Predator Free Rakiura Halfmoon Bay Project—analysis of options for proposed predator fence

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PREDATOR FREE RAKIURA

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CONTENTS

1. Purpose of the document

The purpose of this document is to provide key information relating to critical aspects of the design and use of predator fencing, with specific reference to the Predator Free Rakiura Halfmoon Bay Project on Stewart Island/Rakiura (hereafter Rakiura). This information has been requested by the Predator Free Rakiura (PFR) Governance Group, in order to facilitate consultation with Ngāi Tahu Whānui, the local community, and stakeholders about whether the Halfmoon Bay (HMB) Project should proceed. This project requires the construction of a predator fence.

2. What is a predator fence?

A predator fence is a fence constructed to exclude predators from a designated area. Based on published literature and interviews conducted as part of this investigation, 33 predator fences are known to be in operation in New Zealand. At present, Xcluder® Pest Proof Fencing Ltd. (www.xcluder.co.nz) appears to be the sole commercial operator of predator fencing design and manufacturing within New Zealand. A second company, Pestproof Fences Ltd, was in operation for a number of years but it appears to have gone out of business. In addition, there are a number of sanctuaries that have built their own fences based on a similar design to that described below.

3. Success of predator-fenced sanctuaries

Contact was made with managers at eight fenced sanctuaries during the development of this document[1]. Sanctuary managers unanimously stated that predator fencing had been critical in terms of achieving their project aims. Some managers claimed that 'the fenced sanctuary would be the saviour of a species'[2]. These views are in stark contrast to those of Scofield et al. [1] who claimed that the goals of predator-fence projects are frequently not achieved.

All of the sanctuary managers interviewed considered that biodiversity within their fenced areas had improved significantly (e.g. the forest within the fenced areas is regenerating and bird numbers have greatly increased). Evidence cited in Innes et al. [2] also supports these assertions. At Tawharanui[3] and Shakespear[4] Open Sanctuaries, plant and lizard species respectively have been 'rediscovered' after the fence completion and predator-removal phase, presumably as a result of reduced grazing and predation pressure. In all eight cases, having a predator-free sanctuary has enabled the successful translocation of at least one species into the area. In fact, Burns et al. [3] reported that 63 translocations of 40 species have occurred to 24 predator-fenced sanctuaries (up to December 2009), leading them to suggest that predator-fenced areas are now occupying a similar role to islands in securing native biodiversity. Species translocated into fenced areas have covered the spectrum from highly threatened (such as the Nationally Critical takahē and taiko) through to less vulnerable species (such as North Island robin) [4]. In the case of Zealandia, six of the translocations have enabled the successful return of species to the mainland for the first time in over 100 years[5]. As further evidence of the biodiversity recovery resulting from fencing-off areas and translocating species into them, a number of these sanctuaries have subsequently become source sites for species translocations elsewhere—as Bushy Park board member Allan Anderson[6] says, 'this is the big tick for success'.

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1 The following fenced sanctuaries were contacted: Zealandia (Wellington); Bushy Park (Whanganui); Dancing Star Foundation Ecological Preserve (Stewart Island); Tawharanui Open Sanctuary (Auckland); Shakespear Open Sanctuary (Auckland); Orokonui Ecosanctuary (Dunedin); Glenfern Sanctuary (Great Barrier Island); Sweetwater Covenant (Chatham Islands).

2 M. Bell, Chatham Island Taiko Trust, on taiko, pers. comm.

3 M. Maitland, Auckland Council, pers. comm.

4 A. Parker, Management Committee, Shakespear Open Sanctuary Society, pers. comm.

5 Taken from http://www.visitzealandia.com/what-is-zealandia/conservation-restoration/progress-to-date/ [website viewed October 8 2014].

6 Pers. comm.

4. The 'value' of using predator fences

Within recent scientific literature there has been debate about the 'value' of using predator fences. Scofield et al. [5] questioned the economic value of predator fencing in achieving biodiversity conservation outcomes; their main argument centring on the costs of fencing relative to other approaches and the lack of evidence that predator fences achieve desired conservation outcomes. In response, Innes et al. [2] outlined the emerging conservation benefits from projects utilising predator fences, and identified the multiple goals that fenced sanctuaries seek beyond direct biodiversity outcomes (e.g. public advocacy for species and conservation). Both parties agreed that the ecological and economic value of predator-fenced sanctuaries ought to be properly evaluated; however, it appears that, so far, this assessment has not been done to any great extent (Norbury et al. [6] appears to be the only example at present of such work).

