Best practice techniques for the translocation of Chatham petrels (*Pterodroma axillaris*), Cook's petrels (*P. cookii*) and Pycroft's petrels (*P. pycrofti*)

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New Zealand Government

Department of Conservation
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Cover: Pycroft's petrel chick. *Photo: Helen Gummer*

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Best practice techniques for the translocation of Chatham petrels (*Pterodroma axillaris*), Cook's petrels (*P. cookii*) and Pycroft's petrels (*P. pycrofti*)

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Abstract

This document outlines best practice techniques for the translocation of Chatham petrels (*Pterodroma axillaris*), Cook's petrels (*P. cookii*) and Pycroft's petrels (*P. pycrofti*). It contains methods pertaining to the translocation process, from selecting the most appropriate source and release sites, creating artificial burrows at the release site, and selecting, collecting and transferring chicks, through to caring for chicks at the release site, data collection, and post-release site management and monitoring. It is intended that this information will help to increase the success of future translocations of these petrel species.

Keywords: Chatham petrel, *Pterodroma axillaris*, Cook's petrel, *Pterodroma cookii*, Pycroft's petrel, *Pterodroma pycrofti*, translocation, best practice, New Zealand

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1. Introduction

This document is intended to be read in conjunction with the following documents:

- Field guidelines for burrow-nesting petrel and shearwater translocations (Gummer et al. 2014a)
- Chatham petrel chick translocation guidelines (Gummer 2011a) (for Chatham petrel translocations)

It is one of a series of documents outlining best practice techniques for the translocation of New Zealand bird species. It is intended that this will be used as an advisory document for those planning the translocation of Chatham (*Pterodroma axillaris*), Cook's (*P. cookii*) or Pycroft's (*P. pycrofti*) petrels, and for those assessing proposals for the translocation of these species.

Chatham, Cook's and Pycroft's petrels are small seabirds of the genus *Pterodroma*, which are frequently termed gadfly petrels. All three species are endemic to New Zealand and classified as Threatened or At Risk (Miskelly et al. 2008) under the New Zealand Threat Classification System (Townsend et al. 2008): Chatham petrel—Threatened, Nationally Vulnerable; Cook's petrel—At Risk, Relict; and Pycroft's petrel—At Risk, Recovering. These species are closely related and share similar biological traits (physiology, breeding biology and diet), which means that translocation projects involving any of these species can be approached using similar methodologies.

The described methods are based on established techniques that have been tested and have met with success in four previous translocation projects involving Chatham, Cook's and Pycroft's petrels between 2002 and 2011. Therefore, they are recommended as current best practice techniques for the translocation of these three species. However, anyone that is planning the translocation of Chatham petrels should also read the Chatham petrel chick translocation guidelines (Gummer 2011a), which contains more site-specific information and record sheets (these guidelines are available from DOC's Chatham Islands office).

This document may also be useful as a starting point for those planning the translocation of the closely related black-winged petrel (*P. nigripennis*), which has never been translocated to date.

Anyone considering a translocation of mottled petrels (*P. inexpectata*) should refer to both this document and the grey-faced petrel (*P. macroptera gouldi*) best practice document (Gummer et al. 2014b) as a starting point. Although mottled petrels are closer in size to grey-faced petrels, they are a southern New Zealand species (cooler climate), and some aspects of their biology, e.g. their migratory behaviour, are more similar to the smaller gadfly petrels.

It is recommended that collective advice is obtained from more than one specialist when embarking on new projects, to ensure that these species are suitable for translocation to a specific site and to obtain further information on their biology.

Important note: The use of translocation[1] as a technique for establishing new seabird populations in New Zealand is a relatively recent development. This best practice guideline has been developed to improve the likely success of the transfer phase of a translocation project (i.e. short-term success). To date, no projects in New Zealand have successfully established a self-sustaining seabird population (i.e. long-term success is yet to be achieved). It is also important to note that the behaviour and reaction of birds to capture and translocation can vary between locations, seasons and years. Therefore, a good translocation practitioner will always closely monitor the birds in their immediate care and react to their needs accordingly.

[1] For definitions of key terms in this report, refer to section 17—'Glossary'.

2. Background information

2.1 Methods for establishing burrow-nesting seabird colonies

Three key methods are employed to establish new colonies of burrow-nesting seabirds:

1. **Acoustic attraction**—Involves broadcasting ground and/or aerial calls of the target species via a sound system, which is positioned in suitable habitat and at a place where birds passing by (at sea) can hear it. The exact positioning of the speakers is often dictated by the cable length distance to the solar panels that are required to provide power for the system.

   Acoustic attraction is often trialled for 1 or more years in conjunction with the provision of artificial burrows (see below) to see whether a colony can be established with minimal effort and cost (i.e. it is attempted before a more costly translocation operation). This method is only likely to succeed if there are large numbers of birds that regularly fly in the vicinity of the sound system. Further references to this technique can be found in Gummer (2003); and information on current sound-system technology is available from the Conservation Electronics section of the Science and Capability Group, National Office, DOC.

   Note: Acoustic attraction should also be employed at translocation release sites to maximise the likelihood that chicks returning as adults will find the exact site, i.e. to draw in returning birds; and to provide a social stimulus for retaining recruiting birds.

2. **Provision of artificial burrows**—These should be located near to an acoustic attraction sound system, and of a design that is well-suited and attractive to the target species.

   Note: If chick translocations are to be considered in the future, artificial burrows need to be of a superior design to safely accommodate chicks during artificial rearing, with easy access (by humans) into all parts of the burrow.

3. **Translocation**—Chicks are translocated from the nearest suitable population and housed at the artificial burrow site until they fledge. Translocations involve large numbers of birds, and are costly and labour-intensive. Techniques are constantly evolving, especially with regard to artificial diet. There is usually a set of associated risks for each project at different locations. Translocation is likely to be the only effective way of starting a new colony in a location that is far away from the usual flight-path of a species, i.e. in a place that birds would be highly unlikely to colonise by acoustic attraction and the provision of artificial burrows alone.

Note: When embarking on new acoustic attraction and translocation projects, specialist advice must always be sought with regard to:

- The suitability of establishing the species at a specific site/location.
- The appropriateness of commencing a species colony establishment project with respect to other projects in the region. Projects aiming to establish colonies of the same species within relatively close proximity (e.g. < 100 km) should not broadcast the same recordings, i.e. new projects must play a fresh set of sound recordings that are not being used at any other seabird sites within 100 km. It should also be understood that some translocated birds may be attracted to other sites in the region when they return as adults if they are more attractive or they are lured there by birds looking for partners, which may compromise the success of a project.

2.2 Translocation objectives

The desired long-term objectives for the translocation of Chatham, Cook's and Pycroft's petrels to specific release sites are primarily to:

- Establish additional self-sustaining populations of the species at safe locations, with the aim of increasing the long-term security or recovery of these Threatened or At Risk species

- Enhance biodiversity at the release site, usually as part of a progression towards an ecological restoration goal (such as establishing a seabird-influenced coastal forest ecosystem that is typical of lesser modified islands in the region); and/or to restore seabird nutrient cycles to degraded ecosystems
- Provide public access and education (where possible), and seabird conservation advocacy opportunities

2.3 Gadfly petrels

Chatham, Cook's and Pycroft's petrels are in the order Procellariiformes, family Procellariidae, and are grouped within the genus *Pterodroma*, which are frequently termed gadfly petrels. Translocation projects involving these three species are approached in the same way, as they are closely related and share the following biological traits:

- Size and morphology—Small-sized species ranging from 150 to 200 g, with similar body shape and wing structure.
- Migratory behaviour—Strong; all three species migrate to the north Pacific and/or eastern Pacific Ocean during their non-breeding season.
- Foraging behaviour—Pelagic; feed far from the coast in deep oceanic water, where they prey on fish, squid and crustaceans, and on bioluminescent species during nocturnal foraging.
- Breeding habitat requirements—Excavate burrows under forest or shrub canopy (usually coastal and also at higher altitudes); tree-climbing ability (for take-off).
- Colony visitation patterns—Strictly nocturnal; seasonal, with breeding season visitation during the austral summer/autumn (September–May), although Cook's petrels occasionally visit during the non-breeding period (most likely pre-breeding juveniles).
- Breeding biology—First arrival at the colony between mated pairs is highly synchronised; long pre-laying exodus period (30+ days), when no visitation or only male visitation to the breeding burrow occurs; single egg; long incubation shifts (10–16 days) by each parent and long incubation phase (45+ days).
- Chick-rearing behaviour—Short brood phase; long chick-rearing period (c. 70–80 days); chick is fed at irregular intervals (not nightly); chick weight peaks at up to double the average adult weight; parental abandonment period prior to chick fledging (on average 6–10 days).
- Chick emergence behaviour—Exercising; finding take-off points; site-fixing.
- Site fidelity—Strong; return to their fledging burrow (or nearby burrow) as an adult.

2.4 Animal welfare requirements

When handling wildlife, the animal welfare provisions of the Animal Welfare Act 1999 and its welfare codes (e.g. Transport within New Zealand) must be met. Note that this best practice guideline has been produced to improve the likely success of translocations of Chatham, Cook's and Pycroft's petrels, and thus promotes a high level of care of the birds (i.e. minimum standards relating to the provision of shelter, food and water are covered) and a consideration of general animal welfare. However, it does not attempt to address each of the minimum standards in welfare codes.

Projects trialling new techniques for seabird translocations (including changes to the diet) require approval by an Animal Ethics Committee.

3. Principles of seabird translocations

3.1 Translocation sequence and timetable

The sequence of events involved in a translocation project and an approximate timetable for these events is as follows:

Year 1:
- Follow the process outlined in DOC's 'Translocation guide for community groups' (Collen & Cromarty 2011) when developing your translocation project and proposal.
- Seek expert advice (refer to section 11.4—'Specialist advice') on the suitability of the site for seabird communities and which species are appropriate, if an ecological restoration plan is not already available to address this matter (carried out by project manager of the release site).
- Seek expert advice on an appropriate source colony (carried out by project manager of the release site)
- Develop a translocation proposal in consultation with tangata whenua and key stakeholders (including DOC), and submit this (with full justification for the project) to DOC for approval
- Undertake basic breeding ecology studies if no information is available for the species, or analyse existing research/study data to obtain transfer criteria and fledging data.

Year 2:
- Install a sound system at the release site (if not already in place) for acoustic attraction.
- Install artificial burrows at the release site (if not already in place) to complement an existing sound system—preferably > nine months before any transfers occur (refer to section 8.3—'Installation of artificial burrows at the release site')
- Carry out a reconnaissance (recce) trip if necessary (refer to section 5.2.1—'When is a pre-transfer recce trip required?'), to assess chick availability and confirm breeding dates.
- Undertake first chick transfer.

Year 3:
- Undertake second chick transfer.

Year 4:
- Undertake third chick transfer.
- Commence post-release monitoring and continue annually/seasonally.

Year 5:
- Undertake fourth and final chick transfer of the original translocation (if required).

Year 9:
- Consider supplementary transfers from this point onwards (refer to section 3.4 'Supplementary translocations'). (Note: a new translocation proposal would be required for this.)

Year 10:
- Consider supplementary transfers

3.2 Composition of transfer group

3.2.1 Age of birds

Burrow-nesting seabirds are highly philopatric, with most adults returning to the vicinity of their natal nest site when they are ready to breed. Consequently, the translocation of adults is not feasible, as they would always return to their source colony.

By contrast, chicks that have never ventured outside the natal burrow can be successfully translocated to a new colony location. Burrow-nesting seabird chicks are thought to obtain visual cues (as well as sound and odour) from their surroundings following emergence from the burrow shortly before fledging, and site-fixing (or locality imprinting) is considered to develop during this emergence period. Thus, transferred chicks that first emerge at the release site are tricked into regarding the new colony as their natal site and will return to the new site as adults.

As a general rule, the optimum time for transferring a cohort of chicks tends to be 3–4 weeks prior to the peak fledging time (known or predicted) for the species at a particular location, so that translocated chicks fledge at the same time as the bulk of chicks at the source colony. This does mean, however, that late-fledging chicks may be compromised in terms of survival, especially if they rely on oceanic productivity, which may decline later in the season.

The timing of transfer within each individual chick's rearing period is critical:

- Moving chicks **too close to fledging** has the following implications:
  - Chicks may have already emerged at the source colony, in which case they will already have imprinted on the site and so are more likely to return to the source colony as adults—even chicks that have only been to the burrow entrance on one night are considered unsuitable for transfer.
  - Chicks may be so close to emerging from their natal burrow that they are more prone to stress by being confined in a burrow at the release site for one or more nights during acclimatisation to the new surroundings. This can result in chicks disappearing on their first night out of the burrow at the release site with unknown outcomes.
  - There is insufficient time for lighter-weight chicks that are about to fledge to regain condition following transfer (chicks always lose weight during transfer), which can lead to such chicks fledging at less than desirable weights.
- Moving chicks **prematurely** has the following implications:
  - The artificial diet that is currently used is not ideal for hand-feeding small gadfly petrels for longer than 1 month, and chicks can develop health problems if hand-fed for longer periods.
  - The parent birds may perceive breeding failure, which can disrupt the parental pair bond—and a pair divorce can result in a missed breeding season for one or both birds while they find new mates. This can have a significant negative impact on rare and endangered species.
  - Projects can become unnecessarily lengthy, labour-intensive and costly if chicks need to be fed at the release site for >1 month.

To ensure that chicks are transferred at the right age, they must meet a specific set of wing length and weight criteria for the species on the day of transfer (refer to section 7.2—'Transfer criteria').

3.2.2 Genetics and gender

Due to the numbers of birds taken, it is generally considered that the genetic diversity of transferred birds will be broad and that both genders will be included. However, any new populations of the threatened Chatham petrel will require close screening to ensure that their genetic composition is adequate, given the small size of the source population for this species and thus the associated higher risk of inbreeding depression.

A recent genetic analysis of Cook's petrels indicated that the two existing populations (Hauturu/Little Barrier Island and Whenua Hou (Codfish Island)) are genetically distinct, but that the Whenua Hou population exhibits low genetic diversity (M. Rayner, University of Auckland, pers. comm. February 2012). Therefore, it is recommended that a seabird specialist and geneticist be consulted prior to the translocation of Cook's petrels of Whenua Hou (Codfish Island) descent in order to maximise the genetic diversity of translocation stock sourced from this population.

There are no particular genetics issues for translocations involving Pycroft's or Cook's petrels from their large and genetically diverse source populations on Red Mercury Island (Whakau) and Hauturu/Little Barrier Island, respectively.

The sexes appear identical in the chicks of all three of these species. Therefore, DNA sexing using blood or feather samples would be required to determine the gender of chicks. Both cost and logistics prohibit these analyses from being carried out during translocation operations, however.

Note:

- If considered necessary, the sex of adults can be determined in a variety of ways when they return to the release site, including through vocalisation and DNA sexing. However, the sex ratio will become apparent during the breeding season. If there are no breeding attempts at a new colony well beyond when birds are expected to breed, advice should be obtained from a seabird specialist. Birds can be DNA sexed at this point (by collecting feather samples) to check whether there is a bias towards one gender returning to the colony (refer to section 15.4.7—'DNA sexing of returning adults').
- To date, there has been a strong male bias in returning Pycroft's petrels on Cuvier Island (Repanga Island).

3.3 Number of transferred birds

3.3.1 Number per translocation project

For seabird translocation projects, it is preferable for large numbers of chicks to be moved over several years to account for:

- A naturally high mortality rate at sea prior to the birds reaching maturity. Only 25–50% of burrow-nesting seabirds tend to survive after fledging to return to the colony as adults (G .Taylor, pers. obs.), and there needs to be a big enough pool of birds of both genders arriving at the colony site each season to facilitate pairing. Note: This will be slightly compromised in the first year of any project, as cohort sizes tend to be smaller while the project logistics are being fine-tuned (refer to section 3.3.2—'Number per year').
- A higher than average mortality rate in a particular season that might be attributed to unfavourable weather (e.g. severe storms around or after the time of fledging) or a poor food supply at sea.

Transferring a minimum of 200 birds over a 3–4-year period has now been trialled in several projects (see Table 1), the results of which show that up to 10–20% (to date) of the birds are returning to the new colony site as adults (Gummer 2011b; G. Taylor, pers. obs.). With confidence in translocation techniques increasing, it is now considered advantageous to move more than 200 chicks during a project to increase the pool of birds returning to the new colony site each year. Using current techniques, up to 370 chicks could be transferred over four years (refer to section 3.3.2—'Number per year').

3.3.2 Number per year

It is usually recommended that fewer chicks are transferred in the first year of any new project, even if the species has been transferred before—subjecting fewer birds to potential risk makes sense while logistical issues for the new site are being ironed out, new personnel are trained, etc. In addition, iwi and stakeholder involvement tends to be greatest the first time chicks are transferred from a source colony to the release site, as it is important to acknowledge the transfer of kaitiaki for the birds. The ceremonial protocols around this take time, however, which can sometimes generate issues with respect to timing on the day of transfer, which the transfer team will need to plan for (e.g. if it is likely to adversely impact on the length of time that chicks are held in transfer boxes or the time of day at which chicks are transferred to burrows at the release site). Therefore, it may be more appropriate to transfer fewer chicks in the year that the ceremonial protocol takes place.

In the first year of a project, the recommended number of chicks to transfer to a new site is:

- Only 50 chicks if the team is new to seabird translocations, there are anticipated logistical issues that need to be ironed out and/or the species has never been translocated before (i.e. black-winged petrel)
- 70 chicks for Cook's, Chatham or Pycroft's petrels, but only if the team has prior seabird translocation experience and no logistical issues are anticipated

In any subsequent year, a maximum of 100 chicks is considered appropriate for transfer. A larger cohort size than this would lead to logistical issues, particularly during:

- Burrow searching and chick collection trips at the source colony—In general, at least twice the number of chicks that is required for transfer needs to be found in order to find the target number of chicks suitable for transfer on a single date. The number of burrows that need to be searched depends on the burrow occupancy rates at the source colony. For example, up to 2000 Pycroft's petrel burrows may need to be inspected to find 200 burrows containing chicks, of which only 100 are likely to meet transfer criteria on a single transfer date. In some instances, up to three times the number of chicks required may need to be found.
- Post-transfer management at the release site—A feeding and monitoring regime for more than 100 chicks would have to rely on higher levels of voluntary labour, which often involves less-experienced personnel. Larger numbers may also result in there being a delay in finding and addressing serious problems. These issues may result in the welfare of chicks being compromised.

3.4 Supplementary translocations

Supplementary translocations may need to be considered at some sites for some species if the population is not considered to be self-sustaining, e.g. if the recruitment rate of the next generation of chicks is not high enough to promote colony growth. Supplementary translocations are likely to be recommended by seabird specialists if:

- All potential causes for the lack of population growth have been thoroughly investigated prior to further translocations, e.g. potential predator or competitor threats, habitat suitability, gender imbalance; and
- The period during which all transferred birds are expected to have returned has passed. While the majority of birds return as soon as they reach maturity (i.e. 3–4 years old), it should be noted that in the past some small gadfly petrel individuals have not been recovered at the release site until up to 6 years after transfer (i.e. Chatham petrels; Gummer 2011b), and some have even been found for the first time at 10 years of age (i.e. Gould's petrels (*P. leucoptera leucoptera*); N. Carlile, New South Wales Department of Environment, Australia, pers. comm. 2010).

Supplementary transfers (e.g. an extra 200 birds) may be useful 8–10 years after the first transfer to top-up the population at the new colony site. Returning birds from a supplementary translocation will find the release site particularly attractive if breeding pairs are already present. Supplementary translocations will also provide a mix of non-natal recruits to pair with birds reared at the release site that are returning as adults, which could help with genetic enhancement.

4. Previous translocations of Chatham, Cook's and Pycroft's petrels

Table 1 presents a summary of information on Chatham, Cook's and Pycroft's petrel translocation projects undertaken, to 2013.

5. Source colony

Some of the information that is presented in the following sections has been adapted from information collated by Gardner-Gee et al. (2007) and Gummer (2011c).

5.1 Geographic location

Since all three species have limited distributions and ranges, there are few choices in terms of source populations for Chatham, Cook's and Pycroft's petrels—chicks can only be sourced from the following colonies, all of which have been the subject of basic breeding ecology studies:

- Chatham petrels—South East Island (Rangatira), Chatham Islands. This is currently the only breeding population of this species, which consists of less than 200 breeding pairs. However, translocation projects are aiming to increase the species' distribution within the Chatham Islands. Chicks are sourced from artificial burrows that are scattered across the island.
- Cook's petrels—There are only two breeding colonies that chicks can be sourced from:
  - Hauturu/Little Barrier Island, Hauraki Gulf. This is the main population for the species in northern New Zealand where there are an estimated 300 000+ pairs nesting in forested habitats, mainly above 250 m altitude (Rayner et al. 2007a, b). Inspection hatches are present in approximately 220 burrows; some of these were made during long-term studies by Mike Imber (formerly DOC) and then Matt Rayner (University of Auckland), while others were created during chick collection trips for the 2011 Cape Sanctuary translocation project (Ward-Smith & Storey 2011).
  - Whenua Hou (Codfish Island) near Stewart Island/Rakiura, southern New Zealand. There are an estimated 3000–6000 breeding pairs in this population, which was once abundant, then almost extirpated, and is now recovering (Rayner et al. 2008a). This is potentially a different species/subspecies from the Cook's petrels on Hauturu/Little Barrier Island.
- Pycroft's petrels—Red Mercury Island (Whakau) off the Coromandel Peninsula. This island supports approximately 75% (5000–10 000 pairs) of the known breeding population of this species (Taylor 2000). The colony has been well studied, with over 300 burrows marked (G. Taylor, pers. obs).

Table 1. Summary of information on Chatham, Cook's and Pycroft's petrel translocation projects undertaken, to 2013.

SPECIES / SOURCE LOCATION	RELEASE SITE	YEARS OF TRANSFER	NO. OF BIRDS MOVED	NO. OF BIRDS FLEDGED*	RELEASE SITE STATUS (2012)*	GROUP / PROJECT LEADER (OTHER CONTACTS)
Chatham petrel South East Island (Rangatira)	Pitt Island (Rangiauria)	2002–2005	200	198[1]	17 breeding pairs / four immigrants[3]	Chatham Islands office, DOC; ph: 03 305 0098 (Helen Gummer—feeding contractor)
	Chatham Island (Rekohu)	2008–2011	200	198[2]	Two pairs (2012/13)	Chatham Islands office, DOC; ph: 03 305 0098 (Chatham Island Taiko Trust, www.taiko.org.nz; Helen Gummer—feeding contractor)
Cook's petrel Hauturu/Little Barrier Island	Cape Sanctuary (Hawke's Bay)	2010–2013	347	345[4],[5],[6]	Awaiting first adult returns	Cape Sanctuary / Tamsin Ward-Smith; cape.kidnappers@xtra.co.nz (Shayne Storey—feeding contractor)
Pycroft's petrel Red Mercury Island (Whakau)	Cuvier Island (Repanga Island)	2001–2003	232	≤ 227[7]	14 breeding pairs / 15 immigrants (2010)[6]	DOC / Graeme Taylor; gtaylor@doc.govt.nz (Helen Gummer & Rex Williams—feeding contractors)
	Motuora Island	2013–2015	70 (of 270 planned)	70[8]		Motuora Restoration Society / John Stewart; www.motuora.org.nz (Helen Gummer—feeding contractor)

* References: [1] Gummer 2005; [2] Gummer & Liddy 2011; [3] Gummer 2011b; [4] Ward-Smith et al. 2010; [5] Ward-Smith & Storey. 2011; [6] T. Ward-Smith, Cape Sanctuary, pers. comm June 2013; [7] Taylor 2010; [8] Gummer & Stewart 2013.

5.2 Assessing the source colony

A source colony should be assessed at two different levels:

- Study trip—An expedition made to a potential source colony 1 or more years in advance of a proposed translocation project (first chick transfer) to gather information about one or more of the following:
  - Breeding biology (if not known for the species).
  - Data required to accurately plan the timing of the translocation and to ensure that it has a successful outcome (if not known for the species). This may include chick meal size and feeding frequency by adults; parental abandonment period; number of emergence nights before fledging; fledging dates; and chick growth rate and size at fledging (weight and wing length).
  - Suitability of the source site in terms of access, population size, burrow occupancy, etc.
- Recce trip—An expedition made (if required; refer to section 5.2.1—'When is a pre-transfer recce trip required?') to the chosen source colony during the same breeding season as the planned first chick transfer, to meet the objectives set out in section 5.2.2—'Objectives of a pre-transfer recce trip'.

The following information about recce trips applies to species for which detailed information about their breeding biology is already known. A recce trip would not usually be the first visit to a colony—data on the species' breeding biology and habitat should already have been collected previously.

Important note: The collection of data for other small gadfly species that have never been studied in detail or translocated before (e.g. black-winged petrel) is not considered to be a component of a recce trip; instead, this should be collected during a study trip prior to the transfer year.

Detailed lists of the equipment required at the source colony can be found in section 2.1 of the field guidelines (Gummer et al. 2014a).

5.2.1 When is a pre-transfer recce trip required?

Recce trips are usually carried out if:

- The colony has been used as a previous source of chicks for transfer but has not been visited for many years, i.e. the availability of chicks in recent years is not known and the timing of peak fledging needs to be reassessed; or
- The colony has never previously been used as a source of chicks for a translocation project.

Note: If this is the case, a recce trip may be required not only during the first transfer year, but potentially also in subsequent transfer years.

5.2.2 Objectives of a pre-transfer recce trip

The primary objectives of a recce trip are to:

- Determine the availability of chicks at the source colony for transfer in the same season. Chick availability may fluctuate between years for a variety of reasons; for example, Pycroft's petrel burrows on Red Mercury Island (Whakau) can be susceptible to flooding in heavy rain, which has been known to significantly affect the overall productivity of the colony.
- Locate and mark as many burrows containing suitable chicks as possible, to enable easy recovery of chicks on the collection trip. Note: Not all chicks that are found during a recce trip will still be present or suitable for transfer at the time of the collection trip, so additional search time always needs to be factored in for the later collection trip.
- Identify the safest routes to use on the island to minimise burrow damage.

