait stations or seek expert advice to assist in determining an application rate.



Choosing your approach

The pros and cons of bait station vs. hand broadcast should be considered when deciding which approach is best for your situation.

Bait station operations have the advantage that they generally use less bait and can reduce consumption of bait by non-target species. Uneaten bait can also be recovered, decreasing the amount of toxicant entering the ecosystem. These advantages may also reduce the risk to sensitive native species. However, bait station operations are generally more expensive, require more effort, and entail bait being available for a longer period than those operations in which bait is hand spread. Historically, bait station projects have also had a slightly lower rate of success.

Hand spreading uses more bait and poses a greater risk to non-target species but is less expensive, requires less effort, and may offer a greater chance of success.



Photo: Carlo Iacovino, SPREP

DNA reference samples

A site visit can also be used to collect DNA reference samples from the targeted rodent population. Collecting DNA samples is not essential but is desirable because DNA samples can be used to determine if the operation failed or if rodents reinvaded from elsewhere if rodents are found on the island after the eradication. DNA samples can be obtained by trapping rats, collecting the tip of the tail, and storing these tail tips individually in alcohol or in DNA buffer solution.

What is the process of preparation: site and project?

To ensure a rodent eradication project is successful, every individual within the targeted rodent population must be exposed to the bait. In a ground-based operation, this is done by placing a sufficient quantity of high-quality and palatable rodent bait into every rodent territory on the island. Refer to this step-by-step process as a guide to your site and project preparation.

Step 1. Remove any domestic animals, e.g. pigs, dogs, and chickens, from the project site because these animals could be poisoned, jeopardise the success of the project, or pose a risk to human health (see 'Use anticoagulant rodent bait safely').

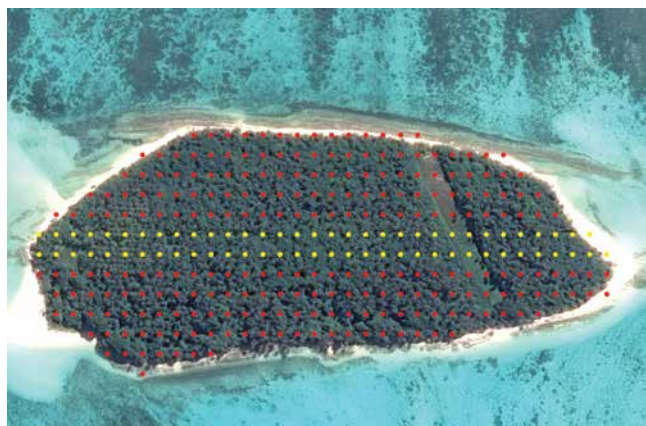
Step 2. Isolate supplies of drinking water from potential contamination (see 'Use anticoagulant rodent bait safely').

Step 3. If practical, remove all alternative sources of food for rodents because this could put the success of the operation at risk. This will not be feasible for most natural food sources but should be possible for food stored or grown for human consumption. Food waste should be burned or buried so that it cannot be accessed by rodents.

Step 4. Establish a grid across the project site. The resources and materials you will require are:

- project team members with the requisite skills and experience;
- machetes for cutting vegetation;
- map of island;
- compasses or GPS;
- measuring tapes, hip chains or another system for measuring the distance between grid points; and
- flagging tape (two colours for marking lines and grid intersections).

The grid will form a 'map' of the exact locations where bait will be applied and should be as simple and as regular as possible. Cutting parallel lines across the entire project site is ideal, and running these lines at right angles to a central transect will generate the best result. The central transect should cross the island at its longest point. Cut the lines so that team members will be able to easily move along them carrying bait.



Step 5. The dimensions of the grid will depend on the rodent species you are targeting. Use the following minimum grid sizes: 20 m × 20 m for mice, 25 m × 25 m for both *Rattus exulans* and *R. rattus*, and 50 m × 50 m for *R. norvegicus*. The same grid dimensions apply across all habitats and whether bait is to be hand spread or deployed in bait stations.

Step 6. Mark the lines with flagging tape so they can be easily followed. Each piece of flagging tape should be visible from the one before and the one after. Mark the ends of lines with two pieces of flagging tape that are visible from the line and the coast.

