# Managing invasive species to recover Polynesian monarchs: achievements and future directions

Invasive Species
INTERNATIONAL

Landcare Research
Manaaki Whenua

# Managing invasive species to recover Polynesian monarchs: achievements and future directions

**Alan Saunders**

*Landcare Research*

*Prepared for:*

**Société d'Ornithologie de Polynésie (Manu)**

PO Box 7023
98719 – Raravao,
Tahiti, French Polynesia

**March 2013**

*Landcare Research, Private Bag 3127, Waikato Mail Centre, Hamilton 3240, New Zealand.*
*Ph +64 7 859 3700, Fax +64 7 8593701,* www.landcareresearch.co.nz

| *Reviewed by:* | *Approved for release by:* |
|---|---|
| Al Glen<br>Scientist<br>Landcare Research | Phil Cowan<br>Research Priority Area Leader<br>Invasive Species International |

| | |
|---|---|
| *Landcare Research Contract Report:* | LC 1218 |

Cover Photo: West coast, Fatu Hiva Island, showing steep terrain. By Alan Saunders

**Disclaimer**

This report has been prepared by Landcare Research for Société d'Ornithologie de Polynésie (Manu). If used by other parties, no warranty or representation is given as to its accuracy and no liability is accepted for loss or damage arising directly or indirectly from reliance on the information in it.

TELARC SAI registered

ISO 14001

**© Landcare Research New Zealand Ltd 2013**

*No part of this work covered by copyright may be reproduced or copied in any form or by any means (graphic, electronic, digital or mechanical, including photocopying, recording, taping, information retrieval systems, or otherwise), in whole or in part, without the written permission of Landcare Research.*

# Contents

## Executive Summary

Managing the impacts of invasive species, particularly the black rat (*Rattus rattus*) is essential if populations of the critically endangered Tahiti monarch and Fatu Hiva monarch are to recover. Creditable progress has been made by the Société d'Ornithologie Polynésie, particularly in the last 4–5 years, in controlling black rats to low densities. Rapid declines in monarch numbers due to rat predation have been halted, juveniles have fledged, and some recently vacated territories have been reoccupied. In addition, knowledge of monarch ecology has improved and a small but growing number of people have the necessary skills and experience to undertake management and monitoring. Plans have been written to guide management activities, funds have been secured and some local residents are contributing to monarch conservation efforts. In combination these are notable achievements, especially considering the remote location of Fatu Hiva, and the difficult terrain involved on both islands. As a result the extinction of both species has been averted, at least for now. The medium- to longer-term prospects for their recovery, however, remain uncertain. Important challenges now are to increase monarch numbers and distribution, including reintroducing them to previously occupied habitats. Improving the efficiency of management programmes, generating wider political, institutional, and community support and engaging a wider family of donors are other goals that need to be actively pursued. Addressing social, political, institutional, and economic factors, as much as logistical, technical and scientific ones, will present the greatest challenges, and opportunities, in the future. Establishing insurance populations of both species on rodent-free islands where minimal management is required is an important short- to medium-term objective, although this should not detract from the primary goal of recovering and restoring both monarch species in habitats where they naturally exist, if this is feasible. A preliminary assessment suggests an aerial eradication operation to remove rodents from Fatu Hiva is technically feasible, although there would be significant logistical challenges and financial costs. Local residents and other stakeholders are likely to have a range of concerns, however, that would first need to be addressed. This will require further commitments to consult, to provide authoritative information, and to appropriately recognise and respond to stakeholder interests. If support could be secured eradicating the rodents from Fatu Hiva and maintaining on-going biosecurity could become an international model for conservation on inhabited islands. While eradication is not currently feasible on Tahiti there are opportunities to further improve pest control and monarch management at selected sites.

# 1 Introduction

Acting on earlier surveys that indicated serious declines, the Société d'Ornithologie Polynésie (Manu) has undertaken activities aimed at recovering the Critically Endangered Tahiti monarch (*Pomarea nigra*), or 'Omama'o' and Fatu Hiva monarch (*Pomarea whitneyi*), or 'Oma'o ke'eke'e', and Fatu Hiva monarch (*Pomarea nigra*), or 'Omama'o' since 1998 and 2002, respectively. These activities have been supported by a number of advisory and donor agencies. Notably, Manu has been a partner in the BirdLife Pacific Partnership since 2002 and has received funding and technical support through the partnership's 'Preventing Extinction Programme'. Intensive rat control has been in place for both species since 2008. Several other management activities have also been initiated.

In 2012 Manu sought an independent assessment of achievements to date and advice about options to enhance the recovery prospects of Tahiti and Fatu Hiva monarchs. In particular, advice was sought on the potential feasibility of eradicating black rats from Fatu Hiva. The assessment was undertaken by Alan Saunders of Landcare Research, in collaboration with Thomas Ghestemme, Manu's Programme Coordinator. Following a review of available material, visits were made to management sites on Tahiti and Fatu Hiva between 29 November and 5 December 2012. Discussions were held with other Manu staff, volunteers, and local residents.

This report includes comments on activities and achievements based on information provided and observations from site visits and discussions. More specific observations were provided in a "de-brief" session with the Programme Coordinator at the end of the trip. Conclusions and recommendations for future action are summarised for consideration as part of the preparation of a new recovery plan.

Comments on an early draft of this report were provided by Mark O'Brien and Steve Cranwell of the BirdLife International Pacific Secretariat. Unfortunately Mark was unable to accompany Alan and Thomas on the field visits as planned.

# 2 Achievements

## 2.1 A shared vision and agreed goals and objectives

A 'Vision' is a long-term, aspirational target with which all stakeholders can agree and identify. Vision statements generally include social and economic dimensions, as well as ecological ones, reflecting the fact that conservation is essentially a social enterprise. No vision statement reflecting the aspirations and needs of stakeholders was noted in the documents reviewed, although a declared intention to 'avert extinction' could be taken as an aspirational target. If so it could be concluded that Phase 1 of the recovery programme, 'Averting extinction', has been achieved and that support is now being sought for Phase 2 – perhaps 'Increasing monarch numbers and distribution, and building capacity and support'. Phase 3 might then involve 'Reducing effort and establishing stakeholder-driven conservation programmes focused on the monarchs as part of island ecosystems.'

A 'goal' is a target that is used to guide allocation of resources for particular actions within a prescribed timeframe. The Short Species Action Plan for *P. whitneyi* includes the following goals:

- '…conservation actions and funding need to be increased rapidly to save this species from extinction'; and
- 'The goal for the recovery program would be 40 pairs protected in 2016.'

An additional goal should also be considered: to increase the number of monarchs and/or expand their distribution within a prescribed timeframe (e.g. 5 years). this would give stakeholders something to aspire to, and practitioners a realistic target to strive for. Annual objectives could be developed to promote progress towards such a goal. Other goals might focus on social (e.g. stakeholders are engaged and contributing to decisions and promoting recovery actions), economic (e.g. 'multi-year funders are involved and local residents are generating some income from employment in the project), capacity building (e.g. 'A core group of 10 skilled and motivated field practitioners is available to undertake planned tasks in Tahiti, and on Fatu Hiva), and other themes.

An 'objective' is a short-to-medium-term target that can be used to guide the allocation of resources, undertake management actions, and measure progress. Objectives should be 'SMART': Specific, Measurable, Achievable, Realistic and Time-bound. An objective might be, for example, to 'Finalise a recovery plan for *P. nigra* and *P. whitneyi* for the period 2013–2017, with the agreement of all members of the Recovery Group, by 30 June 2013.' Objectives often cover a 12-month period, reflecting financial and administrative terms.

