



Best practice techniques for the translocation of grey-faced petrels (*Pterodroma macroptera gouldi*)

Helen Gummer, Graeme Taylor, Rose Collen, Tamsin Ward-Smith and Cathy Mitchell



Note: The names of islands used in this report may not be the official names as gazetted by the New Zealand Geographic Board. Some of the islands mentioned do not have official names.

Cover: Grey-faced petrel (*Pterodroma macroptera gouldi*). Photo: Unknown of Friends of Matakohē-Limestone Island.

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Published by the Terrestrial Ecosystems Unit, National Office, Science and Capability Group, Department of Conservation, PO Box 10420, The Terrace, Wellington 6143, New Zealand.

Prepared by the Publishing Team, National Office, Department of Conservation, PO Box 10420, The Terrace, Wellington 6143, New Zealand.

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Best practice techniques for the translocation of grey-faced petrels (*Pterodroma macroptera gouldi*)

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Abstract

This document outlines best practice techniques for the translocation of grey-faced petrels (*Pterodroma macroptera gouldi*). 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 grey-faced petrels.

Keywords: grey-faced petrel, northern muttonbird, *Pterodroma macroptera gouldi*, Chatham Island tāiko, *Pterodroma magentae*, gadfly petrel, translocation, best practice, New Zealand

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Gummer, H.; Taylor, G.; Collen, R.; Ward-Smith, T.; Mitchell, C. 2014: Best practice techniques for the translocation of grey-faced petrels (*Pterodroma macroptera gouldi*). Department of Conservation, Wellington. 94 p.

1. Introduction

This document is intended to be read in conjunction with the field guidelines for burrow-nesting petrel and shearwater translocations (Gummer et al. 2014b). 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 grey-faced petrels (*Pterodroma macroptera gouldi*) and for those assessing translocation proposals.

Grey-faced petrels (*P. macroptera*) are also sometimes known as great-winged petrels, oi or northern muttonbirds. They are medium-sized seabirds that are amongst the larger species of the genus *Pterodroma*, which are frequently termed gadfly petrels. There are two subspecies: *P. m. macroptera* and *P. m. gouldi*. The latter is a common New Zealand endemic that is classified as Not Threatened under the New Zealand Threat Classification System¹ (Miskelly et al. 2008).

The grey-faced petrel is closely related to, and shares similar biological traits (physiology, breeding biology and diet) with, another large gadfly petrel, the Chatham Island tāiko (*P. magentae*), which has a threat status of Threatened—Nationally Critical (Miskelly et al. 2008). Due to these similarities, translocation projects involving either of these species can be approached using similar methodologies—in fact, the grey-faced petrel has been studied as an analogue species to the tāiko with respect to researching and developing management techniques for the rarer species. However, there is one key difference between these two species that influences some of the techniques used with each (primarily feeding regimes): grey-faced petrels are winter nesters and rear chicks through early summer, whereas tāiko are summer nesters with a chick-rearing period that runs into early winter. In addition, grey-faced petrels are considered to be non-migratory yet highly dispersive, while Chatham Island tāiko appear to show both migratory and highly dispersive behaviours.

The methods described here are based on techniques that have been tested and refined during two grey-faced petrel translocation projects—Taranga (Hen & Chickens Islands) to Matakoho-Limestone Island (2004-2008) and Moutohora (Whale) Island to Cape Sanctuary (Hawke's Bay) (2008-2011)—as well as prior feeding trials listed in Table 1. Although these are recommended as current best practice techniques, the grey-faced petrel has proven a difficult species to translocate, and the methods still need to be refined to the level where health issues are minimal and all transferred chicks fledge in optimum condition with fledging parameters that reflect those of naturally raised chicks. The techniques documented here will evolve further as information from future translocation projects becomes available.

Specific information relating to the translocation of Chatham Island tāiko is not detailed in this document because protocols for this species are already documented in the Taiko Operations Manual (Gummer & Palmer 2009). However, some of the methods employed for tāiko are described in this document where it is considered that the information could be applied to another large *Pterodroma* species.

This document may also be useful as a starting point for those planning translocations of other similar-sized burrow-nesting petrels and shearwaters that share similar biological traits and have not yet been translocated, e.g. white-naped petrels (*P. cervicalis*) and white-headed petrels (*P. lessonii*). Translocation of the Kermadec petrel (*P. neglecta*) would require a very different approach, however, as it is a surface-nesting species—although it may share similar diet requirements.

¹ For definitions of threat categories, see the New Zealand Threat Classification System manual (Townsend et al. 2008): www.doc.govt.nz/publications/conservation/nz-threat-classification-system (viewed 1 May 2014).

Anyone considering a translocation of mottled petrels (*P. inexpectata*) should refer to both this document and the Chatham (*P. axillaris*), Cook's (*P. cookii*) and Pycroft's (*P. pycrofti*) petrel translocation techniques document (Gummer et al. 2014a) 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 translocation² 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 population of grey-faced petrels (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 respond to their needs accordingly.

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 one 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.

² For definitions of key terms in this document, refer to section 17—'Glossary'.

- 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 grey-faced petrels to specific release sites are primarily to:

- 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.

Note: The establishment of additional self-sustaining populations of this species at safe locations with the aim of increasing the long-term security or recovery of the species would not be considered a primary objective because this species is classified as Not Threatened (Miskelly et al. 2008), with an IUCN status of Lower Risk—Least Concern (Taylor 2000). However, in 2011, a project did commence with the aim of salvaging a small colony that inhabited a vulnerable (eroding) location by re-establishing it approximately 20 km away in a predator-free reserve (Sawyer & Fogle 2010).

2.3 Gadfly petrels

The grey-faced petrel is in the order Procellariiformes, family Procellariidae, and is grouped within the genus *Pterodroma*, which are frequently termed gadfly petrels. Grey-faced petrels have the following key biological traits:

- Size and morphology—Medium-sized species ranging from 500 g to 600 g (average c. 550 g).
- Migratory behaviour—Non-migratory; travel long distances to the Tasman Sea (East Australia) and South Pacific. Unlike the migratory gadfly petrels, grey-faced petrels forage across all waters within their known range at sea and are thus considered highly dispersive rather than migratory, i.e. they do not have two distinct foraging zones during and outside the breeding season.

- Foraging behaviour—Pelagic; feed far from the coast in deep oceanic water, where they prey on squid and fish, and bioluminescent species during nocturnal foraging; generalist surface feeders.
- Breeding habitat requirements—Excavate burrows under coastal forest or shrub canopy; tree-climbing ability (for take-off) when required.
- Colony visitation patterns—Nocturnal; seasonal, with breeding season visitation (April-December) commencing during the austral winter.
- Breeding biology—First arrival at the colony between mated pairs is not as synchronised as for migratory gadfly petrels; long pre-laying exodus period (up to 60 days), when no visitation of the breeding burrow occurs (males return earlier); single egg; long incubation shifts (8-23 days) by each parent and long incubation phase (c. 55 days).
- Chick-rearing behaviour—Short brood phase (1-3 days); long chick-rearing period (c. 108-128 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 usually only occurs from when the chick declines food (if this happens).
- Chick emergence behaviour—Exercising; finding take-off points; site-fixing.
- Site fidelity—Strong; return to their fledging burrow (or nearby burrow) as an adult.

Chatham Island tāiko share many of the above biological traits with grey-faced petrels, although a key difference is the time of year at which each species breeds. Consequently, translocation projects involving tāiko are generally approached in a similar way to those involving grey-faced petrels, although they appear to respond to transfer and hand-feeding in a different way from grey-faced petrels due to the time of year when they are rearing chicks.

Tāiko have a body weight of 450-550 g (average c. 475 g). Like grey-faced petrels, they are also considered to be highly dispersive, mainly travelling to the eastern Pacific Ocean during their non-breeding season and visiting the colony during the austral summer (September-May). They have a pre-laying exodus of up to 50 days and incubate eggs for c. 55 days. There is a short brood phase of 1-3 days and the chick-rearing period is slightly shorter than for grey-faced petrels. Parents may desert chicks up to 23 days before fledging (Johnston et al. 2003), or they may continue to visit the burrow until the chick has departed.

2.4 Related research

Grey-faced petrels have been subject to many studies involving the artificial rearing of chicks. This species was primarily chosen to be used in hand-feeding trials of seabird chicks to:

- Develop hand-feeding and other husbandry techniques that could then be applied to the closely related, Nationally Critical Chatham Island tāiko, as recommended by the Chatham Island Taiko Recovery Group (e.g. hand-rearing of abandoned chicks; translocation of chicks to predator-free sites).
- Develop hand-feeding and translocation techniques to allow the grey-faced petrel to be a founder species in seabird-influenced ecosystem restoration projects.

Note: The history of grey-faced petrel chick hand-rearing trials, translocations and diet development can be obtained from the authors of this document.

Other grey-faced petrel studies to date include:

- Research into the breeding biology of the species, which has been carried out in at least two different locations: Moutohora (Whale) Island (Imber 1976; Johnstone & Davis 1990); and Te Henga (Bethells Beach) (G. Taylor, ongoing).

- A Master's study on chick growth rates and parental feeding regimes from hatching to fledging on Te Hāwera a Maki/Goat Island, Motuora Island and Tiritiri Matangi Island (R. Dunn, University of Auckland, pers. comm. 2012).
- A basic banding and monitoring study on Mount Maunganui by the Ornithological Society of New Zealand (ongoing).
- A study into the population demographics on Ruamāhuanui Island in the Aldermen Islands (Ruamaahu) by Landcare Research (www.landcareresearch.co.nz/science/plants-animals-fungi/animals/birds/petrel-populations) (viewed 1 May 2014).
- A Master's study that analysed the nutritional content of the hand-rearing diet used during translocations of eight species of New Zealand petrels (M. Jensen, Institute of Veterinary, Animal and Biomedical Sciences, Massey University, pers. comm. 2011). The study objectives included:
 - Comparing the current hand-rearing diet used in petrel translocations in New Zealand to the nutritional composition of the gut content of selected wild seabird species (including grey-faced petrels) and a powdered artificial seabird diet not previously used in seabird translocations.
 - Determining whether the current diet may be contributing to sub-clinical and clinical disease before fledging, by reviewing previous necropsies and health screening chicks involved in current translocations (including grey-faced petrels).
 - Conducting a dietary trial in translocated petrels of lower conservation status (grey-faced petrels and fluttering shearwaters (*Puffinus gavia*)), to compare fledging success and condition between chicks fed the current hand-rearing diet and those fed a diet with nutrient ratios that more closely reflected those of the species' natural diet.

2.5 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 grey-faced 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)
 - 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.
- 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 > 9 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.
- Year 5:
- Undertake fourth and final chick transfer of the original translocation (if required).
 - Commence post-release monitoring and continue annually/seasonally.
- Year 15:
- Consider supplementary transfers from this point onwards (refer to section 3.4—'Supplementary translocations'). (Note: a new translocation proposal would be required for this).

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 cues) 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. In addition, particularly advanced chicks of other species have been known to disappear 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 large gadfly petrels for longer than 4–5 weeks, 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 if it occurs over several successive seasons—and a pair divorce can result in a missed breeding season for one or both birds while they find new mates. Note: This was a particularly important consideration when translocating the endangered Chatham Island tāiko, although parental bonds in this species appeared to be unaffected by the removal of chicks that were up to four weeks from fledging (Gummer 2012).
 - Projects can become unnecessarily lengthy, labour-intensive and costly if chicks need to be fed at the release site for > 5 weeks.

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. There are no particular genetics issues for translocations involving grey-faced petrel. (Note: blood samples would be required for genetic analysis.)

In grey-faced petrels, the sexes appear identical in both adults and chicks. 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 chick 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').

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 grey-faced petrels 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.

Two grey-faced petrel projects to date have transferred a total of 174 chicks over 5 years (from Taranga (Hen & Chickens Islands)) and 276 chicks over 4 years (from Moutohora (Whale Island)) (see Table 1). It has not been possible to source more than 40 chicks per year from Taranga, as transfer teams have been unable to find enough birds. By contrast, the limit on chick numbers being transferred from Moutohora (Whale) Island has been associated with limited helicopter space—only 75 chicks can be collected in one journey, so increasing chick numbers requires two helicopter trips, which significantly increases project costs. There is still insufficient return information to determine whether the transfer groups in either project were large enough for effective colony establishment.

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. With grey-faced petrels, this can be achieved by increasing the number of chicks transferred each year (to a maximum of 100 birds providing that operators are highly experienced) and/or by spreading transfers over more than the 3 years that is commonly used for other seabird species (e.g. over 4–5 years).

Studies of natural colonies have shown that there is considerable variation in the return rates of different chick cohorts (from different seasons), which is likely to be attributable to differences in the food supply and/or weather conditions at sea following fledging. In some years, only 25% of fledged chicks have returned to the colony in subsequent seasons, while the best return rate has been 50% of chicks produced in one season (G. Taylor, pers. obs.). By transferring chicks over several (up to five) years, the effect of chick losses at sea in poor years can be ameliorated.

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.

Table 1. Summary of information on grey-faced petrel translocation projects undertaken prior to 2013.

| RELEASE SITE | SOURCE | YEARS OF TRANSFER | NO. OF BIRDS MOVED | NO. OF BIRDS FLEDGED* | RELEASE SITE STATUS (2012)* | GROUP / PROJECT LEADER (OTHER CONTACTS) |
|---|---|-------------------|--------------------|-----------------------|---|--|
| Mount Maunganui (Tauranga) | Motuotau Island (off Mount Maunganui beach, Tauranga) | 1999 | 30 | 13 ⁽¹⁾ | Four adult returnees ⁽²⁾ | DOC / Graeme Taylor; gtaylor@doc.govt.nz |
| Tiritiri Matangi Island (Hauraki Gulf) | Captive-raised (NWC) — eggs [†] from Kauwahaia Island, Te Henga (Bethells Beach) | 1996 | 1 | 1 ⁽³⁾ | No recapture data reported (Banding Office, May 2012) | DOC / Graeme Taylor (Helen Gummer — NWC, feeding chicks; Shaun O'Connor — NWC manager) |
| Ihumoana Island, Te Henga (Bethells Beach) | Captive-raised (NWC) — chicks [†] from Kauwahaia Island (Hauraki Gulf) | 2000 | 7 | 7 ⁽³⁾ | One male bred 2 m away from release burrow in 2007 ⁽¹⁾ | DOC / Graeme Taylor (Rose Collen — NWC, feeding chicks; Glen Holland — NWC manager) |
| Ihumoana Island, Te Henga (Bethells Beach) | Captive-raised (NWC) — chicks [†] from Kauwahaia Island (Hauraki Gulf) | 2002 | 4 | 4 ⁽³⁾ | None recovered | DOC / Graeme Taylor (Rose Collen — NWC, feeding chicks; Karen Barlow — NWC manager) |
| Matakohe-Limestone Island (Whangarei) | Taranga (Hen & Chickens Islands) | 2004–2008 | 174 | 152 ⁽⁴⁾ | First adult captures (x 2) in May 2010 ⁽⁴⁾ Seven returnees up to Aug 2012 (3 x 2005 chicks & 4 x 2006 chicks ⁽⁵⁾) | Friends of Matakohe-Limestone Island / Colin Bishop (2 years); Cathy Mitchell (3 years); www.limestoneisland.org.nz (Helen Gummer, Rose Collen, Cathy Mitchell & Tanya Munroe — feeding contractors) |
| Cape Sanctuary (Hawke's Bay) | Moutohora (Whale) Island (Bay of Plenty) | 2008–2011 | 276 | 246 ⁽⁶⁾ | Awaiting first adult returns; plan to move 100 more chicks in 2012 and 100 in 2013 | Cape Sanctuary / Tamsin Ward-Smith cape.kidnappers@xtra.co.nz (Shayne Storey — feeding contractor) |
| Longbush-Waikereru Hills Reserve (Gisborne) | Young Nicks Head [§] (Gisborne) | 2011 | 5 | 5 ⁽⁷⁾ | Plan to move 15–20 chicks per year until a total of 50 have been moved ⁽⁸⁾ | Ecoworks NZ Ltd / Steve Sawyer; ecoworksnz@xtra.co.nz (Tamsin Ward-Smith — feeder) |

NWC = National Wildlife Centre, Mount Bruce, DOC.

* References: ⁽¹⁾ Miskelly et al. 2009; ⁽²⁾ G. Taylor, pers. obs.; ⁽³⁾ Taylor & Collen 2007; ⁽⁴⁾ Barr & Barr 2011; ⁽⁵⁾ Ben Barr, pers. obs. 2012; ⁽⁶⁾ Ben Barr, pers. obs. 2012; ⁽⁷⁾ Steve Sawyer, pers. obs. 2012; ⁽⁸⁾ Sawyer & Fogle 2010.

† Eggs were collected for incubation/hatching trials.