Step 7. Mark the intersections of the grid with flagging tape of a different colour, ensuring grid points can be easily recognised.

Step 8. If using bait stations, choose the type of station that best suits your conditions. Factors that may need to be considered when selecting a bait station type include rodent behaviour, portability, durability, exclusion of non-target species, bait type, habitat type, climate and cost. Bait stations can also be made from locally sourced materials if possible.

Step 9. Bait stations should be established across the project site at least one week prior to the operation to reduce the chance that neophobia will affect operational success. Some rodents can be wary of new things placed in their environment, so giving them more time to get used to the bait stations is better.

Step 10. Position a bait station within 2 m of each grid point across the project site. Factors requiring consideration when installing bait stations include:

- stations must be able to be easily found and accessed multiple times during project implementation;
- stations must be placed so that rodents will access them. Placing stations under some form of natural cover is desirable;
- stations should be secured so they cannot easily be dislodged or fall over. This can be achieved by nailing the bait station to a tree, tying it to a fixed object, or using rocks to secure the station in place; and
- the bait station set-up should be modified if non-target species interference or bait take by other wildlife could occur. To exclude most species of land crab, bait stations should be elevated off the ground by approximately 10 cm (4"). Ensure that crabs cannot climb to the entrance. Bait stations should be placed on the ground for mice, so if targeting mice on an island where land crabs are abundant, consider hand-spreading bait rather than using bait stations.

Step 11. Select the team that will undertake the operation and ensure they are fully briefed on what is expected of them. Any team member could cause the project to fail, so it is critical that every member of the team has the necessary skills and commitment to complete the tasks they are assigned. Team members must understand that bait must be applied at every point or in every bait station on the grid otherwise the project could fail.

Step 12. The operational plan should specify the bait type and application rate for the operation. These decisions will likely require site-specific trials to establish (see above). Make sure you have sufficient bait for the operation and a contingency supply in case some bait is lost or damaged or you end up using more than planned. Ensure you account for steep or higher risk areas that may need a higher bait application rate. Ten per cent of the total amount of bait needed for the operation should be the minimum amount of contingency bait ordered.

Step 13. Plan to apply the same quantity of bait to each station, either by counting out individual blocks or baits or using a measuring cup. This will allow you to calculate the amount of bait taken between checks. This information will become important toward the end of the project when making the decision that the operation is complete. If bait is to be hand spread, calculate how much bait needs to be dispensed at each point of the grid. Divide this by five because this will be the number of scoopfuls you will throw at each point on the grid and then mark this amount on a measuring cup or scoop. If using bait stations, calculate how much bait needs to be dispensed within each station and, from this, the amount you will require for the operation. The amount needed for each station should be sufficient to provide a continuous supply of bait between checks but not overfill the station to the point that bait spills out. Site-based trials may be required to determine the most appropriate bait station and amount of bait required.



Attention!



Ensure all affected stakeholders or communities are notified that the operation is proceeding and ensure they are aware of the hazards and the precautions that must be taken, such as restrictions on visiting the island and a moratorium on food harvesting (see 'Use anticoagulant rodent bait safely').

How do I hand-spread bait?

Whether hand spread or in bait stations, bait must be available for long enough so that every rodent in the population can ingest a lethal dose, including juvenile rats or mice that may be still in the nest at the time when bait is first applied.

Step 1. Ensure all measures are in place to manage risks that have been identified to people and the environment.

Step 2. Obtain a weather forecast and time your bait application so that it coincides with a period of dry weather. This will preserve bait quality and palatability.

Step 3. Place warning signs that explain the hazards posed by rodent bait at all potential entry points to the island (see 'Use anticoagulant rodent bait safely').

Step 4. Equip each team member with the necessary PPE, bait, scoop, and GPS. Have spare equipment on hand in case of loss or breakage. Bait can be carried in plastic buckets, back packs, or tree-planting bags depending on the preference of team members and what is available.



Step 5. To improve the efficiency of implementation, create bait depots before starting bait application or have a separate support team whose responsibility it is to resupply bait to team members spreading bait. Ensure that the team members spreading bait carry sufficient bait to complete bait application between bait depots.



