Seabird reintroduction to Boundary Stream Mainland Island

A strategic guide to the translocation and management of procellariiform birds at Boundary Stream Scenic Reserve

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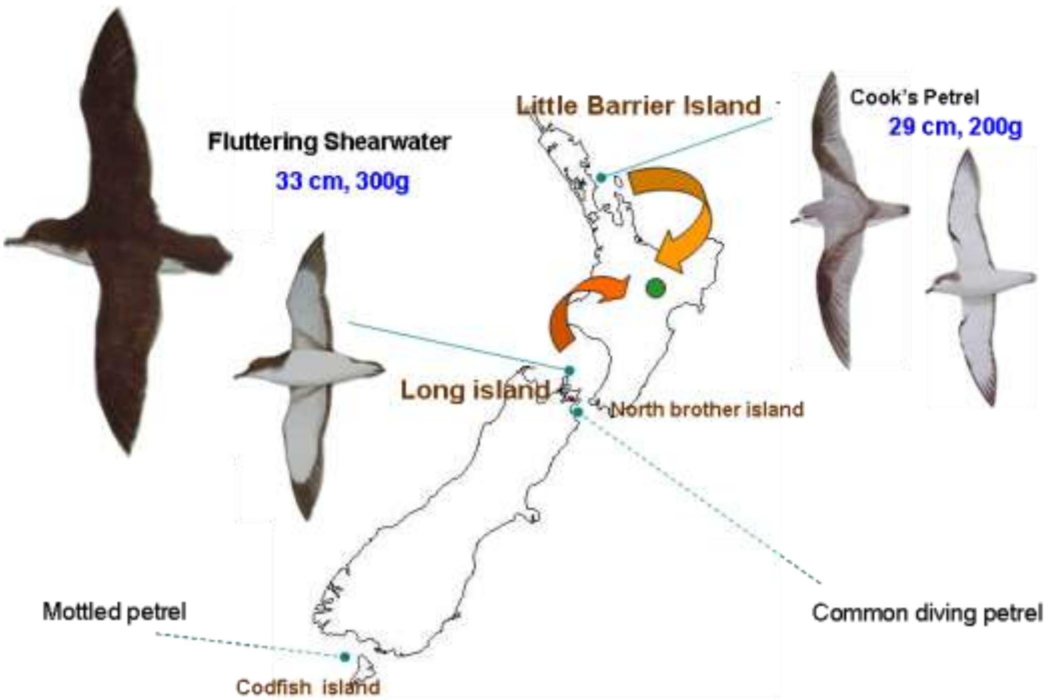

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1 Executive summary

Seabird colonies engineer the ecosystems of which they form a part, structuring the environment and benefiting many organismal groups through a myriad of ecological processes. Along with the decline in much of New Zealand's native fauna, the numerous seabird species formerly abundant on the North and South Islands are now found only on offshore islands. Attempts to restore habitat to pre-human or pre-European states are common in New Zealand, and it is important that the seabird-driven ecosystem processes are considered in the process. Historical attempts to reintroduce seabirds to restoration sites have been variable in their success, with some achieving large numbers (15-18% of fledglings) of birds returning to the translocation site, and others not recording any returning birds. More recent attempts have had a high success rate, and improvements in methodologies over the years have led to a reduction in the number of chick mortalities.

Boundary Stream Mainland Island (BSMI), a fragment of native forest located approximately 25 kilometers inland of Hawke's Bay and 70 kilometers Northwest of Napier, has recently been provided with a large grant (*c.* NZ$900,000), part of which will go towards the restoration of seabirds to the site. This report acts as a comprehensive set of guidelines to the reintroduction process, including discussion and recommendations of the selection of seabird species and release sites, as well as relevant information regarding timelines, methodologies and risk management.

Based on archaeological evidence of former seabird distributions, we suggest four candidate seabird species that are potentially appropriate for reintroduction to BSMI, including *Puffinus gavia* (fluttering shearwater), *Pterodroma inexpectata* (mottled petrel), *Pt. cookii* (Cook's petrel), and *Pelecanoides urinatrix* (common diving-petrel). Of these, we assess a number of factors, including knowledge of previous translocations, knowledge of important biological features, availability of source populations, and vulnerability of the species, to narrow down the four candidate species to two priority species (*Pu. gavia* and *Pt. cookii*). We recommend that these two species are introduced and established over a period of 6-8 years, after which a reappraisal of the remaining candidate species for introduction can take place.

The location of reintroduction site needs to meet a number of prerequisite ecological requirements, including position, availability of take-off facilities, soil type, slope and vegetation. These factors are discussed in detail and a number of potential sites in BSMI are considered. We suggest that seabirds are established at Site B (close to the Kamahi Loop walking track), which meets the ecological requirements and is appropriately situated for volunteer access.

A small section on funding requirements lays out the cost components of the project, with discussion on valuation methods. A conservative estimate for the total expenditure for the reintroduction of the two priority species should not exceed NZ$351,000 if cost-efficient decision-making is employed.

A detailed analysis the risks associated with seabird translocation is undertaken, with important considerations elaborated on. Some important concerns are the impact on source populations, transfer mortality of chicks, biosecurity and health issues, translocation site mortality of chicks, dietary considerations, predator control, inbreeding issues, and potentially harmful effects on the ecology of the reintroduction site. We conclude that if the appropriate procedures are followed and best-practices undertaken, the risks to source populations, seabird chicks, and the translocation site will be minimal. We recommend that approximately 250 chicks of each priority species should be transferred over a period of 6-8 years, where fluttering shearwaters are translocated before Cook's petrels. A detailed discussion of chick selection, disease screening, translocation protocol, burrow design, site vegetation, pest control, and a potential acoustic system ensures that all aspects of the project may be carried out with clear guidelines and appropriate ecological understanding. We finish the report by suggesting how community involvement could benefit the project, particularly through the inclusion of iwi groups at source and introduction sites, and utilising volunteers where possible.

2 Introduction

2.1 Seabird translocations

New Zealand has a high diversity of seabirds (birds obtaining most of their food at sea), with 39% (140 species) of the world total being recorded within the country (Bellingham *et al.* 2010). A large proportion (84 species) of these breed in New Zealand, and there are 35 species that breed nowhere else. Seabirds are an important part of terrestrial ecosystems for a number of reasons. It has long been known that seabirds play a significant role in bringing marine-derived nutrients such as nitrogen and phosphorus into soils, as well as structuring plant communities by burrowing and trampling (Gilham 1956a, 1956b). A recent increase in available literature on former abundances of seabirds (e.g. Worthy *et al.* 2002; Imber *et al.* 2003), as well as their ecosystem-level impacts, has led to the understanding that many seabirds structure, or engineer, the ecosystems of which they form a part (McKechnie 2006). So far burrowing seabirds have been shown to alter soil bulk densities, chemistry, and water-holding capacity, decrease soil pH, alter seedling survival and plant species richness, redistribute organic matter, and add substantial quantities of plant macronutrients to soil (Furness 1991; Norton *et al.* 1997; Mulder & Keall 2001; Hawke & Newman 2004, 2007; Fukami *et al.* 2006; McKechnie 2006). There is also strong evidence to suggest that the presence of seabird colonies has beneficial effects on a wide range of invertebrate and vertebrate taxa (Markwell & Daugherty 2002; Fukami *et al.* 2006).

Human-induced range reductions of many seabird species (through habitat degradation, hunting, and the introduction of invasive vertebrate predators) have meant that these effects are being withheld from large areas of the North and South Islands. It is therefore of considerable importance that seabird reintroductions are incorporated into ecological restoration programs, in order to restore many of the seabird-driven ecosystem processes that are currently lacking. This report should be viewed as a comprehensive set of guidelines to the reintroduction process, including discussion and recommendations of the selection of both species and release sites, as well as relevant information regarding timelines, methodologies and risk management.

There is a current dearth of primary literature relating to the methodology and success of seabird reintroductions/translocations in New Zealand. The few scientific articles that go some way towards amending this are Miskelly and Taylor (2004), Bell *et al.* (2005) and Miskelly *et al.* (2009). Miskelly *et al.* (2009) provides a good overview of most of the petrel (seabirds of the order Procellariiformes, excluding albatrosses) translocations that have taken place in New Zealand since 1954. Of the projects that took place before 2000, there is not a high success rate, with most projects having few, no, or an unknown number of birds returning to the release sites. The more successful projects had return rates varying from 9% to 17% (Miskelly *et al*. 2009). For the translocations that have taken place after 2000, it is still too early to be judging their success, but some have already had more than or equal to 8% of birds returning. It is worth noting that the later projects have also had a substantially higher survival rate of chicks from translocation to fledging, probably due to advances in hygiene protocols (T. Ward-Smith, pers. comm.). There have also been a number of translocation projects begun since the publication of Miskelly *et al.* (2009), including the reintroduction of Cook's petrels (*Pterodroma cookii*) and grey-faced petrels (*Pterodroma macroptera gouldi*) to the Cape Kidnappers and Ocean Beach Wildlife Preserve. It is also too early to judge whether these have been successful or not. It is our belief that it is currently both feasible and worthwhile to reintroduce seabirds into BSMI, and that the probability of achieving autopoietic (largely self-sustaining) populations is not unreasonable.

2.2 Boundary Stream Mainland Island

Boundary Stream Mainland Island is a fragment of native forest located approximately 25 kilometers inland of Hawke's Bay and 70 kilometers Northwest of Napier (Fig.1). BSMI is bordered by the Maungaharuru Range in the West and by farmland on most other sides and ranges in altitude from 300 to 1000 meters above sea level (Adams *et al.* 2008). BSMI has great conservation value not only because it is the largest intact patch of native forest left in the Maungahuru Ecological District but also because it contains a wide variety of habitats ranging from lowland to montane forests (Adams *et al.* 2008). The Mainland Island consists of the Boundary Stream Scenic Reserve on the East and the smaller Section 4 in the West. Together, they cover an area of approximately 800 hectares in size of which 700 hectares is administered by the Department of Conservation (DOC) and 100 hectares is privately owned (Wissel *et al.* 2008).

