The feasibility of eradicating Pacific rats from Beautemps-Beaupré Island, Loyalty Islands, New Caledonia

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3.0	January 2018	Grant Harper & Souad Boudjelas	Antoine Barnaud (ASBO).

Cover image: Beautemps-Beaupré Island. The photo was provided by ASBO. It was produced with the help of Géorep.nc

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EXECUTIVE SUMMARY

This feasibility study assesses whether the Association pour la Sauvegarde de la Biodiversité d'Ouvéa (ASBO) can eradicate Pacific rats from 47 ha Beautemps-Beaupré Island, Loyalty Islands, New Caledonia. Beautemps-Beaupré is a World Heritage site, along with Ouvéa, and is highly valued at a local and national level. It has several seabird colonies, numerous native bird, lizard and invertebrate species and largely intact native forest. It is also large enough to serve as a refuge for some other threatened species if required. Pacific rats, the only invasive mammal, should be removed in order to improve the island's biological values.

An attempt was made by ASBO in late 2015 to eradicate the rats but this was not successful. Several possible factors that may have contributed to the lack of success were identified by ASBO and by this feasibility study and changes were made to the proposed second attempt at eradicating Pacific rats on Beautemps-Beaupré Island. These include conducting the eradication operation in winter to: 1. reduce uptake of toxic bait by land crabs; 2. reduce the likelihood that sooty terns will be nesting; and 3. reduce the chance of significant rain degrading the bait. In addition, external technical advice and experienced bait application personnel need to join the ASBO team to provide additional rigour and training in order to improve the likelihood of operational success. Experience worldwide indicates tropical islands are more prone to eradication failure and projects on small islands can fail if there is insufficient planning and/or lack of experience.

We conclude that with adequate planning and implementation, the eradication of Pacific rats is feasible using hand broadcasting of toxic rodent bait. Outcomes can be sustained through the implementation of effective Island biosecurity. The estimated cost for completing the planning and implementation of the eradication is US$112,800 (including 20% contingency). The cost of on-going biosecurity for the island will be determined when completing the biosecurity plan.

1 INTRODUCTION

A proposal for a second attempt to eradicate the Pacific rat (*Rattus exulans*) on Beautemps-Beaupré Island, Loyalty Islands, New Caledonia is being led by the Association pour la Sauvegarde de la Biodiversité d'Ouvéa (ASBO) with support from the Chefférie (or tribe) of Héo, the landowners, and other partners. This feasibility study is the first step in the planning process for the proposed eradication. ASBO commissioned the Pacific Invasives Initiative (PII) at the University of Auckland, New Zealand to undertake the feasibility study. This was done in collaboration with Biodiversity Restoration Specialists (BRS).

This report documents the findings of the study to determine the feasibility of eradicating the Pacific rat on Beautemps-Beaupré. It describes the goal, objectives and anticipated outcomes of the project; the importance of the site; the likely benefits and costs of removing the rats; the possible reasons why the first attempt was not successful; the recommended eradication methodology; strategies to enhance the likelihood of success and sustain outcomes. The report also makes recommendations for the next steps in the planning of the eradication of Pacific rats on Beautemps-Beaupré and preventing them from reinvading the island. The feasibility study is based on information gathered from ASBO, consultation with eradication experts and a 5-day site visit to the island between 19 and 23 June 2017.

This report will assist ASBO, the Chefférie of Héo and other project partners with their decision-making regarding the proposed eradication. It will also assist with the preparation of funding proposals for the full eradication project.

2 ACKNOWLEDGEMENTS

Special thanks to ASBO, the Chefferie of Héo and the INTEGRE Project for their support for the project. Thanks to the site assessment team of Jacques Adjouhnyiope, Antoine Barnaud, Hnalain Omniwack, Faisen Adjouhnyiope, Daniel Estieux, Joël Wéa, Chrislain Ouckewen, Joenzo Baoutuau, for their valuable input to the field work and wonderful hospitality. Thanks also to Cédric Meaou and Aizick Adjouhnyiope for the safe (though at times bumpy) boat rides from Ouvea to Beautemps-Beaupré and back. Acknowledgment must also go to Araceli Samaniego and Keith Broome for their valuable review and feedback on this report.

Financial support for the feasibility study was provided by the INTEGRE Project. The latter is funded by the European Union and implemented by the Pacific Community (SPC).

3 GOAL, OBJECTIVES AND OUTCOMES

The following have been developed in consultation with ASBO.

3.1 Goal

To allow natural restoration of native fauna and flora on Beautemps-Beaupré Atoll.

3.2 Objectives and Outcomes

The objectives that this action will achieve and the outcomes that can be expected as a result of achieving these objectives are:

Objectives	Outcomes
1. Eradicate Pacific rats from Beautemps-Beaupré Island.	1.1 Protect native land bird species and allow their populations to increase.
	1.2 Protect seabird species and allow their populations to increase. Facilitate the re-population of the island with seabird species currently missing.
	1.3 Allow native plant communities to recover through cessation of rat predation of seeds, fruits and seedlings.
	1.4 Allow native reptile and invertebrate populations to recover.
	1.5 Facilitate the recovery of native flora and fauna and ecosystem processes and interactions.
2. Strengthen biosecurity for the atoll to ensure it remains rat free and reduce the risk of new invasive species introduction.	2.1 Stricter biosecurity measures are in place to reduce the risk of re-invasion by Pacific rats and introduction of new invaders e.g. plants, invertebrates, other mammals.
3. Enable other future rat eradications to be carried on small islands in Ouvéa.	3.1 Key local individuals are trained in planning and successfully executing a rat eradication on small tropical islands.

4 THE SITE

Beautemps-Beaupré Island or Héo as it is known locally, is located about 45 km northwest of Ouvéa Atoll in the Loyalty Islands, New Caledonia. It is a 47 ha raised coral island on the southwestern corner of Beautemps-Beaupré Atoll (20° 24’S, 166° 10’E). The atoll’s emerged land area consists of the main island of Beautemps-Beaupré, the tiny rocky islet located a few

meters off its eastern tip and Motu Tapu islet (~ 50 m long) located 2-3km NE of the main island. Following surveys, Motu Tapu has been considered to be rat-free. This means that with the proposed eradication on Beautemps-Beaupré Island, the whole atoll will become rat-free. The nearest landmass to Beautemps-Beaupré is 12 km away, consisting of a small island in the Northern Pléiades archipelago on the edge of Ouvéa Atoll (Figure 1). Ouvéa and Beautemps-Beaupré Atolls were listed by UNESCO as a World Heritage Site in 2008.