Step 6. Aim to apply bait across the entire island in one day. If this is not possible and bait application extends over multiple days, before recommencing bait application, reapply bait along the last few lines adjacent to areas not yet treated.

Step 7. Spread bait at each grid point. Bait should be thrown out to half the distance between grid points. Throw a fifth of the bait in each quarter—the North, East, South and West—and the last around your feet as shown in the figure.

The only exceptions to this will be grid points on the coast or at the edge of your baiting grid. Bait only needs to be applied above the high tide mark. Be consistent about the number of scoopfuls and the amount of bait thrown at each grid point.

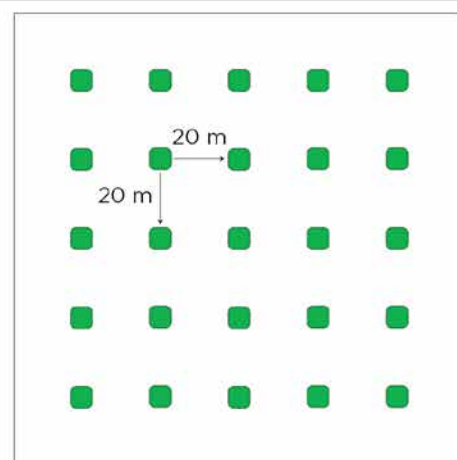
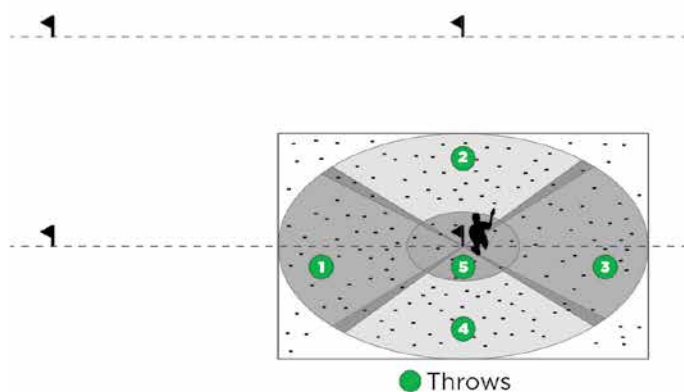
Internal grid dimensions: 25m x 25m

Area at each point = 25m x 25m = 625m² or 0.0625ha

Proposed Application Rate = 20kg/ha

Amount of bait required to be spread at each point = 20kg/ha x 0.0625ha = 1.25kg

Size of scoop = 1.25kg / 5 = 0.25kg or 250g



The five directions in which to spread bait from each grid point (left) and an example of a 20 m x 20 m baiting grid (right)

Step 8. At different stages during bait application, get the project team to pause and assess how much bait has been used. Divide the amount of bait (in kilograms) by the area (in hectares) of the island completed and calculate the bait application rate achieved. If significantly different (e.g. more than 10%) from the planned application rate, modify the size of the scoops or the level of bait in the scoops being used. Most importantly, ensure you do not run out of bait before the island is completed.

Step 9. Apply additional bait to steep areas because of the additional surface area that these parts of the island represent. Equally, apply more bait to areas that may pose a higher risk of failure. These could be areas that have high numbers of non-target bait consumers, such as hermit or land crabs, areas of human activity, or areas where alternative food is more abundant.

Step 10. If there are buildings or structures on the island, ensure that bait is placed inside any enclosed spaces where rodent movement is possible.

Step 11. After an interval of at least 24 days (which will allow any young rodents to emerge from nests), apply a second application of bait using the same specifications as the first application.

Step 12. Once the second bait application is complete, retrieve all flagging tape and ensure all used packaging is recovered and disposed of along with any unused bait in accordance with the manufacturer's recommendations (see 'Use anticoagulant rodent bait safely').

How do I use bait stations?

The overriding objective in a bait station operation is to establish bait stations within every rodent territory and maintain sufficient fresh bait in each station for as long as it takes for every individual rat or mouse to find a station and consume a lethal dose.

Step 1. Obtain a weather forecast and time your bait application so that it coincides with a period of dry weather. Good weather is not as critical for a bait station operation because the bait is protected from the rain. However, applying bait in dry conditions will preserve bait quality and palatability.