5. Why does this project need a predator fence?

The bio-economic analysis of fences conducted by Norbury et al. [6] raises the question of the rationale for a fence, suggesting that, based on recovery measures of two skink species, sustained predator control within the target area and buffers to limit reinvasion is a more effective predator management strategy for large areas than predator-exclusion fencing. However, this analysis is not applicable to the HMB Project for the following reasons:

1. This project is seen as the 'stepping stone' or 'launching project' for the overall goal of the Predator Free Rakiura Project. Achieving eradication here (within the HMB Project area) will provide confidence to investors and the communities of interest to pursue the larger and technically more difficult challenge of removing predators from the entire island.
2. Norbury et al. [6] state that their analysis is not applicable to indigenous species that are highly sensitive to predation and only ever adequately protected on the mainland by exclusion fences. Species such as tīeke /South Island saddleback (*Philesturnus carunculatus*) are considered to be one such species; with tīeke a known species that members of the local Rakiura community seek to see become 'resident in our gardens'[7]
3. The HMB Project is not a predator 'control' programme. Its purpose is to remove every last individual of the target species' population(s). Imperative within that purpose is the ability to manage reinvasion to zero population reestablishment. Without a predator fence, reinvasion by target species back into the project area from the rest of Rakiura would be at a level where complete removal of these animals (from the project area) is unfeasible.

Incursions around the fence by some of the target predators will happen from time to time. Such events would not constitute failure of the fence, so long as there are systems in place to deal with those events before a target predator population can re-establish. Incursion response must be at a level that eliminates the likelihood of requiring another complete predator removal operation. The biosecurity systems required to complement the use of the proposed fence are detailed in the 'Predator Free Rakiura Halfmoon Bay Project—biosecurity options' discussion document [7].

[7] Quote taken from Stewart Island Rakiura Community and Environment Trust (SIRCET) website: http://www.sircet.org.nz/ [website viewed January 15 2015].

6. Design of a predator fence

The current 'best practise' design [8] consists of a 1.8–2.0 m high 'base' fence (Fig. 1). Wire mesh is attached to wooden posts and a 300–500-mm wide horizontal mesh skirt facing the predators is pinned 50–100 mm underground. A folded and/or rolled sheet steel hood is mounted on top of the mesh. This hood extends 250–350 mm horizontally towards the outside of the protected area (i.e. towards the predators). In a 'double hood' design, there is a second hood and mesh skirt facing the opposite direction.

Key considerations for the fence design are:

- The hood must be designed to stop climbing animals from being able to get over the top of the fence.
- The height of the fence must be sufficient to prevent the target animals jumping over it.
- The mesh must have an aperture size smaller than the smallest known gap the target species can fit through.
- The skirt must extend far enough out from the fence to stop animals being able to dig and burrow under the fence.

A significant amount of trialling and research has gone into the development of the design of predator fencing currently used. Zealandia (formerly Karori Wildlife Sanctuary) undertook considerable animal testing of a number of fence designs in the early 1990s, prior to construction of their fence, with nearly 200 animals tested against the prototypes[8]. Xcluder® Pest Proof Fencing Ltd. expanded on this work by Zealandia, with the development of new fence designs.

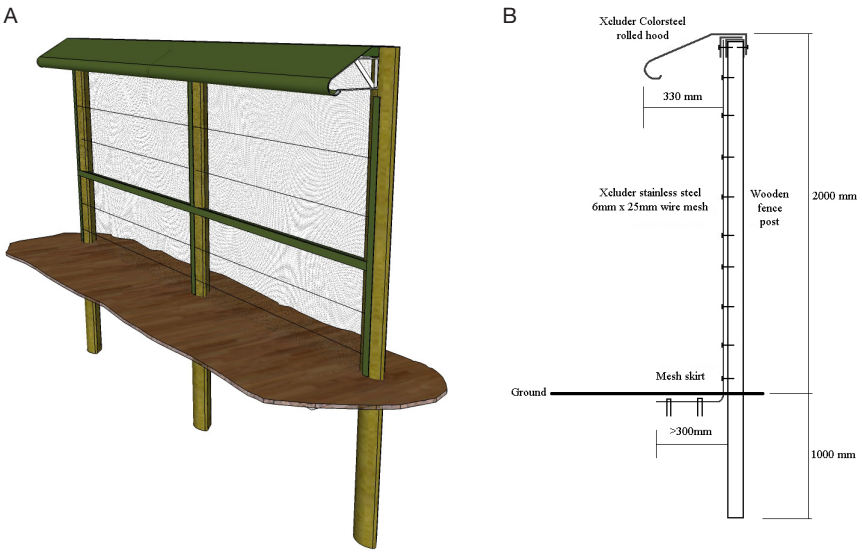

Figure 1. A. Diagram of a predator exclusion fence. B. Cross section of an Xcluder® predator exclusion fence.