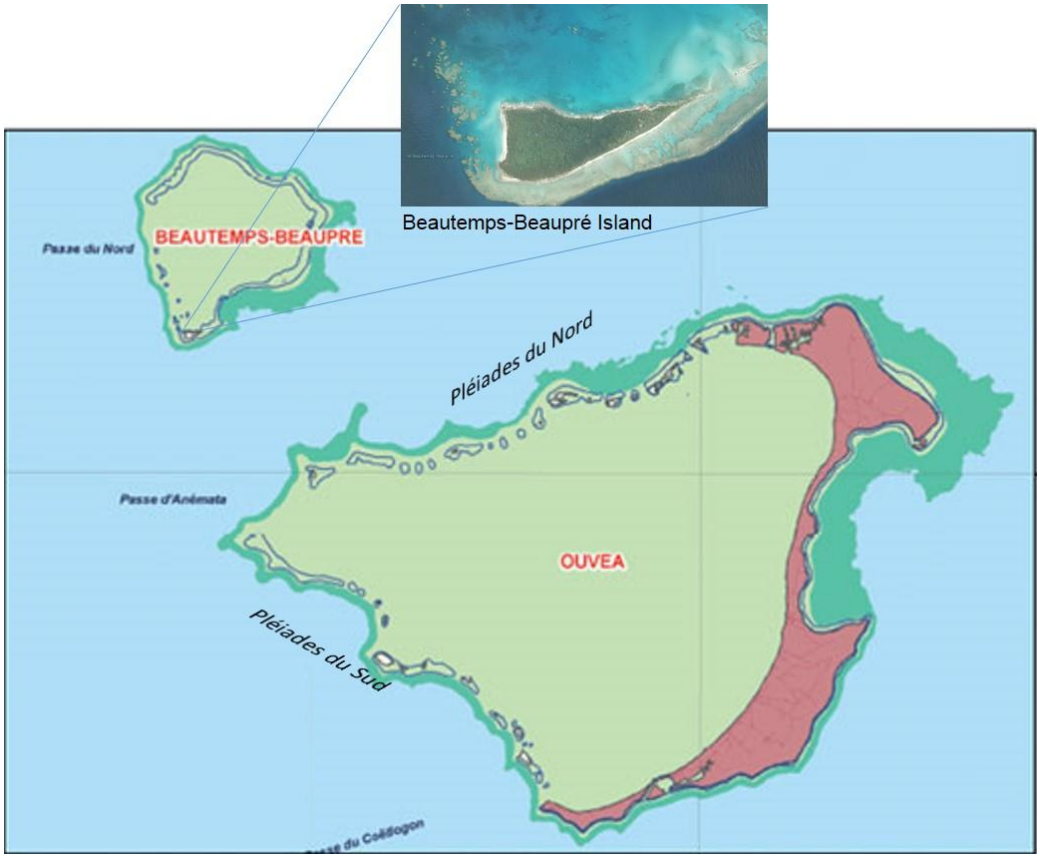

Figure 1. Map of Ouvéa and Beautemps-Beaupré atolls. Beautemps-Beaupré Island (see inset) is located at the bottom left hand corner of Beautemps-Beaupré atoll. The map was adapted from original which can be found at: http://integre.spc.int/en-nouvelle-caledonie/les-atolls-d-ouvea-et-beautemps-beaupre#présentation-du-site

The island of Beautemps-Beaupré has no permanent settlement and is occasionally used as a base for short-term visits by members of the Chefferie of Héo (based on Ouvéa) and other visitors. The only access is by boat with a landing on a surf beach.

The climate is oceanic tropical with an average rainfall of about 1450 mm. There are four distinct seasons. From late December to late March it is the hot season (mean minimum and maximum temperatures of 25-30°C), and is humid and wet (Figure 2). This is followed in April to May by an intermediate season, which is wet, but cooler. The austral winter from June to August/September is cool (mean minimum and maximums of 19-24°C) and sunny with less rainfall. In June and July it is usually dry for about 20-23 days with less than 5mm/day recorded

on 5-6 days, and rainfall over 5 mm/day on only 3-4 days per month. This relatively dry period continues from October to November but becomes warmer.

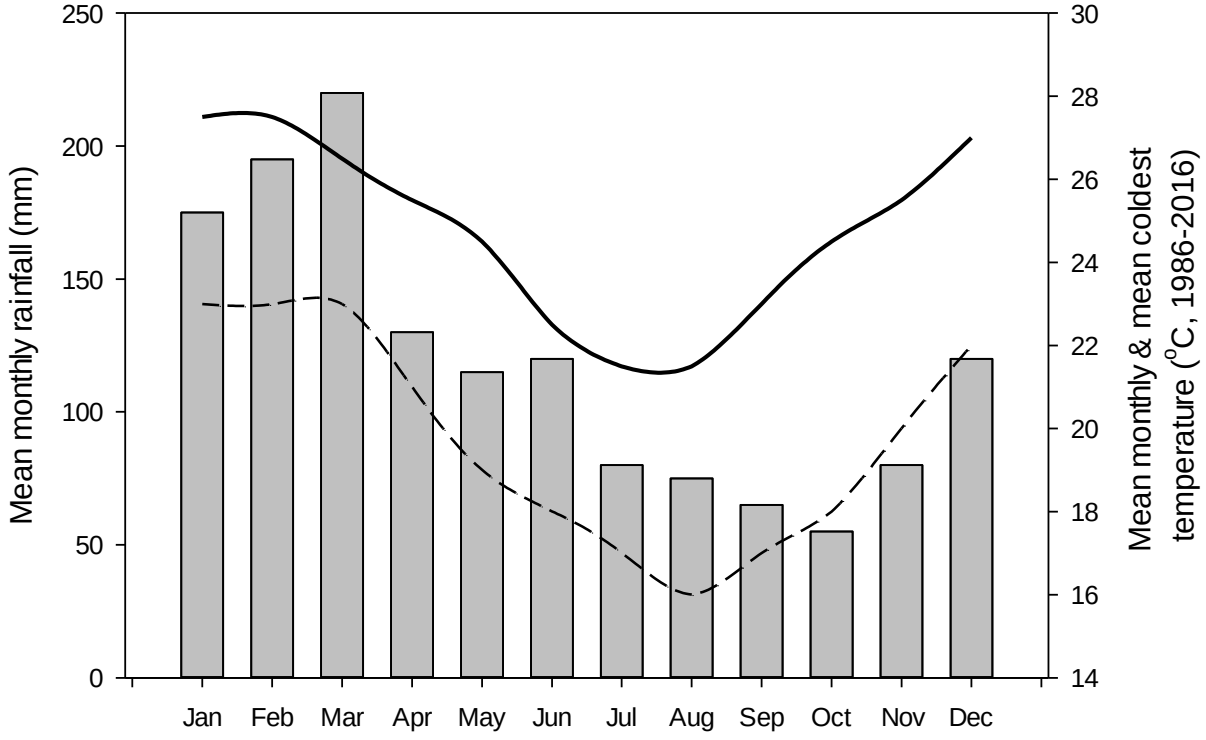

Figure 2. Mean monthly rainfall, mean monthly temperature (solid line) & mean monthly coldest temperature (dashed line) at Ouvéa, New Caledonia.

The island is a very important nesting site for seabirds and turtles. In addition to its significance in relation to biodiversity conservation, the island is also a site of high cultural and historical significance. Being home to the chief of Héo, the island continues to be a special place for members of this tribe. Vestiges of the chief's quarters and crop garden are still visible. The island has the potential to become a sanctuary for native fauna and flora due its isolation and customary reserve status.

The island is principally limestone with a 2 m high highly-eroded raised coast (Figure 3) and only two beaches on the south and west coasts, the latter being used for boat landings. For a substantial portion of the interior there are numerous sinkholes of 2-4 m depth. The entire island is forested, with, native forest species such as pandanus, coconut, banyan as well as introduced faux mimosa (*Leucaena leucocephala*), forming most of the canopy. There are large areas of smothering liana vines in the centre of the island. There is some *Scaevola* and *Pemphis* on the more exposed sections of coast. Rats have access all year round to food in the form of fruit or seeds.

Figure 3. The coastal forest at Beautemps-Beaupré Island, showing coastal limestone.