‡ Chicks were 6–16 days old when transferred from their natal colony into captivity for hand-rearing. These initial wild-to-captive transfers are not included under 'birds moved'.

§ Small mainland colony in vulnerable location due to erosion. Translocation objective is to save this colony by re-establishing it in a safer location.

Table 2. Summary of information on Chatham Island tāiko translocation projects undertaken prior to 2013.

| RELEASE SITE | SOURCE | YEARS OF TRANSFER | NO. OF BIRDS MOVED | NO. OF BIRDS FLEDGED* | RELEASE SITE STATUS (2013) | GROUP / PROJECT LEADER (OTHER CONTACTS) |
|---|--------------------------------------|-------------------|--------------------|-----------------------|---|---|
| Sweetwater Conservation Covenant (Chatham Island) | Tuku Nature Reserve (Chatham Island) | 2007†–2011 | 58 | 58 ⁽¹⁾ | At least eight returnees to Sweetwater (and at least five returnees captured elsewhere in Tuku Nature Reserve) ⁽²⁾ | Chatham Islands Office, DOC; partnered with Chatham Island Taiko Trust (www.taiko.org.nz) (Daniel Palmer & Patrick Liddy – DOC rangers; Helen Gummer & Mike Bell – feeding contractors) |

* References: (1) Gummer 2012; (2) M. Bell and L. Tuanui, Chatham Island Taiko Trust, pers. obs. 2013.

† One chick was transferred in 2006 (not included in this table) for health reasons. This chick was not hand-fed and was presumed to have fledged successfully following veterinary treatment for a wryneck.

The recommended maximum number of grey-faced petrel chicks to transfer to a new site each year is:

- 50 chicks in the first transfer year of a project
- 60-80 chicks in the second and third transfer years (i.e. while the transfer team is still gaining experience with translocating the species)
- Up to 100 chicks in subsequent transfer years (i.e. once operators have at least 3 years' prior experience of translocating the species)

A maximum of 80-100 grey-faced petrel chicks is considered appropriate for transfer in any one year. 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. Not all burrows inspected will have accessible chambers; and assuming that a pool of grey-faced petrel burrows with accessible chambers have been marked and mapped, 400 of these marked burrows may need to be inspected to find 200 burrows containing chicks, and probably only half of these (c. 100) would be likely to meet the transfer criteria on a single transfer date. In some locations/years, more than twice 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 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 the majority of transferred birds are expected to have returned has passed. The majority of grey-faced petrels are expected to return by breeding age (5-7 years old); however, some first-time recoveries (of returning adults) may not be made until up to 15 years after transfer.

Supplementary transfers (e.g. an extra 200 birds) may be useful 15 years after the first transfer or roughly a decade after any first breeding attempts) 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 grey-faced petrels and Chatham Island tāiko

The previous history of translocations of grey-faced petrels and Chatham Island taiko is summarised in Tables 1 and 2.

5. Source colony

The following aspects need to be given careful consideration when selecting a source colony:

- Geographic location, including access practicality and logistics (safety, cost, consultation, etc.), and distance between the source colony and release site
- Impact of chick harvest on the source colony
- Whether there will be damage to the habitat (including impacts on other species)

5.1 Geographic location

Grey-faced petrels breed on many islands, stacks and headlands off the North Island of New Zealand, from the Manawatāwhi/Three Kings Islands in the north, to Omata (near New Plymouth) on the west coast and a headland near Gisborne on the east coast.

Chicks could potentially be sourced for translocation from the following colonies, which are considered to exceed 5000 breeding pairs (as per Taylor 2000)³

- Bay of Plenty:
 - Moutohora (Whale) Island—This island is home to probably the largest of New Zealand's grey-faced petrel colonies, with an estimated 95 000 breeding pairs (Imber et al. 2003). Well-established tracks make movement around the island relatively easy, minimising damage to existing burrows, and there is relatively easy access to and from the island by boat or helicopter (Ward-Smith & McLennan 2008). There are currently no inspection hatches at any burrows.
 - Whakaari/White Island—This island is logistically more difficult to access than Moutohora (Whale) Island (as it is a private island and further offshore) and movements around the island are likely to result in greater impacts. The presence of rats (*Rattus exulans*) on Whakaari/White Island is also likely to result in high rates of breeding failure, i.e. lots of vacant burrows.
 - Motunau (Plate Island).
- Aldermen Islands (Ruamaahu) (off the coast of Coromandel Peninsula):
 - Hongiora—This island holds the largest colony of grey-faced petrels in the Aldermen group, with up to 50 000 breeding pairs (Taylor 2000). However, it is unlikely that access would be approved due to the extremely fragile nature of the island and the fact that there are multiple burrow-nesting species there.
 - Ruamāhuanui and Ruamāhuaiti.

³ Note: Other smaller colonies (of tens to hundreds of pairs of grey-faced petrels) are not included in this list because they would not be used as a source of chicks for translocation due to the colonies themselves being vulnerable and/or recovering.

- Mercury Islands (off the coast of Coromandel Peninsula):
 - Red Mercury Island (Whakau)—This island is fragile and holds the strongest population of Pycroft’s petrel (*P. pycrofti*), so access to collect grey-faced petrel chicks is unlikely to be approved.
 - Kawhitu or Stanley Island.
 - Double Island (Motu rehu)—This island is difficult to access.
- Hen & Chickens Islands (east of Bream Head, Whangarei, Northland):
 - Taranga—Used to source chicks for translocation to Matakoho-Limestone Island, Whangarei (2004–2008). There had been no previous research on grey-faced petrels at this location. Burrows tended to be scattered in groups along the ridges of the island, at least a 45-minute hike from base camp, with some directly above camp. No densely clustered sites were found. Mitchell & Mitchell (2007) estimated that only one in every ten burrows searched contained an accessible chick—most chambers were either too deep to access by study-hole, or were under rocks or tree roots. It is thought that the species may have been suffering from the predation effects of kiore (*Rattus exulans*). A study is currently underway on the island to evaluate the effect of kiore eradication on grey-faced petrel numbers. By the end of the translocation project, inspection holes had been made in c. 50–100 burrows for the purpose of accessing nesting chambers. Burrow markers were all removed following transfers.
 - Lady Alice Island—Relatively easy to access and hut facilities available.
 - Whatupuke Island.
- Mokohinau Islands (east of Bream Head, Whangarei, Northland; 25 km northwest of Great Barrier Island (Aotea)):
 - Burgess Island (Pokohinu) and Fanal Island (Motukino)—Approval to use these islands as a source of grey-faced petrel chicks would not be granted as these islands are approved for harvesting by iwi.

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 one 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 island in terms of access, population size, burrow occupancy, etc.
- Recce trip—An expedition (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’.

This approach to assessing the source colony is based on the fact that details about the breeding biology of grey-faced petrels are already known and source colonies have already been identified. Consequently, only a recce trip is likely to be required.

Important note: The collection of data for other large gadfly species that have never been studied in detail or translocated before 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. 2014b).

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.
- 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:
 - 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).
 - Wing growth rates can vary between colonies, possibly reflecting a difference in the foraging distribution of breeding adults from different colonies, or a difference in food quality or quantity. There may also be a difference in the time that chicks take to reach fledgling condition between natural colonies.
 - 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 the 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 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 1 month before the potential transfer date (i.e. early to mid-November for grey-faced petrels, for an early December transfer).

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. 2014b), 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—note that grey-faced petrel chicks are prone to regurgitating oily parental meals when removed from their burrows; therefore, protocols include methods for avoiding or managing soiling of plumage, which can be fatal. For essential information on regurgitation, refer to section 11.6.1—‘Regurgitation’.

Past experience suggests that it can take a minimum of 2 person-hours of burrow searching to find one grey-faced petrel chick that is suitable for transfer (e.g. the Cape Sanctuary team had 7-8 people searching for 2.5 days to find 75 suitable chicks on Moutohora (Whale) Island). More time (e.g. up to 3 person-hours to find one suitable chick) may be required 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.

Note: Burrow occupancy rates can differ between source colonies. However, as a rough guide, it can be expected that at least 70% of burrows that are inspected in established breeding areas will be occupied by grey-faced petrels—based on the 83% reported by Gardner-Gee et al. (2008) on Motuora Island; and 73-87% reported by Imber et al. (2003) on Moutohora (Whale) Island.

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

All consideration must be given to minimising and managing the impacts of burrow damage at the source colony during visits. 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 (e.g. local DOC office; seabird specialist) prior to the trip.

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

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.

6. Transfer date

6.1 Single or multiple transfers

To date, grey-faced petrel translocation projects have comprised single transfer operations each transfer year. The one exception was a mainland-to-mainland transfer of only a few birds, where the source and release sites were less than 20 km apart, transport time was relatively short and logistics were easy.

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. There may be welfare issues regarding the duration and timing of the transfer, which make it preferable to undertake multiple transfers (on the same day or on different dates), e.g. if it takes a long time to collect the birds and/or transfer boxes are exposed to the heat of the day.
- 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 multiple transfers, the total feeding period will be extended).

Note: Critically endangered Chatham Island tāiko chicks are transferred on an individual basis on a date between 14 April and 6 May, when each chick meets the transfer criteria. The source and release sites are only a few km apart and most of the journey is by foot through dense forest.

6.2 Previous transfer dates

The previous chick transfer dates listed in Table 3 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.

At any source colony, there may be a ‘poor season’ for all chicks due to parents having difficulty provisioning the chicks because of a poor food supply at sea. This can result in chick growth being retarded and chicks taking longer than expected to develop to the size required for transfer and successful fledging. In addition, chick weights may not peak above the average adult weight, as is typical for procellariiform chicks (grey-faced petrel chicks can attain a maximum weight that is up to 200% greater than the adult weight). For example, during the 2011/12 season, only around one-quarter of grey-faced petrel chicks that were weighed throughout the rearing phase at three different east coast colony sites were observed to attain a maximum weight that was equal to or greater than mean adult mass (R. Dunn, University of Auckland, unpubl. data 2012). During this time, wing growth rates were on average only 2.3 mm per day between 50 and 130 days of age (R. Dunn, University of Auckland, unpubl. data 2012), which contrasts greatly with the usual 5 mm per day that is experienced in this species towards fledging (G. Taylor, pers. obs.). Consequently, chicks fledged after an average nestling period of 140 days (compared with the usual mean of 118 days), at which time they still only weighed 94% of average adult mass and had wings that were only 92% of average adult wing length.

Therefore, transfer teams should ideally build flexibility into the project, so that if they arrive at a site and find that a poor season is in progress, they can return later (e.g. 1–3 weeks later) to collect chicks once they have developed a little further. It is also a good idea to decide on the minimum number of birds needed to make a transfer worthwhile ahead of the collection trip, in case the target number of suitable chicks is not found.

Table 3. Dates of previous grey-faced petrel chick transfers from their respective source colonies (as at 2012).

| SOURCE | RELEASE SITE | YEAR | NO. OF CHICKS TRANSFERRED | DATE | NO. OF CHICKS FLEDGED |
|-------------------------------------|-------------------------------------|------|---------------------------|------------------------------|-----------------------|
| Taranga (Hen & Chicken Islands)* | Matahohe-Limestone Island | 2004 | 40 | 1 Dec [†] | 28 |
| | | 2005 | 31 | 3 Dec [†] | 26 |
| | | 2006 | 40 | 8 Dec | 39 |
| | | 2007 | 22 | 15 Dec [‡] | 21 |
| | | 2008 | 41 | 5 Dec | 38 |
| Moutohora (Whale) Island | Cape Sanctuary | 2008 | 50 | 11 Dec [§] | 48 |
| | | 2009 | 75 | 3 Dec | 68 |
| | | 2010 | 76 | 3 Dec | 66 |
| | | 2011 | 75 | 6 Dec | 64 |
| Young Nicks Head | Longbush-Waikaruru Hills Reserve | 2011 | 5 | 6 Dec (× 3); 12 Dec (× 2) | 5 |

* A pool of up to 100 chicks is predicted to be available on Taranga (Hen & Chickens Islands) if future transfers are carried out between 5 and 10 December.

† The chicks at the source colony were in poor condition/immature during these years, so a later transfer date would have been beneficial.

‡ Bad weather delayed the transfer date.

§ Many chicks were slightly too mature at the source colony.

6.3 Wing length estimates to predict transfer dates

Grey-faced petrel chick wings grow at a rate of 2–5 mm/day, depending on the stage of development of the chick. Under normal circumstances (during a good chick provisioning year), wing growth accelerates with age up to a point fairly close to fledging, and then slows in the days leading up to departure. As a **rough** guide, natural wing growth rates are as follows:

- At <150 mm, the primaries may only be growing 2 mm/day.
- At 150–200 mm, the primaries grow at around 3 mm/day.
- At 200–250 mm, the primaries grow at up to 4 mm/day.
- At >250 mm, the primaries of some chicks can grow up to 5 mm/day. (Note: This may be a common growth rate for hand-fed chicks receiving regular meals and may even apply to hand-fed chicks with wings <250 mm.)
- At a point close to fledging, growth rate decreases (in both hand-fed and parent-reared chicks) to ≤ 2 mm/day. The stage at which this decrease occurs is not easy to define using wing length because different chicks will have total wing lengths that differ by up to 40 mm. For example, for a chick that will fledge with a wing length of 330 mm, the growth rate of the wing may slow down from 5 mm/day once it reaches around 320 mm, so that it may then take 3 or 4 days to reach 330 mm; by contrast, for a chick that will fledge with a wing length of 305 mm, the growth rate may slow down when the wing is only c. 290 mm long.

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 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 based on **2 mm growth/day** and **4 mm growth/day** (i.e. the average is likely to be 3 mm/day). 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.

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. 2014b).

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, it still pays to check all burrows at the start of the collection trip to ensure that suitable chicks are not missed and if there is any doubt about burrow identity.

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 (essential) and remeasure (if required) all chicks that are destined for transfer to ensure their suitability (i.e. ensure that the base or pre-feed weight exceeds the minimum weight criterion; refer to section 7.2.1—'Wing length and weight criteria'). This transfer day weight should ideally be taken at least 2-3 days after the first weight was taken, to obtain the chick's true base weight in the absence of a recent parental feed.
- 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 1 kg are required, but it also pays to take a larger set for very heavy chicks.

- 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 three 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) accordingly, to ensure that they are remeasured and reweighed 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 any more advanced chicks have emerged, and to identify which chicks are being fed by their parents during the nights leading up to transfer day (to help anticipate the response to hand-feeding at the release site). For grey-faced petrels, it is ideal if all stick fences are checked every day to obtain a clear picture of when the chicks have been fed. If this is not practical at the site due to time constraints or access to or around the burrows, the chick's weight changes between the two handling events will probably provide some indication of this.

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, 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. These groupings can be ranked in order of priority with respect to how easy it will be to manage these chicks at the release site (Table 4).
- **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 weight loss that is experienced during transfer and the relatively slow (but necessary) transition onto the artificial diet without fledging condition being too compromised. (Note: 22 grey-faced petrel chicks were recorded as losing an average of 47 g (range 10–130 g) over the 24 hours following transfer; Mitchell & Mitchell 2008.) In addition, if heavier chicks disappear prematurely from their burrows (before their plumage is fully developed) and so can no longer be fed, they still have a good chance of fledging within the target fledging weight range.

Important note: Extremely heavy chicks that have been very recently fed prior to transfer (i.e. those exceeding 800 g) must be transferred with extreme caution as there is a high risk that they may overheat and/or regurgitate during transfer. For essential information on regurgitation, refer to section 11.6.1—'Regurgitation'.

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

Table 4. Transfer day wing length and weight criteria for grey-faced petrels and Chatham Island tāiko.

| SPECIES | PRIORITY FOR TRANSFER | WING LENGTH ON TRANSFER DAY | MINIMUM BASE* WEIGHT TAKEN DURING SELECTION/COLLECTION/ TRANSFER TRIP |
|----------------------|--|--|--|
| Grey-faced petrel | 1 (optimum) | 200–240 mm | 500 g Note: Chicks located for the first time on transfer day must weigh > 600 g |
| | 2 (acceptable) | 241–250 mm [†] | 600 g [‡] |
| | 3 (acceptable) | 251–260 mm [†] | 700 g [‡] |
| | 4 (least preferred—if shortage of chicks in above three groupings) | 180–199 mm Note: High risk of sickness at the release site if chicks are < 180 mm | 500 g Note: High risk of sickness at the release site if chicks weigh < 450 g on transfer |
| Chatham Island tāiko | Individual chicks are moved as directed by the Recovery Group | 240–260 mm [§] Chicks have been successfully transferred at 230–278 mm | No minimum weight; all chicks are moved in a transfer year |

Note: Criteria are based on information contained within all of the Cape Sanctuary and Matakohē-Limestone Island transfer reports (refer to section 16—‘References’).

* Base weight is defined as the weight of the chick before its next parental meal, i.e. the weight of the chick without a full crop/stomach. This is usually the lower of two weights recorded over a 3–4-day period.