Table 1 provides a summary of observed behaviours in animals trying to breach a predator fence (during development by Xcluder® staff), with specific regard to the target species in the Halfmoon Bay Project, the maximum height they can jump , and the minimum size hole they are able to squeeze through.

Note that kiore (*Rattus exulans*) have not been formally tested. They are present in areas where predator fencing is currently utilised (e.g. Chatham Islands), and they have not been found within the fenced area following initial predator removal. It is expected that fence elements designed to exclude mice should be sufficient to exclude kiore, hence the inclusion of mice in the above table.

[8] Taken from http://www.visitzealandia.com/what-is-zealandia/conservation-restoration/our-groundbreaking-fence/ [website viewed 8 October 2014]

Table 1. Summary of behaviour observed and physical attributes of species tested by Xcluder®*.

* Based on information obtained from [8].

SPECIES	BEHAVIOUR OBSERVED AND PHYSICAL ATTRIBUTES							
	PUSH	CHEW	DIG	CLIMB	JUMP HEIGHT (mm)	MESH HOLE SIZE TO CONTAIN (mm)	CONTAINED BY ELECTRIC WIRE	LEARNING OBSERVED
Ship rat	✓	✓	✓	✓	800	13	X	✓
Norway rat	✓	✓	✓	✓	800	13	✓	✓
Hedgehog	✓	X	X	X	X	50	✓	✓
Possum	✓	✓	X	✓	1200+	50	X	✓
Cat	✓	✓	x	✓	1800+	50	X	✓
Mouse	✓	✓	✓	✓	400	6	X	✓

Notes:

Mouse included as a surrogate for kiore, and due to their high invasion/biosecurity risk

✓ = exhibited behaviour regularly with competence

✓ = excelled at behaviour and used it very frequently during breach attempts

X = did not exhibit behaviour

X = not contained by that design feature

7. Long-term considerations for design of fence for Halfmoon Bay Project

Any fence designed and built for the HMB Project would need to be designed so as to account for the above behaviours and exceed the physical capabilities of all of the target species as the minimum standard.

The overall goal of Predator Free Rakiura is to eliminate predators from the entire island; the HMB Project would be the first step towards achieving this aim. Consideration, therefore, should be given as to whether the proposed predator fence needs to be built with the long-term biosecurity of the entire island in mind. If the fence is to exclude predators from within the HMB Project area in the short-to-medium term and provide an important biosecurity measure in the long term, it would need to be designed and built in a way that enables it to exclude predators from both directions—those coming from the rest of the island into the Halfmoon Bay area (to protect the Halfmoon Bay area for the first project); and then from any invading animal within the Halfmoon Bay area reaching the rest of the island (once it has been declared predator-free).

To achieve double-sided protection (future-proofing biosecurity for the full island eradication), the fence would require the hood and skirt to be built on both sides of the fence. This decision is best made before any construction occurs, as it is significantly easier and cheaper to build a two-way protective fence from the outset, rather than retrofit aspects to the 'missing' side. For the purposes of this document, all future reference to the fence assumes a double-hooded and skirted fence (providing protection from both directions).

With biosecurity in mind, it is important to note that Xcluder®'s testing showed that the smallest aperture through which any mouse (adult or juvenile) could pass through was a hole size of 7.1 × 40 mm [8]. This mesh size should be sufficient to exclude kiore, the smallest of the target species for the HMB Project (and likely the most difficult to exclude using the fence). However, as noted above, the mesh sizing has not been explicitly tested for kiore—this testing could take place prior to construction to confirm its suitability.

Mice are currently not considered to be present on Rakiura[9]; however, they are a constant biosecurity risk (with some individuals being reported from salmon farms etc. [9]). Consideration should be given to using 6 × 25 mm mesh or smaller to provide some protection for the rest of the island against the possibility of mice invading Halfmoon Bay. It is worth noting that using 12 mm mesh (the next size up) increases the risk of fence failure resulting in incursions, as it only takes one wire breakage or weld failure to create a gap large enough to be exploited by any of the three rat species [10]. The 6 mm mesh would require multiple wire or weld incidents to occur to be vulnerable to breach.

For the purposes of this document, all future reference to the fence assumes the use of 6 mm mesh to exclude kiore (and reduce the risk of any invading mice from entering the rest of the island).

8. Incursions

It is important to state that, in reality, there is no such thing as a predator-proof fence. This is why such fences are called predator fences rather than predator-proof fences. The fence would never be 100% effective 100% of the time; after all, even offshore islands surrounded by sea are at risk from biosecurity breaches and predator incursions. The predator fence described would greatly reduce the reinvasion rate of the target predators, but (based on predator fence use and experience elsewhere) all fences 'leak'.

