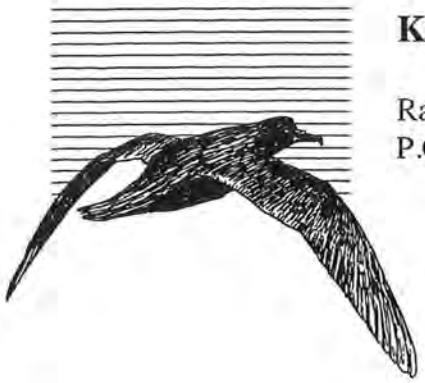
Appendix A: Moller et al. 2003 – Rakiura Tïtï Restoration Project Plan



Kia Mau Te Tītī Mo Ake Tōnu Atu

Rakiura Tītī Islands Administering Body
P.O. Box 743, Invercargill

Command Spill Trustee Council
California, USA.

22 November 2002.

Dear Trustees

Rakiura Māori request your help to repair the damage done to our most treasured species, the tītī (sooty shearwater), by the *Command* oil spill.

With your financial assistance we can eradicate rats from four tītī breeding islands. The rats have been accidentally introduced and kill tītī eggs and chicks. This is the best and fastest way that the reparation funds can replace the adult tītī killed by the spill. It will bring a lasting benefit for our mokopuna (grandchildren).

The following plan has been prepared under our overall direction by Dr Henrik Moller, the principal investigator of our *Kia Mau Te Tītī Mo Ake Tōnu Atu* ("Keep the Tītī Forever") research team. Dr Moller is an academic faculty member at the University of Otago whom we subcontract to conduct an ecological study to ensure that our harvests of tītī chicks will be sustainable. He teaches and researches wildlife management (conservation, pest control and harvest management). We are also grateful to two Californian seabird biologists, Josh Adams and Hannah Nevins, for facilitating the preparation of this application and hope to involve them in the restoration program that comes out of this application.

Please direct any detailed questions concerning the science behind our proposal to Dr Moller at the Zoology Department, University of Otago, P.O. Box 56, Dunedin, New Zealand (Telephone: + 64-3-4797991; Fax + 64-3-4797584; Email henrik.moller@stonebow.otago.ac.nz). He will relay any necessary issues to us for guidance. All issues of overall direction, contracting and execution of the rat eradication and associated monitoring should be directed to the Rakiura Tītī Islands Administering Body at the address above. We are the kaitiaki (environmental guardians) of the tītī and their management.

Many thanks for considering our request.

Yours faithfully

Ron Bull
Kaiwhakahaere (Chairperson), Rakiura Tītī Islands Administering Body

Appendix B: Letter of Support– Ron Bull, Rakiura Tïtï Islands Administering Body 2002

The Rakiura Tītī Restoration Project:

Mitigation of the *Command* oil spill injury by eradication of rats from Sooty Shearwater breeding colonies in New Zealand

Kia Mau Te Tītī Mo Ake Tōnu Atu

The Rakiura Tïtï Restoration Project:
Mitigation of the *Command* oil spill injury by eradication of rats from Sooty Shearwater breeding colonies in New Zealand

A request to the *Command* Trustee Council for funding assistance

By

Rakiura Tïtï Islands Administering Body
Kia Mau Te Tïtï Mo Ake Tönu Atu ("Keep the Tïtï Forever")
P.O. Box 743
Invercargill
New Zealand

Proposal prepared by:

[1]Dr. Henrik Moller, [2]Hannah M. Nevins, and [3]Josh Adams

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January 2003

Frontispiece

Up to 30,000 adult sooty shearwaters may have been killed by the *Command* Oil spill in September 1998. The shearwaters ('Tïtï') are a treasured species of Mäori (New Zealand's indigenous people) and a keystone species on over 40 Nature Reserves in New Zealand. The 'kaitiaki' (environmental guardians) of the tïtï request the help of the *Command* Trustee Council to repair the oil spill injury by eradicating rats from tïtï breeding colonies. (Photo: Tony Palliser)

Pukeweka is the smallest (2.5 ha) of four Tïtï breeding islands targeted for rat eradication. It is sandwiched between Taukihepa and Rerewhakaupoko Islands. Rats must be eliminated simultaneously from all nearby islands to prevent re-invasion by rats swimming between islands. The smaller Tïtï islands are entirely covered by breeding '*manu*' (burrowed ground) under a low *Olearia* forest. (Photo: Darren Scott)

Taukihepa ("Big South Cape") is the largest (929 ha) of all the Tïtï Islands and the main target for restoration through rat eradication. It is fringed by steep cliffs and so in many places is accessible only by helicopter. This is ancestral land of scores of *whänau* (birding families) that still continue their culture and livelihoods by a customary 6-10 week '*heke hao kai tïtï*' (harvesting expedition). This customary practice and cultural identity is threatened by global pollution and catastrophes like the *Command* Oil spill. (Photo: Darren Scott)

This photo shows the understory of a typical Tïtï breeding habitat ('*manu*'). Thick well-developed peaty soil is pitted with breeding burrows under a tangled 3 – 7 m forest canopy. Tïtï lay an egg within burrows that can be up to 5 m long. Tïtï abundance, breeding success and productivity is determined by counting entrance holes and determining burrow occupancy using an infra-red lit 'burrowscope' inserted down the burrows in search of eggs, chicks and breeding adults.
(Photo: Melanie Massaro)

Executive Summary

The Rakiura Tītī Restoration Project seeks to repair the injury to Sooty Shearwaters (*Puffinus griseus*) caused by the T/V *Command* oil spill in 1998 by eradication of introduced rats from breeding colonies on four southern islands of New Zealand. The project is spearheaded by Rakiura Mäori, New Zealand's most southerly group of indigenous people who manage this 'taonga' (treasured species) which they call 'tītī'. The restoration team combines the Traditional Knowledge of the 'kaitiaki' (Mäori environmental stewards) with technical and scientific expertise of the New Zealand Department of Conservation, a University of Otago team of ecologists, and three United States environmental education and seabird experts.

Elimination of rat predation of eggs and chicks on Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui islands is the most reliable and rapid method of replacing about 20,000 tītī estimated to be lost because of the *Command* oil spill. Rat eradication is proposed for mid 2004. Computer simulations emphasise uncertainty in outcomes, but most likely scenarios predict complete recovery of the oil spill injury within a year after rat eradication. However simulations using extremely pessimistic assumptions predict that complete recovery may take 4 decades. Long-term benefits to tītī and several other species and conservation of ecosystem processes will result.

The Rakiura Tītī Restoration Project team request US$ 538,000 from the *Command* Spill Trustee Council over the next 11 years to (i) eradicate the rats, (ii) establish quarantine to prevent re-introduction of rats, (iii) monitor and predict restoration success, and (iv) create educational outreach to inform the people of New Zealand and California about the project. Help in kind from other partners in the team is valued at about US$ 286,000, so the *Command* spill trust fund is being asked to contribute 65% of the overall project cost. The external contributions, together with savings from management and research efficiencies will make the project extremely cost-effective for the Trustee Council.

Rodent eradication would be by rapid aerial application of rodenticide (brodifacoum) from helicopters. Risks to humans and non-target species are considered minimal and

will be reduced by best professional practice that restricts the total amount of toxin discharged, the time of application and the type of bait used.

Intensive study of the rate of loss of tïtï eggs and chicks to rats, and comparisons of productivity before and after rat eradication, will allow computer simulation of rate of recovery of the *Command* oil spill injury in 2006. Longer-term monitoring of tïtï abundance at fixed study plots 8 and 9 years after eradication will then check model predictions and allow more definitive prediction of ongoing restoration outcomes.

A large number of Rakiura Māori visit the islands each year and they transport considerable quantïtïes of food and gear from a variety of departure points. A concerted campaign to improve quarantine precautions will be instigated by this project. Rakiura Mäori scientists and managers will be employed to visit birders and urge care, to prepare posters and place poison bait stations at landing island sites. A Natural History television programme about the restoration project will be used to heighten community awareness and quarantine efforts.

The television documentary will be supplemented by CD-ROMS, interactive web-sites and a complete school educational package to educate Americans and New Zealanders about the project and need for environmental stewardship.

All methods for eradication, managing risks and monitoring outcomes have been proven and refined. Experienced and expert teams will secure the *Command* Trustee Council's investment in the restoration effort and make the operation safe. Recovery of the injury to tïtï is most likely to be rapid. Multiple long-term benefits to four island ecosystems and several non-target endemic species are certain additional outcomes. The Rakiura Tïtï Restoration Project promulgates a model for international and cross-cultural collaboration to mitigate the effects of a significant oil spill. Education effort will bring lasting benefits for conservation. The Rakiura Titi Restoration Project will build confidence that enlightened research, management and litigation can combine to heal environmental injury resulting from negligence.

Mitigation of injury to Sooty Shearwaters by the *Command* Oil Spill

Goals and Nexus to Injury

The Rakiura Tītī Restoration Project (RTRP) will directly replace or recover an equivalent to the estimated 15,591 tītī (Sooty Shearwater, *Puffinus griseus*) killed during the 1998 *Command* Spill by eradicating rats from their breeding areas at the Big South Cape Islands group (Taukihepa, Pukeweka, and Rerewhakaupoko Islands) and Mokonui Island off Stewart Island (Rakiura), New Zealand.

The four main objectives of the RTRP are:

1. Eliminate rodents from four tītī breeding islands, thereby eliminating egg and chick predation;
2. Establish quarantine contingencies to prevent reintroduction of rats to restored island colonies;
3. Monitor the restoration progress and project effectiveness;
4. Create educational outreach to inform the people of New Zealand and California about the Sooty Shearwater restoration project, and the cultural and environmental importance of the bird.

Damage to Sooty Shearwater caused by the Command oil spill

The majority of Sooty Shearwaters that occur off California during the austral winter migrate from New Zealand breeding colonies, where they are known as 'tītī' by Māori (New Zealand's Indigenous People). Sooty Shearwater is the most abundant seabird off central California during May to September[1]. They aggregate in large conspicuous flocks to feed on shoaling fishes, squid, and euphausiids that concentrate in productive shelf waters influenced by coastal upwelling[2]. Single flocks can extend for many kilometres and number in the 10 – 100,000s. Their aggregated dispersion along the populated coast and near offshore shipping lanes makes shearwaters particularly vulnerable to oil pollution. Numbers off California have declined

[1] Briggs *et al.* (1987).
[2] Briggs & Chu (1986).

precipitously during the past decade due to a combination of factors, including marine climate change, incidental fisheries take, and pollution[3].

The T/V *Command* oil spill occurred on 26 September 1998, just prior to the migration of Sooty Shearwater back to southern hemisphere nesting colonies. Sooty Shearwaters were the second most frequent species among oiled birds recovered and were by far the most abundant species counted during aerial surveys within the spill area[4]. During spill recovery efforts, survey personnel recovered a dead, oiled Sooty Shearwater at Seaside Beach, Monterey County. This individual had been banded as it entered a nesting burrow the previous year on Whenua Hou Island, New Zealand. This confirms damage directly linked to the New Zealand shearwater population. This notable recovery along with 11 additional shearwaters recovered on beach surveys provides sufficient evidence that the *Command* Spill negatively impacted this trans-Pacific migrating seabird.

No mortality estimates were calculated for the Sooty Shearwater in the *Command* Trustees Bird Injury Report. We used similar methods as were applied to Common Murre by the Trustees to estimate Sooty Shearwater mortality. Our most probable estimates indicate that around 15,591 shearwaters were killed during the *Command* Spill[5]. Sooty Shearwater was therefore probably the most numerically affected species. Loss of production of chicks because of the death of their parents in the spill would mean that 20,265 fewer tītī were in the population by the current (2002/03) breeding season because of the spill[6]. Furthermore, as this event occurred just prior to the pre-breeding migration, adults exposed to a sub-lethal level of spilled oil may have suffered undocumented compromised reproductive output during the 1998/99 nesting season.

Cultural Importance of Sooty Shearwaters

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[3] Veit *et al.* (1996, 1997), Lyver *et al.* (1999), Uhlmann & Moller (2000), Oedekoven *et al.* (2001), Uhlmann (2001).

[4] 11 – 346 birds km^{-2} were reported by Boyce and Hampton (2002).

[5] Our estimate ranged from 1,489 – 29,606 (Appendix A).

[6] This calculation (Appendix A) is incorporates the median scenario for lost production from the 1998/99 to the 2002/03 breeding season and the natural wasting away of the missing adults had they not been killed by the spill. If rat eradication can be achieved in 2004, it will be 2011 before an

The Rakiura Mäori, New Zealand's southern-most indigenous people, considers the tītī (Sooty Shearwater) to be a '*Taonga*', a treasured species. The Ngäi Tahu Settlement Act (1987) established the Rakiura Mäori as *Kaitiaki* (environmental stewards) for this species and returned to them ownership and management rights of tītī breeding islands[7]. The islands are covered in a low coastal forest under which the tītī dig breeding burrows in a thick, peat soil (see Frontispiece). The annual journey to harvest chicks from the Tītī Islands is a defining cultural activity that generates social cohesion and group identity amongst Rakiura Mäori. The Rakiura Mäori abide by strict traditional teaching and bylaws to regulate chick harvest and to protect the revered adult birds and their island breeding habitat. Maintaining the number of tītī is paramount to safeguarding customary practices and Rakiura Mäori culture. The Rakiura Mäori community instigated a long-term research project called *Kia Mau Te Tītī Mo Ake Tönu Atu* ("Keep the Tītī Forever") to ensure that the tītī remain plentiful for the *mokopuna* (grandchildren)[8]. The Rakiura Tītī Islands Administering Body (RTIAB) is the executive group directing this research on behalf of the whole Rakiura Mäori community to assess the potential population level impacts of their chick harvests[9].

In California, Sooty Shearwater is appreciated by thousands of coastal visitors each summer. The large, conspicuous feeding flocks in Monterey Bay and off Santa Cruz, and Halfmoon Bay focus attention on the unique habitat and importance of California coastal waters to seasonally migrating marine wildlife. Each year local Monterey Bay area newspapers cover the dramatic phenomenon of thousands of feeding shearwaters, further increasing public awareness of marine issues. Several local visitor

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increased number of adults triggered by rat eradication will enter the breeding population. By then 23352 fewer tītī would be in the population because of the oil spill.

[7] Moller *et al.* (2000) outlines the ways that the Ngäi Tahu Settlement Act (1987) designates taonga species and the way the Tītī Islands where the sooty shearwaters breed must be managed as nature reserves while still allowing a sustainable harvest of chicks.

[8] You can read about research project goals and design on its website: http://www.otago.ac.nz/Zoology/tītī/default.html. A review of the project's wider context of co-management and multicultural approaches is also given by Taiepa *et al.* (1997) and Moller *et al.* (2000).

[9] First predictions of harvest sustainability are due in 2007 (Moller, in press), but there are preliminary signs that any harvest impacts could not be a sufficient explanation for recent declines. There have been large-scale declines at both harvested and unharvested islands, even where unharvested islands are a long way from harvested ones. This separation makes it less likely that harvesting has triggered some of the decline at unharvested ones by reducing or cutting off sources of immigration. Nor could harvest impacts explain the correlations we have observed with El Nino climate oscillations and tītī adult survival (Lyver & Moller 1999; Lyver *et al.* 1999).

destinations (*i.e.*, Seacliff Beach State Park) in the area feature educational displays involving aspects of the shearwater's occurrence, unusual historical events, and ecology in the Monterey Bay area. The Channel Islands National Marine Sanctuary has acknowledged the importance of shearwaters in the California Current by recently naming their new research vessel the R/V *Shearwater*.

Ecological Importance

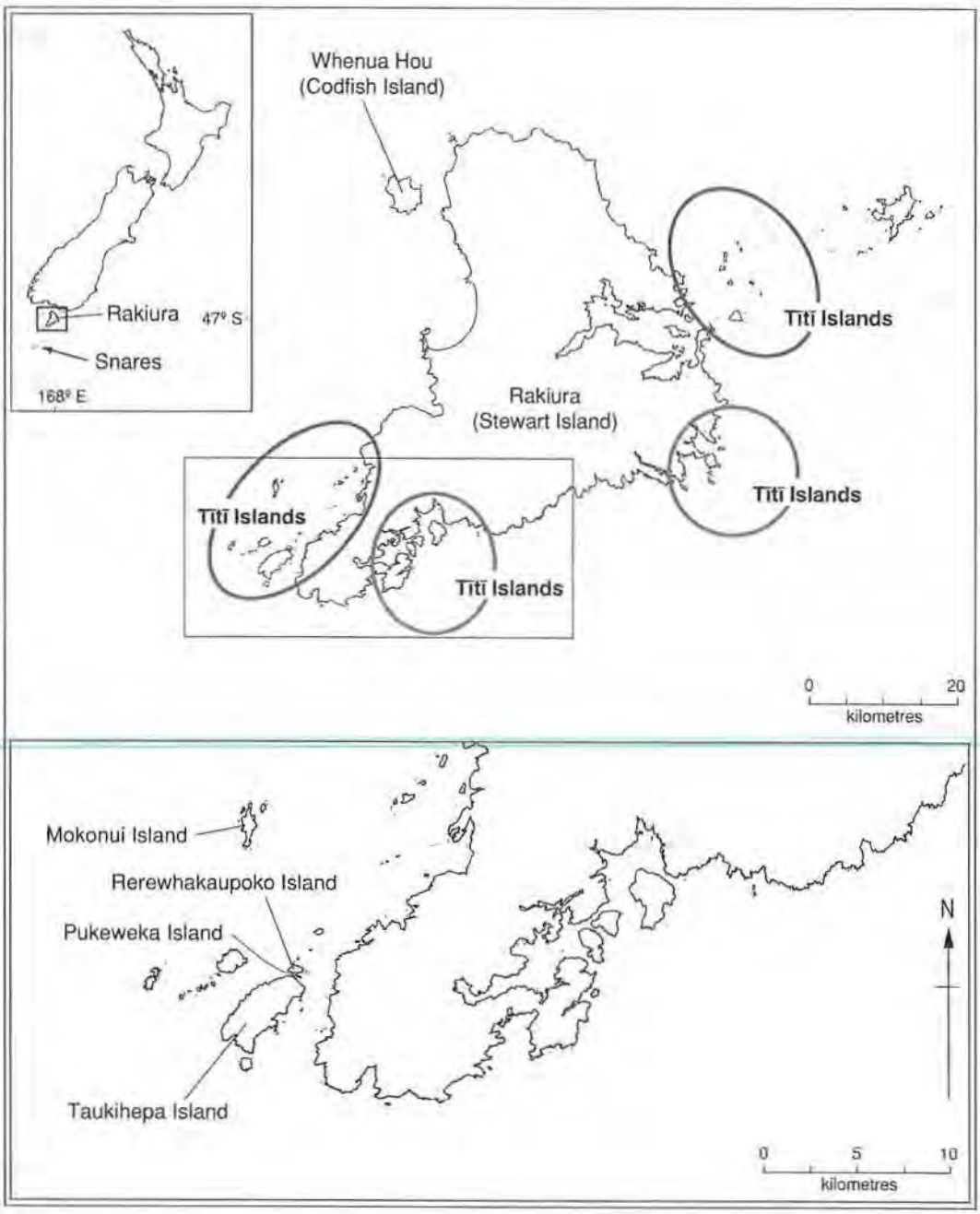
Tītī are a keystone species[10] on 36 islands around Rakiura[11] (Fig. 1), and on The Snares (a globally important sub-Antarctic nature reserve). Nest-site excavation and guano deposition enhance soil formation, aeration, nutrient-cycling, regeneration, and vegetation succession[12]. Any long-term decline in tītī numbers will profoundly affect the ecology of more than 40 nesting islands through cascading bottom-up effects to indigenous plants, invertebrates, lizards, and terrestrial birds. Tītī are therefore the most important species to protect in these island nature reserves.

Impact of Introduced Predators on Shearwaters

The most easily reversed detrimental impact to New Zealand tītī breeding populations is predation by introduced predators. Rats (*Rattus spp.*), stoats (*Mustela erminea*), feral ferrets (*M. furo*) and feral house cats (*Felis catus*) were introduced 125–200 years ago and now kill both tītī adults and chicks at mainland colonies[13]. Kiore[14] (*R. exulans*) were introduced to breeding islands by Mäori several centuries ago and black rat (*R. rattus*) during the 1960s. Whereas Norway rats (*R. norvegicus*) are destructive predators of tītī on mainland colonies, and until recently on Campbell Island, the most widespread rat and the more serious threat to tītī eggs and chicks is

[10] This is a species that has a disproportionate effect on several other species in the ecological community (Paine 1994).
[11] Rakiura is the Mäori name for 'Stewart Island'.
[12] Campbell (1967), Towns *et al.* (1990), Hawke & Newman (2001).
[13] Hamilton & Moller (1995), Hamilton (1998), Lyver (2000), Jones (2000, 2001).
[14] Also known as the Polynesian rat, kimoa or Pacific rat.

Fig. 1. Location of the Tītī Islands, the main breeding colonies of Sooty Shearwaters (*Puffinus griseus*). The banded sooty shearwater killed in the *Command* oil spill was breeding on Whenua Hou (Codfish Island). The four islands nominated for rat eradication are Taukihepa, Pukeweka, Rerewhakaupoko (the 'Big South Cape' group) and Mokonui.


Whenua Hou
(Codfish Island)
Rakiura
47° S
Snares
168° E
Titi Islands
Rakiura
(Stewart Island)
Titi Islands
Titi Islands
Titi Islands
0
20
kilometres
Mokonui Island
Rerewhakaupoko Island
Pukeweka Island
Taukihepa Island
N
0
5
10
kilometres

posed by the black rat and the smaller kiore[15]. Rats probably kill some eggs but their main population impact is caused by predation of young chicks just after the 'guard stage' when both parents must leave the chick unattended in order to forage for themselves and their chick. Direct action to eliminate predation of tītī by introduced rats at breeding colonies will provide the greatest and most certain return to tītī populations and damaged island ecosystems.

Our proposal is in many ways similar to one currently underway in the United States of America, funded by the *American Trader* Trustee Council, where black rats are being eradicated on Anacapa Island, California. The National Park Service and Island Conservation Group along with the American Trader Trustee Council successfully implemented two phases aimed at removing introduced black rats from Anacapa Island through helicopter application of rodenticide (Brodifacoum)[16]. Rats were introduced to Anacapa over 100 years ago, and have affected vegetation, nesting seabirds, and the island ecosystem. The Anacapa Restoration Project is intended to enhance the seabird populations on the island, as a main goal of the American Trader Trustee Council, but also will serve to enhance the overall ecosystem. To fully evaluate the eradication effects, seabird monitoring was established on the island prior to the eradication, and will continue for up to 10 years following the removal of the rats.

Whereas Sooty Shearwater breed on both the New Zealand mainland and island sites, predator control on mainland colonies would bring only temporary relief because ubiquitous introduced predators would re-invade cleared areas every year. Also, predator control on the mainland will only restore small numbers of tītī because the colonies have dwindled to only a few breeding pairs[17]. Eradication of introduced predators on the Tītī Islands is a more efficient strategy, providing a permanent refuge with undisturbed breeding habitat for shearwaters and other native flora and fauna. The large, dense breeding colonies around Rakiura offer the best, most feasible prospects for the *Command* Trustee Council to repair the injury to tītī as quickly as possible.

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[15] Kiore were once considered to be predominantly vegetarian, but more recent diet studies show it to be omnivorous (Atkinson & Moller 1990).

[16] American Trader Trustee Council Annual report 2001, Jan 2002, 4 pp.

Although there have been no formal studies of the impact of rats on tītī abundance, accumulating evidence indicate negative effects of rat predation are occurring. Inferences indicating rat impacts include:

- Declines in seabird abundance and total elimination of some seabird breeding colonies have been well documented in New Zealand and other Pacific islands[18].
- Predation by introduced mammals has been identified as the most serious threat to New Zealand seabirds[19]. Norway rats, black rats, and kiore are listed as main threats, especially to the smaller seabirds. Continued eradication of rats from island breeding colonies is the main recommended conservation strategy. Rats impact Grey Petrel, Black Petrel, Cook's Petrels, Chatham Island Taiko, New Zealand Sooty Tern, and several non-threatened seabird species.
- Norway rats killed virtually every Sooty Shearwater chick on Campbell Island during a 1985/86 study[20].
- Breeding of tītī in 1994/95 and 1995/96 totally failed at the Taiaroa Head Reserve colony where mustelids and feral house cats were virtually eliminated, but rats were abundant[21].
- Rats occur at very high densities on the Big South Cape Islands group considered in this proposal for eradication[22].
- Kiore were recently filmed taking Little Shearwater eggs and significantly affect their productivity[23].
- Kiore impact threatens Pycroft's Petrel productivity[24].
- Chick harvest rate declined sharply from 1970 to 1973 on Taukihepa (the main Big South Cape Island proposed for eradication) 6 to 9 years after the accidental

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[17] Hamilton *et al.* (1997), Jones (2001), Jones (in press).
[18] Atkinson *et al.* (1978), King (1990), Towns *et al.* (1990).
[19] Taylor (2000a & b).
[20] Taylor (1986) found rapid decline in burrow occupancy just after hatching (when non-guarding begins) and abundant sooty shearwater feathers and flesh in rat stomachs. No other predator existed on the island so it is certain that rats were responsible for wiping out over 95% of the annual productivity. Historical records show that sooty shearwaters were much more abundant on the Campbell Island mainland before rats were introduced.
[21] Lyver *et al.* (2000). The rats were not identified, but probably were *R norvegicus*.
[22] See comments by Tītī Harvesters recorded at http://www.otago.ac.nz/Zoology/hui/Main/Talks2/Tane.htm
[23] Pierce (1995), Booth *et al.* (1996).
[24] Pierce (1995).

introduction and irruption of *R. rattus*[25]. The timing of this decline coincides with when the 1964 and 1965 cohorts of eggs and chicks would have re-appeared for breeding if they had not been killed by rats. The tïtï research team is currently seeking additional chick harvest diaries to determine if similar perturbation in harvest rates occurred on Pukeweka and Rerewhakaupoko, compared with nearby rat-free islands[26].

- Rats irrupted at Kaihuka Island in 1990[27]. The species was not formally identified but probably was *R. rattus* as it predominates on the islands off the eastern flank of Rakiura. There was abundant sign of rat digging and scrapes that year (a characteristic feeding sign from rats digging for invertebrates). No formal measurements of impacts were taken, but it was obvious that there were hardly any chicks present that year. In contrast, there was an excellent harvest season on nearby, rat-free Breaksea Island and on other Tïtï Islands. Two muttonbirder '*whänau*' (families) abandoned harvesting on Kaihuka after only one week in 1990. The one family that stayed on caught very few birds. A concerted rat poisoning effort was made later that year and poison baits are now administered regularly, resulting in reduced rat sign. No other chick failure years apart from the '*kiaka*' (naturally occurring starvation years) have been recorded in the 25 years that Peter and Joyce Topi have harvested on Kaihuka.

The Rakiura Tïtï Restoration Project

International RTRP working group

The Rakiura Tïtï Restoration Project (RTRP) preliminary working group includes members of the Rakiura Tïtï Islands Administering Body (RTIAB), Rakiura Tïtï Islands Committee (RTIC), New Zealand Department of Conservation (DoC), the *Kia Mau Te Tïtï Mo Ake Tönu Atu* ("Keep the Tïtï Forever") research team from the University of Otago, the United States-based non-profit research group *Oikonos*, and independent consultants from the United States. Support and ongoing collaboration with California researchers is envisaged to help guide the RTRP.

[25] Harvest rates are described by Moller (2002). Bell (1978) describes the detail of the rat irruption and impacts on several land birds and bats in particular.

[26] Without this replicated evidence we can not conclude for certain that the rats caused the perturbation observed on Taukihepa in 1970-1973.

The RTIAB consists of 10 elected representatives of the Rakiura Mäori community. They consult with the Rakiura Mäori community of over 1000 people in annual '*hui*' (traditional gathering in a Mäori meeting house) and special meetings called to discuss issues such as the proposed rat eradication. In accordance with many indigenous people's societies around the world, decisions are taken by consensus after considerable community debate. The RTIAB is a statutory non-profit making body established under the Ngäi Tahu Settlement Act 1997. The Mäori custom is to conduct business '*konohi ki konohi*' (face-to-face), so members of the RTIAB request to meet the Trustee Council from time to time to speak to their proposal.

Another group within the Rakiura Mäori community that must be involved in the implementation of any rat eradication campaign is the Rakiura Tïtï Islands Committee (RTIC). This represents a group of "beneficial owners" and includes the whänau on Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui. Access to the islands is only possible with the beneficial owners' agreement. While the RTIAB direct the overall research and tïtï restoration initiative of which this rat eradication will become part, the RTIC will be involved in all decision making. There have already been extensive community discussions about rat eradication and the strong consensus is to proceed. More discussion of the details of project will follow if funds are found to enable eradication.

Both Hanna M Nevins and Josh Adams have been involved in public hearings for the *Command* Spill issues and will assist the Trustee Council by sitting on a restoration review committee and by acting as liaisons between New Zealand efforts, the Trustees, and the general public in California. They would meet the RTIAB annually in the early years of the project and will provide the Trustees Council with information regarding the progress of the project by presenting results from the project. We are not aware of any potential problems should funding be allocated to the RTIAB for this project, but a US-based organisation such as *Oikonos* could serve as a recipient and foundation to fund work in New Zealand if the Trustees are not able to, or are unwilling to fund groups outside the USA.

[27] Peter Topi, pers. comm. (25 November 2002). Kaihuka is an islet off the eastern coast of Rakiura.

Collaboration with Dr Richard Veit (CSI/CUNY, Staten Island, NY) and our research team has also been proposed. Dr Veit's survey work in the Californian current neatly complements our research on the tītī breeding islands so we plan to work together, share data and combine analyses. Dr Veit's research is focussed on tītī in the Californian current. Collaboration to understand tītī population dynamics will help interpretation of monitoring results to measure the restoration success after rat eradication. Support of exchange visits between our teams will help to build international collaboration.

Selection of islands for rat eradication

The 'Big South Cape Islands' include Taukihepa (939 ha), Pukeweka (3 ha), and Rerewhakaupoko (30 ha) and are a natural choice for restoration via black rat eradication. Taukihepa is the single largest island where tītī breed. The Big South Cape Island group is sufficiently far from the Rakiura mainland that rats could not re-invade naturally. Currently about 47% of the total area of Sooty Shearwater breeding ground in New Zealand is infested with rats[28]. Eradication of black rat from the Big South Cape Islands will more than halve the total rat infested breeding area and benefit the shearwater population dramatically. In addition to black rat eradication from the Big South Cape Islands, we also propose to eradicate kiore (*R. exulans*) from Mokonui (86 ha), the next largest island in the area with rats remaining. Successful eradication would leave only about 14% of the total New Zealand tītī breeding area with rats.

Rats can swim at least 500 m. Therefore, our eradication campaign must eliminate every last rat from all islands in the vicinity. This means that rat eradication must occur simultaneously on all three of the Big South Cape islands – it would be a waste of money to do just one or two of the proposed islands. The isolated nature of the Mokonui (Fig. 1) precludes potential natural reinvasion. Eradication of kiore from Mokonui could be left undone if there were insufficient funds for the entire project. However, combining the Mokonui with Big South Cape islands operations allows

[28] This calculation assumes that 45% of Taukihepa has '*manu*' (burrowed breeding grounds), ignores the very small mainland colonies, Solanders and Campbell Island colonies, but includes the Snares.

significant cost-sharing and would be much more cost-effective than eradicating rats from each island separately. Efficiency gain results from taking full advantage of the assembled helicopter teams and equipment and trained personnel when at the remote southern islands. We urge the *Command* Trustee Council to allocate sufficient money to complete rodent eradication on all four islands to capture maximum cost efficiency.