[†] A good amount of down cover is preferred on these chicks to indicate that they have not yet emerged at the source colony. Note: Grey-faced petrel chicks tend not to emerge from burrows before their wings have reached 250 mm in length, although the occasional chick has been found on the surface with smaller wings (e.g. 237 mm).

[‡] Chicks taken at less than the minimum weights set here are likely to be closer to emerging (too advanced) and may be more prone to stress at the release site during the burrow familiarisation period before they are allowed to emerge. Heavier chicks are also preferred because they are more likely to stay longer at the release site before fledging (refer to section 9.2.2—‘Maximum weights and wing lengths’, Table 6 for target fledging parameters), which is considered important for maximising the likelihood that individuals will return to the release site as adults.

[§] Chatham Island tāiko chicks are not known to emerge from burrows before their wings have reached 270–280 mm in length.

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 criteria for grey-faced petrels are based on the **base** or **pre-feed weights** of chicks. To determine their base weight, chicks must be weighed on two occasions over a 3- or 4-day period, with the second weight taken on transfer day. The lowest weight gives an indication of the base weight of the chick (while the higher weight would represent a post-feed weight one or more days after a parental meal has been delivered).

Important note: If stick fences have been erected at all burrow entrances during the first chick handling event, and these sticks are still intact on the second burrow inspection (i.e. there has been no interim parental visit) and the chick was known to weigh less than the required transfer day weight on first handling, then a second weight should not be required as the chick will clearly not have gained any further weight and so will not be suitable for transfer.

It is not uncommon to find grey-faced petrel chicks that meet the wing length criteria but not the minimum weight criteria at the source colony, i.e. they are too light to transfer. There have been reports throughout New Zealand of many seabird species, including grey-faced petrels, struggling to keep up with chick feeding demands in some years. This may be attributed to

El Niño-Southern Oscillation weather patterns, which cause ocean currents to be warmer at a time of year when cooler waters would usually be bringing down the smaller fish species that seabirds forage on during chick-rearing periods (Ward-Smith et al. 2010).

7.2.2 Chick emergence at the source colony

It is very rare for healthy grey-faced petrel chicks to emerge from their burrows with wings less than 250 mm in length. However, the occasional chick might emerge prematurely (either at a natural colony or following transfer to a release site) with wings shorter than 250 mm, e.g. small, slow-developing chicks.

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.
- 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

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

- Preparing equipment, notebooks and data forms.
- Extracting and handling chicks—grey-faced petrel chicks are prone to regurgitating 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.

7.3.1 Wing length guide for selecting chicks

A wing length guide has been developed for use in the days leading up to a grey-faced petrel transfer (Table 5)—although **this has yet to be trialed and confirmed**.

Table 5. Wing length guide for use in the days leading up to a grey-faced petrel transfer. Different flagging tape colours (to mark the burrows) are allocated to each of the three wing length categories. Priority (for transfer) numbers relate to those presented in Table 4.

Important note: There is a reasonable likelihood of measurement error with this species because longer wings can be more difficult to measure consistently. All attempts should be made to straighten and flatten primaries to obtain the maximum wing length.

| DAYS BEFORE TRANSFER | TARGET WING LENGTH RANGES (mm) FOR CHICKS | | |
|----------------------|---|-----------------------|-------------------------------------|
| | MARGINAL—SMALL (Priority 4)* | OPTIMAL (Priority 1)† | MARGINAL—ADVANCED (Priority 2 & 3)‡ |
| 5 | 175–184 | 185–215 | 216–245 |
| 4 | 180–187 | 188–220 | 221–248 |
| 3 | 185–190 | 191–225 | 226–251 |
| 2 | 190–193 | 194–230 | 231–254 |
| 1 | 195–196 | 197–235 | 236–257 |
| Transfer day | Any chicks opportunistically found with wings measuring 200–250 mm and exceeding 600 g; or any chicks with wings between 251 and 260 mm and exceeding 700 g. (Note: Base weights are unknown, hence heavier minimum weights.) | | |

* May or may not meet minimum wing length (200 mm) by transfer day.

† Almost certainly will be 200–240 mm on transfer day.

‡ 241–260 mm on transfer day.

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

- Optimal (Priority 1): Subtracted 5 mm (the maximum predicted daily growth rate) from the upper end of the range and subtracted 3 mm (the minimum predicted daily growth rate) from the lower end of the range.
- Marginal–Advanced (Priority 2 & 3): Subtracted 3 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 5 mm from the lower end of the range and set the upper end to meet the lower end of the Priority 1 range.

Minimum and maximum wing growth rates rather than average wing growth rates were used in the calculations because individuals grow at different rates and growth rates vary at different stages of development. Consequently, some suitable chicks would be unnecessarily eliminated from the transfer if only averages were used.

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. 2014b). 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 large gadfly petrels is based on the standard pet carry box. Ideally, only one chick should be held per box, to ensure that there is sufficient space to avoid any issues with overheating and the wing or tail feathers becoming damaged. In the past, two chicks have been held temporarily in one box for part of a journey, e.g. where chicks have needed to be carried across difficult terrain (but under forest canopy) for a period of up to 2-3 hours at a source colony to reach an area where the boxes could be safely placed in the shade (on Taranga (Hen & Chickens Islands)), or where chicks needed to travel in the confined space of a helicopter between the source and release site (Cape Sanctuary). Where this occurred, a single diagonal divider was firmly secured down the middle of the box to prevent the chick on one side from leaning into it and reducing the compartment size for the chick on the other side. Only fluteboard boxes (425 × 240 × 310 mm) have been used this way; the **cardboard carry boxes would be too small** to hold two chicks for any period of time (see below).

Important note: Placing two chicks in one pet carry box increases the risk of the chicks overheating and therefore should only be done when considered absolutely necessary. All chicks that exceed 700 g in weight on collection must be placed individually in boxes, as they will be most prone to overheating and regurgitating during transfer.

Two types of pet carry boxes have been used to transfer grey-faced petrels and Chatham Island tāiko 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 should 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. Grey-faced petrels are transferred in December when conditions can be 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 large gadfly petrels. However, boxes can be custom-made to a specified size at extra cost. Grey-faced petrels were successfully transferred to Matakoho-Limestone Island in boxes that were 230 × 230 × 300 mm high; this size is perfect for a single chick.
- The supplier details can be found in section 2.1 of the field guidelines (Gummer et al. 2014b).
- 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 and are not suitable for holding chicks overnight, if necessary.
 - Are slightly smaller than the fluteboard boxes, only having room for a single grey-faced petrel chick.

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 lid, 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.

For grey-faced petrels, it is recommended 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, and reduce the risk of it not returning to the burrow during the emergence period. However, chicks should 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.

In practice, it is not always possible to collect nest material, especially if there is little accessible material in the natal burrow and there is not enough time to handle it on transfer day (see points below). However, it may be worth attempting this, particularly for some of the more advanced chicks that will have a shorter burrow-familiarisation period at the release site before they emerge.

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.

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. 2014b). These include:

- Weighing and measuring each chick on transfer day to double-check its suitability for transfer, i.e. determining the base weight of each chick.
- 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. 2014b)), 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 base 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 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

Grey-faced petrel chicks have been successfully transported by air, sea and road:

- Helicopter 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. A fast transfer operation is especially important when chicks are at peak weights with very thick subcutaneous fat layers. Boxes may be temporarily packed together in the craft, but should be of sufficient height to allow for enough ventilation

during a relatively short helicopter flight. Helicopter was the chosen mode of transport for translocations in one year of the Matakohe-Limestone Island project (30 minute flight) and for all Cape Sanctuary translocations (50 minute flight).

- Note: Transfer boxes containing chicks were transported beneath a helicopter inside large sacks within a cargo net, from the main ridge on Taranga (Hen & Chickens Islands) to the main helicopter landing area by the lighthouse (2-3 minute trip). They were then loaded onto the helicopter for the flight to the release site. However, subsequently this method was abandoned and a more cost-effective approach used whereby chicks were carried from either end of the island along the main ridge to a central location that was suitable for boat pickup/transport.
- Plane travel has only been used for transporting large gadfly petrels between the upper and lower North Island (during captive hand-rearing trials of wild-origin grey-faced petrel chicks), and between the Chatham Islands and New Zealand (transport of a tāiko chick requiring veterinary care). Chicks have been involved in plane journeys of up to two hours.
- Boat travel was used in the later transfers of chicks between Taranga (Hen & Chickens Islands) and Matakohe-Limestone Island. The chicks were held overnight in transfer boxes under a shelter at the source colony, so that the boat could be scheduled for early morning, before the heat of the day; and they seemed to cope with a noisy boat trip of four hours, during which the boxes were spaced out inside the boat away from direct sunlight. However, boat trips longer than 3-4 hours may be problematic, as chicks will be more vulnerable to overheating and there may not be enough time to process chicks at the release site before dark. If transfer boxes are being transported on deck, they can be placed loosely in individual plastic bin bags (with the tops left untied for ventilation) to protect them from salt spray and should be spaced out; however, they 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 grey-faced petrels and Chatham Island tāiko to or from air or sea drop-off points. Grey-faced petrels have tolerated up to around 2 hours in a truck (e.g. northern Wairarapa to Wellington airport; Auckland airport to Te Henga (Bethells Beach)). A tāiko chick (a species that is usually more prone to stress) has also been successfully transported by ATV and truck for up to two hours at a time (Sweetwater to Chatham Island airport).

Note: When large numbers of boxes are being transported by road, every effort should 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.

In previous translocations, large gadfly petrel chicks have successfully tolerated 24 hours or more total transit time:

- Chicks collected on Taranga (Hen & Chickens Islands) were carried in boxes strapped to backpack frames from burrows to a shelter at sea level (which, in some cases, took up to 2 hours), where they were held overnight (in transfer boxes) ready for the morning boat trip (4 hours) to Matakohe-Limestone Island. They were then driven up to the artificial burrow site, giving a total travel time of up to 32 hours for some birds.
- Several grey-faced petrel chicks have been driven from the National Wildlife Centre (NWC) in northern Wairarapa to Wellington airport, held overnight in transfer boxes in Wellington, flown to Auckland airport (during which the cardboard transfer boxes were placed inside a kennel to protect them during the flight) and finally driven to Te Henga (Bethells Beach) (west Auckland).

- One grey-faced petrel chick has been driven from NWC to Wellington airport, flown to Auckland airport, held overnight (in transfer box) in Auckland, and then driven to the ferry terminal and taken by ferry to Tiritiri Matangi Island.
- One tāiko chick has been driven by ATV then truck from Sweetwater to the Chatham Islands airport, flown to Wellington airport and then driven to Wellington Zoo, giving a total travel time of around 6-7 hours.

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, grey-faced petrels 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.

While it is not considered best practice to plan to hold chicks overnight in transport boxes, this has been the case for two projects where the chicks were collected from burrows on the day before transfer and then transported early the following morning (by boat) before the heat of the day. Chicks can also be held overnight in boxes if there is an unexpected delay in transit. If chicks need to be held for prolonged periods in boxes, it is preferable for them to be held overnight when it is cooler, rather than during the heat of the day.

If chicks do need to be held overnight, the following requirements must be met:

- Chicks **must** be held in separate, individual boxes to allow extra space to keep cool and to minimise disturbance for each chick. Boxes need to be weatherproof if they are stored outdoors, or alternatively should be stored under a shelter, e.g. tarpaulin.
- Still consider collecting the lightest chicks on the day of transfer (if time permits) to allow them the benefit of any extra parental meal.
- Consider hand-feeding some of the lighter chicks immediately on arrival at the release site rather than leaving them until the day after transfer (refer to section 9.5.4—'First (introductory) meals').

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. 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 20 mL of oral fluids (e.g. Lactated Ringer's™ solution, Hartmann's™ solution or Vytrate™) to each chick before it is placed in its allocated burrow. 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 hot weather. For essential information on regurgitation, refer to section 11.6.1—‘Regurgitation’.

Note: 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 rock 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.)

Note: If lightweight chicks have been held in transfer boxes overnight prior to transfer and have potentially missed out on a final parental meal, consider feeding them on arrival at the release site (refer to section 9.5.4—‘First (introductory) meals’).

8. Release site

8.1 Suitability of release site

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

- Be situated within an appropriate geographical location / ecological zone.

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 (G. Taylor, pers. obs.). 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. Therefore, grey-faced petrels should only be considered for translocation in northern New Zealand (i.e. from Taranaki/Hawke’s Bay north).

- 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: Close proximity to the sea is considered paramount for optimising project success, especially if aiming to attract passing birds at sea—unlike some of the small gadfly petrels such as Cook’s petrels (*Pterodroma cookii*); grey-faced petrels are rarely reported inland away from coastal areas.

- Be sufficiently far away from bright lights (e.g. towns and cities)—grey-faced petrels 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 grey-faced petrels. 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.

Whilst grey-faced petrel adults are large and robust enough to fend off some mammalian predators, eggs and small chicks that are left alone in the burrows while the parents are at sea are extremely vulnerable to all predators (rats, mustelids, cats, dogs, etc.). Norway rats (*Rattus norvegicus*) are known to eat unattended eggs, and young and weak chicks, and at their worst caused colony productivity to be negligible on Moutohora (Whale) Island (Imber et al. 2000). It is unlikely that remnant mainland populations, such as the unfenced colony on Mount Maunganui, would persist in the absence of stock exclusion (to prevent trampling of burrows) and ongoing predator control (trapping).

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 of smaller-sized species enter burrows containing grey-faced petrels.
- 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 digging their own burrows, which can undermine the 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

Grey-faced petrels require a combination of elevation and wind for successful take-off—although birds can depart from a very high cliff top in the absence of wind or take off from a lower elevation in a very strong wind. Therefore, grey-faced petrels should have access to both of the following key features at a colony site to enable them to take off to sea:

- Elevation—At most colony sites, birds will take off from high vantage points (clear areas on cliff tops, above bluffs or from ridges) 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.
- Mature trees—Grey-faced petrels are tree climbers, although probably not quite as agile as the small gadfly petrels. Chicks will climb large trees if required to depart from the colony site. Note: Birds are capable of wandering 50 m or more to a suitable tree (sloping, emerging from the canopy, rough bark). Birds may not necessarily climb to the canopy, but can take flight from part way up a mature tree, e.g. an exposed limb. Mature forest also provides more shade, keeping burrow sites cooler during the day (refer to section 8.1.5—‘Shading / vegetation cover’).

Immature forest can shelter sites from the wind and make take-off difficult because there are no mature trees to climb, and no clear and exposed runway areas for lift-off. Fogarty & Douglas (1973) reported that grey-faced petrel burrows on the Aldermen Islands (Ruamāhuanui) were mostly concentrated on gentle slopes under tall trees with little undergrowth and on ridges, and were less dense in areas covered in low vegetation (where birds had the choice). On Matakohē-Limestone Island, fewer transferred grey-faced petrel chicks fledged on calmer nights, probably because the regenerating vegetation was sheltering the site from any wind. This may have caused some birds to delay their departure and depart in less than optimum condition. To facilitate take-off, ramps were installed at the site in the final transfer year, and there were signs that these were used by the last chicks to depart the site (Mitchell & Mitchell 2009). Vegetation can be managed in later years at the colony site to provide take-off opportunities (refer to section 14—‘Post-release site management’).

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 (Cook’s petrels; Rayner et al. 2007). Grey-faced 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. Burrows are commonly found in coastal broadleaf forest dominated by pōhutukawa (*Metrosideros excelsa*) (R. Dunn, University of Auckland, pers. comm. 2012).

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, māhoe (*Meliclytus 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. Rushes and flax (*Phormium* spp.) are suitable at sites with grey-faced petrels, although smaller seabird species 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.
- In any of the above habitats, as a minimum it would be beneficial to clear a pathway to an exposed bluff or cliff top to allow birds to easily access an area that is suitable for take-off in all conditions.

8.1.4 Slope of ground and soil type

Where possible, the new colony site should be located in terrain that replicates areas where most burrows are found at the source colony. Grey-faced petrel burrows are usually found on sloping or steep terrain, as burrows will extend up to several metres underground.

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.

8.1.5 Shading / vegetation cover

The shading of burrows is an extremely important factor to consider at grey-faced petrel release sites, as there can be real overheating issues for transferred chicks (mid-summer), as well as for breeding adults in later years (refer to section 8.2.5—‘Temperature’).

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. 2014b).