- Collect data on chick size (wing length only) to assist with planning the transfer date. Wing measurements collected on the recce trip can only offer a rough guide to the likely transfer date, however, because:
  - Gadfly petrel wing growth rates can vary greatly within an individual, i.e. there may be growth spurts due to recent parental provisioning, or rates may slow when there are lengthy periods between meals (R. Dunn, University of Auckland, unpubl. data 2012).
  - Wing growth rates can vary considerably between different chicks (e.g. due to varying foraging efficiencies between adults).
  - Overall chick growth rates at a colony can vary between seasons depending on the adult food provisioning rate, which is related to the food supply at sea.

  Therefore, the optimum transfer date tends to be refined once data have been collected over one or more years at the source colony, and after the first one or two transfer operations.

  Note: For species that have never been translocated before, wing measurements will offer only a rough idea for predicting transfer date unless the exact wing growth rates in the early phases of the chick-rearing period are known for the species.
- Assess all logistics in terms of collecting the chicks, e.g. team size, transportation.
- Train (or upskill) staff and volunteers in all relevant tasks (e.g. burrow inspections, chick handling).
- Preserve fragile and damaged burrows containing birds (refer to section 5.3—'Managing burrow damage at the source colony')—some burrows may be damaged either accidentally or when inspection holes are made to access chambers.

5.2.3 Timing of the recce trip

The recce trip should be timed to occur:

- After the majority of chicks at the source colony are predicted to have hatched, thus avoiding disturbance of incubating adults.
- When chicks are robust enough (i.e. not too young) to be handled/measured, and to withstand any impacts of burrow damage.
- When chicks are big enough to be effectively measured in relation to potential transfer dates—ideally no earlier than one month before the potential transfer date (i.e. early to mid-February for Pycroft's petrels; mid-February for Cook's petrels from Hauturu/Little Barrier Island; mid-March for Cook's petrels from Whenua Hou (Codfish Island).

5.2.4 Searching for burrows on the recce trip

Detailed protocols for inspecting natural burrows at the source colony can be found in section 3 of the field guidelines (Gummer et al. 2014a), which includes protocols for:

- Searching for occupied burrows
- Inspecting natural burrows (includes creating study/inspection holes where required)
- Extracting and processing chicks at natural burrows

Specific details of how each of the above was carried out for recent Pycroft's petrel recce trips are held by the Motuora Restoration Society.

Past experience shows that it generally takes 1–2 person-hours of burrow searching to find one chick that is suitable for transfer in the following circumstances:

- Where the source colony has no marked burrows, i.e. has not been the subject of research in recent years or has not previously provided chicks for translocations
- During the first recce visit at the start of any new project (i.e. new personnel, new location)

- During the collection trip if there has been no previous recce trip in that season and any marked burrows from previous translocations or research projects are difficult to find (e.g. covered up with leaf litter)
- At colonies that are sited on difficult terrain

The locations of burrows should be numbered and mapped for future reference. The global positioning (GPS) location can be recorded to within a few metres; however, hand-written maps are also helpful where there are dense clusters of burrows in one location.

5.3 Managing burrow damage at the source colony

Detailed lists of the equipment required at the source colony can be found in section 2.1 of the field guidelines (Gummer et al. 2014a).

5.3.1 Burrow damage repair

All consideration must be given to minimising and managing the impacts of burrow damage at the source colony during each visit. Burrow damage can be accidental or deliberate (for chamber access).

It is essential that appropriate materials are taken to allow the effective repair of the burrows of any species that may be encountered. Every effort must be made to ensure that damaged burrows are made light-proof and waterproof, and all methods employed need to be discussed with the relevant parties (i.e. local DOC office; seabird specialist) prior to the trip.

Materials that have been used to repair burrows in previous projects include:

- Suitable-sized rocks that are available at or near the source colony to cover inspection holes without collapsing burrows.
- Suitable-sized plywood boards (usually treated so that they withstand the weather and of a range of sizes from 300 × 300 mm to 500 × 500 mm) to cover entire burrows or inspection holes, which are weighed down effectively with rocks or logs.
- Custom-made artificial burrows that are suitable for the species and environment (refer to section 5.3.2—'Why install artificial burrows at the source colony?'). The installation of these is often considered if it is anticipated that the source colony will be providing chicks for multiple translocation projects.

The repair of damaged burrows can be prioritised as follows:

- Essential for all damaged burrows containing chicks.
- Should be attempted for all damaged burrows containing adults. However, because there is a high likelihood of adults permanently abandoning a damaged burrow even if they have a chick, it is best to make rapid minimal repairs (boards only) with minimal disturbance to avoid causing an adult to leave the colony during daylight. It is then feasible to make a better repair attempt on another day if the adult is not present and if time permits.
- Can be carried out for damaged empty burrows if they are considered to be in good sites and there are enough materials. However, preservation of these burrows is of lower priority in areas with particularly friable soil.

5.3.2 Installation of artificial burrows

Why install artificial burrows at the source colony?

For some species, artificial burrows can be installed at a small proportion of burrows that contain chicks at the source colony for the immediate management of burrow damage, i.e. to repair broken burrows or to preserve extremely fragile burrows that contain chicks. This is likely to be an investment for projects that involve multiple transfers, as there is a high chance that the stabilised burrows will be reused by the same pairs in subsequent years—thus, all future

inspections of the burrows will be safer and easier, and the burrows are more likely to remain productive. For example, it was found that ten trial plastic burrows installed on Red Mercury Island (Whakau) consistently provided eight suitable chicks for transfer each transfer year during the Cuvier Island (Repanga Island) translocation project (2001–2003).

Note: **Permission is required** to do this from the relevant parties (e.g. local DOC office and landowner).

Artificial burrow design for use at the source colony

For the small gadfly petrels, the most practical chambers to transport into remote source colony locations are manufactured Philproof™ recycled-plastic boxes, because they are lightweight and can be stacked (refer to section 8.2.2—'Design' and section 8.2.3—'Materials'). The Philproof™ flat-ground burrow design is ideal for open areas of ground with friable soil that are under canopy cover. However, since the boxes need to be sunk deep into the ground to be well insulated and light-proof, they are not suitable for use in wet areas where burrows are prone to flooding, or in areas that are very exposed to sunlight where burrows can heat up. For these reasons, boxes must also be a neutral colour, e.g. dark green, as black may absorb too much heat, and white is too translucent and will let light through. Until recently, the lids of these boxes were only made in black because they must also be light-proof; however, if black is unavailable, other coloured lids will need to be painted (at manufacture) so that no light can penetrate.

Wooden burrows can be used at the source colony instead of plastic burrows, if preferred; however, these are less practical with regard to transport logistics.

Tunnels can be made from 110 mm diameter ridged PVC drainage pipe. Note: Only single pipe lengths must be used (no joins), and a mixture of pipe lengths and shapes are required at the source colony. Pipes can be bent into a range of curves with the application of heat (steadily turned above a low gas-stove flame, gently bent into a curve, and then plunged in cold water). These should be prepared before the trip.

Artificial burrow installation at the source colony

Detailed protocols for installing the flat-ground burrow design in burrows containing chicks at the source colony can be found in section 4.1 of the field guidelines (Gummer et al. 2014a).

Burrow installation during the chick-rearing phase (i.e. on the recce trip and/or the chick collection trip) should only be attempted by experienced personnel, or those under the instruction of experienced personnel. Incorrectly or poorly installed burrows will cause parents to abandon their chick and to permanently abandon the burrow, which defeats the purpose of installing these burrows.

Once in place, artificial burrows cannot be removed as, all going to plan, they will be occupied by breeding birds each season. Therefore, since plastic burrows will take decades to break down, approval must be obtained from DOC before installing them.

The locations of all artificial burrows should be numbered and mapped for future reference. The global positioning (GPS) location can be recorded to within a few metres; however, hand-written maps are also helpful where there are dense clusters of burrows in one location.

6. Transfer date

6.1 Single or multiple transfers

Whether a transfer is undertaken on a single date or over multiple dates depends on several factors:

- The size of the source colony and ease with which chicks can be collected on a single day. If it takes a long time to collect the birds, there may be welfare issues regarding the duration of the transfer, which will make it preferable to undertake transfers across multiple dates.
- The number of chicks that will meet the transfer criteria on a given day. Sometimes chicks of suitable age and size are spread over several weeks, meaning that two transfers (on different dates) will result in more chicks of the correct size becoming available (refer to section 6.3—'Wing length estimates to predict transfer dates').
- The resources available to cater for chicks over extended periods at the release site (i.e. with two transfers, the total feeding period will be extended).

6.2 Previous transfer dates

The previous chick transfer dates listed in Table 2 give an indication of the optimum transfer dates for future translocation projects. Note: The most recent transfers tend to have been scheduled on the more optimal dates.

6.3 Wing length estimates to predict transfer dates

The estimated wing growth rates for each species are:

- Chatham petrels—Min. 2 mm/day, max. 4 mm/day.
- Cook's petrels—Min. 2 mm/day, max. 5 mm/day.
- Pycroft's petrels—In a good chick provisioning year, min. 3 mm/day, max. 4 mm/day; the average growth rate of 90 chicks over four weeks from mid-February to mid-March 2013 was 3.8 mm/day (Gummer & Stewart 2013). In a poor provisioning year, growth rates could be less than 3 mm/day (e.g. an estimated 2 mm/day), which could affect the transfer date.

Note: Minimum and maximum wing growth rates should be used rather than average wing growth rates because individuals grow at different rates and growth rates vary at different stages of development.

The wing measurements that are obtained from chicks on the recce trip and the estimated wing growth rates above can be used to calculate the number of days (both minimum and maximum) over which each chick needs to grow to meet the optimum transfer wing length criteria (see Table 3). For each chick, there will be a date range for when it is likely to meet the transfer criteria.

This date range can then be used to:

- Determine the optimum transfer date, on which the greatest number of chicks will fit the transfer criteria.
- Identify the time/labour requirements for the collection trip, i.e. considering how many additional chicks might need to be found over those that were already marked on the recce trip.

Table 2. Dates of previous Chatham, Cook's and Pycroft's petrel chick transfers from their respective source colonies (as at 2013).

SPECIES / SOURCE SITE	RELEASE SITE	YEAR	NUMBER TRANSFERRED	DATE
Pycroft's petrel Red Mercury Island (Whakau)	Cuvier Island (Repanga Island)	2001	30	16 Mar
		2002	100	15 Mar
		2003	34	5 Mar
			68	7 Mar
	Motuora Island	2013	70	12 Mar
Chatham petrel* South East Island (Rangatira)	Pitt Island (Rangiauria)	2002	36	30 Apr
			5†	14 May
		2003	49	1 May
		2004	55	28 Apr
		2005	55	1 May
	Chatham Island (Rekohu)	2008	43	21 Apr*
			4†	28 Apr
		2009	44	25 Apr
		2010	39	24 Apr*
		2011	33	21 Apr
			37	29 Apr
Cook's petrel Hauturu/Little Barrier Island	Cape Sanctuary	2010	50	8 Mar
		2011	102	8 Mar
		2012	80	6 Mar
		2013	50	11 Mar
			65	22 Mar

* Some Chatham petrel transfer dates were scheduled early to allow for the possibility of delays associated with bad weather.

† Opportunistic transfer that was added onto other species work at the source colony.

7. Selecting, collecting and transferring chicks

Detailed lists of the equipment required at the source colony can be found in section 2.1 of the field guidelines (Gummer et al. 2014a).

7.1 Objectives of the selection/collection/transfer trip

The selection/collection/transfer trip is often a 4- to 6-day trip, depending on the size of the team. The primary objectives of this trip are to:

- Revisit and inspect all burrows that were marked as containing chicks on the recce trip (or marked in the previous season if no recce trip was required). Even if it was expected that some chicks would be the wrong size for transfer during the recce trip, all burrows should still be checked at the start of the collection trip if there is any doubt about burrow identity and to ensure that suitable chicks are not missed.

  Note: All burrows containing chicks should have been marked on the recce trip (e.g. with flagging tape).
- Weigh and measure all chicks to determine which individuals are suitable for transfer—both prior to and on transfer day.

  Note:

  – On transfer day, reweigh (highest priority) and remeasure all chicks that are destined for transfer to ensure their suitability.

  – Chick weigh bags need to be around standard pillowcase size (e.g. 450 × 700 mm) to ensure that wing feathers are not damaged and to allow space for potential regurgitation within the bag—birds in small bags could get covered in their own regurgitant, which could be fatal. (For essential information on regurgitation, refer to section 11.6.1—'Regurgitation'.) Pesola scales with a minimum capacity of 600 g are required.
- Band all chicks that are potentially suitable for transfer.

  Note: There will not be time to band chicks on transfer day, so any banding must either be carried out during the first handling event or be delayed until at the release site. Banding chicks at the source colony is best practice, however, because it means that if the transfer of a chick that has already been collected cannot proceed for any reason, it can be reliably returned to its natal burrow, providing that the burrow has been effectively marked. Where a decision has been made not to band chicks at the source colony, hydration equipment, tins of sardines and associated hygiene gear must be taken in case there are any major unforeseen delays to the transfer. Furthermore, any chick that has not been banded at the source colony must be weighed and measured on transfer day to ensure that it fits the transfer criteria—an unbanded chick in a marked burrow may not be the original occupant that was first handled, as two burrows can share the same entrance or chicks can wander. It should also be noted that if the banding of chicks is delayed until the release site, it must occur within the first two days after transfer before any blockades are removed (refer to section 10.3—'Blockade removal').
- Mark burrows of potentially suitable chicks accordingly, so that they can easily be found on transfer day.
- Mark burrows of marginal chicks (predicted to be very close to the minimum or maximum wing length and/or weight criteria) accordingly to ensure that they are remeasured on (or just before) transfer day.
- Search for additional chicks (i.e. in unmarked burrows) if necessary to reach the target number of chicks for transfer.

- Use stick fences to help determine whether chicks have been fed by their parents the night before transfer day (to help plan the feeding schedule at the release site), if time permits.

Note: Personnel can expect to undertake the same tasks as on the recce trip (refer to section 5.2.4—'Searching for burrows on the recce trip' and section 5.3—'Managing burrow damage at the source colony') in terms of burrow searching, chick extraction and burrow damage repair (including burrow installation if relevant), as well as additional chick processing tasks (banding, weighing and measuring).

7.2 Transfer criteria

The following transfer criteria have been set to ensure that only those chicks that will have an excellent chance of fledging, surviving and returning to the release site are included.

Chicks should be selected for transfer if they meet the following criteria **on transfer day**:

- **Wing length** falls within a pre-set range—to avoid transferring chicks that are too young or too close to fledging. This wing length range is usually divided up into wing length groupings, which also have a minimum weight requirement.
- **Weight** exceeds a minimum that has been set for each wing length grouping—to avoid taking chicks that are too light for their age. Heavier chicks are more capable of tolerating the relatively slow (but necessary) transition onto the artificial diet without fledging condition being too compromised. In addition, if heavier chicks disappear prematurely from their burrows (before their plumage is fully developed) and so can no longer be fed, they will still have a good chance of fledging within the target fledging weight range.
- **Have not yet emerged** at the source colony—any chicks that are suspected to have emerged should not be taken, even if their wing lengths are within the pre-set range. The maximum wing length criterion accounts for the fact that it is not always easy to determine whether a chick has emerged (refer to section 7.2.2—'Chick emergence at the source colony').

Note: Minimum weight criteria tend to be increased for the more advanced birds because there is less chance that a chick has emerged if it is particularly heavy. This strategy allows enough time at the release site to block such chicks into their burrows for an acclimatisation period of up to two nights before they begin to emerge, without causing too much stress (refer to section 10.2—'Burrow acclimatisation period').

7.2.1 Wing length and weight criteria

Fluctuations in weight as a result of large, irregularly delivered meals can make it difficult to detect the exact base weight (pre-feed weight) of individual gadfly petrel chicks. For example, two chicks that are identical in weight on one handling day may have completely different body or base weights: one may be a chick with a light base weight that is slowly digesting a very large meal that it was fed on the previous night, while the other may be a chick with a heavy base weight that has not been fed for many days and is awaiting its next meal.

Transfer day weight criteria have been developed to incorporate these fluctuations (see Table 3), i.e. the criteria can be applied to chicks that have been recently fed as well as to those that have not received a parental meal for some time.

It is important that all chicks are weighed on transfer day—even if their wings are predicted to fall well within the wing length criteria at transfer on first handling—to see if they have dropped below the minimum weight criterion. This may be because they have not received any further meals from their parents since they were first weighed, in which case they must not be taken. Other chicks that may have been initially too light and unlikely to be suitable may have reached the minimum weight criterion by the transfer day, i.e. some chicks may be slowly gaining weight or awaiting a large parental meal which takes them up to the minimum weight.

Table 3. Transfer day wing length and weight criteria for Chatham, Cook's and Pycroft's petrels.

SPECIES	PRIORITY FOR TRANSFER	WING LENGTH ON TRANSFER DAY	MINIMUM WEIGHT ON TRANSFER DAY
Chatham petrel	1 (optimum)	170–210 mm	300 g
	2 (acceptable)	211–215 mm	300 g*
	3 (least preferred)	216–225 mm†	290 g*
Cook's petrel	1 (optimum)	160–210 mm	300 g
	2 (acceptable)	211–220 mm	330 g
	3 (least preferred)	221–230 mm†	320 g (or 300 g if fence intact)
Pycroft's petrel	1 (optimum)	155–195 mm‡	220 g
	2 (acceptable)	196–200 mm	240 g
	3 (least preferred)	201–205 mm†	260 g

* Note: The minimum weight criterion of the more advanced Chatham petrel chicks used to be higher (330 g) to avoid taking chicks that might have emerged. However, it has now been lowered to 300 g for Priority 2 chicks and 290 g for Priority 3 chicks (relatively lower than for the other two species). This is because the Chatham petrel is a threatened species and burrows at the source colony are intensively managed; therefore, it is much easier to tell if Chatham petrel chicks have emerged from burrows at the source colony (i.e. the criteria do not need to attempt to eliminate chicks that might have emerged).

† A reasonable amount of down cover is preferred on these chicks to indicate that they have not yet emerged at the source colony.

‡ Minimum wing length of 150 mm is to be tested in 2015 (by Motuora Restoration Society).

7.2.2 Chick emergence at the source colony

It is vital that transferred chicks have not emerged at the source colony. The erection of stick fences at burrow entrances on the day before transfer and inspection of these on transfer day can help to determine whether a chick that is suspected to be close to emerging has visited the surface:

- If the stick fence is intact on transfer day, the chick did not emerge on the night before transfer day. Therefore, the chick can be taken.
- If the stick fence is down, a parent visited the burrow and/or the chick emerged from the burrow on the night before transfer day. Therefore, further assessment is required: the burrow entrance and chick must be carefully inspected to decide if there is a chance that it could have emerged.

Note: If time permits, it would be beneficial to observe activity at the burrow entrance over several nights before transfer day, to obtain a clearer picture of whether or not a chick might have emerged.

If a chick is very downy and needs to squeeze through a natural entrance, it can be easy to see if it has emerged, as it will leave lots of down at the entrance (and knock the stick fence down). However, it can be quite hard to determine whether a chick has emerged in the following circumstances:

- At burrows with wide natural entrances or where artificial pipes have been installed.
- If the chick is not particularly downy by the time of its first emergence—this may be because:
  - The chick is particularly advanced with well-developed plumage
  - The chick's natal burrow chamber is small/tight inside so the down has worn off rapidly
  - Down has been lost from the chick through a previous flooding event or through previous handling in wet weather
- Where chicks have previously been pulled out from reach-in burrows (chamber access through burrow entrance) and have lost down during the first extraction. In this situation, down will have been deposited at the entrance and should be removed at the time—otherwise it can later be mistaken for down that has been deposited by an emerging chick

7.3 Selecting chicks

7.3.1 Chatham petrel chicks

Methods for selecting Chatham petrel chicks differ from those used to select Cook's and Pycroft's petrel chicks because the Chatham petrel is a threatened species and so all burrows at the source colony are managed (clearly marked and mapped). These methods are documented in the Chatham petrel chick translocation guidelines (Gummer 2011a).

7.3.2 Cook's and Pycroft's petrel chicks

Detailed protocols for selecting chicks at source colony burrows can be found in section 5 of the field guidelines (Gummer et al. 2014a). These include:

- Preparing equipment, notebooks and data forms.
- Extracting and handling chicks—chicks of these species may regurgitate oily parental meals when removed from burrows; therefore, handling protocols include methods for avoiding or managing the soiling of plumage, which can be fatal. For essential information on regurgitation, refer to section 11.6.1—'Regurgitation'.
- Banding, processing and assessing chicks—first measurements for chick selection.
- Marking burrows—depending on suitability for transfer.
- Confirming chick suitability for transfer—second measurements.
- Checking fences at burrow entrances leading up to transfer day—if time permits.
- Transcribing data daily—to determine how many new chicks (if any) need to be found.
- Searching for additional chicks.

Wing length guide for selecting Cook's petrel chicks

A wing length guide has been developed for use in the days leading up to a Cook's petrel transfer (Table 4)—although **this has yet to be trialled and confirmed.**

The wing length ranges provided in Table 4 were calculated as follows:

- Optimal (Priority 1): Subtracted 4 mm (the maximum predicted daily growth rate) from the upper end of the range and subtracted 2 mm (the minimum predicted daily growth rate) from the lower end of the range. (Note: The minimum growth rate of 2 mm/day may still need to be confirmed in future translocation operations.).
- Marginal—Advanced (Priority 2 & 3): Subtracted 2 mm from the upper end of the range and set the lower end to meet the upper end of the Priority 1 range.
- Marginal—Small: Subtracted 4 mm from the lower end of the range and set the upper end to meet the lower end of the Priority 1 range.

Wing length guide for selecting Pycroft's petrel chicks

A wing length guide has also been developed for use in the days leading up to a Pycroft's petrel transfer (Table 5).

Minimum and maximum wing growth rates rather than average wing growth rates (e.g. approximately 3 mm for Pycroft's petrel chicks) were used in the calculations because individuals grow at different rates and growth rates vary at different stages of development—wing growth rates slow down as chicks get closer to fledging, i.e. more advanced chicks may not be growing as quickly as younger chicks. Consequently, some suitable chicks would be unnecessarily eliminated from the transfer if only averages were used.

Table 4. Wing length guide for use in the days leading up to a Cook's petrel transfer.

Different flagging tape colours (to mark burrows) are allocated to each of the three wing length categories. Priority (for transfer) numbers relate to those presented in Table 3.

DAYS BEFORE TRANSFER	TARGET WING LENGTH RANGES (mm) FOR CHICKS		
	MARGINAL—SMALL*	OPTIMAL (Priority 1)†	MARGINAL—ADVANCED (Priority 2 & 3)‡
5	140–149 mm	150–190 mm	191–220 mm
4	144–151 mm	152–194 mm	195–222 mm
3	148–153 mm	154–198 mm	199–224 mm
2	152–155 mm	156–202 mm	203–226 mm
1	156–157 mm	158–206 mm	207–228 mm
Transfer day	Any chicks opportunistically found with wings measuring 160–220 mm§ **and** meeting the weight criterion set for that wing length.		

* May or may not meet minimum wing length (160 mm) by transfer day.

† Almost certainly will be 160–210 mm on transfer day.

‡ 211–230 mm on transfer day.

§ The upper limit is set to 220 mm because birds that are found opportunistically on transfer day will not have had their burrows monitored; hence, chicks may already have emerged if their wings are longer than this and their burrow entrance has not been watched.

Table 5. Wing length guide for use in the days leading up to a Pycroft's petrel transfer.

Different flagging tape colours (to mark burrows) are allocated to each of the three wing length categories. Priority (for transfer) numbers relate to those presented in Table 3.

DAYS BEFORE TRANSFER	TARGET WING LENGTH RANGES (mm) FOR CHICKS		
	MARGINAL—SMALL*	OPTIMAL (Priority 1)†	MARGINAL—ADVANCED (Priority 2 & 3)‡
5	135–144 mm	145–175 mm	176–195 mm
4	139–146 mm	147–179 mm	180–197 mm
3	143–148 mm	149–183 mm	184–199 mm
2	147–150 mm	151–187 mm	188–201 mm
1	151–152 mm	153–191 mm	192–203 mm
Transfer day	Any chicks opportunistically found with wings measuring 160–220 mm **and** meeting the weight criterion set for that wing length.		

* May or may not meet minimum wing length (155 mm) by transfer day.

† Almost certainly will be 155–195 mm on transfer day.

‡ 196–205 mm on transfer day.

The wing length ranges provided in Table 5 were calculated as follows:

- Optimal (Priority 1): Subtracted 4 mm (the maximum predicted daily growth rate) from the upper end of the range and subtracted 2 mm (the minimum predicted daily growth rate) from the lower end of the range. (Note: The minimum growth rate of 2 mm/day is only likely to occur in a poor chick provisioning season.)
- Marginal—Advanced (Priority 2 & 3): Subtracted 2 mm from the upper end of the range and set the lower end to meet the upper end of the Priority 1 range.
- Marginal—Small: Subtracted 4 mm from the lower end of the range and set the upper end to meet the lower end of the Priority 1 range.

7.4 Preparations on the day before transfer

Details of the tasks that need to be undertaken on the day before transfer can be found in section 6.1 of the field guidelines (Gummer et al. 2014a). These include:

- Compiling a master list of the chicks available for transfer (suitable and marginal) and assigning one person as coordinator
- Dividing the selected chicks amongst the collectors
- Erecting stick fences at all burrows containing chicks that are advanced (i.e. all those predicted to be in Priority 2 or 3 wing length groupings on transfer day) to see whether they emerge from their burrows
- If time permits, erecting stick fences at all other burrows containing suitable chicks, to assist with meal planning at the release site
- Preparing transfer boxes (refer to section 7.5—'Transfer boxes')

7.5 Transfer boxes

7.5.1 Transfer box design

The transfer box design that is used for the small gadfly petrels is based on the standard pet carry box. Two chicks can be comfortably held in one box (containing a single diagonal divider) for < 1 day whilst in transit, as there is enough space to avoid issues with overheating and the wing or tail feathers becoming damaged.