Elimination of rodents from Big South Cape islands and Mokonui would leave rodent threats on smaller islands near the Rakiura mainland, some small near-shore islands in Fiordland[29], and dwindling colonies on mainland South Island[30]. Natural reinvasion of these islands following control makes them unsuitable for eradication attempts. Therefore, the *Command* Trustee Council will have taken all practicable and cost-effective steps available to replace the tītī killed in the spill by funding the Big South Cape Islands and Mokonui eradications.

Eradication methods

The RTRP will use "Pestoff"™ rodenticide[31] (20 ppm Brodifacoum). Cereal baits will be dyed green to minimise uptake of baits by birds as per Department of Conservation requirements. The bait has a field life equivalent to approximately 1-inch of rainfall. We plan two drops of baits using helicopters, the first at 8 kg/ha to be carried out on the first suitable forecast (predicting 3 fine nights) after an agreed date. The optimum time for the drop will be around 1st of July when rats are unlikely to be breeding and probably have the least natural foods available as alternatives to bait. The breeding shearwaters will be absent from the islands at this time. The second drop will be at 4 kg/ha[32], which will take place in the next suitable weather window at least 5 days after the first drop. This second drop is to ensure that there are no gaps in the bait coverage and to lengthen the time that rats have access to bait. The first drop will be done in strips with 50 % overlap between passes (*i.e.* 4 kg/ha coming out of the helicopter delivery bucket, sowing the 8 kg/ha on the ground). The second will involve 20% overlap. This strategy gives the proven quality standard required for total eradication.

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[29] Fiordland is the southern western region of South Island, New Zealand.

[30] A full list of the Tītī Islands and their rodent status is given in Moller *et al.* (1999). A copy of this report has been forwarded to the *Command* Spill Trustee Council with this application.

[31] Manufactured by Animal Control Products Ltd., Wanganui, New Zealand.

[32] This can be increased to 8kg/ha if the first drop is washed out due to unpredicted rainfall.

and minimises the amount of toxin introduced to the environment. On each drop, cliff areas will be flown twice to ensure sufficient bait is applied to these areas (*i.e.* 16 kg/ha over steep areas equates roughly to 8 kg/ha planar area).

These methods have been used successfully for other eradication projects in New Zealand including Whenua Hou (1900 ha), Kapiti Island (2200 ha) and Raoul Island (1300 ha). The first two operations were proven successful, and results are pending two more years post-drop before success can be established. If funded, the Big South Cape Islands RTRP will be the largest black rat eradication in New Zealand history.

Monitoring mitigation success and reporting outcomes

Sooty Shearwater population recovery is expected to be slow relative to other birds because shearwaters are long-lived[33], have low annual productivity[34] and do not begin breeding until about 7 years of age[35]. Hence we will need to evaluate restoration success using mathematical models and by measuring breeding success before and after rat eradication. Preliminary mathematical models of tītī population dynamics have already been developed[36], so the simulations of the proposed rat eradication project will be rapid and cost-effective. The RTIAB hopes to continue to monitor population trends to independently validate model predictions. Therefore, we propose a long-term, intermittent monitoring of population trends for the decade following rat eradication.

Population monitoring before and after the application of rodenticide (experimental 'impact') will provide data to evaluate the effectiveness of this project and determine the recovery time for these tītī colonies. We propose 'before' and 'after' monitoring data (burrow occupancy, hatching success, chick survival, and breeding success) during 3-5 years of intensive monitoring on the Big South Cape islands and Mokonui

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[33] The oldest banded tītī recovered so far was at least 37 years old (Newman 2001). Annual survival of breeding adults is 0.872 (S.E. = 0.035) (Scofield *et al.* 2001). In general seabirds are long-lived, slowly reproducing and have delayed maturation so that population turnover and recovery from perturbations is very slow (Croxall 1984, Croxall & Gaston 1988).

[34] Only one egg is laid per year, can not be replaced if lost and about a third of adults skip breeding each year.

[35] Richdale (1963).

[36] Hamilton & Moller (1995), Hunter *et al.* (2000a), Yearsley & Fletcher (2002, in press), Jones (in press).

(impact sites) and islands with and without rats (control sites). The impact to breeding after eradication will be assessed using a before-after control–impact paired design[37] and mathematical modelling using measures of egg and chick losses to rats. A thorough survey of the area of Taukihepa covered in manu (breeding ground) and the proportion of it birded will be needed to improve model predictions. A major report will follow the main rat eradication effort and computer simulation of expected recovery of the spill injury. First reliable indications of the return for investment will be available for the *Command* Trustees in late 2005.

Predicted recovery will then be tested by repeated monitoring of fixed plots on impact and control sites 8 and 9 years after eradication (2012 & 2013), by which time the extra fledglings triggered by the RTRP will have been recruited to the breeding population. This external validation of the computer models will then allow more detailed and reliable long-term projection of restoration success.

The RTIAB seek to establish and develop their own scientific monitoring capacity to allow better future management and conservation for tītī. An important first task will be to establish base-line plots[38] on Taukihepa, and Rerewhakaupoko to measure changes in tītī egg and chick productivity before and after rat eradication. The *Kia Mau Te Tītī Mo Ake Tōnu Atu* research team has already established plots on Pukeweka and some monitoring plots in the southern end of Taukihepa[39], but more will be needed at the northern end of Taukihepa[40] and on Rerewhakaupoko and Mokonui[41]. It is imperative that such plots are established as soon as possible to get 'before' rat eradication measures of chick density. An extensive suite of 'non-

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[37] BACI; Stewart-Oaten *et al.* (1986)

[38] Fixed transects have been established where the number of breeding burrows and their occupancy can be re-measured to monitor population and productivity changes (Moller *et al.* 1999). A miniature camera and infra-red lights mounted on the end of a tube inserted down the burrows is used to assess occupancy and breeding success (Hamilton *et al.* 1998, Lyver *et al.* 1998).

[39] Newman *et al.* (2002 a, c & d); Scott *et al.* (2002 a & d).

[40] The Traditional Environmental Knowledge of the tītī harvesters emphasises how much the tītī ecology varies from one 'manu' (breeding ground) to another (Lyver 2000, 2002), so large numbers of placed in a stratefied random way will be needed for robust statistical estimates.

[41] Owners have complete discretion about whether or not a science team visits their manu. Therefore the research team can not categorically promise that access will be granted. However, growing trust between the tītī harvesters and research team has allowed several recent visits to new islands and there is no reason to suspect that the whānau will not accept the extension of sampling in the way now needed for evaluation of rat eradication. If access is prohibited, we will have to rely entirely on comparisons of breeding success on rat-infested islands that are Crown-owned Nature reserves (eg. Bench Island and some of the Fiordland National Park islands with tītī).

treatment' (control) plots have already been established[42] on other islands where rats are present, and will not be eradicated, and on islands where rats have never been present. Some of the earlier plots will have to be rapidly re-surveyed at about the time of eradication to benchmark measurements to the time of the RTRP's experimental impact. Funds allocated by the *Command* Trustee Council will be used to employ a Rakiura Mäori science team, so that these plots can be re-assessed to better determine the effect of rat eradication on tītī productivity[43]. However, additional new study sites with inspection hatches over nesting chambers[44] will also have to be established on rat-infested islands (impact and control sites) to measure rat predation.

The RTIAB is presently working with the community to formulate a community monitoring plan and to test methods. A subgroup of the RTIAB was appointed in August 2002 to work with the research team to investigate ways of building their own scientific monitoring capacity and the immediate critical step was the funding question. A contribution from the *Command* Trustee Council would be a superb start and be extraordinarily well-timed just now to allow employment of Rakiura Mäori scientists to co-ordinate training and capacity building.

Locking in benefits: a public education campaign

Long-term benefits of rat eradication are critically dependent on establishing effective quarantine measures amongst the Rakiura Mäori tītī harvesters and other visitors to the Big South Cape Islands. If pessimistic scenarios apply for the tītī restoration rate, complete replacement of the injured tītī could take decades[45]. Investment by the *Command* Trustee Council in public education about effective quarantine measures could therefore determine the difference between partial and complete restoration of the injured resource.

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[42] Moller *et al.* (2002 a & b), Newman *et al.* (2002 b & d), Scott *et al.* (2002 b & c).

[43] The University field research team is due to finish its field research in 2005. Thereafter ongoing monitoring will have to be by Rakiura Mäori's own science unit. The University team has agreed to train young Rakiura Mäori scientists as they build their own capacity to take over the work. (Moller *et al.* 2000, Moller 2001).

[44] Described by Hunter *et al.* (2000b).

[45] See Appendix A for the basis of this calculation. At worst, full restoration could be achieved in 2039 if rat eradication is achieved in 2004, but much more rapid repair of the injury is likely.

The RTRP will establish quarantine measures to be maintained by the RTIAB, thus ensuring long-term viability of the eradication. Similar programs have been established on the Pribilof Islands, Alaska by State and Federal agencies in co-operation with the Tribal Government of the Pribilof Islands and the native Tanadgusix Corporation. They work and plan together to protect these important seabird colonies from potential "rat spills"[46]. These well-planned programs provide a model framework for similar effective measures to be imposed by the RTRP.

The harvesters carry considerable quantities of gear and food supplies to the Tītī Islands, so effective management and educational outreach is essential to prevent re-introduction by rodent 'stowaways'. We request funds to mount an intensive public education campaign amongst the birding community to safeguard the investment of the *Command* Trustee Council in rat eradication.

Our public education and rat spill prevention campaign will use:

- A special issue of the harvesters' newsletter, *Tītī Times,* dedicated entirely to rodent (and insect and seed) quarantine precautions
- Regular articles in *Tītī Times* on the need for rodent quarantine
- A natural history documentary will be produced about the project and distributed to birding whānau
- Posters at '*marae*'[47] and at vessel transport facilities emphasising the importance for vigilant quarantine
- Establishment of a web-based and paper-based media that outlines the threat of rats to islands, effective quarantine measures, contingency plans in the event of potential spills, and a list of contact personnel and their specific roll in responding to a potential rat spill
- Provision of rodent poison bait stations and poisons (i.e., rat spill kits) at main departure points on the mainland and main landing sites on the islands
- Employment of part of the science monitoring team to visit the *whānau* before each harvest season to ask them to take added care to ensure strict quarantine measures are established before travel to the islands. Similar briefings also will be developed for scientific and monitoring personnel.

[46] See website: http://www.akrrt.org/AIPlan/WPG_Pribs_April2002.pdf

Tītī Times is an ideal platform to heighten the harvesters' awareness of the need for quarantine effort. It is a biennial newsletter sent free of charge to about 500 harvesting families and another 400 policy makers, researchers, and stakeholders. A copy of the latest issue (No 11, Novemeber 2002) is reproduced at Appendix B of this proposal. A complete set of the newsletters has been sent to the Trustee Council for reference. The kaitiaki and research team have spent a considerable time and energy in building up a mailing list and servicing the production of this newsletter. We know it to be well-read and eagerly awaited by most of the harvesting community. The normal series of *Tītī Times* is funded by a New Zealand government 'Public Good Science Fund' research grant to Rakiura Mäori. Such funding can probably be maintained until 2006. Our request to the *Command* Trustee Council is to immediately fund an additional special issue entirely on the quarantine issues and then to take over part of the production costs[48] of the remaining *Tītī Times*.

Personal outreach to harvesters is an essential component to best ensure strict quarantine procedures are followed. Extension of the science monitoring staff responsibilities to include educational visits to families and communities before they depart to the islands is therefore needed.

International Education and Outreach

Education about the *Command* oil spill and the restoration of tītī breeding colonies from rat eradication will help the public understand the vulnerability of shared natural resources in United States waters and abroad. The RTRP will develop natural history television, radio programs, and educational materials that describe seabirds and island ecosystems, their vulnerability to disturbance and restoration activities.

The inadvertent introduction of rats to the Big South Cape Islands in 1964 and resulting faunal extinctions were recognised as a national and international tragedy that underscored the devastating effects of rats on New Zealand's ecological

[47] Marae are traditional Mäori community meeting houses and community centres for learning.

communities. A large flightless beetle, three endemic land birds, and the world's most unusual bat (the Greater short-tailed bat, *Mystacina robusta*)[49] went extinct. Analogous to the infamous 1969 Santa Barbara Oil Spill in California, this single catastrophe galvanised conservation concern and action like no other event in New Zealand history. Both ecological disasters have increased public awareness about ecosystem damage and resulted in new environmental policies.

The RTRP will receive great public support in New Zealand, extensive media coverage, and further promote nation-wide environmental awareness. In addition, a documentary film will greatly assist in building motivation for increased quarantine precautions in New Zealand and USA alike. The kaitiaki and *Kia Mau Te Tītī Mo Ake Tōmu Atu* research team will facilitate community discussion and decision-making about the preparation of a professional documentary. The entire story (spill and climate change impacts, legal action, reparations, rat eradication, and ecological restoration) will assist public education about environmental threats and their management. Our preliminary budget request to the *Command* Trustees includes provision of USA$10,000 to make a documentary film using students of the postgraduate Diploma in Natural History Filmaking & Communication (Pg Dipl. NHFM&C) at the University of Otago[50]. An alternative would be to contract a private filmmaking team[51] to make a full-length natural history film for international distribution[52].

A parallel public outreach campaign in California via educational materials distributed to State Park visitor centres, local TV and radio stations, and an interactive, informational website, will help educate people in California that

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[48] A fifth of the production and circulation costs would need to be levied to allow the rodent quarantine issues to be kept in the minds of the readers.

[49] Bell (1978), Ramsay (1978).

[50] See http://www.otago.ac.nz/Zoology/naturalhistory/index.html for a description of this course. Negotiations are underway at the moment for films produced by the Pg Dipl. NHFM&C classes to be distributed by National Geographic.

[51] Peter and Judy Morrin have already gathered film of the Campbell Island rat eradication and are potentially keen to combine it with new material from this project. A rough 'educational cut' for internal use about the Campbell Island rat eradication has been forwarded to the *Command* Trustee Council along with this proposal. If funds allow, Peter and Judy Morrin would be keen to prepare a parallel or combined film on the two restoration projects.

[52] Budget allocation for the film will have to be adjusted once detailed negotiations are possible, but the USA$10,000 will definitely secure a Pg Dipl. NHFM&C production (it will meet helicopter and equipment costs).

shearwaters are an important cultural, environmental, and economic (e.g. ecotourism, bird-watching) resource throughout the Pacific. This joint US-NZ effort will also serve as a model for future international restoration efforts for migratory species that are affected by oil pollution.

The RTRP will develop a grade k-12 Seabird Ecology- Marine Science Curriculum educational package designed to meet California Educational Standards for Science. Products will include a seabird slide show presentation on CD-ROM to be made available via an interactive website, and quantitative lab exercise worksheets based upon the RTRP[53]. These materials will be designed for use in both US and New Zealand schools. Such a program would further increase cross-cultural understanding of a shared resource.

Suitability of this proposal for meeting *Command* Trustee Council's Selection Criteria

Nexus to Injured Resources

The Trustee Scoping Document and Bird Injury Report[54] did not provide an estimate of the total number of tītī killed. We have therefore improvised by using the methods for estimating injury to Common Murre as outlined in the Bird Injury Report[55]. We conservatively estimate that 15,591 (range = 1,489 – 29,606) shearwaters were killed (Table 1; see Appendix A for the details of the calculations). We then used a simple computer simulation to estimate the size of the injury in successive years after the spill, allowing for natural wastage that would have occurred had the killed tītī survived and allowing for lost production of the chicks they would otherwise have fledged. By the time of the proposed rat eradication (2004), the most likely injury level will have escalated to 20,820 because of this lost production from killed tītī (Table 1; Fig. 2).

[53] Ms Nevins has already successfully put together an education package for local high schools (9-12 grades), based on her thesis data and marine mammal studies in Monterey Bay.
[54] Boyce and Hampton (2002)
[55] Ford (2002).

'Pessimistic', 'median' and 'optimistic' rates of replacement of the tītī by rat eradication were then simulated. Optimistic scenarios used plausible maximum estimates of (i) tītī productivity, (ii) survival rate, (iii) chick density (iv) area of breeding ground on Taukihepa, (v) proportion of chicks remaining unharvested and (vi) current egg/chick predation rates (i.e. losses if no eradication is attempted). Pessimistic simulations used plausible minimum estimates for these parameters.

Pessimistic and optimistic scenarios provide extreme outer bounds for rate of recovery because they string several extreme parameter estimates together. The real-life parameters will be a mix of high and low estimates. Accordingly the median scenario is by far the most likely outcome. Nevertheless we can not categorically exclude the possibility that the outer upper and lower bounds apply until more field research is completed. We have also made several simplifying assumptions (Appendix A), so our projection models must only be used for approximate, order-of-magnitude predictions.

The wide range between 'pessimistic', 'median' and 'optimistic' scenarios (Fig. 2) reflect uncertainty in the population parameters, but the main determinant of the outcome is how many eggs and chicks are currently killed by rats (predation rate).

The worst-case scenario (pessimistic recovery model and pessimistic injury level) predicts that 14% of the tītī lost from the oil spill will be replaced already within the first breeding season (2004/05) after eradication (Table 1). There will be complete replacement of the median injury level by 2013 even if pessimistic recovery rates apply (Fig. 2). If the pessimistic rate of recovery applies, complete replacement of the pessimistic injury level will not occur till 2039, 42 years after the spill.

The best-case scenario (optimistic recovery model and optimistic injury level) predicts that 362 times more extra tītī will be generated by the rat eradication than died in the spill already one year after rat eradication (Table 1).

The most plausible (median) scenario also predicts that sufficient extra chicks will be fledged within a single year after eradication to replace all of the birds killed by the *Command* oil spill, no matter which scenario is used to estimate the size of the injury

(Fig. 2). The indications are therefore very encouraging for the *Command* Trustee Council. It is most likely that their investment in rat eradication can immediately replace all the lost tītī and then go on to restore the injury many times over provided that the islands remain rat-free for decades to come.

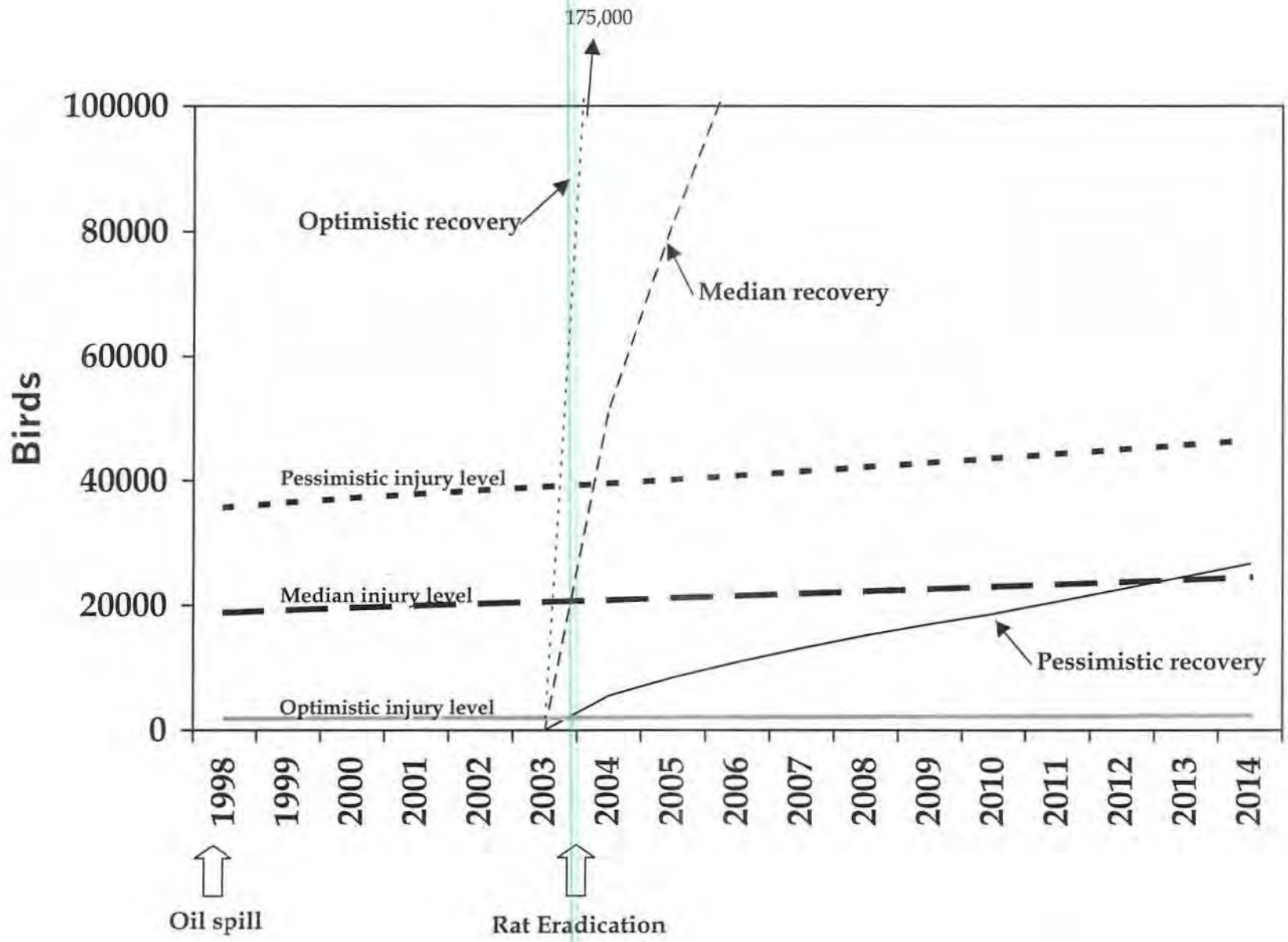
Feasibility

The rodent eradication project methods we propose have been proven to be effective against rats on islands throughout the world. Our proposed sampling to monitor mitigation effects have been developed and tested during the past 8 years by the *Kia Mau Te Tītī Mo Ake Tōnu Atu* research team. Furthermore, the infrastructure to conduct our public education campaign is already in place.

Table 1. Number of tītī killed and subsequently missing because of the *Command* oil spill and the number recovered by rat eradication from Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui. Basis for the calculations is given in Appendix A.

	Pessimistic	**Median**	**Optimistic**
Injury from oil spill (1998)	29,606	15,591	1,489
Projected number of tītī missing from population at time of rat eradication (2004)	34,931	20,820	2,417
% predation by rats	1%	5%	10%
Extra fledglings each year for first 6 years after rat eradication	5497	51,858	175,335
% Replacement of injured birds after 1st breeding season following rat eradication	14%	249%	8818%
% Replacement of injured birds after 10th breeding season following rat eradication	56%	924%	36197%

Fig. 2. Number of tītī lost because of the *Command* oil spill and the expected number of replacements generated by eradicating rats from Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui according to optimistic, median and pessimistic assumptions. The median scenarios (long dashes) are by far the more likely outcomes. See Appendix A for basis of simulations.


175,000
100000
80000
60000
40000
20000
0
Birds
Optimistic recovery
Median recovery
Pessimistic injury level
Median injury level
Pessimistic recovery
Optimistic injury level
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Oil spill
Rat Eradication

Legality

Proposed actions are all fully legal provided the statutory processes for Environmental Impact Assessment and resource consents are followed (see *Public Health & Safety* and *Likelihood of Adverse Impacts* below). The New Zealand Department of Conservation and RTIAB *kaitiaki* guiding the overall project will handle all statutory requirements.

Aerial broadcast of rodenticide requires resource consent from the Southland Regional Council. The working group will apply for consent[56]. Similar to the United States legal process, consent requires an Environmental Impact Assessment. The project will be publicly announced and any individual or group interested has the opportunity to submit formal comment on the proposed eradication. The council will consider all objections before aerial dispersal of rodenticide. There is then the opportunity for either party to appeal the decision to the New Zealand Environment Court. The *Kia Mau Te Tītī Mo Ake Tōnu Atu* research team on behalf of the RTRP will make submissions to this process to facilitate permitting[57].

Likelihood of success

World-wide, in the course of more than 100 island rodent eradication attempts, there have been no cases of failure where proven methods were applied with appropriate care and planning[58]. There can never be an absolute guarantee of success, but the experience of the New Zealand team is second to none in the world. The same team that would direct the eradication project described here has just completed the largest and most hazardous rodent eradication program yet attempted – to rid the sub Antarctic Campbell Island of Norway rats. Campbell Island is more than ten times

[56] This group will at least include the Rakiura Tītī Islands Administering Body, the Rakiura Tītī Islands Committee, the New Zealand Department of Conservation and the *Kia Mau Te Tītī Mo Ake Tōnu Atu* research team. The *Command* Spill Trustees Council could be formally associated with the application and process if it so chooses, or it could leave all responsibility with the local groups.

[57] There is little chance that the eradication attempt would be prevented, but rising (and at times irrational) public concerns about any use of aerial application of poisons make it paramount that a thorough and professional risk assessment is completed. Once the likelihood of net conservation benefit is understood, most New Zealanders support poison applications. A vigorous education campaign must accompany all proposals.

[58] C.R. Veitch (in litt. 26 November 2002).

the size of the combined islands targeted in this proposal[59] and much more remote. Proof of eradication success at Campbell Island will not be available for 2 more years, but preliminary signs are encouraging[60].

Even in the extremely unlikely event that complete eradication of rats fails, the density of rats will be suppressed to near zero for at least 3 years[61]. Median and optimistic scenarios suggest that even this initial knockdown will be sufficient to completely repair the oil spill injury. The *Command* Trustee Council can therefore be reasonably confident that the oil spill injury will be mitigated irrespective of whether the ultimate goal of complete eradication is achieved or not.

Cost Effectiveness

The current US$ to $NZ exchange rate will make this a highly cost effective project. The experience of the Department of Conservation management teams and associated helicopter pilots in similar island rodent eradication campaigns allows maximum efficiency. GPS guidance systems are used to ensure even coverage of bait application to minimise waste and toxin discharge while ensuring that no gaps are left that could harbour surviving rats. From the *Command* Trustees Council's point of view, the investment is extremely cost effective because they need not pay for the main time and experience of the Department of Conservation management team guiding the eradication[62]. A letter of support for the Tītī Island Restoration Project and promise of technical support is at Appendix D. All statutory requirements will be handled by DoC and a voluntary group of kaitiaki guiding the overall project including the *Kia Mau Te Tītī Mo Ake Tōnu Atu* research team. Furthermore, the cost of monitoring the outcomes for the tītī from the Trustee Council's investment is a fraction of what would have been required had this initiative not been attached to an existing research project by the University of Otago team with established protocols for monitoring tītī on other islands. Equipment and trained personnel are available to

[59] Campbell Island is 11,200 ha, whereas the four Tītī Islands considered here for rat eradication have a combined area of 1058 ha.
[60] P. McClelland pers. comm.
[61] The Department of Conservation waits 2 - 3 years after an eradication attempt to test for success, because it would take at least that long for any few survivors to multiply sufficiently to become detectable again. In the case of the Big South Cape islands, more than 3 years may be needed for reinstatement of any population because the islands are very large.

monitor outcomes and report them. Comparative data from non-treatment areas (where rats have not been eradicated) can be contributed without accruing much extra expense, although some rapid re-surveying of marked plots is forced by the need to monitor restoration from rat eradication.

Multiple Resources Benefits

The RTRP will benefit multiple island ecosystems including the terrestrial faunal community, as well as restoring the oil spill injury to tītī. Introduced rats have probably altered regeneration patterns, so restoration of plant processes can also be expected[63]. Re-introduction of several threatened native species (e.g. saddleback) or ones similar to those driven extinct by the rat irruption would follow proof that eradication has been successful. Replacement by analogue species (e.g. the Snares snipe) and several lizards and invertebrates will be considered once rat eradication is achieved. A general increase in invertebrate, lizard, bird and bat populations is expected after initial reductions immediately following poisoning[64]. There will be immense satisfaction and large environmental gains from through effective island restoration.

Duration of Benefits

The RTRP will effectively replace the equivalent to the injured Sooty Shearwater and ensure that the risk from predation by rats will be removed indefinitely from four important island breeding colonies. The supreme advantage of going for rodent eradication as a mechanism to replace adult tītī killed by the *Command* spill is that the benefits will be ongoing. If the eradication is coupled with intense community education regarding stringent quarantine precautions, there is every reason to hope that the benefit will be indefinite. Hundreds and thousands times more tītī will be generated as a result of the investment in restoration through rat eradication, than ever were killed by the *Command* oil spill.

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[62] See Appendix C for details of how costs have been calculated.

[63] Such effects will have come directly from seed predation but also indirectly from altering tītī abundance (tītī burrow and destroy seedlings).

Public Health and Safety

The rat eradication operation will require a full health and safety plan, as required by the NZ Department of Conservation's policy. The safety plan will cover the handling of bait, work around helicopters, boat travel, etc. An example of earlier plans can be supplied to the *Command* Trustees if required.

New Zealand has now successfully promulgated scores of such aerial poisoning campaigns to eradicate rodents from islands[65]. There have never been any problems or serious public concerns once the proper professional wildlife management standards are in place.

The islands targeted in this proposal are remote and uninhabited at the time of the year proposed for the work. Just prior to the operation, the tītī harvesters will disconnect spouting that collects water off house roofs for storage in tanks for muttonbirders' use in March-May. The spouting will be reconnected before the next birding season after the aerial operation is completed.

As further safeguard, because the New Zealand Department of Conservation will be involved in the use of toxins, it is required by it's own policy to obtain additional internal consents. It is required to notify the local 'Medical Officer of Health' who will consider, advise of and manage any human health issues.

Likelihood of Adverse Impacts

Biodiversity risks mainly concern potential poisoning of non-target native species[66]. Brodifacoum is long-lasting in the environment so extreme care is needed to minimise loading and deliver it in a way that minimises risks to non-targets[67]. All species present on the Tītī Islands proposed for rat eradication have been present during previous poisoning operations elsewhere in New Zealand and most of them have been

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[64] Towns *et al.* (1990), Towns (1991), Veitch (1994), Towns (1996), Empson & Miskelly (1999), Taylor (2000a), Veitch & Clout (2002).

[65] Veitch & Bell (1990) and Veitch & Clout (2002) provide reviews of rodent eradication campaigns from New Zealand and around the world.

[66] Colvin *et al.* (1991), Department of Conservation (1996), McClelland (1999).

[67] Godfrey (1985), Eason (1992), Eason & Spurr (1995), WHO (1995).

monitored during at least one such operation. Monitoring has shown that while there may be some individual losses at the time of poisoning, no species is at risk at a population level[68]. The monitoring has also shown that the populations rapidly recover from any losses and will generally reach numbers far in excess of levels when rats were there.

The loss of some individual birds in the short term has already been discussed with the Rakiura tītī birders and they are happy that the benefits of increased numbers of current native species present. Successful rat eradication will enable reintroduction of several species that were wiped out by the rats when they first got to Taukihepa, Pukeweka and Rerewhakaupoko.

Opportunities for Collaboration

The restoration initiative proposed here is important in the wider sense of fostering multicultural community-led environmental management[69]. If the *Command* Trustee Council can make the funds available for the rat eradication, it will allow the biggest and ecologically and culturally most important co-management collaboration yet promulgated between the New Zealand Department of Conservation and an '*iwi*' (Mäori tribal group)[70].