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 up to 20 m). It is common for adults to prospect very close to the speakers, commonly within a 10-m radius (S. Sawyer, Ecoworks NZ Ltd, pers. comm. 2012), 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. However, tunnels in burrows that are installed for transferred chicks may be slightly shorter than is desirable for grey-faced petrel adults, because the chicks must be accessible in all parts of the pipe.
- 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 large 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:

- **Sloping-ground / cliff burrow design**—Primarily developed for steep-sloping sites, which tend to be more exposed to the wind and may have less vegetation cover, i.e. are not as

shaded, especially if they are within areas of regeneration (see Fig. 1). The soil in these locations also tends to be much firmer. This burrow type has been employed for grey-faced petrels on the steeper, more exposed slopes at Cape Sanctuary (see Fig. 2) and consists of the following:

- A chamber with three sides made of treated timber and an earthen back wall, forming a rectangular box shape (Fig. 3). 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.
- **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 wooden nest box made of treated timber, which is dug into the ground with a removable lid at ground level (see Figs. 4, 5 & 7).
 - A slightly sloping roof on the chamber to prevent rainwater from collecting on the roof and leaking into the inspection hatch. The chamber roof can be a double-lid system or can incorporate a ‘chimney’ in warmer climates or at more exposed sites, to improve insulation (see Fig. 6), or alternatively sandbags can be used to insulate a burrow (see Fig. 5).
 - 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).

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 favoured for release sites. Plastic burrows are not currently available for the large gadfly petrels, as Philproof™ (the manufacturer of small plastic burrows that are used for the small gadfly petrels) have not invested in a mould for larger burrows due to the cost.

8.2.4 Dimensions

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

- Rectangular sloping-ground / cliff burrow design—**Internal** dimensions 500 × 400 × 300 mm deep, constructed from 300 × 25 mm rough-sawn planks of treated timber. This rectangular design is longer and narrower than the square design (see Fig. 3).



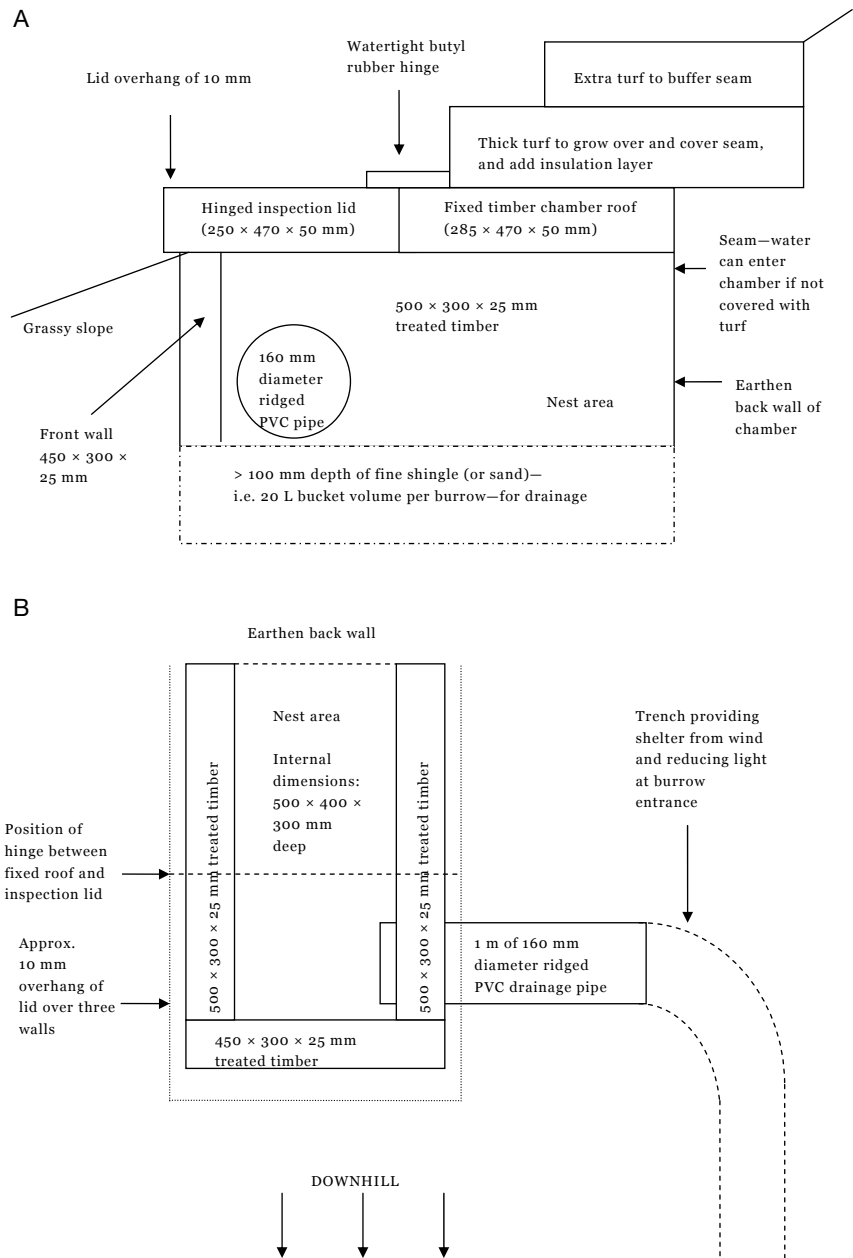
Figure 1. Sloping-ground wooden burrows at a fluttering shearwater artificial colony site on Mana Island. Photo: D. Cornick.



Figure 2. Sloping-ground burrow design used for grey-faced petrels at Cape Sanctuary. Photo supplied by Cape Sanctuary. Photo supplied by Cape Sanctuary.

Figure 3. Diagram of the artificial sloping-ground / cliff burrow design (adapted from Gummer & Adams 2010). A = cross section, B = top view (without lid).

Note: This burrow design is based on that used for fluttering shearwaters, but has been upscaled and modified for grey-faced petrels. The equipment required to make this burrow is listed in section 2.2 of the field guidelines (Gummer et al. 2014b).



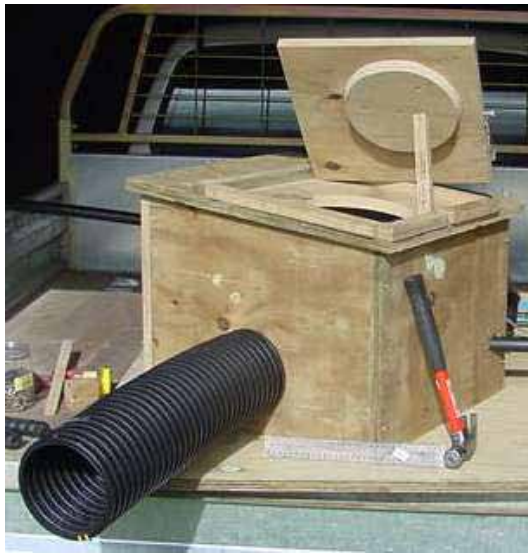


Figure 4. Flat-ground wooden burrow (with sloping lids) used for tāiko—see Fig. 7. Note: The small black pipe on the back wall of the box is only used in tāiko burrows. Photo supplied by DOC, Chatham Islands.



Figure 5. Flat-ground wooden burrow and insulating sandbag used for grey-faced petrels. Photo supplied by B. Barr, Friends of Matakoho-Limestone Island.



Figure 6. Addition of a 'chimney' above the inspection hole on a flat-ground burrow on Matakoho-Limestone Island to improve insulation. Photo supplied by B. Barr, Friends of Matakoho-Limestone Island.

- Square flat-ground burrow design—**External** dimensions 450 × 450 × 320 mm deep, constructed of 20 mm-thick treated timber. The internal height of the chamber needs to be a minimum of 300 mm (e.g. for a sloping roof, the shortest wall can be 300 mm high and the tallest wall 320 mm) (see Fig. 7).

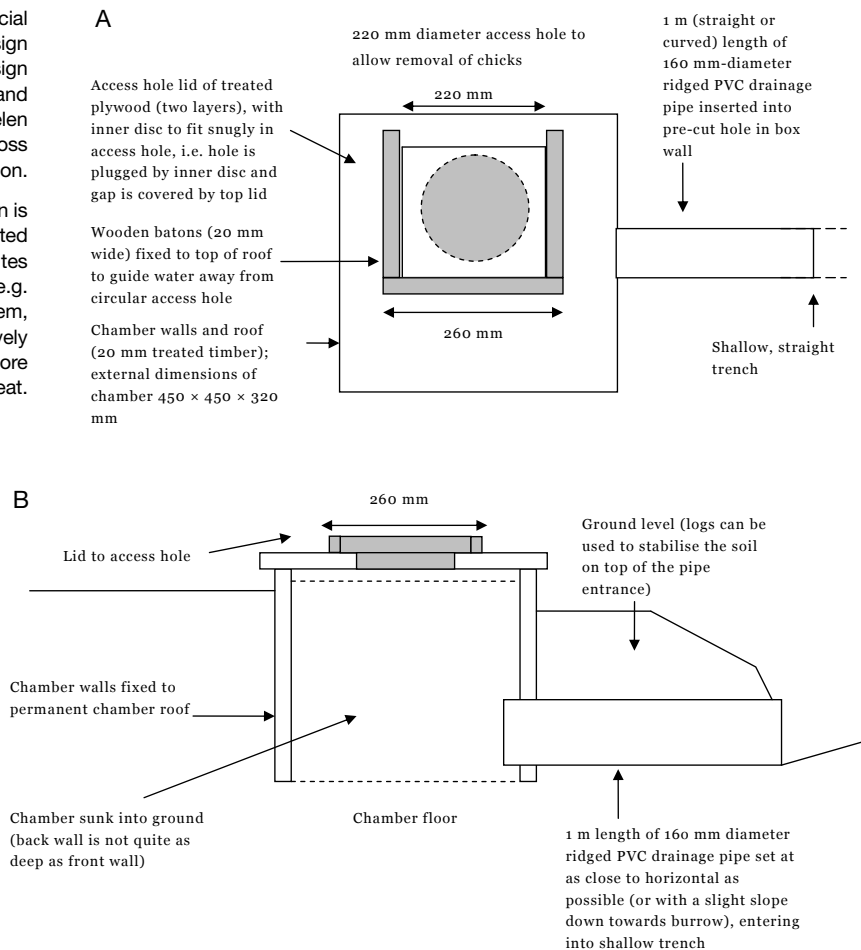
Note: The burrows need to accommodate a pair in future seasons and up to three birds at the same time (pair plus growing chick). Both burrow designs require similar amounts of space inside the chamber.

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:

- 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. 1, 2 & 3.)

Figure 7. Diagram of artificial flat-ground wooden burrow design for Chatham Island tāiko (design by Roger Worsley (Taiko Trust) and Graeme Taylor; diagram by Helen Gummer). A = top view, B = cross section.

Note: This single-lid design is useful for well-shaded forested areas. Burrows at less-shaded sites should have more insulation, e.g. some kind of double-lid system, so that burrows are effectively deeper in the ground and are more insulated from the sun's heat.



- Square flat-ground burrow design—Solid lids are incorporated into the boxes during construction, and a large round hole is subsequently 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 all gaps (see Figs. 4, 5 & 7). 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, either the roof timber will need to be quite thick or a double-lid system (e.g. ‘chimney’) might need to be incorporated to improve insulation in more exposed (regenerating) areas and to avoid reliance on sandbags (see Fig. 6).

Note: With any lid system, it is important to consider the ease with which chicks can be lifted in and out of the burrow on a regular basis. On Matakoho-Limestone Island, the plug components of the lids were eventually removed as they swelled up and became problematic to use (too tight a fit); the plain single plywood lids were then held in place by the wooden beading on the burrow roofs and by the weight of sandbags. At Cape Sanctuary, volunteers found it tricky to lift birds out and return them through the inspection hole. Chamber contents also need to be clearly viewable (i.e. entire chamber floor area) for chick management purposes.

Tunnels are made of 160-mm diameter ridged (for grip) PVC drainage pipe with the following features:

- Tunnel length of 1 m (1.5 m maximum), to reduce light levels inside the chambers. Avoid longer tunnels of this pipe size, because it would be very 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 generally cooler than the ambient temperature is maintained within burrows 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.

At burrow sites in areas of new regenerating forest, several measures have been taken to keep burrows cool and to maintain humidity in the absence of good shade cover from mature trees, including:

- Keeping the burrows covered at all times with up to two sandbags.
- Keeping the sacks and tunnel entrances damp by spraying water onto the burrow sites.
- Laying branches of dense vegetation (e.g. mānuka) over some of the more exposed burrows and tunnels.

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.
- Adding a small amount of gravel to the floor of tunnels, so that plumage is not soiled as chicks pass through the pipe if it is collecting water.

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 autumn or early winter, when the soil is easier to dig. This also allows the burrow site to settle for a few 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 expected main take-off point (e.g. a ridge, hill or suitable take-off tree)—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 large gadfly petrel species, the entrances of burrows should be at least 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. (Adult grey-faced petrels are known to fight at burrows if an intruder enters the wrong burrow.)

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. 2014b).

Detailed instructions on how to install artificial burrows at the release site can be found in sections 4.2 and 4.3 of the field guidelines (Gummer et al. 2014b).

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. 2014b).

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 companion guide (Gummer et al. 2014b)).

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 this 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 where the chicks may not be able to turn inside the pipe (tunnel) and may have difficulty 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 some of the above ways in 110 mm diameter pipes before internal blockading was established; the larger grey-faced petrel chicks are proportionally similar in size in relation to a 160 mm diameter pipe.

External blockades still need to be put in place at all burrows with internal blockades to prevent any 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 fine so that a chick's bill cannot be pushed through it at all; or c. 25-30 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. 2014b).

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—large 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 must ensure that the different types of fat reserves that gadfly petrels require to get them through the post-fledging period (when they disperse or migrate, and while they learn to forage) are appropriate to the species—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 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:

- Within the known fledging weight range 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, although this may be less critical for non-migratory species such as grey-faced petrels.
- 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 fledging condition of hand-fed grey-faced petrel chicks in previous translocation projects appears to have varied considerably depending on the colony site location. In some cases, some of the fledging size and weight data that were recorded may in fact have been from chicks that had disappeared prematurely and could not physically return to their burrows or were never found. Therefore, at this stage of projects, it is better to model target fledging condition on known averages of naturally reared (i.e. non-translocated) chicks (see Table 5). For causes and implications of premature chick disappearance, refer to section 10.5—‘Missing chicks’.

9.2.1 Minimum weights and wing lengths

Fledging weight should match or slightly exceed the most common adult weights, which are within the range of 520–550 g. Although some adults have been found to weigh as little as 400 g, and so the occasional chick may fledge below 470 g and survive, ideally projects need to set targets that maximise the chances of post-fledging survival of all chicks.

At a minimum, wing lengths should be within the known adult wing length range, which is 305–340 mm (G. Taylor, pers. obs.). Chicks that leave a site with wings shorter than 305 mm may be compromised during or after fledging.

9.2.2 Maximum weights and wing lengths

The weight of grey-faced petrels peaks at around 75–80 days of age (c. 175–190 mm wing length), at which time well-provisioned healthy chicks can occasionally reach 800–1100 g after being fed in a good season (G. Taylor, pers. obs.). However, Dunn (unpubl. data 2012) found that the 25% of chicks in his study that exceeded adult weight during development typically peaked at 660 g. Parental meals may reduce in size and frequency after chick weight peaks, as chicks need to lose weight in order to fly/fledge and complete their plumage development. Note: In a poor chick provisioning season, chicks may not reach a peak weight at all, but rather continue to gain weight up to departure, fledging at or below the average for the species (R. Dunn, University of Auckland, unpubl. data 2012).⁴

⁴ Adult grey-faced petrels have been known to weigh as much as 800 g on the first day of an incubation shift; however, this kind of weight would include reserves to cover a period of 2–3 weeks of no foraging. In reality, adult base weights are thought to rarely exceed 600 g.

Table 5. 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 grey-faced petrel and Chatham Island tāiko chicks. For fledging weight and wing length, values in parentheses are the wider target ranges; for emergence period and time at release site, values are targets with ranges provided in parentheses.

| SPECIES | TARGETS FOR TRANSLOCATED CHICKS ^a | | | |
|----------------------|--|---|---|---|
| | FLEDGING WEIGHT ^b 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 |
| Grey-faced petrel | 520–550 g (500–600 g) ^c | 315–320 mm (305–340 mm) ^d | ≥ 15 nights (10–25 nights) ^e | ≥23 days (15–34 days) |
| Chatham Island tāiko | ≥ 485 g (450–520 g) ^f | ≥ 303 mm (295–313 mm) ^g | ≥ 12 nights (6–20 nights) | ≥20 days (12–31 days) |

^a All target values for grey-faced petrels are based on data collected from wild colonies during long-term studies by Graeme Taylor at Te Henga (Bethells Beach) and by Imber (1976), as well as on data from the Matakoho-Limestone Island translocation project, where the majority of chicks fledged within the parameters recorded from wild populations. The burrow site at Matakoho-Limestone Island is unfenced, allowing chicks to return to their burrows at all times (e.g. after practicing take-off) before finally fledging (i.e. there was less chance of chicks disappearing prematurely). Target values for tāiko are based on the results of five years of transfers (Gummer 2012).

^b Fledging weights presented in this table are final pre-feed weights rather than post-feed weights.