Three Cook's or Pycroft's petrel chicks can be held in one box in certain circumstances (using the larger Corflute™ boxes; see below), e.g. to enable 100 chicks to be transferred in one Squirrel helicopter. However, care must be taken to ensure that the dividers are appropriately placed such that each of the compartments has a long outside wall and receives an equal amount of ventilation, and that one chick is not sandwiched between two others in a potentially less-ventilated and warmer compartment. Cook's petrels have been held for almost 12 hours in this way, but regular inspections of birds are critical to ensure that there are no overheating issues.

Note: Chicks that need to be held for longer than 1 day due to exceptional or emergency circumstances must be held individually, i.e. one chick per box (refer to section 7.7.2—'Time of day').

Two types of pet carry boxes have been used to transfer small gadfly petrels to date: Corflute™ (fluteboard) pet carry boxes (425 × 240 × 310 mm high) and cardboard pet carry boxes (380 × 200 × 265 mm high). It should be noted that:

- When using fluteboard pet carry boxes:
  - White boxes reflect heat more than cardboard boxes. However, white boxes must contain a black lining (e.g. black cardboard) and black divider (if necessary) to darken the inside, which will help to reduce chick stress levels.
  - Black or dark-coloured boxes **must** be covered with some sort of reflective white material. Cook's and Pycroft's petrels are transferred in March when conditions are hot and sunlight can still penetrate the coastal forest at the source colonies.
  - Boxes are splash-proof, so no bin bags are required during the collection of birds in the rain—although bin bags may be required if there is any boating involved.
  - Boxes can be washed, disinfected and dried so that they can be reused the following year. If properly looked after, boxes would probably last several years of transfers; however, some projects prefer not to have to spend time maintaining boxes after a transfer.

    Note: Spiders and other insects have been known to crawl into the open ends of stored fluteboard boxes, so it is important to be aware that recycled boxes might not pass

quarantine regulations for most islands. Corflute™ boxes would need to be thoroughly disinfected and dried, and stored in insect-free containers to be guaranteed to meet quarantine requirements if planning to take them back to the source colony.

  - Boxes are an option for back-up accommodation in severe flooding conditions at the release site.
  - Boxes of standard template (with fixed-size 20 mm diameter ventilation holes set in the upper walls) are suitable for small gadfly petrels.
  - The supplier details can be found in section 2.1 of the field guidelines (Gummer et al. 2014a).
- When using cardboard pet carry boxes, they:
  - Must be disposed of after use and new ones bought for each transfer.
  - Remain fairly dark inside and will reflect heat if white on the outside.
  - Quickly become soggy in wet weather—therefore, a supply of large drawstring bin bags needs to be carried at the source colony to place boxes in if it starts to rain.
  - Often become too battered or wet to use as back-up accommodation.
  - Are slightly smaller than the fluteboard boxes, so two large, bulky chicks may be a little more restricted. (They can hold a maximum of two chicks per box.)

7.5.2 Preparing transfer boxes

Transfer boxes should be prepared on the day before transfer as follows:

- Line the transfer boxes with folded newspaper to give improved grip and to absorb excrement. Anti-slip matting can also be taped carefully to the bottom of the box over several layers of newspaper (to absorb excrement), to give even better grip. Note, however, that the tape (e.g. duct tape) must be strong enough that it does not peel off and stick to the birds, and can be taken underneath the floor of the box as the boxes are being constructed for use. **Avoid using shredded paper** as it may cause chicks to overheat.
- Ensure that the diagonal dividers (if used) sit flush on the floor of the boxes and that there are no gaps for feet or legs to slip under. There needs to be a small gap at the top so that the box can be closed securely without damaging the locking mechanism, but try to make this as small as possible. Note: Gadfly petrel chicks do not tend to jump up in boxes, but long wing feathers could become caught up in any gaps.
- Stick strips of packing tape above each compartment on top of the lids on which the source colony burrow numbers and fence status can be written—it is easier to read details on the lid rather than on the side of the box if it becomes necessary to relocate a chick. If using Corflute™ boxes, the tape can be replaced the following year.

Some project managers recommend that some of the nesting material from the natal burrow is also removed to provide a familiar scent in the artificial burrow at the release site, which will help the chick to 'settle in' and fix to its new burrow. This is not considered essential because chicks quickly scent up their new burrow at the release site during the acclimatisation period when they are blocked in, with down being rapidly deposited in the burrow soon after transfer. However, it can be a useful tool to improve the chances of a more advanced chick returning to the same burrow after night-time excursions. If you do choose to transfer nesting material from the natal burrow to the release burrow, note that:

- There is a potential biosecurity issue with transferring nesting material (which may contain invertebrates, seeds, pathogens, etc.) between locations, especially if the release site has high ecological value.
- Sticks and twigs must not be placed in transfer boxes with the chicks because there is real potential that they may cause injury to the chicks in transit.

- It is time-consuming for personnel to collect material on transfer day, especially if it needs to be placed in a clearly labelled zip-lock bag, and to then distribute it in the correct burrow (with the right chick) at the release site.
- It is important not to remove too much material from the nest, so that scent is still retained for the breeding pair, reducing the risk that they will perceive breeding failure.

7.6 Collecting chicks

Detailed protocols for collecting chicks on transfer day can be found in section 6.2 of the field guidelines (Gummer et al. 2014a). These include:

- Weighing and measuring each chick on transfer day to double-check its suitability for transfer
- Inspecting the burrow entrance for signs of chick emergence
- Checking to ensure that adults are not accidentally transferred
- Checking each chick for any abnormalities or obvious signs of poor health
- Recording fence status on the morning of transfer **if** fences were erected on the day before transfer day (for meal planning at the release site)
- Leaving all burrow markers in place at the source colony (essential, in case a chick needs to be returned to its burrow for any reason)

Important note: If a chick is to be moved but is known to have been fed in the previous 1–2 nights, **extreme care** must be taken during the handling process. The chick's head must be kept clear at all times to allow projection of any regurgitant (refer to section 11.6.1—'Regurgitation'). If a chick badly soils itself with regurgitant, consider not transferring the chick, instead returning it to the natal burrow following a cleaning attempt (refer to section 3.4 and 3.7 of the field guidelines (Gummer et al. 2014a)), as such chicks are unlikely to do as well at the release site because:

- They have a low chance of survival if waterproofing has been compromised
- They may have fallen below the minimum weight criterion for transfer after regurgitating

7.7 Transport requirements

Seabird chicks are particularly vulnerable to overheating when removed from their below-ground burrows. Gadfly petrel chicks have thick subcutaneous fat layers that make them more vulnerable to overheating than some other species, especially in warm conditions, in confined spaces with limited ventilation and if exposed to the hot sun.

Note: Past experience with fluttering shearwaters (*Puffinus gavia*) showed that heavier chicks that had recently been fed by their parents were at a higher risk of suffering from heat stress during transit than lighter chicks (Gummer & Cotter 2012).

7.7.1 Mode of transport

Small gadfly petrel chicks have been successfully transported by air, sea and road:

- Helicopter or plane is the preferred mode of transport for long-distance transfers during the summer months, as this minimises the risk of chicks overheating and reduces the movement of boxes. Boxes may be temporarily packed together in the craft, but should be of sufficient height to allow for enough ventilation during a relatively short flight. Helicopters and planes have been used to move Cook's petrels from Hauturu/Little Barrier Island to Cape Sanctuary (25- and 90-minute flights, respectively), and a helicopter was used to move Pycroft's petrels from Red Mercury Island (Whakau) to Motuora Island (30-minute flight).

- Boat is currently the only transport option for Chatham petrel chick transfers. Chicks are able to tolerate fairly choppy sea conditions for up to two hours on a fishing vessel (in autumn). Boxes are usually placed loosely in individual plastic bin bags (with the tops left untied for ventilation) to protect them from salt spray and are spaced out on the deck. Pycroft's petrels have tolerated boat trips of up to three hours between islands (in summer) with difficult landings at either end (boulder beach to dinghy to launch; and launch to dinghy to wharf). However, boat trips longer than three hours may be problematic, as chicks will be more vulnerable to overheating if they are kept in a confined space for too long (e.g. below deck) and there may not be enough time to process chicks at the release site before dark. Transfer boxes should only be placed outside on deck if the conditions are not hot and sunny. Transfer boxes stored below deck must be spaced out in a ventilated area.
- Road travel has been used to move birds from air or sea drop-off points to new colony sites. Chatham petrel chicks have tolerated two or more hours in road vehicles (truck/trailer/ATV), but every effort must be made to ensure that the boxes are well secured (tied down) and well spaced (lay down planks of wood between rows of boxes to improve airflow and reduce the risk of overheating). Cook's petrels have been transported by road for 1 hour; however, only vehicles with air conditioning have been used and reflectors were taped to the windows to keep the temperatures down.

7.7.2 Time of day

Ideally, chicks should be collected and transported during the cooler part of the day. Boxes must never be left in exposed sunlight during the hottest part of the day.

It is important to note that chicks do not necessarily need to be installed in artificial burrows on immediate arrival to the colony, especially if this is during the hotter part of the day. In fact, these species are more tolerant of being in transfer boxes for prolonged periods than some other species, providing that they have adequate space. It is good practice to inspect all chicks (visually in the box) immediately after the transfer to ensure that none have been injured in transit. It may then be best to store the boxes somewhere dark and cool (e.g. in a shed or under dense canopy) for several hours, so that the chicks can be processed (bands checked, rehydrated and placed in artificial burrows) later in the day when it is cooler, allowing up to three hours to complete this in daylight. It is not good practice to process chicks in the dark by torchlight at the end of a transfer day.

Note: While it is not considered best practice to plan to hold chicks for longer than 1 day in transport boxes, they can be held overnight in boxes if there is an unexpected delay in transit or another emergency **provided that** they are housed in individual boxes (to provide extra space for them to keep cool and to reduce the amount of disturbance for each chick). For this reason, it can be beneficial for some projects (location dependent) to carry additional cardboard boxes along with the transferred birds that can be used as emergency temporary accommodation if required.

7.8 Installing chicks in artificial burrows at the release site

Before chicks are installed in burrows, they need to be checked over and rehydrated (when necessary). This involves:

- Checking each chick methodically for any physical injury afflicted during transport; for example:
  - Wings and legs are held correctly and have normal strength and movement
  - Eyes are clear and bright (not closed or weepy)
- Delivering oral fluids (e.g. Lactated Ringer's™ solution, Hartmann's™ solution or Vy'trate™) to each chick before it is placed in its allocated burrow (up to 15 mL for Cook's petrels; up to 10 mL for Pycroft's petrels). Although some chicks will reject these fluids and there is a high risk of triggering regurgitation in recently fed birds, oral fluids are considered to be

important for counteracting dehydration in species being transferred in very hot weather, i.e. Cook's and Pycroft's petrels—especially for those chicks that had not been fed by their parents for several nights prior to transfer. For essential information on regurgitation, refer to section 11.6.1—'Regurgitation'.

Note:

- Oral fluids are no longer deemed essential for Chatham petrels, which are transferred in a cooler climate at a cooler time of year, and nor are they delivered to very heavy Pycroft's petrel chicks if they are known to have been fed by parents the night before transfer because of the high risk of inducing a regurgitation response. However, it is generally considered that the transfer of chicks in warm conditions, combined with the associated stress symptoms (e.g. increased heart rate), will lead to increased water loss. Therefore, attempts should be made to hydrate at least the lighter chicks of the more northern New Zealand species, as the occasional chick has proven to be quite thirsty (20 mL readily accepted).
- To reduce handling on transfer day, weights and wing lengths can be recorded for all chicks on the day after transfer.

- Placing each chick directly into its allocated burrow chamber, and checking that the internal blockade is safely in place and that the blockade at the entrance is present, safely positioned and secure. (Refer to section 8.4.3—'Preparing artificial burrows' for more information on internal and external burrow entrance blockades.)

8. Release site

8.1 Suitability of release site

For a site to be considered suitable for small gadfly petrels, it must meet the following criteria:

- Be situated within an appropriate geographical location / ecological zone. Favoured safe release sites for Chatham, Cook's and Pycroft's petrels are listed in the 'Action plan for seabird conservation in New Zealand' (Taylor 2000), based on the historical range of each species. In summary, each species should only be considered for translocation to the following regions:
  - Chatham petrel—Within the Chatham Islands only
  - Cook's petrels from Hauturu/Little Barrier Island—The North Island and upper South Island
  - Cook's petrels from Whenua Hou (Codfish Island)—The lower South Island and Stewart Island/Rakiura
  - Pycroft's petrel—Northern New Zealand only

  Note: The location of release sites in relation to feeding grounds is not important for these species because they are pelagic feeders that travel rapidly over very long distances to forage (Rayner et al. 2008b, 2011, 2012). However, if birds need to travel an extra distance (e.g. 100 km) to reach the colony, this may affect their breeding fitness—an aspect that may need to be investigated in future projects.
- Be free of predators and competitors.
- Feature appropriate habitat, including:
  - Easy take-off and landing points—relates to distance above sea level
  - Suitable ground for burrowing
  - Shade for artificial burrows that are in hot, sunny locations

- Preferably be accessible to passing 'immigrants' as well as to returning transferred birds.

  Note: Until recently, close proximity to the sea has been considered paramount for optimising project success, especially if aiming to attract passing birds. However, for Cook's petrels, inland sites that are a considerable distance from the species' current range are now being considered because there is evidence that this species occurred historically at such sites.
- Be sufficiently far away from bright lights (e.g. towns and cities)—these species are strongly attracted to light and can become grounded near such light sources.

8.1.1 Predators

In the past, predator-free offshore islands have been the preferred release sites for these species. However, mainland island sites are now considered suitable providing that fenced areas are proven to be 100% free of all mammalian predators, as well as free of some specified avian predator species (e.g. weka (*Gallirallus australis*)) and all farm stock, feral pigs (*Sus scrofa*), etc.

Fences must be of an appropriate size and carefully sited so that chicks have plenty of space to engage in practice take-off flight activities, with minimal risk of landing on the other side of the fence before they are actually ready to fledge, i.e. they must be able to return to the burrow site after a night of practice take-offs. There must also be a long-term commitment to maintaining the predator-proof fences.

Small gadfly petrels are not large enough to withstand any kind of mammalian predator attack, making colonies extremely vulnerable to predator invasion.

8.1.2 Competition

The potential short-term and long-term impacts of competition with other seabird species need to be carefully considered for all release sites. Other seabird species may:

- Already exist naturally at the release site, or have been introduced there through previous translocations
- Not currently be resident but feature on an acoustic attraction system, i.e. may arrive at any time
- Be planned for future introduction to the site via translocation

Restoration projects must consider what the original mix of seabirds would have been at the site, as well as what mix is now appropriate for the site. Therefore, specialist advice (refer to section 11.4—'Specialist advice') must be sought to determine:

- The normal interactions and compatibility between species, or predicted interactions if not known
- Recommendations for the order in which different species should be introduced and their priority
- Recommendations for the relative proximity of burrow sites for different species

The short-term negative impacts of placing colonies of different species close to each other include:

- Transferred chicks that are housed at an artificial burrow site may wander into adjacent burrows of other species during the emergence period, which could result in:
  - An extremely labour-intensive search effort being required to find chicks that still require feeding
  - Chicks never being found if the other burrows are natural
  - Injury to the chicks caused by resident chicks or adults defending their burrows, if chicks enter burrows containing larger species that are breeding

- Monitoring efforts for adults in the years following translocation may be compromised. For example, monitoring methods for one species may disturb the normal activity of another species that is present at the colony—e.g. a nocturnal monitoring regime for one species that might be well into the breeding season could disturb another species that might still be prospecting and is therefore more sensitive to disturbance.

The long-term negative impacts of placing colonies of different species close to each other include:

- Larger species may dig their own burrows, which can undermine burrows of smaller species.
- Similar-sized species may compete for the same burrows, which can result in breeding failure for one or both species if their breeding seasons overlap.

8.1.3 Take-off/landing points

Chatham, Cook's and Pycroft's petrels require at least one of the following key features at a colony site to enable them to take off to sea:

- Mature trees—All three species are agile tree climbers, and even chicks are able to climb near-vertical trees during the emergence period and for fledging. If mature trees are present that the birds can climb to take off into the wind, burrow sites can be relatively close to sea level. Note: Birds are capable of wandering 50 m or more to reach a suitable tree (sloping, emerging from the canopy and rough bark).
- Elevation—At some colony sites, birds will take off from high vantage points (clear areas on cliff tops or ridges at island summits) or rocky outcrops, even if mature trees are present. This is because the sites are already elevated, so climbing a tree is not always necessary to depart from the colony site.

Sites that have both mature trees and elevation are thought to be superior, as these areas tend to be more densely populated at the source colonies. Indeed, Rayner et al. (2007b) suggested that mature forest and close proximity to ridge tops are key habitat requirements for Cook's petrels—although it should be noted that the location of burrows under mature forest on Hauturu/Little Barrier Island was likely to be a function of predation history by feral cats (*Felis catus*). Established vegetation canopy is also considered to offer protection from aerial predators and the sun (M. Rayner, pers. comm. 2012).

On landing at the colony, forest-nesting petrels tend to drop to the forest floor through a point in the canopy that is usually fairly near to their burrow. Birds are also known to land away from their burrows and then walk up to 100 m along the ground to reach them (Rayner et al. 2007b). Chatham, Cook's and Pycroft's petrel burrows are often located in areas of less dense forest, where the risk of collision with obstructing vegetation (which can lead to mortality) is reduced.

When selecting a release site, project managers should consider the following:

- When existing forest habitat is present at the location for release, it is safer for the birds (and easier for monitoring and management) if an artificial burrow site is located in an area where the understorey is sparse or only comprised of soft, broadleaf vegetation (e.g. kawakawa (*Macropiper excelsum*)) as opposed to scrubby, dense vegetation (e.g. red matipo (*Myrsine australis*), muehlenbeckia (*Muehlenbeckia* spp.), mānuka (*Leptospermum scoparium*)). Plant species that are suitable at release sites include ngaio (*Myoporum laetum*), karo (*Pittosporum crassifolium*), pōhutukawa (*Metrosideros excelsa*), māhoe (*Melicytus ramiflorus*) and *Astelia* spp., providing that regrowth is thinned out so that it does not become too dense and hedge-like, as birds can become entangled in this (refer to section 14.1—'Managing vegetation').
- In regenerating (immature) forest habitat in coastal cliff environments, the right type of vegetation for stabilisation needs to be planted; however, this should not conflict with the seabird habitat requirements. Again, trees that have a shrubby/dense growth form are not a

good option, as birds can become entangled, and rushes and flax (*Phormium* spp.) are also traps for birds, which may get stuck in the central part of the plants.

- Vegetation growth and density should be monitored annually and controlled as required (refer to section 14.1—'Managing vegetation'). Small, establishing colonies of seabirds would be unable to keep an area free of vegetation through their normal disturbance regimes on the surface.

8.1.4 Slope of ground and soil type

Where possible, the new colony sites should be located in terrain that replicates areas where most burrows are found at the source colonies:

- Chatham and Pycroft's petrel burrows are usually found on relatively flat areas of coastal forest floor or on gentle slopes at various altitudes above sea level (from a few metres to up to c. 150 m height a.s.l.). These areas tend to be where there is less erosion and the soil is more friable.
- Cook's petrels are found on steep slopes on Hauturu/Little Barrier Island (Rayner et al. 2007b). While much of the steep terrain has a high rate of erosion, resulting in shallow soils on slopes and rocky substrates, the petrels are concentrated at higher altitudes (mostly >300 m a.s.l.) near to the ridge, where the soil is thicker and more stable. By contrast, Cook's petrels on Whenua Hou (Codfish Island) nest in a broader range of habitats (Rayner et al. 2007b); therefore, slope may not be quite as significant as other habitat requirements for this species.

Sites need to be checked prior to burrow installation during the wet season and/or after heavy rain to monitor how boggy the ground becomes. Soil needs to be friable and deep enough for birds to burrow into, and not too wet.

8.2 Artificial burrows

Detailed lists of the equipment required at the release site can be found in section 2.2 of the field guidelines (Gummer et al. 2014a).

8.2.1 Function

Artificial burrows have the following functions, all of which need to be considered before they are installed at a site:

- Optimise attractiveness of the colony site to prospecting adults—Burrows tend to be installed in close proximity to the sound system speakers (usually in front of the two speakers, which are separated by c. 10–20 m). It is common for adults to prospect very close to the speakers, sometimes within a 1 m radius, so some burrows need to be placed as close to the speakers as possible (including in front of and behind a speaker).
- Provide safe places for adults to nest in that can be easily monitored—Burrows need to be maintained to optimise rates of occupation (refer to section 14.4—'Preparing burrows for returning adults').
- Provide safe and secure housing for translocated chicks—Burrow design does not need to compromise the attractiveness of burrows to adults if they are installed correctly and are made as light-proof as possible inside.
- Facilitate safe, easy and regular access for chick management, which also enables safe and easy access for monitoring breeding adults in future seasons.

8.2.2 Design

Two artificial burrow types have been used in small gadfly petrel colony establishment projects, the choice of which is primarily dependent on the terrain (degree of slope and soil type) at the release site:

- **Flat-ground burrow design**—Developed for relatively flat or only slightly sloping sites where the soil tends to be more friable (especially if under shaded forest). This burrow type consists of the following:
  - A square, four-sided nest box made of treated timber or moulded plastic, which is dug into the ground with a removable lid at ground level (Figs. 1–3). Wooden burrows of this type are more commonly used for Chatham and Pycroft's petrels at release sites, and tend to be preferred for the following reasons: they are generally drier inside, resulting in the plumage condition of fledglings usually being excellent; there is a lower risk of the burrows flooding (as burrows are not dug so deep into the ground); and there is easier access to the chamber (see Figs 1, 3, 7 and 8)). However, some moulded plastic burrows have also been used for Pycroft's petrels. (Fig. 2)
  - A chamber roof, which can be a double-lid system (wooden burrow only) in warmer climates to improve insulation (Fig. 7).
  - A PVC drainage-pipe tunnel that is sunk as close to horizontal as possible into a channel leading from one side of the box, preferably along a gentle slope (rather than sloping steeply downhill or uphill from the box).
- **Sloping-ground / cliff burrow design**—Primarily developed for steep-sloping sites, which tend to be more exposed to the wind and have less vegetation cover, i.e. are not as shaded (Figs. 4 & 5). The soil in these locations also tends to be much firmer. This burrow type has been employed for Cook's petrels on the steeper, more exposed slopes at Cape Sanctuary (see Figs. 6 & 9) and consists of the following:
  - A chamber with three sides made of treated timber and an earthen back wall, forming a rectangular box shape. The two long sides (treated timber) are set into the slope, while the back end is deeper below the surface. The earthen back wall allows further digging by prospecting adults, and the front end (treated timber) emerges from the surface and is fitted with an access lid.
  - A chamber roof, made of thick treated timber, which is divided into two parts: a fixed chamber end that is permanently buried in the slope where it is cooler and a hinged access lid.
  - A PVC drainage-pipe tunnel that is sunk horizontally into a channel along the steep slope leading from the front-side of the box. Birds have to enter a trench below ground level to enter the pipe, which effectively extends the tunnel, sheltering the entrance from wind and keeping the burrow darker.

Note: At most sites, only one of these burrow designs is chosen and installed because the burrow area is either predominantly flat or sloped. However, a combination of designs may be used at some sites, e.g. at a gently sloping site that may feature some areas of steeper slope with firmer soil.

It may be beneficial to make half of the burrows with left-handed entries and half with right-handed entries to:

- Avoid having all burrows that are installed on slopes facing the same way (with entrances all potentially facing into the prevailing wind)
- Provide a range of options for prospecting adults

8.2.3 Materials

Wooden burrows are often favoured for easy-to-access release sites for the reasons listed in Table 6. If plastic Philproof™ burrows are chosen, they are already manufactured to a mould (approximately 350 × 350 × 300 mm), details of which can be found at www.philproof.co.nz. However, note that in 2012, the once suitable black lids were no longer available and the red lids that are currently available are unsuitable as they are not light-proof (G. Taylor, pers. obs.); therefore, methods need to be found for modifying these red lids.

Figure 1. Flat-ground wooden burrow (double-lid version) used for Chatham petrels on Pitt Island (Rangiauria). *Photo: H. Gummer.*

Figure 2. Flat-ground plastic burrow—the entire box is buried underground, with the neck and lid emerging above ground level. *Photo: Philproof™ www.philproof.co.nz*

Figure 3. Flat-ground burrows (double-lid type) at the Chatham petrel artificial colony site, Pitt Island (Rangiauria). *Photo: H. Gummer.*

Figure 4. Sloping-ground wooden burrows at the fluttering shearwater artificial colony site, Mana Island. *Photo: D. Cornick.*

Figure 5. Sloping-ground burrows on Mana Island after installation. *Photo: D. Cornick.*

Figure 6. Sloping-ground burrow used for Cook's petrels at Cape Sanctuary. *Photo: Cape Sanctuary*.