The Short Species Action Plan and final reports (March and December 2011) contain a mix of goals, objectives and targets. The consistent use of standardised planning terms would lead to more effective decision making, and allow progress to be more objectively evaluated. As models for application here, there would be value in using species recovery plans where goals and objectives are being achieved.

## 2.2 Species recovery plan in place

An objective has been declared and progress is being made in preparing a new recovery plan. Preparation of a detailed plan that sets out goals, objectives and performance measures is a timely development. An earlier recovery plan for the Fatu Hiva monarch (Gouni 2006) contains important information on the ecology and threats to the species. It is not clear, however, how useful this plan was in identifying goals and objectives, or in supporting decision making and guiding recovery actions. The Short Species Action Plan, covering both species (Ghestemme 2012), has been useful as an interim plan in that it includes a number of short-term actions and identifies information and management actions required. Progress has also been reported in relation to identified objectives.

Although preparation of a new recovery plan has begun and a recovery group has been established, priority has been given to "field conservation actions with data collection" (Ghestemme et al. 2011a, b). Presumably there have been insufficient people or resources to prepare the recovery plan, as well as undertake field work. While this decision is understandable, it is important to have an agreed plan for both species. This will provide a basis for allocating resources, and an incentive for recovery group members to focus on

agreed objectives. The lack of a comprehensive and cohesive recovery plan is likely to be an important impediment to further progress.

The process of preparing a recovery plan can be as important as the plan itself. This is when potentially contentious issues and areas of uncertainty can be discussed, and agreement reached on how to proceed. The engagement of Recovery Group members in preparing the plan, and their subsequent involvement in information sharing and decision making will also be important. In addition to guiding management actions, recovery plans can also serve as useful educational, promotional, and marketing documents.

Some objectives and actions will differ between the two species. However, similarities and potential synergies suggest a single plan and a single recovery group would be most appropriate. Site Support Groups should guide implementation in Tahiti and on Fatu Hiva. A single plan is likely to be more useful as a promotional document to underpin funding proposals, for example, than two separate recovery plans. Consideration should be given to integrating monarch recovery objectives with wider conservation planning – perhaps incorporating monarch recovery into island restoration plans and the recovery of other threatened species. Such integrated approaches make good sense and may present important opportunities for enhanced effectiveness and efficiency, especially on islands.

## 2.3 Knowledge of monarch ecology

Previous studies have provided a basic understanding of monarch ecology and behaviour. Research will continue to be an important tool to support decision making. Identifying and prioritising research needs (i.e. High priority "Need to know" information to improve management, versus lower priority "Nice to know" questions) will be important, especially while population numbers are at critically low levels. Given the potential for significant resources to be wasted on less relevant research, an important role of the recovery group should be to review research, monitoring and survey needs regularly, as part of its oversight of the recovery programme. The Short Species Action Plan includes an objective to "acquire further data" on breeding and habitat requirements, including nest position and forest structure, and nestling feeding rates. Since much effort and resources can go into research, priority should be given to research that will enable more effective and efficient management.

BirdLife Pacific and Manu have facilitated the involvement of several very capable international volunteers who have made important contributions to knowledge of both species, and to survey and monitoring regimes. This will likely continue to be an important part of recovery efforts, on both Tahiti and Fatu Hiva. It will be important that all volunteers are carefully assessed for their suitability, and for the skills they bring to the programme. As with all field staff, they should be appropriately supported, and the information and insights they gather should be formally recorded.

## 2.4 Populations surveyed and trends monitored

There is evidence of rapid population declines in both species, with Ghestemme (2012) estimating a 97–99% decline over 21 years. Objectives to obtain better knowledge of the entire populations, including surveys of areas previously not covered, and monitoring to determine trends in managed and un-managed areas are included in the Short Species Action

Plan. The critically small populations of both species, coupled with the known impact of black rats (and other threats), make it very important that the whereabouts of all remaining monarchs are known and that as many as possible are included in management regimes. Completing delimiting surveys should therefore be a high priority. As the result of inputs from several committed observers, good information is currently available on monarch breeding behaviour and nesting success in both populations. It will be important that this level of monitoring is maintained.

## 2.5 Threats identified and managed

Black rats have been recognised as the primary threat to the continued survival of both monarch species. Significant reductions in rat predation have only been reported since intensive, year-round rat control programmes have been in place. Successful monarch breeding has only been observed in areas where rats have been effectively controlled, reinforcing the importance of managing rat predation.

Common mynahs (*Acridotheres tristis*) may now be significant predators of Tahiti monarchs and a primary threat to monarch recovery now that effective rat control is in place (Ghestemme et al. 2011a, b). The threat that red-vented bulbuls (*Pycnonotus cafer*) may pose is less clear, although they clearly disturb nesting monarchs (C. Blanvillain, pers. comm.). An 'emergency measure' in 2010 involved shooting mynahs around monarch nests to eliminate them, or to scare them off. While effective, it was concluded that more sustainable measures were required – especially if continued rat control also benefited mynahs. Further efforts to understand the impacts of invasive birds on monarchs, and the merits of controlling them, are needed, however, to inform decisions on the priority of mynah and bulbul control. Maintaining links with other organisations undertaking invasive bird control, such as in the Cook Islands, will also be useful as further control techniques are developed. Biosecurity measures to ensure these birds do not establish populations on Fatu Hiva deserve a high priority.

Earlier reports suggest both monarch species were more widely distributed (Ghestemme, 2012), presumably in a range of habitat types. Habitat loss due to burning and felling has probably contributed to further fragmentation of remaining monarch habitat and to the current distribution of both species. Burning still seems to be a problem in some areas on Fatu Hiva, at least. It will only be through improved understanding and support of landowners and local resource users, coupled with political and institutional support through local councils and government agencies, that the impacts of burning may be reduced. Current efforts, including dialogue with key landowners, should be maintained.

Reducing the impacts of habitat fragmentation and genetic isolation could well emerge as a key strategy in the new monarch recovery plan, especially as riparian habitats appear to be favoured. Research into the ability of monarchs to move between habitat remnants through areas of less suitable, modified forest could be important in guiding the selection of potential management (and restoration) sites and informing decisions about reintroductions.

Browsing by feral goats and soil disturbance by feral pigs probably also constitute a threat to monarchs through their effects on forest structure and composition. Localised effects of both species may be quite severe, especially in steep, wet sites. Goats and pigs may also exacerbate weed problems through their disturbance to substrates and forest understorey, and

by distributing weed seeds. Pigs may also interfere with trapping and baiting infrastructure, and may consume baits and trapped animals. While pigs and goats may be problematic locally, they are probably not the main threat to monarch survival. Since both species are valued as game animals, and as a food source, acknowledging these values and using a diplomatic approach to promoting their control will continue to be needed. There may also be implications for public health if pigs that have consumed brodifacoum baits for rodents are killed and eaten by people (see below). Support to exclude these ungulates from existing and potential monarch habitats could be generated through Site Support Groups. A recent Manu initiative to assist a local Tahiti landowner to contain his pigs and goats by fencing them at a site near the forest edge in a lower valley is a good practical example of collaboration. Since it is very difficult to contain ungulates behind fences, especially in steep, rocky areas, there may be greater merit in establishing a fenced containment area at a site further away from the forest where it is easier to construct and maintain effective fences.