^c Most parent-reared grey-faced petrel chicks at Te Henga (Bethells Beach) (west Auckland) fledge within the range of 520–550 g, and this is the preferred narrow target range for translocated chicks within the general range of 500–600 g (which is slightly heavier than the overall known range at Te Henga (Bethells Beach) of 480–580 g) (G. Taylor, pers. obs.). The average fledging weight on Moutohora (Whale) Island is 542 g (range 470–605 g) (Imber 1976).

^d Most parent-reared grey-faced petrel chicks at Te Henga (Bethells Beach) fledge within the range of 315–320 mm (G. Taylor, pers. obs.).

^e Imber et al. (2000) reported that fledglings leave their burrows over about 15 days before departure; and Dunn (unpubl. data 2012) found that under-provisioned chicks emerged on Te Hāwera-a-Maki/Goat Island for an average of 14 nights (range 10–18 nights).

^f Nineteen tāiko chicks weighed 430–545 g on the day before fledging (Gummer 2012). However, the slightly smaller range of 450–520 g is preferred as a target.

^g Non-translocated tāiko have been recorded as fledging with wing lengths of 290 mm, but translocated chicks have all fledged at 295 mm or above.

Unlike migratory species, which need to store dense layers of cavity fat prior to departure, it may be less critical for non-migratory seabird chicks such as grey-faced petrels to fledge at weights heavier than average adult weight because they can forage fairly locally after fledging. (It has been found that grey-faced petrels do not tend to show as high a peak in weight prior to fledging as some of the other gadfly petrels, including tāiko.)

Although reserves are considered an advantage in fledglings, if chicks are too heavy then their flight ability is compromised, especially since they do not have the well-developed flight-muscle mass that adults have. Fledglings need to be able to move offshore as quickly as possible, so that they can feed in pelagic waters and are less vulnerable to attacks by coastal predators, e.g. large gulls. Ensuring that grey-faced petrel chicks are not too heavy when they depart the colony means that they are less likely to become grounded on the shore or stranded on near-shore waters, where they are extremely vulnerable to exposure and attack by both aerial and underwater predators, immediately after departing the colony site. Grey-faced petrel chicks fledge at the height of summer when the weather is often calm with periods of little or no wind, which may explain why chicks of this species benefit from being fairly trim by fledging time (i.e. not heavier than average adult weight).

Wing growth tends to slow once chicks have completed the bulk of wing growth, which is highly synchronised with the weight loss in naturally reared grey-faced petrels, i.e. wing growth reduces in line with weight loss so that chicks meet optimum fledging weight and wing length simultaneously.

9.3 Artificial diet

The artificial diet that is currently used to feed translocated large gadfly petrels is still in its developmental phase 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 (1995–2003), as well as chicks involved in wild-to-wild translocations (2004 onwards).

The artificial diets presented in this document are used to feed the large gadfly petrels (grey-faced petrels and Chatham Island tāiko) 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. (It has been found that alternative diets and supplements are required to rear grey-faced petrel chicks in the earlier phases of growth.)

It should be noted that there may be unknown impacts on the long-term survival of birds if they are fed the diets presented here for longer than 4–5 weeks. Therefore, it is important to avoid hand-feeding translocated birds this diet for too long, to reduce any risks that may be associated with it.

It can be difficult to keep the weight on grey-faced petrel chicks in the weeks after transfer, especially if the average transfer weight is relatively low due to issues with parental food supply at the source colony. Hand-feeders must aim to fledge translocated chicks at around the average fledging weight for parent-fed chicks, whilst **avoiding the negative impacts of overfeeding chicks** (refer to section 9.5.3—‘Overfeeding’). By contrast, tāiko have proven less problematic. This difference is probably related to the time of year at which these two species are transferred. Grey-faced petrel chicks are susceptible to heat stress during their summer rearing period, which may affect their metabolism, whereas tāiko are reared in May when it is cool. Consequently, it has been noted that grey-faced petrels process the artificial diet noticeably faster, need to be fed higher volumes to maintain their weight, and appear more awake and alert during the day, while tāiko chicks need less food and are not as active when their burrows are opened to remove them for feeding, meaning that they have fewer issues in terms of weight maintenance.

Important note: Any modifications to the current artificial diets presented here 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.

9.3.1 Supplementary oils

For most seabird species translocated in New Zealand over the last decade, chicks that have been reared on the artificial diet (which consists of tinned sardines in soya oil) have tended to fledge at weights that are on average heavier than parent-reared chicks. However, despite this, there are still concerns that the composition of a plant-based oil (i.e. soya oil) may not contain the suitable fatty acid ratios that are beneficial to the growth and development of young chicks.

It seems that translocated grey-faced petrel chicks require greater meal sizes and frequencies than other hand-fed species to obtain average or below average fledging condition. Therefore, it is possible that the original sardine/soya oil diet may not be energy-rich enough for this species, although further analysis is still required. Consequently, the artificial diet for large gadfly petrels differs from that used for other burrow-nesting species, through the addition of supplementary oils. These supplementary oils provide energy and hydration, while keeping meals at a similar size to those they would receive naturally in the wild, thereby avoiding gut blockage/infection. Hydration appears to be particularly important for grey-faced petrels that are transferred during summer in very warm northern climate conditions.

Supplementary oils (i.e. oils that are fed either in addition to or as a replacement to the soya oil that the sardines are stored in) used in recent years include:

- Cod liver oil—This was selected as one of the early supplements during grey-faced petrel and Chatham Island tāiko translocations. However, **it is generally no longer recommended (particularly in proportions that exceed the recommendation for other avian species)** because it contains high levels of vitamin A, which is potentially toxic at incorrect doses and is already available to hand-fed chicks in the form of a supplementary seabird vitamin/mineral tablet. For seabirds, the absolute toxic level of vitamin A is not known; however, although it is assumed that they have a relatively high tolerance for vitamin A compared with other birds, more research is required in this area. Vitamin A toxicity is known to cause a range of symptoms in other avian species.

Cod liver oil has been used in the following circumstances:

- Chatham Island tāiko—Cod liver oil continues to be added to the sardine/soya oil diet for tāiko in small volumes (no more than 3% of total food mix) on a very cautious basis, but breeding attempts of birds that have now returned as adults will be monitored to determine whether this has had any detrimental effects.
- Grey-faced petrel—Cod liver oil was added in relatively high volumes (c. 7-9% of total food mix) to all meals for a small proportion of lightweight chicks during transfers from 2006 to 2011, which occurred before seabird vitamin/mineral tablets were added to the diet. To date, four of the grey-faced petrels that were transferred in 2006 have returned to Matakohe-Limestone Island, two of which were fed cod liver oil prior to fledging—and one of which was fed 9% cod liver oil on ten occasions (i.e. every meal on every second day). The monitoring of breeding birds will be essential to assess their long-term health and productivity.
- Olive oil (extra virgin)—This was selected as one of the supplements for Chatham Island tāiko. It continues to be added to the sardine/soya oil diet for tāiko at the same proportion as cod liver oil (3% per total volume) to boost the general oil content in the mix. No detrimental effects of using olive oil have been observed, and it is considered less risky to add olive oil to the tāiko diet than to double the quantity of cod liver oil. However, healthy fatty acids are absent in this plant-based oil, so its nutritional role is questionable, and the long-term effects of feeding over 20% by total meal volume of olive oil to lightweight birds in one-off high-oil-content meals remain unknown.

Note: The olive oil must be of excellent quality and very fresh. Therefore, a New Zealand-made olive oil that is packaged in a container that protects it from light (e.g. tin can or dark bottle) should be used, rather than risking using imported olive oils that are often rancid on arrival to New Zealand.

- Fish oil—This is the most nutritionally appropriate oil to feed seabirds and is currently being trialled as a full replacement for soya oil, as well as a supplement to the sardine/soya oil diet, in a study that has been initiated by Micah Jensen BSc BVSc MANZCVS (Avian Health), a Master's student at Massey University (refer to section 11.4—'Specialist advice' for contact details), and which will extend to 2014 (M. Jensen, pers. comm. 2013). The use of fish oil (which tends to be derived from a variety of fish species) is recommended because it contains much safer levels of vitamin A than cod liver oil, and preliminary results show that it has a great effect on chick development, particularly due to its Omega 3 and 6 fatty acid ratios. In short, while fish oil may not necessarily improve fledging success, it is likely to improve the quality of the chicks that are fledging.
- However, sourcing and storing fish oil remains problematic because:
 - No supplier has been found to date that will provide the relevant quantities of the appropriate fish oil—very small quantities of fish oil products can be obtained from health food stores but they are very expensive. (Contact Tamsin Ward-Smith, Helen Gummer or Micah Jensen for current information on potential suppliers; refer to section 11.4—'Specialist advice').

- Fish oil has a limited lifespan (e.g. < 6 months), so it must be obtained fresh each transfer year, i.e. purchased as close to the time of the feeding operation as possible and then disposed of after the operation.
- There is a high risk of the oil going rancid (oil that has oxidised is toxic to birds). Therefore, it must be kept in an air-tight container in a cool, dark place, as it is the exposure to air and light that causes the oxidation and rancidity. It is recommended that fish oil used during seabird translocation projects is stored in a Cornelius or soda keg (originally used in the soft drink industry and commonly used for storing home-brewed beer). In these containers, pressurised gas (from carbon dioxide canisters) is forced into a 'gas-in' port, and pushes the oil from the bottom of the keg, out of the 'liquid-out' port and through a tap; thus, the oil remains out of contact with air. Kegs must be thoroughly cleaned before and after use, which may require a commercial cleaning process. Micah Jensen has developed detailed instructions for the operation of such a keg. A cheaper alternative to the keg is to store the fish oil in multiple small, dark, air-tight containers (each one filled to the brim with oil to reduce air contact). Containers can be opened one at a time, as required, and used soon after opening, i.e. limiting the amount of oil in contact with air and the contact time.
- It may not be easy to detect if oil is turning rancid. However, there is a test that can be carried out at a nutrition laboratory (e.g. Massey University Nutrition Laboratory) to check whether fish oil is going rancid; therefore, it is recommended that projects budget for this test so that any oil that appears to be turning (e.g. darkening in colour or changing in smell) can be tested towards the end of a transfer. Alternatively, a supplement (e.g. vitamin E) can be added to the fish oil to prevent it from going rancid (specialist advice from a nutrition laboratory is required).

Important note: Before starting a grey-faced petrel translocation project, ensure that you seek specialist advice on the latest recommendations around supplementary oils and consult with the project managers of the most recent grey-faced petrel translocation. There may be new information to assist your project, or you may even be able to participate in further trials to help develop the optimum diet for this species.

9.3.2 Current grey-faced petrel diet composition

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

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%).
Note: Trials are underway (in 2013) with grey-faced petrels in which all soya oil is tipped off and replaced with 20 mL fish oil per tin.
- One-third Mazuri® Vita-zu seabird tablet (vitamin/mineral supplement: product code 'Small 5M25').
- 50 mL cold water (previously boiled >3 minutes) (volume is doubled for first few meals; see Table 6).
- Fish oil—added at a rate of 5 mL fish oil to 50 mL sardine puree as a diet supplement for the following chicks:
 - Lighter chicks that need to gain weight but where overfilling of the crop (with large volumes of puree) must be avoided.
 - Chicks that are approaching fledging and problematic to feed (e.g. regurgitating meals) but need weight maintenance and hydration, e.g. chicks that are not departing in periods of very calm weather (no wind for take-off).

Note: A total of 800 tins of sardines should be sufficient to feed 80 grey-faced petrel chicks for up to one month at the release site, as chicks are not fed on a daily basis; i.e. allow an average of ten tins per chick.

9.3.3 Current Chatham Island tāiko diet composition

The diet that is used to feed translocated Chatham Island tāiko chicks evolved during a set of transfers between 2007 and 2011 and comprises the following recipe:

- 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%).

Note: Fish oil has not been used with the critically endangered tāiko to date because of the potential risks involved in safely transporting and storing the oil on the Chatham Islands. However, the use of fish oil is currently under review.

- One-third Mazuri® Vita-zu seabird tablet (vitamin/mineral supplement: small 5M25).
- 50 mL cold water (previously boiled >3 minutes).
- 5 mL extra virgin olive oil (approximately 1 level teaspoon).
- 5 mL cod liver oil (approximately 1 level teaspoon).

Note: This diet differs from that used for grey-faced petrels in that cod liver and olive oil are added to every meal for every chick. In addition, very oily feeds have been given to three lightweight tāiko chicks of concern, which consisted of 15 or 20 mL olive oil, 5 mL cod liver oil, and the rest of the meal made up to the appropriate volume required by the individual chick with the standard tinned fish/oil/water slurry. However, this higher proportion of cod liver oil (than is used in the normal recipe presented above) may no longer be appropriate until we have a greater understanding of vitamin A toxicity and the actual requirements in seabirds (and at least until the birds that were fed these occasional oily meals have been identified as breeding adults).

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. 2014b).

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

- Plexi-vet™ syringes (50 mL) with custom-made clear Teflon crop tubes (6–6.3 mm outside diameter / 3 mm inside diameter × 140 mm length for grey-faced petrels or 120 mm length for Chatham Island tāiko). 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 hand-fed to grey-faced petrels is around 20 mL (approximately 20 g in weight)—much less than this is not considered to be worth the handling stress for chicks. A similar volume also works when supplementary oral electrolyte fluids or oil need to be delivered to a chick, which may include:

- Electrolyte fluids given on transfer day (≥ 20 mL).
- Electrolyte fluids given between meals if there is concern regarding hydration, e.g. if a chick is not needing to be fed every other day yet the climatic conditions are very hot; a chick that is close to fledging is receiving such small meals that hydration is still a concern; or a chick is unwell and is thought to require fluids on a daily basis (20–30 mL).
- If supplementary oil-only meals are recommended for an individual (20–30 mL oil feed is an appropriate volume). Note: Supplementary oil-only feeds have been tried and tested on translocated Chatham Island tāiko chicks (refer to section 9.3.3—‘Current Chatham Island tāiko diet composition’), and pure olive oil feeds of 30 mL have been tried on parent-reared grey-faced petrel chicks in poor condition at a natural colony without issue (G. Taylor, pers. obs.). Such oily meals have yet to be tried on translocated grey-faced petrel chicks, however.

Note: Chatham Island tāiko chicks are fed a minimum of 15 mL meals.

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 11.6.1—‘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 standard volume of artificial food that should be fed to grey-faced petrels in any one hand-feeding event is normally 100 mL (approximately 100 g in weight). Occasionally, a maximum of 130 mL is fed to chicks but, as a rough guide, regularly-fed artificial meal sizes should not exceed one-quarter of the chick’s body weight (i.e. a chick should ideally weigh > 500 g if it is receiving a meal of 130 mL in one feeding event). Also, be very careful about feeding a chick 130 mL in two or more successive meals because there can be issues with overfeeding, especially if the chick is < 500 g and/or has any kind of underlying ailment (refer to section 9.5.3—‘Overfeeding’). Although it may appear desirable to put a lightweight chick onto such a schedule of regular, large meals to boost its weight (and in some cases this may work), it is generally considered safer to supplement the diet of these chicks with more oil, rather than increase the size of the sardine slurry meal. Alternatively, it is possible to feed a smaller volume of food on a daily basis; e.g. feeding a chick with 80 mL per day over five days may be safer than feeding it 130 mL every other day over a 5-day period, as long as the bird does not exhibit extra handling stress.

Note:

- Studies have shown that grey-faced petrel chicks receive an average meal size of 77 g (R. Dunn, University of Auckland, unpubl. data 2012) to 97 g (Imber 1976) from their parents. The largest meals received by chicks in one night have been calculated as 160 g (Imber 1976) and up to 171 g (R. Dunn, University of Auckland, unpubl. data 2012), and this is likely to be the upper limit of single meals—anything more than this is thought to reflect a double feed (i.e. a meal from both parents on the same night), e.g. Dunn recorded a meal size of 295 g in a chick aged 104 days, 26 days before it fledged. Double feeds are not a regular occurrence and chicks receiving double feeds are unlikely to receive another meal for many nights (potentially up to 2 weeks).

- Chatham Island tāiko chicks should be hand-fed a maximum of 80 mL, which is a suitable volume to feed a chick on alternate days. Although up to 100 mL is occasionally fed, this is not generally fed over successive meals.

9.5.2 Importance of planning feeding frequency

Gadfly petrel chicks are fed at irregular intervals by their parents, rather than nightly. For example, grey-faced petrel chicks are fed on average once every four nights by a parent (Imber 1976; R. Dunn, University of Auckland, unpubl. data 2012). It is likely that an individual adult makes a combination of short and long foraging trips at sea, as is typically seen in petrels; therefore, the chick provisioning rate is more likely to range from every 2-3 days (short foraging trips) to up to 7 days (long trips). Consequently, chicks have slow metabolisms and large fat reserves, and an ability to convert fat to water if required.