Seven of the eight sanctuaries contacted in this assessment had suffered incursions into predator-proof-fenced areas since being built. The one exception was the Sweetwater covenant (8 ha) where the fence has been in place since 2006 and has had no known incursions. However, most sanctuary managers consider incursions to be a rare event. Table 2 provides the details of incursions (up to November 2014) into the eight sanctuaries contacted.

Of particular interest is that predator populations had established at only three sanctuaries as a result of incursions—Tawharanui Open Sanctuary (once [11]), Shakespear Open Sanctuary (once[10]), and Dancing Star Foundation Ecological Preserve ('extra follow up required every 3 years on average'[11]). In all cases the invading animals were rats. Glenfern Sanctuary on Great Barrier Island (Aotea) manages a resident population of kiore to low densities, but responds to other rat species when they invade[12]. Evidently, the protocols and methods in place at these sanctuaries more often than not result in early detection and response to individual incursion events; predator populations seldom re-establish—the true measure of successful incursion responses.

Mice incursions have not been included in Table 2 as, in the context of the HMB Project, mice are not considered to be currently present on Rakiura and could therefore not breach the predator fence to establish a population in the HMB Project area. Mice have breached predator fences and established populations within some of the fenced sanctuaries listed in Table 2; in others, mice were never eradicated. If the HMB Project were to proceed and mice arrived from the mainland and established a population within the HMB Project area, it would be highly desirable to have a predator fence capable of excluding them from invading the entire island.

9. Response to incursions

Incursion detection and response is an essential component of the proposed HMB Project. It is not a question of if an incursion takes place, but when. The key is to be prepared—if you expect the sanctuary to be invaded by any of the target predators or mice you can plan for it at the outset (including the design of the fence).

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[9] B. Beaven, Department of Conservation, pers. comm.

[10] A. Parker, Management Committee, Shakespear Open Sanctuary Society, pers. comm.

[11] B. Beaven, Department of Conservation, pers. comm.

[12] S. Sambell, Glenfern Sanctuary, pers. comm.

Table 2. Incursion history by sanctuary, excluding mice incursions. Information based on interviews with sanctuary staff carried out by Phil Bell.

SANCTUARY	PENINSULA OR ENCLOSED BY FENCE	SPECIES DETECTED	FREQUENCY OF INCURSION	ASSUMED REASON
Zealandia	Enclosed	Rats Weasels	Total of 3 incidents in 15 years	Storm damage resulting in windfall tree 'bridge' or culvert being held open by debris
Bushy Park	Enclosed	Rats Weasels	Total of 3 incidents in 9 years	Culvert grill displaced; windfall tree 'bridge'; bought in by bird (due to injuries observed)
Dancing Star Foundation Ecological Preserve	Peninsula	Rats Possums Cats Deer	'Regular' invader Average of 2 per year Average of 1 per year Average of 2–3 per year	Around the fence ends, as it terminates at high water mark.
Tawharanui Open Sanctuary	Peninsula	Rats Possums Cats Weasels Stoats	16 incidents in 6 years 9 individual in 6 years 4 individuals in 6 years 4 individuals in 6 years 2 individuals in 6 years	Around fence ends, as it terminates with up to 60 m of beach exposed at low tide. Can't rule out accidental introduction with visitors/ campers
Shakespear Open Sanctuary	Peninsula	Rats Possums Cats Weasels Rabbits	8 incidents in 3 years 1 individual in 3 years 2 individuals in 3 years 1 individual in 3 years 3 individuals in 3 years	Around the fence ends, as it terminates at high water mark. Can't rule out accidental introduction with visitors.
Orokonui Ecosanctuary	Enclosed	Rats Weasels Stoats Rabbits	Average of 1–2 incursions in total per year	Storm damage to the fence
Glenfern Sanctuary	Peninsula	Rats Cats Rabbits	Multiple detections Average of 2 per year Infrequent	Around the fence ends, due to initial poor buffer defences. Rats swim from Kaikoura Island.
Sweetwater Covenant	Enclosed	None	NA	NA

In tandem with this discussion document a similar report on biosecurity options for the HMB Project has also been prepared for consultation [7]. Should the project proceed, detailed operational planning and advocacy work will be required, including the design and implementation of a detection system and response plan for invading target predators and mice.

10. Fence ends

Peninsula fences have a higher incursion risk profile than complete circular fences, as animals are able to walk around the ends of the fence into the sanctuary. Breaches at either end of the fence are the biggest disadvantage of peninsula fences (see Burns et al. [3] and Innes et al. [2]), The risk of incursion via the fence ends is largely dictated by a combination of topography and fence design (e.g. the fence at Tawharanui Open Sanctuary ends with 60 m of tidal beach exposed at low tide (see Fig. 2).