A pest-proof fence surrounding one or more monarch habitats might reduce the costs and risks of on-going pest control measures. While pest fences can be very effective in excluding a suite of terrestrial mammals, significant costs are invariably involved in designing, constructing and, in particular, maintaining them. This is especially true if fences are intended to exclude rodents, in addition to ungulates and other mammals. The steep terrain, rocky substrates and salty environments in both Tahiti and Fatu Hiva would present major logistical and financial challenges to using fences as a species recovery tool. Fences can also limit stakeholder attention to the contained areas, and may actually impede activities at other sites. Perspectives and conclusions drawn from a study of the feasibility of erecting an ungulate-proof fence on the Mareati'a Plateau in the Punaruu Valley (Pacific Invasives Initiative Newsletter September 2012) may be informative. A detailed feasibility study, including a cost-benefit analysis, should be undertaken if any proposal to construct a predator fence to protect monarchs is promoted.

Encroachment by invasive plants such as the ecosystem modifying *Miconia calvescens* has potentially serious longer-term implications both for monarch recovery and for the conservation of forest communities more generally. There would be value in studying monarch use of "weedy" habitats and prioritising weed management activities accordingly. Removing high-risk weeds from important monarch management sites at the early colonisation stage when they are at low densities is likely to be the only effective weed strategy to limit their impacts. A habitat restoration plan that integrates weed management with other habitat protection and restoration objectives would be useful.

Little fire ants (*Wasmannia auropunctata*) are present near, though not yet adjacent to, monarch management sites in Tahiti, and Yellow crazy ants (*Anoplolepis gracilipes*) have recently arrived on Fatu Hiva (Roberto Maraetaata pers. comm.). These and other invasive tramp ants could represent a threat to monarch recovery. Advice on biosecurity measures to minimise the risks of these ants colonising monarch areas, including containment and possible eradication, and more effective biosecurity to prevent these or other ant species invading Tahiti and/or Fatu Hiva should be sought. The Pacific Ant Prevention Plan produced by the Pacific Invasives Initiative could be used to guide management actions, perhaps including both local (island-focused) and national biosecurity objectives and actions.

Further consideration of the risk of disease might also be given, recognising the vulnerability of small populations. Standard protocols and procedures have been developed to establish

baselines in disease status, and the application of sensible precautionary measures to limit the risk of disease outbreaks as a consequence of handling or moving monarchs.

The impact of these and other threats, and management priorities, will need to be carefully reviewed – especially as monarch populations expand and further habitat is required. Creating new management areas, controlling other plant and animal pests, restoring habitats and, perhaps, reintroducing monarchs will all require the support and involvement of local stakeholders. The recovery planning process should provide a valuable opportunity to build on the success of rat control programmes and to engage local residents, recovery group members and others in discussions about other threats, and their management.

## 2.6 Rat control maintained and improved

### 2.6.1 Controlling black rats has been a critical action

Intensive, year-round rat control regimes have been maintained at all sites (Tahiti and Fatu Hiva) since 2008. This has been a major commitment of time and effort by field staff. Control areas were expanded to include all known, accessible monarch territories for both species by 2011. The rapid rate of decline observed before the initiation of rat control, and the lack of any recorded predation following control suggests rat control has averted the imminent extinction of both monarch species for now. This is a significant achievement, especially considering the remote, steep, and wet terrain involved. Experience from elsewhere suggests that if rat control stopped, rat numbers would quickly increase, along with predation rates, and extinction would again be imminent.

### 2.6.2 Improving the efficiency of rat control

Improving efficiency (i.e. reducing effort and cost while maintaining effectiveness) will be a key to enhancing the sustainability of rat control in the medium-term. There may be opportunities to fine-tune control regimes to reduce effort and costs, without allowing any rat predation of monarchs. For example:

- limiting rat control operations to territories where monarchs are nesting. This will require detailed and current knowledge of monarch territories and breeding activity. Control could be quickly extended to further areas as required. It will be important that rat control regimes reflect the home ranges of rats
- limiting control to periods when monarchs are breeding, rather than year-round. There may be limited opportunity to do this if monarchs are able to breed several times a year. Rat control and consequent reductions in predation rates and, quite possibly, increases in food availability, may lead to monarchs breeding more often, and perhaps year-round. Observers should be alert for this possible response
- using rat traps, such as break-back snap traps, as an additional control or alternative to toxins. Provided they were properly maintained, traps could be used, for example, to achieve a "rapid knock-down" of rats in the vicinity of a monarch nest as soon as it is located, thereby reducing the risk of predation at a critical time. Traps are relatively cheap, easy to set, and may catch rats that have become "shy" of bait stations or baits. Traps have additional advantages in that control operators can monitor what they have

caught, and trapping does not involve any risk of environmental contamination. Consideration might be given to interspersing more traps with bait stations in control areas. Traps would need to be placed under covers that are fixed to the ground, to minimise the risk of birds and other non-target species. Operating traplines in warm, wet environments can require more intensive maintenance. The development of locally adapted trapping techniques may need to be encouraged to minimise this effort whilst maintaining trapping efficacy.

Any moves to reduce effort and to increase the efficiency of rat control will need to be undertaken experimentally, ensuring that risks of rat predation do not increase.

Caution should be exercised in interpreting bait-take, or plastic bag interference, as a measure of rat abundance, or of the effectiveness of rat control. Although tracking tunnels are more informative, and should continue to be used, they too only provide an index of rodent abundance. The incidence of rat predation on monarchs is the ultimate performance measure, and monarch survival, breeding, and successful recruitment are the most important parameters that should be monitored.

### 2.6.3 Reducing non-target risks and environmental effects of using toxins

While the second-generation anticoagulant brodifacoum is a very effective rat control tool, it is relatively persistent in the environment (Fisher 2010; Fisher et al. 2010; Parkes et al. 2011) and has the potential to cause both primary and secondary poisoning of non-target species (Fisher 2010). For these reasons brodifacoum is not used by the Department of Conservation in on-going control operations in New Zealand, although it is still the toxin of choice for one-off eradication operations. Baiting on Fatu Hiva is quite localised, being confined to sites in a few valleys. The environmental risks of such localised use may be acceptable. The scale of rat control, however, has already increased on both islands and it is likely to increase further as the number of occupied monarch territories increases. It will be important that landowners, local residents, management agencies, funders, and other stakeholders have current and authoritative information on the environmental effects of toxins that might be used, as well as their benefits, so that they can contribute to decisions about rat control based on good information and sound advice.

Baiting in bait stations has been augmented by catapulting bait blocks containing brodifacoum higher up inaccessible slopes to increase the size of the area around monarch territories in which rats are controlled. Baits have also been hand-spread in inaccessible areas, such as in the lower reaches of the Omoa Valley on Fatu Hiva, in an effort to control cats using a secondary-poisoning effect (see cat control section below). The frequency of catapulting or hand-spreading baits has been increased during the monarch breeding season in recent years. The benefits and the environmental or non-target risks associated with this practice are unknown. It may be that bait blocks become wet and unpalatable relatively quickly in the humid environment and are therefore ineffective. A wider variety of non-target insects, reptiles and birds may have access to hand-spread baits than those in bait stations, and tmore toxin from hand-spread baits may leach into substrates than from bait stations. While the environmental risks of catapulted, exposed baits may be low, there may be value in determining any additional reduction in rat indices as a result of catapulting and hand-spreading baits.