Funding from the *Command* Trustees Council for the actual rat eradication work would be ideal because the Department of Conservation is restricted in the funds it can give to the operation. It has a statutory obligation to advise the kaitiaki and assist their management. Thus the Department can offer their expertise to the *Command* Trustees Council to ensure that their investment is safe and realises its aims, but they can not fund the actual operation.

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[68] Towns (1991), Robertson *et al.* (1993), Cole & Singleton (1996), Ogilvie (1997), Empson & Miskelly (1999).

[69] This can be appreciated by visiting the website for the proceedings of a conference organised by the kaitiaki and the tītī research team (Howard & Moller 2001). Proceedings are recorded at http://www.otago.ac.nz/Zoology/hui/Main/default.htm)

[70] The Southland Conservancy of the Department of Conservation have facilitated co-management of the Tītī Islands (see http://www.otago.ac.nz/Zoology/hui/Main/Talks2/Tane.htm) and provide administrative support for the RTIAB. The previous two rodent eradications co-managed by the two groups were much smaller than the ambitious project proposed here.

Members of the *Command* Trustees Council would be welcome to observe the main rodent eradication operation and associated field trips to monitor outcomes if they wanted.

Requested Budget

We present an approximate budget for the proposed RTRP rat eradication, outlined in Table 2 below. A detailed breakdown of the cost of the eradication is given in Appendix C.

In total we request USA$538,000 from the *Command* Spill trust funds allocated during the next 11 years, with the bulk of the expenditure in 2004 when the rat eradication operation is most likely to occur and when intensive monitoring is needed to measure rat predation and restoration efficacy. There is a resurgence of expenditure on monitoring in the last two years as surveyed plots are re-measured to check the predictions of restoration rate generated by mathematical models. Educational outreach is also concentrated in the year of rat eradication and just after. Throughout there is moderate expenditure on establishing quarantine awareness, training and precautions. Persistence will be needed to build commitment to quarantine amongst some birders.

Altogether 44%, 37%, 13% and 6% of the *Command* Trustee grant would be spent on eradication, monitoring and prediction of restoration, quarantine and educational outreach respectively (Table 2).

The figures are extremely provisional and based on an exchange rate of 1 NZ Dollar = 0.517 US$. This exchange rate has been fluctuating markedly in recent months.

The overall project is very cost effective for the *Command* Trustee Council because of several contributions from other partners in the project as detailed in Table 3. Principal amongst these is an estimated $101,000 contribution by the Department of Conservation team in servicing the actual eradication, and an initial 3 years of research of non-impact sites and measurements of population parameters by the

University of Otago ($150,000 over the 3 years). Altogether help-in-kind from other partners will be valued approximately $286,000. The grand total for the entire project is therefore $824,000. We request that the *Command* Spill trust fund contributes 65% of the overall project expenditure.

Table 2. Provisional budget requested of the *Command* oil spill funds for the Rakiura Tītī Restoration Project. Figures are in USA$.

Year	Objective 1 Eradication	Objective 2 Quarantine	Objective 3 Monitoring	Objective 4 Educational Outreach	Total for Year
2003	$25,700	$5,880	$31,000	$2,700	**$65,280**
2004	$193,000	$12,200	$36,200	$12,700	**$254,100**
2005	$13,000	$5,880	$31,200	$7,700	**$57,780**
2006	$5,000	$5,880	$38,500	$0	**$49,380**
2007	$0	$5,880	$0	$0	**$5,880**
2008	$0	$5,880	$0	$0	**$5,880**
2009	$0	$5,880	$0	$0	**$5,880**
2010	$0	$5,880	$0	$0	**$5,880**
2011	$0	$5,880	$0	$0	**$5,880**
2012	$0	$5,880	$24,400	$0	**$30,280**
2013	$0	$5,880	$38,200	$7,700	**$51,780**
All years	$236,700	$71,000	$199,500	$30,800	**$538,000**
% each objective	44%	13%	37%	6%	

Table 3. Value of support provided by other partners to the Rakiura Tītī Restoration Project. Figures are in USA$.

Year	Objective 1 Eradication	Objective 2 Quarantine	Objective 3 Monitoring	Objective 4 Educational Outreach	Total for Year
2003	8500	1000	50500	$0	**$60,000**
2004	102000	1000	50500	$0	**$153,500**
2005	1000	1000	50500	$0	**$52,500**
2006	1000	1000	500	$0	**$2,500**
2007	1000	1000	500	$0	**$2,500**
2008	1000	1000	500	$0	**$2,500**
2009	1000	1000	500	$0	**$2,500**
2010	1000	1000	500	$0	**$2,500**
2011	1000	1000	500	$0	**$2,500**
2012	1000	1000	500	$0	**$2,500**
2013	1000	1000	500	$0	**$2,500**
All years	119500	11000	155500	$0	**$286,000**
% each objective	42%	4%	54%	0%	

Conclusion

Even including the value of inputs from other partners, the Rakiura Tītī Restoration Project will only expend just over half of the cost of the Anacapa Island eradication project. This is extremely cost-effective especially if one considers that the Rakiura project will eradicate rats from an area 3 times larger than cleared of rats at Anacapa. If the value of contributions from other partners is not considered, the *Command* spill trust funds would contribute about a third of the expenditure invested on Anacapa.

All methods for eradication, managing risks and monitoring outcomes are in proven and refined. Experienced and expert teams will secure the investment in the restoration effort. Computer simulations suggest recovery of the injury to tītī is most likely to be rapid. Multiple long-term benefits to four island ecosystems and several non-target endemic species are certain outcomes. A model for international and cross-cultural collaboration to mitigate the effects of a significant oil spill will be promulgated. Education for heightened environmental awareness will bring lasting benefits for conservation. The Rakiura Tītī Restoration Project will build confidence that enlightened research, management and legislation can combine to heal environmental injury resulting from negligence.

We urge the *Command* Spill Trustee Council to fund the Rakiura Tītī Restoration Project.

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Appendix A: Calculation of number of tītī killed in the *Command* oil spill and projected rate of replacement.

Pessimistic, median and optimistic scenarios

Our aim in these calculations is to determine the range of number of tītī killed by the *Command* Oil spill and the outer limits in projected rate of replacement of these birds after rat eradication. The outer limits will be extremely wide because in one scenario we have loaded all the pessimistic values of every step in the calculation, and vice versa for the optimistic scenario (Tables A1 and A2). Extreme low or high estimates are most unlikely to occur for all steps in the calculation (a mixture of high and low estimates would be much more probable). The 'median' projection simply uses means or the mid-points between the two extremes. The median is therefore more likely to capture the true rate of replacement of killed tītī than the extremes, but we can not categorically rule out that the pessimistic or optimistic scenario could occur.

Estimated Number of tītī killed in the oil spill

Our approach to estimating sooty shearwater mortality uses similar methods to those in the bird injury report for Marbled Murrelet, by comparing the ratio of the number killed to number at risk for the Common Murre to the shearwater, solving for the number killed. The number at risk was determined with at-sea densities observed during aerial surveys at time of spill by the California Dept. of Fish and Game. Aerial surveys estimated densities between 11 and 346 Sooty Shearwater per km^2. The variability in the at-sea density was used to derive the high and low range of estimated killed.

Dead oiled tītī were the second most numerous species recovered in beach surveys (12 of 171 collected, plus 1 unknown shearwater spp.). We provide an estimate of total mortality for this species based on the premises detailed in their document for the estimated mortality of Common Murre and Marbled Murrelet.

Assumptions:

1. Sooty Shearwaters (SOSH) and Common Murre (COMU) have the same probability of becoming oiled and the same amount of oil kills both species.

This is probably valid, since these two species are of similar body size, habits (roost on water, dive to obtain prey) and at-sea distribution (shelf and near-shore waters).

2. SOSH have greater propensity to move out of area after becoming oiled.

This is well support by the fact that a New Zealand banded oiled SOSH was collected at Seaside (Monterey County), 50 km south of the main affected area off the San Mateo Co. coast. Also, SOSH are highly mobile and have flight throughout their time in California (May – Oct), whereas COMU are moulting during the fall and are flightless. Shearwaters are more mobile, and were beginning migration back across Pacific to New Zealand during the time of the spill (Sept, Oct). COMU tend to come to shore when oiled, whereas SOSH may be more likely to stay at sea and sink.

3. Estimate of total mortality to the number at risk of COMU is valid comparative measure for SOSH.

This ratio was used to estimate the total mortality of Marbled Murrelets (although no MAMU were collected dead) resulting from this spill by the Trustee Council and should be valid for the SOSH as well.

Calculation:

The number of SOSH killed relative to the number at risk is proportional to the number COMU killed relative to the number of COMU at-risk.

$$\frac{M_{cm}}{R_{cm}} = \frac{M_{sh}}{R_{sh}}$$

(..... Equation 1).

Where,

M_{cm} = Estimated mortality of COMU (1,490 from Ford 2002)

R_{cm} = Number of COMU at risk (11,193 from Ford 2002)

M_{sh} = Estimated mortality of SOSH

R_{sh} = Number of SOSH at risk (See Below)

Number at-risk (R_{sh}) = Total Area Affected * Average Density (SOSH/km^2)

Total Area Affected was not explicitly detailed in Boyce and Hampton report. Therefore we obtained the area from image analysis of Map 1, Boyce and Hampton (2002). Total Area = (Area A) 560 km^2 + (Area B) 60 km^2 + (Area C) 38 km^2 = 658 km^2

Average Density was calculated with data from aerial surveys provided in Table 2 of Boyce and Hampton (2002).
Ave. Density (SOSH/km^2) = {346.25(Sept. 29); 280.27 (Sep. 30); 73.00 (Oct. 1); 11.72 (Oct 2)} = 177.81, SD =160.6

We used plus/minus one standard deviation (SD) to generate low and high ranges of mortality estimate. (e.g. low is 177.81 + 160.6 = 338 SOSH/ km^2; high is 177.81 – 160.6 = 17 SOSH/ km^2).

Therefore, the number at-risk (R_{SH}) = 658 km^2 * 177.81 SOSH/ km^2 = 117,124 SOSH (Low/High Range: 11,186 – 222,404 SOSH[71]).

Following this, we solved for Total Mortality (M_{SH}) in equation 1, with low and high estimates, giving:1,490/ 11,193 = M_{SH} / 117,124, = 15,591 Shearwaters killed (Low/High estimates: 1,489 – 29,606)

[71] This is same order of magnitude of densities observed during boat surveys conducted during the spill, including a flocks of 6,000+ at Pillar Pt. 29 Sep 98 (Area B: 6,000/60 = 100 birds/km), and "several hundred" near Pescadero 2 Oct 98 (Area C: 500/38 = 13 birds/km).

Conclusion: Number of tītī killed.

Most probable estimates are for 15,591 (range 1,489 to 29,606) tītī having been killed. We believe this is probably within the order of magnitude of the numbers directly affected by the *Command* spill. Many more birds could have potentially been affected by sub-lethal ingestion, thus having affects on reproduction and survival; these effects were not measured.

Calculation lost production because of the Command spill

A 'Leslie Matrix' model has been generated on an Excel™ spreadsheet to calculate the number of tītī lost from the population in successive years after the spill. The simulation used estimates of annual survival for chicks, juveniles and prebreeders and proportion of adults skipping breeding as for the 'Average breeder' model[72] for short-tailed shearwater, a sibling species with very similar demography, ecology and behaviour. Determination of the age at first reproduction of tītī is not yet complete, but a few of our banded birds have begun at 4 years and more at 5. We expect the mean age at first reproduction to be slightly more[73] than the 6-7 years seen for short-tailed shearwater in Australia[74]. Accordingly our simulation has assumed that all tītī first breed at age 7.

We assumed that all ages of tītī were equally likely to have been killed in the oil spill. Initial stable age structure was therefore first estimated by a vertical life-table calculation using the parameters in Table 1 of Hunter *et al.* (2000).

The number of missing tītī was then determined by projecting the Leslie Matrix forward from 1998 (the year of the spill) for 50 years, starting with our pessimistic, median and optimistic estimates of the number killed (29606, 15591 and 1489 respectively).

---

[72] See Table 2 in Hunter *et al.* (2000).

[73] Sooty shearwaters are slightly bigger than short-tailed shearwaters and the bigger the bird, the longer reproduction is delayed (Croxall 1984, Croxall & Gaston 1988).

[74] Serventy & Curry (1984).

The number of tītī predicted to be missing from the population because of the spill changes linearly for the first 6 years because of expected natural wastage of the juveniles and adults and the lost production of chicks from killed breeders. By year 7 after the spill (2005), the number of missing tītī compounds because of the absence of prebreeders reaching breeding age.

By the earliest feasible time of the rat eradication (2004) initial injury levels are projected to have become 2417, 20820, 34931 for optimistic, median and pessimistic scenarios respectively because of lost production of the killed cohort.

Calculation of rate of replacement of tītī following rat eradication

There are no extensive surveys of the area of Taukihepa covered by 'manu' (breeding ground), but the *Kia Mau Te Tītī Mo Ake Tōnu Atu* research team's visits to part of the island suggest between 35% (pessimistic) and 55% (optimistic) of the island has breeding colonies. Our calculations of the area of manu protected by rat eradication (Table A1) assume that all of Pukeweka, Rerewhakaupoko and Mokonui are covered in manu (breeding ground).

We estimated the number of chicks per m^2 of manu based on transect counts of entrance holes and burrow occupancy estimated by burrowscoping just before chicks fledged at Pukeweka and on the southern end of Taukihepa in the 1998/99 – 2001/02 seasons[75]. Burrowscoping probably underestimate occupancy[76] so our calculation of restoration rate is conservative. Our pessimistic scenario uses the lower 95% confidence interval for chicks per m^2, and the optimistic scenario uses the upper 95% confidence interval. We have assumed that the density of chicks on the northern end of Taukihepa, Rerewhakaupoko and Mokonui is about the same as on our transects elsewhere.

[75] Newman *et al.* (2002a, c, e); Scott *et al.* (2002 a, d).
[76] Hamilton *et al.* (1997, 1998).

Table A1. Calculation of the number of extra tītī fledglings produced annually immediately following eradication of rats from the four islands.

	Pessimistic Scenario	Median scenario	Optimistic scenario
Assumed % of Taukihepa covered by manu	35%	45%	55%
Area of manu from which rats will be eradicated (Ha)	455.1	548.0	640.9
Chick production per m^2	0.149	0.212	0.274
Current total chick production from manu from which rats will be eradicated	680,292	1,159,182	1,753,351
Proportion harvested	0.20	0.15	0.10
% predation by rats	1%	5%	10%
Extra fledglings each year for first 6 years after rat eradication	5497	51,858	175,335

We do not have exact data for harvest off-take rates for these islands, because we do not have accurate information on the proportion of breeding ground remaining unharvested. We have set 10 – 20% harvest rates as probable overestimates (Table A1) so that the calculations can be interpreted as being overly cautious about the expected rate of repair of the injury from the oil spill.

Calculation of the rate of replacement of tītī killed by the *Command* Oil spill is dependent on knowing what proportion of the eggs and early stage chicks are currently killed by rats. While we know that some losses do occur to rats, there has been no systematic study of predation rates of tītī by black rats or kiore. Assuming that the very high rates of egg and chick loss reported for Norway rat predation also apply to black rats is clearly inappropriate – otherwise the birders would have noticed a huge drop in harvest rate when rats arrived on Taukihepa, Pukeweka and Rerewhakaupoko. However, chick harvest rate is related to chick density in a

curvilinear way[77] because once moderate densities of chicks are present the main determinant of harvest rate is the chick 'handling time' rather than chick encounter rate. The hunter is therefore 'saturated' and even quite major changes in density of chicks have little noticeable effect on harvest rate. Accordingly there may have been considerable impacts on tītī productivity without immediate impact on harvest rates.

We consider that it is very unlikely that 20% of the chicks are killed by rats in most years (predation during extreme peaks in rat abundance during the irruptions on Taukihepa and Kaihuka are exceptions) but we infer that up to 10% could be taken in normal years as follows. Rat density in the order of 10 per hectare is expected on offshore islands[78] and rats are regularly seen on Taukihepa. Every hectare of manu has approximately 2100 chicks, so every rat would have about 210 chicks available to it. Chicks are guarded for the first week after hatching (late January) until they can thermoregulate without being sat on by the parents. By mid March the chicks are big and capable of delivering a sharp bite. This leaves at least 6 weeks where the parents are usually not present to guard the chick and when the chick will be relatively defenceless. The chicks are therefore vulnerable for at least 6 * 7 = 42 days. A rat would only have to kill 1 chick every 2 days, a very plausible predation rate[79], to destroy 10% of the chicks.

It is therefore entirely plausible that between 1% and 10% of the eggs and/or chicks are killed by rats. We used 10% as the 'optimistic' scenario because the higher the assumed predation rate, the faster the mitigation of the oil spill injury if rats are eradicated. Median and pessimistic scenarios were set at 5% and 1% respectively (Table A1).

Multiplying assumptions for each scenario about area of manu, chick density, proportion of chicks not harvested and assumed current probabilities of escaping rat predation, leads to prediction of the extra productivity possible if rats were eradicated. We predict that an extra 5497, 51858 and 175335 fledglings will be produced in the

[77] Lyver (2000), Kitson (in press).
[78] Daniel (1978), Moller & Craig (1987).
[79] Often rats only consume a small part of a kill.

season immediately following rat eradication for pessimistic, median and optimistic scenarios respectively (Table A1).

These annual additions to the tītī population were then incorporated into Leslie matrix model using the parameters in Table A2 to simulate potential rates of recovery of tītī in the years following rat eradication. Pessimistic recovery rates are simulated using (i) the minimum number of extra fledglings following rat eradication, (ii) minimum juvenile, pre-breeder and adult survival, (iii) minimum breeding success and (iv) minimum proportion of adults not skipping breeding in a given year (Table A2). Optimistic recovery rates used maximum productivity and survival parameters. All scenarios assumed first reproduction at 7 years.

Resulting rates of recovery in relation to the size of the injury from the oil spill are presented in Table 1 and Fig. 2 in the main body of this report (Pp 20 and 21).

Table A2. Parameters for Leslie Matrix models to calculate the rate of replacement of tītī following eradication of rats from the four islands. The parameters are taken from Table 1 of Hunter *et al.* (2000) except that all tītī are assumed to start breeding at age 7.

	Pessimistic Scenario	**Median scenario**	**Optimistic scenario**
Juvenile survival	0.534	0.583	0.63
1st year Pre-breeder survival	0.838	0.867	0.891
2nd year Pre-breeder survival	0.902	0.923	0.939
3rd year Pre-breeder survival	0.919	0.938	0.951
4th – 6th year Pre-breeder survival & Adult survival	0.901	0.912	0.923
Proportion of fledglings reaching adulthood (7 yrs)	0.271	0.332	0.394
Age at first reproduction (years)	7	7	7
Proportion of adults skipping breeding in any year	23%	31%	33%
Breeding success	59%	61%	64%

Appendix C: Costs of eradication of rats from Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui islands.

Calculation of cost of rat eradication

Area requiring coverage by poisons:

Taukihepa - 939ha
Solomon (Rerewhakaupoko) - 30 ha
Pukeweka - 3ha
Mokonui – 86 ha

This is a total area of 1058 ha, and gives a working area to be covered of approximately 1400ha including double runs on cliffs etc.

Bait cost (21 tonne) includes 20% contingency, transport and storage, this is calculated at 2 drops by helicopter, 1 of 8 kg/ha and 1 at 4kg/ha (this is standard to make sure there are no gaps and in case of bad weather). .....NZ$128,000[80]

Bait deployment costs	
Helicopter hire for bait drops	NZ$ 98,000[81]
Boat to transport bait	NZ $ 15,000
Helicopter ferrying bait	NZ$ 23,000
Boat and Helicopter ferrying people[82]	NZ$ 32,000
Boat and helicopter for reconnecting water systems after drop	NZ$ 20,000[83]
Consents, forecasts, bait testing, safety gear etc.	NZ$ 12,000[84]
Post drop monitoring	NZ$ 20,000
Total eradication cost:	NZ $ 348,000

This calculation does not include "help in kind" to the project from the Department of Conservation from supervising the application of poisons. We estimate this contribution to be around 125 people-days (assuming lengthy preparations for Environment Court hearings are avoided). At a standard DoC charge out rate of NZ$52 per hour, this equates to US$101,000 in-kind assistance to the Rakiura Tītī Islands Restoration project.

[80] All the costs are listed in this Appendix are in New Zealand Dollars unless otherwise stated. At the time of writing this proposal the local currency exchange rate was 1 NZ Dollar = 0.517 US$.
[81] This is a minimum estimate that assumes that Peter Garden is available. Otherwise we must add another $15000 to bring in another suitable pilot.
[82] A dedicated team is needed to put bait around all the houses on the islands on the day of the drop.
[83] This is based on taking down a limited number of people on a catameran and ferrying them to the sites to do the work – if each whānau wanted someone to go down this would increase substantially.
[84] This will increase if the proposal must go to the New Zealand Environment Court.

Cost of Rakiura Māori scientist/manager for monitoring and quarantine programme

An annual salary of NZ $ 35,000 is required and ca NZ$ 15,000 in expenses (transport, bait stations and poison baits) for years when both monitoring and quarantine tasks are being completed (2003-2006; 2012 & 2013). More than one Rakiura Māori community member will be employed for part of the year so that support peaks at the time of fledging. $10,000 of this allocation will be dedicated to quarantine issues every year throughout the programme.

University of Otago science studies to monitor and report outcomes and predict long-term restoration.

Around NZ$ 11,000 is needed in each of the first two years to establish new benchmark plots on impact islands to assess the effect of rat eradication. This involves a team of 4 people monitoring working in the field for 3-4 weeks each year. An intensive study of rat predation for 4 years (two before impact, two after) will require NZ$ 15,000 per year and an additional NZ$ 20,000 in 2006 to synthesise, model and report the predicted rate of recovery of the oils spill injury from all these preliminary studies. NZ$ 20,000 has been allocated for the last year of the RTRP (2013) to re-survey the impact and control plots and check whether model predictions have been realised and publish the outcomes in a peer reviewed journal.

Collaboration between New Zealand and USA scientists and educationalist

We have scheduled visits of Hannah Nevins and Josh Adams to New Zealand (visits in 2003, 2004, 2005, 2012 and 2013 (@ NZ$ 11,000 per visit) to participate in fieldwork, study design, synthesis and publication. Similar visits by Dr Dick Veit are scheduled for 2004 and 2006 (@ NZ$ 5,000 each). Reciprocal visits by Drs Moller or Newman from the tītī research team to USA are scheduled for 2005 and 2013 (budgeted @ NZ$ 5,000 each).

Production of Tītī Times, Films and Educational packages for quarantine and outreach

A special issue of *Tītī Times* on quarantine issues will be prepared and distributed in 2004 (cost NZ$ 4,500) and a fifth of issues in all other years (@ NZ$ 1800 per year) to build awareness and dedication to quarantine efforts.

A provisional budget for NZ$ 22,000 has been allocated to preparing the natural History film about the restoration project. This will be used for both general public outreach and educational packages for schools and quarantine education and workshops, so half of its cost was allocated to the quarantine budget and half to the educational outreach in Table 2.

Preparation of educational material, websites etc, by *Oikonos* is costed as USA$ 5,000 in each of 2004, 2005 and 2013.

Support by the kaitiaki

Rakiura Māori kaitiaki will help in eradication operation, planning, resource consent application, negotiation and monitoring of the overall project, reporting and filmmaking. NZ$ 17,500 has been allocated per year for the first 3 years (2003 – 2005) for this role, followed by NZ$ 9,000 in the last year (2013) for final synthesis, reporting and closure issues. At least one visit to the *Command* Trustee Council in California will be requested and funded out of this allocation.

Appendix C: Letter of Support – Chris Carter, NZ Minister of Conservation, 2006

Office of Hon Chris Carter
MP for Te Atatu
Minister of Conservation
Minister of Housing
Minister for Ethnic Affairs

2 2 MAR 2006

RECEIVED
MAR 27 2006
SACRAMENTO FISH
& WILDLIFE OFFICE

Charlene Andrade
NRDAR Branch Environmental Contaminants Division
US Fish & Wildlife Service
2800 Cottage Way
W-2605 Sacramento
Ca 95825
USA

Dear Charlene Andrade

This letter is to formally thank you, and the other trustees of the Command Oil Spill Fund, for providing the funding for the upcoming rat eradication operation on Taukihepa, Pukeweka, Solomon and Mokonui islands off the southwest coast of Stewart Island, New Zealand.

I understand that this is the first time any United States oil spill mitigation funds have been allocated outside the USA. This is itself an important precedent, which further reinforces my belief that no country on its own can deal with its conservation issues in isolation. We need to share skills and experience, as well as funding, where it can be put to best use, and I am heartened by your generous contribution. It is important to note that this has come about because sooty shearwaters that breed on islands around New Zealand were killed in an oil spill off the Californian coast but that much long-term good for this species and many others can be done through the funding that you have provided.

My Department of Conservation has several good examples of sharing its expertise in threatened species management and in pest eradication around the world. The knowledge the department has gathered is now being freely shared with many countries, including yours.

In addition to the many thousands of titi/sooty shearwater which breed there, the Titi Islands are also home to a wide range of other endemic flora and fauna. Each of the islands contains a unique assemblage of plants and animals. Returning species to these islands is of real conservation value. In addition to sooty shearwaters, the eradication will have internationally significant conservation benefits for a range of other threatened species including sea and land birds as well as lizards and invertebrates. I note that you are also funding research into benefits of the project, and advocacy for the project. I hope that this will give an increased profile for the operation of your trust and highlight the fact that you have looked internationally for the best ways to mitigate the effects of the Command spill.

My department informs me that the preparation for the eradication is progressing very well and, with weather permitting, the first bait drop will take place in early July this year.

I should also note my thanks to Oikonos and Ka Mate Nga Kiore for their integral roles in co-ordinating the funding and liaison with the muttonbirders.

Parliament Buildings, Wellington, New Zealand Telephone: 64 4 470 6568, Facsimile: 64 4 472 8034
Email: ccarter@ministers.govt.nz Website: www.beehive.govt.nz

I look forward to hearing from my department when the bait drops have been completed. Once again my sincere thanks for this wonderful example of international cooperation in conservation management.

Yours sincerely

Hon Chris Carter
Minister of Conservation

Appendix D: Permit Document – Resource Consent, Environment Southland, 2006

environmen
SOUTHLAND
Te Taiao Tonga
Cnr North Rd & Price
Private Bag 9011
Invercargill New Zealan
Phone 03 211 511
Fax 03 211 525
Tollfree (Southland only
0800 76 88 45
Email service@es.govt.n
Website www.es.govt.n

8 February 2006

Ka Mate Nga Kiore Inc
P O Box 147
Te Anau

Our Reference:K085-001
Refer Accession No:
Enquiries to:Stephen West

Dear Sir/Madam

Council Decision on Resource Consent Application K085-001
To discharge poisoned baits onto Muttonbird Islands

At its recent meeting the Consents Committee considered the above application and resolved to grant it.

This resolution is made in accordance with Section 104 of the Resource Management Act 1991 and the matters to be considered therein.

Eradication of rats from Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui Islands Islands will have a positive effect on native flora and fauna on the islands, and improve their potential use as refuge areas for endangered species. The aerial dispersion of poisoned pellet baits is the most practical and effective method of eradicating the rats in this instance. The discharge may result in the deaths of individual non-target birds, particularly weka, but the applicant will mitigate the effects on the weka populations by translocating birds. The discharge will have little other adverse effect on the environment.

The Council recognises that the public have concerns about aerial dispersal of poisons. However, alternatives, such as hand-laid poisons and traps are unlikely to achieve eradication of the rat populations, would also result in by-kill of native species, and would require creation of access tracks, further disturbing the native ecosystem. This would be very costly, particularly as the baits and traps would need to be maintained to retain adequate control of rat numbers. In the circumstances, the proposed aerial discharge of poisoned pellets is the best practicable option to achieve eradication of rats on these islands.

The following matters were considered with regard to this application:

- the provisions of Section 104 of the Resource Management Act, including:
  - Part 2 of the Resource Management Act;
  - the applicant's assessment of effects on the environment;
  - the provisions of Sections 2 (specifically the definitions of discharge and dumping), 15, 15A, 15B, 77C, 104C, 105 and 107 of the Resource Management Act;

air water coast land

for now and your future

Environment Southland is the brand name of Southland Regional Council

- Objectives 2.1, 2.2, 5.1, 5.4, 8.4, 13.1, 13.2, 13.3, 13.4 and 13.8, and Policies 2.5, 5.2, 5.8, 5.9, 8.4, 13.1, 13.3, 13.4, 13.5, 13.10 and 13.13 of the Regional Policy Statement for Southland;
- Rule 4.2.S1(c) and the water quality standard objective of the Transitional Southland Regional Plan;
- Objective 1, and Policies 3 and 13 and Rule 8 of the Proposed Regional Fresh Water Plan;
- Objective 1, and Policy 2, and Rule 8 of the 2005 Water Quality Variation to the Proposed Regional Fresh Water Plan;
- General Principles 2, 5, 9, 10 and 11, and Policies 1.1.2, 3.2.2, 3.5.1, 4.2.1, 4.2.2 and 5.1.7 of the New Zealand Coastal Policy Statement;
- Objective 7.3.5.2, and Policy 7.3.5.1, 7.3.5.2, 7.3.5.3 and 7.3.5.4, and Rule 5.3.1 of the Proposed Regional Coastal Plan for Southland;
- Rule 6.5.6 of the Regional Air Quality Plan for Southland.

Pursuant to Section 104C of the Resource Management Act 1991 , a discharge and coastal permit is granted to Ka Mate Nga Kiore Incorporated subject to the following conditions:

1. This resource consent shall expire on 30 November 2011.
   (Note: Pursuant to Sections 123 and 124 of the Resource Management Act 1991, a new consent will be required at the expiration of this consent. The application will be considered in accordance with the plans in effect at that time, and the adverse effects of the proposed activity).

2. This consent authorises the aerial discharge of Brodifacoum bait to:
   (a) land in circumstances where contaminants may enter water; or
   (b) land in the coastal marine area where contaminants may enter coastal water;

   for rat eradication on Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui Islands and surrounding rock stacks and islets, as detailed in the application to this consent.

3. The cereal baits shall:
   (a) be within the colour range No. 221 to 267 as defined by NZS 7702:1983; and
   (b) contain, on average, no more than 20 ppm of brodifacoum.

4. The application of brodifacoum bait shall not exceed the following:
   (a) a total of 20,000 kg of bait; and
   (b) a maximum average rate of bait application of 18.81 kg/ha.

5. The consent holder shall, at least 24 hours prior to the discharge of brodifacoum bait:

(i) notify, in writing, the Southland Regional Council's Environmental Compliance Manager (fax (03) 211 5252) of commencement of the discharge; and
(ii) publicly notify the timing and the target area of the operation in the local newspaper;
(ii) advise local dive and fishing clubs of the location and timing of the discharge, and that there is potential for baits to enter the marine environment around the islands.

6. The consent holder shall ensure that the activities authorised under this consent comply with any requirements of the Pesticides Act 1971, or any other relevant regulations.

7. The consent holder shall ensure that signage is erected in prominent positions on each island during the application of brodifacoum bait and the signage shall be maintained until the bait has ceased to be toxic. The signage shall inform the public of the discharge of the bait and any hazards associated with the discharge.

8. The consent holder shall ensure that all drinking water catchment systems are covered or disconnected while bait application occurs.