Feeding frequency is known to decline as fledging approaches, and in the wild the parental abandonment period (where parents make no further visits to the burrow) varies. For grey-faced petrels, the abandonment period, if it occurs at all, is likely to be dependent on chick behaviour, i.e. a parent may continue to visit if the chick is still hungry and begging, or stop visiting if the chick is refusing food because it is too heavy.

Note: An abandonment period is likely to be less pronounced in the non-migratory grey-faced petrels than in a migratory species, where parents make no further visits to the burrow because they need to depart on migration.

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 being fed a natural diet for the following reasons:

- Chicks are not able to take large volumes of food (>100-130 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 one 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.

To date, there have been two different approaches to feeding large gadfly petrel chicks, with the following feeding frequencies:

- Grey-faced petrels—For practical reasons, the two main translocation projects to date have chosen to feed all chicks (<76 birds) on alternate days (see Table 6). Although minimal labour is required on the alternate non-feed days, a large number of people must be recruited on the intensive feeding days to help prepare food, process chicks (including measurements) and clean up afterwards. Chicks could expect to be fed up to 15 times at the release site, although heavy and/or advanced chicks that require less frequent feeding may not be fed on every feeding day, but instead may have a gap of three or more days without being fed (i.e. fed every fourth day).

Table 6. Guide to hand-feeding grey-faced petrel chicks for the first 11 days following transfer (based on information in Mitchell & Mitchell 2009).

Note: One tin = 106 g Brunswick® sardines in soya oil; Mazuri® Vita-zu (one-third tablet per tin of sardines) was also added as per the recipe presented in section 9.3.2—‘Current grey-faced petrel diet composition’; ‘-’ = no feed; 1 mL of food weighs approximately 1 g.

| FEEDING DAY | DIET RECIPE (SARDINES : WATER) | TRANSFER DAY CHICK WEIGHT | | |
|--------------|---|--|---------------------------|--------------------------|
| | | LIGHT (500–550 g) | MEDIUM (550–650 g) | HEAVY (> 650 g) |
| Transfer day | No feeding, except lightest chicks* 1 tin : 100 mL | ≥20 mL electrolyte fluids or up to 50 mL puree for chicks that have not been fed for two or more nights | ≥20 mL electrolyte fluids | 20 mL electrolyte fluids |
| Day 1 | 1 tin : 100 mL | 50 mL puree | 50 mL puree | ≤ 50 mL puree |
| Day 2 | 1 tin : 100 mL | 50 mL puree | 50 mL puree | ≤ 50 mL puree |
| Day 3 | 1 tin : 100 mL | 100 mL puree | 100 mL puree | ≤ 50 mL puree |
| Day 4 | – | – | – | – |
| Day 5† | 1 tin : 50 mL | 100 mL puree Supplementary oil as required‡ | 100 mL puree | ≤ 100 mL puree |
| Day 6 | – | – | – | – |
| Day 7 | 1 tin : 50 mL | 100 mL puree Supplementary oil as required‡ | 100 mL puree | ≤ 100 mL puree |
| Day 8 | – | – | – | – |
| Day 9 | 1 tin : 50 mL | 100–130 mL puree Supplementary oil as required‡ | 100 mL puree | ≤ 100 mL puree |
| Day 10 | – | – | – | – |
| Day 11 | 1 tin : 50 mL | 100–130 mL puree Supplementary oil as required‡ | 100 mL puree | ≤ 100 mL puree |

* Where chicks have been held overnight in transfer boxes before being transferred, consider feeding the lightest chicks on transfer day. If birds arrive at the release site during the late morning or early to mid-afternoon, there should be time to achieve this.

† From Day 5, all chicks can be fed every second day, although some of the heavyweights may only need meals every fourth day. Fluid or food supplementation can be given between scheduled feeds for those considered to need it, i.e. if they did not receive a full meal on the scheduled day due to regurgitation. Fluid supplementation in between scheduled meals is thought to be particularly important for some birds where projects are operating in very hot conditions/climates.

‡ Fish oil can be used to supplement the diet of lighter chicks that need to gain weight at a rate of 5 mL per 50 mL puree, e.g. 100 mL puree + 10 mL oil = 110 mL meal volume.

Important note: A meal of 130 mL would only be fed to chicks weighing ≥500 g (to avoid overfeeding). Avoid feeding two very large meals (e.g. 130 mL) on two successive feeding events to ensure that all food is being digested. A regime of 130 mL on one day, followed by 100 mL two days later, then 130 mL two days after that, etc. may be effective and reduce any risk of overfeeding.

- Chatham Island tāiko—Feeding regimes for tāiko have followed the approach used for the small gadfly petrels, with at least some chicks being fed on each feeding day at the release site for the first two weeks, and then ‘non-feed’ days being scheduled where chicks can be grouped onto the same feeding days, e.g. every other day (refer to section 9.5.6—‘Chatham Island tāiko feeding regime’, Table 7B). The feeding schedules are designed around the individual chicks’ transfer days, because chicks are usually transferred one at a time. Feeding frequencies vary for each individual depending on their weight, wing length and general stage of development. Tāiko chicks have received up to a maximum of 13 meals at the release site.

Note: For the large gadfly petrels, individual chicks rarely get fed on two days in succession, unless birds that are in very poor condition have been accidentally transferred.

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. Experience with small gadfly petrel chicks shows that these appear to prevent or slow down digestion (possibly blocking part of the digestive tract) and, once regurgitated, chicks often feed normally.

Overfeeding can be avoided by allowing daily weight gains of no more than 15 g over a 24-hour period (or 30 g over 2 days) (Collen & Bishop 2006). A weight gain of 10–15 g per day is reasonable, but if a chick has increased by more than this beware—they may be being overfilled and unable to digest the volume of food given. This is usually evident by feeling the belly area—it will feel swollen and firm when full, but soft and flat when empty (practice feeling the belly gently before and after feeding to be able to recognise this). If a chick has made a large weight gain that suggests it still has some undigested food; the next meal must be reduced in size or delayed, to ensure that all traces of the previous meal are digested. It also pays to examine the cloaca of chicks that make large weight gains, to check that there are no blockages at the vent. Cloacal obstruction could be caused by a crust forming in the region, or by a feather or fat occluding the cloaca; it can also be compounded by the inflammation associated with a build-up of urates (McInnes 2007).

9.5.4 First (introductory) meals

Chicks of any species should be fed a relatively small introductory meal 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.

Table 7. Guide to hand-feeding Chatham Island tāiko chicks (developed for the Taiko Operations Manual). A. Timing of the first (introductory) meals; B. meal size and feeding frequency.

Note: One tin = 106 g of Brunswick® sardines in soya oil; 1 mL of food weighs approximately 1 g.

A

| WEIGHT AT TRANSFER | TIMING OF FIRST (INTRODUCTORY) MEAL | LIKELY FEEDING FREQUENCY THEREAFTER |
|--------------------|---|--|
| < 600 g | Feed 2 days after transfer (particularly if wings are at short end of transfer range), providing that no parental meal was received on the night before transfer (otherwise feed 3 days after transfer) | Chicks likely to be put on a schedule of feeding on alternate days |
| 600–750 g | Feed 3–5 days after transfer, depending on wing size, i.e. feed chicks with wings at short end of transfer range after 3 days, and those with wings at long end of transfer range after 5 days | Chicks likely to be put on a schedule of feeding every 3–6 days depending on wing length |
| > 750 g | Feed no sooner than 7 days after transfer | Chicks likely to be put on a schedule of feeding once per week |

B

| WEIGHT AT TRANSFER | LIKELY MEAL VOLUMES | LIKELY FEEDING FREQUENCY AFTER FIRST (INTRODUCTORY) MEAL |
|--------------------|--|--|
| 450–550 g | First (introductory) meal—20 mL. Second meal—40–50 mL. Third meal—50–60 mL. Fourth meal—same or larger than the third meal depending on weight gains and wing length, etc. Note: There is a limit of c. 80 mL if feeding on alternate days, or 100 mL if feeding less frequently. Later meals will eventually decrease in volume, especially if chick is not showing signs of emerging. | Alternate days, eventually decreasing to every third day based on weight gain/stability. Try to increase base weight slowly (e.g. by no more than an average of 10 g/day to ensure that undigested food does not remain in the gut). Aim to have birds at ≥ 500 g by emergence time. |
| 550–650 g | First (introductory) meal—20 mL. Second meal—up to 50 mL. Note: Meals are unlikely to exceed 50 mL in volume. | Once every 3–4 days—if wing at long end of transfer range, i.e. > 260 mm; or Once every 2–3 days—if wing at short end of transfer range, i.e. < 260 mm. |
| 650–750 g | First (introductory) meal—20 mL. Second meal—up to 40 mL Note: Meals are unlikely to exceed 40 mL in volume. | Once every 6–7 days—if wing at long end of transfer range, i.e. > 260 mm; or Once every 4–5 days—if wing at short end of transfer range, i.e. < 260 mm. |
| > 750 g | Usually only energy feeds of around 20 mL to provide immediate energy for activity and help conserve fat reserves. Note: Meals unlikely to exceed 20–30 mL. | Once every 7–8 days—if wing at long end of transfer range, i.e. > 260 mm (although some chicks refuse food even after 10 days); or Once every 5–6 days—if wing at short end of transfer range, i.e. < 260 mm. |

Ideally, you will know which chicks are likely to have received a parental meal the night before transfer by the status of the stick fences at burrow entrances (refer to section 7.4—‘Preparations on the day before transfer’). This will help you to decide whether any of the lighter chicks will need to be fed more urgently than the others. Consider feeding chicks on arrival at the release site if they:

- Weigh 500–550 g (considered relatively lightweight at this stage in development); and
- They **did not** receive a parental meal on the night before transfer.

Some of these chicks may not have received parental food for many nights and they will need to be fed sooner so that they do not fall too far behind in weight. Ideally, lightweight chicks that have not been fed for two or more nights should be fed on transfer day, especially if they were held overnight in transfer boxes at the source colony prior to actual transfer (in which case these chicks would have gone three nights without receiving a meal). Dunn (unpubl. data 2012) recorded daily weight losses in eight chicks that fledged and found that weight loss could be as much as 1.9 g/hour (46 g/day) for chicks that had not been fed for 24 hours. It should also be noted that a chick that has undergone the stress of transfer may have a larger weight loss.

9.5.5 Grey-faced petrel feeding regime

The first **introductory meal** should be no more than 50 mL. Therefore, the mixture for this meal will need to be more dilute than the normal recipe for this species that is presented in section 9.3.2—‘Current grey-faced petrel diet composition’, to help avoid dehydration and improve digestion of the new food (i.e. for one 106 g tin of sardines, increase water from 50 mL to 100 mL). Note: Some very heavy and/or more advanced chicks may take less than 50 mL of the introductory meal because they need to lose weight, especially if they received a large meal shortly before transfer.

For the **second meal**, it is appropriate to deliver a volume of 50 mL (of the more dilute sardine puree mix) to each chick, to prevent them from being loaded up too much with the new diet so early on.

Note: 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 50 mL introductory feed and the 50 mL second meal (unless they are very heavy).

On **day 3**, a meal of 100 mL of diluted sardine mix should be fed, and after this the food should be thickened to the normal puree dilution.

For all **subsequent meals**, meal size and feeding frequency for each chick can be planned using Table 6 and the following guidelines:

- Make decisions on subsequent meal size and feeding frequency based on:
 - The change in pre-feed weight since the last feed—if a chick needs to gain weight, allow no more than a 10–15 g gain over 24 hours; if a chick needs to lose weight, aim to prevent it from losing much more than 15 g over 24 hours. The Matakoho-Limestone Island project found that once the feeding regime in Table 6 was established, chicks rarely lost or gained more than 30 g over a 48 hour period.
 - 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 feeding behaviour 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. 2014b)). 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.

Strategies to feed lighter chicks that need to gain weight include:

- Feeding smaller volumes on a daily basis (e.g. up to 80 mL per day) rather than on alternate days.
- Splitting the large 130 mL meal in two and feeding half of this first thing in the morning and then the other half last thing in the afternoon (e.g. 6–8 hours later) after some of the earlier meal has been digested; this may be more logistically feasible if feeding days are only scheduled on alternate days.

Note: 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 every second day will tend to stay on that regime for most of the rearing period. Volumes may then need to start decreasing **as the chick gets closer to fledging** (refer to section 9.5.8—‘Reducing meal sizes’), depending on the chick’s response at feeding. It should be noted that Table 6 relates to chick weight at transfer rather than age—although some of the light chicks may be more advanced than others, the approach is still the same, and the more advanced chicks will start to reject food sooner than younger birds.

Chicks that are problematic to feed (e.g. regurgitating meals) but are considered to require weight maintenance and hydration can have their diets supplemented with fish oil at a rate of 5 mL oil to 50 mL puree if there is concern that they may be very light at fledging. Chicks can also be given up to 30 mL oral electrolyte fluids (e.g. Lactated Ringers™ solution) to maintain hydration if they are unable to retain the regular feed, or a combination of oral electrolytes and fish oil (e.g. 30 mL fluids and 5 mL oil).

9.5.6 Chatham Island tāiko feeding regime

A rough feeding guide has been specifically developed for Chatham Island tāiko chicks, so that feeders can identify an approximate feeding regime that is likely to suit the individual, based on its weight and wing length at transfer (Table 7). The regimes range from small meals that are fed infrequently (for heavy chicks), through to large meals that are fed regularly (for young, lightweight chicks). Over five transfer years, 58 tāiko chicks were fed an average of five meals during their stay at the Sweetwater release site (range 1–13 meals).

Table 7A can be used to determine the timing of delivery of the first (introductory) meal, which is primarily based on:

- The time of the last parental meal—Tāiko chicks are not fed in the first three days following transfer if they are thought to have been fed the night before transfer by parents. This allows the chick several days to digest the rich parental meal before receiving artificial food, and avoids the risk of inducing a regurgitation response.
- Chick weight at transfer.

Table 7B can then be used as a rough guide for all subsequent meal sizes and feeding frequency. In practice, each chick’s meal pattern should be planned one to two meals ahead by looking at transfer data (weight/wing length) and:

- Estimating the time of fledging by calculating the remaining wing growth (tāiko chick wings grow at approximately 4 mm/day to reach a length of around 305 mm).
- Predicting the bird’s weight at the estimated time of fledging (tāiko chicks lose approximately 10–15 g/day, aiming for a fledging weight of 450–500 g):
 - If the predicted weight is still going to be above the average fledging weight at the time the wing is fully grown, the chick will only require energy top-ups, e.g. 20 mL no more than once/week.
 - If the predicted weight is lower than the average fledging weight and more wing growth remains to be completed, the chick may need bigger, more regular meals.

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 meal the 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, agitated, and reluctant to accept the crop tube into its 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 resistance in the throat and a tightness around the crop tube as it is introduced. Note: Where chicks are only receiving 20 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 that is rejecting food, 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 10-20 mL at its next feed event, although that is not standard for every chick.

Note:

- In projects to date, hand-fed grey-faced petrel chicks have often departed when still receiving standard (100 mL) meal sizes. While some of these chicks fledged on the night of the feeding day, most departed on the second night after feeding. Chicks were found to still lose the appropriate weight even whilst being fed 100 mL meals—most likely attributed to the extra exercise close to fledging.
- Chatham Island tāiko chicks are known to have fledged on the night following a meal of up to 30-40 mL, so not all regimes for this species drop to the minimum meal size of 15-20 mL.

To date, two different methods have been used to reduce meal sizes close to fledging, which are related to the weights chicks attain at the release site during their stay there:

- Chicks with weights around or less than the normal adult weight or known fledging weight whilst they are at the release site—For these chicks, meal sizes are only ever reduced in response to the chick showing signs of meal rejection. On Matakohe-Limestone Island, chicks were fed 80 mL of slurry for as long as possible after the first signs of meal rejection, followed by 50 mL of slurry (plus 5 mL of cod liver oil); and if they would not take that, they were given 30 mL of oral electrolyte fluids (plus 5 mL of oil). Chicks were always given something on each (alternate) feeding day, because dehydration was a potential risk in the very hot conditions at the site.
- Chicks with weights greater than the normal adult weight or known fledging weight whilst they are at the release site—These chicks need to be fed in such a way as to maintain a gradual weight loss of around 10-15 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, if possible, aim for a gradual decline in weight of around 10 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.

Both cutting short the hand-feeding period prematurely and extending it longer than necessary have implications for chicks:

- If hand-feeding is stopped prematurely and a chick loses weight at too fast a rate close to fledging (i.e. > 15 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; plumage not quite fully developed).
- If continued hand-feeding slightly delays a chick's departure, the chick will be continuing to site-fix during the slightly extended emergence period and the wings will continue to grow towards optimum length. However, there is a risk that the chick will not be trim enough to get out to sea if it does attempt to fledge a little earlier than expected. Therefore, there is a fine line between reducing meal sizes too early in some chicks, and delaying this in others.