Feral pigs consuming brodifacoum baits may constitute a specific risk. Pigs are known to consume rat baits in control areas in New Zealand. In some cases they have broken into 'Philproof' bait stations, of the type used on Fatu Hiva and Tahiti, to reach the baits. While pigs may eat large quantities of bait and suffer little effect, brodifacoum may accumulates in their organs (particularly the liver) and pose a potential health risk to people eating pigs that have consumed bait. Although there are apparently few pigs in the Fatu Hiva and Tahiti rat control areas, this may not continue to be the case – especially if monarch management areas are expanded. A range of measures might be used to reduce the environmental effects of using brodifacoum, including any risk to human health from consuming pig products that might contain brodifacoum residues. Apart from the option of not using brodifacoum at all, other options include only using brodifacoum as an "initial knock-down" tool at the start of a control pulse, or interspersing its use with less persistent first-generation anticoagulants (e.g. diphacinone or pindone) and traps. This could also help reduce the chances that rats will develop physiological or genetic resistance to toxins.

The preparation of a new recovery plan is an opportunity to engage local residents, and other stakeholders in discussions about the costs, risks and benefits of different pest control options and specific tools. Consideration of which toxins to use should be informed by a comprehensive assessment of environmental effects.

## 2.7 Cat control maintained and improved

On Tahiti observations suggest feral cats are in low numbers in monarch habitats, and none have been caught during some trials. Ghestemme et al. (2011a, b) suggested secondary poisoning of cats, through their eating rodents that have eaten brodifacoum baits, will be sufficient to achieve control. Cat control has been underway on Fatu Hiva since August 2010 (Ghestemme et al. 2011a, b). An increasing number of 'Belisle 220' and 'SA.Connibear 120' kill-traps set in boxes have been used. In addition, some cats have been shot or killed by dogs when they have been located by field staff in monarch areas.

Effective cat control requires skilled and motivated hunters, ideally with a range of tools at their disposal. Cats are sophisticated animals that can easily become trap-shy or neo-phobic. Cat hunters must be resourceful and prepared to refine techniques to reflect the behavioural differences of individual cats.

Many families have pet cats. Most appeared to be well cared for and are undoubtedly valued pets in many households and also rat controllers. It will be important to recognise the affinity and affection people feel for cats and dogs as companion animals and to ensure that appropriate measures are taken so that family pets are not put at risk by control operations. Attempts to achieve 'secondary poisoning' of cats by hand-spreading brodifacoum baits in lower valleys from which cats might disperse up-valley towards monarch territories, for example, should not by undertaken if there is any risk that pet cats might be put at risk. Cat and dog owners should be kept informed and consulted as part of the operational planning process.

In addition to keeping records of where and when cats are caught, and focusing trapping appropriately, there may be merit in establishing "sand pits" and installing surveillance cameras to monitor cat presence and behaviour. The use of trained "cat dogs" might be a

useful tool to refine cat control, especially when control areas are large and cats are at low densities.

## 2.8 Feasibility of mynah and bulbul control

Disturbance and predation by mynahs and bulbuls has been identified as an important threat to the survival of the Tahiti monarch (Blanvillain et al. 2003; Ghestemme 2011a, b). An objective to apply and refine control of mynahs and bulbuls in Tahiti has been declared (neither species is present on Fatu Hiva). Important progress has been made recently by a Manu contractor, Susanna Saavedra, in trapping mynahs. She has applied her considerable skills as a trapper to catch many mynahs on private residential properties adjacent to the forest. Observations suggest that mynah numbers have decreased in monarch habitats, and the number of mynah–monarch interactions has declined. There would be value in studying mynah behaviour and distribution as control continues, and investigating the relationship between mynah control and mynah-monarch interactions. Controlling mynahs to low densities on forest margins may lead to insignificant mynah-monarch interactions up the valleys in the forest-proper. Conversely, mynah and/or bulbul control may lead to no observed difference in monarch breeding success. It is through research targeting important questions such as this that improvements may be made to the recovery programme.

Another feature of Susanna's trapping activities is the rapport she has developed with local residents and landowners. This has led, in many cases, to permission being granted for her to enter private property without further consultation, to service traps. Because local residents also benefit from reduced mynah numbers (e.g. reduced damage to fruit and other crops, reduced nuisance value) the promotion of mynah control in residential areas could be a productive way to build further local understanding and support for monarch conservation. Since "success" is a powerful motivator, it would be useful to share with local residents the progress that has been made, not just in catching mynahs, but in increasing monarch breeding success and reducing their impacts on crops.

Controlling red-vented bulbuls in Tahiti monarch habitats is more problematic. They are relatively common virtually everywhere, including in monarch habitats. Unlike mynahs, bulbuls seldom venture below the forest canopy and typically use secondary forest areas on upper slopes. As a result, bulbuls are very difficult to trap in the forest understory within monarch habitats. Recent trials to determine if bulbuls will eat non-toxic baits from raised feeding platforms on slopes above monarch territories appear promising. Following further trials and refinements, there is potential to "pulse" toxic baits using the avicide DRC 1339 once large numbers of bulbuls are feeding on the platforms. Once best practice techniques have been established a combination of trapping and poisoning, perhaps undertaken by local volunteers, could be applied to manage the impacts of these pest birds.

Because controlling these pest birds is likely to involve significant commitments to refine management strategies and tools, and to maintain control programmes, determining the benefits to monarchs in controlling mynahs and/or bubuls deserves further attention. Lessons learned here, and techniques and skills developed, may lead to benefits in other species recovery programmes around the world.

## 2.9 Investigate prospects for establishing insurance populations of monarchs

Single-island populations are naturally susceptible to extinction by virtue of their small size and isolation. Island endemics are especially vulnerable to invasive species. Most recorded extinctions have taken place on islands, with invasive species such as rodents being responsible for many extinctions (Howald et al. 2007). The vulnerability of single-island endemics such as the Tahiti and Fatu Hiva monarchs may be further increased by climate change effects, such as severe storms.

While extinctions have been averted and species have been recovered as a result of successful translocations, moving animals from where they naturally exist to other sites, especially where they have not occurred previously, can be a high-risk venture. In principle priority should be given to maintaining monarchs at sites where they naturally occur, and expanding their distribution by facilitating their dispersal and natural re-colonisation of previously occupied habitats through a programme of progressively expanded rat control. This is the approach currently being applied on both Tahiti and Fatu Hiva.

An objective has been declared to undertake trial translocations to reintroduce monarchs to recently vacated habitats where black rats are now being managed, and where natural recolonisation by monarchs is unlikely. Initial attempts on both Tahiti and Fatu Hiva resulted in translocated monarchs returning to original sites (T. Ghestemme pers. comm.). This is an important objective, especially if suitable birds (e.g. non-territory-holding juveniles) are available. Techniques such as soft-release (Seddon & Cade 1999) and acoustic anchoring (Molles et al. 2008) may be useful in refining within-island reintroductions, and reducing the chances that translocated birds will return to natal sites. The steep terrain on both islands, and the mosaic of different vegetation types probably limit the ability of monarchs to disperse – either to new habitats, or to return to original sites following translocation.

As a result of further declines in core populations, creating ‘insurance populations’ of Polynesian monarchs on other islands has been proposed as a counter-measure against extinction. It has been suggested that establishing monarch populations on other islands should be a priority action recognising the challenges in maintaining and expanding rat control programmes, and in restoring habitats on Tahiti, in particular (S. Cranwell, BirdLife International Pacific Secretariat, pers. comm.). A study by Emmanuelle Portier from the University of Reunion Island, to assess the potential of establishing monarchs on other predator-free islands determined that without further rat eradications Rimatara was the only suitable island. Priority has been given to translocating the Tahiti monarch to this island (Ghestemme et al. 2011). No island has been identified to date as a potential site for an insurance population of the Fatu Hiva monarch. The successfully translocation to Atiu of the Rarotongan monarch (*Pomarea dimidiata*), involving personnel, such as Ed Saul and Hugh Robertson who have experience of the Rarotongan monarch, has been a useful tactic.