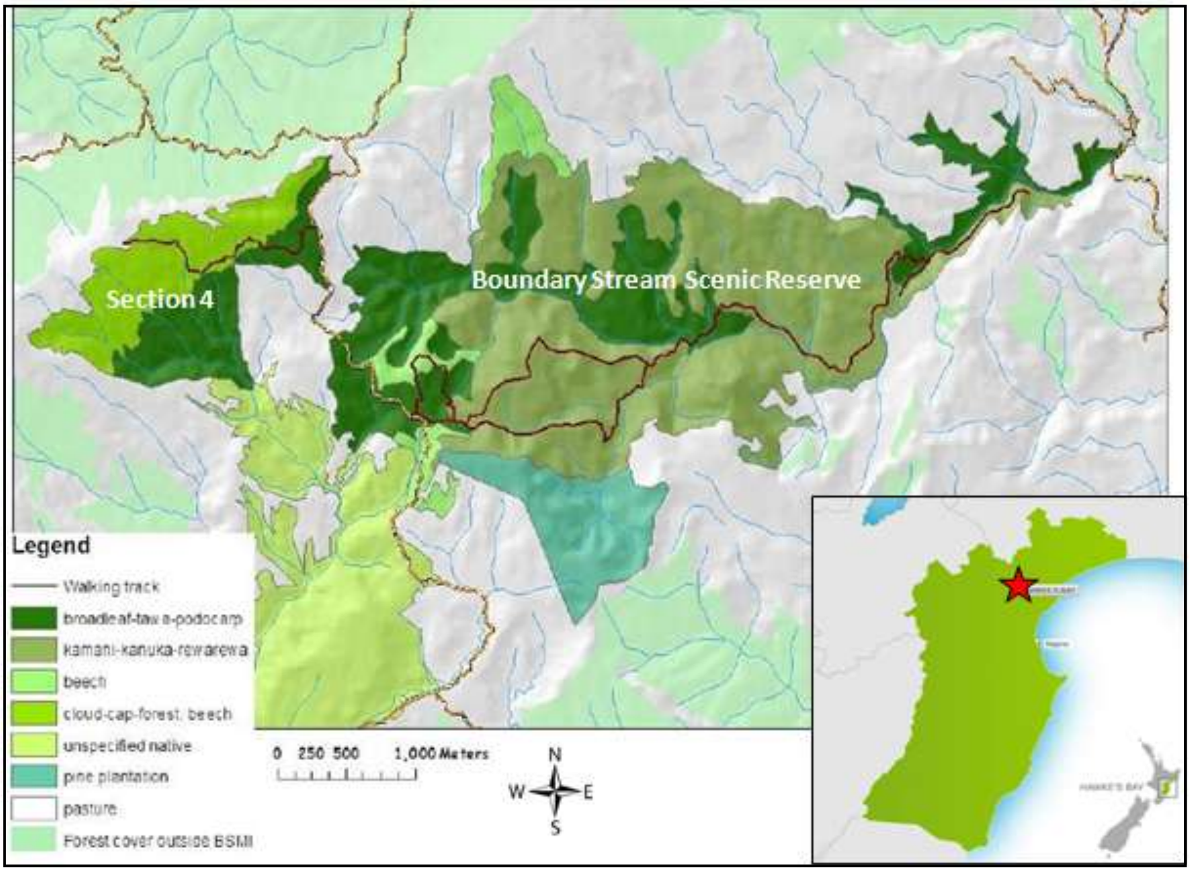

Figure 1: Location and vegetation cover at Boundary Stream Mainland Island. Map provided by the Department of Conservation.

The long-term vision of BSMI is to contribute to the learning process of how to restore native forest in a landscape dominated by non-native systems (Adams *et al.* 2008). As part of this vision, intensive pest control of feral goats (*Capra hircus*), deer (*Cervus* spp.), various rats (*Rattus* spp.), possums (*Trichosurus vulpecula*), European rabbits (*Oryctolagus cuniculus*), hedgehogs (*Erinaceus europaeus*), feral cats (*Felis catus*), mustelids (*Mustela* spp.), and invasive plant species has been undertaken ever since its establishment as a Mainland Island in 1996 (D. Fastier, pers. comm.). Reducing the numbers of mammalian pests has had a positive effect on native plant generation which is now dominated by indigenous processes and shows recovery of threatened species such as yellow-flowered mistletoe (*Alepis flavida*) (Adams *et al.* 2008). Maintaining predators at low levels and consequently the greater availability of food allowed for the re-introduction of several threatened bird species including black robins (*Petroica traversi*) in 1998, North Island brown kiwi (*Apteryx mantelli*) in 2000, kokako (*Callaeas cinerea*) in 2001 and saddleback (*Philesturnus carunculatus*) in 2004 (D. Fastier, pers. comm.). Thereby, BSMI has become a source population for other endemic birds including North Island rifleman (*Acanthisitta chloris*) and whitehead (*Mohoua albicilla*). Keeping in mind the vision of BSMI and their past experience and success with the re-introduction of birds, translocating seabirds back to Boundary Stream Mainland Island is a logical next step in the process of restoring the native forest present at this site.

3. Species under consideration

3. 1 Candidate species

Taxonomic relationships of the order Procellariiformes are still being debated (e.g. Penhallurick & Wink 2004; Rheindt & Austin 2005), so we have simplified the process by classifying species into the four traditional (extant) families: Procellariidae (shearwaters, fulmarine petrels, gadfly petrels, and prions), Diomedeidae (albatrosses), Hydrobatidae (storm-petrels), and Pelecanoididae (diving-petrels). Species from two of these families, the Procellariidae and Pelecanoididae, are viable candidates for reintroduction into BSMI. These candidate species are presented here, with justifications for their choice and further details into their biology and life histories below:

- Order Procellariiformes
  - Family Procellariidae
    - *Puffinus gavia* (fluttering shearwater)
    - *Pterodroma inexpectata* (mottled petrel)
    - *Pterodroma cookii* (Cook's petrel)
  - Family Pelecanoididae
    - *Pelecanoides urinatrix* (common diving-petrel)

These four species were chosen based on their historical distributions (around the time of human arrival in New Zealand), success of previous translocation attempts, suitability of source populations, degree of vulnerability and population status, and understanding of species' biology and requirements. Of the four candidate species, we recommend two priority species (*Pu. gavia* and *Pt. cookii*) for introduction into BSMI starting in 2011 or 2012, with the possibility for future translocations of the other two species. All species biology and ecology, unless otherwise indicated, are taken from Brooke (2004), Onley & Scofield (2007), Shirihai (2008), and IUCN (2010).

3.1.1 Fluttering shearwater (*Puffinus gavia*)

Puffinus gavia is a medium-sized (mean fledging weight FW 411 g, total length TL 32-37 cm, wingspan WS ~76 cm) shearwater that breeds only in New Zealand, with larger colonies on many islands from the Three Kings group south towards the Bay of Plenty, and on numerous islands of the Cook Strait. It breeds in small (0.5 – 1 m), sparsely-lined burrows, usually in coastal scrub or forest, laying one egg in mid-September to early October and fledging from late January. Fluttering shearwater numbers are declining, but are currently considered by the IUCN as Least Concern, because of their large range size and population. This species was chosen because translocations will benefit from knowledge of previous projects (e.g. the nearby Cape Kidnappers and Ocean Beach Wildlife Preserve), as well as the understanding that before human arrival in New Zealand they bred on the mainland (Worthy *et al*. 2002). Best potential source populations for fluttering shearwaters are islands supporting large colonies that are located in the Cook Strait. One example of this is Long Island (117 ha; Fig. 2), where fluttering shearwaters have previously been harvested for translocations to Maud Island (Bell *et al.* 2005) and Mana Island (Miskelly *et al.* 2009). We recommend chick collection and transfer for this species to take place in early to mid-January, which allows ample time for site imprinting to occur whilst minimizing the resources required to feed and monitor the chicks until fledging. Translocations should be carried out once per year over a three-year period, with the first returning birds anticipated to arrive 4-6 years after the initial translocation. Based on previous fluttering shearwater programs, it is expected that approximately 10-20% of translocated birds will return to breed to the site, with breeding occurring after 5-7 years (Miskelly *et al.* 2009).

3.1.2. Cook's petrel (*Pterodroma cookii*)

Pterodroma cookii is a small (FW 204 g, TL 25-30 cm, WS ~65 cm), threatened species of gadfly petrel that breeds on just three New Zealand islands. Two of these (Little Barrier and Great Barrier Islands) are located in the Hauraki Gulf, and one (Codfish Island) at the southern tip of the South Island. Cook's petrels dig burrows (1-5 m) on steep, (ideally unmodified) forested ridge tops with a low, open canopy and numerous large stems that are used for takeoff (Rayner *et al.* 2007). Birds (in northern colonies) lay a single egg from late October to mid-November, with chicks fledging from mid-March to early April (Imber *et al.* 2003). This species was chosen because it is vulnerable to extinction and declining, and was previously one of the more common birds on New Zealand coasts and throughout the interior (Worthy *et al.* 2002; Imber *et al.* 2003). It is therefore likely that this species contributed greatly to the diversity and fertility of mainland terrestrial ecosystems. Best potential source populations for Cook's petrel are Little Barrier Island and Codfish Island. Little Barrier Island (~300 ha; Fig. 2) is recommended for chick collection and transfer to BSMI as it has the largest colony (*c.* 286 000 breeding pairs) and is more accessible. Translocations should be carried out once per year (with transfers taking place in mid- to late February) over a three-year period, with the first returning birds tentatively estimated to arrive 2-5 years after the initial translocation. Return rates are similarly uncertain, but expected to be on the order of 10-20%, as has been the case with other *Pterodroma* species (T. Ward-Smith, pers. comm.).

3.2 Other candidate species

Based on archaeological data (Worthy 2000; Worthy *et al.* 2002) and current distributions, *Pe. urinatrix* and *Pt. inexpectata* are deemed appropriate for reintroduction to BSMI in the long-term but are not recommended currently for a number of reasons. Most importantly, logistical problems become much greater when more than three species are considered at any one time, especially when fledging times overlap. For example, *Pt. inexpectata* fledges around the same time of year as *Pt. cookii*, and therefore will need additional burrows built as well as requiring higher numbers of personnel to manage the feeding and monitoring processes. Furthermore, depending on the final size specifications of the enclosure, there may be too little space available for more than one or two species at any one time, particularly as colony sizes begin to expand naturally. Current potential source populations for these species could be North Brother Island (4 ha; *Pe. urinatrix*) and Codfish Island (140 ha; *Pt. inexpectata*) (Fig. 2). Note that *Pe. inexpectata* presents an additional difficulty in that the only reasonable source population is located much further from BSMI than the others (J. McLennan, pers. comm.). In summary, the two priority species are chosen because they are more feasible and likely to form self-reliant colonies. Although introducing more species would increase species richness, at the moment they are likely to drain resources at the cost of the priority species.