Figure 2. Photo showing the koru design at the end of the Tawharanui Open sanctuary predator fence; note the length of beach visibile between fence end and the sea. *Photo: Matt Maitland*

Peninsula projects typically have intensive predator control in a 'buffer' immediately outside the fence, and especially at the coastal ends of the fence, in an attempt to stop the invading animals walking around the ends of the fence. The 'Predator Free Rakiura Halfmoon Bay Project—biosecurity options' discussion document [7] outlines the likely set up for buffer/perimeter control for the HMB Project.

At Tawharanui, the fence was built with an experimental 'koru' design, the intention being that the spiralling fence ends would increase the level of containment, thereby channelling animals encountering the fence towards multiple predator control tools (i.e. traps, bait stations etc.) [11]. It is unclear how effective the 'korus' have been.

For most other peninsula sanctuaries in New Zealand, the fence extends to the high water mark (e.g. Shakespear Open Sanctuary, Dancing Star Foundation Ecological Preserve). Often the fence finishes as a straight line (see Fig. 3), leaving a gap along the coast for animals to enter the sanctuary at low tide.

Figure 3. Photo showing one end of the predator fence at Dancing Star Ecological Preserve. *Photo: Brent Beaven*

When the Dancing Star fence was first constructed in 2005, the eastern end was built 30 m from the sea at low tide. Ongoing rat and possum incursions led to a decision to reduce this gap to less than 3 m. The result has been a considerable reduction in rat and possum incursions [12].

11. Fence ends—can they be built into the sea?

Possums [13] and feral cats are generally reluctant to enter the water or swim for any length of time. Therefore, it is likely that the incursion rate around a peninsula fence could be further reduced by extending the fence into the sea.

The Tawharanui Open Sanctuary investigated the possibility of extending their fence into the intertidal zone as one of a range of options aimed at reducing the number of occurrences of predators moving around the fence ends. A panel of experts concluded that if the fence ends could be extended to the low tide mark or beyond, then pest numbers entering the park around the ends would be significantly reduced [12]. However, the concept was ultimately dismissed for the following reasons [11]:

- Engineering challenges associated with storm swells and shore sediment drift
- Subsequent and significant maintenance costs if built
- Expected difficulty in obtaining resource consent to build into the coastal marine area
- Impeding coastal access in an area designated for public recreation

The panel estimated that the engineering and construction costs required to create a structure that would remain in position across the range of expected environmental conditions would be in excess of $1000 per metre [12]. The ongoing maintenance costs would be additional.

Obviously, the costs for undertaking this work need to be weighed up against the benefits (environmental, financial, and otherwise) of reduced incursion events and the potential cost savings from reduced response operations across the life of the fence. The key question here is whether the investment in the research and development required to design and then build sea-faring fence ends is worth the anticipated (and likely significant) savings from reduced incursion responses.

For the HMB Project, it is considered structurally feasible to build 'jetty-like' structures into the sea that the proposed fence would then sit on or tuck underneath[13]. Jetty-like fence-end structures would be required at both extremities for either fence option. A jetty structure once existed at Maori Beach and some of the old piles are still visible from the air. This structure could be resurrected to minimise 'new' development at this location, if Option A for the fence was chosen.

There is definite merit in getting the conceptual design phase of building a predator fence to take the fence into the sea (i.e. understanding the consent needs, conceptual drawings, rough order costing, etc.) as a minimum to enable an informed investment decision on whether to pursue the new development work. The wider programme (financial, environmental and social) benefits of fewer incursions into the Project area also need to be factored into any decision making in regard to fence design. As with all other preliminary work to inform final decision making and operational planning, funding would be required for this planning work and cost-benefit assessment.

[13] A. Bramley, Department of Conservation, pers. comm.

12. Earthworks and vegetation clearance

Earthworks along the fence line would likely be required to provide a stable long-term foundation to protect the fence base from erosion, and facilitate ready access for inspection and maintenance. On steeper fence sections, and through areas of vegetation, a 5–8-m-wide fence platform is usually formed using a digger. A platform of this width is necessary to accommodate the fence and provide room on the outside of the fence for a vehicle (e.g. quad bike) to pass for fence inspections. Room on the uphill side of the fence is also required for the construction of a water table to trap and channel all runoff[14] and remove vegetation that could provide a platform for predators to 'spring board' over the fence.

Xcluder® have observed that surface water runoff tends to bounce off the fencing mesh, causing accelerated erosion[15]. Water, therefore, must be prevented from flowing through the line of the fence in any concentrated way by mounding the fence platform and drawing surface runoff under the fence through screened culverts. The number of culverts required for the HMB Project fence will remain unknown pending a decision about the project and the subsequent detailed design work for the fence.