The intention to establish insurance monarch populations as quickly as possible is understandable, given the intensity of effort that must be sustained, and the continuity of funding required to recover both populations. Even a brief disruption to rat control programmes at a critical time could lead to extinction. While there are risks associated with introducing monarchs to new islands, they may be less than those associated with maintaining existing populations. However, a more focused effort to engage relevant agencies (including central and local government) and other stakeholders might lead to enhanced, more consistent support for rat control and monarch recovery objectives, and, consequently, to a reduced

extinction risk. These objectives may not be mutually exclusive. The relative priorities of managing monarchs *in situ* or introducing them to other islands should be determined by the recovery group.

While the justification for selecting the Tahiti monarch, rather than the Fatu Hiva species, for translocation to Rimatara may well be sound, there is an urgent need for a wider set of possible recipient islands to be considered, in tandem with regional eradication strategies. If the recovery group was to set out some specific habitat requirements for a nominated founder population, for example, and criteria that could be used to select potential islands, it is quite possible that potentially suitable islands in the region might be identified and, if necessary, prioritised for rodent eradication before monarch releases.

Introductions to novel sites – including other islands – principally to reduce the risk of a species going extinct require careful consideration of the likely effects on the receiving system of the new species, as well as the effect on the source population of removing a number of individuals. IUCN guidelines for reintroductions and other conservation translocations emphasize the need for rigorous justification, careful assessment of the feasibility and associated risks, the incorporation of social, economic and political factors, and the application of sound project management procedures (IUCN 2012).

Concerns have been expressed about the risks of disease associated with monarch transfers. While such concerns are valid, they can generally be managed using established health management and information gathering procedures.

### 2.10 Enhance local awareness and support

Considerable effort has been made by Manu, with support from the BirdLife Pacific partners, to raise awareness of monarch conservation issues among key stakeholder groups. Personal dialogue and rapport have been established between project staff and key landowners in Tahiti, resulting, in many cases, in landowner support to control mynahs and confine their goats and pigs at monarch sites. The tenuous nature of some landowners' support, however, was demonstrated with the withdrawal of permission for Manu's access by the owner of land in the Hopuetamai Valley – a key management area. The landowner was concerned about the environmental impacts (including risks to freshwater, and to feral pigs) of using brodifacoum rat baits. Following a series of meetings and field visits where further information was provided, permission to manage the monarchs in this valley may be restored. Providing comprehensive, current and authoritative information to address such concerns is essential. Similarly, landowners in the Maruapo Valley have agreed to goat control in an important monarch management area, and financial support was secured from the French Polynesian Government for a contract to allow management on another property.

A conservation advocacy programme has been undertaken focused on local landowners, school children, and authorities. Posters have been produced and distributed to primary schools in the Paea and Punaauia districts adjacent to monarch habitats, a number of talks have been presented, and a T-shirt produced and circulated. Meetings have been held with community groups, as well as one-to-one discussions with key local stakeholders. A fund-raising project, with support from local news media (newspaper, television) reportedly increased local awareness and resulted in $US5,000 being donated by local businesses. Commitments from an airline to provide further support have also been received. These

efforts to generate support from local funders are to be applauded. Local sponsorship can be taken as an important indicator of local "ownership".

On Fatu Hiva a slow increase in community interest and involvement has been reported, including an increased willingness by local residents to accommodate Manu field staff during their stays on the island (Ghestemme et al. 2011). Two public meetings have been well attended and talks have been presented at schools in both villages. School children have been taken to observe a monarch nest and most school children are now aware of the monarch, and the conservation programme. The employment of local people to service the bait stations and to monitor the monarchs has also been useful – not only because it is the most efficient approach, but also because it promotes awareness and fosters local support. Continuing to build the cadre of local people with the skills and motivation to undertake this work will be an important on-going objective.

Support for monarch conservation and local engagement in management programmes on Fatu Hiva has resulted largely through the rapport between the project manager and key people in the Fatu Hiva community. This is a result of his consistent engagement and the priority he has given to communicating with the community. Working with communities requires willingness to listen, acknowledgement that local residents are the "owners" of their natural resources, respect for alternative views, acceptance of compromise, and an understanding that some things take time to change.

A positive relationship has also developed between the Fatu Hiva Mayor and the project manager, although further council support is needed. The project manager intervened in 2010, 2011 and 2012 to prevent a proposal by the Mayor to construct a road through key monarch habitat. This showed that further work is needed to raise awareness and generate support for the objectives of the monarch programme within local authorities and relevant agencies such as the Environment and Agriculture Departments. Engaging these institutions as part of the recovery planning process will be important so that policies and regulations limiting further habitat destruction, and promoting biosecurity and other conservation measures may be developed and implemented. Indeed, engaging these institutions to oversee wider environmental conservation objectives that will also benefit the monarchs on Tahiti and Fatu Hiva, should be important objectives in the new recovery programme.

While there is not universal support for monarch conservation, and some people have real concerns about proposed tools and techniques, there is nevertheless a large measure of stakeholder awareness and support on Tahiti and Fatu Hiva. This can be attributed to Manu's commitment to communicate, and the consistency shown in liaising with stakeholders shown by the project manager, and other staff. It will be critical that these efforts are maintained so that relationships with landowners, in particular, continue to evolve based on common understanding, mutual respect and trust. Further efforts are needed to secure political and institutional support through the French Polynesian Government and local councils. These agencies have key roles in supporting monarch recovery through the promotion, implementation, and enforcement of laws and regulations in relation to land-use practices, in promoting biodiversity conservation and in securing funds for the monarch recovery programme. While it was beyond the scope of this study to explore opportunities to generate further political and institutional support identifying a person with standing and political influence who might act as a "Champion" for monarch recovery could enhance Manu's efforts in political circles.

Facilitating the involvement of local people in the recovery programme will be the key to conservation outcomes being sustained in the long term. Site Support Groups may be an important forum through which the interests of local people, and their motivations for being involved, may be determined. Identifying wider benefits such as increased crop yields following mynah control in Tahiti, and, possibly, improved water quality as a result of ungulate control on Fatu Hiva, in addition to benefits for monarchs, could be a key to generating further support and involvement.

Prospects of paid work for local residents are likely to be an important stimulus for community interest and support. Manu has already shown its commitment to employing local people when appropriate. This will need to continue. Providing support, including training, to key individuals, will lead not only to appropriate best practice standards being met, but also to further support within the community. Manu's experience to date shows that supporting local field staff can require considerable effort and consistent resourcing. Providing such support, and increasing the pool of local staff and volunteers is likely to be an important on-going objective.

The important contributions international volunteers have made to the recovery programme to date show they also have an on-going part to play. There may be opportunities to increase the number of international volunteers to contribute to on-going field programmes such as rat control and monitoring, and nest monitoring, as well as specific projects, including research. Coordinating, training, supporting, and hosting international volunteers will require significant inputs. In addition to using the resources of international networks, such as BirdLife International, there may be opportunities to engage local conservation and community groups to take a role in hosting and supporting volunteers. While engagement programmes would need to be developed with care, there is potential for important social and economic goals, as well as ecological ones, to be met if more local people were to be engaged, either as volunteers, or as paid staff.

### 2.11 Establish and engage Site Support Groups

A Site Support Group (SSG) was established in Tahiti in 2010, involving farmers and landowners, teachers, the Mayor, City Council employees, Agriculture Department representatives and pig hunters. Unfortunately, landowner participation in the SSG has been low and Manu has focused on liaising directly with relevant landowners to inform them and seek their support.