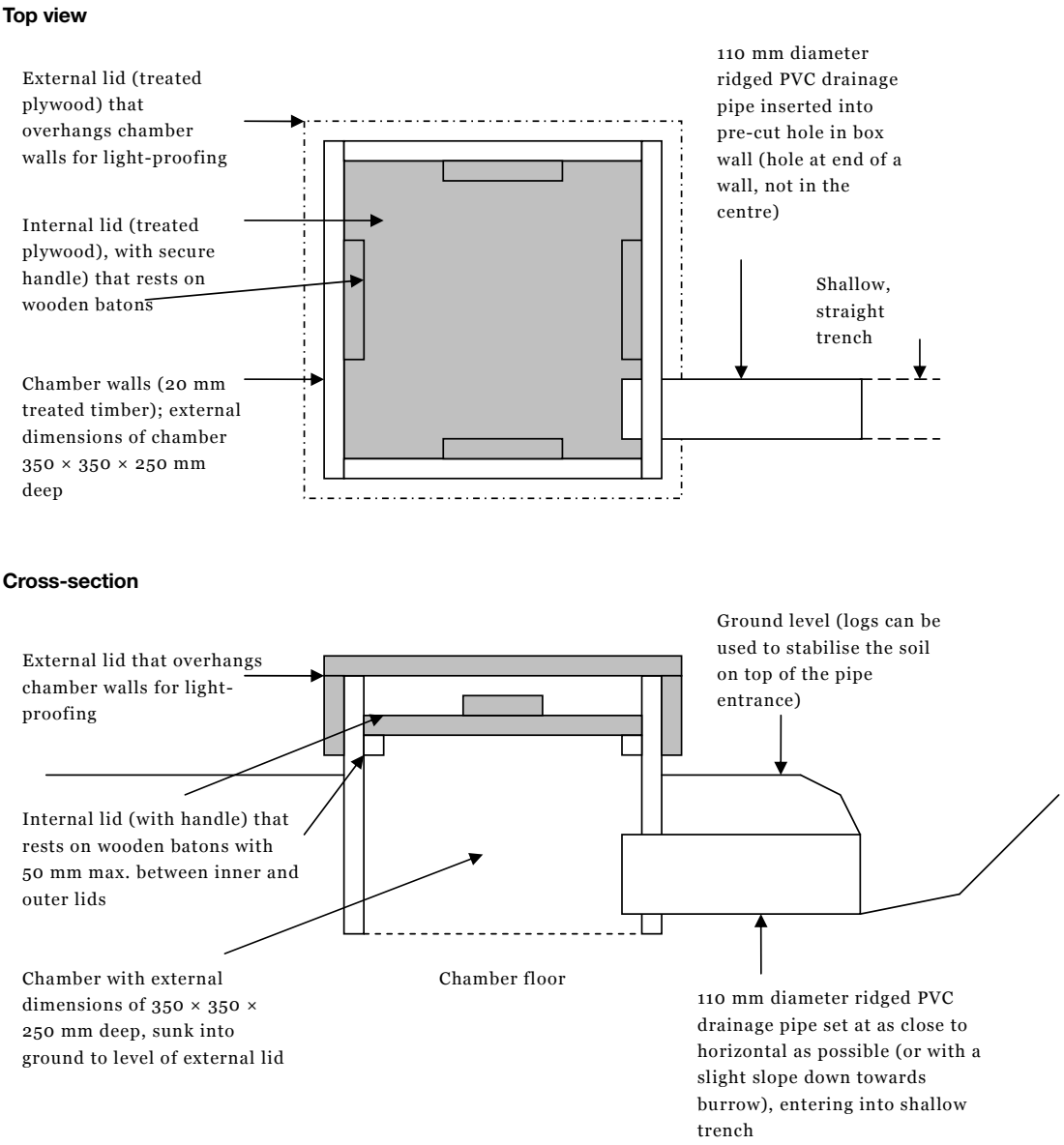


Figure 7. Diagram of the artificial flat-ground burrow design (wood) for Pycroft's petrels. (Diagrams by Helen Gummer.)
Note: Pipe dimensions are external diameters.

8.2.4 Dimensions

The following **minimum** dimensions are preferred for artificial burrows installed for Chatham, Cook's and Pycroft's petrels, to allow birds to sit comfortably within the chamber without their wing primaries and tail feathers bending up against the chamber wall:

- Square flat-ground burrow design—**External** dimensions 350 × 350 × 250 mm deep, constructed of 20 mm thick treated timber. The internal height of the chamber needs to be a minimum of 200 mm (see Figs 7 and 8).
- Rectangular sloping-ground / cliff burrow design—**Internal** dimensions 450 × 250 × 200 mm deep, constructed from 200 × 25 mm rough-sawn planks of treated timber. This rectangular design is longer and narrower than the square design. (Note: Boxes wider than 250 mm may be trialled for Cook's petrels to improve burrow ventilation; see Fig. 9).

Note: Both burrow designs require similar amounts of space inside the chamber.

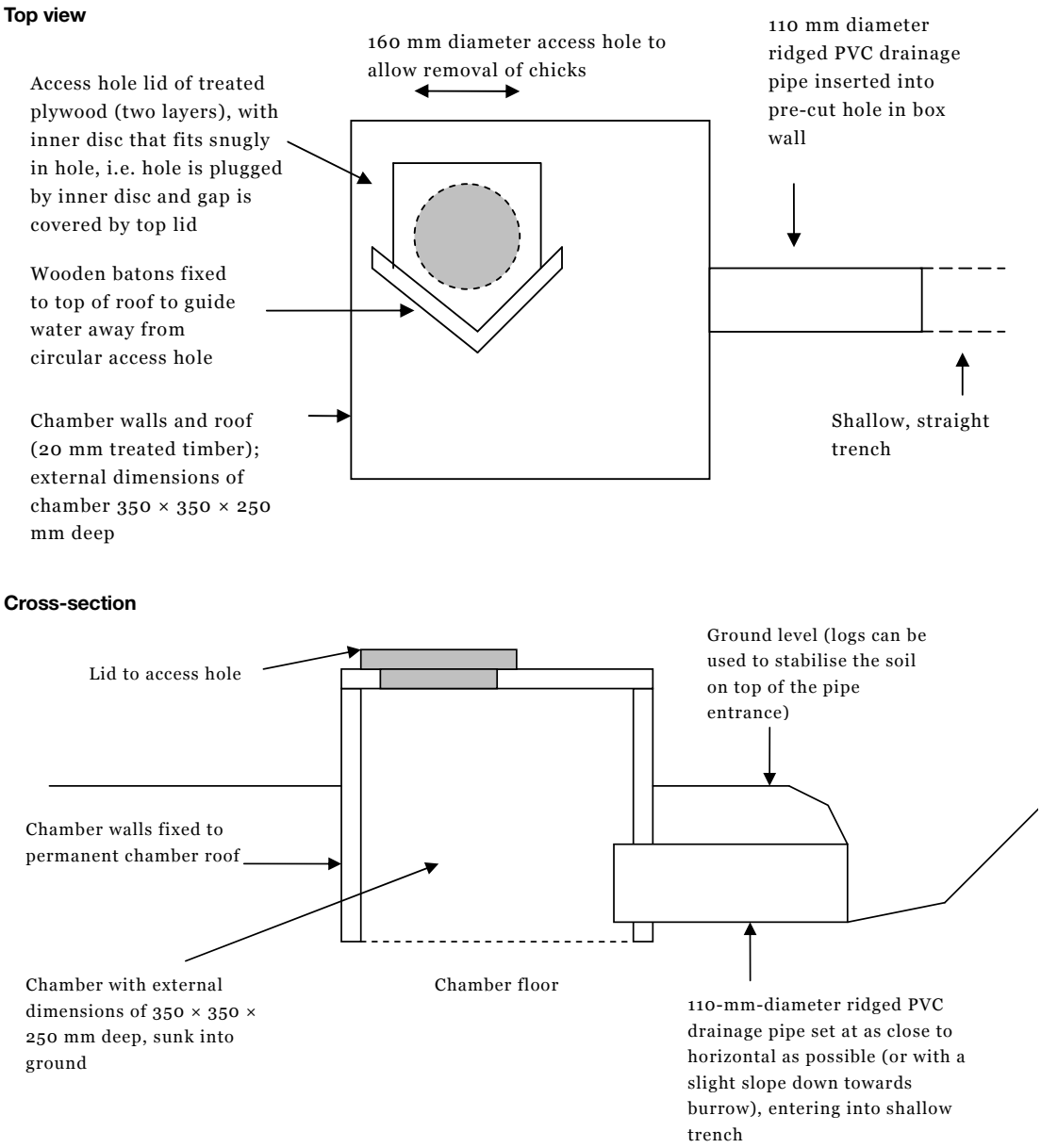


Figure 8. Diagram of the artificial flat-ground burrow design (wood) for Chatham petrels (designed by Roger Worsley (Taiko Trust) and Graeme Taylor). Diagram by Robin Gardner-Gee and Helen Gummer. Note: Pipe dimensions are external diameters.

Roofs need to be well fitting (light-proof) and thick (for insulation); and for inspection purposes, lids (whole or part of the chamber roof) need to open smoothly and easily (no noise or sudden movements). Lids should be designed as follows:

- Square flat-ground burrow design—Options used to date include:
  - Lids that form the entire chamber roof, i.e. square lids that extend over the box walls. Lids can be made of timber or thick plywood (> 20 mm); although they may warp slightly over time, burrows can still be kept light-proof if there is an internal lid (usually made of thinner plywood and set up to 50 mm below the top lid), or if the top lid features an overhang. Care must be taken to ensure that inner lids do not swing into the chamber, however. (See Figs. 1 & 7.)
  - Solid lids that are incorporated into the boxes during construction, following which a large round hole is made in the roof. The circle of wood that has been removed is then used to create an inspection lid or plug, and another larger piece of wood is layered (fixed) on top of the round plug to prevent it from falling into the chamber and to cover

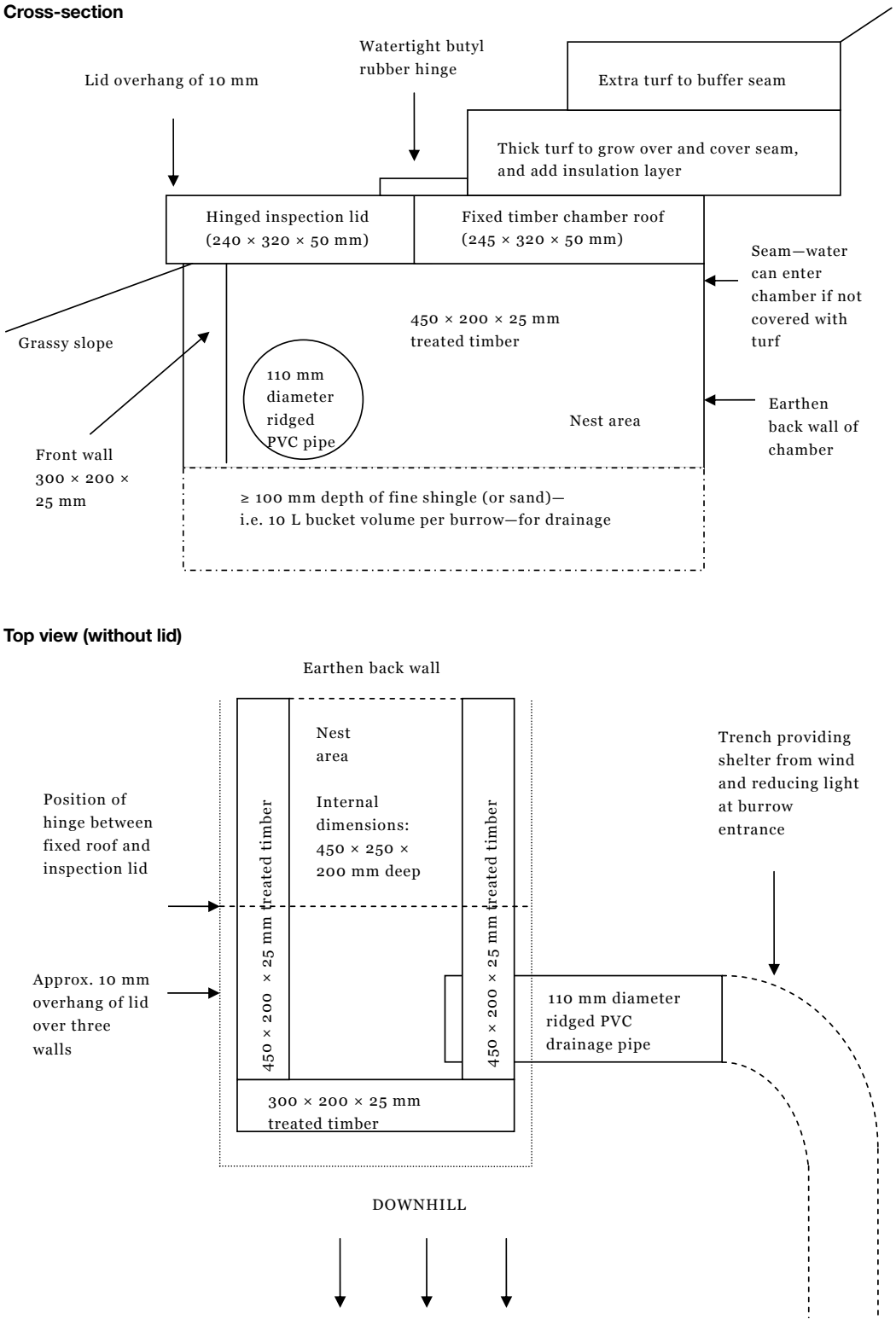


Figure 9. Diagram of the artificial sloping ground / cliff burrow design for Cook's petrels (adapted from Gummer & Adams 2010). Note: This burrow design is based on that used for fluttering shearwaters. However, the burrow is deeper (minimum 200 mm) for two reasons: Cook's petrels are more upright in the sitting position and so more headroom is required; and *Pterodroma* petrels are more sensitive to overheating (thick subcutaneous fat layers) and so benefit from additional air space within the burrow for improved ventilation.

The equipment required to make and install this design can be found in section 2.2 of the field guidelines (Gummer et al. 2014a). Pipe dimensions are external diameters.

Table 6. A comparison of wooden and plastic artificial burrows. (Note: ✓ = advantage; X = disadvantage.)

	WOODEN BOXES		PLASTIC BOXES
✓	Can be used both in open areas where there is no canopy cover and under forest canopy	X	Not suitable for use in areas that are not under forest canopy cover as boxes can overheat
✓	No need to sink very deeply, as shallow burrows remain dark inside and can maintain a stable temperature when installed under forest canopy	X	Need to bury deeply to ensure that they are light-proof (especially if white or light-coloured plastic) and do not overheat in direct sun (especially if black or dark-coloured plastic)
✓	Less vulnerable to flooding, as burrows can be installed just below ground level	X	More vulnerable to flooding, as burrows need to be sunk deeper into the ground
✓	Generally dry inside, as moisture is absorbed by the wood	X	Can be damp, as moisture collects on the internal walls and ceiling, which can result in plumage becoming more easily soiled
✓	Loose-fitting lids provide tiny gaps, which allow for air circulation	X	Ventilation holes can become blocked if the lid is not installed at the correct orientation
✓	Lids are easy to open for inspection of adults, eggs and chicks (although if not correctly fitted they can swing into the burrow and be a risk to an egg, or can swell and be more difficult to open)	X	Lids are not always smooth to open, which can result in more disturbance to the occupants and make it slightly more difficult to view the contents
✓	Lids are clean to open regardless of the weather	X	Lids collect water and mud, making them messy to open (water can spill onto occupants)
✓	Easily cut to assemble / fit over awkward roots if replacing an existing natural burrow	X	More difficult to fit to awkward existing natural burrows
✓	Hole for tunnel can be made at one end of one wall; this allows more space for birds to enter and exit burrows when there are two adults and one large chick during the rearing period	X	Manufacturer's mould has placed a hole for the tunnel in the centre of one wall; this makes it harder for adults to enter and exit when a large chick is blocking the centre of the burrow
X	Shallow-set boxes may not stay as cool; therefore, a double lid system is required for extra insulation layer	✓	May be cooler because they are sunk more deeply than wooden boxes
X	Perishable, especially if wood is not treated (treated wood can be used with these species and should last a minimum of 10 years)	✓	Durable and non-perishable; particularly economical to use at the source colony if such burrow preservation is required there
X	Less economical; materials are expensive, heavy to transport, require more labour to assemble and carry to site, and require more storage room	✓	More economical; light, cheaper to buy, ready-made, and easy to stack and transport

all gaps. This lid design is suited to cooler climates where a double lid is not considered necessary. If using this single-lid design in warm climates, the timber will need to be quite thick to insulate birds from the heat. (See Fig. 8).

- Rectangular sloping-ground / cliff burrow design—Lid is made of thick (50 mm) timber. The back half is fixed and buried into the slope, while the front half (the inspection lid) can be raised and has a watertight butyl rubber hinge. (See Figs. 4-6 & 9.)

Tunnels for these three species are made of 110 mm diameter ridged (for grip) PVC drainage pipe with the following features:

- Tunnel length of 300–400 mm, to reduce light levels inside the chambers. Avoid longer tunnels of this pipe size, because it would be difficult to retrieve chicks that sit in the middle of such a tunnel.
- Drainage holes in the tubing, to help reduce any build up of water or excreta in the pipes.
- Black-coloured pipe, to keep burrows darker inside during the day. There should not be any issues with heat absorption, because a properly installed tunnel will be completely buried under the ground.

8.2.5 Temperature

In non-insulated burrows, burrow temperatures tend to follow ambient (outside) temperatures fairly closely, often being only 1–2°C lower. Therefore, every effort must be made to ensure that chambers are insulated from the heat and remain cool and humid when ambient temperatures are high (e.g. >20°C).

It is essential that a stable temperature that is cooler (or in some cases warmer) than the ambient temperature is maintained within the burrow to prevent:

- Death of chicks through overheating (more likely) or chilling.
- Effects on chick metabolism rates, i.e. chicks spending more energy than usual trying to keep cool (more common) or warm. Transferred gadfly petrel chicks housed in artificial burrows and inspected daily tend to be more awake and active than parent-reared chicks in natal burrows; the latter can enter an almost torpor-like state during long intervals in between parental visits.
- Premature disappearance of chicks, i.e. they find more comfortable places to 'hole-up' during the emergence period.
- Chicks sitting in tunnels.

When installing artificial burrows, it pays to consider the long-term management commitment to those burrows. While sandbags are useful for placing on top of artificial burrows to provide extra insulation for transferred chicks (particularly in northern New Zealand) and reduce temperature fluctuations between night and day, ideally they should not need to be provided for burrows containing adults in subsequent years, thus avoiding a long-term management commitment. Successful breeding attempts should not be dependent on human intervention, such as the provision of sandbags.

Note: Sandbags (hessian or plastic sacks filled with beach sand) are only effective if large and well-filled, or if there are multiple bags. However, this can make them very heavy and unsafe (especially if the sand gets very wet), and time-consuming to lift on and off burrows on a regular basis. In addition, they eventually perish and need to be replaced.

The following points should be considered with respect to burrow temperature in the two different burrow designs:

- Burrows that are located in forest tend to have more stable temperatures because they are shaded by the canopy. Flat-ground burrows ideally need to be able to maintain stable, appropriate temperatures without the use of sandbags if they are to accommodate breeding adults in the future, because adults are unable to modify the four-sided wooden nest box chambers (i.e. extend the burrow underground).
- Burrows on cliff slopes in areas of regenerating vegetation will be more vulnerable to overheating. Sloping-ground / cliff burrows have the advantage that adults can dig further underground in future years if a cooler chamber is required, negating the need for sandbags after the chick translocation years.

8.2.6 Drainage

Good burrow drainage is essential to avoid:

- Death of chicks through chilling or even drowning. Chicks that have never emerged from the burrow before will not leave the burrow when it fills with water—instead, they will stay in the chamber and become wet through. This has proven to be fatal if it occurs during the night, as chicks can chill and die before the inspection the following morning.
- Poor plumage condition in developing chicks.
- Loss of eggs/chicks in flooded burrows during future breeding attempts by returning adults.

Artificial burrow drainage can be improved by:

- Adding a thick layer (100–200 mm deep) of fine beach gravel or sand under the chamber floor and pipe during construction. When there is torrential rain, burrows will inevitably fill up with water, but a layer of free-draining material will 'buy time' for the occupant chick, i.e. the water should start to drain away before the rising level reaches the nest bowl.
- Using a spirit level when installing sloping-ground / cliff burrows, to ensure that they tilt fractionally forwards, so that water runs off the lids and down the slope rather than back towards the chamber rear wall seam.
- Installing entrance pipes horizontally or sloping only fractionally, so that rain is not captured by the pipe and channelled down into the chamber. Note that:
  - Flat-ground burrows under forest canopy can have tunnels that slope down into the burrow, as the canopy shields the tunnel from the direct impact of heavy rain and the soil tends to be more free-draining (be wary of this at sites with clay soils though).
  - Sloping ground / cliff burrows need to have tunnels that slope very slightly down away from the chamber, as these pipes can be more susceptible to the direct entry of rain.

Note: Some soil types are exceptionally free-draining, in which case measures may not need to be as thorough.

8.3 Installation of artificial burrows at the release site

Consider installing up to five more burrows than are required for the number of chicks being transferred, to ensure that:

- Any adults returning to the site during chick transfer years can be accommodated
- There are some spare burrows, which can provide alternative housing for some chicks if their first designated burrow has issues (e.g. poor drainage, invertebrate infestation)

8.3.1 Time of year

It is recommended that burrows are installed in winter, when the soil is easier to dig. This also allows the burrow site to settle for several months before it is used to house any transferred chicks, so that:

- Soil and roots can mesh over the burrows to improve waterproofing
- Burrows can be tested for flooding issues and temperature stability (using thermometers if necessary)

8.3.2 Position

The position of burrows in relation to a predator-proof fence and prevailing winds must be carefully considered. Burrows should be at least 50 m from a fence, as should the predicted main take-off points (e.g. suitable take-off trees)—any closer than this and chicks could flip over the fence during practice take-off and land outside the fence before they are ready to fledge, which will leave them stranded on the wrong side of the fence (refer to section 10.5—'Missing chicks').

For these small gadfly petrel species, the entrances of burrows should be at least 0.5 m apart, and preferably ≥ 1 m apart, to ensure that:

- It is easy to see which entrance relates to which chamber (for burrow entrance fence records)
- People are able to access each chamber with ease, without causing noise or physical disturbance to an adjacent burrow
- Emerging chicks returning to their burrows at night do not enter the wrong pipe, and there is less interference (by neighbours) as burrows become occupied by adults

In general, burrows should be positioned with the following in mind:

- To maximise the occupation of artificial burrows by adults, it is considered beneficial to position burrows with a variety of aspects, so that not all burrows are facing the same direction
- Avoid having entrances facing uphill, as they will be more prone to being blocked with debris and to water running into the chamber
- Avoid having tunnels facing directly out into the full late morning/midday/afternoon sun, as they will be more prone to overheating
- Avoid north-facing slopes in areas of dark sandy soil, as these are particularly prone to absorbing the sun's heat
- Avoid having entrances facing directly into open areas with exposure to strong winds/rain, as they will be more prone to chilling and/or flooding
- Avoid installing burrows in places where they could be damaged or uprooted by unstable trees

Fallen logs and branches can be added around entrances (as long as they are stable), to stimulate the natural tendency to dig under these more stable sites if birds prefer to find a natural site when they return as adults.

8.3.3 Installation method

Detailed lists of the equipment required to install burrows at the release site can be found in section 2.2 of the field guidelines (Gummer et al. 2014a).

Detailed instructions on how to install artificial burrows at the release site can be found in section 4 of the field guidelines (Gummer et al. 2014a).

8.4 Pre-transfer preparations at the release site

Detailed lists of the equipment required at the release site can be found in section 2.2 of the field guidelines (Gummer et al. 2014a).

8.4.1 Food preparation area

To ensure the smooth and hygienic operation of the food preparation area, the following pre-transfer preparations should be made:

- Check that all required feeding equipment is present and that blenders are working
- Thoroughly disinfect the food preparation and washing-up area
- Wash, sterilise and rinse all feeding equipment

8.4.2 Feeding station

A sheltered area must be provided as close to the burrow site as possible, where feeding equipment can be set up for each feeding day, and where chicks can be fed out of direct sunlight and protected from wind and rain. Ideally, this would be a three-sided shelter or a shed, but flysheets can also be used.

In addition, facilities for effective, regular hand-washing will need to be set up, as well as storage for all relevant feeding and cleaning equipment that must stay at the colony site because it is difficult to transport there on a daily basis (refer to section 7.2 of the field guidelines (Gummer et al. 2014a)).

8.4.3 Preparing artificial burrows

In the days leading up to a transfer, the burrows should be prepared as follows:

- Clean out the tunnels and chambers of all burrows (pipes tend to fill with debris during the year), even if they are not going to be occupied by chicks. Look out for any sign that a burrow has been occupied by a prospecting seabird, e.g. digging at the entrance or in the chamber, or new leaf litter in the chamber. Leave suspected 'active' burrows as found and mark them so that they are not used to accommodate transferred chicks.
- Line all artificial burrows with a thick layer of dry nest material (leaf litter for these species). Avoid collecting litter that looks mouldy, as this may contain concentrations of naturally occurring fungal spores that can cause chick health issues (e.g. aspergillosis).
- Place **external blockades** (e.g. rocks, small logs or pieces of wood) at the entrances of all burrows planned to accommodate chicks. Blockades must not prevent ventilation—there should be a small gap for air flow that is sufficiently small to pose no risk of a bird's head getting stuck. (Refer to section 10.2—'Burrow acclimatisation period', for further information on why blockades are needed.)
- Place **internal blockades** (safe and not restricting ventilation, as above) at the chamber end of **all** pipes that have their entrances blockaded, ensuring that these do not take up space in the chamber itself, i.e. restrict chick movement in the box.
- Remove any plant threats such as thistles, brambles, vines or thorny vegetation that have invaded the burrow site (which chicks could get caught up in or injured on).
- Clear the burrow route and area around each burrow, so that chicks can be retrieved from and returned to their burrows safely and easily.

8.4.4 Internal and external blockades

Internal blockading is a recommended practice for all species of this size where the chicks cannot turn inside the 110 mm diameter pipe and may have difficultly reversing back up an externally blockaded (i.e. dead-end) pipe. This scenario can lead to death through stress or physical trauma:

- Chicks that are unable to reverse back up the pipe into the chamber may spend the night in blocked pipes, which can make them vulnerable to stress and potential chilling or overheating. Chicks can also suffer physical trauma if they are struggling inside pipes (e.g. raw wing injuries found on fluttering shearwaters).
- Chicks that can reverse back up a pipe may damage their wing feathers in the process, or even dislocate or break a wing.
- Heavyweight chicks can be pressed against the blockade in downward-sloping pipes and suffer injury or death.