3.3 Locations of source populations

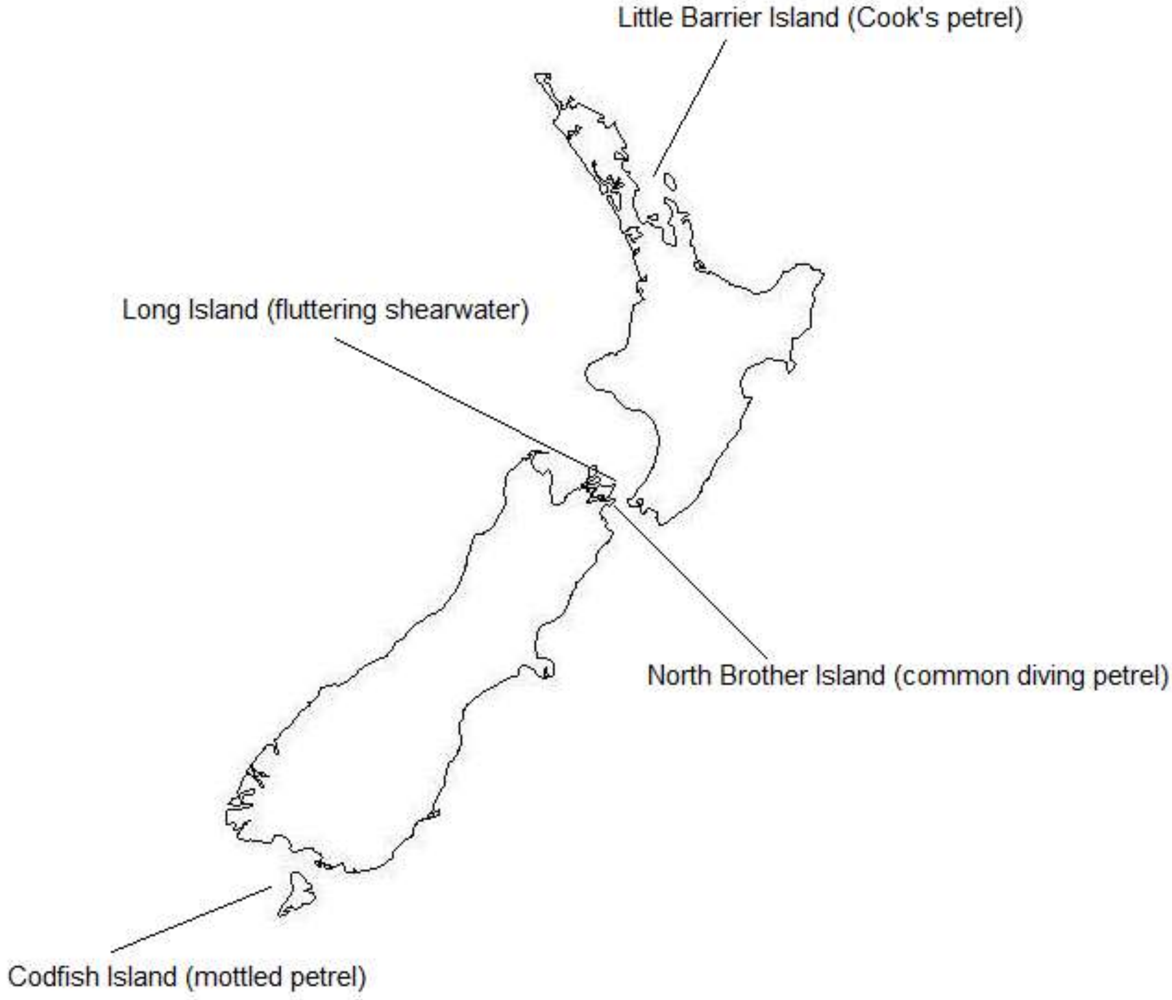

Figure 2: Outline of New Zealand showing locations of islands with seabird colonies that are potential sources of chicks for reintroduction to Boundary Stream Mainland Island.

4 Site selection

The location of the seabird colony needs to meet a number of prerequisites including ecological requirements such as position, availability of take-off facilities, soil type, slope and vegetation (H. Gummer 2007, unpublished). Land ownership therefore needs to be considered since permission from the landowner is required when a site is located on land that is not being administered by the DOC. A final consideration is the practicality of the site because the site needs to be accessible for volunteers, who will likely have access only by walking.

4.1 Ecological and geographical requirements

4.1.1 Geographical position

The site should be located on a spot where the probability of attracting new birds via visual or acoustic attraction or by chance is the greatest (H. Gummer 2007, unpublished). However, because BSMI is located approximately 25 kilometers inland, where the probability of attracting birds by chance is small (i.e. not in the line of a flight path) and no nearby seabird colonies exist (D. Fastier, pers. comm.), the geographical location of the future colony is not a major concern.

4.1.2 Take-off facilities

The site should be positioned in the proximity of cliffs or ridges to make it easier for the birds to take off from land. Proximity to ridge tops has even been described as a "key habitat requirement" for Cook's petrel (Rayner *et al.* 2007).

4.1.3 Slope

Burrows that are built on slopes suffer less from overheating and possible flooding (H. Gummer 2007, unpublished data). Both Cook's petrels and fluttering shearwaters are known to build their burrows on slopes (Rayner *et al.* 2007; Gummer and Adams 2010). Cook's petrels have a preference for slopes of approximately 36° but can dig their own burrows on slopes ranging from 10-60° (Rayner *et al.* 2007).

4.1.4 Vegetation

The vegetation should be open enough to prevent the birds from being trapped in dense understory during landing but open enough to shade the burrows from the sun. Fluttering shearwater burrows have been found under grass, shrubs, and trees, indicating that the type of vegetation present is often not a limiting factor for this species (Marchant and Higgins 1990). A combination of (exotic) grass, flax (*Phormium* spp.) and tauhinu shrubs (*Ozothamnus leptophylla*) were chosen as suitable vegetation for previous translocations of fluttering shearwater chicks to Maud Island and Mana Island (Bell *et al.* 2005; Gummer and Adams 2010). Cook's petrels utilize a more specific range of vegetation types with burrows often found in mature forests with low and open canopies (Rayner *et al.* 2007). These include high-altitude forest dominated by towai (*Weinmannia silvicola*) and tawa (*Beilschmiedia tawa*) and summit forest dominated by *Quintinia* spp., tawari (*Ixerba brexioides*) and southern rata (*Metrosideros umbellata*) (Rayner *et al.* 2007).

4.1.5 Soil

The soil should be soft enough to allow birds to dig their own burrows but should also drain well in periods with heavy rain. A clay loam soil is known to be suitable for fluttering shearwaters (Bell *et al.* 2005). All sites considered for the establishment of a seabird colony at BSMI are either located in the forest or in close proximity to the forest where the soil is generally softer than at more open sites (K. Nakagawa, pers. comm.).

4.2 Legal requirements

Roughly 87%, or 700 hectares, of BSMI is owned by the DOC and the remaining 13%, or 100 hectares, by private landowners. BSMI is managed by the DOC office at Hawke's Bay but supported by a Technical Advisory Group, a Management Group, and a Strategic Advisory Group in which, apart from conservation staff, local iwi and neighboring landowners are represented to ensure that the 5 year operational plans match the objectives outlined in the *Boundary Stream Mainland Island Strategic plan 2008-2010* (Adams *et al.* 2008). Two of the sites considered for a seabird colony are located on land administered by DOC and one site is located on private land.

4.3 Other requirements

A final consideration for choosing the location of the colony is ease of access. Volunteers need to be able to access the site by foot because driving 4-wheel drive cars and bikes requires training that is expensive for large groups of people (D. Fastier, pers. comm.). For this reason, the colony should be located close to walking tracks, especially because the perimeter and most of the rest of the reserve are harder to access by foot.

4.4 Potential sites

Based on the criteria given above, the suitability of three potential sites were analyzed (Fig. 3). A short description of each site is given below.

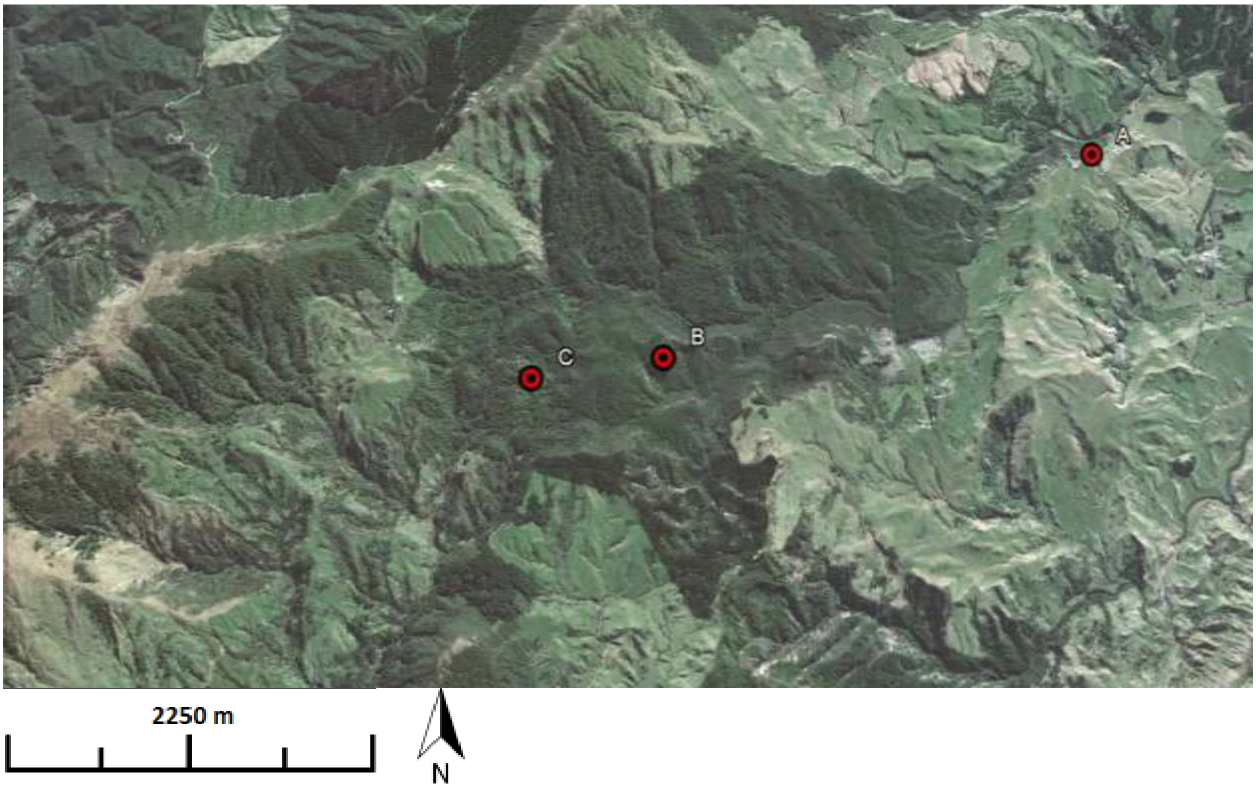

Figure 3: Aerial photo showing the locations of three potential seabird reintroduction sites (A, B, and C) in the Boundary Stream Mainland Island reserve.