A Site Support Group was established on Fatu Hiva in 2010. While it is starting to have some effect, local engagement also remains low. As in Tahiti, concerns have been expressed through the SSG about the effect of brodifacoum on feral pigs. A proposal to protect and restore critical riparian habitats, in conjunction with cropping, is being promoted through the Fatu Hiva SSG.

Despite variable participation, Manu's support for SSGs should be maintained. SSGs may be an important forum through which authoritative information can be provided to raise awareness and inform local decision making. While liaising directly with landowners and other key stakeholders is undoubtedly appropriate, group discussions and interactions within SSG meetings are likely to satisfy the information needs of various stakeholders. Caution should be exercised, however, in relying on such groups for decisions. Their primary

functions should involve fostering communication (between stakeholders, and between Manu and stakeholders), and providing an avenue for authoritative information sharing. There would be value in asking SSG participants for their views on how these groups might be more useful, and how they could be more effective in advancing shared objectives. Given their potential importance as a conduit for communication between stakeholders, and between stakeholders and project staff, Manu should remain flexible to suggested changes to the composition and roles of SSGs.

### 2.12 Build local and institutional capacity

The skills and resourcefulness of project staff and their commitment to succeed are abundantly clear. Manu is fortunate to have, in Thomas Ghestemme, a project manager with the mix of social, project management, and field skills, and the commitment to engage with communities that is so important in island conservation projects. Other project staff exhibit similar enthusiasm and commitment.

Efforts to develop specific skills amongst project staff have led to important benefits for monarch conservation. 'Skills-sharing' exchanges have been very effective. These have allowed a number of Manu staff to visit New Zealand and meet with key specialists, discuss strategic directions, visit pest control projects, and receive practical training in trapping and poisoning operations. It would be useful to extend skills-sharing programmes whereby local hunters could visit New Zealand, or other countries, to gain further insights and skills. Targeted 'one-to-one' training such as this can be extremely cost effective, and lead to long-term impacts.

A more comprehensive capacity building strategy could bring further benefits. This should focus on improving research capacity and information exchange, facilitating the application of new technologies, and generating further political and institutional support, as well as developing field skills.

The employment of local people to undertake field tasks has been an important feature of the programme. Investing in the development of local peoples' understanding and skills should have an equally high priority.

## 3 The feasibility of eradicating rodents from Fatu Hiva

'Eradication' involves the removal of every individual of a targeted pest population from a defined site within a prescribed timeframe. 'Control' is an alternative pest management strategy involving either limiting the number or density of a targeted pest, or containing a pest population to a defined area – or both. Important differences between eradication and control are summarised in Table 1.

**Table 1** Key features of eradication versus control strategies.

| **Eradication** | **Control** |
|---|---|
| Generally involves a "one-off" operation, with on-going biosecurity measures to prevent re-invasion of the targeted pest. | On-going control regimes must be sustained, perhaps with some improvements in efficiency, over time. |
| An "all-or-nothing" strategy resulting in no individuals of the targeted pest remaining. | Populations of the targeted pest remain, albeit at lower densities and/or in confined areas. |
| Threats posed by targeted pests are removed. Significant environmental responses can be anticipated. | Targeted pests continue to have negative impacts – albeit at lower levels, if control is effective. Environmental responses may be less pronounced than for eradication. |
| Unexpected and undesired responses to eradication may occur. Careful planning and detailed monitoring is required so that responses can be interpreted and better-anticipated in the future. | Unexpected and undesired responses are less likely to occur. Responses may be more subtle and, perhaps, difficult to interpret. |
| Risks to non-target species may require mitigation efforts that could add significant costs to an eradication operation. | Non-target risks are generally easier to manage, and less costly. |
| Securing funds for eradication operations can be challenging for small organisations, especially where there are few precedents. | While control is generally cheaper than eradication in the short term, sustaining control year after year can be a major challenge. |
| The relative cost/benefit ratios of eradication can be better than those for sustained control. | The benefits of control are often difficult to quantify in relation to costs. |
| While public and stakeholder perceptions of the costs and risks of eradication are changing, they are generally seen as too difficult, risky and expensive. | Control operations can usually be adjusted to minimise any negative impacts on stakeholders. |

Howald et al. (2007) reported a 90% global success rate for recorded rodent eradications, involving more than 330 islands. Rodenticides, mainly brodifacoum, were used in most operations, typically involving aerial broadcast techniques. As a result of these successes, and resultant conservation outcomes, eradicating invasive rodents from islands has emerged as a powerful tool to prevent extinctions and restore ecosystems. In many cases aerial bait distribution is the only way baits can be distributed across an island in a way that all rats are put at risk.

Black rats have been successfully eradicated from 159 islands worldwide to date. With an area of about 85 km² (8500 hectares) Fatu Hiva is about eight times larger than the largest island from which Black rats have been confirmed as being eradicated to date (Hermite Island, Western Australia. 1022 hectares). However, an operation to eradicate black rats, along with house mice (*Mus musculus*) and European rabbits (*Oryctolagus cuniculus*) is well-advanced on 12 400 hectare Macquarie Island, Australia. While efforts to eradicate the rabbits continue, as planned, neither rats nor mice have been found on Macquarie since the aerial rodent eradication operation in June 2011. The largest island from which Pacific rats (*Rattus exulans*) have been eradicated is Raoul, New Zealand, at 2939 hectares. In their summary of eradications, Howald et al. (2007) concluded that island size is no longer a key constraint to eradication. Rather, it is economic and social factors that are likely to be the key determinants of success.

## 3.1 Initial assessment

In addition to considering relevant precedents from elsewhere, assessing the feasibility of eradicating the rodents from Fatu Hiva will require a detailed investigation in relation to criteria that have been developed and refined over recent years (Cromarty et al. 2002; Veitch et al. 2011). Because there are often significant costs and risks involved, feasibility studies are increasingly undertaken by agencies that are independent of the funders and management agencies. An initial assessment of the feasibility of eradicating the rodents from Fatu Hiva is summarised below in relation to criteria used by Landcare Research (www.isinz.com). It should be noted that this is an initial assessment only, based on a brief visit and limited consultation. It is presented here because Manu requested an initial assessment. A number of questions are identified that will require further consideration.

## 3.2 All individuals of the targeted pest population can be put at risk by the available techniques

- While black rats are likely to be the main predator of wildlife on Fatu Hiva, Pacific rats are also present, and are likely to be having significant impacts. There would be merit in eradicating both rodents as part of a single operation. There are precedents that may be used as models for a multiple rodent eradication. It is not clear whether house mice are also present on Fatu Hiva. If so, consideration may also be given to eradicating mice, although there would be significant additional risks and costs. Not eradicating the mice but removing the rats could lead to an increase in mouse numbers that might have negative consequences.
- The only way all rodents could be put at risk on Fatu Hiva would be by the aerial distribution of toxic baits as part of a single operation. The island is too large and steep for bait to be distributed to every rodent using ground-based techniques.
- The costs and logistics of mounting an aerial eradication operation on Fatu Hiva would be significant, due to its remote location. While helicopters would be able to fly from Hiva Oa to Fatu Hiva, a support vessel would probably be required for the duration of the operation. As an initial comparison the eradication of Norway rats (*Rattus norvegicus*) from Campbell Island, New Zealand – a similarly remote island of a comparable size cost NZ$220 per hectare. If a Fatu Hiva eradication were to cost the same this would equate to roughly 130 million XPF. Ship-based aerial eradication operations have been undertaken at a number of locations in recent years, including Palmyra Atoll (US Pacific), Phoenix Islands (Kiribati), and Henderson Island (UK Pacific). Important benefits, including improved effectiveness and reduced costs can be anticipated as multiple island eradication approaches continue to be refined.