Note: Several translocated fluttering shearwater chicks died in these scenarios before internal blockading was established.

External blockades also need to be put in place at all burrows with internal blockades to prevent chicks that emerge from other burrows from entering dead-end pipes. External blockades also clearly indicate which burrows are internally blockaded.

8.4.5 Blockade materials

Since gadfly petrels have a pre-fledging emergence period during which they are able to site-fix to the colony site, mesh blockades are not considered as important as for species that fledge on their first excursion to the surface (i.e. where looking out at surroundings from the burrow entrance may be important).

Two types of blockades can be used for both internal and external blockades:

- Mesh gates—Although these allow better ventilation, mesh gates do carry some risk if incorrectly designed. The correct mesh size must be used to prevent bills or heads from

becoming stuck, and chicks should not be able to push over a mesh gate else they will become stuck between the gate and pipe. Mesh should either be so fine that a chick's bill cannot be pushed through it at all; or c. 20 mm (too small for a head to be pushed through, but too large for a bill to get jammed).

- Solid gates (e.g. rocks or sections of heavy wood)—Birds are less likely to push these, but care must be taken to ensure that there are gaps for ventilation and that these gaps do not present a hazard. At Cape Sanctuary, short wooden blocks have been used successfully without restricting airflow—these have been cut to fit the tunnel, but with the sides cut down so that they appear hexagonal end-on.

9. Hand-feeding chicks

Detailed lists of the hand-feeding equipment required at the release site can be found in section 2.2 of the field guidelines (Gummer et al. 2014a).

Hand-feeding of seabird chicks is a specialist area because:

- The amount of food and feeding frequency need to be adjusted for each individual chick to meet its needs—small gadfly petrel chicks are not fed on a daily basis.
- An understanding of the growth patterns and trends in weight gain and loss through the rearing period is essential, so that the feeding regime can be adapted to suit the species and each individual.
- The methods used need to ensure that the dense layers of cavity fat that are stored by migratory gadfly petrels prior to departure are retained—otherwise survival will be compromised.
- Feeding regimes cannot replicate natural conditions because:
  - The artificial diet composition is different from the natural diet. In particular, it lacks petrel-produced stomach oil, which is energy dense and a source of hydration.
  - Each meal is artificially delivered (force-fed) at a much faster rate than it would be naturally delivered by parents.
  - Potential peak weights that chicks in the wild normally reach at approximately 3–4 weeks[2] before fledging may not actually be reached if chicks are transferred before this time (in which case, rates of weight loss in lighter chicks will need to be slowed so that they still fledge in optimum condition).
- A meticulous hygiene regime is of paramount importance, especially when feeding large numbers of chicks on any one day.

9.1 Objectives of hand-feeding chicks

Chicks need to be hand-fed at the release site so that they can:

- Complete growth and plumage development
- Be sustained through an appropriate emergence period at the release site
- Fledge with appropriate reserves that will see them through their first days at sea while they learn to forage for themselves

The key to achieving good chick fledging rates and post-fledging survival is to understand the optimum fledging condition for the species. The aim is for the majority of birds to fledge:

2 Pycroft's petrel chicks peak in weight at around 26 days before fledging (Ganglof & Wilson 2004).

- At, or preferably above, the average known fledging weight for the species. Seabird research has shown that, in general, it is the heaviest chicks that fledge from a colony that will survive to return as adults.
- With wings that are very close to completing growth, or have already stopped growing. This is a good indication that the rest of the body plumage is also fully developed, with optimum physical protective qualities (waterproofing and insulation).

9.2 Target fledging condition

The minimum target fledging condition for hand-fed chicks at the release site can be based on one or more of the following:

- Fledging condition of hand-fed chicks of the same species in previous translocation projects (see Table 7).
- Fledging condition of naturally reared chicks of the same species, especially at the relevant source colony (as this condition can change with latitude). Note: Chicks that are fed on the diet presented in this document have the capacity to fledge at heavier weights and with longer wings than naturally reared chicks, as there is no abandonment period and chicks are fed up until departure.
- Adult weight and wing length—If none of the above information is available then the minimum fledging weight should exceed the average adult weight (as seabird chicks tend to fledge at a weight that is slightly heavier than the average adult weight). Wing lengths should fall within the known adult wing length range—although it should be noted that

Table 7. Target fledging size (on the day before the night of fledging), pre-fledging emergence period (number of nights on the surface, including fledging night) and hand-rearing period (total time at release site, including transfer day) for transferred Chatham, Cook's and Pycroft's petrel chicks. Note: With the exception of the time at release site, all values are targets, with ranges provided in parentheses.

SPECIES	TARGETS FOR TRANSLOCATED CHICKS			
	FLEDGING WEIGHT ON DAY BEFORE NIGHT OF FLEDGE	FLEDGING WING LENGTH ON DAY BEFORE NIGHT OF FLEDGE	EMERGENCE PERIOD—INCLUDING FLEDGING NIGHT	TIME AT RELEASE SITE—INCLUDING TRANSFER DAY
Chatham petrel*	≥225 g (190–260 g)*	c. 225 mm (215–238 mm)	9–12 nights (site dependent (3–23 nights)	10–30 days (most have left before 26 days)
Cook's petrel†	≥220 g (190–260 g)	c. 235 mm (225–255 mm)	4 nights (2–11+ nights)	10–30 days‡
Pycroft's petrel§	≥175 g (150–200 g)	c. 218 mm (206–232 mm)	7–10 nights (site dependent) (3–15 nights)	10–30 days

* Target values for Chatham petrels are based on the results of eight transfer operations (400 chicks to two different release sites). Note: Chicks weighing ≥260 g on disappearance from their burrows were considered to be 'holed-up' for a further night or two before they successfully departed to sea.

† Target weight and wing length values for Cook's petrels are based on the results of one transfer operation (102 chicks in 2011) and data collected by Matt Rayner (University of Auckland) on Hauturu/Little Barrier Island. Emergence period values are based on results from the 2011 transfer and data in Imber et al. (2003).

‡ Although Cook's petrels appear to have a shorter emergence period than the other two species, it is considered appropriate to stay at the release site for a minimum of 10 days to ensure that the chicks imprint on the site (other factors may also be involved, such as smell and sound of the new colony site). In addition, their emergence period may be longer at sites where take-off options are limited to trees (i.e. where suitable trees must be found by the chicks during the emergence period).

§ Target values for Pycroft's petrels are based on the results of four transfer operations (156 chicks monitored through to fledging date on Cuvier Island (Repanga Island) and 70 chicks fledging from Motuora Island).

parent-reared Pycroft's petrel chicks have been recorded as fledging with wings that are on average 98% of the length of adult wings (Gangloff & Wilson 2004). Adult weight ranges for each species are as follows:

- Chatham petrel: 160–270 g (G. Taylor, unpubl. data 2012)
- Cook's petrel: 150–220 g (Imber et al. 2003)
- Pycroft's petrel: 134–184 g (J. Stewart, Motuora Restoration Society, unpubl. data 2009)

9.3 Artificial diet

The artificial diet that is currently used to feed translocated small gadfly petrels has been established following many years of trials, which were initiated by Graeme Taylor in 1995. These trials have involved wild-origin grey-faced petrel chicks that were hand-reared in captivity and translocated back to the wild (1995–2004), as well as chicks of several gadly petrel species involved in wild-to-wild translocations (2001 onwards).

The artificial diet presented in this document is used to feed the small gadfly petrels for the last part of the rearing phase prior to fledging. At this stage, the chicks have completed their skeletal growth, and are in the phase of plumage development and building up fledging reserves.

In previous transfers, some Cook's and Pycroft's petrel chicks are believed to have fledged successfully after being fed this diet for almost 50% of the rearing period. However, there may be unknown impacts on the long-term survival of birds if they are fed the diet for this length of time. For example, to date, the return rate of Chatham and Pycroft's petrels (as adults) remains less than the 30–40% of that expected for these species (G. Taylor, pers. obs.). Therefore, it is important to avoid feeding the birds this diet for too long to reduce any risks that may be associated with it.

Detailed protocols for preparing chick food can be found in section 7 of the field guidelines (Gummer et al. 2014a).

In brief, to prepare the artificial diet, the following ingredients are blended together:

- One 106 g tin of Brunswick™ sardines in soya oil (include oil contents)—tin contents (in 2011) are sardines (89%), soya oil (10%) and salt (<1%)
- One-third Mazuri® Vita-zu seabird tablet (vitamin/mineral supplement: product code 'Small 5M25')
- 50 mL cold water (previously boiled >3 minutes)

A total of 150 tins of sardines should be more than sufficient to feed 100 Chatham, Cook's or Pycroft's petrel chicks for up to 1 month at the release site, as chicks of these species are not fed on a daily basis.

Important note: Any modifications to this artificial diet must be discussed with Graeme Taylor and other seabird specialists (who have knowledge of previous hand-feeding trials), and will require Animal Ethics Committee approval**.**

9.4 Hand-feeding equipment

Detailed protocols for setting up hand-feeding equipment can be found in section 8 of the field guidelines (Gummer et al. 2014a).

Food is delivered directly to the crop using a crop tube attached to a syringe. Two main systems have been used to date:

- Bovivet™ Plexi syringes (30 mL) with custom-made clear Teflon crop tubes (6.2 mm outside diameter / 3 mm inside diameter × 95 mm length). The Luer-lock system can be removed from the syringe and a custom-made, low-friction tube (with blunted end) can then be screwed directly into the syringe barrel. The wider diameter exit hole helps to reduce

blockages and negates the need to sieve food. This setup allows for an effective hygiene regime to be used in between birds.

- Disposable catheter-tipped syringes (up to 50 mL) with catheter tubing. The tubing is pushed over the end of the syringe, so there is a higher chance of blockages occurring if the syringe exit is narrow. Therefore, food needs to be blended extremely well—sieving of food is not ideal, as this may remove some components that complete the diet. Soft, round-ended catheter tubing is a little harder to effectively clean in between birds, so separate tubes may be needed for each bird. Plastic tubing from hardware stores is not friction-free and needs to be lubricated (e.g. with sterile water) before introducing it to the chick's oesophagus.

9.5 Planning meal size and feeding frequency

9.5.1 Importance of planning meal size

Identification of the **minimum** meal size for each chick ensures that the chick experiences an appropriate weight gain, maintenance or loss (depending on the stage of chick development), so that it can fledge in optimum condition. The minimum volume of food that should be fed to each of these three species is 5 mL (approximately 5 g in weight).

Identification of the **maximum** meal size for each chick before feeding reduces:

- The risk of triggering the regurgitation response by overfeeding, which can have fatal consequences (refer to section 11.76.1—'Regurgitation' for essential information)
- Any risks associated with the slow digestion of meals and gut blockage, which can have fatal consequences (refer to section 9.5.3—'Overfeeding' for essential information)

The maximum volume of artificial food that should be fed to Chatham and Cook's petrels in any one hand-feeding event is 35 mL (approximately 35 g in weight), while the maximum hand-fed meal volume for a Pycroft's petrel chick is generally 30 mL (although the occasional large chick will accept 35 mL).

9.5.2 Importance of planning feeding frequency

Gadfly petrel chicks are fed at irregular intervals by their parents, rather than nightly. For example, Cook's petrel chicks are fed on average once every three nights by a parent, with an average feed weighing just over 37 g (Imber et al. 2003); and Pycroft's petrels have been recorded as receiving average parent meal sizes of 34 g (Gangloff & Wilson 2004). Moreover, feeding frequency is known to decline as fledging approaches, and in the wild parental abandonment (where parents make no further visits to the burrow and depart on migration) occurs 3–10 days prior to fledging in Chatham, Cook's and Pycroft's petrels.

Identification of a suitable feeding frequency for each chick ensures that the chick experiences an appropriate weight gain, maintenance or loss (depending on the stage of chick development), so that it can fledge in the best possible condition. Although feeding all chicks the same amount of food at the same frequency might result in most chicks surviving to fledge, they will not necessarily do so at optimum weights, and this may mean that some chicks are under- or overfed (refer to section 9.5.3—'Overfeeding').

Gadfly petrel chicks that are fed an artificial diet generally require more regular and slightly smaller meals than parent-fed chicks fed on a natural diet for the following reasons:

- Chicks are not able to take large volumes of food (> 35 mL) in a short delivery time (few minutes) without the risk of regurgitation. Natural parental meal delivery time would occur over a minimum period of half an hour, but more commonly over 1 or more hours during the night.
- The artificial diet is not as energy-rich as the natural, oily diet that is delivered by parents.
- The artificial diet (particularly the blended form) is likely to be processed by chicks at a faster rate.

- Translocated chicks may have increased metabolism of valuable reserves as a result of the stress of transfer.
- Hand-fed chicks are also presumed to experience an increased metabolism rate as a result of the stress of regular handling as well as potentially from the loss of a stable air temperature in the burrow during inspection. (Naturally reared chicks tend to have a reduced metabolism during the daytime, and can enter an almost torpor-like state during long intervals between parental meals.)
- The chances of survival following departure are maximised by providing chicks with energy boosts prior to fledging, even though this may not replicate the normal abandonment period by parents.
- Site fidelity to the new colony site may be maximised by allowing chicks to experience an average or longer emergence period prior to fledging, i.e. heavier chicks take longer to reach an appropriate fledging weight. This also affords chicks plenty of time to find suitable take-off points.

Small gadfly petrel chicks will be fed 1–15 meals during their stay at the release site, depending on their age and weight on arrival. Chicks are rarely fed on 2 days in succession unless chicks that are in very poor condition have been accidentally transferred and require supplementary meals. The following feeding frequencies should be used:

- Every second day—Youngest chicks, light in weight.
- Every third day—The most common feeding pattern.
- Once every 4–6 days—A few heavy chicks.
- Once every 7–10 days—A few very heavy chicks. There are usually only a few very heavy chicks that do not require feeding at all because they were approaching double the fledging weight at transfer. However, it is recommended that even these chicks are given the occasional very small meal to provide immediately available energy/fluids if required—although many chicks will even reject this, in which case no hand-feeding is required at all. One meal is the minimum number that any chick would receive at the release site (i.e. where a chick was attempted to be fed but rejected the food).

Note: Some projects choose to feed all chicks on one day, and space these days at regular intervals—often every 3 days. (This approach has been used at mainland sites where it is logistically feasible to get labour for one full feeding day every 3 days.) However, some of the more lightweight chicks that normally benefit from being fed every 2 days will require supplementary feeds to maintain their weight if they are only being fed every 3 days—trials using supplementary fish oil have been undertaken at Cape Sanctuary (T. Ward-Smith, pers. comm. 2013). Any projects that choose to follow a once every 3 days feeding pattern must obtain specialist advice because lighter chicks need to be fed more frequently.

9.5.3 Overfeeding

Feeding a chick a volume of food that is greater than it can digest/metabolise at a normal rate can have the following serious consequences:

- Food accumulates in the gut (gut stasis) and if it sits in the proventriculus/ventriculus for too long it can allow the growth of bacteria/fungi, causing an infection (usually fatal) (refer to section 11.6.2—'Ventriculitis/proventriculitis')
- The digestive system slows down further and is unable to process any further meals
- Birds may regurgitate and choke on the excess food—refer to section 11.6.3—'Aspiration of food'

Often, chicks that are overfed show no symptoms of ill health until it is too late, e.g. 1–2 days before death. Symptoms include:

- Immediate regurgitation of all or part of the meal following feeding or in the burrow

- Chicks tend to be fairly light in weight
- Dead chicks can be found inside or outside their burrows, often with their heads lying in a pool of regurgitant

Note: Some chicks that have displayed the above symptoms have later been found to have regurgitated squid beaks in the burrow. These appear to prevent or slow down digestion (possibly blocking part of the digestive tract) and, once regurgitated, chicks often feed normally.

9.5.4 First (introductory) meals

Chatham, Cook's and Pycroft's petrel chicks should be fed a relatively small introductory meal of 15 mL for the following reasons:

- Chicks that are fed large volumes in their first hand-feeding event may regurgitate, and this will include the very valuable previous parental meal
- Chicks need to adapt to the new diet and feeding technique—the digestive system will be able to process the new food more effectively if there is less of it to begin with

For this small volume of food, the mixture does not need to be more dilute than the normal recipe (one 106 g tin of sardines : 50 mL water) because dehydration seems to be less of an issue for these species: chicks have slow metabolisms and larger fat reserves, and an ability to convert fat to water if required. Note: Some very heavy and/or more advanced chicks in the longer transfer wing length categories may take less than 15 mL of the introductory meal because they need to lose weight.

Ideally, you will know which chicks are likely to have received a parental meal the night before transfer, if there was time to erect stick fences at burrow entrances at the source colony (refer to section 7.4—'Preparations on the day before transfer'). Thus, the chicks can be divided into two main groups:

- Chicks that **did not** receive a parental meal on the night before transfer—Some of these chicks may not have received parental food for many nights. Therefore, they should be fed sooner so that they do not fall too far behind in weight.
- Chicks that **did** receive a parental meal on the night before transfer—These chicks must be allowed to process at least some of their rich, oily parental meals before more food is introduced. Thus, these chicks should be fed a little later when there is a lower risk of regurgitation.

In practice:

- Compile a list of all chicks that may require feeding on Feed Day 1 (based on the natal burrow fence status data recorded on the transfer boxes).

  Note: Any heavy chicks in this list will be eliminated from the list the following day (see next point) and rescheduled for feeding for an appropriate later date.
- Weigh and measure all chicks at their burrows on the morning after transfer (before feeds commence), and subdivide the two groups described above (chicks that did and did not receive a parental meal) into 'light', 'medium' and 'heavy' chicks.
- Refer to Table 8 (for Chatham and Cook's petrels) or Table 9 (for Pycroft's petrels) to determine which chicks need to be fed on which days.

Table 8. Guide to hand-feeding Chatham and Cook's petrel chicks for the first 9 days following transfer.

Note: Weights and wing lengths are those recorded on the **day after** transfer; '–' = no feed; 1 mL of food weighs approximately 1 g.

	CHICKS **NOT FED** BY PARENTS DURING NIGHT BEFORE TRANSFER			CHICKS **FED** BY PARENTS DURING NIGHT BEFORE TRANSFER		
	LIGHT	MEDIUM	HEAVY	LIGHT	MEDIUM	HEAVY
Chatham petrel	<320 g Any wing length	320–340 g Any wing length	>340 g Any wing length	<320 g Wing < 215 mm	320–340 g Any wing length **or** <320 g Wing >215 mm	>340 g Any wing length
Cook's petrel	<320 g Any wing length	320–340 g Any wing length	>340 g Any wing length	<320 g Wing <225 mm	320–340 g Any wing length or <320 g Wing >225 mm	>340 g Any wing length
Day 1	15 mL	–	–	–	–	–
Day 2	–	15 mL	–	15 mL	–	–
Day 3	20 mL	–	15 mL	–	15 mL	–
Day 4	–	20 mL	–	20 mL	–	≤15 mL with caution
Day 5*	≤30 mL	–	–	–	20 mL	–
Day 6*	–	–	20 mL	≤30 mL	–	–
Day 7*	≤30 mL	≤30 mL	–	–	–	–
Day 8*	–	–	–	≤30 mL	≤30 mL	≤20 mL with caution
Day 9*	≤30 mL	–	≤30 mL	–	–	–

* Volumes may need to start decreasing as the chick gets closer to fledging. This is gauged primarily by each individual chick's response to feeding. A few chicks may require and accept 35 mL instead of 30 mL.

9.5.5 Second meals

It is appropriate to provide chicks with 20 mL of food at their second meal to prevent them from becoming too loaded up with the new diet so early on.

At this stage, avoid using the chick's response to feeding as a guide to future meal sizes, as any food rejection during the first couple of feeding attempts can be attributed to the feeding technique (unless chicks are very heavy, in which case they may just be too full). Most chicks will readily take the 15 mL introductory feed and the 20 mL second meal (unless they are heavy).

9.5.6 Planning all subsequent meals

For all subsequent meals, meal sizes can be divided into four categories to aid with planning the appropriate quantity of food for each chick at each feed:

- Big meal = 20–30 mL of food (occasional 35 mL meals are fed)
- Medium meal = 10–20 mL of food
- Small meal = up to 10 mL of food
- Energy meal = small meal (5 mL) given to any chick that requires an energy boost rather than food for growth and development

Feeding regimes range from small meals that are fed infrequently (for heavy chicks), through to large meals that are fed regularly (young, lightweight chicks). The meal size and feeding frequency for all subsequent meals for each chick can be planned as follows:

Table 9. Guide to hand-feeding Pycroft's petrel chicks for the first 10 days following transfer.

Note: Weights and wing lengths are those recorded on the day **after** transfer; '–' = no feed; 1 mL of food weighs approximately 1 g.

	CHICKS **NOT FED** BY PARENTS DURING NIGHT BEFORE TRANSFER			CHICKS **FED** BY PARENTS DURING NIGHT BEFORE TRANSFER		
	LIGHT	MEDIUM	HEAVY	LIGHT	MEDIUM	HEAVY
Pycroft's petrel	<240 g Any wing length	240–260 g Any wing length **or** <240 g Wing >c. 190 mm	>260 g Any wing length	<240 g Wing <c. 190 mm **or** <210 g Wing >c. 195 mm	240–260 g Any wing length **or** <240 g Wing >c. 190 mm	>260 g Any wing length
Day 1	≤15 mL	–	–	–	–	–
Day 2	–	≤15 mL	–	≤15 mL	–	–
Day 3	≤20 mL	–	≤15 mL	–	≤15 mL	–
Day 4	–	–	–	≤20 mL	–	≤15 mL with caution
Day 5*	≤25 mL	≤20 mL	–	–	–	–
Day 6*	–	–	≤20 mL (or delay to Day 7 if very heavy)	≤25 mL	≤20 mL	–
Day 7*	≤30 mL	–	–	–	–	≤20 mL with caution (or delay to day 8 if very heavy)
Day 8*	–	≤30 mL	–	≤30 mL	–	–
Day 9*	Continue to feed hungry chicks on alternate days	–	–	–	≤30 mL	–
Day 10*	Some birds can now be fed every 3rd day if full or rejecting food on Day 7	–	Feed ≤20 mL (or delay to day 11 or 12 if very heavy)	Continue to feed hungry chicks on alternate days and others every 3rd day	–	–

* Volumes and/or feeding frequency may need to start decreasing as the chick gets closer to fledging. Chicks with more advanced wings (e.g. >190 mm) are unlikely to want the maximum food volumes presented here, while younger chicks (e.g. <190 mm wings) will. This is gauged primarily by each individual chick's response to feeding. Young, hungry chicks can be expected to take several of the 30 mL meals in a row (e.g. up to around six 30 mL meals) with the occasional chicks needing one or two 35 mL meals included.

- For Chatham and Cook's petrels—Use Table 8 as a guide to feeding frequency and meal size.
  - Note: For Chatham petrel chicks, Table 8 should be used in conjunction with the detailed feeding guide provided within the Chatham petrel chick translocation guidelines (Gummer 2011a), which was specifically developed so that feeders could cross-reference the current pre-feed (base) chick weight with wing length shortly after transfer, to identify an approximate feeding regime that is likely to suit the individual. That guide will need to be referred to several times over the subsequent weeks in order to identify when to change the plan, e.g. reduce food volumes.
- For Pycroft's petrels—Use Table 9 as a guide to feeding frequency and meal size.
- Make decisions on subsequent meal sizes and feeding frequency based on:
  - The volume of the last meal that was successfully delivered (recorded on field data sheets).
  - The ease of delivery of the last meal (notes written on field data sheets regarding chick behaviour during feeding and incidences of regurgitation, overflow, etc.).

- A feeding calendar can be filled in with estimated meal volumes on the appropriate days for each chick (refer to the example in section 10.4 of the field guidelines (Gummer et al. 2014a)). This calendar will help to:
  - Identify the work load for the next feeding day.
  - Establish the total volume of food (number of tins of sardines) that needs to be made.
  - Identify (towards the end of the project) any potential 'non-feed' days where chicks are monitored but none are fed, easing the work load (refer to section 9.5.9—'"Non-feed" days'). These may be days when only a few chicks are scheduled to be fed, and where the feeding of such chicks can be brought forward a day or delayed a day without compromising the individual chick's welfare.

Note: Although meal sizes are slowly reduced as the chick advances in development (refer to section 9.5.8—'Reducing meal sizes'), once a chick has been put on a feeding regime, the frequency of feeding for that individual does not usually change, i.e. a chick that is fed on every second day will tend to stay on that regime until fledging (or very close to fledging).

9.5.7 Monitoring chick condition in relation to feeding regime

It is critical that every burrow is carefully and consistently inspected for signs of regurgitation on a daily basis—especially in the first week after transfer while chicks are adjusting to the new diet and feeding regime—and to ensure that chicks are passing waste matter (faeces/urates). During the first few days, it is useful to have someone with a 'trained eye' involved in extracting chicks from their chambers to check for the above and pick up on anything abnormal (refer to section 11.6.1—'Regurgitation').

9.5.8 Reducing meal sizes

Observation of a chick's response to feeding will help with the identification of the exact point at which the meal size should be reduced. Responses that indicate this can include:

- Food overflowing out of the mouth—This is not meal rejection, but a sign that there is no more room in the crop for food. Note: Sometimes this can be a reaction to the feeding technique used, but if it still occurs on the second feeding attempt, it is probably a sign of fullness.
- The chick regurgitating—In the event that a chick regurgitates the artificial meal, it will tend to reject only the portion of the meal that it no longer requires, rather than the entire amount delivered.
- The chick gaping and gagging—It is difficult to describe this response, but a chick that is no longer interested in food can sometimes be very difficult to handle, with agitated movements and a reluctance to have the crop tube introduced into the throat. The response is also sometimes known as 'flaring' (the bill is open and the corners of the mouth and throat are stretched wide).
- A tight food pipe—As chicks reduce their intake, it is sometimes possible to feel a certain resistance in the throat and a tightness around the crop tube as it is introduced. Note: Where chicks are only receiving 5–10 mL of food, it is sometimes easier to deliver this by inserting the crop tube only just past the air pipe rather than the usual distance down the food pipe.