Step 2. Equip each team member with the necessary PPE, equipment, and bait. Bait can be carried in plastic buckets, back packs, or tree-planting bags depending on the team's preference.

Step 3. Create bait depots before starting bait application or have a separate support team whose responsibility it is to resupply bait to team members. Ensure that team members filling bait stations carry sufficient bait to fill all stations between bait depots.

Step 4. When bait stations are first filled, aim to fill all stations on the grid on the same day. Ensure your team is the appropriate size to do so.



Step 5. Ensure you have sufficient bait for the operation and a contingency supply in case some bait is lost or damaged or you end up using more than planned. Fill each bait station with sufficient bait to ensure the station does not run out before it is checked again.



Step 6. If there are buildings or structures on the island, ensure that bait stations are also placed inside any spaces that might be used by rodents.

Step 7. Initially, stations should be checked on a daily basis if possible to ensure a continuous supply of bait. The frequency of checks can be reduced when you are confident that bait will not run out in any of the stations on the grid between checks.

Step 8. At each check, document the following information:

- Date
- Time
- Person responsible for conducting the check
- Condition of bait station
- Condition of remaining bait
- Presence of rodent sign (e.g. faeces)
- Evidence of bait take by non-target species
- Quantity of bait remaining
- Quantity of bait removed
- Quantity of fresh bait added
- Any other information that might be important to the success of the project or future projects

Step 9. At each check, remove any old bait that has become mouldy or damaged and replace with fresh bait if necessary. Replace old bait regardless of condition every two weeks to ensure bait remains palatable to rodents. Dispose of old bait away from possible rodent or non-target species access. If storing for disposal, place in sealed containers that are clearly labelled so that old bait does not get re-used.

Step 10. At each check two weeks after bait was first applied, count the number of bait pellets or estimate the quantity of bait remaining and remove all sign of rodents and other non-target species from bait stations. Any bait take or sign of rodents observed after this time will need to be taken into account when declaring the operation finished.

Step 11. Bait stations should remain in place and contain bait for at least one month after the last evidence of rodent bait-take or suspected take is observed.

Step 12. Once the operation is deemed completed, retrieve all flagging tape, bait stations, bait packaging, and unconsumed bait. Dispose of bait and bait packaging in accordance with the manufacturer's recommendations (see 'Use anticoagulant rodent bait safely').



How can I tell if my project is successful?

Monitoring is important to measure the short- and long-term impacts of your project and confirm its success. Monitoring can be broken into three categories: Operational Monitoring, Environmental Monitoring, and Outcome Monitoring.

Operational Monitoring

Operational monitoring encompasses the monitoring completed during project implementation to maximise the likelihood that the project will be successful. Several types of operational monitoring are recommended for rodent projects.

- Bait quality should be monitored while in storage to ensure that when it is applied, it is in good condition and that it will be palatable to rodents. Similarly, bait deployed in bait stations should be checked regularly and replaced if there is any deterioration in quality.
- The amount of bait used should be checked at various stages during bait application to ensure the amount is consistent with what was planned and that you do not apply insufficient bait or run out of bait before finishing.
- Auditing the accuracy of bait application may be warranted, especially if your team has limited experience. To do this, check every bait station or grid point to ensure it has been visited and bait applied. If there is inadequate time or resources to check the entire grid, visit a random selection of bait stations or points on the baiting grid.
- For projects where bait is broadcast, it is recommended that you monitor bait availability on a daily basis between the first and second application. Bait availability is monitored by marking a representative sample of bait pellets with pin flags or flagging tape and recording the number of pellets remaining on a daily basis. Information from this monitoring can be used to modify the strategy for the second or subsequent applications; e.g. if bait disappears too quickly, the application rate for subsequent applications can be increased.
- For operations where bait is hand broadcast, degradation of bait may be an important indicator of when it is safe to reintroduce livestock or non-target native species. Bait degradation can be measured by placing bait in cages so that it is exposed to the elements but not accessible to bait consumers.



- Recording rainfall is recommended because rainfall can be used as a predictor of the rate of bait degradation.
- A sample of the bait should be stored for future reference. If the operation is unsuccessful, this sample can be used to check if there was a problem with the bait, e.g. the toxicity.