## 3.3 Mortality will exceed recruitment at all densities

- Based on the high success rate of aerial rodent eradications to date, provided established best practice aerial bait distribution procedures are applied there is a high probability this criterion can be satisfied. An important advantage of aerial bait distribution is that the entire island can be covered in just a few days, meaning all

rodents have access to baits virtually simultaneously. Trials may be required to confirm that Fatu Hiva rodents will consume baits in the presence of other foods.

- If it is determined that a less persistent 'first-generation' anticoagulant, such as diphacinone, is to be used, instead of brodifacoum, trials will be required to determine baiting regimes to ensure this criterion can be met (Parkes et al. 2011).

### 3.4 The risk of re-invasion is near-zero

- The relative isolation of Fatu Hiva and limited access points to the island probably make maintaining biosecurity measures more achievable than at many other islands. Provided there is strong local support for biosecurity it is likely that the risks of rodents re-invading following an eradication operation could be managed to acceptable levels. Biosecurity would also need to focus on other risk species for monarchs, such as mynas and bulbuls, invasive tramp ants and weeds.
- There have been few rodent eradications to date on inhabited islands. Even small island communities may involve people with different perspectives and potentially conflicting values and interests. Securing enough political support to proceed with an eradication involving the aerial distribution of toxic baits across an island probably represents "several steps too far" for many communities today. While there is probably a multitude of reasons for this, concerns about environmental risks and other implications for local residents of an eradication operation, and the constraints and costs associated with undertaking an operation and on-going biosecurity measures are probably paramount. If there was a shared vision for a rat-free island and strong local support for an eradication operation on Fatu Hiva it is possible there may also be support for on-going biosecurity measures. Benefits in relation to reduced rat impacts on crops, and improved food security and public health may reinforce local support. The potential for locally driven biosecurity programmes to protect livelihoods and lifestyles, as well as the island's biodiversity, deserves further investigation. Critical measures will be to ensure local residents and other stakeholders are well informed about ecological complexities, logistical risks, and operational costs, as well as about potential (ecological, social, and financial) outcomes.

### 3.5 Institutional and donor support is declared

- Because they involve high risks and costs, eradications generally require declarations of support from the highest levels in appropriate government organisations and management agencies. Consistent support from these organisations through all phases of planning and implementation, and for on-going biosecurity will be critical.
- The early engagement of donor agencies, perhaps beyond French Polynesia, is likely to be required. Donors generally require detailed information about how costs and risks will be managed, and outcomes sustained.
- It was beyond the scope of this assessment to determine the level of potential institutional and donor support for rodent eradication on Fatu Hiva. It is worth noting, however, that Fatu Hiva is an Important Bird Area for 5 species of bird in addition to the monarch. It is classed as one of the top 60 Key Biodiversity Areas in the CEPF Polynesia Micronesia Hotspot. It is also classed as an Alliance for Zero Extinction site

as it is the sole location for the critically endangered Fatu Hiva monarch. There is little doubt that most organisations with interests in conserving biodiversity at national, regional or international scales would rate the restoration of Fatu Hiva very highly.

### 3.6 Local support is assured

- Conservation is essentially a social activity. The key roles that local people must play, and the fundamental importance in facilitating their support is evident in relation to eradications where, by their very nature, everyone is affected, and where there can be a fine line between success and failure.
- In addition to their impacts on biodiversity, rodents can also have negative effects on island economies and lifestyles through their predation of crops, consumption and fouling of stored food, damage to wiring and electrical equipment, direct and indirect health effects (e.g. as vectors of Leptospirosis), among others. Given the reliance of Fatu Hiva residents on local produce such as pawpaw and banana, and the reported impacts rats are currently having on these and other crops, evaluating the economic and social implications of rodent eradication would be timely, to inform these discussions.
- While most people are likely to support the concept of a rat-free Fatu Hiva, a range of concerns are likely to be expressed that will need to be acknowledged and appropriately addressed. Challenges involving eradication technologies and approaches, non-target and environmental effects, possible perverse outcomes, implications for lifestyles and livelihoods, and financial risks and costs will need to be clearly set out and objectively assessed in an open process. If a feasibility study were to be commissioned an important early step would be to consult with local residents to ensure local perspectives, interests, and concerns are identified, and that communication lines and decision-making mechanisms are in place. Because there are few precedents for rodent eradications on inhabited islands much has still to be learned about stakeholder interests and concerns in relation to eradications, and how these might or might not be addressed.

No conclusions about the feasibility of eradicating rodents from Fatu Hiva can be drawn from this initial assessment. While the costs and logistics of undertaking an eradication operation on Fatu Hiva would be impressive, it could well be technically achievable using established techniques. If there was a large measure of stakeholder support for the concept of a rat-free Fatu Hiva, the next step would be to undertake a feasibility study where the full range of challenges and opportunities could be examined.

## 4 Conclusions and recommendations

Important progress has been made in relation to most recovery objectives for both species. Extinction has been averted, at least for now. Manu, its partners and all those involved in the recovery programme to date should take pride in these achievements. The continued survival and recovery of these special birds, however, is far from assured. The following conclusions and recommendations mimay helpthe recovery group as it prepares the next plan:

- The lack of a comprehensive and cohesive recovery plan is an increasing impediment to further progress. The preparation of a new recovery plan involving the engagement of recovery group members and a wider set of stakeholders is a timely initiative.
- Important future goals should involve increasing monarch numbers, improving the efficiency of management programmes and generating further political, institutional, donor and landowner support.
- Effective rat control has averted the imminent extinction of both monarch species. It will be critical that rats continue to be controlled in all monarch breeding areas. Small refinements may lead to important efficiencies, and to increased sustainability, although care will be needed to ensure refinements do not increase the risk of predation of monarchs.
- Further precautions may be needed if brodifacoum continues to be used in areas where feral pigs are hunted. It will be important that detailed, authoritative information is provided to recovery group members, Site Support Groups, and stakeholders more generally to inform their decisions about toxin use – whether for on-going control, or for eradication.
- While predation by black rats is clearly the most immediate threat to monarch survival, a variety of other factors may also need to be more actively managed. Greater institutional engagement and support from government environmental and agriculture agencies, for example, could lead to reduced threats from inappropriate developments, such as fires, forest clearance and roading in monarch management areas. The development of a habitat restoration plan that integrates the management of all identified threats would be useful.
- Completing surveys so that as many monarchs as possible can be included in management programmes should be given a high priority. Continuing to monitor nesting success, though time-consuming, will also continue to be important to guide management actions. High standards currently in place for data collection and collation should be maintained.
- Trials to refine reintroduction techniques so that monarch distribution can be expanded into recently vacated habitats should continue. A range of potential techniques are available, and advisors, if required. Introducing monarchs to "new" islands in order to establish insurance populations, while important, should be seen as a secondary objective. There is a risk that efforts to establish monarchs on new islands will lead to reduced interest and support for projects at original sites. There is a need for a wider set of possible recipient islands to be considered for monarch introductions, in tandem with regional eradication and island restoration strategies.
- It will be important that research needs are clearly identified, and priority is given to addressing those that will enable more effective and efficient management.
- Important recent progress has been made in controlling mynahs and bulbuls in Tahiti. Manu's employment of a highly experienced and resourceful bird control specialist has underpinned this progress. Further investigations are needed to determine the impacts of mynahs and bulbuls, and the value of controlling them. Biosecurity measures to ensure these birds do not establish populations on Fatu Hiva deserve a high priority.
- A detailed feasibility study, including a cost-benefit analysis should be undertaken if any proposal to construct a predator fence is promoted as part of the monarch recovery programme.