9. The Council may, in accordance with Sections 128 and 129 of the Act, serve notice, during the period May to July each year, of its intention to review conditions for the purpose of:

(i) dealing with any adverse effects on the environment which may arise from the exercise of this consent; and/or
(ii) complying with the requirements of a regional plan.

Under the Resource Management Act 1991 you have a right of appeal against the Council's decision to the **Environment Court.** Any appeal is to be lodged with the Registrar, Environment Court, Department of Justice, Tribunals Division, 85 Armagh Street, P O Box 2069 Christchurch. A copy of any appeal must be served on Council, the applicant, and any person who has made a submission on the application.

Every notice of appeal lodged with the Environment Court must be accompanied by a filing fee of $55.00, inclusive of GST.

The appeal shall be in the prescribed form and shall :-

- state the reasons for the appeal and the relief sought;
- state any matters required by regulation; and

- **be lodged with the Environment Court and served on the Regional Council within 15 working days of this decision being received by yourself in accordance with the above Act.**

Alternatively, you may lodge an objection to the Regional Council in respect of this decision. The Council must then review its decision, and it may dismiss or uphold your objection wholly or in part. The objection must :-

- be in writing;
- set out the reasons for objecting and the relief sought; and
- **be lodged with the Council within 15 working days of notice of this decision being served on you.**

Full details regarding processing costs for this application will be forwarded to you shortly and your consent and an invoice will follow at the close of the appeal period.

Yours sincerely

John Engel
Consents Manager

CC: Te Ao Marama Inc, P O Box 990, Invercargill. Attn: Michael Skerrett

Appendix E: Tïtï Islands Eradication Operational Plan, Torr, 2006

Operational Plan for the Eradication of Rats from Taukihepa, Pukeweka, Rerewakaupoko, and Mokonui Islands

(SOME OPERATIONAL DETAILS WILL CHANGE PRIOR TO OPERATION)

Prepared by Nick Torr

For Department of Conservation
Southern Islands Area Office
State Insurance Building
Don Street, Invercargill
New Zealand

Revised: 4/2006 HMN

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1 OPERATIONAL SUMMARY

This plan sets out the operational requirements for the eradication of ship rats (*Rattus rattus*) from Taukihepa (Big South Cape), Pukeweka, and Rerewakaupoko (Solomon), and kiore (*Rattus exulans*) from Mokonui (Big Moggy) islands during the winter of 2006. This will be achieved using aerial application of the anticoagulant brodifacoum incorporated in a cereal pelleted bait over the total surface area of all four islands. A helicopter using an underslung spreader bucket and a Differential Global Positioning System (DGPS) will be used to apply the bait.

There will be two applications of bait spaced no less than, and as close as possible to, seven days apart to all islands. For each application to be most effective bait will be applied when there is an expected weather window with minimum or no rainfall for a period 3 nights immediately following each drop.

Because it is desirable to expose all individuals in the target population to the poison simultaneously, each application will be completed in a single day if at all possible. To make this feasible, bait, helicopter fuel, and spreading equipment will be transported to and stored on Taukihepa prior to the expected start date for the first bait application. This will necessitate a small team (two people) being based on Taukihepa to look after the bait and make sure everything is ready to go from when the bait arrives until the second bait drop is completed.

Once the bait has arrived on the island the services of a professional weather forecaster will be employed to help predict suitable weather conditions for each bait drop. The helicopter will be loaded with bait for all islands including Mokonui from one central location on Taukihepa. A team of suitably skilled personnel will undertake this bait loading by hand.

As soon as is practical after the completion of the second bait drop, all equipment and waste generated by the operation will be removed from Taukihepa and transported back to the mainland for disposal. Two years after the operation, suitably skilled personnel will visit all four islands and monitor for rat presence before considering a declaration that they are rat free.

Prior to the eradication, measures should be put in place to stop reinvasion. A suitable rodent quarantine procedure will need to be designed and implemented for all people visiting and working on and around the islands. Quarantine procedures should be in place by the time the poison operation is completed. Effective quarantine will require the full co-operation of <u>all</u> island users and visitors, and of the fisherman working and mooring around the islands. A commitment that these groups are prepared to adhere to conditions set out in a rodent quarantine plan should be gained before this eradication goes ahead.

2 INTRODUCTION

Taukihepa (939 ha), Pukeweka (approx 3 ha) and Rerewakaupoko (26 ha) islands are part of the group of muttonbirding (titi) islands lying off the south-western corner of Stewart island. In 1964 ship rats made their way to these previously rodent-free islands and since then have had a catastrophic impact on their biota.

The rat invasion quickly threatened the survival of Stewart Island snipe, Stead's bush wren, South Island saddleback and the greater short-tailed bat. These species had already been driven from the mainland by predators and survived only on these three rat-free islands. South Island saddleback was saved through a last-ditch effort by the Wildlife Service to transfer them to neighbouring rat free islands (Kaimohu and Big), but the other three species are now considered extinct, (there is a possibility that greater short-tailed bats survive on Putauhinu).

The greatest distance between these three islands is less than 150 metres, and this is within the known swimming range of ship rats. Due to this close proximity, these islands must be treated as one unit for the purposes of the eradication.

Mokonui/Mokinui (86 ha) lies 7.5 km north of Taukahepa and has kiore present. They were probably introduced by early Maori visiting the island to harvest muttonbirds. Mokonui has no neighbouring islands with rodents present and could be considered for a stand-alone eradication, however for logistical and financial reasons it makes sense to include it in this operation.

Since the mid 1980s, progress in the field of eradicating rats from islands around New Zealand and overseas has been rapid and spectacularly successful. It has reached a stage where there are sound and well-proven techniques such as those proposed in this plan, that allow a high level of confidence in taking on an operation such as this. Kiore have been eradicated from many islands including Whenua Hou, Putauhinu and Raratoka using the techniques proposed for this operation.

Operations targeting ship rats have been much less common. They were successfully eradicated from 700 ha St Paul Island in the Indian Ocean in 1997, using similar techniques to those described in this plan. Because ship rats remain a relatively untested species for island eradication, a cautious approach has been taken when considering variances to the basic prescription for aerial baiting aimed at rodent eradication. This has influenced decisions such as the choice to use the longest lasting bait available, the application rate of the bait, and the decision to do two separate drops over each island.

3 CONSULTATION AND NOTIFICATIONS

3.1 Resource consent

Resource consent is required from the Southland Regional Council (Environment Southland). An application for resource consent has been completed following peer review of this plan and the Assessment of Environmental Effects (AEE) by the birding committee and the Island Eradication Advisory Group (DOC).

3.2 Technical Advice

The planned operation has been considered by:

- DOC's Island Eradication Advisory Group, who can provide technical advice on rat eradication
- The Taukihepa Eradication Committee, Nga Mate Kiore, consisting of birders from the islands involved. This group will consider if the techniques required for the eradication are logistically and culturally acceptable to the birders.
- Southern Island Area and Southland Conservancy staff.

3.3 Public safety and health notifications

The titi islands are closed to the public and there shouldn't be anyone visiting them during the time of this operation, however public notices will be placed in newspapers covering the Southland District alerting the general public to the operation. Large poison warning signs will also be placed at key sites along the coast where boats are known to moor.

All birders using these islands will be briefed on the operation, what the bait looks like, the risk it poses to animals and humans and how to dispose of any bait they may find when they return to the islands for the 2007 season.

4 OPERATIONAL DETAILS

4.1 Project team

<u>Project manager</u>

Throughout the planning and execution of this operation, one person will need to have clear overall responsibility for this process and for the operation as a whole. This person will be called "the project manager". The project manager (Pete McClelland) will coordinate all aspects of planning and will keep all stakeholders fully informed as the

programme develops through the planning stages. During the poison operation they will have responsibility for decision making for all aspects of the operation except for decisions on flying and shipping that relate to safety.

Operational team

From the time of delivery of the bait to Bluff, suitably skilled people will need to be available to supervise its unloading, storage and shipping to Taukihepa. Two people will remain on the island to look after the bait for the duration of the operation. On bait drop days, it is probable that an additional seven/eight people (including helicopter pilot and crew, and the project manager) will be needed to load bait and organise the operation, meaning a total of nine/ten people will be required. A further small team of people may also be required to hand-lay bait in buildings on the islands and to deal with water supplies.

There will be additional personnel tasked to specific roles such as public spokeperson, health and safety coordinating ground baiting teams etc. These positions will be decided between the project manager and Nga mate Kiore.

4.2 Timing of the operation

The proposed timing of the operation in mid-to late winter was chosen to take advantage of the fact that rats are expected to be under maximum stress at this time through lack of food and cold temperatures. Alternative food is in short supply and rats are not breeding which reduces the risk of young rats not having access to bait. The operation will be timed to take place within the period 1 July to 30 September 2006, however, if it is delayed past this point due to weather or other unforseen circumstance the situation will be reviewed at that time before a decision is made to either postpone the operation or extend the acceptable time-frame.

The target date for the first drop is 1 July 2006 and the drop will take place as soon as there is a suitable weather window after that date. The second drop will take place in the next period of suitable weather a minimum of 7 days later. The aim is to complete each drop over all islands on a single day. To make this feasible all bait, helicopter fuel and spreading equipment will be transported to Taukihepa in late June.

Once bait has arrived on the island, long-range weather forecasting will be monitored and all operational staff will be placed on standby. When a suitable forecast is received, all operational staff and the bait spread helicopter and crew will travel to Taukihepa on the day before the first drop is to commence. On that day the DGPS base station will be set up and the helicopter will log the boundaries of all four islands into the DGPS system. The bait loading site will also be prepared. The process will be repeated for the second drop except that it will not be necessary for the island to be re-logged and it may be possible for the bait spread helicopter and operational crew to travel to Taukihepa early on the day of the drop. This decision will be made based on how long it has taken to do the first drop.

4.3 Weather forecasting

After funding and resource consents have been secured, weather poses the greatest risk to this operation. Severe weather could seriously delay the operation or reduce its chance of success by washing out bait shortly after it is applied. Bad weather could also cause problems while transporting the bait from Bluff to Taukihepa and while the bait is being stored.

To help guard against these risks and to ensure that suitable weather can be utilised, accurate weather forecasting is essential. From mid-June Andy Fraser of 45 Degrees South Weather Services will be contracted to provide 5 day forecasts specific to the operational area. Information provided will be in the following format:

- Probability of more than 1mm of rain per day
- Probability of more than 10mm of rain per day
- Wind speed and direction estimates at sea level and at 300masl
- Swell height and direction (for shipping of bait to Taukihepa only)
- Current and forecast situation maps

A forecast of less than 20 knots and four fine days (3 fine nights) without significant (less than 6mm) rainfall is preferred for each drop day. Cloud level will also be monitored and the drop will not go ahead if visibility is not adequate.

4.4 Choice of bait and toxin

The preferred bait for this operation is "Pestoff 20R" manufactured by Animal Control Products (ACP), Wanganui. Pestoff 20R is a cereal based Wanganui No.7 pellet incorporating the anticoagulant rodenticide brodifacoum at 20ppm (0.02 g/kg). It was chosen for this operation primarily because it is known to have superior weathering characteristics to other available baits and will therefore remain available to rats longer once sown. This bait has been used successfully for a large number of island rodent eradications both in New Zealand and overseas, and was the bait used for the successful eradication of ship rats from St Paul Island.

Pestoff 20R is available in several pellet sizes. For this operation the 10 mm, 2 gram pellet has been chosen because the pellets are known to be a more uniform size at manufacture. Uniform-sized pellets flow better through spreader buckets and avoid potential problems with bridging and blockages at low sowing rates. 10mm pellets will also produce a comparatively dense pattern of bait on the ground once sown ensuring all rats have access to bait.

The bait will be dyed green to make it less attractive to birds. To maximise palatability to rats, the bait will not contain lure or "Bitrex".

4.5 Bait ordering

As soon as it looks likely that the eradication will go ahead, a pre-order notification for approximately 15 to 20 tons of bait will be given to the ACP factory in Wanganui. This quantity of bait will be sufficient to do two drops over the surface area of all four islands at the nominal combined rate of 12 kg/ha. It also allows for extra applications over the steeper parts of the islands, and the coastal strip and for reapplication on any areas where problems may have occurred with the bait spread.

The initial "informal" notification will give the factory time to programme in the required manufacturing time and will need to be given no later than the end of February 2006. Once resource consents and funding for the eradication are confirmed a formal written order will be placed with ACP.

The formal order should be subject to the standard DOC bait contract. Specifications in this contract will clearly state requirements for size, weight, toxin loading, moisture content, colour, hardness and maximum allowable levels of fragmentation of the bait. The contract will also stipulate the requirements for packaging and transport of the bait. The formal bait contract will need to be let more than one month before the required delivery date.

4.6 Non-toxic bait for bucket testing/calibration

A quantity of non-toxic bait will be required for testing and calibrating the spreader buckets to be used for the poison operation. The specifications of this bait need to be as close as possible to the bait used for the actual operation. The poison factory should be alerted to the need for this bait at the time that the informal notification is made, as runs of non-toxic bait are difficult for them to fit into their bait production schedule.

4.7 Bait quality /toxin assay

Bait quality will be monitored by ACP and by experienced DOC staff who will visit the ACP factory on each day during production to visually inspect fragmentation, colour and moisture levels. The DOC representative will ensure that bait is cooled less to than 8 degrees C above ambient temperature and given a chance to cure before bags are sealed and that the pallets used for transport and storage are clean and dry.

To ensure that the bait contains the correct toxin loading the DOC representative will collect a 50g (25 bait) sample at random from each one-ton batch of bait during production. Each sample will be separately bagged and clearly labelled with the name of the collector, the batch number from which it was taken and the date it was collected. These samples will then be sent to Landcare Research at Lincoln to be tested for toxin

loading. Payment for the bait will not be made until it is confirmed that all the bait is within the specified toxin loading.

4.8 Bait delivery and storage at Bluff

The transport of bait from the poison factory in Wanganui to Bluff will be the responsibility of ACP. Bait will be packaged in 25kg paper-walled bags and stacked on 1.6 x 1.1 m pallets then shrink-wrapped. With 40 bags to a pallet each pallet will weigh 1050 kg. There will be approx 15 pallets. On arrival in Bluff, the bait will be delivered to a suitable shed where it will be unloaded using a forklift and stored until ready to be transported to the island. A suitably skilled person will be on site to supervise unloading. At no stage during transport or storage will the pallets be stacked on top of each other this is to avoid crushing of the bait. The storage shed will be dry and secure. During storage at Bluff a suitably skilled person will be made responsible for regularly checking the bait to ensure that: it is not exposed to moisture; suitable controls are in place to stop rodents interfering with the bait; and the bait is accessible when required.

4.9 Bait, fuel and equipment transport to Taukihepa and storage until drop

Bait, helicopter fuel and other equipment will be shipped to Taukihepa as close to the proposed start date of the poison operation as possible, but with enough time to ensure that it is all there and ready to go when that date is reached. It is imperative that while bait is being shipped there is no risk of it getting wet. This will influence what shipping option is used and possibly what weather/sea conditions bait can be shipped in. It is highly desirable that the bait be shipped in a sealed hold. There are two vessels operating locally that may be suitable (The Marine Countess and The Foveaux Freighter), but the options need to be investigated further.

On reaching Taukihepa, the bait and other equipment will be flown ashore using a helicopter. This machine needs to be capable of lifting heavy loads up to 1000kg. The pilot will need to be experienced at flying loads on a long strop and at unloading from boats. It would also be an advantage if they have previous experience of flying around these titi islands, as there are numerous unmarked wires and cables that could present a hazard to inexperienced pilots.

Because there is likely to be a lengthy wait (possibly up to 12 weeks) for suitable weather conditions to complete both drops it is important that bait is stored in a way that minimises the risk of it getting wet or deteriorating in any other way. There are two options available for storage:

Option One: Pods

Bait would be preloaded into prefabricated 1.2m x 1.2m plywood "pods" in Bluff before shipping. Pods would then be flown ashore to a sheltered location on Taukihepa and the bait would remain in the pods until needed for spreading.

This method was used successfully on Campbell Island where bait remained in good condition for up to 4 weeks before being spread. The disadvantages of this option are the extra cost of the pods, the need to repack the bait into the pods in Bluff and the need to open the pods each time the condition of the bait is to be checked. Bait may also need to be packed in non-standard 30kg bags at the factory to facilitate efficient packing in the pods.

The advantages of this option are that once bait is packed in the pods it will be more weatherproof during shipping and flying ashore. Pods can be easily shifted from the storage location on Taukihepa to a remote loading location should the preferred loading site be different from the storage site. Pods also make a good platform for loading the spreader bucket.

It should be noted that although this method worked well on Campbell Island, the pods never had to endure sustained heavy rain or extremes of temperature. If pods are used for this operation it may be desirable to rig some sort of cover over them at the storage site to keep most of the rain off them and to protect them from direct sunshine.

Option Two: Tents

Bait would be shipped to Taukihepa on the original pallets. To make the pallets flyable, the top layer of five bags will be removed from each one, and redistributed on extra pallets. After this redistribution, each pallet should weigh around 950 kg. The bait would be flown onto the island on these pallets.

Need to discuss this with the helicopter operator that gets this job, may have to make loads even lighter

The pallets would be stored at a sheltered location in a large tent or tents until required for spreading. Polythene would be laid on the ground under the pallets to reduce ground moisture and once inside the tent the shrink-wrap would be removed to reduce sweating.

This method of storage was used successfully on Whenua Hou and Little Barrier Island. Bait was stored on each of these islands for over a month while waiting for suitable conditions to do the drop. On Whenua Hou two large 3.5 x 9m pipe framed "Coverall" tents were used to store 25 tons of poison. These tents worked well, were easy to erect, and may still be available from within DOC. On Little

Barrier a large 6 x 30m marquee was used to store 55 tons of bait and also worked well but was relatively expensive and needed specialists to erect and dismantle it.

The advantages of this option are that the condition of the bait can be inspected easily and any problems are likely to be picked up early, there is good air circulation around bait, and the risk of sweating and condensation is reduced and can be easily managed. If the "Coverall" tents are still available from within DOC it could be a relatively inexpensive option.

The disadvantages are that the tents are susceptible to strong wind and the storage site would need to be sheltered from any risk of extreme wind. It would also need to be relatively flat. If the tents are damaged all the bait is at risk of being ruined at once. If no tents are available through DOC it could be an expensive option. If bait needs to be shifted from the storage site to a remote loading site it would need to be either re-shrink wrapped on the original pallets or loaded into flight bags.

The site for the storage area will be chosen primarily for its dryness and its shelter from wind. Ideally, the site would be:

- relatively flat
- open enough to long-strop bait into easily
- near a suitable location to load the spreader bucket
- at a central location
- close to suitable accommodation for the crew based on the island to look after the bait.

Two sites that may suit these needs are: somewhere in the clear area approx 400m upstream from Murderer's Cove; or perhaps somewhere near the dwellings at Potted Head. All options need to be discussed with birders on the island and it is proposed that DOC staff visit the island during the 2006 muttonbirding season to confirm the best site/ most suitable technique.

After the bait has been transported to Taukihepa a suitably skilled person along with a second person (probably a volunteer) will be based on the island until the second drop is complete. These two people will be responsible for monitoring the bait's condition and taking any actions necessary to keep it in good condition. Bait will be inspected regularly for signs of moisture damage or any other problems. If pods are used this will mean opening a sample of pods for inspection and may also mean opening pods during periods of good weather for airing. Rodent damage will be minimised by a layout of snap traps around the storage area and those traps will be checked on a daily basis.

4.10 Bait application

The bait will be applied during two separate aerial applications spaced a minimum of seven days apart. The reasons for doing two separate applications are:

- To ensure complete coverage of the islands with bait and minimise the risk of any gaps in the coverage
- To minimise the risk of bad weather washing out both applications of bait
- To ensure rats are exposed to bait for a long period of time
- To take every precaution with bait spread while targeting the relatively untested ship rat

Although the last point (above) doesn't apply to Mokonui (as it has only kiore present), a second drop there would give an extra degree of confidence for little extra cost. However if funding does become a problem, consideration could be given to treating Mokonui with a single application at a higher bait application rate (as done on Putauhinu and Raratoka).

The bait will be applied with a helicopter using an underslung spreader bucket. The bucket will be fitted with a spinner that throws bait out to an effective swath width of 80m (40m either side of the helicopters flight path). The helicopter will fly parallel flight lines guided by a DGPS so that there is an overlap between each swath.

The entire surface area down to the waterline of all four islands will be covered once like this on each bait application. In addition, a band two swath-widths wide will be flown round the entire coast of all islands to guard against gaps at the end of the parallel flight lines. Any cliffs or areas of steeply sloping ground (over 60 degrees) will be treated a second time during each bait drop. The total extra area is to be calculated after the initial fly-by the coastal regions for all islands. Bait will also be applied to all coastal rock stacks and islets using the helicopter.

Aerial bait spread will cover all parts of the island including sites where buildings are located, however, on the day of the first bait drop, or as soon as possible afterwards, bait will also be placed in and under all buildings on the island by hand. Baiting the buildings is discussed in more detail below.

4.11 Application rate

For the first bait drop the spreader bucket's calibrations and air speed will be matched to give a nominal application rate of 4 kg/ha. Based on the bucket delivering an 80m wide swath, the parallel flight lines will be spaced at 40m to give a 40m (50%) overlap and an effective application rate of 8kg/ha.

For the second drop the bucket's calibration and airspeed will be set to give a nominal application rate of 4 to 8 kg/ha and flight lines will be determined to give an effective application rate after discussions with IEAG and helicopter operator.

4.12 Monitoring bait spread and dealing with gaps

The quality of each drop will be monitored by checking a printout of the lines flown by the helicopter while spreading bait. At the completion of each drop and before leaving the island the helicopter operator will provide a printout from the DGPS of the days flying to the project manager. This printout will preferably be a paper copy and will be of a large enough scale to clearly see any deviations in the flight lines. The project manager will check the printout for any potential gaps and these areas will be retreated immediately.

4.13 Bait loading

A team of five people will undertake the loading of the bait into the bait-spreading bucket. The team will need to include at least two people with previous experience of this type of loading. One of them will be designated the site controller and will be responsible for the safe and smooth running of the loading site. The remainder of the team should all have at least some experience of working around helicopters.

Before loading starts the load team will receive a safety briefing from the project manager and the drop pilot. All personnel involved in the handling and loading of bait will comply with the practices laid out in the DOC's Animal Pest, Quality Conservation Management Module "The safe handling of pesticides" and will be required to wear the appropriate safety gear which will be provided. This will include facemasks, gloves, goggles, helmets, steel cap boots and overalls. Water will be available at the loading site for everybody to wash before eating, drinking or smoking.

The loading for all four islands will take place from one site on Taukihepa. Although Mokonui is approx 7.5 km from Taukihepa it will require less than three full bucket loads of bait per drop to cover the island. It is therefore more cost-effective and logistically practical to load the bucket on Taukihepa rather than set up a separate loading site on Mokonui.

The project manager in consultation with the drop pilot will choose the most appropriate loading site prior to the drop. It is likely to be higher up on the island which will require the bait to be ferried up to it as required by a second helicopter on the day of the drop.

A loading platform made of wooden pallets or pods (if the pod option is used for storage) will be constructed at the loading site before the drop commences. Between loads, the load team will open enough bags for one bucket load by removing the strings from the top of the bags. When the empty bucket arrives two people will be responsible for tipping the bags into the bucket, while two people will be responsible for controlling the empty bags and ensuring there is no chance of them or other loose material blowing into the rotors.

After the helicopter has left the loading site to spread each load, all empty bags and other loose material will be stowed in such a way that it cannot blow around the site on the helicopters return. Nobody but the five man loading team will be allowed in the

immediate vicinity of the loading site without the express permission of the site controller. The site controller will be in contact with the drop pilot and the project manager via VHF radio at all times.

4.14 Requirements of the bait drop helicopter

The bait drop contractor will be selected based on their experience spreading the type of bait used for this operation and in using DGPS. Before they are contracted for this job they will demonstrate to the project manager that they have the ability and the equipment to do the bait drop to the required high standard effectively and reliably. It would be a big advantage if the contractor had had previous experience with island rodent eradications.

When funding and resource consents have been confirmed the project manager will work towards selecting a preferred operator by inviting expressions of interest from companies interested in this work. These expressions of interest will include previous experience in this type of work, detail of equipment to be used, detail of backup available and an estimate of cost to complete both drops. The project manager will follow this up before making his selection by visiting any potential candidates to discuss their experience and establish the suitability of their equipment.

Operators will be expected to provide sufficient equipment to cover contingencies such as breakdown or malfunction. This will include having a spare bucket on site on the days of the poison operation and access to a backup helicopter at short notice. All helicopters and crew carrying out aerial application will hold the appropriate air service certificates and agrochemical ratings.

Some time before the target start date for the first poison drop, the buckets of the chosen bait drop operator will be checked and calibrated using non-toxic bait. This will be done with the project manager or other DOC representative present. It is recognised that these calibrations are not final and the operator will be required to have a full selection of bucket orifices on hand on the days of the poison drops so that the bait application rate can be fine tuned as the drops proceed.

During these trials other aspects of the bait drop equipment will be checked. These will include the swath width produced from the bucket and the amount of fragmentation of bait as it passes through the bucket. The operator's ability to download from the DGPS and produce a suitable image of flight lines and the area flown so that it will show any potential gaps in coverage will also be checked at this stage.

4.15 Personnel and transport requirements

From the time that the bait is delivered to Bluff, a suitably skilled person will be required to take responsibility for its unloading and storage until it is transported to Taukihepa.

That person will also be required to organise and supervise its loading onto the ship for transport to Taukahepa and may be required to organise and oversee loading of the bait into pods if this option is used. Personnel requirements for building and loading pods will be assessed when a decision on bait storage is made.

Personnel required for bait unloading on Taukihepa will travel to the island aboard the vessel transporting the bait and spreading equipment and aboard the helicopter used to unload the bait. Three or four people will be required on the island to position bait and equipment as it is flown ashore while two people will be required aboard the vessel to ensure the bait travels safely and to assist the boat crew with unloading. The crew flying to the island will arrive on the island before the ship and in time to prepare the storage site. After unloading, the crew will assist with making sure the bait and equipment is securely stored before departing on the helicopter. This may include erecting tents or covers over the bait.

From the time that the bait arrives on Taukihepa until after the second drop is complete, a team of two people will be based on the island with the primary task of looking after the bait. One of these people will have previous experience of this task while the second person will be a volunteer, probably a person who birds on the island. These two people will travel to the island with the bait as part of the unloading team. Consideration will be given to rotating one or more of these people if the programme is drawn out due to bad weather but it is preferable that they are prepared and available to stay on the island for an extended period of at least eight weeks.

The team for the bait drops will consist of: five loaders; the helicopter pilot and one crew; and the project manager and his assistant. It is anticipated that the two people responsible for looking after the bait on Taukihepa will make up part of the loading crew. The remainder will fly to the island aboard the bait drop helicopter and a second machine.

For the first drop the team will travel to Taukihepa on the day prior to the drop so that there will be time to set up the base station for the DGPS, log in the boundaries of all four islands, and prepare the loading site. They will spend the night on the island and be ready for an early start the next day. For the second drop it may be acceptable for the team to arrive on the island early on the day of the operation. The second helicopter will stay on if required to ferry bait to remote loading sites or to ferry people around to place bait in buildings. For both drops all personnel will remain on the island until the bait drops have been completed to the satisfaction of the project manager.

4.16 Accommodation

Accommodation will be required on Taukihepa for the two-person bait minding team from when the bait is delivered to the island in late June until after the second drop has been completed. The period of this stay will depend on weather conditions and how quickly both drops can be completed but will be between three and twelve weeks. It will

be up to Nga Mate kiore to arrange accommodation in one of the mutton-birder's huts near the bait storage area.

The bait drop crew of up to ten people will also need accommodation on Taukihepa at a location preferably near the bait storage area for the nights immediately prior to and perhaps after the bait drops. Again, It will be up to Nga Mate kiore to arrange accommodation in one of the mutton-birder's huts for this.

4.17 Baiting around buildings

Although aerial baiting will cover all parts of the islands including around buildings there is a slight risk that any rats living in or under buildings might not have access to bait. To counter this, bait will be placed in and under all buildings as soon after the first poison application as possible. This will preferably be on the day of the drop but it would be acceptable if it were completed within two days of the drop.

The best way to do this ground baiting needs to be discussed with the birding committee for each island and the buildings' owners. If everyone were in agreement, the most cost-effective way of achieving this would be to have a small team of two or three people with permission to enter all buildings to place bait. The most cost effective option would be to use the two people already based on the island to look after the bait storage. The same team could then be ferried to Solomon and Pukeweka while the helicopters were in the area around the time of the poison drop. However it is recognised that a lot of birders will want to be involved in the project, and if properly managed this is a good way for them to play a role. Having said that, quality control is vital and the more people involved the more chance of an error occurring. This will need to be discussed between the project manager and Nga mate Kiore. It is likely that a task manger for this will be required to ensure no building are missed – this will require extensive consultation beforehand with all birders.

For Mokonui, ground baiting could be completed by one person with permission to enter all buildings on the island. That person could be incorporated in the bait loading crew and flown out to the island around the time of the drop. Or it is likely to be 2 -4 birders on the island. Once again this needs discussion between the Project Manager and Nga Mate Kiore.

Bait placed inside and under building will be in open dishes so that it is as clean and easy to remove as possible when the owners return to the island next season.

4.18 Protecting water supplies from bait contamination

Because some bait will end up on the roofs of buildings during aerial baiting it will be necessary to make sure all water tanks are disconnected and any open tanks are covered before the first poison drop takes place. All birders will be required to do this prior to

leaving the island at the end of the 2006 season. They will also be asked to do the same for any buildings not used during the season.

Water collection systems will need to be cleaned out and reconnected in time to ensure tanks are full before the following season. The most efficient way of achieving this needs to be discussed with the birding committee and building owners. If it can be agreed that all building owners are happy for a small group of representatives to visit the islands to deal with all water supplies this will result in a major saving of costs. From a contamination point of view it will be safe to undertake this task after one month from the second drop or after 30mm of rain has fallen.

4.19 The risk to non-target species

Experience gained from similar projects including neighbouring Putauhinu give a high degree of confidence in predicting the impact from this operation to non-target species present on these islands. They are covered in detail in the Assessment of Environmental Effects for this project.

There are not expected to be any significant long-term negative impacts to any species except maybe weka. What is expected is that there could be some losses at an individual level of a few species such as tomtit/ngiru-ngiru, kakariki, black-backed gull/karoro, blackbird and song thrush from eating bait. There could also be some losses of ruru and harrier hawk/kahu from eating poisoned rats. For all these species, and for the ecosystem as a whole, the evidence shows that the long-term gains from having no rats will far outweigh any short-term losses.

Weka is the one non-target species expected to be significantly impacted by the poison operation. Weka are known to eat cereal bait and during the rat eradications from Kapiti and Chetwode Islands, mortality of up to 98% was estimated for this species. It is reasonable to expect that there will be high weka mortality during this operation but it is difficult to predict exactly how high it will be, or if the whole population might be at risk.

4.20 The possibility of eradicating Weka

Weka were introduced to Taukihepa and there is some recent evidence that they have a significant impact on titi productivity as well as on a wide range of other native species. If there is any long-term plan to attempt to eradicate them from these islands for the benefit of titi, this poison operation could provide a rare opportunity to pursue this option. However it would still require a significant effort to hunt down and remove any weka that survive the poison operation, and it would only be worth attempting if adequate resources were available to make a realistic attempt. If this is to be attempted it is important that it be planned and carried out in a systematic way (Derek Brown, 2004). Any proposed weka eradication must be driven by the birders and assistance would be provided by DOC.