9.5.9 'Non-feed' days

All chicks must still be checked for wellbeing on days when they are not fed, but not handled unless necessary (refer to section 8.5 of the field guidelines (Gummer et al. 2014b)).

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. 2014b), 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 aim to contain meals for no more than around ten chicks, i.e. for as many chicks as can be fed in one hour. This is because the food is warmed up in batches at the burrow site and should be used within the hour to avoid contamination issues—warm fish mix is particularly prone to contamination. Thus, for the large gadfly petrels receiving meals of up to 100 mL (on average), pottles should hold around six tins-worth of mixture (e.g. 1-L pottles). Food pottles of this size can be effectively warmed up in a yoghurt maker containing hot water; slightly larger pottles can be warmed in a small chilly bin with 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 (as for Chatham Island tāiko, or if projects choose to feed half of all grey-faced petrel chicks on one day and half on the next) 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.

Note: If grey-faced petrel chicks are all fed on designated feeding days, it is unlikely that chicks will be missed out accidentally.

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. 2014b), 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 wings are measured every 3 or 4 days (usually coinciding with handling for feeding) to assist with meal planning and to schedule blockade removal. Weighing and measuring frequency may increase towards fledging to capture the fledging data as close as possible to each chick's departure.

- 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 may 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. 2014b)):

- 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. 2014b), 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 large 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. 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 that have a long-distance flight ahead of them once they depart the colony. Grey-faced petrel chicks are rarely observed in inshore waters after fledging, indicating that they immediately head offshore to pelagic waters. (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. Grey-faced petrel chicks are thought to mostly take off from ridges, outcrops, bluffs or cliff tops. However, they are also considered to be a tree-climbing species and have been observed climbing trees such as pōhutukawa to reach a branch from which they can take flight. Chatham Island tāiko mostly use take-off trees to exit the forested valley in which they nest.
- 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 of small gadfly petrel species 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 may 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.

The total number of nights over which chicks emerge prior to fledging varies between species, individuals and sites (see Table 5). 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:

- Grey-faced petrels that were translocated to Matakōhe-Limestone Island spent an average of three nights longer exploring on the surface than those that were transferred to Cape

Sanctuary in later years. The Matakoho-Limestone Island burrow site was closer to sea level and in areas of regenerating forest, so it is thought that birds would have taken longer to find exposed areas for take-off and/or needed to lose more weight for effective take-off from the site, especially during periods of exceptionally calm weather (i.e. no wind at all).

- Forty-three Chatham Island tāiko that were translocated to Sweetwater had an average pre-fledging emergence period of 12 nights (range 6-20 nights), which was relatively shorter than recorded for chicks fledging from ‘Tuku Valley’ (southern Chatham Island) (range 16-27 days from first emergence to departure; Johnston et al. 2003). This is likely to be due to the Sweetwater burrow site being more elevated and exposed, potentially making it easier for birds to find suitable take-off trees that are relatively close to their burrows. Furthermore, within the densely forested ‘Tuku Valley’, Johnston et al. (2003) found that chicks fledging from the leeward side of the valley had longer emergence periods (24-27 days before departure) than the single chick on the windward side (16 days), although the sample size was limited.

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 three 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

Grey-faced petrel chicks usually start to emerge after their wings have reached a length of 250 mm. However, a few may emerge earlier than this (at a wing length of 240-250 mm) and these individuals are also likely to fledge at the lower end of the wing length range. When chicks emerge with wings less than 240 mm it is usually an indication of a health problem—early emergence in natural colonies is often associated with sick or starving chicks. On Matakoho-Limestone Island, a few chicks (four in 2008) did not emerge for the first time until their wings were over 285 mm long (Mitchell & Mitchell 2009).

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

Burrow entrance blockades (internal and external) can be removed:

- **3 days** after transfer day (i.e. no burrow blockades from the fourth night onwards) for all chicks weighing **> 500 g and with a wing length of ≥ 240 mm** on the day of blockade removal. This is likely to apply to around half of the chicks transferred.
- **4-6 days** after transfer day for all other chicks (i.e. as they reach 240 mm wing length).

Note: Transfer criteria should mean that very advanced chicks have not been moved; however, it is occasionally necessary to remove blockades from the entrances after < 3 nights (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.

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 > 6 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 are < 500 g.
- All chicks transferred in the **Priority 4** transfer group.
- 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 Island tāiko chick was found to be extremely wet through (to the skin) after a 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 blocking a chick in would still outweigh the risk of a light chick permanently disappearing and not being able to receive more meals before fledging. 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 therefore stress).

It is difficult to set clear criteria for blockade removal due to the range of individual chick sizes and emergence periods. However, as a guide, it is helpful to identify the individual wing growth rate for the chick in question and use this to predict the number of days it will take to reach the minimum fledging wing length (305 mm). The chick should then be allowed the minimum emergence period of 10 nights prior to that date. For example, if the wings of a lightweight chick (e.g. < 500 g) are growing at 4 mm/day, the blockade could be removed once the chick’s wings reach 265 mm (roughly 10 days before the expected earliest fledging date).

In the absence of any clear criteria, there are two alternative options that may avoid the need to make decisions on blockade removal:

- Set the internal blockade (e.g. rock or log) back by around 100 mm (so that it can still be retrieved and also prevents the chick from walking far into the pipe) and place a stick fence in such a way that it can be used to monitor whether the chick has ventured into the first 100 mm of pipe (i.e. put its head into the entrance and displaced the fence in a way that is clear to see).
- Install a temporary cage or dome at the burrow entrances of lightweight/problem chicks, to allow them to safely visit the surface once they are ready, while also giving a clear indication of when they can finally be allowed to emerge. This would negate the need to make subjective decisions about when a chick should be allowed to emerge, help to reduce any stress associated with a chick being blocked into a chamber and allow good air flow

into the burrow because the internal blockade could be removed after three days (when the chick has settled but should still not be allowed to disappear prematurely). The cage (with roof) would need to completely enclose the end of the pipe, be firmly anchored to the ground and be constructed of materials that present no hazards to chicks (both the chick occupying the burrow and other chicks wandering on the surface). The cage size could be approximately the same size as the burrow chamber, i.e. enough room for a large chick to turn right around so that it can go back up the tunnel head first. A stick fence set at the entrance would indicate the night on which the chick first emerges, after which the cage can be removed.

Both of these options need to be trialled, however, to determine their effectiveness.

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. Fledging is also dependent on wind (Imber et al. 2000), so periods of very calm weather may delay some chick departures, leading to an extended emergence period for some chicks.

Note: Where a chick does not emerge for one 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 5)
- For grey-faced petrels, wing growth rate has started to decrease from up to 5 mm/day to 1-3 mm/day, or has ceased
- Weight falls within the known fledging weight range for the species (see Table 5)
- 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 5)
- 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 extremely unlikely to fly directly to sea on their first night out of the burrow.
- The chick is heavier than the upper known fledging weights for the species (i.e. > 600 g)—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 ≥ 4 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 0–3 mm per day by departure time.
- The chick has >10% down coverage—Transferred grey-faced 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. It is possible that chicks fledging from release sites where there has been no rain or wind will be covered in slightly more down.

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’).

10.4.3 Use of radio-tracking

Grey-faced petrels and Chatham Island tāiko are the only species to date where radio transmitters have been attached to translocated chicks prior to fledging. There has been a need to radio-track individuals of these species for the following reasons:

- Grey-faced petrels—To confirm fledging success from the Longbush-Waikereru Hills Reserve (near Gisborne) release site in the first trial transfer year, to ensure that chicks were not becoming grounded outside the predator-exclusion fence on the mainland (7.5 km distance to sea) where they would be vulnerable to predators.
- Chatham Island tāiko:
 - To confirm fledging success from the Sweetwater release site in the first two transfer years, to ensure that chicks were not becoming grounded outside the predator-exclusion fence where they would be vulnerable to predators.
 - To enable young and/or lightweight emerging chicks that were reliant on hand-feeding for successful fledging to be found and fed if they wandered away from their burrow. This ensured that all chicks fledged in optimum condition.

There must be **strong justification** for the use of radio-tracking to track birds from the release site out to sea, because there are risks associated with:

- The device or tag attachment procedure, e.g. feather damage or loss
- The additional energy cost to tag-bearing chicks as a result of tag weight, profile and position in relation to the bird’s centre of gravity:
 - During the emergence period and on the bird’s maiden flight to sea
 - At sea, whilst learning to forage and commencing the long-distance flights

The use of transmitters over five years of Chatham Island tāiko transfers provided an opportunity to refine device attachment protocols for large gadfly petrel chicks. If transmitters are attached to chick tail feathers before they have stopped growing, the distance between the transmitter and the preen gland increases as the tail continues to grow, moving the transmitter further from the bird’s centre of gravity (compromising flying birds) and increasing the likelihood of damage to, or loss of, tail feathers. In addition, the transmitter attachment process can weaken the base of the growing feathers, causing them to fall out before they are fully grown and/or irritate the

chick, causing it to pull its tail feathers out. Therefore, chicks requiring transmitters should have them attached as close as possible to the time of first emergence. Transmitters should be fitted close to the preen gland to take account of further anticipated growth. If a chick's tail has not yet reached a specified length (> 110 mm for tāiko chicks; longer (but not yet defined) for grey-faced petrels) when it is ready to emerge, the transmitter should be first fitted to the chick's back and then moved to the tail once the tail feathers have stopped growing.

Important note: Any projects considering the use of radio-tracking as part of a translocation must obtain specialist advice and read the following Standard Operating Procedures (SOPs), copies of which can be obtained from a local DOC office:

- Planning bird radio-tracking and data-logging projects SOP (DOC 2011)
- Attaching radio and data-storage tags to birds: feather/skin mounts (tape/ties/glue) SOP (DOC 2011)

10.5 Missing chicks

10.5.1 How often do chicks go missing?

In most translocations of large gadfly petrels, chicks occasionally disappear from their burrows. At Cape Sanctuary, a trained and certified dog located many chicks that went missing in each of the first three transfer years (refer to section 10.5.3—'Searching for missing chicks') and at least four chicks permanently disappeared well before the expected fledging date, i.e. were never found.

For small gadfly petrels, 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.

Chicks can disappear either temporarily or permanently:

- Some chicks disappear temporarily, returning to either their own or a different artificial burrows after a period of one or more days. Grey-faced petrel chicks have been known to go missing for up to five days before being recovered again (on the sixth day); during this time, their base weight dropped by c. 50 g. Such chicks tend to be a priority for feeding as soon as they are found.
- 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?'
- Some small gadfly petrel chicks are not present in their burrows by day, but are suspected to return to their burrow 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. This pattern has not been reported in grey-faced petrels to date, however.

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 a very strong possibility, particularly at sites where burrows or take-off points have been sited too close to a fence.

- Fallen down a steep decline, bluff or cliff 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*)), 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 three nights (or two nights if very advanced and showing signs of wanting to emerge): 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, potentially losing an average of around 10-25 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. In an investigation of eight grey-faced petrel chicks that fledged, Dunn (unpubl. data 2012) found that weight loss could be as high as 1.9 g/h (46 g/day) for chicks that had not been fed for 24 h; however, the rate of weight loss decreased with time since the last meal, so that 48 h after last being fed a chick would have lost on average 1.1 g/h (26 g/day), and 5 days or more after the last meal it would have lost on average up to 0.7 g/h (17 g/day).

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 of small gadfly species 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 transfer (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).

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 and effective method for recovering missing grey-faced 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 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 (if required), 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 may not be able to depart from some sites (site dependent).
- If a chick has lost some 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 may 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 one 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.

10.7 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 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.⁵ 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 (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.

⁵ 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.

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 grey-faced petrel translocations:
 - Rose Collen—translocation specialist and contractor to DOC (email: rcollen@doc.govt.nz; ph: 021 2200550). (Note that rates may apply.)
 - Cathy Mitchell—veterinarian (email: mitchfam@xtra.co.nz; ph: 09 4340508).
 - Tamsin Ward-Smith—Cape Sanctuary Manager (email: tamsin@capesanctuary.co.nz; ph: 06 875 0308).
- For further research information on fish oil:
 - Micah Jensen BSc BVSc MANZCVS (Avian Health)—Veterinary Resident in Avian, Zoo Animal and Wildlife Health, Institute of Veterinary, Animal and Biomedical Sciences (IVABS), Massey University (email: M.Jensen1@massey.ac.nz).

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.

Vets 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 (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; ext. 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 (e.g. Chatham Island tāiko) (refer to section 11.6.10—‘Feather waterproofing’).

11.5.2 Remote locations

Where the source or release site is in an isolated 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

Six chicks on Matakoho-Limestone Island (one in 2005, four in 2007 and two in 2008) showed neurological symptoms (Mitchell & Mitchell 2009). These symptoms included arching back of the head (opisthotonus); ventroflexion of the head (bending towards the belly); lack of coordination; trembling; and distress when handled. These chicks seemed to sit quietly in their burrows, but the 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 (> 310 mm wing length, with a reduced growth rate of 1 mm/day) when the symptoms developed. Chicks displaying these symptoms in 2008 were among the later fledging birds (i.e. had been at the site for between 18 and 37 days). Two of the birds from 2007 and the two from 2008 developed symptoms on the same day, and in all cases, the symptoms coincided with a period of hot, calm weather. It is thought that the delay in departure contributed to their condition, and that infection was not involved in the problem (C. Mitchell, pers. obs. 2012).

All six affected chicks recovered from their neurological symptoms and five of the six were presumed to have fledged successfully, some as soon as the night after recovery. One of these chicks has since been recaptured as an adult back at the release site (Barr & Barr 2011). The sixth chick was found to have arthritis of a carpal joint, which eventually prevented fledging; consequently, this bird was euthanised.

The following treatments were given in the three different transfer years:

- 2008 (two chicks)—Fluids, vitamin B (Multiject B 0.03 mL orally) and anti-inflammatory (Metacam 0.03 mL orally) given within 10 hours of marked signs first being seen; both birds appeared normal 12 hours later.
- 2007 (one chick)—Fluids, antibiotic/vitamin B/anti-inflammatory given orally 24 hours after mild but marked neurological signs were first noted; symptoms subsided less than 12 hours later (a blood smear, uric acid and bile acids on this chick were recorded as normal).
- 2007 (two chicks)—Fluids and antibiotic; improvement noted 48 hours later; vitamin B and anti-inflammatory given orally 60 hours later, by which time symptoms were minimal.
- 2005 (one chick)—Fluids and antibiotic; recovered within 24 hours.

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 transferred to Cape Sanctuary, where the Mazuri® supplement (containing B vitamins) was added to the diet (C. Mitchell, pers. obs. 2012). It is recommended that oral administration of fluids, B vitamins and anti-inflammatory drugs could be used during other seabird translocations should similar symptoms arise (Mitchell & Mitchell 2009). Tunnels should be blocked for the first night after treatment to avoid chick disappearance and/or death due to misadventure.

11.6.5 Dehydration and heat stress

Dehydration can lead to visceral gout and kidney disease. Visceral gout is caused by the inability of the kidneys to excrete uric acid from the blood, which is subsequently deposited in the tissues (McInnes 2007). Gout has been identified in grey-faced petrels in the past and has been attributed to the fact that an artificial diet lacks the petrel-produced stomach oil, which is energy dense and a source of hydration.

Dehydration has been attributed as the cause of death for three chicks (at two release sites) that disappeared prematurely from burrows and were later found on the surface. Chicks are unlikely to have survived the exposed conditions at the time without shelter, with one chick disappearing from its burrow when daytime temperatures were > 30°C.

Dehydration can also be caused by not including enough water in the diet. Hydration is important for kidney function, and water must be provided at the correct amount in the diet

and in the atmosphere, as these are the only sources for transferred seabird chicks. In warm, dry conditions or in chicks of concern, hydration can be maintained by delivering oral fluids (electrolytes) in between meals and by considering the addition of more oil to the diet as a supplement, following consultation with Graeme Taylor and other seabird specialists and vets.

Heat stress can be reduced or avoided in chicks in burrows if the appropriate burrow temperatures are maintained (refer to section 8.2.5—“Temperature”). In non-insulated burrows, burrow temperatures tend to follow ambient 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 are cool and humid when ambient temperatures are high.

11.6.6 Eye infections

Six chicks at Cape Sanctuary had mild to moderate eye infections. They were found at the release site with their eyes sealed closed with a crusty discharge. Topical antibiotics cleared up the infection within 2–3 days in four of these chicks; however, two chicks did not respond to this treatment. During physical examination, the eyes of these two chicks were stained with dye, which revealed ulcerations or abrasions. Therefore, treatment was continued and, although scarred, the eyes of both chicks had improved by the time they fledged. Similar eye conditions were also reported in a few birds at the source colony.

11.6.7 Wounds

Emerging chicks can be susceptible to injury, especially when they crash-land to the ground following any 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).