- Priority should be given to generating further support and facilitating the involvement of landowners and local residents. Stakeholder engagement through Site Support Groups will be a key to outcomes being sustained. Given their potential importance as a conduit for communication between stakeholders, and between stakeholders and project staff, Manu should remain flexible to suggested changes to the composition and roles of SSGs.
- Increasing the involvement and support of mayors and local councils, and government agencies such as the Environment and Agriculture Departments will be important if further progress towards habitat conservation goals is to be made and conservation outcomes are to be sustained.
- The current project manager is very adept at liaising with local people. He is also a highly competent field operator and biologist. Manu will need to ensure the project manager is not overly-burdened with administrative responsibilities that detract from these primary roles.
- Progress has been made in building capacity within the Manu project team. Benefits are apparent, for example, in the rat and cat control measures that are in place. Important further benefits could be expected if Manu was to develop a more comprehensive capacity building strategy involving local people and volunteers. Supporting further 'skills-sharing' exchanges for selected practitioners would lead to important benefits.
- Continuing to build the cadre of local people with the skills and motivation to undertake this work will be an important on-going objective. Consistent support for a small number of local project staff is likely to lead to further community awareness and support for the project.
- Volunteers will continue to play an important part in the recovery of Tahiti and Fatu Hiva monarchs. Manu should ensure these people are properly trained and adequately supported. There would be merit in requiring all volunteers to provide a written report outlining their activities, achievements, and perspectives, as well as furnishing all information collected, before their leaving the project.
- An initial assessment suggests an aerial bait distribution operation to eradicate the rodents from Fatu Hiva may be technically feasible, although it would be logistically challenging and very expensive. Rodent eradication is probably the most important single action required to ensure the long-term survival of the Fatu Hiva monarch. The interests and concerns of local people, as well as the wider opportunities and benefits from a rat-free island, will need to be comprehensively addressed. If appropriate, the next step would be to commission an independent feasibility study where these issues, and necessary actions, could be identified.
- Biosecurity is an important part of any invasive species management programme. Once risks have been identified, on-going quarantine, surveillance, and rapid response measures are required to ensure conservation benefits continue to flow. While islands present unique biosecurity opportunities, due largely to their isolation, there are few precedents to date of eradications on inhabited islands. The possible eradication of rodents from Fatu Hiva may serve as an important international conservation model.

## 5 Acknowledgements

Thanks are due to a number of people who assisted in this investigation. Thomas Ghestemme provided information, responded to my many questions, and accompanied me on my visits and meetings. Susanna Saavedra provided accommodation and her insights into invasive bird control. Mark O'Brien and Steve Cranwell commented on an early draft, and offered advice. Caroline Blanvillaine offered insights and an historical perspective. Roberto and Simone Maraetaata provided hospitality and contributed a local Fatu Hiva perspective. Jacob Hjorth Jorgensen also contributed to discussions on Fatu Hiva. Al Glen, Landcare Research, reviewed a draft.

## 6 References

Blanvillain C, Salducci JM, Tuturai G, Maeura M 2003. Impact of introduced birds on the recovery of the Tahiti Flycatcher (*Pomarea nigra*), a critically endangered forest bird of Tahiti. Biological Conservation 109: 197–205.

Cromarty PL, Broome KG, Cox A, Empson RA, Hutchinson WM, McFadden I 2002. Eradication planning for invasive animal species on islands – the approach developed by the New Zealand Department of Conservation. In: Veitch CR and Clout MN eds 2002. Turning the tide: the eradication of invasive species. Proceedings of the international conference on eradication of island invasives. Occasional paper of the IUCN Species Survival Commission No.27. Invasive Species Specialist Group, IUCN, Gland, Switzerland, and Cambridge, UK. Viii + 414pp.

Fisher P 2010. Environmental fate and residual persistence of brodifacoum in wildlife. Envirolink 884-HBRC131. Landcare Research contract report LC57 prepared for Hawke's Bay Regional Council

Fisher P, Griffiths R, Speedy C, Broome K 2010. Environmental monitoring for brodifacoum residues after aerial application of baits for rodent eradication. In: Veitch CR, Clout MN, Towns DR eds 2011. Island invasives: eradication and management. Proceedings of the international conference on island invasives. Gland, Switzerland: IUCN and Auckland, New Zealand: CBB. xii +542 p.

Ghestemme T, Yan L, Matohi A, Terorohauepa E, Portier E, Mose I, Cantois L, Yan L, Ricatte S, Gouni A 2011a. Preventing extinctions initiative: conservation of Fatu Hiva Monarch (Pomarea whitneyi). Final unpublished report. Société d'Ornithologie de Polynésie.

Ghestemme T, Yan L, Matohi A, Terorohauepa E, Cantois L, Portier E, Blanvillain C, Ricatte S, Autai T, Gouni A 2011b. BirdLife International Conservation Community Fund: saving the Monarchs of French Polynesia for the future generations. Final unpublished report.Société d'Ornithologie de Polynésie.

Ghestemme T 2011, Impacts of introduced birds on the last population of the Tahiti monarch. Pacific Invasives Initiative Newsletter, December 2011.

Ghestemme T 2012. Fatu Hiva Monarch Short Action Plan. Unpublished report SOP MANU.

Gouni A. 2006. Rapport de mission du Suivi des populations de Monarque de Fatu

Hiva. Société d'Ornithologie de Polynésie, Papeete, p 19.

Haydock N, Eason C eds 1997. Vertebrate pest control manual: toxins and poisons. Wellington, Department of Conservation.

Howald G, Donlan CJ, Galvan JP, Russell JC, Parkes J, Samaniego A, Wang Y, Veitch D, Genovesi P, Pascal M, Saunders A, Tershy B 2007, Invasive rodent eradication on islands. Conservation Biology 21(5): 1258–1268.

International Union for the Conservation of Nature (IUCN) 2012. Guidelines for reintroductions and other conservation translocations. Gland, Switzerland, IUCN.

Molles LE, Calcott A, Peters D, Delamare G, Hudson J, Innes J, Flux I, Waas J 2008. "Acoustic anchoring" and the successful translocation of North Island kokako (*Callaeas cinerea wilsoni*) to a New Zealand mainland management site within continuous forest. Notornis 55: 57–68.

Parkes J, Fisher P, Forrester G 2011. Diagnosing the cause of failure to eradicate introduced rodents on islands: brodifacoum versus diphacinone and method of bait delivery. Conservation Evidence 8: 100–106.

Seddon JP, Cade TJ 1999. Bird re-introductions, pre-release preparations, releases and post-release monitoring: Improving the rigour of re-introduction project assessment, planning and execution. In: Adams NJ, Slotow RH eds Proceedings of the 22nd International Ornithological Congress, Durban. Johannesburg, BirdLife South Africa. Pp. 3174–3176.

Veitch CR, Clout MN eds 2002. Turning the tide: the eradication of invasive species. IUCN SSC Invasive Species Specialist Group. Gland, Switzerland and Cambridge, UK, IUCN. Viii + 414 p.

Veitch CR, Clout MN, Towns DR Eds 2011. Island invasives: eradication and management. Proceedings of the international conference on island invasives. Gland, Switzerland: IUCN and Auckland, New Zealand: CBB. xii +542 p.