4.4.1 Site A – Kakabeak Block

Site A is located in the Kakabeak block, a long narrow patch of indigenous forest and pasture on the eastern end of BSMI (Fig. 3 and 4). Site A is situated at a relatively low altitude of approximately 500 meters above sea level (a.s.l.) which makes the site warmer and dryer than the other sites (Wissel 2008; Appendix I). The vegetation at Site A is classified as pasture in combination with indigenous forest with alternating dominance of kamahi (*Weinmannia racemosa*), kanuka (*Kunzea ericoides*) and rewarewa (*Knightia excelsa*), characteristic for drier slopes (Wissel 2008; Appendix I). One of the benefits of site A is the presence of slopes that are suitable for the construction of burrows. The vegetation at this site is comparable to vegetation on offshore islands where colonies of both species are known to breed (e.g. fluttering shearwaters at Maud Island and Cook's petrels at Little Barrier Island). In comparison to Site B and C, the vegetation at Site A is more open which should make both landing (in a helicopter) and construction of a fence easier. The main disadvantage of Site A is that it is located on private land which means that permission for the use of land, the access to the site and the building of a fence needs to be obtained from the landowner (K. Nakagawa, pers. comm.). This does not necessarily have to be a problem because the seabird colony at Cape Kidnappers is located on privately owned land (T. Ward-Smith, pers. comm.), but it is a consideration. A second disadvantage is that although there are cliffs present, these are quite sheltered, meaning that the wind does not reach the site from all directions making it harder for the birds to take off. A final concern might be accessibility for volunteers. There are a few sites along the cliff that are accessible from the Shine's Fall track running below the cliff, but sites located higher on the higher slopes (i.e. where wind exposure is greater) would be difficult to access from this track (K. Nakagawa, pers. comm.). It would be possible to access these sites from the farmlands on the upper side of the cliffs but permission from the landowner will be required.

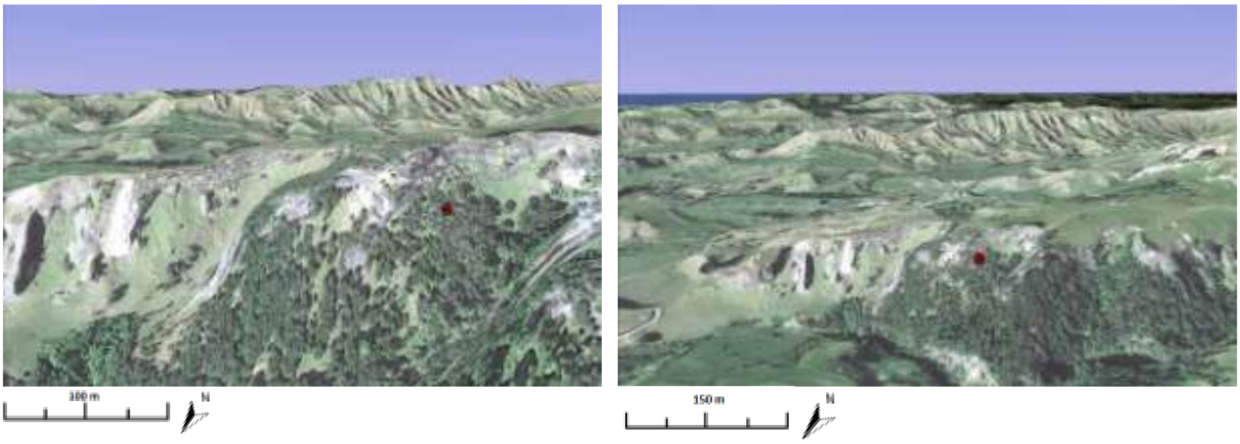

Figure 4: Aerial images of Site A from close (left) and distant (right).

4.4.2 Site B – Kamahi Loop

Site B is located on a cliff at approximately 730 meters a.s.l. (Appendix I) within easy access of the Kamahi loop, one of the main walking tracks in BSMI (Fig. 3 and 5). The vegetation at Site B is comparable to that of Site A with kamahi and rewarewa forming a dense canopy and with understorey formed by ferns, mingimingi *(Coprosma propinqua)* and other *Coprosma* spp. (K. Nakagawa, pers. comm.; Appendix I). The cliff is exposed to most wind directions which allows the birds to take off in many different directions. The aspect of the slope is depended on the position on the cliff but remains within the range described by Rayner *et al.* (2007). The only concern about Site B is the denseness of the canopy which could make parts of this site less accessible for birds, although clearing a small patch of vegetation would solve this problem.

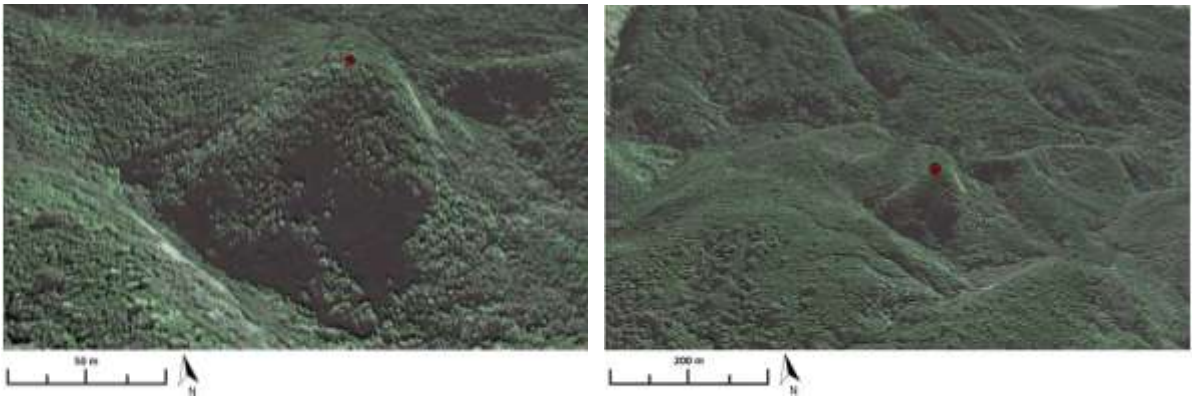

Figure 5: Aerial images of Site B from close (left) and distant (right).

4.4.3 Site C – Tumanako Loop

Site C is located at the top of a valley at approximately 700 meters a.s.l. (Fig. 3 and 6; Appendix I). Site C is also located in close proximity of the Tumanako loop, one of the shorter walking tracks of BSMI. The vegetation at Site C is classified as indigenous broadleaf forest which is characteristic for wetter regions at high altitude (Wissel 2008). Common plants are a variety of large podocarps and both red and black beech (*Nothofagus* spp.)

(Wissel 2008; Appendix I). Broadleaved forest is a common type of vegetation on several offshore islands where seabirds nest (e.g. fluttering shearwaters at Long Island and Cook's petrels at Little Barrier Island). Because Site C is located on a ridge with moderate to steep slopes and valley on both sides, the site is exposed by wind coming from multiple directions. A disadvantage of Site C is the presence of a dense understory of scrub, pepperwood (*Pseudowintera colorata*) and ferns (K. Nakagawa, pers. comm.) that could injure birds when landing (Gummer, 2007, unpublished).

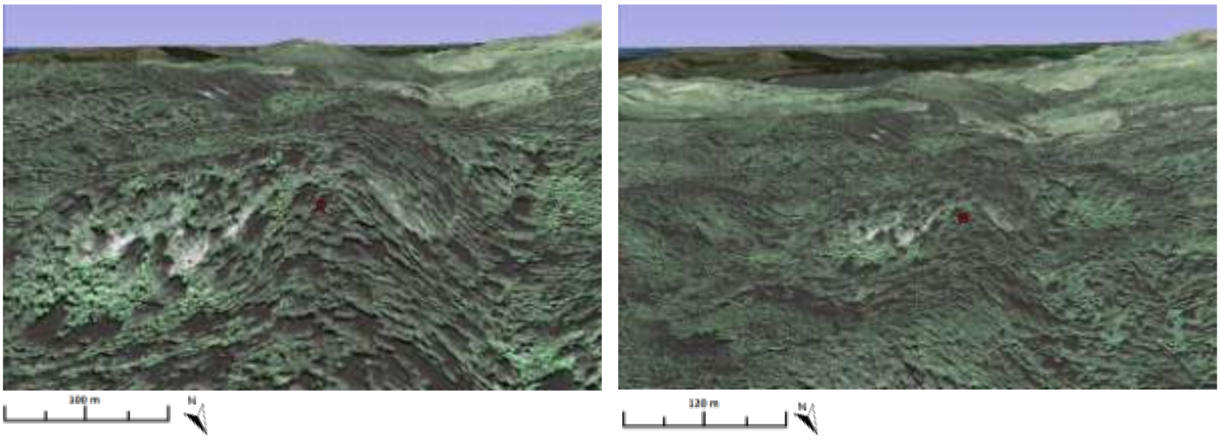

Figure 6: Aerial images of Site C from close (left) and large distance (right).

4.5 Site recommendations

Based on the criteria stated above, we would recommend establishing the colony at Site B because of its advantages in accessibility for volunteers and suitability for seabirds. Initially we would recommend an enclosure of approximately 1.5 – 2 hectares, which is comparable to the enclosure at Cape Kidnappers (T. Ward-Smith, pers. comm.). An enclosure of this site is easy to manage and allows the seabird population to grow for years after translocation.