Once meal size has been reduced for a chick, it rarely increases again. Every subsequent meal will most likely be slightly less, or sometimes the same. As a rough guide, it works well to decrease a chick's meal size by 5 mL at its next feed event, although that is not standard for every chick.

Chicks need to be fed in such a way as to maintain a gradual weight loss (around 5–10 g per 24-hour period) as they approach fledging. The amount of weight loss per day tends to decrease as chicks get closer to fledging, so allow a chick a gradual decline in weight of 5 g per 24 hour period in the final week leading up to fledging, so that the chick will be able to depart under its own steam in optimum condition for its size.

Note: It is not considered a problem if continued hand-feeding slightly delays a chick's departure because the chick will be continuing to site-fix during the slightly extended emergence period. By contrast, if hand-feeding is stopped prematurely and a chick loses weight at a faster rate close to fledging (i.e. >5 g/day), it may fledge prematurely and/or fledge at a lighter than desirable weight, i.e. it may not be quite ready to depart for other reasons (e.g. not emerged for long enough, or plumage not quite fully developed).

9.5.9 'Non-feed' days

'Non-feed' days (days on which no chicks are fed) can usually be scheduled at some stage in the third or fourth feeding week. The timing is totally dependent on the age and condition of chicks at transfer: if the average chick weight at transfer is high, then 'non-feed' days may occur as soon as the end of the second week of feeding, whereas if the average transfer weight is low and chicks are younger, such days may not occur until the fourth week of feeding.

All chicks must still be checked for wellbeing on days when they are not fed. Ideally, chicks should not be handled unless necessary (e.g. for measuring); however, regular physical examination of emerging chicks can be useful to find any injuries that may have been incurred during excursions, as chicks actively climb trees and crash-land at night (refer to section 8.5 of the field guidelines (Gummer et al. 2014a)).

9.6 Chick food preparation

Detailed equipment lists and protocols for daily chick food preparation can be found in section 7 of the field guidelines (Gummer et al. 2014a), which includes methods for:

- Preparing syringes/crop tubes
- Preparing sterilising solution for crop tubes
- Making food
- Cleaning and sterilising food preparation equipment
- Checklist of items to take to the colony site each day

Note: Food pottles should contain meals for no more than ten chicks, i.e. for as many chicks as can be fed in an hour. This is because the food is warmed up in batches at the burrow site and should be used within an hour to avoid contamination issues—warm fish mix is particularly prone to contamination. Thus, for the small gadfly petrels receiving meals of up to 30 mL, pottles should hold around 1.5 tins worth of mixture (e.g. 250 mL pottles). Food pottles of this size can be effectively warmed up in a food thermos flask containing hot water.

9.7 Chick feeding, measuring and monitoring

9.7.1 Team size and structure

Refer to section 12.2—'Labour requirements' for information on the personnel required at the source and release sites.

For a three- to four-person team, it is most efficient to have one feeder stationed under shelter (concentrating on feeding, food temperature and hygiene), and two or three handlers each collecting their designated chick, holding it for feeding and returning it to the burrow before collecting their next designated chick.

9.7.2 Preparing notebooks / data sheets

The main drawback of a regime that involves feeding different chicks on different days is that there is room for errors, such as chicks being missed off a daily feeding list. Therefore, with such a regime it is critical to plan ahead and communicate clearly. On the day before each feeding day:

- Clearly indicate on the chick data sheets what processing is to occur for each chick on their respective page of records. Feeders should be able to turn to the records of a chick (in the folder at the feeding station) and see whether it requires a meal and what the meal size is.
- Write out a separate list (in a waterproof notebook) of all chicks that are to be fed on the following day as a quick reference to which chicks need to be collected and brought to the feeding shed. Double-check this list against the chick data sheets and the feeding calendar (if used). This list can be used by the handlers to check against when collecting the birds for feeding.

9.7.3 Processing chicks on a chick feeding day

Detailed protocols for chick feeding, measuring and monitoring can be found in section 8 of the field guidelines (Gummer et al. 2014a), which includes methods for:

- Setting up feeding equipment at the feeding station.
- Checking all chicks for presence and welfare (chick roll-call).
- Extracting chicks from burrows.
- Weighing and measuring chicks (with band check).

  Note: Each chick is initially weighed on every feeding day, and then daily from when it is expected to depart (to obtain fledging data) until it has fledged. As a rough guide, daily data collection can commence for the small gadfly petrel chicks when they are emerging, their wing tips are just extending beyond the tip of the tail when they are in a resting position with their wings folded, and there is < 10% down cover on their upper surface.
- Hand-feeding chicks.
- Returning chicks to burrows.
- Food hygiene and temperature control.
- Clean-up after feeding.

Note: At all times it is critical that birds are handled in a way that minimises damage to their flight feathers. A chick that has damaged or lost wing or tail feathers will be compromised at fledging time (refer to section 10.6—'Assisting chicks to fledge').

At the end of each chick feeding day, once the chicks are well settled back in their burrows and before personnel depart from the colony site, the following tasks should be undertaken (details of which are also documented in section 8 of the field guidelines (Gummer et al. 2014a)):

- Remove blockades (internal and external) from relevant burrows to allow chick emergence.

  Note: A large proportion of blockades will have been removed after three nights (i.e. on the third day after transfer), but the entrances of the burrows of particularly young and/or lightweight birds may need to remain blockaded for some time to prevent premature disappearance, and will be removed on a case-by-case basis (refer to section 10.3—'Blockade removal').
- Restore stick fences at burrow entrances and carry out final burrow security checks.

On return from the colony site at the end of a feeding day, data should be transcribed onto computer spreadsheets. This should occur on a daily basis (or at least on alternate days) in case field records are damaged. Notebooks and/or data sheets should also be prepared for the following feeding day (refer to section 13.3—'Chick feeding and measurement records').

9.8 Cleaning equipment after feeding chicks

Detailed protocols for cleaning up at the end of chick feeding days can be found in section 9 of the field guidelines (Gummer et al. 2014a), which includes methods for:

- Washing-up and sterilising feeding equipment
- Washing weigh bags and towels
- Boiling water for food and for use during feeding (for rinsing disinfected crop tubes)

10. Managing emerging chicks

10.1 Emergence behaviour

The small gadfly petrels all have an emergence period prior to fledging, during which they leave their burrows each night to explore on the surface. In general, chicks tend to stay in the near vicinity of their burrow entrances on their first excursion, stretching their wings and walking for the first time. In the following nights, they will venture further afield—emerging chicks have been found over 50 m from their burrows during the night and been observed climbing trees. Close to fledging time, chicks can be away from their burrows for much of the night, or may not even return to their burrows, spending the day in another location.

Such emergence behaviour allows chicks to:

- Stretch and exercise outside their burrows—This is thought to be particularly important for chicks of the migratory species, which have a long-distance flight ahead of them once they depart the colony. Chicks of these species are rarely observed in inshore waters after fledging, indicating that they immediately head out to the open sea. (Note, however, that fledglings are sometimes found on land having been attracted by lights, e.g. street lights.)
- Familiarise themselves with the environment and surroundings, which is important for site-fixing (locality imprinting).
- Explore options for take-off and landing—Tree-climbing species tend to practice climbing trees during the emergence period. Fledglings of all three species have been observed climbing near-vertical trees to reach a tall canopy, and then flapping in the breeze and dropping down to the forest floor before returning to their burrows. Pycroft's petrels have also been observed engaging in practice take-off flights across the top of the canopy (i.e. between tree tops) and crash landing with some force back to the ground.
- Emerge on the surface in wet weather, which may play an important role in stimulating chicks to preen and optimise the waterproofing of their plumage before embarking on their maiden flight. The down may also be easier to preen off when it is wet. Chicks are commonly observed emerging early and in large numbers on rainy nights—rain appears to stimulate many chicks to emerge from their burrows for the first time (refer to section 10.5—'Missing chicks'). Chicks also tend to exit burrows during rainfall to avoid predators—rainy nights tend to be dark, which reduces the risk of chicks being seen on the surface by aerial predators, particularly when they are preening and wing flapping. In addition, chicks may be thirsty, and it is thought that this may be a driver for parent-reared chicks that have been abandoned to eventually depart to sea.

The total number of nights over which chicks emerge prior to fledging varies between species, individuals and sites (see Table 7). However, there appears to be a strong correlation between the average length of the emergence period at a particular colony site and the ease with which birds can take off from the site. For example:

- Translocated Chatham petrels spent on average three nights longer exploring on the surface at the Pitt Island (Rangiauria) colony site than the same number of transferred chicks spent at the Chatham Island (Rekohu) site. This reflects the fact that the Pitt Island (Rangiauria) site is closer to sea level, meaning that all birds needed to climb tall trees to take off, whereas chicks at the more exposed and elevated Chatham Island (Rekohu) site could lift off more easily from lower vegetation.
- Wild and translocated Cook's petrels have been found to have a shorter emergence period than both Pycroft's petrels (which are lighter in weight) and Chatham petrels. This is likely to be related to the exposed and elevated nature of the terrain at the source site (Hauturu/Little Barrier Island) and at the site of the first translocation project (Cape Sanctuary).

However, it may also be an adaptation to nesting on larger islands (as well as historically on the mainland), where colonies are exposed to land-based predators (e.g. rails)—by contrast, the Pycroft's petrel is tropical in origin and has always nested on predator-free offshore islands. It would be predicted that the average emergence period for Cook's petrels would be slightly longer if chicks were translocated to a more inland site that was less elevated and/or where chicks needed to climb tall trees to be able to depart.

- Translocated Pycroft's petrels appear to spend on average three nights longer exploring on the surface at the Motuora Island colony site (c. 50 m a.s.l.) than at the Cuvier Island (Repanga Island) site (c. 150 m a.s.l.). This is likely to reflect the fact that all birds need to climb trees to take off from Motuora Island, whereas chicks on the very elevated Cuvier Island (Repanga Island) have the option of taking off directly from cliff tops.

10.2 Burrow acclimatisation period

Gadfly petrels show a strong affinity for their natal burrow. Following transfer, a strategy is employed at the release site to encourage chicks to gain an affinity for the new artificial burrow and to prevent them from wandering away from the site. Chicks are blocked into their artificial burrows for an acclimatisation period of **at least two nights** after transfer, using an internal (chamber end of pipe) and external (burrow entrance) blockade (refer to section 8.4.3—'Preparing artificial burrows'). During this time, the chicks will settle, adjust to the new temperature and humidity, and build up their own scent (e.g. deposited down, excrement) in the chamber.

10.3 Blockade removal

It is critical that all internal blockades are methodically removed at **exactly the same time** as the external blockades so that they do not get forgotten (refer to section 8.4.3—'Preparing artificial burrows'). It is good practice to feel along the entire length of the entrance/exit pipe at this time, to ensure that there are no obstructions preventing the chick from exiting its burrow.

At the time of blockade removal, stick fences should be erected at the entrance of each burrow to monitor emergence behaviour.

10.3.1 Standard blockade removal—optimum chicks

Most burrow entrance blockades (internal and external) can usually be removed two days after transfer day (i.e. no burrow blockades from the third night onwards), providing that chick wing lengths have reached a minimum of 190 mm for Chatham and Pycroft's petrels, and 200 mm for Cook's petrels.

Note: Transfer criteria should mean that very advanced chicks have not been moved; however, it is occasionally necessary to remove blockades from the entrance after one night (to avoid stress) for chicks that have been transferred at a larger size (Priority 2 or 3; Table 3). If chicks are digging inside the burrow or experience abnormally high weight loss compared with other chicks, it could indicate high levels of activity inside the burrow and the need to remove the blockades. Such chicks would have little down cover remaining and their wing lengths are likely to exceed the minimum known fledging wing length for the species. If the tips of the wing primaries reach the tip of the tail feathers when the chick is in a relaxed resting position with its wings folded across its back (this can be viewed in the burrow), then the chick is particularly advanced and ready to emerge.

10.3.2 Delayed blockade removal—lightweight/problem chicks

Where projects do not have daily access to a trained species detection dog and handler, there is an obligation to delay blockade removal at any burrows that contain chicks that would be

severely or fatally compromised if they permanently disappeared well before the predicted fledging time and were unable to be found for feeding.

For any **lightweight and/or young** chicks, or chicks requiring medical treatment, blockade removal can be delayed until > two days after transfer day, to avoid the premature disappearance of these chicks, which are reliant on regular hand-feeding for successful fledging (refer to section 10.5—'Missing chicks'). Blockade removal should be delayed at burrows that are occupied by:

- Chicks transferred at the **younger end of the Priority 1** transfer group (Table 3) that weigh the following on the day after transfer:
  - Chatham petrel: < 300 g
  - Cook's petrel: < 280 g?? (to be trialled/confirmed)
  - Pycroft's petrel: < 220 g
- Chicks with **health issues that need to be resolved** before they are allowed to emerge (and potentially disappear). Blockades should be left on the burrows of chicks that require essential drug treatment (such that if the bird departed without receiving the full course of treatment it would be likely to perish) or where further advice from a vet is required.

  Note: In some cases, a blockade gate may need to be reinstalled after it has been removed, to allow a chick to receive treatment or a period of rest. For example: a Chatham petrel chick that had already emerged for several nights was found back in its burrow with a very weak leg (a possible strain); the chick was prevented from emerging to allow rest, and eventually assisted to fledge. Another chick of the same species was found to be extremely wet through (to the skin) after its first night of emergence in the rain, and so was blocked in for a day and night to give it time to dry out and warm up before emerging again. (Chicks like this may have waterproofing issues, which can be addressed in some situations; refer to section 11—'Managing chick health issues'.)

Blockades can be removed on a case-by-case basis when feeders feel that the chick would have a chance of surviving if it disappeared prematurely and there was no means of finding it (e.g. no certified detector dog, as described in section 10.5.3—'Searching for missing chicks'). There may be a risk of stressing the chick if it wants to emerge earlier, but maintaining the blockade would still outweigh the risk of a light chick permanently disappearing and not being able to receive more meals before fledging.

As a guide, blockades can be removed when a chick fits all of the following criteria (regardless of weight):

- Down coverage is <50% (looking down on the chick from above); and
- The chick's wing measures >210 mm (Chatham petrels), >215 mm?? (Cook's petrels—to be trialled/confirmed), or >95 mm (Pycroft's petrels).

10.4 Monitoring chick emergence and fledging

Chick emergence behaviour and final departure from the burrow are monitored by recording the status of the stick fence at the burrow entrance on a daily basis.

10.4.1 Deviations from normal emergence patterns

Once a chick has begun to emerge from its burrow, it will normally emerge on every subsequent night until departure. However, there are occasions when one or more chicks at a release site do not emerge on a particular night, which can be attributed to any of the following reasons:

- The chick has received a very large meal and as a result may feel too full to move outside the burrow at night. For example, because chicks are not fed daily, a chick may emerge for the first time on a night following a non-feed day, but then may not emerge on the next

night if it receives a large meal that day. This can be one of the indications that meal size needs to be reduced for that individual.

- There is a full or near-full moon with no cloud cover—Chicks are more vulnerable to predation if the burrow site is lit up by bright moonlight and have an instinct to avoid such conditions.
- It is a calm night—Some chicks would waste energy exploring on the surface on such a night if there is no wind to give any lift when exercising or practicing take-off.

Note: Where a chick does not emerge for 1 or more nights between its first emergence and departure, the non-emergence nights should **not** be counted when calculating the emergence period for that chick.

10.4.2 Assessing fledging success

Fledging date can only be recorded for a chick if it fits **all** of the parameters required for a successful fledging. This will involve looking at the most recent weight, wing measurement and emergence data. Fledging parameters include:

- Wing length falls within the known fledging wing length range for the species (see Table 7)
- Wing growth rate has started to decrease from c. 3 mm/day to 1–2 mm/day, or has ceased
- Weight falls within the known fledging weight range for the species (see Table 7)
- The chick has emerged from its burrow for a number of nights that falls within (or exceeds) the known range for the species (see Table 7)
- The chick does not have > 10% overall down cover

Do not presume that a chick has fledged if the following applies:

- The chick has not emerged on any previous nights—Chicks of these species that have not previously exercised would be unlikely to fly directly to sea on their first night out of the burrow unless they are particularly well-advanced and probably light in weight.
- The chick is heavier than the upper known fledging weights for the species—Such chicks can be 'holed-up' elsewhere at the site (or outside a fenced area or down a steep decline) because they have crash landed after a fledging attempt.
- The chick's wings are still growing at ≥ 3 mm/day—Usually the primary feathers will slow in growth towards fledging, with chicks that are presumed to have fledged successfully only experiencing growth rates of 0–2 mm per day by departure time.
- The chick has > 10% down coverage—Transferred Pycroft's and Chatham petrel chicks tend to lose most of their down before fledging. Most chicks tend to fledge with no down cover or with only wisps remaining, and only a few chicks might fledge with around 10% down cover. Chicks fledging from release sites where there has been no rain may be covered in slightly more down; one of the last regions on the body from which down is lost is the nape area. (Note: Down coverage at fledging has not yet been recorded in detail for Cook's petrels.)

If the chick does not fit the fledging parameters, it should be recorded as missing; and although its fate will be unknown (refer to section 10.5—'Missing chicks'), the likelihood that it will survive to fledging can be predicted (refer to section 13.4—'Chick emergence behaviour and fledging records').

10.5 Missing chicks

10.5.1 How often do chicks go missing?

In most translocations of small gadfly petrels, chicks occasionally disappear from their burrows. There is a pattern for more chicks to be missing from their burrows on a morning following a night of rain (especially heavy rain). This is probably due to chicks finding it harder to follow their scent trails back to their burrows and effectively getting lost, resulting in them 'holing-up' in another burrow or, more commonly, under vegetation. Chatham petrels, which are transferred in late autumn when conditions can be very wet, appear to be more prone to disappearing than the other species.

Chicks can disappear either temporarily or permanently:

- Some chicks disappear temporarily, returning to either their own or a different artificial burrow after a period of 1 or more days. Chatham petrel chicks have been known to go missing for up to six days before being recovered again; during this time, their base weight dropped by 40 g (Gummer & Liddy 2011). Such chicks are a priority for feeding as soon as they are found.
- Some chicks are not present in their burrows by day, but are suspected to return to their burrows at night (from the fence status pattern) for a few nights before finally disappearing, i.e. they are not seen by day. During the day they are probably 'holed-up' under vegetation.
- Other chicks are never found again and are assumed to be in one of the situations described in section 10.5.2—'What happens to missing chicks?'.

Regular measurements and good record-keeping are important when assessing whether a chick that is absent from its burrow is likely to have fledged or is missing (refer to section 13.4—'Chick emergence behaviour and fledging records').

10.5.2 What happens to missing chicks?

Chicks that have disappeared before they meet target fledging condition (refer to section 9.2—'Target fledging condition') are likely to be in one of the following situations:

- Sheltering under vegetation away from the burrow site.
- Landed outside a predator-proof fence (if present) and unable to get back through the fence to the burrow site. Although this has never been proven to date, it remains feasible, particularly at sites where burrows or take-off points have been sited too close to a fence.
- Fallen down a steep decline during practice take-off and unable to negotiate the terrain to return to the burrow before daylight.
- Plummeted down to the sea, and too heavy or weak to take off again.
- Been attacked by aerial predators (i.e. harrier hawks (*Circus approximans*))—as has been found for grey-faced petrel chicks—following which the corpse may have been carried away from a burrow site.

The **consequences** of chicks disappearing from burrows before they are ready to fledge are:

- Missing chicks can no longer be hand-fed, which will have different implications for heavy and light birds:
  - Heavy, well-developed chicks can survive not being hand-fed during the time they are missing and will still fledge in good condition, i.e. at average or above-average fledging weights. This is why their blockades can be removed after two nights: if they disappear, there is still a good chance that they will be able to fledge successfully and survive their first days at sea without further hand-feeding, providing that they can find shelter from the elements and avoid predation for the time between disappearing and fledging.
  - Lightweight chicks that are reliant on hand-feeding will be compromised at fledging to varying degrees, depending on their stage of development. Chicks that are far from

fledging will be severely compromised, losing up to 10 g/day in weight. While there is still a chance that they could fledge at the lighter end of the fledging weight range (providing that they find shelter from the elements and potential predation), they will have few reserves to get them through the post-fledging period and are the most likely chicks to perish because they will be weak at the time of fledging.

Note: Blockades are left in place for longer at burrows containing lightweight chicks for two reasons: there is an obligation to ensure that these chicks do not suffer a long and drawn-out death through starvation; and if they disappear prematurely, they are extremely unlikely to return as adults which defeats the purpose of translocating them in the first place.

- Missing chicks that cannot find suitable shelter in time (before dawn) can be left sitting on the surface (or under minimal cover), where they are exposed to the elements (sun's heat or rain) and/or to potential predators. For example:
  - Chicks have been found wet and chilled on the surface in some projects. Lightweight chicks are particularly compromised by becoming wet-through, and need to be blockaded back in their burrows until they are dry and have regained energy, even though this causes stress.
  - A desiccated grey-faced petrel chick corpse was found at Cape Sanctuary in more open terrain; this bird may have died as a result of heat exposure when daytime temperatures exceeded 30°C (Ward-Smith & McLennan 2009).
  - Grey-faced petrel chicks that are missing from burrows are known to have been predated on by harrier hawks in situations where the burrows were relatively exposed at the time of transfers (Ward-Smith & McLennan 2009).
- Missing chicks that have plummeted down to the sea prematurely would be in an extremely vulnerable and exposed situation in near-shore waters, where they may be taken by aerial or underwater predators.
- Missing chicks that have suffered injury through misadventure may never be recovered for treatment and rehabilitation. For example, a grey-faced petrel chick that had attempted to fledge was found on the shoreline with severe haemorrhaging, implying that it suffered some kind of impact when it left the colony site (Mitchell & Mitchell 2009).
- The overall average fledging weight of a translocated cohort will be reduced if some chicks cannot be fed for an optimum period. (Note: Managing blockade removal on a case-by-case basis improves average fledging weight.)

10.5.3 Searching for missing chicks

There is usually limited time available to search for missing chicks on any day, and manual searching can be a daunting and often fruitless task. At a minimum, all vacant artificial burrows at the colony site should be checked for chicks that might have wandered into them.

The setting and following of blockade removal criteria removes the need to search for chicks because missing chicks will still have a chance of fledging from the colony site and are less likely to perish before their fledging attempt.

An alternative method for recovering missing small gadfly petrel chicks is to use a trained protected species detection dog and handler (refer to section 15.4.6—'Using protected species detector dogs to find natural burrows'). This can be useful if transferred chicks at a release site are regularly going missing and their disappearance is of concern.

10.6 Assisting chicks to fledge

During an assisted fledge, the chick is taken directly to the cliff edge or sea for release because its mobility or tree-climbing ability is compromised in some way and there are no options with regard to veterinary facilities to improve the condition of the chick before it fledges. Assisted fledges are only attempted when a chick has been assessed to be in otherwise good condition and capable of recovering from any symptoms whilst at sea. To date, assisted fledges have been attempted at remote release sites where chicks need to make some effort to get out to sea, i.e. where they must climb take-off trees and/or walk some distance to a take-off point (e.g. Chatham Island tāiko (*P. magentae*) fledging from some burrows in the Tuku Nature Reserve).

Assisted fledges should be considered in the following circumstances:

- When a chick's mobility is slightly compromised and veterinary attention or treatment is not feasible or unlikely to improve the condition; or it is considered that holding the chick back for rehabilitation may result in other more serious complications (feeding problems, etc.).
- When a chick has returned from veterinary treatment, and it is urgent for it to get to sea to feed for itself and no further recuperation is required at the release site burrow (as per veterinary advice).
- If a chick has a slight weakness in one limb—The chick may not be able to climb a tree, but once at sea it can rest the limb in flight and exercise it on the water.
- If a chick has lost two or more tail feathers—There is not enough time for these to be replaced before fledging. Experience has shown that the loss of central tail feathers can be a real disability when chicks are climbing trees, as they need to use the tail as a prop during the ascent. If they cannot climb a tree, they will never be able to depart from some sites.
- If a chick has lost one or two significant wing flight feathers, in which case it may be a good idea to assist it to fledge in case the chick needs some flying time to adjust to balance issues. This may be particularly important if the chick needs to negotiate an area of mainland (with predators) before reaching the sea. An assisted fledge will avoid the risk of the chick becoming grounded outside a fenced area if it is not flying well—it would be safer for the chick to land on the sea surface and practice further flights from there. However, if quite a few flight feathers are missing and survival is predicted to be compromised, veterinary rehabilitation should be considered, if practical.

Note: Chicks with more severe issues must be referred for veterinary advice/treatment, or in remote locations euthanasia may need to be considered (refer to section 11—'Managing chick health issues').

Chicks can be released just after dusk by placing them in an elevated and exposed place that is as close as possible to the sea. Always check the weather conditions beforehand and avoid releasing a bird in the following extreme weather conditions:

- Gale-force or stronger winds—The chick could be blown inland
- Extremely calm sea with no breeze—The chick may not get enough lift for successful take-off and its journey out to sea may require more energy (more wing flapping)

Note: The bird should flap and fly away reasonably quickly (i.e. within 1 hour). The bird can be gently encouraged by lifting it off the ground and allowing it to spread its wings, or by nudging it from behind.

10.5 Managing vacant burrows

Blockades should be left off all vacant (unoccupied) burrows:

- To ensure that any chicks that may have been accidentally placed in the wrong burrows (e.g. vacant burrows) after being fed are able to emerge/depart.
- To provide additional places that wandering birds can occupy, reducing the incidence of birds disappearing and missing feeds.
- To provide burrows for non-breeding adults that are prospecting at the colony site late in the season (when transferred chicks are in residence).