4.21 Clean up

Empty bait bags, bait loading and transport equipment, fuel drums and other waste generated by this operation along with the bait spreading buckets and other equipment will be removed from Taukihepa as soon after the second poison drop as is practical. A suitable vessel and helicopter will be required for this task. One option may be to use the DOC vessel, *Southern Winds*, if it was available at an appropriate time, or a suitable fishing boat.

The wooden pallets and any other untreated timber could be left on the island for firewood if any of the birders are interested in them.

Empty bait bags and any bait brought back from the island will be disposed of at an approved Environment Southland landfill.

The bait buckets and any other loading and spreading equipment will be thoroughly decontaminated before being shipped back to the mainland.

4.22 Occupational safety and health

This operation will follow the practices laid out in the Department of Conservation's Animal Pest, Quality Conservation Management, Module "The Safe Handling of Pesticides".

Staff and contractors working on this operation will comply with the Health and Safety in Employment Act 1992 and any regulations made under that act. Before commencing work, contractors will supply their health and safety plan to the project manager.

A separate safety plan will be prepared covering key tasks in this operation. The operation manager or his/her delegate will ensure that all operational staff are fully briefed and comply with the provisions outlined in this document.

5 TIMETABLE OF KEY EVENTS

Operational Phase	Date	Action	Person responsible NB – may be delegated to other personnel
Planning	Oct-04	Prepare draft operational plan	Nick Torr
Planning	Oct-04	Prepare draft AEE	Derek Brown
Planning	Nov-04	Nga Mate Kiore (NMK) PM, review of AEE and op plan	NMK Pete McClelland

Planning	Nov-04	IEAG review of AEE and op plan	IEAG
Planning	Nov-04	Finalise AEE and submit with draft operational plan as part of resource consent application	Derek Brown/Pete McClelland
Planning	Dec-04	1st revision of draft operational plan	Nick Torr
Planning	Dec-04	IEAG meeting – update on RMA application, input into draft op plan	IEAG
Delay**		Eradication Delayed for 1 year, planned for July 2006	
Pre Op Tasks	Dec-05	Assess and decide on preferred bait storage option for Taukihepa –this may require visit in April re site.	NMK/ Project manager
Pre Op Tasks	Dec-05	Investigate shipping options for bait and identify preferred option	Project manager
Planning	Jan-06	Prepare tender and contract documents for aerial works	Project manager
Pre Op Tasks	Feb-06	Aerial works contract tendered	Project manager
Pre Op Tasks	Feb-06	Aerial works tenders close	Project manager
Planning	Feb-06	Prepare evidence for consent hearing	Consent team
Pre Op Tasks	Mar-06	Preferred aerial works contractor selected	Project manager
Pre Op Tasks	Mar-06	Finalise Project Team	Project manger/NMK
Planning	Mar-06	2nd revision of draft operational plan	Nick Torr/ Project manager
Planning	Mar-06	Consent hearing	Consent team
Pre Op Tasks	Mar-06	Finalise bait transportation details	Project manager
Pre Op Tasks	Mar-06	Finalise bait unloading operational details	Project manager
Pre Op Tasks	Mar-06	Make arrangements for site specific weather forecasting during operation	Project manager
Pre Op Tasks	Mar-06	Confirm storage shed availability in Bluff	Project manager
Pre Op Tasks	Mar-06	Order construction of pods and other stores for bait storage and loading site (if pod option is selected)	Project manager
Pre Op Tasks	Mar-06	Confirm availability of trucks/forklifts and drivers for container/ship loading	Project manager
Pre Op Tasks	Mar-06	Investigate and confirm accommodation on Taukihepa for bait-minding team and operational team	Project manager

Pre Op Tasks	Apr-06	Ensure all water supplies at mutton birders' huts are disconnected at the end of titi season	Project manager/TEC
Pre Op Tasks	Apr-06	Aerial works contract signed	Project manager - Kevin O'Connor/Aerial works contractor
Pre Op Tasks	Apr-06	Place order for bait	Project manager
Pre Op Tasks	Apr-06	Bait supply contract signed	Project manager - Kevin O'Connor/ACP
Pre Op Tasks	Apr-06	Period for bait transport vessel to be on standby confirmed and contract signed	Project manager
Planning	May-06	Consent application approved	Environment Southland/Southland District Council
Planning	May-06	Appeal period ends 30th May	Environment Court
Pre Op Tasks	May-06	Obtain internal approval/project sign-off (if DOC signoff necessary)	Project manager
Pre Op Tasks	May-06	Ensure the wooden pods have or will be constructed on time (if pod option selected)	Project manager
Pre Op Tasks	June -06	Calibrate spreader buckets/DGPS printouts	Project manager /Helicopter operator
Pre Op Tasks	June-06	Take representative samples of each bait batch and have assayed for toxicity	Wanganui DOC staff/ Project manager
Pre Op Tasks	June-06	Public notification	Project manager
Pre Op Tasks	Jun-06	Road freight bait to Bluff	Project manager /ACP
Pre Op Tasks	Jun-06	Complete period of quarantine for bait and other stores	Project manager /Gilly Adam
Pre Op Tasks	Jun-06	Transfer bait into the wooden pods for shipping (if pod option selected)	Project manager
Pre Op Tasks	Jun 06	Re-pack bait into 900kg pallets if tent option selected	Project manager
Pre Op Tasks	Jun-06	Transport bait to wharf and load on ship	Project manager
Pre Op Tasks	Jun-06	Unload bait and fuel at Taukihepa	Project manager /Project Team/Island Transport/Helicopter operator
Pre Op Tasks	Jun-06	Set up bait storage areas on Taukihepa and install 2-person bait-minding team on island	Project manager/Bait-minding team
Before Op	July-06	Upon receipt of favourable forecasts make decision to proceed with first	Project manager/Project team

		drop	
Before Op	July-06	Notify contractors, project team members of go ahead for operation	Project manager
Before Op	July-06	Notify consent authorities of go ahead	Project manager
Before Op	July-06	All personnel and helicopters arrive on the island at 1300 hrs on day preceding operation	Project manager
Before Op	Jun-06	Set up DGPS base station	Helicopter operator/ Project manager
Before Op	Jun-06	Fly island boundary	Helicopter operator/ Project manager
Before Op	Jun-06	Set up poison warning signs around islands	Project manager
Before Op	Jun-06	Pre operational briefing for all personnel on the islands	Project manager
Before Op	Jun-06	Make final decision on go ahead	Project manager
During Op	Jul-06	Monitor Health and Safety	Project manager
During Op	Jul-06	Commence bait application	Helicopter operator
During Op	Jul-06	Monitor and check DGPS printouts and order gaps reflown	Project manager/Helicopter operator
During Op	Jul-06	Hand lay bait in/under all buildings on islands	Project manager/bait laying team/task manager
During Op	Jul-06	Commence second drop in suitable weather, a minimum of seven days after first drop	Project manager
Post Op	Jul/Aug-06	Order vessel for clean up operation	Project manager
Post Op	Jul/Aug-06	Initiate cleanup	Project manager
Post Op	Jul/Aug-06	Dispose of toxic waste in Environment Southland landfill	Project manager
Post Op	Aug-06	Hold post-operation debrief	Project manager
Post Op	Oct-06	Reconnect birders' water supplies	Birders/Project manager
Post Op	Oct-06	Publish post-operation report	Project manager
Post Op	Mar-07	Carry out rodent presence/absence monitoring	Project Manager /NMK

Post Op	Apr-07	Make statement about success of operation	NMK

Appendix F: Island Biosecurity Plan, Agnew and Roberts, 2004

Island Biosecurity Plan: Southland Conservancy

22 November, 2004

Plan writers: David Agnew and Andy Roberts

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Invercargill

Department of Conservation
Te Papa Atawhai

Department of Conservation
Te Papa Atawhai

Approval

This Department of Conservation Island Biosecurity Plan for Southland Conservancy was approved by the Conservator, Southland for use within the Conservancy effective from 19th November, 2004.

Signature

Date 24/11/04

Amendments

When amendments are made to this plan the details are to be recorded in the electronic copy. Changes are also to be made to all printed copies of plan (refer to the distribution list).

Amendment date	Amendment details	Version	Signature of copy holder and date

Distribution List

Held by	Office:
Technical Support Manager (for Conservator)	Southland Conservancy Office
Programme Manager Biodiversity (for Te Anau Area Manager)	Te Anau Area Office
Programme Manager Biodiversity (for Murihiku Area Manager)	Murihiku Area Office
Programme Manager Offshore Islands (for Southern Islands Area Manager)	Southern Islands Area Office
Programme Manager Biodiversity	Stewart Island Field Centre
Ranger (Quarantine Store)	Quarantine Store, Southern Islands Area

Ranger, Kakapo Programme	Codfish Island/Whenua Hou
Ranger, Kakapo Programme	Chalky Island/Te Kakahu
SOP Co-ordinator	Southern Regional Office

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Introduction

Prevention of pest invasion is easier to manage than eradication of a pest.

Quarantine is risk management. Quarantine Standards should match the risk.

Contingency planning allows the best chance of preventing an invading pest becoming established - aim to overkill.

Attitude is everything - a plan is only as good as the people who use it.

0.1 Island Biosecurity Plan for Southland Conservancy

0.1.1 This plan covers biosecurity processes for pest invasion on the islands managed by the Department of Conservation in the Southland Conservancy. Te Anau, Murihiku and Southern Islands Areas of Southland Conservancy will implement this plan.

0.1.2 Quarantine and contingency operations seek to keep islands managed by the Southland Conservancy free from the effects of pests.

Pests can have massive ecological impacts, and islands are among the least modified and most valuable of conservation lands. This plan covers the following pests: rodents, mustelids, other mammalian pests, birds, reptiles, amphibians, invertebrates, weeds, disease and micro-organisms. The prevention of colonisation of islands by pests is an important activity.

0.1.3 The islands covered by this plan are located in:

- Te Anau Area between Awarua Point and Puysegur Point on the coast, including Breaksea, Chalky/Te Kakahu, and Secretary Islands. This plan also includes islands in Lakes Te Anau and Manapouri.
- Murihiku Area between Puysegur Point and Waikawa harbour, including Omaui and Pig/Tihaka Islands on the coast. This plan also includes islands in Lake Hauroko.
- Southern Islands Area includes Stewart Island/Rakiura and the islands adjacent to it, Solander Islands, and the Subantarctic Islands (Snares/Tini Heke, Auckland, Campbell/Motu Ihupuku, Antipodes and Bounty Islands).

There are > 1000 islands in Southland Conservancy which together cover > 100,000 hectares.

0.1.4 Unless stated otherwise within the standards in this Biosecurity Plan, all of the standards apply to all of the islands covered by this plan. The Department of Conservation will advocate for the use of the standards in this plan on islands in Southland Conservancy that are not under the Department's management.

0.1.5 If a standard in the biosecurity plan can not be met for a particular island trip or activity, then the Area Manager (or a delegate) may approve an alternate standard provided that:

- A specific risk assessment of the new standard has been carried out and documented.
- The risk of the new standard failing to protect the islands is no greater than the risk of the old standard failing to protect the islands.
- The new standard is approved prior to the trip or activity commencing.
- The new standard is reported to the SOP co-ordinator so that new best practice can be shared for use elsewhere.

Part I Risk Assessment

This section presents information in three categories:

1. Island groups: Island Management Groups in Southland Conservancy
2. Risk assessment
3. Public interest risks

1.1 Island management groups in Southland Conservancy

1.1.1 The following islands will not be covered by this plan and they will be managed as if part of the adjacent mainland:

- Islands in Bluff Harbour.
- Islands that are within 300m of the coast between Puysegur Point and Oraka Point (western end of Colac Bay).

1.1.2 There is one island, Ulva, with a pest invasion history. It will be managed with a prescriptive plan as detailed in this document.

1.1.3 Three island management groups will be used to manage biosecurity in Southland Conservancy. The following table lists island groups (as defined by where they are serviced from.)

Management Group	Islands	Serviced from
Fiordland	All islands along the coast from Big Bay to Puysegur Point, all islands in Lakes Te Anau and Manapouri	Te Anau Area Island Quarantine Store

Southern Islands {Note: includes islands administered by Murihiku Area Office].	Stewart Island/Rakiura, all DOC managed islands adjacent to Stewart Island/Rakiura, Codfish/ Whenua Hou, Solander, Titi Islands, Snares/Tini Heke, Auckland, Campbell/Motu Ihupuku, Antipodes, Bounty, and Islands in northern Foveaux Strait (Pig/Tihaka, Dog, Omaui, Centre Island/Rarotoka), islands in Lake Hauroko.	Southern Islands Quarantine Store
Stewart Island/Rakiura	All DOC managed islands adjacent Stewart Island/Rakiura, some Titi Islands.	Stewart Island Field Centre Workshop

1.2 Risk assessment

1.2.1 *Table 1: Risk Assessment for island groupings in Southland Conservancy.*

Consequence = potential impact to natural values on any island invaded (see figure 2, page 35).

Probability = perceived likelihood of pest invading any island in the group. Where the pest is already present in the group, this measure relates to islands in the group currently free of the pest.

Group: Fiordland			
Pest	**Present in the group**	**Consequences**	**Probability**
Rat	***Yes***	***High***	***High***
Mouse	***Yes***	***High***	***High***
Mustelid	***Yes***	***High***	***High***
Other mammals	***Yes***	***High***	***Medium***
Weka	***Yes***	***Medium***	***Medium***
Other Birds	***Yes***	**-**	**-**
Reptile/amphibian	***Yes***	**-**	**-**
Invertebrate	***Yes***	***Medium***	***Medium***
Weed	***Yes***	***High***	***High***
Micro-organism / disease	***Yes***	***Medium***	***Medium***

Group: Southern Islands

Pest	**Present in the group**	**Consequences**	**Probability**
Rat	***Yes***	***High***	***Medium***
Mouse	***No****	***High***	***High***
Mustelid	***No***	***High***	***Low***
Other mammals	***Yes***	***High***	***Low***
Weka	***Yes***	***High***	***Medium***
Other Birds	***Yes***	**-**	**-**
Reptile/amphibian	***Yes***	**-**	**-**
Invertebrate	***Yes***	***Medium***	***Medium***
Weed	***Yes***	***High***	***High***
Micro-organism / disease	***unknown***	***Medium***	***Medium***

* Mice present on Auckland Island and two main islands in the Antipodes group.

Group: Stewart Island/Rakiura

Pest	Present in the group	Consequences	Probability
Rat	***Yes***	***High***	***High***
Mouse	***No****	***High***	***High***
Mustelid	***No***	***High***	***Medium***
Other mammals	***Yes***	***High***	***Medium***
Weka	***Yes***	***Medium***	***Medium***
Other Birds	***Yes***	**-**	**-**
Reptile/amphibian	***Yes***	**-**	**-**
Invertebrate	***Yes***	***Medium***	***Medium***
Weed	***Yes***	***High***	***High***
Micro-organism / disease	***unknown***	***Medium***	***Medium***

* Mice present at Halfmoon Bay (occasional records) and on salmon farm barges at Big Glory Bay.

1.2.2 DOC-managed islands with huts in Southland Conservancy.

Management group	Islands
Fiordland	Breaksea, Anchor*, Chalky /Te Kakahu*, Secretary.
Southern Islands	Stewart Island/Rakiura*, Codfish/Whenua Hou*, Snares/Tini Heke (North East Island), Enderby, Auckland, Adams, Campbell/Motu Ihupuku, Antipodes.

* Denotes islands with Resident Rangers. Chalky/Te Kakahu will have a resident ranger until April 2005. From April 2005 the ranger will be resident on Anchor Island.

1.3 Public interest risks

Public access restrictions

No extra restrictions are placed on public access to any islands. There are no community groups likely to have significant concerns about the access restrictions or other quarantine measures.

1.3.1 The following islands or groups of islands are in private (or in part private) ownership and have important conservation values.

Island or group	Type of ownership
Stewart Island/Rakiura	Some freehold land (many owners), iwi (multiple owners, Rakiura Maori Land Trust, etc), DOC administered land, Southland District Council Land.

Ulva, Bravo	Some freehold land (Hunter Family Trust), DOC administered land.
Titi Islands, Ruapuke Island Group, Centre Island/Rarotoka, Ernest Island (outer), various other islands.	Iwi (multiple owners, Ngai Tahu, Rakiura Titi beneficiaries, Rakiura Maori Land trust, etc)
Various islands along Southland coast.	Some freehold land (many owners), Iwi (multiple owners), DOC administered land, Southland District Council, Invercargill City Council, Maritime Safety Authority.

The biosecurity standards in this plan will also be used to advocate for improved biosecurity standards on privately owned island or islands where part of the land is in private ownership.

Part II Standards for island biosecurity

Instructions

- All standards in this Island Biosecurity Plan are mandatory and
- Apply to all islands covered by the plan (unless stated otherwise within the individual standard).
- A process for temporary departure from a particular standard is provided in section 3.3 of the Island Biosecurity SOP (wgncr-46409).

2.1 General standards

Best Practice Manual sections:

2.2 Pest-proof rooms
5.2 Training staff
(refer to glossary or follow link)

2.1.1

- Operational training so that DOC staff are proficient in island biosecurity procedures to be implemented.
- DOC staff are to be proficient in operational procedures before becoming Trip Leaders or Resident Rangers.
- Responsibility: Programme Manager

2.1.2

- A DOC representative is required to be present on all island trips.
- Responsibility: Programme Manager
- Islands: All Subantarctic Islands, Breaksea group (Fiordland), Chalky/Te Kakahu, Codfish/Whenua Hou, Solander Islands, Bench Island.

2.1.3

- Overnight stays are prohibited at the following islands (unless for management purposes).
- Responsibility: Programme Manager
- Islands: All Subantarctic Islands, all Minimum Impact Islands (see Appendix 9), Codfish/Whenua Hou, Bench and Ulva Island Scenic Reserve (excluding private property).

2.1.4

- Huts should be built only when absolutely necessary; a specific risk assessment to be carried out and documented in each case.
- Use of temporary huts should be considered over permanent huts. If a new hut is being built, then the whole hut should be rodent proofed and demolition material should not be used for building (unless from the island in question).
- Responsibility: Area Manager

2.2 Quarantine store standards

Best Practice Manual sections:

2.1 Setting up and managing a quarantine store
2.2 Pest-proof rooms
2.5 Translocation and quarantine measures

2.2.1

- Pest-proof storage (quarantine store) is required for all locations that service islands.

Quarantine stores must (as much as possible) be kept free of rodents, invertebrates, weed seeds, or disease/micro-organism carriers through a regular planned programme of cleaning, trapping, baiting, spraying, fumigation, and surveillance. Sticky pads/traps should be used in the store at all times.

- All doors, windows and other openings must be tightly fitting and have a metal lip to prevent rodents gnawing through. There shall be no gaps greater than 5 mm around the walls and doors etc.
- A detailed quarantine maintenance plan for each store is set out in Appendix 4.
- Responsibility: Programme Manager
- Quarantine store(s) are located at:
  - 65 Eye Street, Invercargill, for Southern Islands.
  - Stewart Island Field Centre for Stewart Island/Rakiura.
  - 210 Milford Road, Te Anau, for Fiordland.

2.2.2

- A building that houses a quarantine store **may** also be used for other storage, provided a specific risk assessment of this use is carried out and documented.
- The quarantine store must occupy a room of its own within the building.
- Quarantine procedures have priority over all other activities, they are to be maintained and a specific check for pests shall be carried out prior to use for island trips.
- Responsibility: Programme Manager
- Quarantine store(s): All
  - 65 Eye Street, Invercargill
  - Stewart Island Field Centre
  - 210 Milford Road, Te Anau

2.2.3

- Instructive signs are required at all the quarantine stores (Eye Street, Milford Road, Halfmoon Bay) and they should detail operational requirements (e.g. keep doors shut at all times).
- Instructive signs are required on the DOC boats Jester and Southern Winds, reminding passengers to check for pests.
- Responsibility: Programme Manager

• Quarantine stores:	All • 65 Eye Street, Invercargill. • Halfmoon Bay, Stewart Island/Rakiura. • 210 Milford Road, Te Anau.
• Boats:	MV Jester, MV Southern Winds.

2.2.4

- High standards of housekeeping are required at all quarantine stores.
- All rubbish removed from islands is to be disposed of before containers are returned to the quarantine store.
- Where there is a known biosecurity risk on an island (which is absent from the mainland or other islands in the group), the same standards used when entering the island must be applied when exiting it.
- All equipment and containers are to be cleaned of dirt and checked for invertebrates and seeds (as much as practicable) before return to a quarantine store.
- Quarantine stores may have a designated area marked for the temporary storage for items returned from islands, prior to a final cleaning.
- Responsibility: Trip Leader, Resident Ranger or Programme Manager

2.2.5

- All equipment and containers are to be stored and cleaned in a "return quarantine store" and to be cleaned before return to the quarantine store (so as not to infect the store and then other islands).
- Responsibility: Trip Leader or Programme Manager
- Island(s): All islands in Southern Islands management group.

2.3 Bait station and pest detection methods

Best Practice Manual sections:

1.1 Pest control and detection methods
1.2 Mammals and birds
1.3 Invertebrate detection
1.4 Weeds
1.5 Disease and micro-organism detection
1.6 Bait stations, traps, tracking tunnels, indicators, etc.
1.7 Other Best Practice Manuals
2.1.6 Example quarantine store: Te Anau Area Office
2.3 Pest-proof rooms
3.1 Rodent control methods adapted for island situations
3.2 Pest invasion kits
4.1 Programmed surveillance

2.3.1

- Permanent bait stations and/or trap sets must be maintained and regularly serviced at all sites listed below (see Table 2).
- Consideration should be given to establishing surveillance and/or contingency measures at Antipodes, Adams, Enderby and Snares Islands.
- Traps or baits should only be used when their servicing can be maintained, the trap will still catch effectively and the bait quality will last through the servicing period.
- The risks to non-target species should be considered.
- Use of toxins must comply with Animal Pest SOP's (QD-NH 3003).
- All pest captures or bait take are to be reported in writing to the programme manager.
- Responsibility: Programme Manager

Table 2: Trap and Bait Station Requirements.

Southern Islands management group						
Location	**Trap or bait**	**Target pest**	**Number**	**Spacing**	**Servicing**	**Bait type**

	station type					
Eye Street Quarantine Store	IPM bait stn	Rat	4	n/a	monthly	P/Butter
	IPM bait stn	Mouse	20	n/a	monthly	P/Butter
	IPM bait stn	Rat/mouse	20	n/a	monthly	Pestoff
	Sticky pads	Inverts	10	n/a	monthly	-
Plaza Supervalue	IPM bait stn	Rat/mouse	10	n/a	monthly	Pestoff
	Sticky pads	Inverts	5	n/a	monthly	-
South East Air Hanger	IPM bait stn	Rat/mouse	5	n/a	monthly	Pestoff
Codfish Island mooring point (Sealers Bay)	Snap trap & poison tunnel	Rat	21	50	monthly	Talon, P/Butter & oats
Codfish Island Hut Area (Sealers Bay)	Snap trap	Rat	9	n/a	fortnightly	P/Butter & oats
	Snap trap	Mouse	17	n/a	fortnightly	P/Butter & oats
	IPM bait stn	Rat/mouse	25	50	fortnightly	Talon
Stewart Island/Rakiura management group						
Halfmoon Bay Quarantine Store	Victor snap trap	Rat/mouse	3	N/A	monthly	P/Butter
Wharf Halfmoon Bay	IPM bait stn	Rat	6	50m	monthly	Diphacinone
Wharf Golden Bay	IPM bait stn	Rat	7	50m	monthly	Diphacinone
Wharf Thule	IPM bait stn	Rat	11	50m	monthly	Diphacinone
Ulva Island (Post Office Bay)	IPM bait stn	Rat	13	50m	monthly	Pestoff
Ulva Island (Post Office Bay)	Victor snap traps in corflute tunnels.	Rat	18	50m	monthly	P/Butter & 1 Egg
Ulva Island (West End)	Victor snap traps in corflute tunnels.	Rat	9	50 - 300m	monthly	P/Butter & 1 Egg
Ulva Island (Boulder Beach)	Victor snap traps in corflute tunnels.	Rat	4	50m	monthly	P/Butter & 1 Egg
Ulva Island (Sydney Cove)	Victor snap traps in corflute tunnels.	Rat	2	100m	monthly	P/Butter & 1 Egg
Ulva	Victor snap	Rat	8	50m	monthly	P/Butter &

Island (The Snuggery)	traps in corflute tunnels.					1 Egg
Ulva Island (Roger Bay)	Victor snap traps in corflute tunnels.	Rat	3	50m	monthly	P/Butter & 1 Egg
Ulva Island (East End)	Victor snap traps in corflute tunnels.	Rat	6	50m	monthly	P/Butter & 1 Egg
Fiordland management group						
Milford Road Quarantine Store	IPM bait stn	Rat/mouse	6	N/A	monthly	Pestoff, Storm, Contrax
	Glue boards	insects	3	N/A	monthly	N/A
MV Southern Winds	IPM bait stn	Rat/mouse	1	back deck	monthly	Pestoff, Storm
	Victor snap trap	Rat/mouse	6	held in stock	daily as needed	
Fiordland Helicopters Hangar	IPM bait stn	Rat/mouse	1	N/A	2 monthly	Storm, Contrax
Deep Cove Wharf	IPM bait stn	Rat/mouse	2	N/A	monthly	Racumin paste sachets
Deep Cove	Mk IV Fenn trap	Rat/Stoat	60	25m	monthly	
Blanket Bay Islet Wharf, Secretary I.	IPM bait stn	Rat/mouse	2	N/A	3 monthly	Storm, Contrax
Bauza Island Utah Island	Mk IV Fenn trap Mk IV Fenn trap	Rat/Stoat Rat/Stoat	36 4	150m NA	6 monthly 6 monthly	Egg Egg
Breaksea Island	Mk IV Fenn trap	Rat/Stoat	18	50m	6 monthly	Egg
Hawea Island	Mk IV Fenn trap	Rat/Stoat	4	N/A	6 monthly	Egg
Anchor Island	Mk IV Fenn trap	Rat/Stoat	100	100m along trap lines	6 monthly	Egg
Luncheon Cove Barges, Anchor Island	IPM bait stn	Rat/mouse	2	N/A	3 x per year	Talon
Useless Island	Mk IV Fenn trap	Stoats/ Rats	2	N/A	2 x per year	Egg
Stop Island	Mk IV Fenn trap	Stoats/ Rats	2	N/A	2 x per year	Egg
Prove Island	Mk IV Fenn trap	Stoats/ Rats	2	N/A	2 x per year	Egg
Passage Island (Dusky)	Mk IV Fenn trap	Stoats/ Rats	2	N/A	2 x per year	Egg

Nomans Island	Mk IV Fenn trap	Stoats/ Rats	2	N/A	2 x per year	Egg
3 x islands to NE Anchor Island	Mk IV Fenn trap	Stoats/ Rats	2 per island	N/A	2 x per year	Egg
Chalky/Te Kakahu	Mk IV Fenn trap	Rat/Stoat	40	50m	2 x per year.	Egg
	Tracking tunnel	Rodent / Stoat	4	N/A	monthly	Egg
North Passage Island (stepping stone island)	Mk IV Fenn trap	Rat/Stoat	60	50m	6 monthly	Egg
South Passage Island (stepping stone island)	Mk IV Fenn trap	Rat/Stoat	70	50m	6 monthly	Egg
Great Island (Mainland)	Mk IV Fenn trap	Rat/Stoat	100	50m	2 x per year.	Egg
Snares Island	IPM bait stn	Rat/Mouse	12	n/a	Ad hoc	Talon
Campbell Island	IPM bait stn	Rat/Mouse	20	n/a	annually	Talon
	Tracking tunnel	Rat/Mouse	10	n/a	annually	n/a
	Gnaw sticks	Rat/Mouse	20	n/a	annually	n/a

2.3.2

- Unless identification of the pest is obvious, a voucher specimen with full details should be collected and sent to an expert for identification.
- Responsibility: Programme Manager

2.3.3

- Wharves, mooring blocks and lines are not to be set up by the Department on/around any islands without a specific risk assessment and approval by the Area Manager.
- The Department will advocate that any other permanent moorings should be restricted to beyond 300m from shore.
- Responsibility: Area Manager

2.4 Standards for preparing for an island visit

Best Practice Manual sections:

1.1 Pest control and detection methods
1.3 Invertebrates
1.4 Weeds
1.5 Diseases and micro-organisms
2.1 Setting up and managing a quarantine store
2.2 Pest proof rooms
2.3 Pest-proof containers
2.4 Frog (*Leiopelma*) chytrid infection protocols
2.5 Translocation and quarantine practice
3.2 Pest Invasion kits
4.2 Weed surveillance
5.3 Island Entry Permits

Informed risk-assessment based upon local conditions, is the key step towards reducing risk from potential new invasive species or disease. Risk assessment should consider the likelihood of such things as seed germination, through to production of viable seed from fruit where seeds are eaten (e.g., tomato, kiwifruit, blackberries). Consider issues such as foodstuffs with the potential for plant disease (disease, virus [e.g. cucumber mosaic virus], invertebrates, etc) or poultry products where avian disease may be transferred. Check with botanical experts and others. Also consider the amount of natural bird migration in the area as weed or disease risk or spread may be associated with this. A common-sense approach is required where there are resident staff with vegetable gardens or island restoration programmes involving plantings etc. Islands that have been farmed in the past may be less susceptible to possible disease spread through soil being brought in.

2.4.1

- When a number of islands are being visited, the islands that are most pest-free should be visited before visiting islands where pest species are present.
- Responsibility: Trip Leader or Programme Manager

2.4.2

- All island visitors and transport providers must be informed of requirement to adhere to entry permit conditions and biosecurity procedures.
- The following pamphlets are to be issued to each Trip Leader (e.g. Pest and Disease Quarantine.)
- The following pamphlet is to be issued to each expedition member: Minimum Impact Code pamphlet, "Help protect New Zealand's offshore islands" (see Appendix 6).
- The Trip Leader (or Resident Rangers) may be asked to carry out instructions from an Incident Controller (under CIMS structure) until a pest invasion response team arrives.
- Make sure that all Trip Leaders (or Resident Rangers) know that they could be called on to carry out some contingency responses.
- Responsibility: Programme Manager

2.4.3

- All equipment and supplies (as practicable) for islands must be stored, inspected and packed in a quarantine store.
- All personnel travelling to an island must travel via the appropriate quarantine store for a biosecurity check using the Self-Audit Check Sheet (Appendix 3).
- A suitably qualified DOC staff person must visually inspect all equipment and supplies for soil, seeds and plant material, invertebrates and rodents, etc.
- All bags, packs, etc must have all openings securely fastened and must not have any holes and they must be packed or re-packed the day of departure.
- Persons unable to travel via a quarantine store must have this approved by the Programme Manager but must still use the Self-Audit Check Sheet (Appendix 3).
- Responsibility: Programme Manager

2.4.4

- Personal luggage and gear (e.g. boots, packs, bags. socks, jackets, trousers, and all pockets etc) must be clean and free of soil, seeds, etc.
- All boots must be thoroughly scrubbed prior to travel to an island.
- All tents must be cleaned, exposed to sunlight and dried and be thoroughly checked for soil, seeds and plant material, invertebrates and rodents, etc.
- Any equipment and materials considered to be high-risk may be subjected to fumigation.
- All equipment used for aquatic work (e.g., nets) must be free from any fragments of weed as well as any other aquatic organisms.
- Responsibility: Programme Manager

2.4.5	• Any clothing and equipment that has been in contact with birds (especially aviary birds, waterfowl, poultry) and/or reptiles must be disinfected with Jeyes™ or Virkon™. • On no occasion should there be travel from a known disease outbreak area to an island without seeking specific advice from a recognized expert or a veterinarian. • Responsibility: Trip Leader or Programme Manager
2.4.6	• Footwear to be thoroughly scrubbed and washed in disinfectant (e.g., Jeyes or Virkon™ biocide foot baths). • Sniffer-dogs may be used to check for the presence of rodents or mustelids in all equipment and goods prior to departure (this is not a general requirement, but a recommendation that the need is assessed on a case by case basis). • Responsibility: Trip Leader or Programme Manager • Islands: All Subantarctic islands
2.4.7	• Every person visiting islands categorised as 'minimum impact islands' or other specified islands in Southland Conservancy is supplied with sealable plastic containers for transporting gear.
2.4.8	• All fruit and vegetables taken to the islands are to be purchased from a supermarket. • No fruit or vegetables from home gardens should be taken to the islands as they may pose a higher level of pest risk than commercially grown crops. • Vegetables which have any soil attached should not be taken e.g. unwashed potatoes. • For leafy vegetables, removal of outside leaves or shrink-wrapping may be considered. • Any slugs, snails or other invertebrates found on any vegetables should be killed and sealed as rubbish for removal from islands. • Responsibility: Trip Leader or Programme Manager
2.4.9	• Islands where poultry products are prohibited: • No poultry meat to be taken to Subantarctic Islands (eggs are permitted but shells <u>must</u> be sealed as rubbish and removed from the islands).