11.6.8 Arthritis

Chronic arthritis was observed in two chicks that were transferred to Matakohē-Limestone Island. In both cases it was not known whether the chicks were transferred in this condition or how the condition was caused. Both chicks were euthanised.

11.6.9 Burrow hygiene

Grey-faced petrels are fed fairly large volumes of food on a regular basis following translocation, and so a build-up of waste matter can be expected in artificial burrows housing chicks. Burrows at release sites tend not to contain the invertebrates that are normally associated with seabird burrows, which may help to break down waste matter. Therefore, it can be common for many burrow chambers to emit a strong ammonia smell, especially around 2–3 weeks after transfer (Collen & Bishop 2006).

Nesting material needs 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. This is especially important if faeces and regurgitant are oily (since the grey-faced petrel diet includes supplementary oils), as oily waste matter in the burrow may spoil feathers and lead to serious waterproofing issues (refer to section 11.6.10—“Feather waterproofing”). However, it is important not to remove all of the material because it holds the scent that may help the chick to relocate its burrow when returning from night-time excursions on the surface.

In past projects, it was thought that particularly strong-smelling burrows may have been the reason why some chicks were reluctant to return to their chamber, instead sitting in the tunnel, perhaps to gain fresher air. In these instances, the chamber walls had to be washed down with

water. Chicks that are retrieved from tunnels often have soiled breast feathers that need to be cleaned. Also, in some cases, chicks can be seen in the pipe in daylight, making them potentially vulnerable to aerial predators (e.g. harrier hawks). Therefore, chicks should be discouraged from sitting in tunnels wherever possible.

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™.

11.6.10 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.

11.6.11 Misadventure

Transferred grey-faced petrel chicks have died as a result of the following misadventures:

- Three chicks were known to have departed from their respective colony sites but were found dead on the shore: one had a haemorrhage (likely to have been caused by an impact at fledging from the Matakoho-Limestone Island site); one had probably drowned in the sea (beneath the Cape Sanctuary site); and one was found grounded beneath the site and was considered to have become dehydrated.
- Two chicks are thought to have been preyed on by harrier hawks at the Cape Sanctuary site during the emergence period. The presence of vegetation cover at a site is likely to help chicks to avoid predation by aerial predators, as they are able to find cover more easily on the surface and are less likely to be seen whilst sitting near pipe entrances by day.
- Two chicks suffered fractured tibias, possibly as a result of poor handling, and both failed to survive prolonged treatment. Consequently, protocols at Cape Sanctuary now recommend that two people extract and return chicks to burrows if they are inexperienced handlers.
- Two chicks suffered injuries that are thought to have been sustained during encounters with other chicks at night. One of the chicks was found with a broken neck after an apparent fight with another chick, while the other had a beak injury that required veterinary treatment off site for five days; the latter chick survived to fledge normally.

11.7 Necropsy advice

There is a standard process that should be followed for any dead wildlife encountered.⁶ 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.

⁶ 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.

- 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/learning/departments/centres-research/wildbase/wildbase-pathology/how-to-submit-a-specimen.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. Note: Grey-faced petrel rearing occurs over Christmas/New Year, so it is even more important to contact the laboratory as it may not be operating for an extended period; the staff can then give advice on storage until the laboratory reopens.
- Interpreting and reporting pathology results—Consult with vets and seabird translocation specialists; include outcomes in annual reports for the benefit of subsequent projects.

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 any 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 source colony. This person is likely to be familiar with the colony through research or because they routinely visit as part of DOC management. They should be 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.

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 grey-faced petrels is involved in any new projects to train the relevant personnel at the new release 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 grey-faced petrels, which are not a straightforward species to work with.

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 at least two person-hours of burrow searching to find one chick that is suitable for transfer. This means that it could take a minimum of 160 person-hours to find 80 chicks (i.e. four people over five full (8-hour) search days or six people over approximately 3.5 search days).

12.2.2 Source colony collection trip

The following labour requirements are recommended if collecting up to 80 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.

12.2.3 Release site artificial burrow installation

As a rough guide, allow six people at least five 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 8 provides a breakdown of the labour requirements that are recommended for feeding/monitoring up to 80 chicks. Note, however, that labour requirements may vary greatly depending on the release site location and chick-feeding approach:

- If every chick is fed every second day, then the maximum number that would be fed on any particular day (i.e. maximum expected labour) is 80–100 chicks, while minimal labour would be required on the interim days. This kind of regime can work well at mainland sites.
- If chicks are assigned an individual meal plan whereby they may be fed every second, third, fourth, etc. day, there will be chicks to feed every day (e.g. up to 50 per day) and the labour requirements will be very similar from day to day. This kind of regime works well in more remote locations, where day-to-day logistics can be more challenging and a smaller team is more practical.

Other related tasks include assisting with food preparation/clean-up, end-of-day clean-up, data entry and meal planning.

Table 8. Breakdown of the labour requirements for feeding and monitoring chicks at the release site.

| WEEK | LABOUR REQUIREMENTS |
|------|--|
| 1–3 | <ul style="list-style-type: none"> • 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. • The number of people that is required to undertake feeding, monitoring and cleaning at the release site for the first 2–3 weeks is: <ul style="list-style-type: none"> – A minimum of six people (including an experienced operator) if feeding all chicks on alternate days. One to two people are required to check the health and welfare of all birds on the alternate non-feed days. – Approximately three to four people if feeding a proportion of chicks every day. Some of the team should have prior experience with seabird feeding regimes and routines, as there is enough time to train completely inexperienced operators when there are large numbers of chicks to manage. |
| 4 | <ul style="list-style-type: none"> • The number of people that is required to undertake feeding, monitoring and cleaning at the release site in week 4 is: <ul style="list-style-type: none"> – Six or fewer people (including an experienced operator) if feeding all chicks on alternate days, with the exact number depending on site logistics, etc. By keeping six personnel, runners collecting chicks can keep up with feeders and the job is completed sooner. – At least three people if feeding a proportion of chicks every day. However, it may pay to have a fourth person on standby for the fourth week (or part of the fourth week) in case the transfer contains a large proportion of younger chicks. By this stage, there will be non-feed days (i.e. chicks will be grouped into specific feeding days) • Only one person is required to check burrow occupancy, and the health and welfare of all birds on a non-feed day, although a second person could be useful if there are any problems to deal with. |
| 5 | <ul style="list-style-type: none"> • A minimum of two people (including an experienced operator) would be able to feed and monitor burrows in the fifth 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 leave when there are only a few chicks remaining, providing that the two left behind to complete the project are experienced personnel. |

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. 2014b).

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. 2014b).

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

- Wing length, weight (first and second weights) 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 (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

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. 2014b). 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.

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. 2014b).

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 at the time they left their burrow (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 one 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 for grey-faced petrels to ensure that there are:

- Areas of ground that are free of dense vegetation, so that birds can walk easily to appropriate take-off sites. This may involve creating and managing ‘pathways’ that are wide enough for birds to pass from burrows to ridges, cliff tops or suitable mature take-off trees.
- Open, safe areas where birds can land, i.e. that are free of dense scrub that birds can become entangled in, such as *muehlenbeckia* vines. Although there is probably a lower risk that large gadfly petrels will get strung up in vegetation when crash-landing compared with smaller (and lighter) species, it may still be beneficial to create open spaces, especially at sites where vegetation is planted/regenerating. This 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. For grey-faced petrels, this must be done after the last transferred chicks have departed in January and before any adults might return to nest prospect in April.

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 grey-faced petrels 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 2 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 (see Fig. 8), 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.

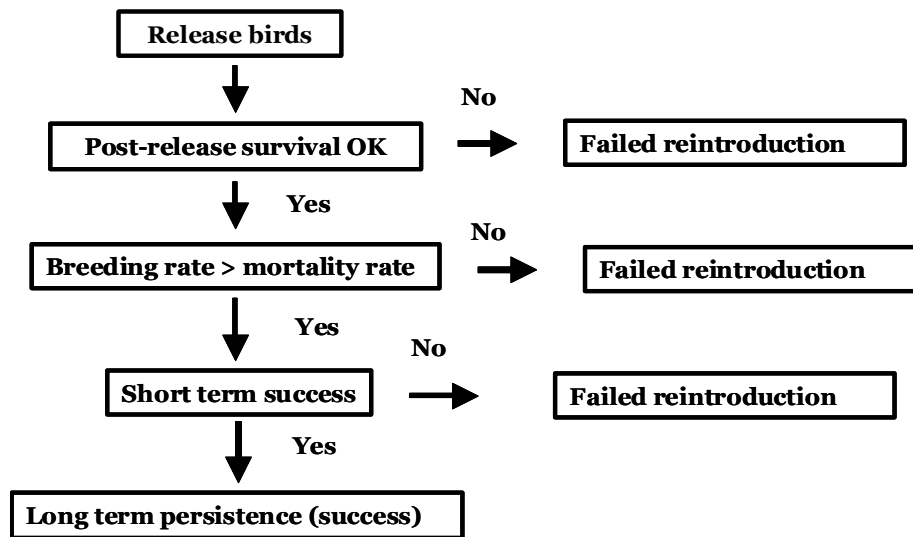
On the other hand, successful translocations provide useful information for similar projects in the future.

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 (refer to 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 large 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 up to 20 years). In addition, the colony is on course to be self-sustaining when the first release-site-bred chicks return to breed (which could be more than 15 years after the first transfer), i.e. F2 birds are producing F3 generation birds. 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 8. 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 two decades for grey-faced petrels.

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 three 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.

Note: kiwi (*Apteryx* spp.) have been known to regularly use artificial grey-faced petrel burrows and it can be difficult to ascertain which species is using a burrow if fences are being knocked over but no other sign is left (Barr & Barr 2011).

15.4.2 Monitoring timeframes

The earliest age that a translocated grey-faced petrel chick has been known to return as an adult is at 3 years and 8 months old (based on an estimated hatch date of 1 September; Barr & Barr 2011). This bird fledged during December 2006 and was recovered for the first time in May 2010, during the usual prospecting period for this species. Therefore, the first monitoring for returning adults can effectively commence at the start of the fourth breeding season following the first chick transfer, i.e. if there are four transfer years, monitoring would commence in the season immediately following the final transfer.

Those carrying out the monitoring should be aware that different individuals and birds of different ages may return to the colony as adults for the first time at different stages of the breeding season. Furthermore, first visits will not necessarily occur at the start of the season but can also occur during the incubation period, or even as late as the chick-rearing period. For grey-faced petrels, these stages occur at the following times of the year:

- Prospecting and courtship phase—April to June, with peak activity in the last two weeks of April and the first two weeks in May. Note that younger birds arrive a little later, for example:
 - 3-year-olds (non-breeders) have been recorded at the colony for the first time between July and September
 - 4-year-olds (non-breeders) have been recorded arriving between May and September
 - Birds older than 4 years (breeders and non-breeders) have returned between April and September
- Pre-laying exodus—Breeders predominantly at sea from May to June
- Egg-laying—June to July, with peak egg-laying during the last week in June and the first week in July
- Incubating phase—July and August
- Hatching—August to September
- Chick-rearing phase—September to December, with late chicks fledging by early January
- Departure from the colony—All non-breeders leave the colony by mid-September (e.g. Te Henga (Bethells Beach)) or mid-October (larger colonies)

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 very 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 necessary to identify the majority of returning grey-faced petrel adults, and usually involves catching birds on the surface or luring them out of burrows using call playback. All birds are then visibly marked (using Twink (correction fluid) on the head) so that they are not handled a second time.

Grey-faced petrels are generally fairly tolerant of disturbance and are less likely to be deterred from returning to the colony site or using burrows if captured at night than some other unrelated seabird species may be. (Note: Te Henga (Bethells Beach) colonies have increased massively despite regular catching taking place there two to three times per year over the past 20 years.)

It is recommended, however, not to overdo night-time monitoring to ensure that disturbance is kept to a minimum. Select a few really suitable nights (dark, stormy, windy, rain-threatening, etc.) and leave good gaps in the burrow-checking schedule to give birds time to visit without disturbance.

The most effective times of year to carry out night work are:

- April and May—for prospecting breeders and early-arriving non-breeders.
- Mid-August to mid-September—for breeders that are rearing chicks, failed breeders (egg stage) and late-arriving non-breeders. It may take at least one week to catch a pair, as they will not visit their burrow nightly. It is also important to note that incoming adults may have a high chance of regurgitating if captured before they have fed their chick; therefore, 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.

Note: For burrows that contain birds that are unlikely to breed that season (and where it may not be possible to lure the birds out on scheduled monitoring nights), erect stick fences at the burrow entrances and check any active burrows early in the day to record the bands on any birds that are remaining there during the day (refer to section 15.4.5—‘Handling burrow occupants for identification’).

15.4.5 Handling burrow occupants for identification

If a weekly (or more frequent) daytime burrow entrance 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.

Grey-faced petrels are fairly tolerant of handling during the breeding season. However, it is difficult to determine the full effects of handling (and whether burrow desertion ever occurs as a result of handling) because the species is also thought to be affected by intraspecific competition for nest sites at natural colonies between April and September, i.e. many younger prospecting birds desert burrows because they are ousted by more aggressive birds. Generally, it is considered that grey-faced petrels 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).

The safest times to handle grey-faced petrel adults for identification are:

- When they arrive at the colony for the pair-bonding/copulation (prospecting) period (April–May), 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 across an extended period of weeks and, even then, non-breeders may never be captured; therefore, night work tends to be more practical, as more birds can be recaptured in a concentrated period of time (refer to section 15.4.4—‘Night-time monitoring’).
- Once they start rearing chicks, or after a natural egg failure. Birds are unlikely to remain in their burrows during the day, however, so night work is necessary (refer to section 15.4.4—‘Night-time monitoring’).
- Earlier in the day (i.e. not in the late afternoon), so that any birds that are handled have the rest of the afternoon to settle before nightfall.

We strongly advise against handling the large gadfly petrels at the burrow during incubation because there is very **high risk of egg damage**. The safest way of identifying grey-faced petrel adults during incubation (if this is the only opportunity) is to lure the birds out of the burrow at night using call playback or ‘war-whooping’ (refer Glossary); you should then return at 10-day intervals to identify the partner (as they will take over for the next incubation shift).

Note: Although it is becoming more common to identify adults of the small gadfly species during the incubation or brooding (guard) phase, when birds are guaranteed to be present in their burrows by day, this is not recommended for grey-faced petrels because they are less tolerant than the smaller species during burrow inspection and handling, greatly increasing the likelihood that the egg will be broken.

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 you wait until such a time when it is likely that several burrows might be found (e.g. 5+ 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. Feathers that have been cut, or samples that consist only of down 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 (2010), copies of which can be obtained from a local DOC office.

15.3.8 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. 2014b) for an example of a monitoring form.

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18. Glossary

Base weight—The body weight of a chick without a full crop/stomach, i.e. before its next meal (parental or artificial). At the source colony, this is usually the lower of two grey-faced petrel chick weights recorded over a 3–4-day period. At the release site, this is the pre-feed weight that is recorded immediately before the next hand-feeding event.

Endemic—Unique to a defined geographical location, i.e. not found elsewhere. Endemic to New Zealand means a plant that is restricted to the New Zealand botanical region as defined by Allan (1961), or an animal that only breeds within the New Zealand Exclusive Economic Zone, as defined in the Territorial Sea and Exclusive Economic Zone Act 1977. This includes animals that disperse or migrate outside this area, but only breed within this zone.

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. Most species are dark above and pale or white below, although the grey-faced petrel is dark above and 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 2000⁸). Recent tracking data show that the Chatham Island tāiko exhibits both migratory and highly dispersive behaviours (G. Taylor, pers. obs.).

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

⁸ Heather, B.; Robertson, H. 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 6 December 2011).

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 that is required for planning any future field operations.

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.

War-whooping—A technique described by Tennyson & Taylor (1990) where *Pterodroma* petrels can be lured out of burrows by a distinct human vocalisation imitating their own calls. Birds may also respond vocally.

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 experts who contributed to and reviewed this document

This document was contributed to by experts with extensive experience in grey-faced petrel and Chatham Island tāiko translocation:

- 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
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The document was also reviewed by other experts with grey-faced petrel translocation experience or translocation process experience:

- Colin Bishop—Ranger Biodiversity Threats, Murihiku District Office, DOC; former Matakoho-Limestone Island Ranger
- Pam Cromarty—former Technical Advisor Systems Improvement, and coordinator of the translocation process, DOC
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Any new information or suggested improvements to this document can be sent to:

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¹¹ For more information, refer to www.haumoana.com/pages/capesanctuary.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. Standard pet box used to transfer burrow-nesting seabird chicks in New Zealand; note inside of box needs to be darker for most species. Fluttering shearwaters (here) tolerate lighter box interiors. Ventilation holes are preferred on all walls. Photo: *V. Waanders*.



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-glass syringe and custom-made Teflon crop tube. Photo: *D. Cornick*.