11. Managing chick health issues

11.1 Wildlife health management requirements

Translocations involving land animals (excluding invertebrates) must meet the requirements of DOC's Wildlife Health Management standard operating procedure (SOP) (DOC 2010). The purpose of this SOP is to help minimise any disease risk that may be related to conservation management practices by implementing practical and achievable disease management actions. The SOP covers hygiene; observations of illness; mass mortality events; necropsy; surveillance for disease; translocation health management; captive wildlife health management; and wildlife rehabilitation. More than one section of the SOP will need to be referred to when carrying out a translocation, particularly those relating to hygiene, necropsy and translocation health management.

Any costs associated with the health management programme and necropsy will need to be met by the project.

11.2 Disease screening

It is important that DOC's processes for disease risk assessment and management for translocations are followed.[3] Disease testing/screening may be required as part of a health management programme associated with a translocation.

Screening may involve one of the following:

- Sampling all translocated chicks; or
- Sampling a proportion of translocated chicks (which would then be used to assess the health state of the entire translocated cohort); or
- Sampling birds at the source colony that are not actually being translocated (to give an indication of the presence of certain parasites or pathogens at the source colony).

Screening can involve the collection of faecal samples and/or cloacal swabs and/or blood samples. (Note: Blood-sampling may only be undertaken by vets or highly experienced operators.)

If screening is to occur at the release site after transfer, the following must be considered:

- A settling-in period of a few days should be allowed before invasive procedures (e.g. blood-sampling) are carried out, but screening should ideally occur as soon after transfer as practical. It is ideal to coincide screening with the period when burrows are still blockaded

[3] These processes are outlined on the DOC intranet (http://intranet/our-work/biodiversity-and-natural-heritage/wildlife-health/translocation-health-management/disease-risk-assessment-/) and can be obtained from your local DOC office.

(e.g. around day 3 or 4 at the release site), as this will prevent chicks from disappearing from burrows as a direct result of the invasive procedure. Therefore, it is likely that a sample of chicks that are younger and in burrows where blockade removal is not scheduled until at least a day or two after the screening date would be selected for screening.

- Screening procedures should be scheduled to occur **before** feeding, i.e. not straight after a chick has been fed, and preferably not even on the day after it has been fed. This will help to reduce the incidence of regurgitation as a result of handling birds with full stomachs.
- Invasive procedures should not be carried out on emerging chicks (to reduce the chance of them disappearing). If a blood sample is required from an already emerging chick for any reason, the chick should be blocked in the chamber (with ventilation) for the remainder of the day to ensure that it settles there.

In addition to screening for translocation purposes, some projects also provide researchers with the opportunity to collect samples for baseline health screening of a species or for a particular health study, in which case all costs will be covered by the relevant research institution.

11.3 Physical examination

As well as the physical health check made prior to transfer, a full physical examination should be given in the event of unexpected and/or unusual chick behaviour. Examples of such behaviour include aggression/biting, especially if the chick has previously been quiet (this could indicate a painful fracture or joint problem); failure to emerge despite being mature enough to do so; wandering; and more obvious symptoms, such as sudden weight loss, excessive weight gain, vomiting, poor plumage condition, etc.

11.4 Specialist advice

11.4.1 Seabird translocation advice

When embarking on a new project, it is recommended that collective advice is obtained from more than one specialist. The following seabird specialists can be contacted for advice and information relating to seabird translocation:

- For advice on seabird distribution, ecology and habitat; artificial colony location and design; and seabird behaviour, diets and translocation techniques:
  - Graeme Taylor—seabird/seabird translocation specialist and Principal Science Advisor, Transformation and Innovation Unit, Science and Capability Group, DOC (email: gtaylor@doc.govt.nz; ph: 04 471 3294 or 027 4910703).
  - Contact information for other highly experienced seabird specialists who are familiar with the distribution and ecology of seabirds in each region can be obtained via the above contact.
- For advice on artificial colony location and design; and seabird behaviour, diets and translocation techniques:
  - Helen Gummer—seabird translocation specialist (email: helengummer@paradise.net.nz; ph: 04 239 9002). (Note that rates may apply.)
- The following people have experience in planning and implementing Chatham or Cook's petrel translocations:
  - Chatham petrels: Antje Leseberg—contractor to DOC (email: antjeleseberg@gmail.com).
  - Cook's petrels: Tamsin Ward-Smith—Cape Sanctuary Manager (email: tamsin@capesanctuary.co.nz; ph: 06 875 0308).

11.4.2 Veterinary advice

Before any project commences, contact should be made with appropriate veterinarians so that they know to expect potential correspondence regarding sick or injured birds, and can advise on protocols for dealing with such birds–*in situ* treatment or transfer to appropriate veterinary facilities. Therefore, it is important that you obtain their emergency contact details, e.g. mobile phone numbers.

Veterinarians who are experienced in seabird rehabilitation include:

- Wildbase, Massey University, Palmerston North (ph: 06 350 4525):
  - Dr. Brett Gartrell (email: B.Gartrell@massey.ac.nz; ext. 7398)
  - Dr. Kerri Morgan (email: k.j.morgan@massey.ac.nz)
  - Dr. Micah Jensen (resident) (email: M.Jensen1@massey.ac.nz)
- The Nest, Wellington Zoo (ph: 04 803 0760):
  - Dr. Lisa Argilla (email: Lisa.Argilla@wellingtonzoo.com)
- New Zealand Centre for Conservation Medicine (NZCCM), Auckland Zoo (ph: 09 360 3800):
  - Dr. Richard Jakob-Hoff (email: Richard.Jakob-Hoff@aucklandcity.govt.nz; ph: 09 360 3814)
- Department of Conservation Threatened Species Veterinarian and Wildlife Health Coordinator:
  - Dr. Kate McInnes (email: kmcinnes@doc.govt.nz; ph: 04 495 8604; VPN: 8314)

11.5 Managing sick or injured chicks

11.5.1 Utilising veterinary facilities

Where a chick is sick or injured, and diagnosis (and potential treatment) is not possible without veterinary assessment and advice, it may be feasible to either get a vet to visit the release site or send the chick to an appropriate veterinary facility.

Methods for treating and rehabilitating seabirds are improving all the time; in fact, some individual birds are now even being sent for rehabilitation if they have plumage issues, i.e. are lacking waterproofing. Chicks that lack waterproofing are highly likely to perish at sea, so treatment or rehabilitation is considered to be important, particularly for endangered species (refer to section 11.6.8—'Feather waterproofing').

11.5.2 Remote locations

Where the source colony or release site is in an isolated island location, it is not always practical to transfer sick or injured birds to a veterinary facility due to weather conditions and cost restrictions. In these cases, contact must be made with the local DOC office and/or a vet, to discuss the possibility of euthanasia. The method of euthanasia chosen would depend on the skills and experience of the person carrying out the procedure.

11.6 Managing specific health issues

11.6.1 Regurgitation

Regurgitation has several extremely negative impacts on chick welfare:

- Soiling of plumage, which spoils waterproofing and insulation (can be fatal, as chicks with compromised waterproofing are unlikely to survive the elements at sea)
- Possible asphyxiation (fatal)
- Inhalation of food particles, which can lead to aspiration pneumonia (fatal)

- Loss of valuable parent meals that are rich in oil (natural food and oils can still be seen in regurgitant up to a week after transfer in small gadfly petrels)

Important note: The need to avoid regurgitation and handle chicks appropriately at all times cannot be overemphasised, because if the chick is unable to project the vomit away from its head, one of the above serious consequences is highly likely to occur.

All handlers should be aware that regurgitation can occur at any stage of a transfer operation, but there is an increased risk:

- During first handling at the source colony, i.e. during chick extraction from a natural burrow, especially if the chick has been recently fed by its parents
- During hand-feeding, especially if meal sizes are too large or the chick has a gut blockage (e.g. squid beak), and towards fledging time, when a chick may not require as much food
- As a result of another ailment, i.e. chicks in poor health can regurgitate in their burrow in between handling events; therefore, burrows must be checked on a daily basis for this

11.6.2 Ventriculitis/proventriculitis

Ventriculitis/proventriculitis is the inflammation of the gizzard and forestomach, which is associated with bacterial or fungal infections. The following factors can lead to the condition (alone or in combination) (McInnes 2007):

- Gut stasis—If the food sits in the proventriculus/ventriculus for too long, it can allow bacteria/fungi to grow for long enough to cause an infection. Gut stasis is affected by the temperature and humidity of the surroundings, the temperature of the food at feeding, the water content of the food, and any systemic illness that might be affecting the bird.
- Food quality—Contaminated food, feeding tubes or other equipment can pass pathogenic bacteria or fungi into the gastrointestinal tract of the bird and cause a rapid infection. The quality of food is affected by the hygiene level at preparation; the raw ingredients used; storage conditions (temperature, hygiene, time); and hygiene during feeding.

If caught in time (e.g. if multiple regurgitations occur in a reasonably alert chick, or when regurgitant is first seen in the burrow of a sick, lethargic chick), treatment (such as the administration of fluids and antibiotics) can be successful. However, chicks tend to lose more weight because they are not feeding well and food volumes must be reduced to allow digestion.

11.6.3 Aspiration of food

Aspiration of food particles can occur as a result of overfeeding, a poor hand-feeding technique, or when a chick regurgitates (particularly if it is weak or in poor health at the time).

Pathological examination of deceased grey-faced petrel chicks has shown that chicks with a very full proventriculus also have food present in the oesophagus (food pipe) and trachea (windpipe), indicating that they have regurgitated and aspirated some food, which has resulted in death (Ward-Smith et al. 2010). In these instances, asphyxiation could be either a primary or secondary cause of mortality.

In other seabird translocation projects, aspiration of small food particles is known to have caused aspiration pneumonia, which has also been fatal. Symptoms of this may not become apparent until it is too late to treat the chick.

If aspiration of food is suspected, discuss it as soon as possible with your veterinary advisor to determine whether treatment is required. Symptoms include choking sounds or coughing during or after feeding, followed by (immediately or within two days) increased respiratory effort and audible breath sounds.

11.6.4 Neurological symptoms

To date, neurological symptoms have not been observed in any of the small translocated gadfly petrels. However, six translocated grey-faced petrels have shown symptoms, which included arching back of the head (opisthotonus); ventroflexion of the head (bending towards the belly); lack of coordination; trembling; and distress when handled. These symptoms became more obvious on handling, possibly due to the lack of coordination. In all cases, the chicks were of fledging weight and wing length when the symptoms developed, and the symptoms coincided with a period of hot, calm weather (C. Mitchell, veterinarian, pers. comm. 2012).

All affected chicks recovered from their neurological symptoms following treatment, which comprised the oral administration of fluids, B vitamins and anti-inflammatory drugs (Mitchell & Mitchell 2009). Such treatments could be considered during translocations of small gadfly petrels if similar symptoms arise. Tunnels should be blocked for the first night after treatment to avoid chick disappearance and/or death due to misadventure. For further information, refer to the grey-faced petrel best practice document (Gummer et al. 2014a).

Important note: The above symptoms were observed in chicks that were fed on a diet that did not include a Mazuri® seabird vitamin supplement. No neurological symptoms have been seen in chicks since the Mazuri® supplement (containing B vitamins) was added to the diet (C. Mitchell, pers. comm. 2012).

11.6.5 Wounds

Emerging chicks can be susceptible to injury, especially when they crash-land to the ground following tree-climbing activity.

First aid includes thorough flushing of the wound site with saline solution and application of an antiseptic liquid. Creams must be avoided because they affect the waterproofing of feathers.

Wounds can subsequently be flushed with a chlorhexidine solution if necessary (on veterinary advice), as prolonged use of antiseptic liquids such as Betadine® is not recommended because they inhibit the growth of new cells (L. Argilla, The Nest, Wellington Zoo, pers. comm. January 2013).

11.6.6 Other potential health issues

The following health issues have been observed in translocated grey-faced petrel chicks:

- Dehydration and heat stress
- Eye infections

These problems have not yet been observed in translocated small gadfly petrels; however, there is the potential for them to occur. For further information on preventing or dealing with these, refer to the grey-faced petrel best practice document (Gummer et al. 2014a).

11.6.7 Burrow hygiene

The burrows of translocated small gadfly petrels do not become as soiled as those of some other translocated species, and so they tend not to require cleaning while chicks are in residence.

However, nesting material does need to be replaced if it gets too wet (e.g. from a chick being outside on a rainy night), or is badly soiled by excreta or regurgitations. It is important not to remove all of the material though because it holds the scent that may help the chick to relocate its burrow when returning from night-time excursions on the surface.

If there is any suspicion that a chick has died from an infectious disease, the burrow should be blocked to prevent other chicks from entering it. Ideally, such a burrow would be replaced with a new one before the next translocation, due to the difficulty of disinfecting wood and substrate. At the very least, all of the old nest material should be removed and the box sprayed with Virkon™ or Trigene™.

11.6.8 Feather waterproofing

A lack of waterproofing becomes obvious when an emerging chick is continually found in a wet state in its burrow (when other emerging chicks are dry) after there has been rain or heavy dew during the night. This can happen when chicks do not preen effectively (a common symptom in chicks that are not well), or their feathers have been soiled with oil or some other substance (e.g. fish diet spilt during feeding, or regurgitation). Chicks that lack waterproofing are highly likely to perish at sea.

If only the down layer is superficially soiled, the affected down can usually be removed (pulled off) and the growing feathers beneath the down may be unaffected. However, a chick's waterproofing can be seriously affected if the down layer is penetrated. For example, if a young chick regurgitates a very oily parental meal over itself at its natal burrow (e.g. during a first handling event), this can have a seriously detrimental effect on the new emerging feathers and may permanently affect the chick's waterproofing later on in development (i.e. no waterproofing many weeks later after transfer).

A lack of waterproofing can be difficult to detect during periods of dry weather (no rain or dew). However, a good indication that a chick is not preening is where feathers are observed to be in a tatty state (i.e. are not being 'zipped up' as occurs during preening), and when there are signs of dirt or excrement on the feathers (e.g. from burrow walls) that is not being preened off. Any chick receiving treatment for an ailment (including parasite loadings) should be suspected as having potential waterproofing issues.

It is now becoming routine practice to record the waterproof status of individual chicks at a release site. This can be achieved as follows:

- After rainy nights at the release site—The following morning identify any chicks that appear bedraggled compared with other drier chicks, especially in their head and body feathers (wing and tail tips are commonly damp after a night of emerging in the rain).
- If there is no rain at the release site when chicks are emerging—Perform a basic waterproofing test by liberally spraying feathered chicks (i.e. those that are largely free of down) with a fine mist of water to ensure that there is beading and no absorption of water over the feathers. In very dry conditions, this can be repeated for all chicks (e.g. once per day) for a number of days to encourage normal preening behaviour.

Any chicks that are found to be wet through to the skin should be considered not waterproof and not fit to fledge, and will require careful follow-up monitoring (e.g. further tests) and management (e.g. regular spraying or vet care, if considered necessary) following veterinary advice.

To avoid soiling chicks' plumage, the following measures should be taken:

- Handlers must always have clean hands, wear latex gloves, or use a clean, soft towel to contain the bird, so that there is no contamination of the plumage during handling.
- Handlers must avoid handling birds if they have applied any kind of product to their hands, such as moisturiser or sunscreen. Alcohol wipes and hand sanitisers should also be avoided, as these may remove the natural oils from feathers.
- Personnel that are involved in cleaning out burrows should not be handling birds at the same time.
- Feeders must have clean hands (i.e. no bits of fish food on the hand that holds the chick's head).
- Feeders should always be holding a chick's head forward, so that if a meal overflows during feeding it does not flow down the neck and breast feathers. Feeders must also be ready to let go of the bill immediately after the crop tube is withdrawn to allow a chick to project potential regurgitant away from its body.
- When cleaning a chick after feeding (if necessary), wipe forwards, **against** the direction of the feathers around the face, to prevent more feathers from becoming soiled.

11.7 Necropsy advice

There is a standard process that should be followed for any dead wildlife encountered.[4] Since seabird translocation methods are constantly evolving, it is normal practice to investigate all causes of death if it is clear that this was not a result of misadventure, by sending corpses for necropsy. However, it is also very useful to examine any chicks that have died through injury by a known cause, so that body condition can be assessed and any physiological abnormalities identified, as these could be related to diet and hence chick management at the release site. This would need to be clearly stated as an intention in the documentation that is sent to the pathologist.

It is important that protocols are in place for dealing with dead birds appropriately at the following levels:

- Immediate response—Inspect the corpse for any external signs of the cause of death, e.g. injury, missing feathers, staining (blood, faeces, regurgitant) around the vent or head region; inspect the burrow for signs of abnormal faeces or any regurgitant (collect any recent faeces and place in a plastic zip-lock bag); keep the corpse as cool as possible (avoid freezing) until it can be dispatched to Massey University for post-mortem examination.
- Dispatching the corpse to Massey University pathologists—Instructions on how to submit a specimen to Massey can be found at www.massey.ac.nz/massey/research/centres-research/wildbase/wildbase-pathology/pathology_home.cfm (viewed 1 May 2014). All corpses must be accompanied by a Wildlife Submission Form, from www.massey.ac.nz/massey/fms/NZ%20Wildlife%20Health%20Centre/huia_submission_form.pdf (viewed 1 May 2014). The laboratory should be phoned to check the suitability of the sending date (usually closed at weekends) and to advise staff of the pending arrival of the package.
- Interpreting and reporting pathology results—Consult with vets and seabird translocation specialists; include outcomes in annual reports for the benefit of subsequent projects.

[4] This process is outlined on the DOC intranet (http://intranet/our-work/biodiversity-and-natural-heritage/wildlife-health/need-help-with-sick-injured-or-dead-wildlife/dead-wildlife/) and can be obtained from your local DOC office.

12. Personnel

12.1 Experience requirements

The following sections highlight the need to involve a seabird expert, preferably with prior seabird translocation experience, in all projects (whether they are led by DOC or community groups).

In the first year of a project, consider employing a person with extensive experience to set up the system, train all personnel at the release site and provide advice should problems arise. In subsequent transfer years, it can be valuable to continue to involve the experienced operator because of the responsibility involved in making management decisions for each individual chick on a relatively large scale (e.g. meal plan and blockade removal). This continued involvement can be full-time or to a lesser degree in subsequent seasons, depending on the competency and time availability of the trained personnel at the release site.

12.1.1 Source colony

The minimum level of experience that is required at the source colony by one or more personnel is:

- Experience with the location of all relevant burrows at the source colony—This is usually required on the first visit to the site. This person is likely to be familiar with the colony through research or because they routinely visit as part of local DOC management. They should able to provide advice on terrain and potential risks to the colony (as well as all logistics associated with transport, accommodation, etc.).
- Extensive seabird handling experience, so that they can demonstrate all relevant bird handling/measuring techniques and all relevant damaged burrow repair/preservation methods.
- At least one banding permit holder (for the relevant species)—Banding cannot be undertaken at the site unless such a person is present.
- An experienced wing measurer—All personnel should calibrate wing measurements with the most experienced wing measurer to ensure that all measurements are made correctly and consistently.

Note: It is important that personnel visiting source colonies have a high level of fitness because all of the source colonies for these species have difficult boat landings; there is much walking involved to access different burrow sites on the islands; and the work involves long hours of constant kneeling activity.

12.1.2 Release site

Someone who has previous experience with artificial burrow installation will need to demonstrate the process of installing burrows at the release site and undertake quality control checks of all new burrows to ensure that they meet the required standards. It is important that burrows are installed correctly with respect to accommodating not only translocated chicks, but also future breeding pairs.

It is essential that someone who has previous experience with hand-feeding a closely related (and similar-sized) species is involved in the following circumstances:

- For any new species that has never previously been translocated; i.e. for any new small gadfly petrel species (e.g. black-winged petrel), a feeder should be employed who has former experience with either Chatham, Cook's or Pycroft's petrels.
- For any new release site, i.e. to train up the relevant personnel at the site. Although the team at the release site may already have previous experience with a different seabird species, they also need to become familiar with the different techniques that are used for the small gadfly petrels.

12.2 Labour requirements

The following sections are intended as a guide, and may vary depending on the proportion of project personnel that are highly experienced and familiar with the key locations.

12.2.1 Source colony recce trip

Allow up to 2 person-hours of burrow searching to find one chick that is suitable for transfer. This means that it could take 200 person-hours to find 100 chicks. The actual number of people required is dependent on their fitness and experience, and on the site logistics. A team of six personnel was required to find 182 Pycroft's petrel chicks (in 1500 burrows searched) over an approximate 5–6-day period in February 2013 (Gummer & Stewart 2013).

12.2.2 Source colony collection trip

The following labour requirements are recommended if collecting up to 100 chicks for transfer:

- Four to six people to band and select chicks—at least one, but preferably two, of whom should hold a current banding permit for the species.
- Four to six people to collect chicks on transfer day—one of whom should ideally have excellent wing measuring skills to make the final selection of marginal chicks that may be just too small or large for transfer.

Note: The actual number of people required is dependent on their fitness and experience, and on the site logistics.

12.2.3 Release site artificial burrow installation

As a rough guide, allow six people at least four full days to install 100 artificial burrows (a volunteer could be expected to install roughly three to four burrows per day), or longer if the site is difficult (slow) to access. Allow additional time to carry out quality control of new burrows and make adjustments as necessary.

12.2.4 Release site chick feeding and monitoring

Table 10 provides a breakdown of the labour requirements that are recommended if feeding/monitoring up to 100 chicks, using the recommended feeding regime presented in Tables 8 and 9, i.e. where a proportion of chicks are fed each day by a single feeding team (note that 50 chicks are likely to be the most that would be fed on any particular day). Other related tasks include assisting with food preparation/clean-up, end-of-day clean-up, data entry and meal planning.

Note:

- More personnel will be required on feeding days if the alternative approach is taken, whereby nearly every chick is fed on every third day. With this alternative regime, two feeding teams will be needed on a feeding day to feed up to 100 chicks, but only two people will be required on the in-between days to monitor chicks in burrows and deliver a small number of supplementary meals to lightweight chicks where required.
- The maximum number of suggested personnel would be required if the burrows were situated a fair distance from the feeding station, i.e. if the minimum number of chick handlers could not keep up with the pace of the feeder.

Table 10. Breakdown of the labour requirements for feeding and monitoring chicks at the release site.

WEEK	LABOUR REQUIREMENTS
1–2	• An experienced operator is required to set up the feeding regime for the first few days—it is preferable that this person is not part of the chick collection team so that they are fresh into the job. They need to be able to work long hours in the first few days and focus on making important decisions regarding the meal plans and welfare of each chick. • Three to four people (including the experienced operator) would be able to carry out feeding, monitoring and cleaning at the release site for the first two weeks. However, some of the team should have prior experience of seabird feeding regimes and routines, as there will not be enough time to train three completely inexperienced operators when there are 100 chicks to manage.
3	• A total of three people (including the experienced operator) would be able to feed and monitor burrows in the third week—chicks will be fledging from week 2 onwards. However, it may pay to have a fourth person on standby for the third week (or part of the third week) in case the transfer contains a large proportion of younger chicks.* (Note: One team of three experienced people is sufficient to feed and monitor 70 Chatham petrel chicks and 70 Pycroft's petrel chicks.)
4	• A minimum of two people (including a contractor) would be able to feed and monitor burrows in the fourth week. However, it may pay to allow for a total of three personnel for part of the final week, in case the transfer contains many younger chicks. One person could then leave when there are only a few chicks remaining, providing that the two left behind to complete the project are experienced personnel. (Note: The final two feeders would be monitoring chicks daily, but could feed all remaining chicks on the same day.)*

*'Non-feed' days can be scheduled at some stage in the third feeding week (refer to section 9.5.9—'Non-feed' days).

13. Data collection and reporting

13.1 Source colony recce trip records

Sample forms for recording data from chicks that are handled during recce trips to the source colony can be found in section 10.1 of the field guidelines (Gummer et al. 2014a).

The primary data that need to be recorded on a recce trip are:

- Burrow number, location (mapped) and access to the chick, so that the chick can easily be found on the collection trip
- Chick wing measurements to help plan the transfer date(s)

13.2 Source colony collection trip records

Sample forms for recording data from chicks that are handled during collection trips to the source colony can be found in section 10 of the field guidelines (Gummer et al. 2014a).

The primary data that need to be recorded when selecting chicks prior to transfer day are:

- Wing length, weight and number of days until transfer, to assess the suitability of the chick for transfer
- Burrow number and location (mapped), and band number of any chick that is suitable for transfer

Note: Field notebooks need to be prepared for each handler prior to each chick handling day, and these should include the wing length guide to allow the suitability of chicks handled on each day leading up to the transfer to be determined (e.g. see Table 4).

The primary data that need to be recorded when collecting chicks on transfer day are:

- Natal burrow number, band number, presence of adults and fence status (burrow entrance)—also recorded on the transfer box.
- Wing length, weight and whether or not the chick is transferred. Recording the weight on the transfer box can help managers at the release site to decide whether or not chicks require oral fluids on arrival at the release site. For Pycroft's petrels, oral fluids are not delivered to chicks >250 g that are known to have been fed by parents on the night before transfer (to avoid triggering regurgitation).

13.3 Chick feeding and measurement records

Sample forms for recording data from chicks that are handled/hand-fed at the release site can be found in section 10 of the field guidelines (Gummer et al. 2014a). Data for each chick should be recorded on a separate page, so that the chick's progress can be followed each day in the field.

These record sheets, which need to be prepared before the transfer date, should be held at the feeding station and may or may not need to be waterproof, depending on the type of shelter used. They are usually transported off site each day and used to plan for the next feeding day. The processing that is to occur for each chick on the next day is then clearly indicated on their respective page of records. (For example, the size of the planned meal; circling the 'wing (mm)' box to indicate that wing measurement is due.) To avoid confusing the feeding team, only complete records for the next day, rather than any dates further out.

Note: The predetermined (planned) meal size is filled in on the afternoon/evening before, and the amount that was successfully fed is filled in on the actual feeding day.