Several land crabs species are present, including coconut crabs (*Birgus latro*), hermit crab species (*Coenobita* ssp.) and at least two species of burrowing crab.

There are at least two species of lizards present; a skink and a gecko and at least two turtle species nesting, green (*Chelonia mydas, EN*) and loggerhead (*Caretta caretta, VU*) turtles.

None of the many bird species that are resident on the island are listed as threatened. Nine land bird species have been recorded, eight of which are resident breeders. None are regarded as threatened in the region (Tarburton 2014). The red-bellied fruit-dove (*Ptilinopus greyi*) and buff-banded rail (*Rallus philippensis*) are likely to consume toxic rodent bait directly, and peregrine falcon (*Falcon peregrinus nesiotes*) and sacred kingfisher (*Todirhamphus sancta*) may be susceptible to secondary poisoning. The island supports 18 recorded seabird species, of which 12 breed there. The sooty tern (*Onychoprion fuscata*) population is far and away the largest. Breeding does not appear to be strongly seasonal and can occur at any time of the year. Two booby species, brown booby (*Sula leucogaster plotus*) and masked booby (*Sula dactylatra personata*) have breeding colonies on the eastern end of the island and are present in small numbers (~100 individuals) year round. Wedge-tailed shearwaters (*Ardenna pacific)* and herald petrels (*Pterodroma heraldica*) have been recorded breeding in small numbers (Tarburton 2014).

It is possible that a population of the endangered Ouvéa parakeet (*Euynmphicus uvaeensis*) could be established on the island as an 'insurance' population in case black rats or other predatory animals become established on nearby Ouvéa.

A population of the Pacific flying fox (*Pteropus tonganus*) is present on the island.

A common, shared management process has been set up for Ouvéa and Beautemps-Beaupré by Ouvéa's five chiefly councils, the Loyalty Islands Province and Ouvéa municipality. As part of the management process the Bomene Tapu (forbidden island) environmental GDPL (special local-status association) was established in 2011. Its objective is to "develop and preserve practices related to traditional natural resource management on Ouvéa and Beautemps-Beaupré atolls insofar as they protect and sustainably preserve natural resources in the interests of present and future generations". The association has 34 members drawn from the island's 20 tribes.

As part of the objective, funding from the INTEGRE project for the Loyalty Islands is being used to undertake Activity 4 of the project, which aims to eradicate Pacific rats to protect seabird colonies and establish biosecurity measures on BeautempsBeaupré Island.

5 TARGET SPECIES, IMPACTS AND BENEFITS OF ERADICATION

The Pacific rat (*Rattus exulans*) is likely to have been introduced to the island by humans when they discovered and settled the archipelago.

Rat impacts on native species are likely to be substantial. The Pacific rat diet mainly comprises plant material and arthropods (Bassford et al. 2007), which includes native insects and the seeds and seedlings of native trees. On Kure Atoll, Wirtz (1972) recorded 62% of their diet as plant material and 30% was insects, predominantly grasshoppers, spiders, cockroaches and flies. Eight percent of the diet was vertebrate flesh, mainly seabirds. On other tropical islands Strecker and Jackson (1962) found about 90% of their diet was plant material. Fall *et al*. (1971) found insects in 10% of stomach samples. Small crab species are also likely to be highly affected by Pacific rat predation (Harper & Bunbury 2015, Samaniego *et al*. in press). Selective consumption of seeds and fruits of particularly favoured plants, along with seedling predation can change the composition and structure of native forests over time. Of the vertebrates, small reptiles such as geckos and skinks are vulnerable to rat predation, along with newly hatched turtles. Terrestrial birds, particularly small passerines, are also vulnerable to Pacific rats, particularly through predation at the nest where eggs, chicks and incubating adults are likely to be taken, often leading to their local extirpation (Harper & Bunbury 2015).

At present, the it may be difficult to introduce the endemic Ouvéa parakeet to Beautemps-Beaupré, due to the threat posed by Pacific rats. Moreover, it is unlikely the current populations of land birds, particularly small passerines such as the Cardinal Myzomela (*Myzomela cardinalis lifuensis*) and Melanesian Flycatcher (*Myiagra caledonica*), will increase much above their low numbers with Pacific rats present.

Meta-analysis of impacts of rats on seabirds concluded that *inter alia* species that weighed less than 300 g were most in danger of being extirpated (Holly et al. 2008). It appears that almost all species of tropical seabirds up to the size of albatross are vulnerable to Pacific rat predation

in some form and, unsurprisingly, the smaller species such as terns are overly represented. Predation of sooty tern nests by Pacific rats has regularly been recorded, and Pacific rats have been the cause of severe declines in smaller petrel breeding success (Harper & Bunury 2015). Vanderwerf (2006) and Vanderwerf et al. (2007) noted that the most limiting factor for seabird nesting in the Kwajalein archipelago and Lehua Island, Hawaii, was the presence of Pacific rats, along with other introduced predators, such as feral cats.

It is likely that the extended presence of Pacific rats on Beautemps-Beaupré has resulted in major changes to the forest and fauna with depressed numbers of many invertebrate and vertebrate species and the likely unrecorded extinction of some species in the past. Responses to a rat eradication will probably include marked increases in the numbers, and changes in the species composition, of land crabs, small reptiles and land birds, with increased breeding success of sooty terns and other seabirds. Over time, the forest is likely to change as seeds previously preferentially eaten by rats become more common. This may however, also result in an increase in invasive plant species already present on the island.

6 PREVIOUS ERADICATION ATTEMPT

An attempt at eradicating Pacific rats on the island was carried out by ASBO from the 13th November to 15th December 2015. Prior to the baiting operation, parallel lines had been cut by hand across the island at 25 m intervals. Pestoff Rodent 20R bait containing 0.02 g/kg brodifacoum was hand-broadcast on a 25 m grid at a rate of 27 kg/ha and then 30 kg/ha five weeks apart. An additional 10% contingency was applied at the likely risk sites i.e. the tern colony and in dense areas of lianas. A check five months later, where 300 snap-traps were set for a night, revealed no sign of rats. However, in November 2016 however, numerous rats were trapped. These checks suggest the eradication came close to being successful as rat numbers were severely reduced for many months, but did ultimately fail.

Several reasons were postulated for the eradication failure which included: bait consumption by land crabs; the presence of nesting sooty terns; difficulties with forming straight transect lines in thick vegetation; a lack of experience with hand-spreading of bait that could have resulted in bait gaps; and rain (not forecasted and amount unknown) within 48hrs of the first bait application (A. Barnaud, pers. comm.). It is plausible that all these factors, either by themselves or in combination, could have contributed to operational failure. These factors will need to be addressed in order to significantly reduce the likelihood of failure in future.

7 PROJECT FEASIBILITY

Eradication means the complete and permanent removal of the target species from the site of interest, usually an island (Cromarty et al. 2002). Eradication of invasive rats, has been successfully conducted at a suite of islands around the world and is a proven and enduring method for protecting the biodiversity values of those islands (Howald et al. 2007). *R. exulans*, the target species for the eradication on Beautemps-Beaupré, has been successfully eradicated

from over 50 Pacific islands, ranging in size from small islet to large atolls (DIISE 2015). There are seven criteria that an eradication project must fulfil to increase the likelihood of lasting success. These are examined in sections 7.1 to 7.7 below.