Vegetation needs to be cleared along the platform corridor in perpetuity. Typically, 10 m of vegetation clearance at ground level is required to ensure a 5 m gap at the full height of the canopy. This distance between trees on either side of the fence is required at all times to prevent animals from using travel between trees to cross over the fence.

It is possible that opening up a 'corridor' within the forest would increase the occurrence of wind-fallen trees, as the forest gap removes any buffering effect, therefore vigilance would be needed to ensure the fence is kept clear. Remote surveillance as outlined in 'Inspection and maintenance' would assist in alerting staff to any tree fall events onto the fence itself.

The base of the fence would also need to be maintained free of vegetation to ensure that anything growing up the fence would not compromise its performance. Given this area of cleared vegetation will increase the risk of weeds invading the site, vigilance will be required to detect such problem plants and remove them during routine fence maintenance work.

13. Inspection and maintenance

Maintaining the integrity of a predator fence is vital (see Table 2). Research at Maungatautiri (a sanctuary utilising 47 km of predator fencing) found that any breach in the fence was highly likely to be located and exploited by a predator within 24 hours (with an estimated 99% likelihood in summer and 85% likelihood in winter) [14]. This research suggests that all of the target predators on Rakiura would be capable of finding and using a breach, with the highest risk from rodents.

The HMB Project predator fence would require ongoing inspection to ensure it is well maintained and that all faults are repaired immediately. At Maungatautiri, the predator fence is inspected weekly with an intensive check every month [3]. Staff at Maungatautiri aim to respond within 90 minutes to any breaches that trigger the fence's automated alarm system [3]. Remote surveillance technology has been developed to provide round-the-clock reporting of any fence breach (e.g. caused by tree fall) and gates left open. Xcluder® consider remote surveillance as an essential fence integrity monitoring tool, especially where the risk of tree fall is a threat to fence integrity and/or where there are likely to be frequent gate openings[15]. For the HMB Project fence, a similar automated reporting system and response and inspection regime would be required.

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[14] Taken from http://www.xcluder.co.nz/xcluder-fences/fence-construction.html [website viewed 3 October 2014]

[15] Taken from http://www.xcluder.co.nz/xcluder-fences/fences-designs.html [website viewed October 9 2014]

Video recordings by Connolly et al [14] at Maungatautiri showed that numerous predator species were often present directly outside the fence, thus creating an increased risk of invasion in the event of a breach in the fence. This 'invasion pressure' may be able to be reduced by controlling predator numbers around the outside of the fence. It is recommended that this approach be used for the HMB Project whilst predators remain on the rest of Rakiura.

The mesh skirt does not eliminate the problem of holes forming under a fence due to predators attempting to burrow beneath it. As such, ongoing fence line maintenance, including locating and destroying such holes, is essential for continued fence integrity [8].

14. Placement in the landscape

The best location for a predator fence on a peninsula is along ridgelines from coast to coast. This reduces the necessity for the fence to cross major waterways, as these places are recognised as having significant potential for breaches. [3].

Two options for fencelines for the HMB Project have been identified that fulfil this criterion (for details of each, see Appendix 1)..

The first option (A) is completely within the boundaries of Rakiura National Park (public conservation land), and begins at North Arm and ends at Maori Beach. **Please note that the exact end points are not known, so the map is indicative only**. The total length of this route is approximately 8.8 km, and it would result in an operational area for predator removal of approximately 4733 ha (Map 1).

The second option (B) crosses a combination of public conservation land and private land (namely Rakiura Maori Land Trust land). It starts near Ryans Creek and ends near Peters Point. **Please note the exact end points are not known, so the map is indicative only**. The total length of this route is approximately 7.25 km, and it would result in an operational area for predator removal of approximately 2151 ha (Map 2).

15. Protection ratio

The 'protection ratio' of a predator fence is the ratio between the area which predators are excluded from and the length of predator fence required. The national average in 2009 was only 74 ha for 1 km of fence [3]. The protection ratio for Option A is 540 ha for 1 km of fence, while the protection ratio for Option B is 298 ha for 1 km of fence.

16. Track crossings and pedestrian gates

The proposed fence line in Option A crosses maintained tracks at 3 points—twice across the Rakiura Track (at Maori Beach and at the approximate mid-point of the fence), and once across the North West Circuit Track at the North Arm end).

The proposed fence line in Option B crosses maintained tracks at 2 points—once across the Rakiura Track by Peters Point, and once across Kaipipi Walk (towards the Ryans Creek end).

Pedestrian gates would be required whenever the fence crosses a maintained track. These gates would need to be designed so that they can be passed through without the possibility of animals being able to pass through at the same time. One such design is a 'double-door' system that uses a closed cell which does not allow both doors to be open at the same time. The person enters the cell through one door, it closes behind them ('containing' the person within the cell), and then the other door (to exit the cell) can be opened and the person is able to move through the fence. An example of a pedestrian gate is shown in Fig. 4.