Data need to be entered into Excel spreadsheets—preferably on the same day or every other day—for eventual data analysis and backup purposes. This is important in case the original data are lost or damaged, as each chick will be on an individual meal and blockade management plan.

An example of a chick feeding calendar that can be used to help with the planning of chick feeding days can be found in section 10.4 of the field guidelines (Gummer et al. 2014a).

13.4 Chick emergence behaviour and fledging records

A separate waterproof notebook is required to make daily records of fence status at each burrow (indicating whether or not the chick has emerged the previous night) and chick presence/absence following chamber inspection. These records should then be copied immediately onto the individual chick record sheets (at the feeding station) so that they can be readily referred to at feeding time and copied into Excel spreadsheets each day.

When recording fledging data:

- Record fledging date as the date on which the burrow is found empty. (If using the day before the burrow is found empty as the fledging date, this should be stated in all documentation.)
- Assign missing chicks into one of the following three groups, based on what you know of the features of the site and each individual chick (refer to section 10.4.2—'Assessing fledging success' and section 10.5—'Missing chicks'):
  - **Chick likely to have fledged** at a later date and from an unknown location. These are chicks that have gone missing before completing the normal emergence period (10 or more days), but are close to meeting fledging parameters, and have enough reserves to last to the estimated fledging time and to still depart within the known fledging weight range for the species. There must also be plenty of safe, sheltered areas for such chicks to 'hole-up' under until final departure.
  - **Chick likely to have perished** before or during fledging because its weight was at, or predicted to fall below, the known fledging weight for the species before its estimated fledging time.
  - **Fate of chick is unknown** because it disappeared at a weight that greatly exceeded the normal fledging weight range and has the potential to survive to and after fledging, but only if it can find a safe, sheltered area to 'hole-up' under until final departure. If a site contains no such safe, sheltered areas and the chick cannot return to its burrow, it is likely that it will have dropped prematurely to sea as it attempted to move away from an environment in which it felt exposed/vulnerable (e.g. if it fell outside a fenced area or down a steep bluff).

13.5 Analysis of chick data

When analysing chick fledging data, it is recommended that the data from chicks that have gone missing from their burrows prematurely are analysed separately from the data from chicks that are presumed to have fledged successfully. With every transfer, there is likely to be a small proportion of chicks that are far too heavy to have actually fledged when they disappeared (i.e. they are likely to be 'holed-up' elsewhere at the colony site before finally departing on an unknown date), and a small proportion of lightweight chicks that disappear from their burrows well before expected and are compromised at fledging time (i.e. die before or shortly after fledging).

The fledging data for such chicks (fledging weight and wing length, emergence periods, and time spent at the release site) will be unknown, as the final dates of departure cannot be established.

Therefore, the last data that were recorded for these chicks should not be included in the analysis, as they will bias the average fledging data, which, in turn, will make annual comparisons meaningless and targets difficult to set. (Note, however, that trimming exceptionally light and heavy chicks from the data can give 'expected' data, and so must be done carefully and only if those chicks are presumed to have perished (too young) or departed at much later dates (too heavy and downy to have departed).)

Note: No matter how experienced the team, the premature disappearance of lightweight chicks can rarely be completely avoided, and so there is no issue with declaring that this is suspected to have happened to a proportion of chicks. The inclusion of such information can give a clearer picture of project success when assessing the proportion of chicks that eventually return as adults.

At a minimum, the analysis of chick transfer and fledging data should include the sample size, mean, standard deviation and range for the following parameters:

- Transfer weight and wing length on transfer day or the day after transfer day (aim to be consistent between transfer years with when these measurements are taken).
- Fledging weight on the day before the night of departure—Use the pre-feed (base) weight and indicate whether the chick received a final meal on the day before transfer. Data collected more than a day before fledging can be extrapolated, based on individual daily weight loss rates.
- Fledging wing length on the day before the night of departure (or sooner than this if the wing had stopped growing).
- Down cover at the time of fledging—This can be useful if it has not previously been recorded for the species.
- Emergence periods—Include the night of fledging as an emergence night (e.g. a chick fledging on its second night out of the burrow had an emergence period of two nights).
- Total time spent at the release site.

Note: Some projects also record the total volume of artificial food that each individual chick received, as this can help with ongoing diet research/development.

All of the above tend to be cross-referenced when birds start to return as adults, and this information is important as it helps with the further refinement of protocols for subsequent projects.

14. Post-release site management

14.1 Managing vegetation

Vegetation may need to be managed annually at the artificial colony site to ensure that there are open, safe areas where birds can land, i.e. that are free of dense scrub that birds can become entangled in. This is especially important at sites where vegetation is planted/regenerating, and may involve:

- Thinning some areas of understorey in a forest situation so that birds can safely drop through the canopy to the forest floor. When thinning plants, it is important to allow for regeneration at the site by leaving small patches to naturally self-thin and avoiding removing all of the saplings, so that some can eventually replace the canopy cover and provide future take-off trees.
- Weed-eating grassy, low-scrub areas, so that birds can move easily on the surface to reach their burrows.
- Removing plant threats such as thistles, brambles, gorse (*Ulex europaeus*) or other thorny plants (i.e. plants that could injure the birds) in the vicinity of burrows.

14.2 Maintaining sound systems

Sound systems need to be regularly checked, preferably at night, to ensure that they are functioning and to check the volume:

- The volume should be loud enough that birds passing at sea can hear the sounds during unfavourable weather conditions. The system not only needs to provide a focus for returning birds, but should also be able to draw in new immigrants.
- The volume should not be so loud that it is distorted and causes discomfort (to people) when listening.
- When translocated chicks are in residence, reduce the volume to make it more comfortable for the emerging chicks. The volume must then be returned to normal levels once the chicks have all fledged, however, i.e. before the start of the next breeding season. (Note: Although returning adults can choose where they nest in relation to the sound system, transferred chicks are allocated to burrows and so must not be discouraged in any way from returning to them during the emergence period.
- At sites where more than one sound system is playing (i.e. different calls are being played to attract different species to different areas within the same site), careful consideration must be given to the respective volume of each system to ensure that one does not compromise the other, i.e. one system must not dominate over the other, as the target species of the quieter system may not hear the broadcast calls of their species.

14.3 Preparing burrows for the next chick transfer

Open lids to air the burrows and leave them exposed to sunlight for several days where possible to help freshen them before the next season's chick transfer. This must be done after the last transferred chicks have departed and before any adults might return to nest prospect.

14.4 Preparing burrows for returning adults

Returning birds can be monitored most effectively in artificial burrows. Therefore, the artificial burrows need to be maintained on a regular basis. Priority tasks prior to the start of the breeding season are:

- Ensuring that chambers and entire tunnel lengths are free of blockages/obstacles before birds are expected to return at the start of the breeding season. Nest material is best left undisturbed in most burrows so that the scent of birds remains as an attractant to prospecting adults. With regard to hygiene, there is time for the burrows to 'fallow' before birds return for the next breeding season. However, vets recommend that all burrows are aired (exposed to sunlight if possible); the burrow nesting material is removed after a transferred chick has fledged if there have been any health issues; or the burrow is replaced, or at least thoroughly disinfected, if the transferred chick died from an infectious disease.
- Clearing around the burrow entrances so that they can easily be seen and erecting stick fences to monitor burrow activity (refer to section 15.4.1—'Burrow monitoring method').
- Clearing the tops of burrows so that they can easily be found and inspection lids can be lifted without debris falling in on the birds.

Avoid building any nests, as the presence of new nesting material that has been dragged into the burrow (along with feathers and droppings) is a good indicator of adult presence.

15. Post-release monitoring

15.1 Purpose

Post-release monitoring informs future management about translocated populations and can help to answer questions such as (Parker et al. 2013):

- Will the reintroduction be successful?
- Is management needed/sufficient?
- Will supplementary translocations be needed?
- Is genetic diversity sufficient?
- Do the translocation techniques need to be refined?
- Does release site selection need to be refined?

Post-release monitoring and reporting also informs stakeholders from source locations that 'their' birds have been well taken care of.

Monitoring must also relate back to the operational targets in the translocation proposal. The design of post-release monitoring needs to match the questions you are trying to answer and the subsequent intended use of the data.

The need for monitoring is related to uncertainties about the translocation. As mentioned in the Introduction, no translocation project to date involving these species in New Zealand can be considered to have successfully established a self-sustaining population (i.e. long-term success is yet to be achieved). In addition, it should be noted that annual increases in the number of active burrows may be slowed down or prevented by other factors (e.g. interaction with other colonies, especially if large populations are in close proximity to the release site; food supplies at sea; climate variability). For example, Gardner-Gee et al. (2008) reported that the average number of active burrows in a remnant population of grey-faced petrels on Motuora Island remained the same over a 10-year period from 1995, and that there was also no significant growth in the population in the following two years, indicating that population growth was extremely slow (if occurring at all) at that site.

Post-release monitoring can be used to determine where translocations have failed (Fig. 10), whether a different management approach would prevent failure if the species was translocated to the same site again and, if not, the feasibility of future translocations.

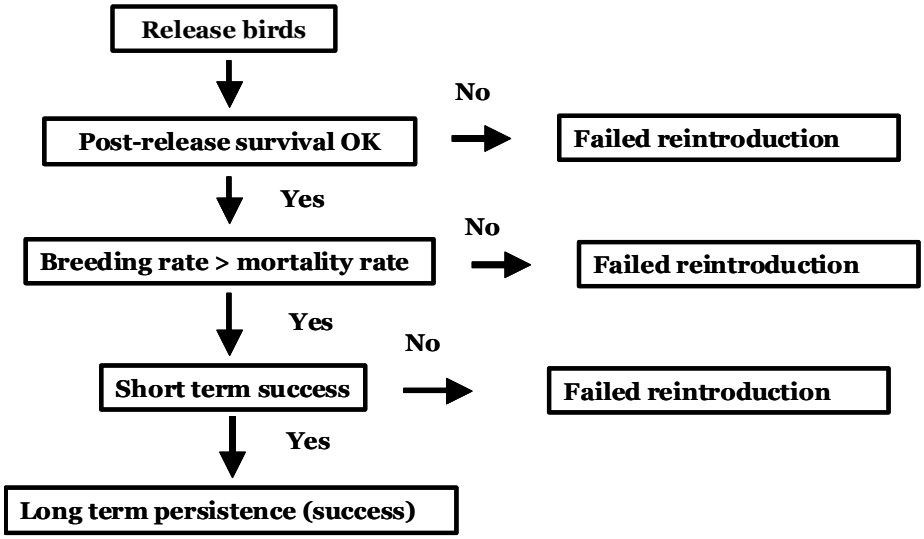
On the other hand, successful translocations provide useful information for similar projects in the future.

15.2 Monitoring objectives

To assess project success, the release site should be monitored on a long-term basis (i.e. in the order of decades) until the new colony is considered to be self-sustaining (see section 15.1—'Purpose').

Basic monitoring tends to include:

- Identifying adults (to determine return rates of translocated birds)
- Banding new immigrants (to determine the proportion of new immigrants to birds that fledged from the site)
- Marking all burrows found (to establish breeding outcomes)
- Banding chicks (to facilitate future monitoring of birds of known age and origin)



Note: Long-term persistence (success) for these small gadfly petrel species is presumed to be a trajectory of the number of breeding pairs increasing annually, especially once all the initially transferred F1* birds have returned (which may take over 10 years). The colony is on course to be self-sustaining once the first chicks that were bred at the release site return to breed, i.e. F2 birds are producing F3 generation birds (no sooner than 6 years after the first transfer). Anticipated population growth rates, however, should realistically reflect those of other wild populations of the species (e.g. the source population).

* 'F1' is the founder generation, i.e. the birds that were originally transferred; 'F2' are the offspring of the founder (F1) generation, i.e. chicks bred at the release site; and 'F3' are the offspring of the F2 generation.

Figure 10. Determining the success or failure of a translocation (adapted from Parker et al. 2013).

Monitoring may also need to include an assessment of:

- Gender balance (if no breeding has occurred within an expected timeframe)
- Genetic diversity in later years (project dependent and only if considered necessary based on specialist advice). It is considered that only one new migrant into a subpopulation (e.g. colony) would be required per generation to maintain genetic diversity (Mills & Allendorf 1996); this would equate to approximately once every decade for these species.

15.3 Monitoring for returning adults at the source colony

Monitoring the source colony for any birds that may return there (instead of to the release site) is not a requirement of the translocation project. Therefore, it can be undertaken on an opportunistic basis, i.e. during ongoing research at specific source colonies.

15.4 Monitoring for returning adults at the release site

15.4.1 Burrow monitoring method

Artificial burrows can be monitored for returning adults by carrying out daytime inspections of fences that have been erected at the burrow entrances. Fences need only consist of a couple of thin sticks, which should not be too firmly set else they may deter birds from entering their burrows. When fences are knocked down, chambers can be inspected for signs of activity: a bird; the presence of fresh nesting material; petrel feathers; and/or petrel excreta. There may also be evidence of fresh digging near burrows.

15.4.2 Monitoring timeframes

The earliest age that small gadfly petrel chicks (translocated and non-translocated) have been known to return as adults is at exactly 2 years old:

- Chatham petrels have returned in April/May exactly 2 years after fledging in May/June.
- Cook's and Pycroft's petrels may return in February/March 2 years after fledging in March/April. However, this is unknown, so projects could expect the arrival of birds earlier than February in the second season.

However, it is more common for birds to first return to the colony towards the end of their third year, or in any year after that:

- Chatham petrels normally return to the colony for the first time from January (i.e. mid-breeding season) onwards 2.5–3 years after fledging. They then start to look for a burrow and mate so that a first breeding attempt can be made the following season in their fourth year.
- Although no data are available, Cook's and Pycroft's petrels could be expected to return to the colony at a similar point in their breeding season (e.g. November) from 2.5–3 years after fledging.
- Therefore, the first monitoring for returning adults can effectively commence during the second breeding season following the first chick transfer, i.e. one whole season can be missed.

Breeding birds of all species will arrive within the first two months of the known season, while mature non-breeding birds can arrive at the colony in any month during the breeding season:

- Mature Chatham petrels (breeders and non-breeders) can arrive at the colony in any month from November onwards (see Rayner et al. 2012).
- Mature Cook's petrels can arrive at the colony in any month from September onwards, although calls have been heard at the colony prior to this in August (M. Rayner, pers. obs. 2012).
- Mature Pycroft's petrels can arrive at the colony in any month from September onwards (M. Rayner, unpubl. data 2012).

Monitoring for returning adults tends to overlap with the last chick transfers:

- Any burrows that are suspected as being visited by adults should not be used to accommodate a transferred chick.
- Any adult that is found in a burrow by day with a transferred chick, or in a burrow that belongs to a transferred chick that has prematurely disappeared (i.e. is not yet ready to fledge), should be placed in a spare, unoccupied artificial burrow elsewhere in the colony.

15.4.3 Daytime burrow monitoring frequency

Weekly checks of stick fences at the entrances of burrows throughout the season should pick up any sign of visiting adults and general burrow activity patterns. Inspections of active burrows will reveal the status of individuals (breeding or non-breeding). The frequency of checks can be decreased or increased depending on site logistics and project objectives.

More frequent monitoring will help to pick up more regular bird activity, and will narrow down the key dates for breeding activity (pre-laying exodus periods, egg-laying dates, hatching dates).

Activity is likely to start quite slowly during the very first monitoring year, with signs of first visits possibly occurring mid season rather than at the start of the season, as immature birds tend to arrive a little later when they first return to land.

Refer to section 15.4.5—'Handling burrow occupants for identification' for recommended handling times.

15.4.4 Night-time monitoring

Night-time monitoring is not essential for identifying the majority of returning adults, as most eventually become breeders and can be found in burrows by day during incubation. However, night-time monitoring may be useful for the following birds:

- Non-breeders, which may not stay in burrows during the day or may do so only on random occasions, making them difficult to catch if burrow monitoring is not carried out daily. Therefore, some night work may be required to catch such birds if wanting to obtain their identities as soon as possible (as opposed to waiting for a subsequent season when these individuals might be breeding).
- Breeders that may have been missed during the prospecting or incubation periods. These birds can be identified at night during the rearing phase.

Chatham, Cook's and Pycroft's petrels are generally more tolerant of disturbance than many other species and are therefore less likely to be deterred from returning to the colony site or using burrows if captured at night. However, because they also show a strong affinity to the site/burrow from which they fledged and a high rate of artificial burrow use, there is not as much to gain from night searches as there may be with some other species.

15.4.5 Handling burrow occupants for identification

If a weekly (or more frequent) burrow monitoring regime is carried out, the breeding status of burrow occupants will become clear as the season progresses, allowing a decision to be made about when birds can be handled for identification.

Small gadfly petrels are fairly tolerant of handling during the breeding season and are not likely to desert a burrow as a result of handling **unless** they are in the very early stages of prospecting (e.g. an unpaired bird making a first visit to a burrow), or potentially during very early incubation.

The safest time to handle adults for identification is when they arrive at the colony for the pair-bonding/copulation (prospecting) period, prior to the pre-egg-laying exodus. However, the only hope of catching birds by day during this period is if burrow inspections are made on a daily basis, which is not feasible at many release sites. Consequently, it is becoming more common to identify adults during the incubation or brooding (guard) phase, when birds are guaranteed to be present in burrows by day. However, it should be noted that this is a **high-risk procedure** that can result in egg (or chick) damage.

When scheduling adult identification to occur during the incubation period:

- Choose a period during the peak incubation time to identify as many adults as possible in one trip (e.g. mid- to late January for Chatham petrels; early to mid-December for Cook's petrels; late December for Pycroft's petrels).
- Ensure that handlers are experienced at extracting eggs and incubating birds from burrows, and returning eggs and birds to burrows. If necessary, seek assistance or advice from a seabird specialist.
- Visibly mark all birds (using Twink (correction fluid) on the head) so that they are not handled a second time.
- Schedule a second trip 5–10 days later to catch the partners that take over for the next incubation shift. This may required several repeat trips.

Alternatively, birds can be targeted for capture at night (refer to section 15.4.4—'Night-time monitoring') during the rearing period (post-guard phase). Handlers need to be aware that it may take at least 1 week to catch a pair, as they do not visit nightly, and that incoming adults may have a high chance of regurgitating if captured before they have fed their chick. Consequently, it is best practice to capture such an adult after it has fed its chick, so that any small chicks do not miss out on an important meal.

15.4.6 Using protected species detector dogs to find natural burrows

If it is suspected that birds are using natural burrows rather than artificial burrows, a dog search using a trained protected species detection dog and handler can be attempted to find these burrows. Such a search effort will be more cost-effective if timed for when it is likely that several burrows can be found (e.g. 3+ years after the final transfer), rather than in the earlier years of post-transfer monitoring when fewer birds have returned.

For more information, contact the Protected Species Dog Programme Supervisor, National Office, DOC, Wellington, or conservationdogs2@doc.govt.nz.

15.4.7 DNA sexing of returning adults

DNA sexing has a high level of accuracy and can be carried out using blood or feather samples. It usually takes at least a week to obtain the results, however.

Feather sampling is the least invasive and most commonly used method for gender assignment of returning adults in seabird translocation projects, if required (refer to section 3.2.2—'Genetics and gender'). The quill tip of the feather (where it contacts the skin) is the most important section of the feather, meaning that the feather must be plucked, not cut—'down only' or cut feather samples are unlikely to yield DNA.

Blood sampling for sexing would only be considered if samples needed to be taken for other purposes (e.g. health diagnostics or genetics).

Information on how to obtain blood or feather samples can be found in DOC's avian blood/feather and reptilian tissue sampling SOP (DOC 2010).

15.4.8 Keeping burrow monitoring records

It is important that you keep records of the location and activity of all burrows at the artificial colony, including all dates of burrow checks/inspections; and all details about fence status, occupants (all species) and signs of activity. These data will be useful in subsequent monitoring years. Refer to section 10.5 of the field guidelines (Gummer et al. 2014a) for an example of a monitoring form.

16. References

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17. Additional sources

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18. Further reading

The following paper summarises all seabird translocations that have been carried out in New Zealand up to 2008, and provides good background information within a national context:

Miskelly, C.M.; Taylor, G.A.; Gummer, H.; Williams, R. 2009: Translocations of eight species of burrow-nesting seabirds (genera *Pterodroma*, *Pelecanoides*, *Pachyptila* and *Puffinus*: Family *Procellariidae*). *Biological Conservation 142(10)*: 1965–1980.

19. Glossary

Extirpated—Locally extinct. The species no longer exists in a particular geographic area, although it still exists elsewhere.

Gadfly petrel—Medium to large petrel that generally has a short, deep and heavily hooked bill; and nostrils that are encased in a tube and joined at the base of the bill. Many species give high-pitched repetitive calls across the breeding grounds at night (Heather & Robertson 2000[8]). Most species are dark above and pale or white below. Sexes and ages are alike in appearance, with males slightly larger than females. Under-wing patterns are often distinctive between species. Generally oceanic, rarely being seen near land except during the breeding season. Many species are highly migratory with two distinct foraging zones, one of which is used during the breeding season and the other outside the breeding season (birds may not feed during the journey between the two feeding grounds); e.g. Chatham, Cook's and Pycroft's petrels. Other species may be technically non-migratory yet highly dispersive, foraging across all waters within their known range with no distinct foraging zones during and outside the breeding season; e.g. grey-faced petrels and Chatham Island tāiko (adapted from Heather & Robertson 2000).

Necropsy—The post-mortem (after death) examination of a specimen to detect abnormalities and determine the cause of death.

Philopatric—Tending to return to the same area. Species that return in consecutive years to the same breeding site or territory exhibit breeding philopatry or site fidelity.[9]

Procellariidae—The largest and most diverse family of seabirds; includes a wide variety of species, from giant petrels to diving petrels and gadfly petrels (*Pterodroma*). All have distinctive external nostrils that are encased in a tube on the top or sides of the bill. In the New Zealand region, 49 species have been recorded, including 11 endemic species and 23 other breeding species (Heather & Robertson 2000).

Recce trip—A reconnaissance trip, which is carried out to obtain information.

Self-sustaining population—A population that is able to increase and/or maintain itself without additional management.

Supplementation—The addition of individuals to a population that is already present at the release site. Also referred to as enhancement, re-enforcement, re-stocking, enrichment or augmentation (based on the definition in IUCN (1995).[10])

Translocation—The managed movement of live indigenous plants or animals (taonga) from one location to another. Translocation covers the entire process, including planning, the transfer, release, monitoring and post-release management (up to some predetermined end point). A translocation can consist of one or more transfers.

Transfer—The part of the translocation that involves the physical movement of plants or animals from one location to another and their release or planting at the new site.

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[8] Heather, B.D.; Roberston, H.A. 2000: The field guide to the birds of New Zealand. Penguin Books, Auckland.

[9] Taken from the Free dictionary: http://encyclopedia.thefreedictionary.com/philopatric (viewed 1 May 2014).

[10] IUCN 1995: IUCN/SSC guidelines for re-introductions. Prepared by the SSC Re-introduction Specialist Group, Approved by the 41st Meeting of the IUCN Council, Gland Switzerland, May 1995. http://intranet.iucn.org/webfiles/doc/SSC/SSCwebsite/Policy_statements/Reintroduction_guidelines.pdf (viewed 1 May 2014).

Appendix 1

Details of the contributers to and reviewers of this document

This document was contributed to by experts with extensive experience in Chatham, Cook's and/or Pycroft's petrel translocations:

- Helen Gummer (authored and co-compiled this information)—Seabird translocation specialist employed by the Department of Conservation (DOC) and community groups
- Graeme Taylor (authored and reviewed this information)—Seabird translocation specialist; Principal Science Advisor, Transformation and Innovation Unit, Science and Capability Group, DOC; and former Manager of the National Banding Office, DOC
- Rose Collen (co-compiled this information)—Translocation specialist with experience in shorebird and seabird translocations, and contractor to DOC

This document was reviewed by experts with translocation experience for other seabird species or translocation process experience, or who have conducted research at the source colony locations:

- Mike Bell—Wildlife Management Consultant with Wildlife Management International Ltd and Secretary of the Taiko Trust [11,12]
- Pam Cromarty—Former Technical Advisor, Systems Improvement, DOC
- Dr Robin Gardner-Gee—Former project manager Motuora Restoration Society seabird translocation projects
- Dr Matt Rayner—Seabird specialist, particularly small gadfly petrels (*Pterodroma*); Centre of Biodiversity and Biosecurity, School of Biological Sciences, University of Auckland

It was also reviewed by a writer of translocation proposals, who is part of the target audience for the document:

- Denise Fastier—Ranger and Team Leader for Boundary Stream Maungaharuru, DOC

Any new information or suggested improvements to this document can be sent to:

- Troy Makan (coordinator of DOC's translocation process)—email: tmakan@doc.govt.nz.

[11] For more information, refer to www.wmil.co.nz (viewed 1 May 2014).

[12] For more information, refer to www.taiko.org.nz/index.html (viewed 1 May 2014).

Appendix 2

Photographs illustrating aspects of New Zealand seabird translocations

A. Sound system speaker on Matiu/Somes Island. The burrows with rocks on have been visited by prospecting adult fluttering shearwaters. *Photo: D. Cornick*.

B. Example of mesh blockade used to block entrance of diving petrel burrow. *Photo: H. Gummer.*

C. Animal carry box with three compartments used to transfer small burrow-nesting seabird chicks (e.g. Pycroft's petrels) in New Zealand. Exterior walls are white. Note: use less tape than seen here to fix matting to floor so as to optimise drainage of excrement. *Photo: H. Gummer*.

D. Collecting a fluttering shearwater chick from a burrow for feeding; note weather-proof carry box to transport the chick to a feeding station. *Photo: D. Cornick*.

E. Hand-feeding fluttering shearwater chick on Matiu/Somes Island; note yoghurt maker for warming food. *Photo: D. Cornick*.

F. Hand-feeding fluttering shearwater chick on using plexi syringe and custom-made Teflon crop tube. *Photo: D. Cornick*.