	• Islands where "home grown" vegetables are prohibited:	• Home grown vegetables are not to be taken to any island covered by this plan. • Vegetables with soil attached shall not be taken to any island. • Shrink wrapping and removal of outside leaves should be considered for leafy vegetables.
	• Responsibility: Trip Leader or Programme Manager	
2.4.10	• Disposal of high risk food waste.	• Eggshells, potatoes and the seeds from "pumpkin type" vegetables should be sealed as rubbish and removed from all islands covered by this plan.
	• Responsibility: Trip Leader or Programme Manager	

2.5 Standards for dog use on islands

Best Practice Manual sections:

1.6 Bait stations, traps, tracking tunnels, indicators, etc.
2.6 Dog vaccination

2.5.1

- Prior to any use of dogs at an island, a risk assessment of disease transfer to resident wildlife, or the risk of dogs becoming a vector for a disease already present on the island, is to be carried out.
- All dogs must be certified for DOC use.
- Dogs should be in healthy condition. If there are any concerns, veterinary advice should be sought at least six weeks before departure.
- Make sure that dogs' coats and paws are free of any seeds.
- Responsibility: Trip Leader or Programme Manager

2.5.2

- Dogs may need to be screened for pathogens.
- Dog owners must demonstrate compliance with a vaccination schedule, for each dog, as detailed by a veterinarian based on the risk assessment. A sample vaccination schedule is provided in the Best Practice Manual.
- Responsibility: Programme Manager

- Islands where dogs may pose a disease risk:
  - Snares Island/Tini Heke group
  - Auckland Island group
  - Campbell Island/Motu Ihupuku group

2.6 Rodent and invertebrate proofing standards

Best Practice Manual sections:

1.1 Pest control and detection methods
1.2 Mammals and birds
1.3 Invertebrates
2.1 Setting up and managing a quarantine store
2.2 Pest proof rooms
2.3 Pest-proof containers
2.5 Translocation and quarantine practice
3.2 Pest Invasion kits

2.6.1

- Rodent proof containers must be used to transport equipment and stores (as practicable) to and from island(s).
- Plastic containers, with lids that can be tightly sealed, are the preferred option. However containers may also be wooden or other hard material. Cardboard boxes may also be used for some islands providing the following conditions are satisfied.
- The cardboard containers can be tightly sealed i.e. there are no holes (banana boxes are not suitable), and all edges and joins are sealed with parcel tape.
- Cardboard containers are only to be used when there is little chance of water damage or tearing of the box.
- Should the box be water damaged or ripped, it must not be used again and must be replaced.
- Responsibility: Programme Manager

2.6.2

- Rodent proof containers must only be wooden or plastic with lids that can be tightly sealed.
- Responsibility: Programme Manager

- Islands: All Subantarctic Islands, Solander Islands, Codfish/Whenua Hou.

2.6.3

- All packing containers must be at least as tightly sealed as those used for the rodent proofing of stores.
- Lids must be securely fastened so they don't lift or fall off.
- Stores and equipment are to be held at transit points for the shortest time possible.
- Shrink-wrapping, sprays or fumigation may be required for some supplies that may attract invertebrates.
- Responsibility: Programme Manager

2.7 Checking & response standards for bulky items, buildings, boats and aircraft

Best Practice Manual sections:

1.1 Pest control and detection methods
1.2 Mammals and birds
1.3 Invertebrates
1.4 Weeds
1.5 Diseases and micro-organisms
2.1 Setting up and managing a quarantine store
2.2 Pest proof rooms
2.3 Pest-proof containers
2.4 Frog (*Leiopelma*) chytrid infection protocols
2.5 Translocation and quarantine practice

2.7.1

- All items should be visually checked prior to transit and again on arrival at the island.
- Items small enough must go through the quarantine store for checking.
- Items to be checked, double-bagged, and sealed. Wrapping the item in cardboard may be suitable if all joins are sealed with parcel tape.
- Responsibility: Programme Manager

2.7.2

- All items that can not go through a quarantine store should be visually checked prior to transit and on arrival at the island.
- Bulky items (such as construction materials) require a separate biosecurity procedure (approved by the Area Manager). For example:
  - ◊ transport on the day of departure,
  - ◊ visual check,
  - ◊ insecticide on hand at inspection,
  - ◊ any storage sites checked
  - ◊ use of bait stations,
  - ◊ on-going weed surveillance at the site, etc.
- No contaminated construction materials to be used, in particular, all gravel must be from a source that is as weed-free as possible.
- Responsibility: Programme Manager

2.7.3

- The hut shall be thoroughly inspected for any pests, and may be fumigated prior to transit.
- Huts should have a separate biosecurity plan sign-off by Area Manager before they are taken to an island.
- Responsibility: Programme Manager

2.7.4

- Expert advice should be sought to identify and respond to the infestations in all cases.
- Trapping or poisoning should be expanded at once. Invertebrate sprays and/or fumigation should be used where an infestation of invertebrate pests is known or suspected.
- Use the Pest Invasion Form (Appendix 2).
- The programme manager must consider the immediate halting of servicing islands from the store.
- Any island trips should not depart until it is known that the pests have not infected the stores and equipment.
- Approval to proceed can only be given by the Area Manager.
- Responsibility: Programme Manager

2.7.5

- Equipment or supplies may be loaded on board at night, or boats may depart at night, only if the wharf is well lit, bait stations are maintained in the area (or on the boat) and all supplies have gone through a quarantine store or biosecurity procedure.
- A DOC representative must authorise and supervise all loading and unloading.
- Boats (used for servicing islands) are to be kept free (as much as practicable) of pest seaweed as well as any other aquatic pest organisms.
- Responsibility: Programme Manager

2.7.6

- Vessels are to be kept free of pest seaweed as well as any other aquatic pest organisms through contract conditions with the boat owner or for DOC boats less than 6 metres to be steam cleaned.
- Responsibility: Programme Manager

2.7.7

- Pilots to be made aware of the risks of pest invasion.
- Visual check of aircraft to check luggage space etc. for the presence of pests (including helicopter nets).
- Ensure helicopters take-off from sites where weeds are controlled.
- If rubbish is transported in an aircraft (or in a helicopter net) from a pest-infested island it must be securely packed with lids tightly sealed.
- Responsibility: Programme Manager

2.7.8

- Programme Manager only permits departure of vessels after sign-off using the Self-Audit Check Sheet (Appendix 3).
- Responsibility: Programme Manager

2.8 Pests found during transit

Best Practice Manual sections:

1.1 Pest control and detection methods
2.1 Setting up and managing a quarantine store
2.2 Pest proof rooms
2.3 Pest-proof containers
3.1 Rodent control methods adapted for island situations
3.2 Pest Invasion kits

2.8.1

- If any pest is detected during travel to, or on arrival at an island, then the planned visit must not proceed until that pest has been killed and pest free status of the stores or vessel is confirmed by the Trip Leader (or Resident Ranger) to the Programme Manager.

- Approval to proceed is with the Area Manager, but expert advice should be sought in all cases.
- A voucher specimen with full details should be collected and sent to an expert for identification (if necessary).
- The Trip Leader or the Resident Ranger may be asked to carry out instructions from an Incident Controller (under CIMS structure) until a 'pest invasion response team' arrives.
- Make sure that all Trip Leaders and Resident Rangers know that they could be called on to carry out some contingency responses.
- Responsibility: Trip Leader, or Resident Ranger or Programme Manager

2.9 Biosecurity standards while on the island

Best Practice Manual sections:

1.1 Pest control and detection methods
1.2 Mammals and birds
1.3 Invertebrates
1.4 Weeds
1.5 Diseases and micro-organisms
2.2 Pest proof rooms
2.5 Translocation and quarantine practice
3.1 Rodent control methods adapted for island situations
5.1 Advocacy
5.3 Entry Permits

2.9.1

- All huts on islands should be rodent-proof (or have a rodent-proof room) where stores are unpacked and checked immediately after arrival.
- All doors, windows and other openings must be tightly fitting and have a metal lip to prevent rodents gnawing through. There shall be go gaps greater than 5 mm around the walls and doors etc.
- The rodent proof hut (or room) shall have traps set when stores are being unpacked, and/or rodent bolt holes (refer to glossary) in the corner of each room.
- Responsibility: Programme Manager
- Island(s): This standard applies to all islands with huts.

2.9.2

- Where there are more stores and equipment than can be checked at one time (or where the supplies are too large), an alternate island specific checking standard must be developed and approved by the Area Manager. (e.g. visual inspection, checklist, pre-set traps at specified site, etc)
- Responsibility: Programme Manager

2.9.3

- Equipment should be unpacked within a closed tent, where practicable, or
- The packing of stores must include a check and sealing process with a written checklist in a quarantine store on the mainland or an adjacent island.
- Responsibility: Programme Manager
- Island(s): This standard applies to all islands with no huts.

2.9.4

- Where visits between islands (of different pest status) within the same island group occur, biosecurity standards must be applied as if moving from the mainland to that island (and/or back again).
- The number of such visits must be kept to an absolute minimum.
- Responsibility: Trip Leader or Programme Manager

2.9.5

- All rubbish (biodegradable or not) is to be securely sealed so that access for pests is restricted.
- High standards of housekeeping are required on all islands.
- Responsibility: Trip Leader, Resident Ranger, or Programme Manager

2.9.6

- All rubbish (biodegradable or not) should be packed securely and removed from the island.
- A regular programme of rubbish removal from staffed islands (or islands with high visitor numbers) is required.
- Responsibility: Trip Leader or Resident Ranger
- Island(s): Breaksea, Codfish/Whenua Hou, Chalky/Te Kakahu, Bench, Ulva, Auckland Islands group, all Minimum Impact Islands, and all other islands where safe disposal at sea is not an option.

2.9.7

- All non-biodegradable rubbish should be removed from the islands.
- Biodegradable rubbish (e.g., peelings, cores, composting toilet wastes, etc) may be:
  - ◊ buried at least 15 cm deep (only if a risk assessment has been carried out);
  - ◊ or disposed of at sea (unless in a marine reserve) on the out-going tide;
  - ◊ or may be boiled to kill living tissue and then buried or disposed at sea.
- High risk foods (e.g., potatoes, seeds, egg shells) should be removed from the islands.
- A regular programme of rubbish removal from staffed islands (or islands with high visitor numbers) is required.
- Responsibility: Trip Leader or Resident Ranger
- Island(s): All islands covered by this plan except those specified above in section 2.9.6.

2.9.8

- Paper and cardboard may be burnt in a stove or an incinerator on the island provided that a specific risk assessment of the use of the stove or incinerator has taken place and its use has been approved by the Area Manager.
- Responsibility: Trip Leader or Resident Ranger
- Island(s): Breaksea, Codfish/Whenua Hou, Chalky/Te Kakahu, Enderby, Auckland, Campbell/Motu Ihupuku.

2.9.9

- If rubbish is transported from an island with pests to a pest-free island the rubbish should be left at the nearest adjacent pest-infested site prior to going to the pest-free island.
- Or rubbish should be sealed and securely held in the boat or aircraft while landings are made.
- Responsibility: Programme Manager

2.10 Standards for species management on islands

Best Practice Manual sections:	1.5.2 Diseases and micro-organisms (handling species) 2.5 Translocation and quarantine practice 5.1 Advocacy 5.3 Entry Permits

2.10.1 Any work involving wildlife must comply with the Wildlife Health Management SOP NH-1176	• The standards within this SOP shall apply. • Responsibility: Trip Leader or Programme Manager	
2.10.2 Captive management facilities on islands	• Maintain high cleanliness standards at all captive facilities on islands e.g. ensuring that facilities can be thoroughly disinfected and that separate footwear and overalls are used. • Responsibility: Programme Manager	
2.10.3 Translocations must comply with Translocation SOP QD-NH 1042	• The standards within this SOP shall apply. • Responsibility: Programme Manager	
2.10.4 Plant introductions	• All new plant introductions should be propagated in sterile potting mix or bare-rooted. • Responsibility: Programme Manager • Island(s): All islands **except** Centre Island/Rarotoka and other highly modified islands where large scale restoration is taking place.	

2.11 Advocacy standards

Best Practice Manual sections:	5.1 Advocacy

2.11.1

- Interpretative signs that outline:
  - ◇ island biosecurity principles,
  - ◇ the values of pest-free islands and
  - ◇ preventative measures (encouraging visitors to take responsibility for own actions).

  These are required on Stewart Island/Rakiura at all major public departure points and on Ulva Island.
- Responsibility: Programme Manager

• Departure points:	• Halfmoon Bay wharf, Golden Bay wharf, Thule wharf, Freshwater hut and jetty, Rakeahua jetty, Fred's Camp hut. • All water taxis display small version of same sign.
• Island(s):	• Ulva Island

2.11.2 Pamphlets and other publicity

- A pamphlet on values of islands (benefits of pest free islands), risks, how to minimize risks, and other biosecurity measures for all island visitors should be published. (e.g. *"Help protect New Zealand's offshore islands from pest animals, plants and insects"*, *"Pest and Disease Quarantine"*, *"Minimum Impact Code"*, etc. Appendix 6).
- The pamphlet(s) should be given to island visitors prior to their departure.
- Pamphlets to be placed in DOC boats, information centres, ports, wharves and with concessionaires and other tourist operators.
- Pamphlets may also be distributed to people who live on islands with high natural values.
- Posters on values of island, risks and how to minimize risks may also be published.
- Responsibility: Programme Manager
- Island(s): All islands where an entry permit is required:
  all Subantarctic Islands, Breaksea Island group (Fiordland), Chalky/Te Kakahu, Codfish/Whenua Hou, Solander Islands, and Bench Island..

2.11.3 Public awareness programmes

- An awareness programme is to be developed to target high-risk user groups.
- Responsibility: Programme Manager

• Island(s) where a public awareness programme would be beneficial:	All islands covered by this plan.
• Target groups include:	• DOC staff; • Home owners (Ulva); • Residents (Stewart Island/Rakiura); • Visitors to the islands; • Local fishers; • Iwi; • Muttonbirders: • Maritime Safety Authority; • Coast Guard; • Charter boat operators; • Concessionaires; • Dive Clubs; • Boating Clubs; • Local marine radio; • Researchers; • Helicopter pilots;
• The programme will use the following methods:	• Talks by staff members; • Open days on island(s); • Volunteer holidays; • Concessionaires' briefing for visitors; • Use of honorary rangers; • Static displays; • Newspaper articles on regular basis over summer period; • Press releases to promote islands; • Radio advertisements;

Part III Surveillance

3.1 Setting surveillance standards

Best Practice Manual sections:

4.1 Programmed surveillance
4.2 Weed surveillance

3.1.1 Weed surveillance plans

- All weed surveillance work is to follow the standards in the appropriate Area Weed Surveillance Plans (see hyperlinks in Appendix 5).
- Responsibility: Programme Manager

3.1.2

- The pest trapping and poisoning regime outlined in Table 2 (Page 12) of this plan is also used for pest surveillance purposes.
- Stoat surveillance will be carried out at Stewart Island/Rakiura (as set out below in Table 3).
- No other surveillance sites will be permanently established unless new threats become obvious.
- Consideration should be given to establishing surveillance and/or contingency measures at Antipodes, Adams, Enderby and Snares Islands.
- Responsibility: Programme Manager

Table 3: Surveillance only sites.

Location	Target pest	Technique	Site	Frequency
Stewart Island/Rakiura	Stoat	Dog search	Nth coast, Freshwater/ Mason Bay	Annually

3.1.3

- All rat &/or mice free islands that are visited for more than 5 consecutive nights are to be checked for rodent (rat &/or mice) presence (at least once per year if visited).
- When visiting rat &/or mice free islands for less than five nights, checking for rodents is optional, although islands must be checked at least every 5 years if visited.
- Techniques to be used can include trapping, tracking tunnels, gnaw sticks, or specific checks for rodent sign if non-target issues are a risk.
- Minimum rate of 15 trap or tunnel nights (or other techniques) run for 3 nights per 100 ha of island. This rate only applies for islands of up to 500 ha.
- For islands larger than 500ha, use the above rule as a minimum rate, but PM must consider increasing this rate if practical.
- Responsibility: Programme Manager
- Island(s):
  - All rodent free islands covered by this plan except Ulva Island.

3.1.4

- DOC staff who work on islands are to be trained to a level of proficiency in the detection and recognition of pests and pest sign.
- Training should include fieldwork with experienced staff as well as use of current references to pest identification and access to expert advice.
- Responsibility: Programme Manager

3.1.5

- The results of all surveillance monitoring is to be reported to the Area Manager by compiling the Pest Invasion Form or other operational reports that relate to surveillance annually. This will form part of an annual report on Invasion Events in the Conservancy.
- Responsibility: Programme Manager

3.1.6

- All invertebrate or disease surveillance work is to follow the standards in any appropriate Area/Conservancy invertebrate or disease surveillance plans that may already exist, - e.g. Hooker's sea lion disease monitoring sampling programme on Enderby Island (reference: Baker, A, 1999: *Unusual mortality of New Zealand sea lion, Phocarctos hookeri, Auckland Islands, January-February 1998*, Department of Conservation).
- Responsibility: Programme Manager
- Island(s):
  - Enderby Island

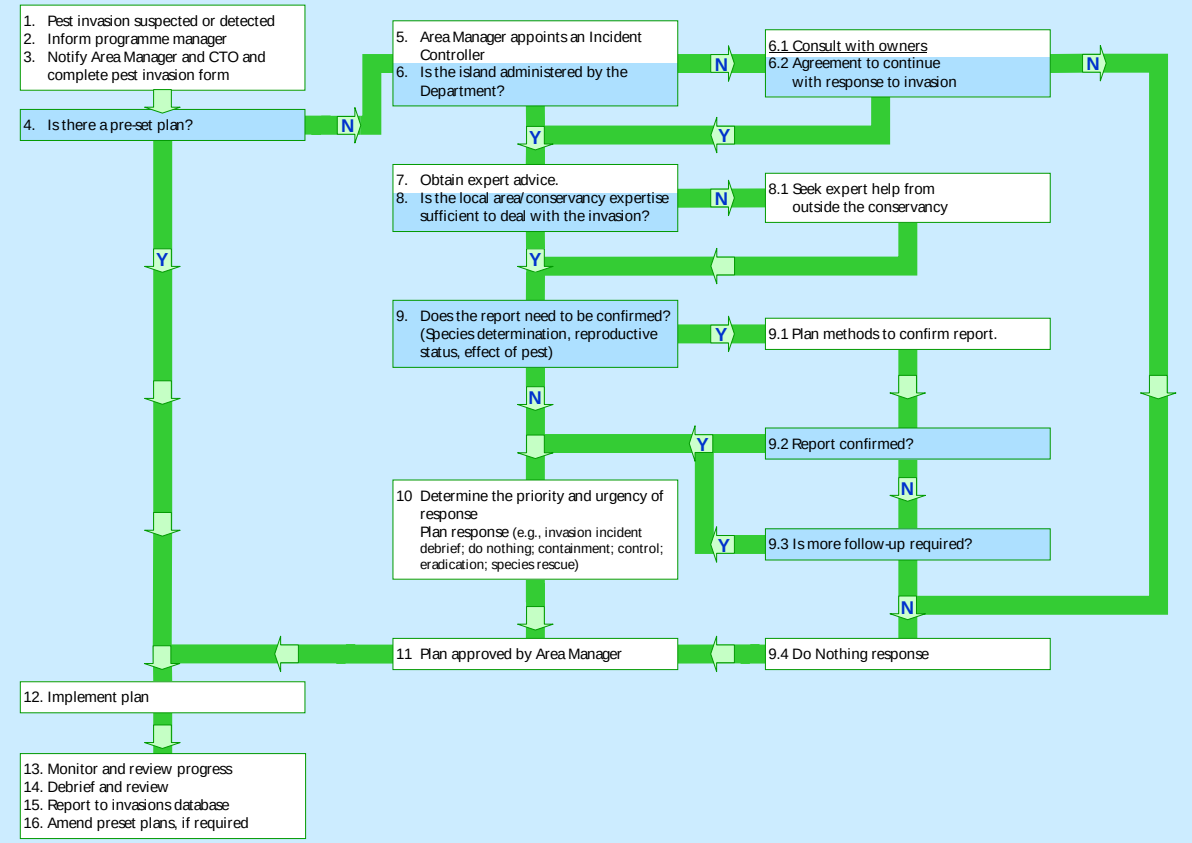
Part IV Contingency plan for pest invasion of islands in Southland Conservancy

Best Practice Manual sections:	1.1 Pest control and detection methods
	1.6 Bait stations, traps, tracking tunnels, indicators, etc.
	1.7 Other best practice manuals
	3.1 Rodent control methods adapted for island situations
	3.2 Pest invasion kits

Contingency operation flowchart

The flowchart below represents the steps to follow when a suspected incursion occurs. Numbers relate to text in the following sections.

Figure 1. Contingency Operation Flowchart.



- **The numbering on the following six pages relates to the above flow chart.**

1.	Pest invasion is suspected or detected	• Contingency plan and operations can be triggered by the following incidents: ◊ A pest is recorded (i.e. trapped, shot, photographed, sampled or seen) on an island thought to be free of that pest. ◊ The presence of a new pest species on an island is highly suspected (i.e., dead carcasses, footprints, droppings or seeds found, animals or plants reported sick or dying, insect damage seen, etc). ◊ Threat of a new animal pest invasion is highly likely (e.g. shipwreck within 1 km of island, ship run aground, report of deliberate introduction, threats made to liberate pests, etc.). ◊ A pest is detected at a quarantine store during preparation for an island trip or servicing. • A pest is detected in transit to an island. • Responsibility: Programme Manager
2.	Inform Programme Manager	• Inform the Programme Manager of the invasion as soon as possible. • Responsibility: Resident Ranger, Trip Leader or Trip Member
3.	Notify Area Manager and Chief Technical Officer	• Notify the Area Manager as soon as possible of any invasion event. • Notify the Chief Technical Officer (CTO–Conservation). Any new incursion should be immediately reported to: ◊ Chief Technical Officer (CTO) – Conservation: Geoff Hicks Phone number 04 471 0726 or vpn 8286, or 025 478 662 ◊ If unavailable, try Biosecurity Technical Officer: Rachel Garthwaite Phone 04 47 3212 or vpn 8213 or 021 442 909. ◊ Refer to: Internal Biosecurity Response Procedure (QD-NH 1323). • Begin filling in: Pest Invasion Form. • Responsibility: Programme Manager
4.	Pre-set invasion plans	• For pest invasion at quarantine store (see Appendix 4). • For contingency events involving rats on Ulva Island, refer to the pre-planned responses in the Ulva Island Open Sanctuary Management Plan (see Appendix 5). • Locations: Eye Street, Milford Road and Halfmoon Bay quarantine stores and Ulva Island. • Responsibility: Programme Manager

12. Implement the pre-set plan	• Put the pre-set plan into effect. • Locations: Eye Street, Milford Road and Halfmoon Bay quarantine stores and Ulva Iisland. • Responsibility: Programme Manager
5. Area Manager responsibilities	• Area Manager responsibilities: ◊ Ensure that Co-ordinated Incident Management System is used in the incident-response and appoint an Incident Controller (IC). ◊ Ensure that this contingency process is followed. ◊ Acts as decision-maker for any contingency response inline with approved delegations. ◊ Keep Conservator and appropriate staff informed. ◊ Ensure that there is financial control over operations. • Area Manager appoints a skilled person to the role of Incident Controller ◊ Skills are required in pest management and in planning. ◊ Ability to consult with others and gather expert advice is required. • Responsibility: Area Manager
5.1 Incident controller responsibilities	• Co-ordinating the appropriate response for the incident. • Control the operation until relieved by another person appointed by the Area Manager. • Use of the Co-ordinated Incident Management System in the response. • Keep Area Manager and other appropriate staff informed. • Ensure a completed Incident Record Form is held. • Ensure an incident log is initiated and that communication is maintained with the island. • Obtain expert advice to develop the action plan. • Prepare an action plan to resolve the invasion incident. • Delegated financial control over operations. • The co-ordination of operations, planning, logistics and relationships may require additional staff resources. An Incident Control Centre may have to be set up. • Responsibility: Programme Manager (or another skilled person) may be appointed as Incident Controller.
6. Does DOC administer the island?	• *Yes /No/some* involvement. • Responsibility: Incident Controller

6.1 Consult with the owners of the island(s).	• If DOC does not administer the island then consult with the owners and other affected and interested parties and obtain support on the response to the invasion. • Expert advice may be required at this stage. • If agreement is not reached initially try talking with the owners again with additional information on the consequences of doing nothing. • Expert advice may be required at this stage. • If no agreement is reached monitor the situation and review progress. • Responsibility: Incident Controller
6.2 Agreement to respond to the invasion	• If agreement is not reached initially try talking with the owners again. • Expert advice may be required at this stage. • If agreement is reached move onto 7: Expert Advice • If no agreement is reached go to 9.4: Do Nothing Response. • Then monitor the situation and review progress. • Responsibility: Incident Controller
7. Obtain expert advice	• Obtain expert advice, if necessary set up an advisory group of technical experts. • The experts (or advisory group of experts) should have input into the response, including the development of an action plan. • Area Manager to approve the list of experts to be consulted, after the Technical Support Manager has also been consulted. • Responsibility: Incident Controller
8. Is local expert advice able to deal with the situation?	• Determine whether the local Area and Conservancy expertise is sufficient to deal with the invasion (consult with TSM). • Responsibility: Incident Controller
8.1 Seek expert advice from outside the conservancy	• A national network of experts to consult is supplied in Appendix 7. • Refer to Internal Biosecurity Response Procedure (QD:NH 1323). • Use other expert contacts that local staff have developed. • Select experts to be consulted, request their assistance via their manager. • Responsibility: Incident Controller

9. Is confirmation of the report required?	• Incident Record Form to be completed as fully as possible. • Ensure that any information gaps are noted and filled in as soon as possible. Are all the following points known: ◇ What is the pest species? ◇ What is the pest's behavioural ecology? ◇ How long could the pest have been present? ◇ Is it a recent invasion? ◇ What is its rate of movement/dispersal? ◇ How quickly does it reproduce? ◇ What sex has been caught? ◇ What is the effect of the pest on species or communities? • Responsibility: Incident Controller
9.1 Plan methods to confirm the report.	• Determine the methods to be used for confirmation. • Consider how much effort will be needed to confirm the report. • Consider the possibility of false positive identification of the pest. • Consider the possibility of not detecting the pest when it is present. • Use expert advice. • The Trip Leader or the Resident Ranger follows instructions from the Incident Controller until a pest-invasion response team arrives. • Responsibility: Incident Controller
9.2 Report confirmed?	• If the report is confirmed, begin planning the response. • Use expert advice. • Try to rule out a false positive result in the confirmation. • Responsibility: Incident Controller
9.3 Report not confirmed: follow-up required	• If the report was not confirmed, more follow-up may be required. • Use expert advice and consider waiting or changing methods of detection. • Try to rule out a false negative result in the confirmation. • Responsibility: Incident Controller
9.4 Report not confirmed: original report considered a false alarm	• Report not confirmed, pest not likely to be present. Report was likely to have been a false alarm. • Use expert advice and consider recommending to Area Manager that no further action be taken. • Go to 14: Undertake debrief and review. • Complete the Pest Invasion Form (send completed copy to SOP Co-ordinator).

- Responsibility: Incident Controller

10. Determine priority and urgency, and plan the response

- Use expert advice.
- Assess the island's values to determine level of contingency response and identify key resources under threat.
- Use Figure 2 (page 35) to determine the priority of the contingency response.
- An invasion debrief may be required to solve immediate biosecurity risks.
- What pest species are already present on the island?
- How large is the island?
- Is a wildlife rescue operation warranted?
- Ensure that risk assessment for native species present on the island is carried out, and plan a wildlife rescue operation if necessary.
- Consultation with landowners, iwi and other interested parties may be required.
- Media liaison staff may be required to deal with any media interest.
- Responsibility: Incident Controller

10.1 Prioritising the contingency response

- A pest invasion that has a High consequence requires a response that may need additional resources from outside the Conservancy, e.g. extra assistance from other Conservancies, BRU or Internal Biosecurity Response Procedure.
- A pest invasion that has a Medium consequence requires a response that will generally be resourced from within the Conservancy.
- A pest invasion that has a Low consequence will generally be resourced from within the Area.

The following questions need to be considered:

- What are the constraints? (Staffing, Logistical, Financial, Legal, Public Interest, and Ecological).
- When should action commence?
- How long should the operation run?
- What are the predictable results of the operation?
- What are the key operational targets and decision-points along the way?
- Decide on trigger points for reducing checks on the pest e.g., after how many days/months of no sign?

Options include:

- Do nothing;

- ◊ Adopted when the cost of a response is greater than the threat presented by the pest invasion, or when the invasion event was determined to have been a false alarm.
- Control the pest (limit its impacts);
  - ◊ Adopted when eradication of the pest is not feasible, and the best that can be done to protect the biodiversity is to keep pest numbers to a minimum.
- Undertake eradication.
- The response plan should be prepared.
  - ◊ Identify boundaries of treatment area.
  - ◊ Decide on treatment method (e.g. application of pesticides, trapping, etc, aerial or ground application).
- Decide on the regime of pesticide application, timing, coverage, repeats, etc or the same for bait stations or traps.
- Responsibility: Incident Controller

11. Response Plan approval	• The Area Manager must approve the Response Plan. The Area Manager will need to be well briefed by the Incident Controller. • Responsibility: Incident Controller
12. Implementing the Response Plan	• The incident controller to co-ordinate the Response Plan. • Maintain clear lines of communication between Incident Controller, experts and the pest invasion response team. • Obtain approvals (DOC, Resource Consents, Local Authority, Medical Officer of Health). • Follow requirements from other Standard Operating Procedures. • Logistical requirements are to be clearly outlined and actioned e.g., staff, transport, accommodation, food, operational equipment and supplies, etc. • Ensure the public notification and media updates are carried out. • Ensure all safety precautions are taken including safe handling of all pesticides and safety in the whole operation. • Responsibility: Incident Controller
13. Monitor and review progress	• Establish monitoring programme. • Individually number and map all bait stations/traps. • Check the control measures (bait stations/traps/spray application) at a regular interval and keep accurate records. • Maintain clear lines of communication between Incident

Controller, experts and the pest invasion response team.