5 Risk Assessment

5.1 Translocation Process

5.1.1 Impact on source populations

Long Island, the source population for fluttering shearwater, has been documented to have 3-4.000 breeding pairs (Gummer and Adams 2010). The habitat is predator free and thus has been successfully supporting a sustainable and growing colony of fluttering shearwater. Hence removing about 50 chicks a year, up to 200 chicks in a three-year span, is unlikely to result in negative impacts on the source population. Previously, there were similar translocation projects that seeded from this population with similar numbers of chicks and no negative impacts have been documented (Bell *et al*. 2005, Miskelly *et al*. 2009). Similarly, the source population on Little Barrier Island for Cook's petrel, is the largest colony of this species with an estimate of 286.000 breeding pairs (Rayner *et al*. 2007). Thus the source populations will be robust to the translocations of up to 200 chicks over a three-year span. As in translocations done for Cape Kidnappers, only easily accessible nests will be checked during the inspection of potential chicks to harvest, consequently concentrating along the trails of the island (Ward-Smith and McLennan 2008, unpublished). The number of participants will be kept to a minimum, perhaps four to five people as in the fluttering shearwater translocations (Gummer and Adams 2010, Bell *et al*. 2005). These efforts will minimize disturbance to only easily accessible areas and will decrease unnecessary damage to the habitat.

5.1.2 Transfer mortality of chicks

Multiple cautionary measures will be made to ensure a successful harvest and transfer of chicks to BSMI. Prior to the days of harvest, the source site will be visited to survey the logistics of the area to make the translocation as efficient and safe for the chicks as possible (Ward-Smith and McLennan 2008, unpublished). Transportation routes, accessibility to different areas and burrows will be assessed to become acquainted with the area. These preliminary survey trips will be made around a month prior to translocation in order to gain a perspective of the range of chick's age and growth. From this trip, we can infer the best time to return for harvesting from measuring the wing length and weight of the chicks. In other words, it is important for the preliminary trip to have the correct timing to ensure that enough chicks within the range to harvest (Gangloff and Wilson 2004), because they must be young enough to have no natal imprints at the source island, but close enough to fledging to minimize their length of stay at BSMI.

On the translocation trip, the first two or three days will be allocated to locating burrows, measuring the chicks to check if they are within the range of harvest (Ward-Smith and McLennan 2008, unpublished). On-site measurements must be done accurately to ensure that only chicks of appropriate age are taken (Ward-Smith and McLennan 2009). This will increase the translocation's chance of success because only the chicks old enough to survive artificial rearing but have not developed natal imprints will be translocated (Miskelly *et al*. 2009). Burrows of potential chicks will be recorded on a GPS or tagged with a conspicuous white pole. The day of harvest will require accuracy, efficiency, and attention for gross abnormalities through a quick health check before harvest and to confirm that the chicks are within range of harvest.

Threats to the chicks during transfer are heat and dehydration (Ward-Smith and McLennan 2008, unpublished). Thus participants must ensure the boxes containing chicks are always in a shade or covered to minimize heat stress. In case of severe weather, they must be handled with appropriate care to prevent drowning or hypothermia (Bull 2003; Gummer and Adams 2010). Chicks will be given an average of 5-10 ml of cooled boiled water via syringe and crop needle upon arrival at BSMI to keep the chicks hydrated (Gummer and Adams 2010, Miskelly *et al*. 2009). If possible, having an experienced individual for translocation and preliminary survey trips will be beneficial, especially for the first translocations for each species since they will be harvested from different source populations. Such recommended experts are Helen Gummer, Tamsin Ward-Smith, and John McLennan

5.1.3 Biosecurity of weed / unintended introductions

The concern for biosecurity is generally low because the seabirds have such high mobility that mixing and transfer of seeds or pathogens are naturally occurring (D. Priddel, pers. comm.). Nest linings from the translocated chick's original burrows will be bagged and labeled to be placed in the artificial burrows for the associated chick. This will only be done for Cook's petrel because in translocations of a closely related species, Pycroft's petrel (*Pt. pycrofti*), nest linings of original burrows made the transition easier for the chicks (Miskelly *et al.* 2009; Gangloff and Wilson 2004). However, previous experience from fluttering shearwater translocations have show that this would be unnecessary effort, thus we do not intend to translocate nest lining for this species (Gummer and Adams 2010). The risks of introducing weed species with lining materials are low; since the source and recipient sites have similar flora and fauna. Similarly in previous translocations to Mana and Manu island, transfer of nest lining were considered to have negligible risk in introducing unintended weed species or invertebrates (Miskelly *et al*. 2009). Potential seeds in the chick's stomach are another risk of introducing weed species to BSMI; however, based on previous experience, this seems to be a minor threat.

Pathogens are another concern because these can directly affect chick mortality and may spark an epidemic on already established seabird colonies if they occur on later translocations. Thus the source population will be monitored and randomly screened for general health exams (as listed below), on the preliminary survey trips (Gummer and Adams 2010). On the day of harvest chicks will undergo a basic health check and will be checked for any visible abnormalities. Random disease screenings (as suggested below) will be conducted to the chicks once they have settled in BSMI.

Suggestions for health exams on the source population are to randomly test adults for the following (Gummer and Adams 2010):

- Clocal swabs and faecal samples for infectious pathogens (i.e. poxvirus, salmonellosis, yersiniosis, erysipelas, haemoparasites, *Contracaecum* species of proventricular nematodes) and gastrointestinal parasites
- Blood samples for white cell counts, haemoparasites and *Erysipelothrix rhusiopathiae*.
- Previously, *Coccidia oocysts* was present in the source population and translocated chicks were given medicine to prevent infection.

At BSMI, the following disease screening will be done as in previous seabird translocations (Ward-Smith and McLennan 2008, unpublished):

- Physical exams for poxvirus
- Blood samples from the wing vein to check for blood count
- PCR screening for *Erysipelothrix rhusiopathiae* and haemoparasites
- Cloacal swabs and faecal samples to test for Salmonella, Campylobacter, Yersinia, Coccidia cultures, and Capillaria worms

Tests can be arranged with New Zealand Veterinary Pathology in Hamilton, as Cape Kidnappers have done. A wildlife vet in the area and or a DOC vet should be notified for the possibility of being approached in the need of veterinary assistance (Gummer and Adams 2010).

5.1.4 Chick loss

As demonstrated in previous translocations, the main cause for fledging failure is chick mortality at the recipient site (Gummer and Adams 2010; Ward-Smith and McLennan 2008, unpublished; Ward-Smith and McLennan 2009; Miskelly *et al*. 2009). To make the transition to the artificial burrows smooth for the chicks, the burrows will be cleaned and aired out before the chicks arrive at BSMI. Several precautions will be taken to minimize chick mortality at BSMI. The burrows will be designed to protect chicks from severe weathers. PVC drainage pipes (110 mm external diameter) will be installed to drain the burrows. Although most likely to be unnecessary with the dense forest canopy at our recommended site, if there is not enough shade, sand bags may be used to cover burrows from direct sunlight to avoid heat stroke.

There have been a few cases where entrances of burrows were too narrow for some chicks which resulted in fluttering shearwater chicks getting stuck and injuring themselves while struggling out (Gummer and Adams 2010, Miskelly *et al*. 2009). Thus burrows will be checked for any wears or constraints when they are visited to pick up the chicks for feeding or health checks.

Hygiene of the burrows will be maintained, especially in between breeding seasons. During the season, guano builds up in the burrows so these will be cleaned to prevent maggots from invading the chick's burrows. This proved to be especially important in recipient sites without an established invertebrate fauna (Gummer and Adams 2010). However, nest linings and contents of the burrows should be untouched if the chicks are old enough to venture out of their burrows. This is in case the chicks use sense of smell to return to their burrows when wandering outside (Miskelly *et al*. 2009). The fortunate ones end up in another chick's burrow, but some get lost in the vegetation and die of dehydration or starvation. Thus until the chicks reach the age when they venture out of their burrows at night close to fledging, the entrance of the burrow will be blocked with a plastic mesh lining to allow them to become acquainted with the habitat without misadventure. If possible, a short fence will be put in place to surround the artificial burrow colony to prevent chicks from wandering too far of the burrows. It is effective to constrain the chicks in a small area to make locating lost chicks easier. At Cape Kidnappers, the dense vegetation, thistles (*Onopordum* spp.) in particular, made it difficult to search for lost chicks (Ward-Smith and McLennan 2008, unpublished). At Mana Island, spear-grass (*Aciphylla squarrosa*) and overhanging branches growing near the burrow entrances were removed to prevent injuries (Gummer and Adams 2010). In addition, there have been personal observations by Rayner *et al.* (2007) that collisions and entanglements to trees and branches caused mortalities for Cook's petrel at Little Barrier Island. Thus, once the predator-proof fence for the seabird colony is established at Site B, the vegetation and slope should be analyzed to see if it is possible to fence out areas with dense understory or to remove some of these patches.

The feeding and any health exams for the chicks will be labour intensive and hectic. Thus it is important to be organized and ready to execute the necessary procedures to minimize the impact on the chicks. The method outlined to feed the chicks is designed to avoid damage to the bill and esophagus, and food from going down the lungs (Bell *et al*. 2005). As suggested by Ward-Smith & McLennan (2008, unpublished), any handling of the chicks will be done with two participants. This will include the collection and return of the chick from its artificial burrow, feeding, measuring, weighing, and performing health exams. It is possible to injure the chick during these procedures (Ward-Smith and McLennan 2008, unpublished), hence two people should perform and attend for care.

Although previous translocation projects do not check for potential risks at the recipient site that could danger the chicks, it will be of our interest to do a general survey of at BSMI before translocation. BSMI houses more than 220 native plant species and a variety of native forest birds and invertebrates (Department of Conservation 2011). Although seabirds may not be susceptible to all diseases prone to forest birds, risks such as nest mites and *Aspergillus fumigatus*, a disease causing fungus which are known to affect fluttering shearwaters (Miskelly *et al*. 2009; Bellingham *et al*. 2010), do exist and should be of concern.

Previous translocation projects have not considered health screening at recipient sites due to the lack of seabird populations at the site or because residing populations did not show signs of disease (H. Gummer, pers. comm.). But since BSMI is quite a lush forested area with existing populations, it will be beneficial to survey the area and community for a health check before translocations. Health checks of the recipient site will be similar to disease screenings as the source populations (see 5.1.3). In addition, postmortem examination, and nest and burrow checks for mites and fungus are recommended. This will be of significant importance for translocations taking place after seabirds begin to colonize BSMI.

5.1.5 Diets

Preparation of the diet must be kept hygienic and prepped in small amounts. To accustom the chicks to the artificial diet, the fluttering shearwater's first feed will be much less, 30 ml (Gummer and Adams 2010), than its regular portion size of a diluted salmon blend (see section 6.4). The regular meal will be 25% water and the first meal will be diluted with 50%

water as Gummer and Adams (2010) did. To achieve optimum daily weight gain of 5-10 g per day, fluttering shearwaters will be fed 80 ml once a day and Cook's petrels once every two or three days. The blended mixture will be heated in small batches to 30-35 degrees Celsius in a warm water bath to eliminate bacterial build-up; otherwise the mixture will be held in airtight containers to prevent spoilage. It is crucially important to immerse all equipments in a chlorhexidine solution and rinse thoroughly with boiled water after each feed to prevent diseases such as candidiasis (*Candida albicans* yeast infection) (Miskelly *et al*. 2009).