Environmental Monitoring

Environmental monitoring is an important part of any project. When designed and conducted appropriately, monitoring can inform future projects by providing a measure of impacts from each project. Monitoring can also help detect impacts as they occur, allowing a response to be formulated.

If project stakeholders want greater certainty about when food resources, e.g. coconut crabs, can be harvested and safely consumed again, samples can be collected after bait application and sent to a laboratory for residue testing. If this is done, samples should also be collected prior to the operation so that the background level of anticoagulants can be determined. Food should not be consumed if residues are detected.

Carcasses found following bait application can also be sent to a laboratory for necropsy and residue testing to determine the cause of death.

Surveys of non-target species abundance before and after the operation can be used to detect short-term impacts to the population. If greater precision is required, marking individuals or attaching radio transmitters and tracking their fate through the operation will provide accurate information on any impacts.

Plans for monitoring should be included in the operational plan and scaled to match the predicted risk associated with the project.



Photo: Carlo Iacovino, SPIREP

Outcome Monitoring

Outcome monitoring is the monitoring done to confirm if the project has met its goals and objectives.

Confirmation of operational success is generally done after at least two rodent breeding seasons have elapsed. In the tropics, this monitoring can be completed one year after the operation. Personnel will need to go back to the island and monitor for rodent presence on the island using traps, chew blocks, track pads, or other methods. If rodents are detected, samples should be collected for genetic analyses to help assess if the eradication failed or if re-invasion occurred. Surveys to estimate species abundance after the operation can be used to confirm long-term ecosystem changes and the recovery of threatened species populations. The timing of repeat surveys will depend on techniques to be used and the species and expected rate of recovery.

How do I report on my project?

It is important to be transparent and remain accountable for the actions undertaken during a rodent eradication. A detailed report that describes the methods used, the results, and the conclusions of the project will help identify what worked, what went wrong, and what can be done to improve things in the future, ideally containing the following sections.

Island Data

Island name, island area, geographic location, habitat types, topography, substrate, climate, sites of human habitation, agricultural areas, other island uses, presence and population density of non-target consumers of rodent bait, target rat species, other target species and invasive species present not targeted, rat population density, rat breeding status, and rat DNA reference samples collected.

If the available time or resources do not allow for a robust estimate of rat population density, an index of abundance should still be measured.

Environmental Variables

Climate, rat population density, rat population breeding status and body condition, observed natural food availability, non-target species, and presence and population density of non-target bait consumers.

Operational Design

Bait type, concentration of rodenticide in the bait, bait additives, bait reference samples, methods of bait application, bait application rate, total quantity of bait applied, spacing of hand-spreading points and transects, timing of bait applications, exclusion zones, tracking and attending to bait gaps, GIS data on the bait application, GPS unit type, number of bait applicators if hand-broadcasting bait, and/or details of bait station design and use (numbers, spacing, bait monitoring, and refill schedules).

Operational Monitoring

Bait availability over time, rate of bait degradation, rainfall, rodent mortality, impacts on non-target species, captive management of non-target species, site/timing-specific variations made in operational plan and explanations why.

Organizational information

Organization name, organisation type, contact details for lead person (project manager), number of staff, number of volunteers and extent of training each received, project team structure, project team roles and responsibilities.

Additional Resources

[Island Conservation](#) staff have conducted Pacific rodent eradications and drafted the text of this booklet.

The Battler Resource Base contains information materials and resources for battling invasive species: www.sprep.org/piln/resource-base

You can contact the Invasive Species Programme through the SPREP website: www.sprep.org/Invasive-Species/bem-invasive-species

Pacific Invasives Initiative: Resource Kit for Rodent and Cat Eradication.
<http://rce.pacificinvasivesinitiative.org/>

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Photo: Carlo Iacovino, SPREP



Join the Fight

Protect our islands from invasive species



Håfa Adåi

Aloha

Mogetin

Rahn Anim

Iokwe

Alii

Kaselehlie Len Wo

Mauri

Ekawomir Omo

Halo

Mālō te ma'uli

Halo

Tālofa

Halo

Tālofa

Ni sa Bula Fakaalofa lahi atu

Bonjour

Mālō e lelei

Kia Orana

Ia Orana

Bonjour

Hello

Kia Ora