7.1 Technical feasibility

7.1.1 Recommended rodenticide

The primary method for eradicating rodents from islands is the use of anticoagulants combined into a highly palatable cereal or wax baits, distributed across every rat territory (i.e. across the whole island) in a methodical and comprehensive manner. This method has been developed and refined over many years and in many different eradication projects. Anticoagulants cause death in rats by preventing blood clothing and hence, causing internal hemorrhaging. The effects of the anticoagulants are not felt by the rats until a few days after consumption and hence, are unlikely to associate the symptoms with the bait and cause them to stop eating it (i.e. bait avoidance or shyness) before they received a lethal dose.

First and second generation anticoagulants have both been used to successfully eradicate rodent on islands. First generation anticoagulants are less potent and less persistent but require multiple feeds over several days to reach a lethal dose. By comparison, second generation anticoagulants are more potent and more persistent but do not require multiple feeds, a lethal dose can be attained through a single feed of bait. This latter characteristic makes them better suited to tropical environments where competition for bait by land crabs and other bait consumers (e.g. ants) can be high and natural food can be available all year around. Therefore, the use of a second generation anticoagulant is recommended for the eradication on Beautemps-Beaupré while acknowledging the need for managing potential non-target and human health issues (see section 7.5.1).

Of the second anticoagulants available, brodifacoum is the most commonly used anticoagulant in rodent eradications (Howald et al. 2007, Parkes *et al*. 2011) and the toxicant recommended for the eradication on Beautemps-Beaupré.

7.1.2 Recommended bait delivery technique

To eradicate Pacific rats on Beautemps-Beaupré the most-cost effective approach with the most likelihood of success would be hand broadcast. This technique has proven a successful method on smaller islands up to about 200 ha. It involves hand spreading of rat bait on a grid, across the island. This will require track cutting prior to the operation. This technique is generally faster than a bait station operation and does not require rats to interact with bait stations as bait is readily available across the ground. Note that the hand broadcast technique involves substantial risks for non-target consumption of toxic bait, as discussed below (Section 6.6).

It is recommended that rodent bait pellets containing 0.02 g/kg brodifacoum are applied by hand broadcast at a rate of 25 kg/ha (Figure 4, Appendix 11.2). This approach, using second-

generation anticoagulants has been used successfully to eradicate rats and mice on a number of islands of similar size, terrain and climate to Beautemps-Beaupré (Table 1).

Two other techniques, aerial application and bait stations, were also assessed. These options were rejected principally on the basis of cost alongside some additional reasons including the local lack of the required technical expertise and likely significant interference with bait infrastructure (in the case of bait stations) from coconut crabs in particular.

Table 1. Successful rodent eradications on wet tropical islands using hand broadcast of toxicants.

Island	Country	Area (ha)	Year	Species	Toxicant
Ile aux Aigrette	Mauritius	25	1987	R. rattus	Brodifacoum
Pigeon	Australia	3	1995	R. rattus	Brodifacoum
Gunner's Quoin	Mauritius	65	1996	R. norvegicus	Brodifacoum
Flat	Mauritius	253	1998	R. rattus	Brodifacoum
Fajou	Guadeloupe	120	2001	M. musculus	Brodifacoum
Tomé	France	30	2002	R. norvegicus	Bromadiolone
Anchorage	Cocos	12	2003	R. exulans	Brodifacoum
Surprise	New Caledonia	24	2005	M. musculus	Bromadiolone
Ile Vache Marine	Chagos Islands	13	2014	R. rattus	Brodifacoum

To enable ease of bait spreading, tracks will need to be cut across the island, in parallel lines 20 m apart. The lines are closer than in the previous eradication attempt to ensure adequate bait coverage including in areas of dense vegetation. These tracks will require the use of GPS navigation and the most suitable GPS for working under dense canopy should be used (e.g. Garmin 64s). This was done for the first eradication attempt and should be repeated for the proposed operation. Some minor obstacles (sinkholes) need to be taken into account but all areas of the island are considered to be suitable for tracks. Track-cutting should be supervised by someone who is knowledgeable in GPS and experienced in rodent eradication operations. This person would need to verify that the accuracy and placement of the tracks is adequate, before any baiting commences. Establishment of tracks will require approval of the owners of the islands, but it is expected that this would be granted, as track-cutting was carried out for the previous operation and any damage will be temporary (pers. obs.).

7.1.3 Bait consumption by land crabs

Land crab population density can be high on the island. In February 2015 (i.e. wet and hot conditions) measurements of crab density recorded hermit crabs *Coenobita* sp. as 'high', burrowing crabs Gecarcinidae at a maximum population density of 350/ha and coconut crabs at 97/ha (A. Barnaud, pers. comm.). Measurements of land crab population density is usually more correctly a measure of 'activity' as they become markedly less active in dry and/or cool conditions (Samaniego *et al*. in press). In the cool, dry conditions that prevailed during the site visit in June 2017, crab activity was very low at night and only 13 crabs (4 very small coconut crabs, 5 small Cardisoma & 4 purple hermit crabs) were recorded on a 250m long, 2m wide

transect (pers. obs.) for an overall population density of 280 land crabs/ha. Ideally, the next eradication attempt should be undertaken in cool and dry conditions.

7.1.4 Presence of sooty terns

When present, the large sooty tern colony on the island is highly likely to be a significant food source for Pacific rats (Kepler 1967, Woodward 1972) and a substantial risk to the success of an eradication (Figure 4).

Figure 4. Sooty tern colony on Beautemps-Beaupré Island, June 2017.

Although sooty terns were thought to breed from about August to November, information supplied by ASBO suggests that the sooty tern breeding activity on Beautemps-Beaupré is not as strongly seasonal. Opportunistic records of the breeding stages over the past five years, when tied to the length of the breeding season of about five-six months [Month 1 – adults arrive, Month 2 – incubating eggs, Month 3-4 chicks growing, Month 5 – chicks fledge and adults depart], reveals a variable timing for breeding commencement over late winter (Figure 5), but with an early breeding season in 2017.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013												
2014												
2015												
2016												
2017												

Figure 5. Timing of recent sooty tern breeding seasons on Beautemps-Beaupré Island.

Sooty tern breeding strategies can be strongly seasonal or of varying timing but are often tied to food supply mediated by cool sea surface temperatures and increasing phytoplankton

production (Erwin & Congden 2007, Jacueqmet *et al*. 2007). On some islands sooty terns breed on an 8-10 month cycle (Ascension, South Atlantic/Great Barrier Reef, Australia) which can be adjusted if tropical cyclones affect breeding success (King *et al*. 1992). Why the sooty tern breeding season timing on Beautemps-Beaupré generally begins in late winter but not in 2017 is unknown, but the uncertainty around breeding commencement will have a strong bearing on the timing of a rat eradication operation, as predicting tern presence would be a significant confounding factor.

In the presence of sooty terns, an eradication could probably proceed if adults had only just arrived and were engaged in breeding activity, as little or no food would likely be available for rats, but should not proceed if eggs have been laid (2nd month of nesting onwards).

7.1.5 Transect establishment and operator experience

In regard to track cutting; attaining straight cut lines is achievable with a suitably managed and trained team. The use of mechanised tools should be considered to assist with particularly troublesome sites, like dense coastal *Pemphis* and areas of lianas (Figure 6). Similarly, hand-spreading of bait is a relatively straightforward technique, although it does require a significant amount of effort and skill. If operators become fatigued, lack motivation or are not performing at a high level then there is an increased likelihood that bait coverage will be inadequate, and some rats may not encounter toxic bait due to the resulting gaps. Importantly, Pacific rats are the smaller of the invasive rats and tend to have the smallest home ranges.