Although tinned sardine diets have become a standard for translocations and yields 86-100% fledging success for burrow-nesting seabirds since 2002 (Miskelly *et al*. 2009), the diet is being reconsidered and analyzed by Micha Jensen at Massey University. Her study will evaluate the nutritional value of tinned sardine diet against the natural diet of regurgitation from parents, and powdered Mazuri®, a new alternative seabird diet. The DOC protocol does not recommend feeding chicks for more than 5 weeks on the current tinned sardine diet because nutritional balance is believed to be very different from the wild. There have been cases of renal compromise, gout, hepatic lipidosis, ventricultis, cloacaitis, and urate nephropathy in translocated chicks (Jensen), which could have resulted from the artificial diet. Based on the outcome of this study, the suggested diet at BSMI can be modified.

5.2 Post Fledging

5.2.1 Predator control

To make the seabird translocations and the colonization of BSMI success, the suggested fenced off seabird colony site must stay predator free (Ward-Smith and McLennan 2008, unpublished). To achieve this, the fence must be maintained by checking for any leaks, such as holes, overhanging tree branches, and any other defaults that may increase the risk of predator reinvasions at the site (Smuts-Kennedy *et al.* 2004). In addition, mustelid and rodent tracking tunnels will be placed on the outside of the fence to monitor the presence of predators. The presence of footprints in these tunnels can be used to increase the predator control around the seabird colony. Due to the diverse community at BSMI, tracking devices will be a box with a double entrance to prevent small birds to wander in and reach the poison. Thus the tracking devices will be tailored to specific pests and exclude non-targeted species inhabiting BSMI.

5.2.2 Inbreeding depression

Previous seabird transocations have shown that non-translocated individuals accompany translocated individuals (Miskelly *et al*. 2009). Although these species are known to be highly philopatric, some non-translocated individuals do visit the site as a potential breeding ground. Due to their wide foraging range, the range of different colonies can overlap resulting in mingling of colonies. For example, post translocation monitoring of common diving petrels translocated to Mana Island has recorded that 20 translocated chicks returned to the site as well as 51 unbanded birds (Miskelly and Taylor 2004). Due to the recruitment of conspecifics from other colonies, the risk of inbreeding or low genetic diversity will be diminished.

5.2.3 Impact on ecosystem

Invasions of non-native predators can have had a devastating impact on the native ecosystem and are known to have eradicated burrow nesting seabirds from their natural habitats (Worthy *et al.* 2002). Seabirds have a significant role in the ecosystem as an ecological driver by transporting marine sourced nutrients to land through excessive amounts of guano, corpses and regurgitation (Jones 2010). Previous studies have shown that this is significantly correlated with an increase in the abundance of species of different trophic levels (Markwell and Daugherty 2002). Seabird-inhabited islands such as Stephens, North Brother and Titi Islands have significantly bigger populations of lizards than seabird-absent islands. Also significantly more Coleopterans, Hymenopterans, Hemiptera, and Araneae are present on seabird-inhabited islands. Hence, seabird translocations are often encouraged to enrich the native biodiversity. However, Jones (2010) concluded that only high densities of seabirds, which she defines as 5-10 burrows per square meter, can restore the nutrient dynamics of the ecosystem to a pre-non-native predator invasion state. But she recognizes that this high density inhibits invertebrate and plant survival. For example on Rangatiria Island, an estimated 1.4 burrows per square meter has caused vegetation to collapse and soil to erode, which was followed by the desertion of the area by the colonies of breeding seabirds (Roberts *et al.* 2007. Roberts *et al*. (2007) states how similar collapses have been documented on Little Mangere Island and Chatham Island with high sooty shearwaters (*Pu. griseus*) densities. Thereby, burrowing, trampling and the addition of nutrients results in a reduction in soil pH and an increase in the phosphorus concentration making the soil less suitable for seedlings and saplings (Mulder and Keall 2001). Because both high and low densities of seabird colonies can have a adverse affect on the local ecosystem, we recommend that artificial burrows at BSMI are placed in a density of 0.04, the mean density at Little Barrier Island (Rayner *et al*. 2007) to 1.19 burrows per square meter (Roberts *et al*. 2007) to avoid negative impacts on the existing forest community.

6 Translocation process and management actions

6.1 Actions at the source island

6.1.1 Chick selection

The wings length and body weight of chicks can provide useful information to evaluate whether or not at chick is suitable for translocation. The wing length can be used to assess how close a chick is to fledging. When chick wing length is close to adult wing length, the chick is close to fledging and has little time left to imprint on BSMI. On the other hand, selecting younger chicks with shorter wing length means that they would stay at BSMI for a longer period thereby increasing the expenses for food etc. (Gummer and Adams 2010). Bodyweight can provide information on the chick's health condition. Chicks that are either too light are either too young or suffer from malnutrition whereas overweight chicks might get stuck in the entrance of the artificial burrows (Gummer and Adams 2010).

In the case of fluttering shearwaters, we suggest selecting chicks with full down and half-grown primary feathers (Bell *et al*. 2005). Because these chicks require a minimum of 10 days to imprint to the new site (Gummer and Adams 2010), the longest known adult wing length is 212 mm (Wragg 1985) and the wings growth with a rate of approximately 3 mm per day, the ideal wing length for these chicks should range between 130-180 mm (Gummer and Adams 2010). The mean fledging weight of fluttering shearwaters is 346 g. Considering the fact that chicks lose approximately 2% of their peak weight 4 days before fledging (Bell et al, 2005), suitable chicks should way 397 ±52 g (Gummer and Adams 2010).

Because Cook's petrel translocations are rare, little is known about the ideal wing length and body weight for this species. However, chicks of the closely related Pycroft's petrel are translocated when their wing length ranges between 149-184 mm and weight between 218-250 g (Gangloff and Wilson 2004). Because the adult mean body weight of Cook's petrels is slightly heavier than that of Pycroft's petrel (200 g and 160 g respectively) (Heather and Robertson 2005), these values can be adjusted slightly (Tab. 1).

Table 1: Selection criteria based on wing length and body weight for chicks.

	Fluttering shearwater	**Cook's petrel**
Wing length (mm)	130-180	149-184
Body weight (g)	345-449	218-250

We recommend a total of 250 chicks of each species to be transferred over the three years which are similar numbers to previous translocations (Miskelly *et al*. 2009), with a conservative 50 chicks the first year and 100 chicks the consecutive years. Long Island is the recommended source island for fluttering shearwater and Little Barrier Island for Cook's petrel. We recommend the use of helicopters and van to transfer the chicks from their source island to BSMI.

6.1.2 Disease screening

We recommend the conduction of a disease screen to ensure that no infectious diseases are transferred from the source islands to BSMI during the translocation process. Based on the advice from veterinarian Kate McInnes working at the threatened species department of DOC this screen should include:

- Physical exams looking for signs of the poxvirus
- Faecal cultures for Coccidia, Salmonella, Campylobacter and Yersinia

- PCR of blood sample for *Erysipelothrix rhusiopathiae* and haemoparasites

There is a possibility that parents transfer pathogens to their chicks via foraging so it might be necessary to conduct a disease screen on the parents (Ward-Smith and McLennan 2008, unpublished).

6.2 Actions at BSMI

6.2.1 Artificial Burrow design

The basic structure of artificial burrows is a four-sided wooden box with an inspection lid and a PVC pipe tunnel close to the entrance (Gummer and Adams 2010; Appendix II). The design of burrows is an important factor in determining the success of the translocation. For fluttering shearwater burrows we suggest using the design of Gummer and Adams (2010) previously used for translocations on Manner Island. These burrows were built on a steep slope to prevent flooding during heavy rain. The chamber (45 x 25 x 20 cm) is comprised of only 3 treated timber walls (two at the sides and one in the front) to allow the chicks to dig deeper. The entrance pipe has a diameter of 11 cm and should be connected to a drainage channel than runs along the slope. The entrance pipe should neither be too long nor be bended to prevent chicks from getting stuck. Beach gravel can be placed underneath the chamber and the entrance to improve drainage.

We suggest using a similar structure for the Cook's petrel burrows but with slightly different dimensions (38 x 35 x 35 cm) (Miskelly *et al*. 2009). We suggest building approximately 120 burrows for each species within the first two years of translocation. Artificial burrows should be cleaned and aired after each translocation until the population starts to expand naturally (Gummer and Adams 2010).

6.2.3 Replanting

The vegetation at the suggested translocation site (Site B) is classified as native forest with an understory of ferns, mingimingi and coprosma and a canopy of kamahi and rewarewa (K. Nakagawa, pers. comm.). Therefore, we do not think that replanting will be necessary. However, any sharp vegetation or overhanging vegetation around the burrows should be removed to prevent injuries (Gummer and Adams, 2010). Although we believe that the aspect of the slope is steep enough to allow birds to leave and enter the site without too much trouble, it might be necessary to clear a part of the canopy when there is any evidence that this is not the case.

6.2.4 Pest control

For any successful restoration plan, the elimination of alien species is a crucial first step. BSMI started with intensive poisoning and trapping since its establishment as a mainland island in 1996. The current pest control includes regular poison to control possums and rodents, fenn traps for mustelids and conibear traps for feral cats (D. Fastier, pers. comm.). Poison control includes cereal based pindone pellets, feratox (cyanide) and rate-abate™ (diphacinone) (Wilson, 2009). Years of intensive pest control resulted in a rapid decrease of mammalian predators (Saunders and Norton, 2001). However, since burrowing nesting seabirds are especially vulnerable to rodent predation (e.g. pacific rats caused 90% of the nest failures of Cook's petrels (Pierce 1998; Dowding and Murphy 2001)), we suggest the construction of a predator proof fence around the seabird enclosure.

6.2.4 Acoustic system

Acoustic systems are used to attract more seabirds to a site but because BSMI is located inland and no near colonies exist, acoustic attraction is unlikely to be successful in the first years. However, acoustic systems can be used when the colonies start to grow. Bell *et al.*

(2005) used a solar power system that operated from dusk to dawn between September and February to attract fluttering shearwaters. To attract Cook's petrels to BSMI, the system should be turned on between October and May. Because seabirds are likely to cluster around the speaker, the speakers should be placed at least 50 meters and preferably 100 meters away from the fence (T. Ward-Smith, pers. comm.).