Map 1. Position of the proposed predator fence Option A.

Map 2. Position of the proposed predator fence Option B (note private land is not coloured).

Figure 4. Tawharanui fence and gate option 1. *Photo: John Dowding*

17. Consent requirements

In the event that the Halfmoon Bay Project is supported and a predator fence agreed to by Ngai Tahu whanui, the community and stakeholders, the question then arises as to what consenting requirements would be triggered.

Due diligence on historical and/or cultural sites identified within the various local Government planning documents in areas where the fences may be placed will be required. These would need to be considered and assessed, in terms of any possible impacts etc., when the consents are sought to construct the fence.

Building a predator fence for the HMB Project would trigger a number of consenting requirements (see Table 3). However, the Resource Management Act (s4)[16] states that work done by the Crown within the boundaries of any land held or managed under the Conservation Act 1987 is exempt from land use requirements (i.e. district plan consenting requirements). In that context, it could be beneficial if the fence were to be constructed entirely on public conservation land to make the consenting process less intensive (as described below).

The fence line proposed in Option A (Map 1) is located entirely within public conservation land. As such, if DOC is the Applicant, it is likely that this fence option would qualify for the exemption described above. This exemption relies on consultation between Southland District Council (SDC) and DOC confirming that the fence is consistent with s4 of the Resource Management Act. Consent would be required for the ends of the fences, as these would enter the area governed by the Regional Coastal Plan (with Environment Southland as the consenting authority). Furthermore, any consent requirements triggered by the Regional Water Plan would also need to be obtained.

A strip of unformed legal road runs along Maori Beach (past Peters Point) and at the proposed fence end that runs nears Ryan's Creek, with Southland District Council (SDC) 'owning' this land. Consequently, an approval would be required from SDC to occupy this land ('Licence to Occupy') for both fence options. Furthermore, as DOC does not administer this land, s4 of the RMA does not apply here. Therefore, if DOC is the applicant, the land use rules of the Southland District Plan apply and consent would have to be applied for and obtained for this section of the fence lines [15].

[16] http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM231900.html [website viewed 14 October 2014]

Table 3. Summary of the consenting requirements, for the HMB Project, depending on applicant [15].

PLANNING DOCUMENT	RULE	OPTION A		OPTION B	
		DOC	Other	DOC^	Other
Operative District Plan	COA.1: Consultation with iwi	×	✓	✓	✓
	COA.2: Buildings & structures	×	✓	✓	✓
	CPA.5: Conservation land	×	✓	×	✓
	HER.1: Heritage	×	✓	✓	✓
	HER.3: Indigenous flora & fauna	×	✓	✓	✓
	PRA.4: Soil displacement	×	✓	✓	✓
	SIGN.7: Signage	×	✓	✓	✓
Proposed District Plan	FRZ.3.1: Buildings & structures	×	✓	✓	✓
	FRZ.3.3: Work of the crown	×*	N/A	N/A	N/A
	BIO.3: Indigenous vegetation clearance	×	✓	✓	✓
	HH.2/3: Historic heritage	×	✓	✓	✓
	FRZ.4: Earthworks	×	✓	✓	✓
	SIGN.1: Signage	×	✓	✓	✓
Regional Coastal Plan	10.1.7/6: Disturbance of the seabed or foreshore	✓	✓	✓	✓
	10.5.3: Vegetation clearance	✓	✓	✓	✓
	10.5.9: Disturbance of sites of cultural value	✓	✓	✓	✓
	5.7.3: Modification or destruction of a cultural site	✓	✓	✓	✓
	11.2.6: Permanent structures in the CMA	✓	✓	✓	✓
Regional Water Plan	28/29: Culverts	✓	✓	✓	✓

Note:

- '×' indicates that a resource consent is not required and '✓' indicates that a resource consent is required.
- This table does not include building consenting requirements in accordance with the Building Act.
- DOC would be subject to the relevant Operative and Proposed District Plan consenting requirements in the area of legal unformed road along Maori Beach.

* Rule FRZ.3.3: Any activity or work of the Crown within the boundaries of a National Park that is not consistent with the relevant Conservation Management Strategy or National Park Management Plan is a discretionary activity. The fence is consistent with the CMS and the National Park Plan therefore this rule would not be triggered. It is included for completeness.

^ DOC would require these consents where the proposed fence crosses land that is not public conservation land.

If DOC is not the applicant or the fence line land is not located on public conservation land—as is the case in Option B (see Map 2)—all relevant land use consents would need to be applied for and obtained. Below is a summary of the consenting requirements, depending on the applicant and fence option.