Figure 6. Forest and lianas on Beautemps-Beaupré Island.

7.1.6 Rain

Rain will affect bait, but a significant amount is required before it breaks down. Pestoff Rodent Bait 20R can still retain its integrity despite 16 mm or more of rain falling in a single night

(pers. obs.), subsequently lighter rainfall is unlikely to adversely affect an eradication operation.

When possible, rat eradications are conducted when rats are not breeding and are food-stressed. As a result, the rats are actively foraging for limited food resources and pregnant females or their young are not present. On a tropical forested island such as Beautemps-Beaupré, rats are likely to breed all year around. Certainly during the site visit, Pacific rats were very abundant on the island (29 and 47 rats/100 uncorrected trap nights on the two trapping grids) and a very high percentage of females were pregnant (63%). This is probably due to a high rate of reproductive activity as the population continues to increase following the previous failed eradication attempt 18 months prior.

Any future rat eradication attempt on Beautemps-Beaupré should be undertaken in dryer periods for two reasons; 1. to reduce interference of land crabs with bait; and 2. to reduce the likelihood of significant rain degrading bait. Certainly in June 2017, land crab activity was low and this was reflected in the bait uptake trials conducted (Appendix 10.2), where bait was still available after four nights (Figure 7). It is clear that the operation should not take place in spring or summer due to the almost certain presence of nesting sooty terns and not in autumn due to the wet, warm weather which would encourage land crab activity and may degrade bait too quickly.

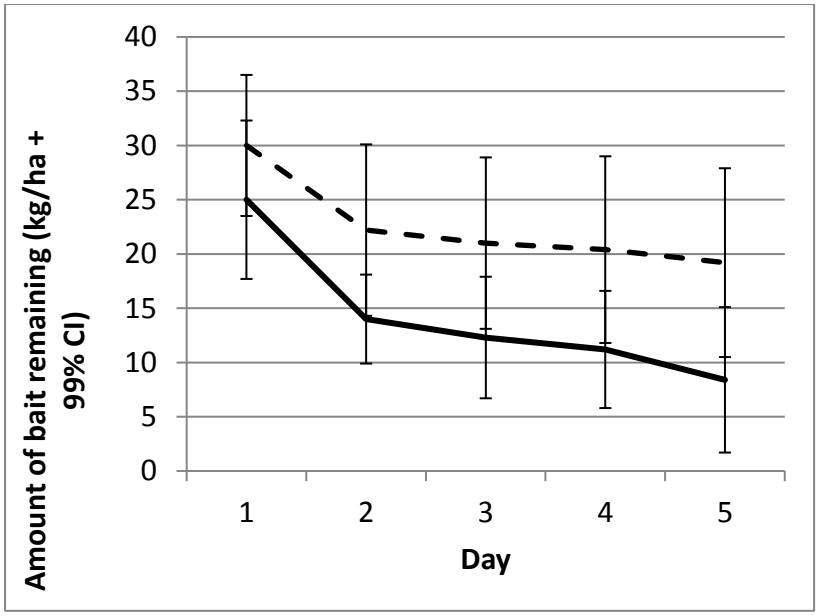

Figure 7. Removal of non-toxic Pestoff 20R bait at two 1-hectare sites on Beautemps-Beaupré in June 2017.

In the case of any future rat eradication operation on Beautemps-Beaupré, most of these issues can be reduced by conducting the eradication during the winter. Cutting lines for the bait application can be conducted shortly before the baiting operation commences and the use of mechanised tools is suggested to aid the process, particularly for areas of dense vegetation. The track cutting team can also check whether sooty terns are engaging in breeding activity to

guide a final decision on whether to proceed. Where required, experienced hand-spreaders could augment the local bait-spreading team and be used for additional training and thereby reduce the risk of inadequate bait coverage over the duration of the operation.

The principal risk is likely to be nesting by sooty terns. Confirmation of the absence of sooty terns on the island will be needed at fairly short notice before an eradication operation commences. This will have a major effect on planning as ordering bait and organising staff, supplies and logistics for the island will need to be completed several months prior to the operation starting, so the initial decision to undertake the operation will have been taken well before sooty terns begin nesting. Taking into consideration the need for drier and cooler weather and judging by recent breeding data, the best time for conducting an eradication operation would be late June or early July. An eradication expert should be involved throughout the planning process and the final decision for when to proceed with the operation.

7.1.7 Logistics

Getting the bait to Ouvéa from New Zealand is relatively easy, via Noumea, with several flights per day. At Ouvea a good road leads to a boat ramp for loading boats for the sea journey (1.5-2 hours) and a new wharf at the port of Ouvéa has recently been completed. Temporary accommodation and several small boats are available for hire.

Although the landing beach at Beautemps-Beaupré is within the lagoon and relatively protected (Figure 8), travel to the island can be delayed due to rough seas but is easily managed in good weather. This should be factored into the planning. Wind speed during June and July is relatively light compared to the summer, with about 27-28 days each month of < 28 km/hr (15 kts) winds and 15-17 days of < 19 km/hr (10 kts). Bait should be transported and stored in sealed plastic buckets. Additional safety equipment, such as life jackets and flares, should be available for the sea journey.

Figure 8. The main landing beach at Beautemps-Beaupré Island.

At least two, and possibly three, bait applications would be required, with the ideal time interval between the first two broadcasts being a minimum of three weeks (Keitt *et al*. 2015), although fine-tuning of the timing would be largely determined by the weather forecasts and sea conditions for landing. During the site visit in June 2017 the seven-day forecast maps provided on the METVUW website provided accurate timing and duration of the rainfall experienced on both Beautemps-Beaupré and Ouvéa.

7.2 Sustainability

Sustainability in this context refers to maintaining the Pacific rat-free status of the island post eradication and hence, safeguarding its outcomes (i.e. species and ecosystem recovery) into the future. This means that is it critical to minimise the risk of re-invasion, a condition of the eradication feasibility. In addition, the risk of introduction and establishment of new invasive species should also be minimised. Managing these risks would require putting in place effective biosecurity measures (or barriers) along a continuum which covers pre-departure to the island, on arrival at the island and on the island itself. These measures will be detailed in the biosecurity plan.

The nearest landmass to Beautemps-Beaupré where the Pacific rat is present is a small island in the northern Pléiades group, located 12 km away and hence, out of swimming range (Pacific

rats have never been recorded swimming for extended periods or long distances (Butler *et al*. 2010, Russell *et al*. 2008)). This leaves Ouvéa as the main potential source of re-invasion by Pacific rats as most of the traffic to Beautemps-Beaupré originates from there. Small boats are usually used to transport people, equipment and suppliers to the island. Any landing or other activity on the island (or the lagoon) is by authorisation from the customary landowners however, there are reports of fishermen from Grande Terre coming to fish lobster and humpback parrotfish during the holiday season without going through existing customary processes. Similarly, some tour operators (also from Grade Terre) bring tourists to spend a few days on the island, again without obtaining prior authorization (Imirizaldu *et al*. 2012). Another potential risk pathway is in the form of international private boats originating from different locations (including Australia, Fiji, New Zealand, Papua New Guinea, Solomon Islands and Vanuatu) arriving at Beautemps-Beaupré without first clearing customs/obtaining phytosanitary clearance at a dedicated port of call in New Caledonia or prior permission from landowners. Also, illegal Asian fishing boats are regularly observed in the area (A. Barnaud, pers. comm.).