6.3 Timing of events

The seabird translocation is a new project at a long-term plan is necessary for the translocation to be successful (summarized in Tab. 2). We suggest starting with the translocation of fluttering shearwaters because previous translocations exist for this species whereas translocations with Cook's petrels are new. We recommend translocating chicks for three years, which is a similar time span to previous translocations (Miskelly *et al*. 2009). After these three years, the translocation of Cook's petrels can start for another three years. The process should be evaluated throughout the six-years and modified if necessary.

The inspection and assessment of chick condition at the source island should occur approximately one month before translocation. Based on the knowledge of fluttering shearwater's fledging, the first visiting date to Long Island should be in late November (Gummer and Adams 2010). The tasks to be completed during this visit include searching for suitable chicks which are chicks in the age range from 10 to 35 days before fledging (this can be determined by the wing length versus body weight ratio discussed in section 6.1.1). Sourcing chicks from Long Island should be relatively easy since approximately a 100 artificial burrows are already in place (Gummer and Adams 2010). Thereby, a preliminary disease screen should be conducted and the chicks can be banded during this visit in order to monitor their future return and survival rates (Miskelly *et al.* 2009). If a vocalization system is going to be used in the future, recording colony sounds can also be done during this visit. The second visit to the source island should occur approximately two days prior to the translocation date in mid-January. During this period, it should be checked if the chicks can be taken from their burrows without any problems (e.g. whether the burrow is not deeper than one arms length) and their bodyweight should be recorded (Bell *et al*. 2005; Gummer and Adams 2010). At the date of translocation, the chicks will be collected and transported to BSMI. What chick comes from what burrow should be recorded in case anything goes wrong at BSMI which would require the birds to be returned to their natal site (Gummer and Adams 2010).

The first birds are expected to return to BSMI 4 to 5 years after translocation (Miskelly *et al.* 2009). We recommend checking for the presence of banding birds twice per day during the breeding season and incubation season. A night check might serve to record any adults coming ashore whereas a day check can be used to record bands of breeding adults (Bell *et al*. 2005). A similar survey during the same period should occur on Long Island to record any chicks translocated to BSMI returning to their natal site.

The translocation process for the Cook's petrel is similar to that of the fluttering shearwater except that the first visit to Little Barrier Island should occur in January and the translocation work in late February. There are currently no artificial burrows in place at Little Barrier Island but we recommend searching for chicks at the mid-altitude forests of this island (Rayner *et al*. 2007).

Tabel 2: Timing of events starting with the pre-translocation inspection and ending with monitoring returning birds 3 to 4 years after the first translocation.

Duty	Fluttering shearwater	Cook's petrel	Notes
Pre-translocation Inspection	Late November	Early January	Select chicks, conduct health check, band chicks and possibly record colony sounds
Artificial burrow Construction	Winter prior to translocation		To allow grass to grow over any exposed seams
Transferring chicks	Mid January	Late February	Record chick's condition and transfer chicks to BSMI
First check for Returning birds	3 to 4 years after the first translocation		Record adults coming ashore and breeding or incubating birds

6.4 Translocation Protocol

On the morning of the translocation, the chick's weight and wing length should be measured to make sure they still meet the selection criteria. Suitable hicks must be placed in ventilated cardboard boxes (39 x 21 x 26 cm) lined with newspaper of leaf litter and with a diagonal divider so that two chicks can be carried per box (Miskelly *et al.* 2009). The boxes should be kept out of the sun at all times to prevent overheating. We suggest bringing extra nest material for the artificial burrows to help the chicks adapt to their new environment (Miskelly *et al*. 2009).

Selected chicks should not be fed on the transfer date because stress-induced vomiting may result in suffocation. However, because previous translocations showed that certain species are vulnerable to heat stress and dehydration, we do suggest giving them 5 – 10 ml of cooled boiled water after arriving at BSMI (Miskelly *et al*. 2009). Unless weather conditions do not permit, the chicks should be transferred to their new burrows on the day that they arrive at BSMI. We suggest blocking the entrance with a plastic mesh or wooden blockade for the first three nights to allow the chicks to adjust to their new environment and reduce the risk of chicks leaving their burrows too early (Miskelly *et al*. 2009). Chopsticks of toothpicks can be erected in front of the burrow entrance to monitor the chicks fledging activity (Gummer and Adams 2010).

After the chicks have settled down in BSMI, fluttering shearwater chicks should be fed one per day and Cook's petrel chicks once every second or third day (Miskelly *et al*. 2009). The chicks should be fed approximately 15-20% of the mean adult weight (Gangloff and Wilson 2004). For the fluttering shearwater, we suggest using the same recipe as used on Mana Island which is comprised of whole salmon smolt (65%), water (25%), golden syrup (3%), muttonbird oil (3%), vegetable oil (3%) and vitamin B1 (Bell, 1994). Again, little is known about the diet of Cook's petrel but Pycroft's petrel chicks are given purred sardines (Gangloff and Wilson 2004). For both species, food should be stored in insulated bins to prevent spoilage and should be warmed up in a 30-35°C water bath before feeding (Miskelly *et al.* 2009).

All chicks have to be hand fed by using a crop syringe. Chicks are fed by two people, of which one operates the syringe and holds the chick's upper mandible and the other helps keeping the chick in place and cleans any spillage. While the crop syringe is placed in the chick's esophagus the neck of the chicks should be kept upwards in a 45 ° angle (Miskelly *et al.* 2009). Chicks will be fed large volumes of food in two or three attempts but should be stopped as soon as the chicks show any sign of vomiting or distress. This feeding strategy changes slightly when the chicks are closer to fledging due to the emergence of regurgitation behavior. Chicks will then be given smaller volumes of food and the back of the throat to allow the chicks to swallow it without any help (Miskelly *et al*. 2009).

During the pre-fledging period, the chick's body weight and wing length should be recorded as well as the eventual emergence and departure date. Necropsy should be performed on chicks that were found dead. Any information that is acquired during this period is valuable and can be used to improve future translocation success.

7. Financial aspects

7.1 Funding situation

The BSMI management authority has recently been provided with a large grant (*c.* NZ$900,000) to utilise for both restoration and continuing protection of the reserve. A potentially large portion of the grant will be dedicated to the translocations of *Pu. gavia* and *Pt. cookii* in an effort to restore the roles of seabird populations in BSMI, which should benefit the ecosystem considerably. To maintain the enclosure site (predator-proof fence and predator-control) and to translocate additional species of seabirds in the future, we believe there is a need for a long-term strategy so as to secure funding for the future.

7.2 Funding allocation

The estimated costs for the project are broken down and explained in Table 3. A small internal fence around the burrows may also need to be constructed, in order to prevent translocated chicks from wandering too far from their burrows. This is unlikely to affect the total cost estimates by any significant amount. As the cost estimates for many features varies considerably based on material choice and other design aspects, the total cost estimates should be interpreted as a lower bound. This considered, the expenditure for the reintroduction of the two priority species should not exceed NZ$351,000 if cost-efficient decision-making is employed.

Table 3: Estimated funding allocation for the reintroduction of two species of seabirds to Boundary Stream Mainland Island and a description of the components that make up each major feature.

Feature	Description	Estimated cost (NZD)
Predator-proof fence	A 2 hectare enclosure will create a predator-proof fence of about 600 m (assuming it is rectangular), whereas a 1.5 ha enclosure has a perimeter of about 500 m. The fence has a life span on the order of decades, and potentially up to 70 years. Prices based on quotes from Pestproof Fences Ltd, Christchurch, and encompass differing material requirements and labour.	130,000 – 210,000
Burrow construction	Approximately 240 burrows made of wood (with volunteer support) with PVC drainage pipe (external diameter of 110 mm) entrances tunnel and turf roofs. Chambers measure 450 x 250 mm, with three walls 150 mm high. Also included is 10 L fine beach gravel, as described in Gummer & Adam (2010). Estimates vary depending on costs of materials.	4,500 – 6,000
Translocation and raising	Translocation of the two species; approval from source population, transportation, food, health exams, and other needs such as electricity, water and hygiene. Estimates are *per species per year*, with first year translocations usually more expensive than subsequent translocations.	10,000 – 20,000
Sound system	A solar powered acoustic sound system to play the two species' calls during raising of chicks to fledgling stage. Likely to be just two speakers, estimates depend on wattage and quality, and expert opinion (e.g. H. Gummer) of site requirements.	10,000 – 12,000
Pest-control	Tracking and trapping stations setup (e.g. purchasing extra traps and baits), trapline maintenance and monitoring. Initial investment (first 2-3 months after completion of fence) relatively high, with minimal costs once enclosure has been declared pest free.	3,000 (maximum)
Total cost		Low – 207,500 High – 351,000

8. Community Relations

8.1 Maori involvement

The New Zealand government recognizes the indigenous and local peoples' rights to shared resources and assets such as the country's natural resources, including seabirds (Craig *et al*. 2000). Originally from the Treaty of Waitangi in 1840, their rights are stated in the Conservation Act and the Resource Management Act. Thus the Maori have the rights to be involved with management of seabirds. To support and value their rights, it is necessary to involve them in the process. Previous translocations suggest contacting a local Iwi group so they can take part in the translocation. An official welcoming by the Maori people upon arrival at BSMI will be prepared for the translocated chicks. This involves a welcoming ceremony known as the Karakia (Ward-Smith and McLennan 2008, unpublished). Thus the Iwi group needs to be updated on important logistics such as dates of each translocation so they can plan accordingly for the Karakia.

8.2 Volunteer

Help will be needed to build the predator-proof artificial colony site and to translocate the chicks and rear them till they fledge. Taking in volunteers is the most effective and financially viable option for BSMI. The project is labour intensive, especially during the rearing of chicks at BSMI, so volunteer opportunity postings will be posted on websites such as DOFBC, NZ Conservation Jobs etc. to attract volunteers. In addition an email should also be sent out to universities in New Zealand to attract interested students. For perspective, a three year fluttering shearwater translocation at Mana Island required 3,000 volunteer hours (H. Gummer, pers. comm.).

8.3 Mentors/expert help

Experts of seabird translocations in the Hawke's Bay area that will be helpful in getting advice and supervision from:

Tamsin Ward-Smith works at Cape Kidnappers for translocations of Grey-faced petrels.

John McLennan is an ecological consultant at Cape Kidnappers and is involved in translocations of fluttering shearwaters and Grey-faced petrels.

Helen Gummer works with numerous translocation projects including fluttering shearwaters and site selection for Cape Kidnappers.

Mike Bell and **Lynn Adams** works with translocating fluttering shearwater on Maud Island, Marlborough Sounds.