Advice received[17] suggests that the timeframe to complete the consenting process and gain the necessary approval would likely be approximately 6 months (including the consultation required) for Option A. This time period for gaining resource (and other) consents for Option B is likely to be considerably longer (potentially up to 2 years, depending on the process required (e.g. legal challenges)). Table 3 summarises the consenting requirements according to applicants.

[17] A. Cameron, Department of Conservation, pers. comm.

18. Cost of the proposed fence options

Xcluder® Pest Proof Fencing Ltd. was contacted by the Department of Conservation, during the development of this document, to provide a cost estimate for a predator fence [10]. Xcluder® were provided with a map indicating the possible location for the fence (Option A; the same map as was provided to the community in early 2014), and requested to base their workings on an anticipated fence length of 9 km. No site visit was undertaken by Xcluder® staff for this specific task.

The costs outlined below are based on Xcluder®'s previous experience on Rakiura with the Dancing Star Foundation fence, as well as their extensive history of predator fence construction. These costs should be viewed as preliminary estimates.

18.1 Option A—8800 m fence

Construction of a 'two-way' fence (hood and skirt in both directions) using 6 mm 'mice' mesh is estimated to cost $3,528,000 (inclusive of earthworks, water crossings and culverts, two vehicle and three pedestrian gates, and surveillance system; but exclusive of GST). This figure works out at approximately $401 per linear metre.

18.2 Option B—7250 m fence

Construction of a 'two-way' fence (hood and skirt in both directions) using 6 mm 'mice' mesh is estimated to cost $2,959,750 (inclusive of earthworks, water crossings and culverts, two vehicle and two pedestrian gates, and surveillance system; but exclusive of GST). This figure works out at approximately $408 per linear metre.

19. Cost ratio

Clapperton and Day [16] stated in their 2001 report that 'exclusion fences are likely to be cost-effective in situations where the area to be enclosed or excluded is large relative to the length of fence line required. Fencing off a peninsula is an obvious example'. While Scofield et al. [5] criticised Clapperton and Day [16] in their subsequent article, they noted that 'the cost per hectare is strongly influenced by the shape of the area being fenced and also if the fence is complete or solely isolates a peninsula'. Scofield et al. [5] calculated the mean cost per hectare protected by predator fencing as approximately $3365 per hectare. The approximate cost ratios for the HMB Project fence options are $745/ha for Option A and $1376/ha for Option B.

20. Fence maintenance costs

Predator fences have an estimated 'functional' life of 25 years [5]. After such time, it is likely that the HMB Project fence would require a significant upgrade (and therefore subsequent further funding) or, if full island eradication has been achieved, the biosecurity measures and need for the fence could be reviewed.

In addition to the initial capital cost, there is the ongoing cost of maintaining the fence over its lifetime (including labour and materials). As an example, the Tawharanui Open Sanctuary requires two Full Time Equivalent (FTE) staff positions and an operating budget of approximately 5% of the capital cost of the fence annually for managing the predators and rabbits (rabbit control is ongoing) within and around the sanctuary, and to maintain the fence [12]. In addition, approximately 1000 volunteer hours are dedicated to inspecting the fence and monitoring for predator incursions (with a likely under-reporting of 50%) [12].

Based on 5% of the capital cost per annum, the approximate maintenance costs for the HMB Project predator fence would be $176,400 (for Option A) or $147,988 (for Option B) each year—approximately $20.05 per metre or $20.41 per metre each year.

21. Timing of construction

Construction would need to take place in the spring and summer months, so as to minimise weather disruption in the use of heavy machinery, especially for the earthworks phase. Construction involves vegetation clearing, earthworks, setting of fence posts, attaching the mesh (including the underground 'skirt' on both sites), and attaching the hoods to the top of the fence. Xcluder®, in their costing report [10], have suggested that the optimal timing for the project would be spread over two summer seasons—the first summer for the earthworks and fence platform creation and the second summer for building the fence (allowing the earlier work time to settle).

22. References

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Appendix 1

Summary of fence options

CRITERIA	OPTION A	OPTION B
Length of fence (approx.)	8.8 km	7.25 km
Area protected by fence (approx.)	4733 ha	2151 ha
Protection ratio of fence	540 ha to 1 km of fence	298 ha to 1 km of fence
Land management	Public conservation land	Mix of public conservation land, Rakiura Maori Land Trust, and private ownership
Expected track crossings	3	2
Resource consent challenges	Low (if DOC is applicant)	High (regardless of applicant)
Cost of fence (approx.)	$3,528,000	$2,959,750
Cost ratio of fence	$745:1ha protected	$1376:1ha protected
Maintenance cost of fence (approx.)	$176,400 per annum	$147,988 per annum