An initial assessment of risk species and risk pathways indicates that it would possible to prevent reinvasion as although the risk is high; it can be managed through effective biosecurity (Table 2). Risk species and risk pathways will be further reviewed during the development of the Biosecurity Plan.

Table 2. Risk species and likely invasion pathways for Beautemps-Beaupré Island.

Species or species group	Source	Pathway	Risk
Name	Where will the invasive species come from?	How will it travel to the island?	How severe is the risk? High/ Medium/ Low
Pacific rat and house mouse	Ouvéa or other islands of New Caledonia.	Unintentional introduction, e.g. in equipment or supplies, stowaway aboard boats travelling to or anchoring off Beautemps-Beaupré.	High
Other rodents (i.e. black and brown rats, house mouse)	Grande Terre or other islands of New Caledonia.	Unintentional introduction, e.g. in equipment or supplies, stowaway aboard boats travelling to or anchoring off Beautemps-Beaupré.	Medium
Other vertebrates (e.g. reptiles)	Ouvéa or other islands of New Caledonia.	Unintentional introduction, e.g. in equipment or supplies, stowaway aboard boats travelling to or anchoring off Beautemps-Beaupré.	High

invertebrates (e.g. ants, snails)	Ouvéa or other islands of New Caledonia.	Accidental introduction, hitchhiking on equipment or supplies, stowaway aboard boats travelling to Beautemps-Beaupré.	High
Invasive plants	Ouvéa or other islands of New Caledonia.	Unintentional introduction, e.g. seeds hitchhiking on personal effects, equipment or supplies. Intentional introduction e.g. crops for planting.	High Medium

7.3 Social acceptability

The previous rat eradication operation, and role of ASBO in conducting it, was fully supported by the island's owners on Ouvéa and several of the clan's members participated in the previous operation and the study site in June 2017. This situation has not changed and the support for ASBO and the rat eradication on Beautemps-Beaupré still remains. The islanders understand the risks of the operation with regard to the consumption of toxic bait by land crabs, as coconut crabs are harvested in small numbers each year.

It is expected that the rat eradication on Beautemps-Beaupré will be used to train locals in order to undertake further rat eradications on several of the other smaller islands near Ouvéa in the Pléiades group and respond to any potential ship rat incursion on Ouvéa. The proposed operation is also seen as a flagship for further eradications as Beautemps-Beaupré is the most highly regarded island in the archipelago; hence the desire to conduct the operation there first rather than on one of the several smaller islands, which would arguably be simpler to carry out and with a higher chance of success.

It is also expected that locals will be employed in the project for a variety of tasks, such as establishment of the baiting grid, bait application, bait consumption monitoring, post-eradication monitoring, , and providing transport for bait, supplies and staff.

7.4 Political and legal acceptability

There are no legal impediments to the importation of Pestoff 20R into New Caledonia, or of its use for rat eradication on the island (A. Barnaud, pers. comm.). The only known requirement is to obtain permission from the island owners to land and stay on the island and to undertake the eradication operation. The operation apparently has strong local support as a flagship operation with a view to undertake further rat eradications on other small islands adjacent to Ouvéa.

7.5 Impacts on the environment

7.5.1 Non-target species

It is likely that several species on the island will be vulnerable to poisoning by brodifacoum either directly, through bait consumption, or indirectly through eating something that has consumed bait (i.e. secondary poisoning). The principal risk to humans is through consumption of coconut crabs, which are known bait consumers. It will be necessary to stop any harvest of coconut crabs for at least 6 months after the eradication operation but it is known that brodifacoum rapidly passes through land crabs (Pain *et al*. 2000, Figure 9). Any ban on harvesting and consumption should include all land crabs and be conservative (i.e. longer than thought necessary) to reduce any possible risk to humans.

Figure 9. Poison warning sign on Beautemps-Beaupré from the 2015 eradication.

Although other species, such as insectivorous birds and doves/pigeons that forage on the ground, are likely to be at risk from poisoning, the presence of these species 18 months after the previous eradication operation suggests that risk is at an individual level, rather than the entire population on the island, although this was not assessed after the last eradication attempt There is a secondary or tertiary pathway for poisoning of reptile predators, such as the sacred kingfisher (*Todirhamphus sancta)*, as it is likely that skinks and/or geckos will ingest brodifacoum either directly or secondarily through eating invertebrates that have eaten toxic bait pellets (Rueda *et al*. 2016). Poisoning of nesting sooty terns or boobies is highly unlikely as they do not consume bait whilst on land, however fatalities of scavenging seabirds, such as

gulls, from toxic bait distributed during rat eradications has been recorded (Buckelew *et al*. 2011). The only possible scavenger species on the island could be the buff-banded rail, which is distributed across the Pacific but it has not been recorded recently. As all these species are still present on the island following the first eradication attempt, it suggests that there will be no effect at a population level. A full bird list is appended (Appendix 10.3).

There are numerous geckos and skinks still present on the island post the first eradication attempt so they appear to be largely unaffected by the poison application. Indeed, lizard numbers are known to increase after eradication of Pacific rat (Parrish 2005) and very few deaths of reptiles have been recorded following application of toxic rodent bait, and certainly not at a population level (Hoare & Hare 2006).

Fruit bats are at a very low level of risk as they forage largely on fruit in the canopy and will not have access to the bait on the ground. Fruit bats are still present on the island despite the toxic bait application in 2015.

Based on the above, it appears that there are no non-target issues requiring specific management for the eradication to go ahead.

Some likely responses to rat eradication may include an increase in invasive plants due to a cessation of rat predation on seeds, or short-term and substantial increase in invertebrates once rat predation ceases. For example, on Henderson Island in 2012, after rat-eradication operation there were massive increases in the number of caterpillars, which almost completely defoliated some plant species (G. Harper pers. obs.). Additional changes could include a peak in bird numbers due to an increase in the amount of food available post rat removal this will likely be a short-term situation that will eventually rectify itself.

It is likely there will be little effect on local people as the island is not permanently settled and is a substantial distance from the nearest settlements on Ouvéa. Visitation to island is restricted so this further reduces the risk.

7.5.2 Fate of the rodenticide in the environment

It is highly unlikely that there would be any effect on marine life, as bait will not be distributed into, or towards, the sea from the cut lines or coastal sites. It is possible that some bait pellets may enter the sea by rolling off or being swept off coastal cliff edges, but at such a low bait density, brodifacoum will be virtually undetectable (Primus *et al*. 2005, Masuda *et al*. 2014). Brodifacoum will enter the soil where it binds with soil particles, and quickly breaks down (Alifano et al. 2012). Brodifacoum is insoluble in fresh water.

Toxic bait pellets will be transported in sealed plastic buckets so the risk of bait spillage during transport to the island is minor. After use the buckets and associated packaging will need to be disposed of in a suitable landfill or incinerated as described in the MSDS (Material Safety

Data Sheet). It will need to be confirmed that these types of facilities exist on Ouvéa or nearby Lifou.