Greame Taylor and **Colin Miskelly** work with translocations of Common Diving Petrels and used acoustic systems.

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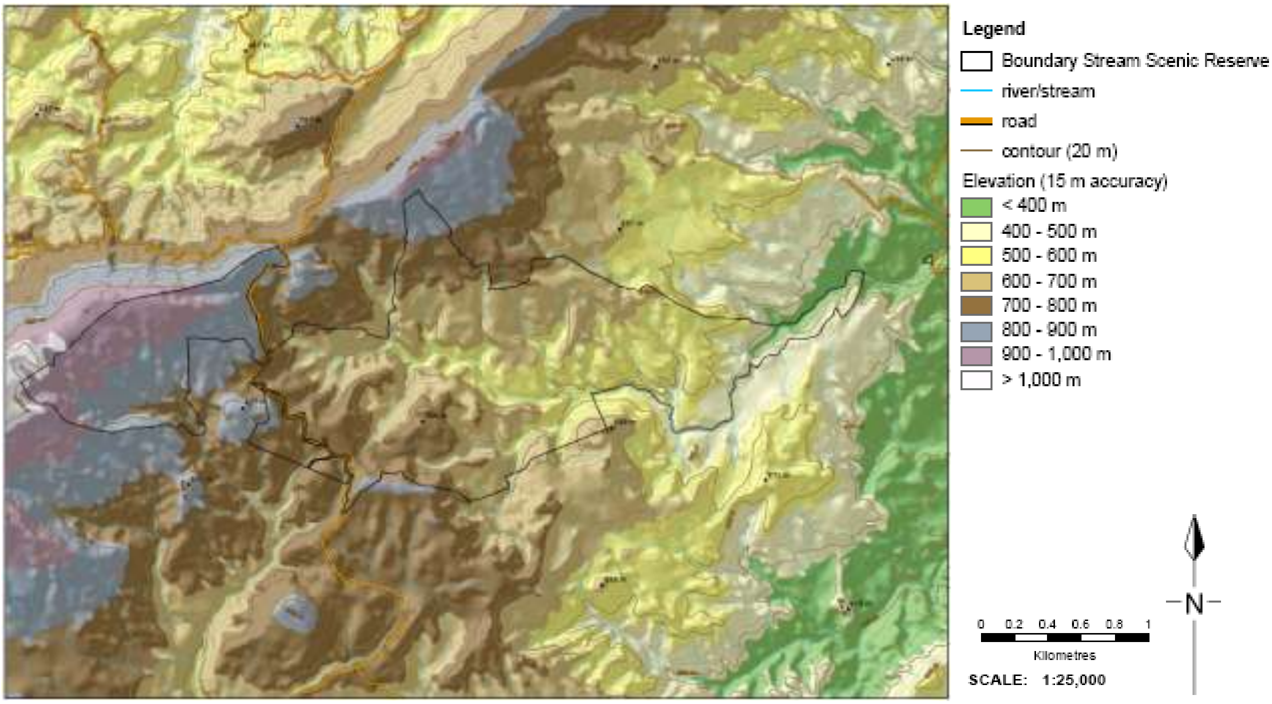
Appendix I: Boundary Stream Mainland Island maps



BSMI Elevation Map. Provided by Department of Conservation.
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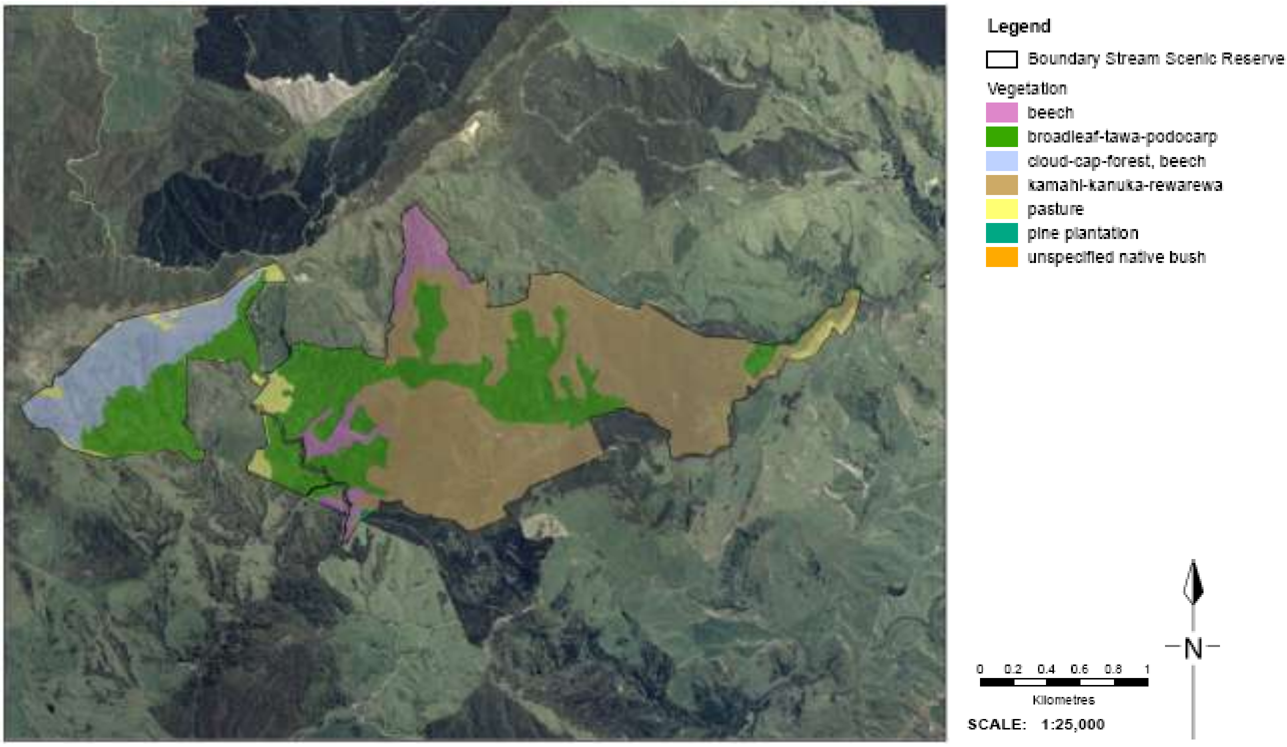

BSMI Vegetation Map. Provided by Department of Conservation.
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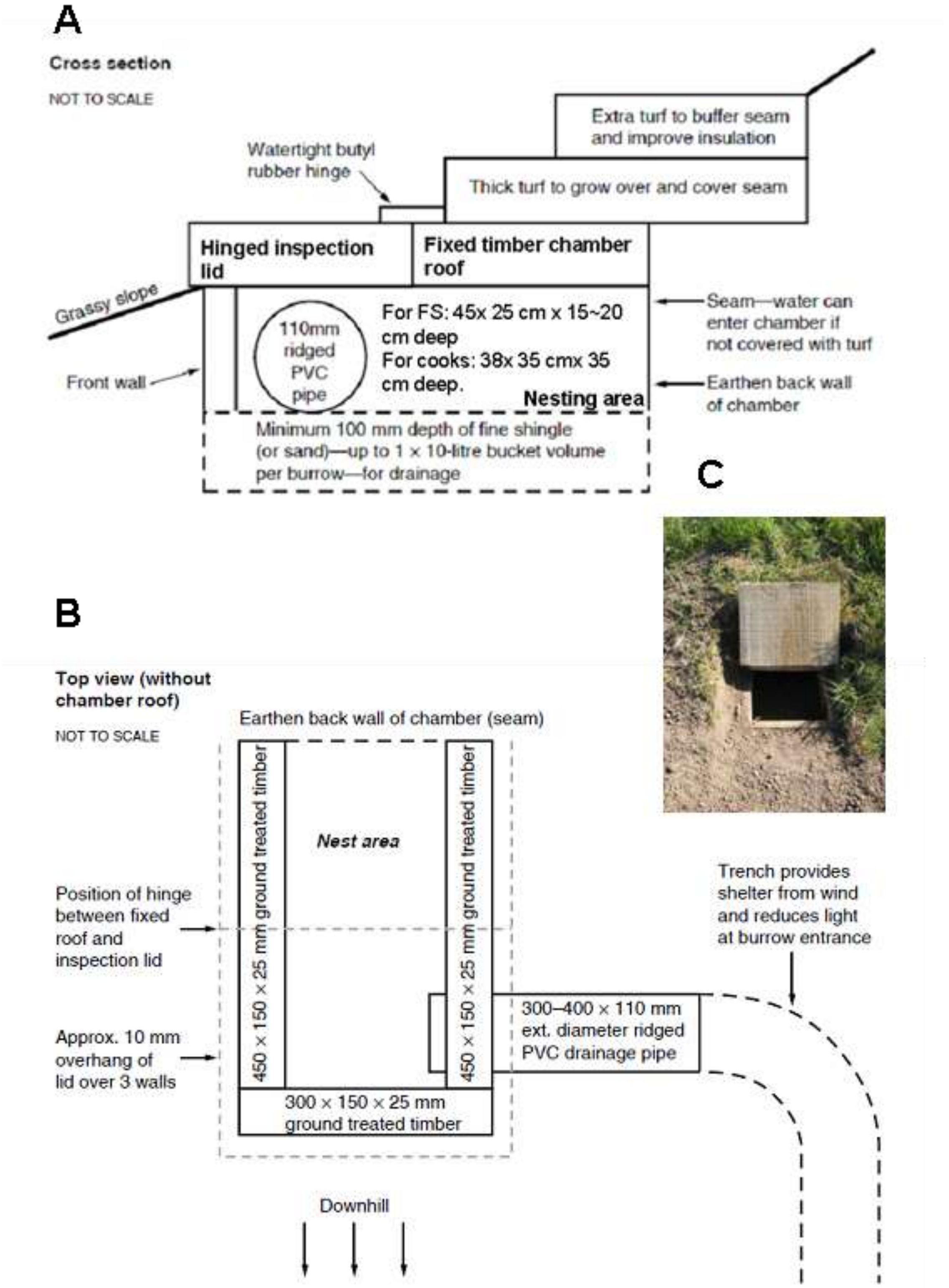
Apendix II: Burrow design



The diagram of artificial burrows. A, cross section, the basic structures are similar whereas various in nesting area to fluttering shearwater (FS) and Cook's petrel. B, longitudinal section of front part. (A & B are edited form photo provided in Gummer and Adams [2010]) C, A real-life photo of settled burrows for fluttering shearwaters (courtesy of T. Ward-Smith).