- Be prepared to review the operational plan if required.
- Use Incident Controller and experts to review success against the key operational targets and decision-points that were set in the planning.
- Modify response plan if required and request Area Manager to approve changes.
- Responsibility: Incident Controller

14. Debrief and review

- A debrief should follow within one month of the completion of every contingency response or near-miss.
- A debrief relating to an actual pest invasion incident may be required more urgently than the one month deadline to reduce further biosecurity risks.
- A report from the debrief should be kept on file.
- Responsibility: Incident Controller

15. Reports to the Island Invasion Database

- The following documents are to be sent to the SOP Co-ordinator who maintains the Island Invasion Database:
  - ◊ A completed copy of the Pest Invasion Form for the particular incident.
  - ◊ The Animal Pest Operational Report (if it was used) to report on the response.
  - ◊ A copy of the report from the debrief of the response operation.
  - ◊ Any new biosecurity standards or procedures set up as a result of the invasion incident.
- Responsibility: Incident Controller

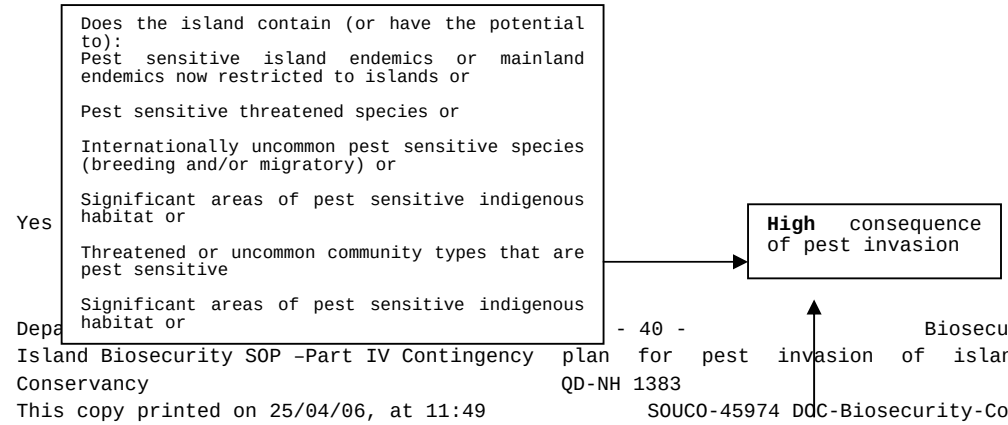
16. Amend plans if required

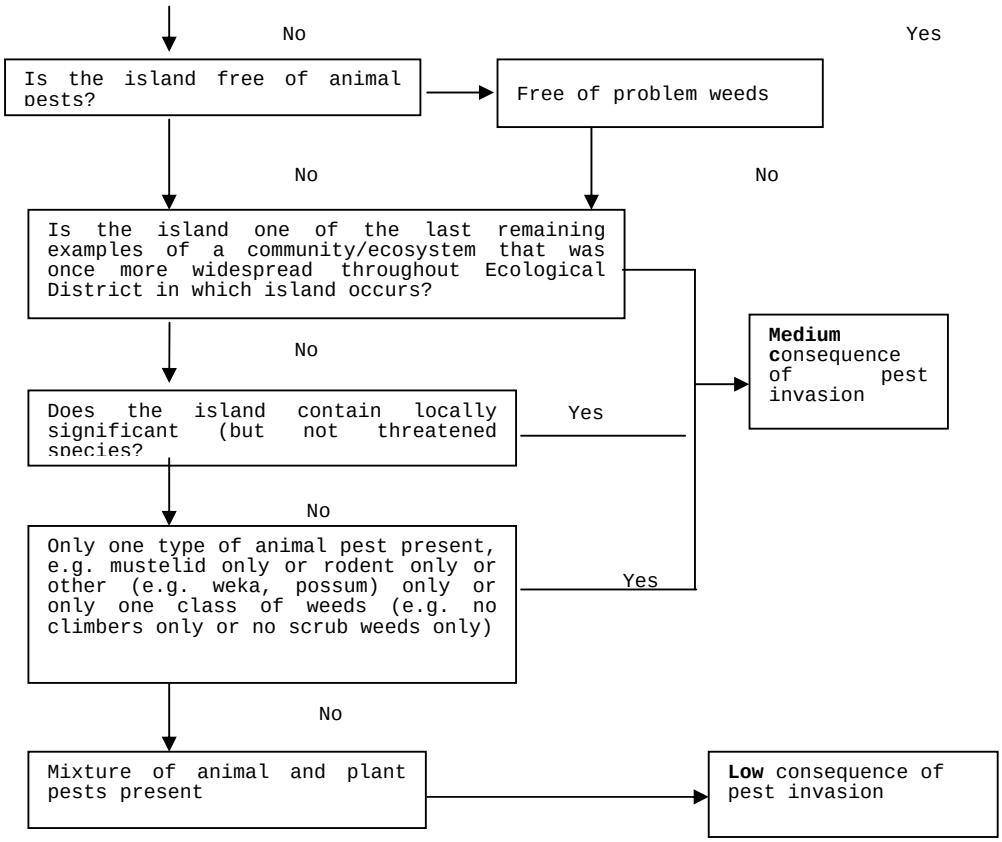
- The Island Biosecurity Plan is to be amended if any new biosecurity standards or procedures are set up as a result of an invasion incident or a near miss.
- Responsibility: TSS - Biodiversity Threats

Prioritising Contingency Response

Use the flowchart below to determine the consequence of the pest invasion.

Figure 2. Consequence of a Specific Pest Invasion Incident




No
Yes
Is the island free of animal pests?
Free of problem weeds
No
No
Is the island one of the last remaining examples of a community/ecosystem that was once more widespread throughout Ecological District in which island occurs?
No
Medium consequence of pest invasion
Does the island contain locally significant (but not threatened species?
Yes
No
Only one type of animal pest present, e.g. mustelid only or rodent only or other (e.g. weka, possum) only or only one class of weeds (e.g. no climbers only or no scrub weeds only)
Yes
No
Mixture of animal and plant pests present
Low consequence of pest invasion

Glossary and definitions

Best Practice Manual	Islands Biosecurity SOP Best Practice Manual: a document providing information on the best known techniques and methods for effectively protecting islands from Biosecurity risks (refer wgncr-45588).
Biosecurity	Protecting an island (or secure area) from a target pest. (It encompasses both quarantine and contingency operations.)
Breaksea group	Breaksea Island, Outer Gilbert Islands, and Entry Islands. At the entrance to Breaksea Sound, Fiordland.
CMS	Conservation Management Strategy.
Contingency operation	Containing the target pest once it has arrived on the island (or secure area).
Control	Reduce the numbers of a pest on an island (or within an operational area) to a level where their impact is minimised or mitigated, when measured against an indicator species.
EPIRB	Emergency Position Indicating Radio Beacon
Eradication	Completely remove all living examples of the pest from an island (or operational area).
IEAG	Island Eradication Advisory Group: provides expert advice to DOC staff on island and eradication best practice. The IEAG members are: • Keith Broome (Chair) • Pam Cromarty • Wayne Hutchinson • Andy Cox • Ian McFadden • Raewyn Empson
IPM bait station	Bell Industries “Industrial Plastic Mould” (IPM) “Protecta LP” bait station.

Invasion event type (developed by MAF)	**Interception**: Where a pest is detected in a secured area either on the mainland or on the island, e.g., quarantine store, wharf, helicopter pad, boat, aircraft, or on the island while unpacking, etc. Implies: picked up outside a barrier. **Incursion**: Where a pest is found in the wild on an island or on a "stepping-stone" island. Implies: a breach; having got past a barrier. **Establishment**: Enough individuals found for a breeding population to establish or evidence of breeding or young found. **Spread**: Pest has already spread over the island at the time of detection. **Suspicion of invasion**: Level of certainty for a possible pest sighting. Used where: • a bird-wreck has been recovered with possible bites or mauls on it; • a bird-wreck which doesn't necessarily have any bites or mauls on it but where a pest has been reported in the vicinity; or • a second-hand report of a pest has been made.
Island management group analysis	The process by which islands are grouped into manageable units. Generally, islands are grouped according to where they are serviced from.
Lead RGM	General Manager accountable

Minimum Impact Islands	The highest category of island assessment used in Atkinson & Towns (1990). The scale ranges from: minimum impact to multiple use: Refer to Appendix 9 for a list of the categories assigned to Southland Conservancy's islands. "**Minimum impact islands** include those with plant or animal species endemic to them, with very fragile biotic systems, or with relatively unmodified systems. The primary aim of management is to minimise human interference. **Refuge islands** include a majority of our island nature reserves which protect not only common lowland and coastal plants and animals but also provide refuge for many relict species of the mainland. It may sometimes be necessary to use some refuge islands to ensure survival of mainland species not originally present on the mainland. **Restoration islands** are a minority group of islands because restoration is a labour-intensive activity and is only appropriate where natural processes cannot be expected to secure the future for certain threatened species and communities. The level of public involvement with restoration on such islands would vary widely according to ease of access and vulnerability of the restored communities to human use. The educational benefit of involving the public in restoration programmes, whenever possible, should never be underestimated. With skilful interpretation it will lead to a broader appreciation of the value of nature conservation. **Open sanctuary islands** are also a minority group because they combine extensive programmes of public interpretation of the New Zealand biota with labour-intensive species-specific management of plants and animals, including those threatened by extinction or destruction. **Multiple-use islands** are those with some conservation function but it is secondary to other uses such as farming, forestry or recreation. Farm parks and many privately owned islands could be included here." (from Atkinson & Towns 1990).
Neophobia	Fear of new things; reference to rats, cats or other pests experiencing new baits, bait stations or traps within their territory.

Pest	An organism which is not wanted on the island or other biologically significant area. Includes both animals and plants.
Quarantine	Kill the target pest before it reaches the island (or other secure area).
Risk assessment	Risk is assessed by considering the consequences and probability of a pest invasion event occurring.
Rodent bolt hole	A box designed to fit into the corner of a room which has holes for rodents to enter (especially mice). Once inside the box the rodent is easy to catch and destroy. Also referred to as rodent boards.
Strait	Body of water between islands, or between an island and the mainland.
Surveillance	Active searching for a target pest; it may not involve killing the pest.
Virkon™ footbath	Virkon™ footbaths consist of an absorbent mat inside a sealed plastic box. The mat is soaked in a solution of "Virkon S" so that island visitors can tread through the box which is then re-sealed. Each kit contains a stock of the concentrate, a container for mixing and full instructions. A pen and slate is provided to record the date of each fresh mixing of the solution. Additional supplies of Virkon™ are available from stock and station agents. While relatively safe for human contact, it should not be used on bare skin and splashes should be washed off immediately.

Appendices

Appendix 1 Island biosecurity checklist for Southland Conservancy

Checklist to be used when:

- planning expeditions to islands; or
- servicing islands
- as an aid to audit procedures.

	Standard	Condition/Application	Island(s)
General standards	2.1.4	All	All islands
	2.1.1	All	All islands
	2.1.2	All permit entry islands	All Subantarctic Islands, Solander Islands, Codfish/Whenua Hou, Bench, Breaksea group (Fiordland),Chalky /Te Kakahu.
	2.1.3	Some (e.g. Minimum Impact Islands see CMS)	All Subantarctic islands, Minimum Impact Islands, and Ulva Island Scenic Reserve.
Quarantine store standards	Standard	Condition/Application	Quarantine Store(s)
	2.2.1	All	All
	2.2.2		All
	2.2.3	All	All quarantine stores **Boats:** MV Jester, MV Southern Winds.
Bait station and pest detection standards	Standard	Condition/Application	Island(s)
	2.3.1	All	Refer table 2, page 11.
	2.3.3	All	All islands
Standards for preparing for an island visit	Standard	Condition/Application	Island(s)
	2.4.1	All	Visit the most pest-free islands prior to visiting islands with pests.

	2.4.2	All	All islands
	2.4.3	All	All islands.
	2.4.4	All	All islands
	2.4.5	All	All islands
	2.4.6	All/some	All Subantarctic islands
	2.4.7	All/some	Fiordland management group
	2.4.8	All/some	All islands
	2.4.9	All/some	All islands
	Self-Audit Check-sheet (Appendix 3) used	All	All islands
Standards for dog use on islands	Standard	Condition /Application	Island(s)
	2.5.1	All	All islands
	2.5.2	All/some	• Snares Island/Tini Heke group • Auckland Island group • Campbell Island/Motu Ihupuku group
Rodent and invertebrate proofing standards	Standard	Condition /Application	Island(s)
	2.6.1	All	All islands
	2.6.3	All	All islands
	2.6.2	All	All Subantarctic Islands, Solander Islands, Codfish/Whenua Hou.
Gear checking standards	Standard	Condition /Application	Island(s)
	2.7.1	All	All islands
	2.7.2	All	All islands
	2.7.3	All	All islands
	2.7.4	All	All islands and Q. stores
	2.7.5	All	All islands
	2.7.7	All	All islands
	2.7.8	All/some	**Error! Reference source not found.**
	2.7.6	All/some	All islands
Pests found during transit	Standard	Condition /Application	Island(s)
	2.8.1	All	All islands
Biosecurity standards while	Standard	Condition /Application	Island(s)

on the island			
	2.9.1	All/some	All islands with huts.
	2.9.2	All	All islands
	2.9.3	All/some	All islands with no huts.
	2.9.4	All	All islands
	2.9.5	All	All islands
	2.9.7	All	All islands
	2.9.8	All	Breaksea, Codfish/Whenua Hou, Chalky/Te Kakahu, Enderby, Auckland, Campbell/Motu Ihupuku.
	2.9.6	Some	Breaksea, Codfish/Whenua Hou, Chalky/Te Kakahu, Auckland Islands group, all Minimum Impact Islands, and all other islands where safe disposal at sea is not an option.
	2.9.9	All	All islands
Standards for species management on islands	Standard	Condition /Application	Island(s)
	2.10.1 Any work involving wildlife must comply with the Wildlife Health Management SOP NH-1176	All	All islands
	2.10.2 Captive management facilities on islands	Some	All islands
	2.2.4	All	All islands and Q stores.
	2.10.3	All	All islands
	2.2.5	All/some	All islands
	2.10.4	All/some	All islands except Centre Island/Rarotoka.
Advocacy standards	Standard	Condition /Application	Island(s)
	2.11.1	Some	**Departure points**: Halfmoon Bay wharf, Golden Bay wharf, Thule wharf, Freshwater hut and jetty, Rakeahua jetty, Fred’s Camp hut.

		All water taxis display small version of same sign.
2.11.2 Pamphlets and other publicity	All	**Islands**: Ulva Island all Subantarctic Islands, Breaksea Island group (Fiordland), Chalky/Te Kakahu, Codfish/Whenua Hou, Solander Islands, and Bench Island..
2.11.3 Public awareness programmes	All	**Islands where a public awareness programme would be beneficia**l: All islands **Target groups**: DOC staff; Home owners (Ulva); Residents (Stewart Island/Rakiura); Visitors to the islands; Local fishers; Iwi; Muttonbirders: Maritime Safety Authority; Coast Guard; Charter boat operators; Concessionaires; Dive Clubs; Boating Clubs; Local marine radio; Researchers; Helicopter pilots; **Programme methods**: Talks by staff members; Open days on island(s); Volunteer holidays; Concessionaires' briefing for visitors; Use of honorary rangers; Static displays; Newspaper articles on regular basis over summer period; Press releases to

promote islands; Radio advertisements;

	Standard	Condition /Application	Island(s)
Surveillance standards	3.1.1 [Murihiku Area: SOUCO-50944, Te Anau Area: SOUCO-23673, Southern Islands Area: SOUCO-23675]	All	All islands
	3.1.2	Some	Stewart Island/Rakiura
	3.1.3	All/some	All rodent free islands covered by this plan except Ulva Island.
	3.1.4	All	All islands
	3.1.5	All	All islands
	3.1.6	All/some	Enderby Island

Appendix 2 Pest invasion and response planning forms

To be completed by the DOC person receiving call, or the first Conservation Officer at the scene. Once completed, a copy should be immediately given to the Area Manager.

Electronic Pest Invasion Form

WGNCR-46235

Use the [Tab] key or arrows to navigate around the form and fill in the boxes.

- Forwards: [→] [↓] [Tab →|]
- Backwards: [←] [↑] [⇧Shift] & [Tab|←]

Assistance with filling in the form is provided in the status bar (at the bottom of the screen), and also whenever [F1] is pressed.

Paper-copy Pest Invasion Form

WGNCR-45511

Appendix 3 Check list for island travel

Departure Date: / /20	Departure Time: am/ pm
Name:	Departure point:
	Destination:

Items being transported	Items have been: • scrubbed clean of all soil, seeds and vegetation, • checked for the presence of rodents and invertebrates. Tents are dry, clean and checked. Boxed = in approved rodent proof container Unboxed = loose items or in cardboard boxes or double bagged.		Date Inspected: / /20 Who inspected?
	Tick if in compliance	Inspected by island biosecurity person	Comments
Pack			
Boots			
Other footwear			
Gaiters			
Socks			
Clothing			
Parka			
Swandri			
Field equipment (boxed)			
Field equipment (unboxed)			
Food stores (boxed)			
Food stores (unboxed)			
Tents			
Day pack			
Other			
Any items of extra risk.			

SIGNED: Person travelling	SIGNED: Staff member responsible for island biosecurity.

Note: Any clothing and equipment that has been in contact with birds (especially aviary birds, waterfowl, poultry) and/or reptiles must be disinfected with Jeyes™ or Virkon™.

Appendix 4 Quarantine store operating procedures

1. **Stewart Island Field Centre Quarantine Store, Half Moon Bay (stwfc-2790).**

2. **Te Anau Quarantine Store, 210 Milford Road, Te Anau (teaao-16654).**

3. **Southern Islands Quarantine Store, 65A Eye Street, Invercargill (souco-29002).**

   [The text below is an excerpt of the most relevant information from the above document as at November 2004. Follow the link, or use the dme number, to view an up to date version of the complete document.]

   The SI Quarantine Store is to provide effective quarantine for the packing, cleaning, checking and storage of equipment and supplies destined for use on islands. The islands are: Stewart Island/Rakiura, all DOC managed islands adjacent to Stewart Island/Rakiura, Codfish/Whenua Hou, Solander, Snares/Tini Heke, Auckland, Campbell/Motu Ihupuku, Antipodes, and Bounty Islands. The store will also service of DOC managed islands in northern Foveaux Strait (Pig/Tihaka, Omaui), and the islands in Lake Hauroko, as well as DOC work on non-DOC managed islands (e.g. various Titi Islands, Centre Island/Rarotoka).

   Whenever practical the store shall be the only site where supplies and equipment for islands are packed and stored.

   The store shall not be used for any other purpose without the express approval of the Area Manager (Southern Islands) and only if compatible with quarantine requirements.

   If the store is unable to be used then an alternative appropriate quarantine plan for servicing the islands must be approved by the AM.

Layout of the quarantine store

The store is comprised of a large open storeroom with concrete floor and two external doors: one swing-door and a roller garage door. There is an office, kitchen, toilet, and two small store rooms. The two small storerooms are the “Inner Sanctum” and “Pete’s Store”. The inner sanctum is to provide a secure area within the store for expedition equipment that has been cleaned and serviced (e.g. tents, radios, EPIRBs) and is ready for immediate use. Pete’s store is used for storing contingency equipment for pest invasions and SIA field equipment for island projects.

Responsibilities

Area Manager (Southern Islands), Andy Roberts: Accountable for all island management.

Programme Manager (Outlying Islands), Pete McClelland: Responsible for all island management including quarantine operations. Regular MOR's and audits are required to manage the islands work.

Ranger (Biodiversity Threats and Assets), Jeremy Carroll: Responsibility for islands quarantine and providing advice on management of store and island quarantine. RE shall: ensure all expedition members have been briefed and given all relevant quarantine information. Trip Leaders: Quarantine Checklist & Pest and Disease Quarantine pamphlet; All team members: Self-Audit Check Sheet & the Minimum Impact Code Pamphlet.

Ranger (Quarantine & Expedition Logistics), Gilly Adam & Sharon Trainor: Responsibility for maintaining day-to-day quarantine standards in all activities at the store, for the flights to Codfish/Whenua Hou and expeditions to Subantarctic Islands. A copy of all Southern Islands quarantine and contingency information is to be on permanent display at the store.

In the absence of Ranger – Quarantine and Expedition Logisitcs (R-QEL) another staff member will take over those duties. Dependent on training and experience they will have the same responsibilities as R-QEL. The Programme Manager (Outlying Islands) must confirm with the deputy what their responsibilities are.

Technical Support Officer: Responsible for advice and audit of quarantine measures for the store.

Standards for Quarantine Measures

All relevant standards in the Quarantine and Contingency Plan for Islands in Southland Conservancy must be adhered to.

Pest Control

A register of rodent and invertebrate traps and indicators at the store and other sites used (aircraft hangers wharves, etc), will be maintained. It will include all records of incidents (servicing dates, captures [identified to species level if possible], incident, person(s) responsible, the island destination (if any), and action taken) and they are to be reported to PM the monthly.

20 snap traps for mice and 10 rodent bait stations, with a measured quantity of anticoagulant bait, shall be maintained within the store. Rat and mice traps and bait stations shall be maintained around the outside of the store. These shall be securely anchored and of a 'tamper-proof' type, with the traps or poison not easily accessible to children or pets. Traps and poison baits shall be checked and re-baited at least once per month.

Insect 'glue traps' or residual insecticide sprays shall be used to detect and control invertebrates at key points within the store – near likely access points (such as under doors, through cracks in concrete etc.), and within the inner sanctum.

Alternative methods of pest control and detection shall periodically be employed, and may include tracking tunnels and other trap types. Passive baits to detect, but not control, rodents (e.g. chocolate, gnaw sticks, butter) may be utilised when rodent presence is suspected. Passive baits **are not** to be used when the store is in use or due for immediate use for island trips.

Quarantine Conditions (General)

If quarantine standards are unable to be maintained R-QEL shall advise the PM. A list of weaknesses that may lower the effectiveness of store shall also be maintained. All practical steps should be taken to rectify these weaknesses (e.g. sealing/painting of floor, damage to roller doors).

Where a possible breach of quarantine has been observed R-QEL must notify the Trip Leader (or team member) and the PM. The R-QEL should then propose the remedial action. R-QEL may cancel or postpone trips where not satisfied with the quarantine measures taken, or upon suspicion of an appreciable risk. In such a case R-QEL should take whatever actions are considered necessary to maintain island biosecurity but must inform the PM as soon as practicable.

Any detected or suspected presence of pests at the store shall be responded to in a similar fashion to island pest contingencies. A designated Incident Controller shall determine a plan of action. The TSM shall be responsible for establishing procedures and a timetable to verify when the store is safe for use again.

If the store is temporarily unsuitable for packing or storing island-bound equipment and stores, a separate facility may be used.

All openings at the store (doors, roller doors, windows etc.) must remain shut, except during exit and entry from the building. No perishable foods are to be held in the store between trips.

Packing

R-QEL may leave teams unsupervised whilst packing **only** if confident of the quarantine standards employed by the Trip Leader and team members.

Packing of supplies and equipment must be done within the designated area at the store.

An appropriate number of sealable plastic bins and pails should be available from the store for transport of supplies to the islands. All containers shall be cleaned in the following manner:

1. Anti-graffiti solvent to remove all markings and tape residue, then steam clean;
2. Visual check and scrub with Vim or steam clean again if necessary;
3. Air/sun dried; ‘Vircon’ spray; and stored in the designated clean area

All foodstuffs (including animal baits or foods) and fatty or waxy items (e.g. soap, candles etc.) shall be packed into wooden or plastic containers with lids that can be tightly sealed. The food is to be packed as soon as practicable

prior to departure. Approved suppliers (e.g. Plaza Price Chopper) can pack supplies that are ordered in advance at their store into approved containers. Adequate quarantine measures are to be implemented and maintained by Plaza for this purpose, R-QEL to check. Approval to allow other suppliers to operate like this is at the discretion of R-QEL.

Containers must be immediately sealed once packed and should not be re-opened until unpacked on the island.

Packs, and day-bags are acceptable for **non-foodstuff items** only. They should be thoroughly cleaned before packing, to remove any soil, seeds, vegetation or invertebrates from both inside and outside the pack. Open every pocket for cleaning and inspection. Bags should be sealed as thoroughly as possible (e.g. packs should not be overfull, and straps and zips must be able to be fully closed or tightened). They should be fully unpacked and repacked on the day of departure and kept at the store until loading begins. Wherever practical, bags should be replaced by sealable plastic bins.

Large items (e.g. field equipment, generators) should, if possible, be broken down to fit within sealed containers or packed into a purpose-built crate. If they can't be placed in sealed containers, then individual quarantine conditions applying to that item or items must be established and agreed upon. These items are to be checked thoroughly, both before departure, immediately before and after reaching the destination. Such items may require fumigation or otherwise treated to ensure their pest-free status.

Gear which has been stored prior to use (e.g. tents), must be opened up, checked and repacked at the store. Any crevice or fold in any container or large folded item (e.g. tents) should be sprayed with insecticide or brushed cleaned and carefully opened and inspected immediately prior to packing.

Inner Sanctum

At all times the door to the inner sanctum shall be immediately closed after entry and exit. The inner sanctum shall be used only for the purpose of storing island expedition equipment in a state of cleanliness and packed food ready for immediate use.

Fumigation

The store shall be fumigated three times a year: pre-summer season (Sept-Oct), mid season (Jan) and end of season (April-May) to kill invertebrate and other pests. Fumigation may be required more frequently if invertebrates become obvious, e.g. presence of slaters on sticky pads.

Tents used since the last fumigation are to be opened out and fumigated as per above schedule. They should then be packed and stored in the inner sanctum as soon as practical after treatment. Large items requiring fumigation and destined for islands shall be treated, as practical, away from the quarantine store (e.g. covered with polythene and treated with methyl bromide or similar).

Cleaning/Disinfecting

Rubbish bins shall be emptied regularly (daily, if any food scraps or food wrappings are deposited). This rubbish is to be deposited into the skip outside Livestock Improvement (NB: SIA does not pay for this skip so don't use for large amounts of rubbish).

All floor space to be thoroughly swept each week as a minimum. Vacuuming shall also be done as required to remove accumulated debris from cracks and crevices.

A spring-clean shall be carried out annually as a minimum requirement. This clean shall entail: removal of all items from areas where they are stored; a thorough steam clean or mop of floor using cleaner or bleach; cleaning of the shifted items as necessary; replacing items once the area is dry; all items assessed for continued usefulness and the owner/project manager consulted in cases of doubt.

Items not directly related the function of the store or inconsistent with the store's primary role in biosecurity are to be removed (after giving adequate notice to the 'owner').

Reverse Quarantine

Rubbish that is brought back from expeditions is to be disposed, preferably at the landfill, **before containers, equipment, and supplies are returned to the store.** Other items (such as animal transfer boxes, traps, insides of boats, etc.) shall be steam cleaned after return, treated with biocide, and thoroughly dried before storage.

Separate areas shall be maintained for 'clean' items (ready for use) and 'dirty' items (returned gear needing cleaning). Painted floor markings will be used to mark the areas. All cleaning shall be done in an outdoor area as much as possible.

Returned items shall be cleaned at the earliest possible opportunity. If serious contamination is likely, they should not enter the store until inspected or cleaned to an adequate level, R-QEL to check. Items should remain in vehicles outside the store (i.e. **not** the Southern Islands Area van) or taken elsewhere overnight, rather than being left in the store. Items such as plant materials, soils, dirty or untreated wood or timber, or non-preserved animal specimens, should not enter the store unless absolutely necessary and approval is given by R-QEL.

Security of store

A monitored electronic alarm system shall be maintained and access to the store will be gained by personally issued key and pre-programmed alarm codes. Only the alarm system operator will keep a register of the individual access codes.

The R-QEL will allow a minimum number of staff full time access to the store and will keep a register of the numbered keys and the pre-programmed alarm codes issued. Up to six codes will be pre-set by the R-QEL annually and allocated, as necessary, to expeditions and contractors.

R-QEL shall hold master keys to all locked areas. All keys, except the master key, shall not be copied. R-QEL is to ensure that these keys are returned when no longer required. Only SIA staff shall hold keys to the inner sanctum.

The security system will be reviewed at least annually, to allow for staff, contractor and expedition turnover.

An effective smoke/fire detection system shall be maintained to fire safety standards. Extinguishers and other fire fighting/detection equipment shall be serviced regularly. Fire exits shall be clearly identified, and kept clear of any materials. The fire detection devices shall be linked to the electronic alarm system.

Storage of hazardous substances is to be maintained to the Departmental standard.

Loan and maintenance of equipment

R-QEL will maintain an inventory of all equipment (including small plant and other assets) held at the store. The inventory will be maintained and updated on an annual basis after an annual inspection of all equipment in conjunction with the Programme Manager – Service.

All equipment is to be in satisfactory working condition before issue.

A loan book shall be maintained to record the details (including the serial numbers of radios and other electronic equipment) of all items issued from the store, and checked off upon their return. Check (or ask users) regarding faults in equipment upon return and ensure that repairs are actioned as soon as practical.

Tags shall be issued to Trip Leaders to attach to all items of expedition equipment that is loaned from SIA. Trip Leaders must record the status of equipment (e.g. functioning, defective, description of suspected fault) on the tag and attach it to the piece of equipment in question. This recording system is vital in terms of identifying any items that become defective in the field. Failure to do so will jeopardise chances of gear being loaned in future.

Used radios and EPIRBs shall undergo a post-season inspection by a commercial firm, and shall have maintenance books kept up to date. If a fault is reported when this equipment is returned to the store it **must** undergo a service check before it can be re-issued.

After every major field trip outboard motors shall be run and all old fuels drained. At least once per month all outboard motors shall be test run and the remaining fuel then drained. Manufacturer’s guidelines shall be followed wherever possible for servicing and maintenance of small engines. A maintenance schedule shall be kept.

Contingency Equipment

A list of island contingency equipment ready for immediate deployment (traps, covers, tracking tunnels and materials, gnaw sticks, etc) will be maintained. Contingency equipment is to be clearly separated from similar equipment intended for general island use and also from that in use within the store.

Packing procedures for food packed at Plaza Price Chopper.

To minimise possible rodent/invertebrate contamination of food orders being prepared by Plaza Supervalue for expeditions to the Subantarctic Islands, Whenua Hou and other pristine islands, the following quarantine operational plan is to be followed.