7.6 Capacity

A team comprising personnel from ASBO and local people from Ouvéa (including some members of the landowner clan) carried out the first attempt at eradicating Pacific rats on the island in 2015, which means there is some local capacity to carry out another attempt. However, there are several technical areas that require specialist input and therefore it will be necessary to augment the future operation with additional experienced staff for training and quality control purposes. Technical assistance with the planning and execution of the Beautemps-Beaupré operation should be used to train staff for any potential future rat eradication operations on the smaller islands in the Pléiades archipelago.

ASBO needs a dedicated Operations Manager to oversee funding applications, manage the eradication teams and organise purchase of equipment and supplies as well as storage and transport of the toxic bait, etc. ASBO should be in contact with a suitable technical advisor from the earliest stages of an operation. Coordinating a hand broadcasting baiting operation is a specialist task. ASBO will need to find an expert that can help with this. PII could help ASBO with finding a suitable person. This person would take responsibility for liaison with the bait supplier to ensure timely delivery, ensure the tracking is suitable for the purpose, then make decisions on when baiting should occur and to oversee the work.

Once the eradication team are on Beautemps-Beaupré, there will need to be an Island Manager, overseeing the campsite and equipment/bait, etc. alongside a Staff Manager who will manage the bait, the bait spreaders, the staff transporting bait to the bait spreaders, as well as assigning baiting lines to the bait spreaders and recording which lines have had bait applied to them. These two managers will work with the technical advisor to ensure the operation runs smoothly and efficiently. Either of these managers could also be the Operations Manager. One cook will be required and they can assist with other work when they have free time.

It is expected that five bait spreaders will be required for the operation. One bait spreader can comfortably distribute bait over about 5 ha/day, so five bait spreaders should be able to cover about 25 ha/day, or a little over half the island. Hence two days would be needed to complete each bait application. Keeping the number of bait spreaders to a minimum ensures better quality management of the bait application and eliminates gaps in bait coverage. The technical advisor can also apply bait. Three bait carriers will move bait to the bait spreaders.

Therefore, the total staff required on the island could number about 10 people. Keeping the team small would also reduce the amount of stores and equipment on the island.

7.7 Affordability

A preliminary estimate of the cost of the project is US$112,800. This is an indicative estimate based on similar scale projects. The estimate includes a 20% contingency to cover any unexpected costs during implementation. A more accurate budget will be produced once the Operational Plan is completed.

The following indicative budget (Table 3) is to complete the operational and biosecurity plans; carry out the eradication operation; implement the biosecurity plan pre-and first year post-eradication and carry out monitoring first year post eradication. The cost of on-going biosecurity will be determined when completing the biosecurity plan.

Table 3. Indicative budget for the Pacific rat eradication on Beautemps-Beaupré Island.

Item	Cost (USD)
Operational plan & review	4,000
Biosecurity plan & review	2,800
Rodent bait	16,500
Equipment	13,450
Bait and equipment transport	4,000
Personnel costs for implementation	24,100
Technical support costs (including travel costs (flights, accommodation, meals, etc.) for implementation	11,200
Boat hire	5,000
Food and other supplies	6,450
Biosecurity infrastructure	2,500
Pre and post-eradication biosecurity implementation	1,500
Post-operational rat monitoring (1 year post-operation)	2,500
Sub-Total	94,000
Contingency (20%)	18,800
Total	**112,800**

8 CONCLUSION

There is a history of successful rodent eradications on tropical islands using the hand-broadcast technique, and of these eradications, several islands are larger than Beautemps- Beaupré. Certainly the terrain and vegetation are not significant barriers to undertaking a hand-broadcast of bait. Several possible reasons exist for the failure in late 2015. An operation conducted in winter would reduce the possible risk factors that were present then, principally the more active land crab population and higher rainfall probability. It is likely, but not certain, that the most significant risk factor, nesting sooty terns, will not be present in late June, the suggested timing for an eradication. Sooty tern activity will require careful monitoring leading up to the decision to proceed with an eradication operation, and if an operation does not proceed in the short term any additional data on sooty tern nesting chronology in the meantime will be vital for informing future operational planning.

If effective biosecurity is in place then the rat eradication will certainly be sustainable, as the distance of Beautemps-Beaupré from land will preclude unassisted reinvasion by rats.

The lack of human settlement and livestock also simplifies both the operational planning and the biosecurity measures, as there will be minimal health risk to humans. The human consumption of coconut crabs will, however, need to be curtailed for a period of 6 months to remove the small risk of secondary poisoning.

There appears to be general local support for a rat eradication on Beautemps-Beaupré, and no resistance was apparent. There are no other obvious political or legal constraints on the project and there is a precedent to the proposed eradication as one has already been attempted and planning for a second attempt led by ASBO and supported by the landowners is underway, with INTEGRE support.

There are few environmental risks from the project, apart from the risks to humans from eating coconut crabs immediately following the operation, as discussed. There are some secondary poisoning risks for a few land birds, but as these are still present after the first eradication attempt, the risk appears to be at an individual level, rather than a risk to entire populations.

It is to be expected that there would be significant conservation gains on the island, particularly with regard to seabirds. Currently ASBO does not have the necessary funding for implementing the eradication but it plans on sourcing funds for completing the project

There is some capacity within ASBO to carry out the operation; however, further technical advice and training is required to enhance the likelihood of success. The personnel that were involved in 2015 should be engaged in the next eradication, particularly if they indicate enthusiasm for being part of future rat eradications on the Pléiades islands. Their experience should improve the odds of successful attempts on those islands. However, in the meantime some of the possible risk factors identified suggest that the Beautemps-Beaupré operation should have external technical assistance to enhance the likelihood of success. To that end having a technical advisor and some experienced bait spreaders would reduce the risk of a repeat of 2015. This suggestion, coupled with advantages of the proposed timing of the next operation, is highly likely to result in a successful rat eradication.

9 RECOMMENDATIONS

- ASBO will need to share the Feasibility Study findings with the island's owners and other key stakeholders (e.g. GDPL) and confirm their support for the eradication and the proposed approach.
- A Biosecurity Plan will need to be prepared and implemented prior to the eradication operation. Without continuous application of effective biosecurity, it is unlikely that the benefits of rat eradication would last long. Land owners and other visitors to Beautemps-

Beaupré will need to commit to the consistent application of the required biosecurity measures.

- An Operational Plan will need to be prepared detailing all aspects of the eradication operation, including detailed procedures, team composition, roles and responsibilities, health and safety, logistics, etc. It is expected that ASBO will contribute to the drafting of this plan and a key person should be nominated for this position.
- ASBO will need to undertake a review of potential funding sources and actively seek funding for the project.
- Technical expertise will need to be sought for the preparation of the Operational Plan and Biosecurity Plan as well as for undertaking the actual eradication operation. This will be in addition to the local project team. Again a key person within ASBO needs to be involved in the planning and execution of the operation in order to develop the skills to undertake further eradications on the smaller adjacent islands.
- ASBO, in collaboration with the land owners and partners, will need to develop indicators to measure project outcomes and establish a baseline for each indicator. A baseline should also be established for introduced/invasive plants present on the island.
- Further training in different aspects of the eradication and biosecurity will be required for the local team prior to the operation and technical expertise will be required for this.

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11 APPENDICES

11.1 Site visit

Souad Boudjelas (PII) and Grant Harper (Biodiversity Restoration Specialists Ltd) visited Beautemps-Beaupré Island for five days from 19-23 June 2017 and were accompanied by several staff from ASBO and two representatives from the Chefférie of Héo (see acknowledgements). Bait uptake trials were conducted on 2 x 1 ha sites with application rates of 30 kg/ha and 25 kg/ha of non-toxic Pestoff 20R. Rats were also trapped on two trapping grids and age, sex, measurements along with DNA samples were taken from a sample of these rats. Crab transects were conducted on one night. Several trips were taken across the island to assess the vegetation and suitability for track cutting along with checks on native fauna. A circumnavigation of the island was also undertaken to confirm the island size, using the 'Calculate Area' function on a Garmin 62S GPS. On the return to Ouvéa the nearly completed wharf was inspected with the aim of improving biosecurity.

11.2 Bait uptake trials

Introduction

Rat bait trials on Vahanga Atoll, South Pacific, suggest that a rat bait application rate of 15 kg per hectare is required where dense populations of hermit crabs are present, to circumvent reduced consumption by rats through bait interference (Griffths *et al*. 2011). As Beautemps-Beaupré has a diverse land crab population (pers. obs.), and significant bait consumption may have occurred at the application rate used in the previous eradication attempt a higher bait application rate was trialed to determine if bait would remain in a simulated hand-broadcast bait application despite likely crab interference.

Methods

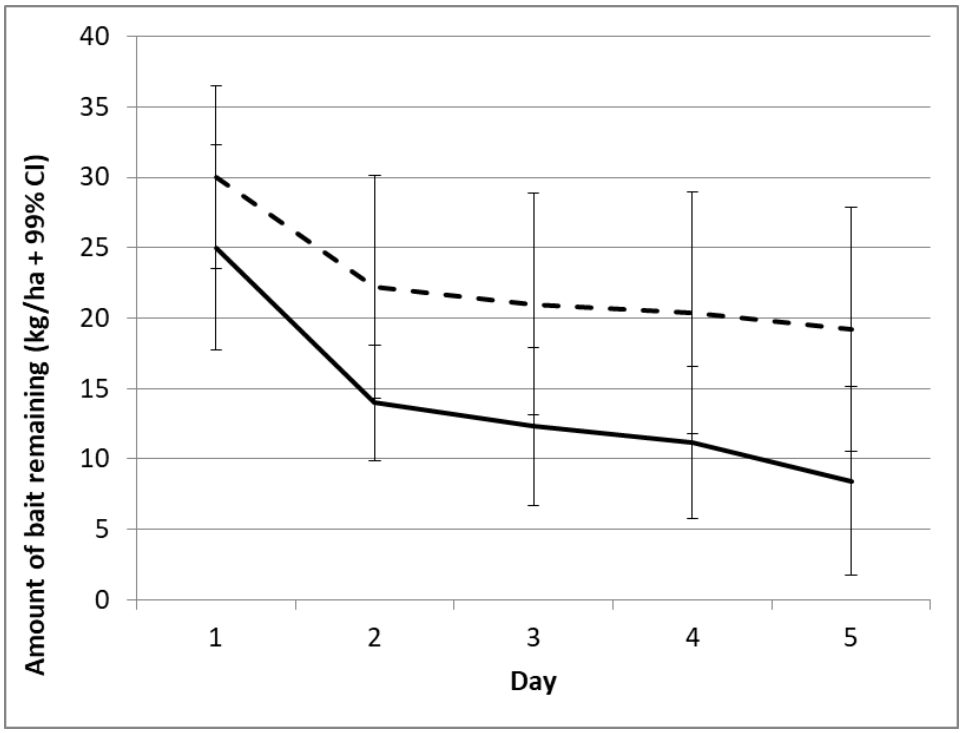
Small-scale trials were carried out to test the suggested 25 kg/ha and a higher 30 kg/ha application rate. The sites had bait applied on a 20 x 20 m grid across each site. An application of un-dyed non-toxic rat bait pellets (Pestoff 20R™) was hand-spread at a rate of 25 kg/ha on one site and 30 kg/ha on the other site.

Five 5 m square plots were established randomly within the three internal lines of the two baited grids to measure bait removal over the four days following the bait application (four nights in total). Baits were counted at all the plots each day and the mean percentage bait removed from each bait grid was calculated.

Results and brief discussion

Bait loss was relatively low at both sites for the duration of the trial. Indeed, at the lower rate tested there was 9 kg/ha of bait remaining after four nights and even at the minimum 99% confidence interval 2 kg/ha of bait was still available. The 30 kg/ha application rate resulted in a minimum of 10.5 kg/ha of bait remaining after four nights. It is likely there will be some variation in the loss of bait across the island, so a bait application rate of 25 kg/ha is

recommended. The low rate of bait removal was likely due to the reduced crab activity due to the cool, dry conditions prevalent at the time.



Removal of non-toxic Pestoff 20R bait at two 1-hectare sites on Beautemps-Beaupré Island in June 2017.

11.3 Bird list for Beautemps-Beaupré Island

Common Name	Scientific Name	Ecological Status
1. Wedge-tailed Shearwater	*Ardenna pacificus*	Res bre
2. Herald Petrel	*Pterodroma heraldica*	Res bre
3. Lesser Frigatebird	*Fregata a. ariel*	Res bre
4. Great Frigatebird	*Fregata minor*	Res bre
5. Little Black Cormorant	*Phalacrocorax sulcirostris*	Vag
6. Masked Booby	Sula dactylatra personata	Res
7. Red-footed Booby	*Sula sula rubripes*	Res bre
8. Brown Booby	*Sula leucogaster plotus*	Res bre
9. Eastern Reef Egret	*Egretta sacra albolineata*	Res
10. Buff-banded Rail	*Rallus philippensis*	Res bre
11. Peregrine Falcon	*Falcon peregrinus nesiotes*	Res Bre
12. Pacific Golden Plover	*Pluvialis f. fulva*	Sum mig
13. Ruddy Turnstone	*Arenaria interpres*	Sum mig
14. Sanderling	*Calidris a. alba*	Sum mig
15. Wandering Tattler	*Tringa i. incanus*	Sum mig
16. Sooty Tern	Onychoprion fuscata serrata	Res bre
17. Fairy Tern	*Sternula nereis exsul*	Res bre
18. Crested Tern	Thalasseus bergii cristatus	Res bre
19. White Tern	*Gygis a. alba*	Res bre
20. Brown Noddy	*Anous stolidus pileatus*	Res bre
21. Black Noddy	*Anous m. minutus*	Res bre 3
22. Silver Gull	Chroicocephalus novaehollandiae forsteri	Vag
23. Red-bellied Fruit-Dove	*Ptilinopus greyi*	Res bre
24. Shining Bronze-Cuckoo	*Chrysococcyx lucidus*	Res?
25. Sacred Kingfisher	*Todirhamphus sancta*	Win mig
26. Dark Brown Honeyeater	*Lichmera incana*	Res bre
27. Cardinal Myzomela	*Myzomela cardinalis lifuensis*	Res bre
28. Melanesian Flycatcher	*Myiagra caledonica*	Res bre
29. Silvereye	*Zosterops lateralis*	Res bre

KEY

Ecological status

End = Endemic to Island unless otherwise stated, **Res bre** = Resident breeder, **Res** = resident ie breeding not proven or not likely. For seabirds it means they have or should be found in that area: note other refs. **Vag** = Vagrant, **Res/mig** = Part of population migratory, **Sum mig** = Summer migrant, **Win mig** = Winter migrant, **Spr/Aut mig** = Passage migrant in Spring and Autumn, **Intro** = Introduced.