- All door and windows to be closed during packing
- All food is to be packed into clean fish bins supplied by Department of Conservation's Eye Street Quarantine Store in Invercargill
- Food is to be packed into fish bins as near to the expedition departure time as possible to minimise contamination of fish bins full of rodent/bug attracting food
- Immediately the fish bin is full the lid is to be fitted
- Fish bin lids to be locked down by a cable tie
- No writing to be applied directly to fish bin surfaces. Clear tape to be applied to fish bin first, then this can be written on with permanent felt pen

Food to be loaded by the following colour code;

- **Blue** Frozen foods or food with high risk of going bad, eg meat
- **Grey** Vegetable produce or food that may deteriorate over a few days
- **White** Non perishable goods

Note: If several expeditions are leaving together (eg Navy Frigate trip) – colour coding may change to become location specific eg:

- **Campbell Island Blue**
- **Auckland Island Grey**

Quarantine Requirements

Plaza food storeroom must contain at least 10 rodent bait stations containing 5 **Pestoff** Possum pellets (**Brodificoum©)** in each

In the same store, at least 5 covered sticky pads to be left near entrance doors for invertebrate and rodent monitoring

The above to be checked and replenished on a monthly basis by Department of Conservation Quarantine staff, until Plaza employs its own independent vermin monitoring service

All foods products are to be clean i.e.; potatoes must be the pre-washed type – cabbages/lettuces must not have dirt or slugs in them.

Appendix 5 Pre-prepared island contingency plans

1. Ulva Island Open Sanctuary Management Plan

   Follow links to view the pre-prepared plan for Ulva Island.

   Cover Page: SOUCO-46076

   Title Page: SOUCO-46075

   Contents Page: SOUCO-46074

   Plan: SOUCO-46073

2. Codfish Island/Whenua Hou Biosecurity Plan [In Draft]: SOUCO-53524

3. Campbell Island Surveillance Procedures [In Draft]: SOUCO-52201

4. Weed Management Strategy – Offshore Islands: wgnho-165026
   Includes Subantarctic Islands plus Solander, Whenua Hou and Titi Islands

5. Weed Management Kits
   Campbell Island (wgnho-166001)
   Auckland Island (wgnho-166922)
   Antipodes Island (wgnho-166923)
   Snares Island (wgnho-166924)
   Adams Island (wgnho-166925)
   Enderby Island (wgnho-166926)
   Whenua Hou (wgnho-167018)
   Solander Island (wgnho-167710)
   Field Forms (wgnho-169587)
   Surveillance List (wgnho-166119)

6. Area Weed Surveillance Plans
   Murihiku: souco-50944
   Te Anau: souco-23673
   Southern Islands: souco-23675

Appendix 6 Pamphlets and posters on island biosecurity

Pamphlets are provided for visitors to the Subantarctic Islands. The **'Subantarctic Islands Minimum Impact Code'** and the **'Subantarctic and Southern Islands Pest and Disease Quarantine'** are given to tourists, researchers and island managers.

http://docintranet/content/sop/IslandFactSheets/SubantarcticMinimumImpactCode.pdf

http://docintranet/content/sop/IslandFactSheets/SubantarcticPestPrevention.pdf

A pamphlet titled **"Help protect New Zealand's offshore islands from pest animals, plants and insects"** has been produced by DOC in Wellington Conservancy. Copies are held in Te Anau and Southern Islands Area offices. Further copies can be ordered through Kapiti Area Office.

Coastal Information on Islands, Marine Reserves and Marine Mammals:
http://wgnhoiis2/Conservation/Offshore-Islands/index.asp

Codfish Island Information Sheets

Whenua Hou Nature Reserve - *Information Sheet for Potential Visitors*: souco-48393

Whenua Hou Nature Reserve - *Information Sheet for all visitors*: souco-45973

Welcome to Whenua Hou Nature Reserve: souco-52275

Appendix 7 Contacts, experts, supplies, transport etc.

Internal biosecurity response

Any new incursion should be reported immediately to:
Chief Technical Officer (CTO) – Conservation:
Geoff Hicks
ph 04 471 0726 or vpn 8286, or 025 478 662.

If unavailable try Biosecurity Technical Officer:
Rachel Garthwaite
ph 04 47 3212 or vpn 8213 or 021 442 909.

Also see: Internal Biosecurity Response Procedure (QD-NH 1323)

Southland Conservancy Island Database

For access to the database contact Southland Conservancy IMU staff.

Glen Tomlinson (5822) or Chris Rance (5853)

New Zealand Defence Forces liaison

If support from New Zealand Defence Forces may be required, then insert contact details. (This may be applicable for Kermadecs, Chathams, and Subantarctic Islands.) It is a role for Conservator or Area Manager.

Position	Location	Phone
Director Joint Operations and Plans	Defence Operations Room, Wellington	04 496 0999

DOC contacts

Technical experts (islands and pests)

Southland Conservancy:

Position	Person	VPN
TSM	Andy Cox	5831
TSS Biod. Threats	David Agnew	5847
PM Biod. Sthn Islands	Peter McClelland	5825
Ranger Biod Sthn Islands	Jeremy Carroll	5830
Ranger Biod Sthn Islands	Gilly Adam	5965/5829
PM Biod Stewart I. FC	Brent Beaven	5905
PM Biod. Te Anau	Murray Willans	5962
Ranger Biod. Te Anau	Kerri-Anne Edge	5942
Ranger Biod. Te Anau	Andrew Smart	5924
PM Takahe Te Anau	Dave Crouchley	5955
Scientist Takahe Te Anau	Jane Maxwell	5926
PM Biod. Murihiku	Vacant	5867
Ranger Biod. Murihiku	Ros Cole	5882

Biodiversity Recovery Unit, Wellington*:

Position	Person	VPN
Manager	Carl McGuiness	8341
SPO (Predators)	Ian McFadden	8348
SPO (Sea Birds)	Graeme Taylor	8294
SPO (Reptiles)	Rod Hitchmough	8249
SPO (Plants)	Andrew Townsend	8079
Manager-NKT	Paul Jansen	8236
Scientist-NKT (Nelson)	Graeme Elliott	5092
Vet., NKT (Wildlife health)	Kate McInnes	5094

Science and Research, Wellington*:

Position	Person	VPN
Manager	Geoff Hicks	8063
Mainland Islands (Hamilton)	Alan Saunders	6120
Predators (Hamilton)	Craig Gillies	6127
Island Ecol. (Auckland)	David Towns	7033
Pred. Ecol. (Christchurch)	Elaine Murphy	5413
Birds/Bats (Christchurch)	Colin O'Donnell	5430
Birds (Christchurch)	Peter Dilks	5432

Regional Offices:

Position	Person	VPN
Northern Region	Keith Broome	6187
Central Region	Pam Cromarty	8693
Southern Region	Wayne Hutchinson	8854

DOC Dog handlers

Trounson Kauri Park, Northland	Scott Theobald 7381

Contractors:

Person	Skills	Location	Phone number
Nick Torr	Planning, field work, trapping, aerial bait spread, species	Te Anau	(03) 249 7736

* Unless otherwise stated.

	management.		
Gary Aburn	Field work, trapping, aerial bait spread, species management.	Whataroa	(03) 753 4016
Derek Brown	Planning, field work, trapping, aerial bait spread, species management.	Havelock	(03) 574 2422
Dick Veitch	Planning, field work, trapping, aerial bait spread, species management.	Auckland	(09) 298 5775
Ian Atkinson	Science (island ecology, rodents, pest invasions, threatened species)	Lower Hutt	(04) 528 1383
Rowley Taylor	Science (island ecology, rodents, pest invasions)	Nelson	(03) 547 3129
Paul Johnston	Field work, trapping, species management.	Stewart Island/Rakiura	(03) 219 1331
Henrik Moller	Science (island ecology, rodents, pest invasions, threatened species)	Otago University	(03) 479 7991

Equipment

Southland Conservancy:

Location	Contact person	Equipment	VPN
SIA store	Gilly Adam	Traps details unknown	5965
Stewart Island FC	Brent Beavan	Traps in store & on Ulva Island.	5902
Whenua Hou/ Codfish Island	KPO (various)	Traps on island and at hut.	025 410 034
Workshop, Bond Street, Invercargill	Graeme Miller	700 Victor No1, 100 Fenn IV, 90 rat traps 30 mouse traps 12 Timms 155 Fenn IV, 62 mouse traps 48 Fenn IV 100 rat traps, 62 mouse traps 250 Victor No1, 178 Fenn IV	5839
Te Anau	Murray Willans	376 Victor No1, 600 Fenn IV, 100 Fenn VI Various traps in Eglinton Valley, Clinton Valley, Iris Burn, Chalky, Passage, Great, Breaksea, Middle Arm Islands	5962
Burwood Bush Rearing Unit	Ross Curtis	3 Timms, 25 FennVI, 240 Fenn IV	5950

Other conservancies:

In each case, contact the Technical Support Manager for assistance.

Non-DOC equipment:

Supplies	Company	Location	Phone
Traps Traps/Bait	Trappers Cyanide Supplies Pest Management Systems	Christchurch Waikanae	(03) 359 4150 0800 111 466
Bait	Wrightsons	Invercargill	(03) 218 8077

	Reid Farmers	Invercargill	(03) 218 1929
	Animal Control Products	Wanganui	(06) 344 5302
	Animal Control Products	Waimate	(03) 689 8367
Safety Gear	NZ Safety	Invercargill	(03) 218 4273
	Protector Safety	Invercargill	(03) 214 4512

DOC contacts for Tangata whenua

Southland Conservancy: staff from this list can advise on who to contact.

Position	Person	VPN
Kaupapa Atawhai Manager	Stephen Bragg	5816
Southern Islands Area Manager	Andy Roberts	5846
CRO - Rakiura Titi Islands Administering Body, Whenua Hou Committee, Kaitiaki Roopu Secretary.	Dianne Williams	5817
Cons Board Executive Officer	Perry Ferguson	5837

Tangata whenua

Iwi members on Conservation Board:

Name	Address	Phone
Jane Davis	11 Margery Street, Riverton	03 234 8745
George Ryan	12 Spencer Street, Bluff	212 8142

Kaitiaki Roopu Members

Name	Iwi/rununga	Phone
Michael Skerrett	Waihopai	214 1573, 217 6390 ah 025 479 166 mobile

Muriel Johnstone Rewi Anglem	Aparima-Oraka Hokonui	(03)234 8192 (03) 234 913 ah (03) 208 7954
Gail Thompson	Awarua	(03) 212 8652

Whenua Hou Committee

Name	Iwi/rununga	Phone
Tane Davis (Chairperson)		213 0788 025 380 366 mobile

Other contacts:

Island owners, residents, caretakers, etc

	Name	Address	Phone
Ruapuke Island	Stephen Bragg	Southland Conservancy	5816
Centre Island/Rarotoka	Muriel Johnstone		(03) 234 8192 (03) 234 8913 ah

Appendix 8 Audit of biosecurity procedures for islands in Southland Conservancy

High-risk situations are to be audited first, such as:

- Sites with high consequences or high probability of pest invasion;
- Locations where there are complex island servicing and management problems to be solved;
- Sites where there are new pest threats
- Examples of best practice or new innovation

Sites where slippage in standards may have occurred or where standards may be difficult to obtain.

Audit schedule for Southland Conservancy

Audits	**Islands** (island management group or individual islands)	**Quarantine Stores**	**Boat / Aircraft**	**Pre-set contingency plans**
Year 2003/04	Auckland Islands, Campbell, Whenua Hou	Southern Islands Q. Store, Stewart Island Field Centre Workshop	MV Southern Winds; S.E. Air	Ulva
Year 2004/05	Fiordland	Te Anau Q. Store	MV Jester	
Year 2005/06	Southern Islands, Stewart Island/Rakiura		Helicopter pads	
Have all islands, quarantine facilities and transport options been audited over the 3 year period?				Y/N

Return to start of audit programme, but ensure that high risk situations are dealt with first.

Appendix 9 Categorisation of Islands in Southland Conservancy

Islands Included in the Mainland Southland – West Otago CMS		
Island	**Location**	**Land Status**
Minimum Impact Island		
Little Solander Island	Fiordland Coast	Fiordland National Park
Refuge Island		
Big Solander Island	Fiordland Coast	Fiordland National Park
Breaksea Island	Fiordland Coast	Fiordland National Park
Centre Island	Lake Te Anau	Fiordland National Park
Entry Island (Breaksea)	Fiordland Coast	Fiordland National Park
Nee Islands	Fiordland Coast	Fiordland National Park
Omaui Island	Southland Coast	Conservation area - CA62
Outer Gilbert Islands	Fiordland Coast	Fiordland National Park
Pig Island	Southland Coast	Scenic Reserve - vested DOC
Rabbit Island	Southland Coast	General Purpose Reserve - vested Ministry of agriculture and fisheries
Shelter Island	Fiordland Coast	Fiordland National Park
Unnamed Island (south of Mary Island)	Lake Hauroko	Fiordland National Park
Unnamed Island, Dusky Sound (E.R. 782772)	Fiordland Coast	Fiordland National Park
Restoration Island		
Centre Island	Southland Coast	Lighthouse Reserve (Public Works Act)- vested Maritime Transport
Chalky Island	Fiordland Coast	Fiordland National Park
Dog Island	Southland Coast	Lighthouse Reserve - vested Ministry of Transport
Nomans Island	Fiordland Coast	Fiordland National Park
Outer Cording Islands	Fiordland Coast	Fiordland National Park
Passage Island (Dusky Sound)	Fiordland Coast	Fiordland National Park
Passage Islands (Chalky Inlet)	Fiordland Coast	Fiordland National Park
Prove Island	Fiordland Coast	Fiordland National Park
Round Island	Fiordland Coast	Fiordland National Park
Seal Islands	Fiordland Coast	Fiordland National Park
Small Craft Harbour Islands	Fiordland Coast	Fiordland National Park
Steep To Island	Fiordland Coast	Fiordland National Park

Stop Island	Fiordland Coast	Fiordland National Park
Thrum Cap Island	Fiordland Coast	Fiordland National Park
Unnamed Island, south-west of Howells Point	Southland Coast	Unallocated Crown Land - DOSLI
Weka Island	Fiordland Coast	Fiordland National Park
Open Sanctuary Island		
Anchor Island	Fiordland Coast	Fiordland National Park
Arran Island	Lake Te Anau	Fiordland National Park
Bauza Island	Fiordland Coast	Fiordland National Park
Belle Vue Island	Lake Manapouri	Fiordland National Park
Buncrana Island	Lake Manapouri	Fiordland National Park
Bute Island	Lake Te Anau	Fiordland National Park
Catherine Island	Fiordland Coast	Fiordland National Park
Coal Island	Fiordland Coast	Fiordland National Park
Cooper Island	Fiordland Coast	Fiordland National Park
Cumbrae Island	Lake Te Anau	Fiordland National Park
Curlew Island	Fiordland Coast	Fiordland National Park
Dot Island	Lake Te Anau	Fiordland National Park
Doubtful Island	Lake Te Anau	Fiordland National Park
Eleanor Island	Fiordland Coast	Fiordland National Park
Elizabeth Island	Fiordland Coast	Fiordland National Park
Entrance Island	Fiordland Coast	Fiordland National Park
Entrance Island	Lake Te Anau	Fiordland National Park
Erin Island	Lake Te Anau	Fiordland National Park
Fanny Island	Fiordland Coast	Fiordland National Park
Fergusen Island	Fiordland Coast	Fiordland National Park
Garden Island	Fiordland Coast	Fiordland National Park
Great Island	Fiordland Coast	Fiordland National Park
Harbour Islands	Fiordland Coast	Fiordland National Park
Heron Island	Fiordland Coast	Fiordland National Park
Holmwood Islands	Lake Manapouri	Fiordland National Park
Indian Island	Fiordland Coast	Fiordland National Park
Inner Cording Islands	Fiordland Coast	Fiordland National Park
Inner Glibert Island	Fiordland Coast	Fiordland National Park
Isolde Island	Lake Manapouri	Fiordland National Park
Joeys island	Southland Coast	Scenic Reserve - vested ICC
John Islands	Fiordland Coast	Fiordland National Park
Lee Island	Lake Te Anau	Fiordland National Park
Little Island	Fiordland Coast	Fiordland National Park
Long Island	Fiordland Coast	Fiordland National Park
Macdonnell Island	Fiordland Coast	Fiordland National Park
Many Islands	Fiordland Coast	Fiordland National Park
Mary Island	Lake Hauroko	Fiordland National Park
Mhara Island	Lake Manapouri	Fiordland National Park
Monkey Island	Southland Coast	Conservation area - CA62
Oke Island	Fiordland Coast	Fiordland National Park

Only Island	Fiordland Coast	Fiordland National Park
Parrot Island	Fiordland Coast	Fiordland National Park
Petrel Island	Fiordland Coast	Fiordland National Park
Pigeon Island	Fiordland Coast	Fiordland National Park
Pomona Island	Lake Manapouri	Fiordland National Park
Resolution Island	Fiordland Coast	Fiordland National Park
Rona Island	Lake Manapouri	Fiordland National Park
Secretary Island	Fiordland Coast	Fiordland National Park
Seymore Island	Fiordland Coast	Fiordland National Park
Shag Island	Fiordland Coast	Fiordland National Park
Spit Island/Te Whare Beach	Fiordland Coast	Fiordland National Park
Styles Island	Fiordland Coast	Fiordland National Park
Unnamed Islands (Awarua Bay)	Southland Coast	Unallocated Crown Land - DOSLI
Unnamed Islands (Cosy Nook)	Southland Coast	Unallocated Crown Land - DOSLI
Unnamed Island (Cormorant Cove)	Fiordland Coast	Fiordland National Park
Unnamed Island (Earshell Cove)	Fiordland Coast	Fiordland National Park
Unnamed Island (south Pahia Point)	Southland Coast	Unallocated Crown Land - DOSLI
Unnamed Island (S.W. Arm George Sound)	Fiordland Coast	Fiordland National Park
Unnamed Island (Teal Bay)	Lake Hauroko	Fiordland National Park
Useless Island	Fiordland Coast	Fiordland National Park
Utah Island	Fiordland Coast	Fiordland National Park
Multiple Use Islands		
Colyers Island	Southland Coast	Freehold Land, Invercargill City Council
Tikore (Spencers) Island	Southland Coast	Freehold Land, Invercargill City Council

Islands Included in the Stewart Island – Rakiura CMS		
Island	**Location**	**Land Status**
Minimum Impact		
Breaksea	Near Ruapuke	Private freehold Maori land
Hazelburgh	Near Ruapuke	Private freehold Maori land
Huirapa	South Cape	Beneficial Titi Island
Little Moggy (Mokoiti)	South West Stewart Island	Beneficial Titi Island
Pohowaitai	South Cape	Beneficial Titi Island
Putauhinu nuggets	South Cape	unallocated
Tameitemioka (Taimaitemioka)	South Cape	Beneficial Titi Island
The Sisters	East of Port Pegasus	Crown Titi Island - CA62
Whero Rock	Off Halfmoon Bay	Nature Reserve - Royal Society
Refuge Islands		

Bench	Off Halfmoon Bay	Nature Reserve - DOC
Betsy	Boat Group	Crown Titi Island - CA62
Big (Stage, Tiorea)	Boat Group	Crown Titi Island - CA62
Bird	Near Ruapuke	Private freehold Maori land
Bunker	Off Halfmoon Bay	Crown Titi Island - CA62
Codfish (Whenua Hou)	Ruggedy	Nature Reserve - DOC
Green	Near Ruapuke	Private freehold Maori land
Herekopare (Te Marama)	Off Halfmoon Bay	Beneficial Titi Island
Jacky Lee	Off Halfmoon Bay	Crown Titi Island - CA62
Kaimohu	South Cape	Beneficial Titi Island
Kundy (North)	Boat group	Crown Titi Island - CA62
Motonui (Motunui, Edwards)	Off Halfmoon Bay	Crown Titi Island - CA62
North (Pikoiti)	Off Halfmoon Bay	Crown Titi Island
Poutama	South Cape	Beneficial Titi Island
Putauhinu (Putauhina)	South Cape	Crown Titi Island - CA62
Timore (Chimneys)	Boat Group	Beneficial Titi Island
Wharepuaitaha (Te Wharepuaitaha)	Breaksea Islands, Port Adventure	Beneficial Titi Island
Womens (Pikomamaku)	Off halfmoon Bay	Beneficial Titi Island
Restoration Islands		
Big Moggy (Mokonui)	South west Stewart Island	Beneficial Titi Island
Big South Cape (Taukihepa)	South Cape	Beneficial Titi Island
Ernest	Port Pegasus	Crown Titi Island - CA62
Ernest Islands - Outer	Mason Bay	Maori Reserve
Kaihuka	Breaksea Islands, Port Adventure	Beneficial Titi Island
Kaninihi	Broad Bay, Port Pegasus	Crown Titi Island - CA62
Kopeka	East of Port Pegasus	Crown Titi Island - CA62
Owens (Horomamae)	Lords River	Beneficial Titi Island
Pihore	Chew Tobacco Bay	Crown Titi Island - CA62
Pomatakiarehua (Te Pohomatakiarehua)	Breaksea Islands, Port Adventure	Beneficial Titi Island
Potuatua (Pohotuatua)	Breaksea Islands, Port Adventure	Beneficial Titi Island
Pukeweka	South Cape	Crown Titi Island - CA62
Rat	Boat Group	Crown Titi Island - CA62
Rukawhakura	Breaksea Islands, Port Adventure	Crown Titi Island - CA62
Soloman (Rerewhakaupoko)	South Cape	Beneficial Titi Island
Takiwiwini	Breaksea Islands, Port Adventure	Crown Titi Island - CA62
Tia (Entrance)	Port Adventure	Beneficial Titi Island
Weka	Port Adventure	Crown Titi Island - CA62
Open Sanctuary Islands		
Anchorage	Port Pegasus	Scenic Reserve - DOC

Lords River Islands	Lords River	Scenic Reserve - DOC
Native	Paterson Inlet	Scenic Reserve - DOC and freehold
Noble	Port Pegasus	Scenic Reserve - DOC
Paterson Inlet Islands - (*All Paterson Inlet islands except Ulva and Bravo Islands*)	Paterson Inlet	Scenic Reserve - DOC
Pearl	Port Pegasus	Scenic Reserve - DOC
Port Adventure Islands	Port Adventure	Scenic Reserve - DOC
Port Pegasus Islands	Port Pegasus	Scenic Reserve - DOC
Rugged Islands	Ruggedy	CA62
Ulva	Paterson Inlet	Scenic Reserve - DOC and freehold
Multiple Use		
Bravo Island	Paterson Inlet	Scenic Reserve - DOC and freehold
Ruapuke	Off Halfmoon Bay	Private freehold
Ernest Islands - Inner	Mason Bay	CA62
Lonekers Rock	Off Halfmoon Bay	CA62
Henrietta Bay, Ruapuke	Off Halfmoon Bay	CA62

TABLE 4 – CATEGORISATION OF SUBANTARCTIC ISLANDS

*** all Subantarctic Islands are nature reserves under the Reserves Act 1977.**

Island	Location	Size	Maximum distance to land (metres)	Settlement	Extent of habitat modification	Introduced weeds	Introduced animal pests
Minimum Impact Islands							
Adams Island	Auckland Islands	10119ha	90		minimum	low	None
Alert Stack	Snares Islands	5ha	60		minimum	low	None
Antipodes Island (includes main island and all outliers not individually mentioned)	Antipodes Islands	2025ha	na		minimum	low	mice present
Archway Island	Antipodes Islands	5ha	1500		minimum	low	None
Auckland Islands (all outliers not individually mentioned)	Auckland Islands	<5ha total	various		minimum	low	None
Bollons Island	Antipodes Islands	50ha	1500		minimum	low	None
Bounty Islands (main group, centre group and east group)	Bounty Islands	135ha	1300		minimum	low	none
Broughton Island	Snares Islands	48ha	100		minimum	low	none
Campbell Island (all outliers not individually mentioned)	Campbell Islands	<5ha total	various		minimum	low	none
Cossack Rock	Campbell Island Group	1ha	300		minimum	low	none
Dent Island	Campbell Island Group	27ha	1400		minimum	low	none
Disappointment	Auckland	566ha	4000		minimum	low	none

Island	Islands						
Dundas Island	Auckland Islands	1ha	2500		minimum	low	none
Ewing Island	Auckland Islands	81ha	750		extensive	high	none
Figure of Eight Island	Auckland Islands	4ha	500		minimum	low	none
French Island	Auckland Islands	1ha	50		minimum	low	none
Friday Island	Auckland Islands	1ha	200		minimum	low	none
Gomez Island	Campbell Island Group	2ha	500		minimum	low	none
Green Island	Auckland Islands	1ha	2500		minimum	low	none
Hook Keys Island	Campbell Island Group	3ha	1300		minimum	low	none
Inner Windward Island	Antipodes Island	5ha	800		minimum	low	none
Jacquemart Island	Campbell Island Group	19ha	550		minimum	low	none
Jeanette-Marie Island	Campbell Island Group	11ha	800		minimum	low	none
Leeward Island	Antipodes Island	6ha	100		minimum	low	none
Monowai Island	Campbell Island Group	6ha	300		minimum	low	none
Monumental Island	Auckland Islands	3ha	90		minimum	low	none
North-East Island (includes all outliers not individually mentioned)	Snares Islands	280ha	na		minimum	low	none
Ocean Island	Auckland Islands	5ha	250	Farming settlement abandoned	moderate	medium	goats eradicated (1940)
Ord Lees Island	Antipodes Islands	1ha	50		minimum	low	none
Outer Windward Island	Antipodes Islands	5ha	800		minimum	low	none
Rose Island	Auckland Islands	75ha	250	Farming settlement	moderate	medium	rabbits eradicated

				abandoned			(1993)
Shoe Island	Auckland Islands	1ha	800		minimum	low	none
Snares Island (western chain islands)	Snares Islands	8ha	4000		minimum	low	none
Survey Island	Campbell Island Group	3ha	400		minimum	low	none
Wasp Island	Campbell Island Group	4ha	1500		minimum	low	none
Yule Island	Auckland Islands	1ha	500		minimum	low	none
Refuge Islands							
Auckland Island (main)	Auckland Islands	50990ha	na	Farming settlement abandoned	moderate	medium	goats eradicated (1990), pigs, cats and mice present
Campbell Island (main)	Campbell Island Group	11216ha	na	Farming settlement abandoned, Met. Station staffed all year round, closed October 1995	extensive	high	eradications of cattle (1984), sheep (1991). Cats and Norway rats present
Enderby Island	Auckland Islands	710ha	300	Farming settlement abandoned	extensive	high	eradication of cattle and rabbits (1993), pigs (date unknown). Mice probably gone but yet to be confirmed
Folly Island	Campbell Island Group	7ha	50		minimum	low	Norway rats present
Masked Island	Auckland Islands	4ha	100		minimum	low	cats and mice present

Scientific Outcomes

Appendix G-1: Harper Rat Report 2006

Report

The relative impacts of ship rats (*Rattus rattus*) and weka (*Gallirallus australis*) on the nest success of tītī (Sooty shearwater: *Puffinus griseus*) on the southern Tītī islands.

2003-2005

By

Grant Harper

Te Tari o Whakāro Kararehe (Zoology Dept.)
Te Whare Wānanga o Otago (University of Otago)

This report was prepared for the *Kia Mau Te Tītī Mo Ake Tonu Atu* Research Project on behalf of the Rakiura Titi Committee, Rakiura Titi Islands Administering Body and Ka Mate Nga Kiore Committee and should not be quoted without their permission.

January 2006

Introduction

Ship rats (*Rattus rattus*) invaded the southern titi islands of Taukihepa, Pukeweka and Rerewhakauopoko (southwest Rakiura) in 1963, causing the extinction of several native bird species and damage to native plants. The rats have now been present for 40 years and may be causing a decline in titi (muttonbird: *Puffinus griseus*) numbers on these islands, by eating titi eggs and chicks during the summer nesting season. At the beginning of the research there was no information on the impacts of rats on titi, but research elsewhere on other large seabirds suggested that ship rats could kill large seabird chicks.

Funding for the eradication of rats from these islands has been secured from the "Command Oil Spill Trustee Council" in the USA (The oil tanker "Command" split oil off the coast of California, which killed titi from the Rakiura islands, and the restoration funds are available to restore the damage done by the oil spill). One of the conditions for securing the funds required research into the impacts of rats on titi eggs and chicks, in order to be able to predict any changes to the titi population on the islands after rat eradication.

The research on rats and their impacts on titi eggs and chicks had to be carried out in the summer, when titi were nesting. The research mainly involved comparing the difference in the loss of eggs or chicks from marked burrows in sites where rats were removed ('treatment' sites) with sites where rats were not removed ('control' sites). On Taukihepa treatment sites were at Upokopotete (Potted Head), southern Parata, and Parakiore. Control sites were at Puketakohe, northern Parata and Waitakua. On Rerewhakauopoko there was one treatment and one control site. In addition to measuring the chick losses on these manu, further samples from rats would add to the data. Stomach contents of rats were checked for remains of eggs or chicks, and rat muscle samples were taken for chemical analysis to provide additional information on whether the rats' diet included titi eggs or chicks.

It became apparent during the first summer of field work that a large native rail, the weka (*Gallirallus australis*), were killing a substantial proportion of titi chicks, and rats were having little apparent impact. To investigate the impact of weka on titi chicks a second summer of research was carried out. This involved repeating the first year's field work with the addition of weka removal from all of the six sites on Taukihepa, the three control sites and the three treatment sites. In this way all the predators of titi were controlled on three sites and just weka on three sites. It was hoped that a difference in the loss of chicks between the two summers could be shown, to clarify whether weka or rats were the main predator of titi chicks.

Methods

Loss of eggs or chicks

Approximately 60 accessible and occupied burrows were selected on each manu in November 2003. The burrows were numbered and marked with cattle tags, then burrow-scoped to check that birds were on eggs.

From early January through to mid-February 2004 the burrows were burrow-scoped every 3 days to check for loss of eggs or chicks, or for failure of the nesting attempt. Nest failure was when eggs failed to hatch but did not go missing. The burrows were burrow-scoped once again in mid-March to check for any further loss of chicks before the titi harvest began.

The process was repeated, using the original marked burrows, in December 2004, and January/February and March 2005.

Rat removal

A 200 x 200m (4 hectares) rat trapping grid was set-up, with the burrow-scoped site in the approximate centre of the grids. Victor rat traps were used, under 1/2" galvanised mesh covers to reduce by-catch of birds. The covers and traps were secured with two metal pins. Traps were cleared of rats every day and reset if necessary. Rats were processed later in the day for various measurements and samples for stable isotope analysis.

Initially 50 traps were set at 20m spacing. This number was increased to 85 traps from January 2004 to increase the rate of rat removal. Rat trapping carried in December 2003, then January to February, and May of 2004 and 2005.

Rat tracking-tunnels

20 black plastic tracking tunnels were set up in two lines of 10, passing through the burrow-scoping sites. Cardboard strips were placed in the tracking tunnels with an ink pad in the centre of the strips. Rat bait (peanut butter and rolled oats) was placed on the ink pad, and when the rats came to eat the bait, they got ink on their paws. They then tracked the ink out over the cardboard as they left the tracking tunnel. The number of tracking tunnels with rat tracks in them was recorded as a percentage of the available tracking tunnels. This method was used on the rat-trapped sites and the non-trapped sites. As density of rats could be estimated at the trapped sites, the percentage of tracked plates at trapped sites could be related to the density of rats. This density/tracking rate relationship could then be used to estimate the density of rats at the non-trapped sites.

Tracking plates were used in January 2004 and 2005.

Weka removal
All weka seen at the burrow-scoped sites were removed in January and February 2005, to reduce the numbers of titi chicks being killed by weka. This did not result in complete removal of all weka on each manu, but reduced the numbers of weka there.

Results

Marked burrows
347 burrows were marked and burrow-scoped in 2003-2004. 349 burrows were marked and burrow-scoped in 2004-2005.

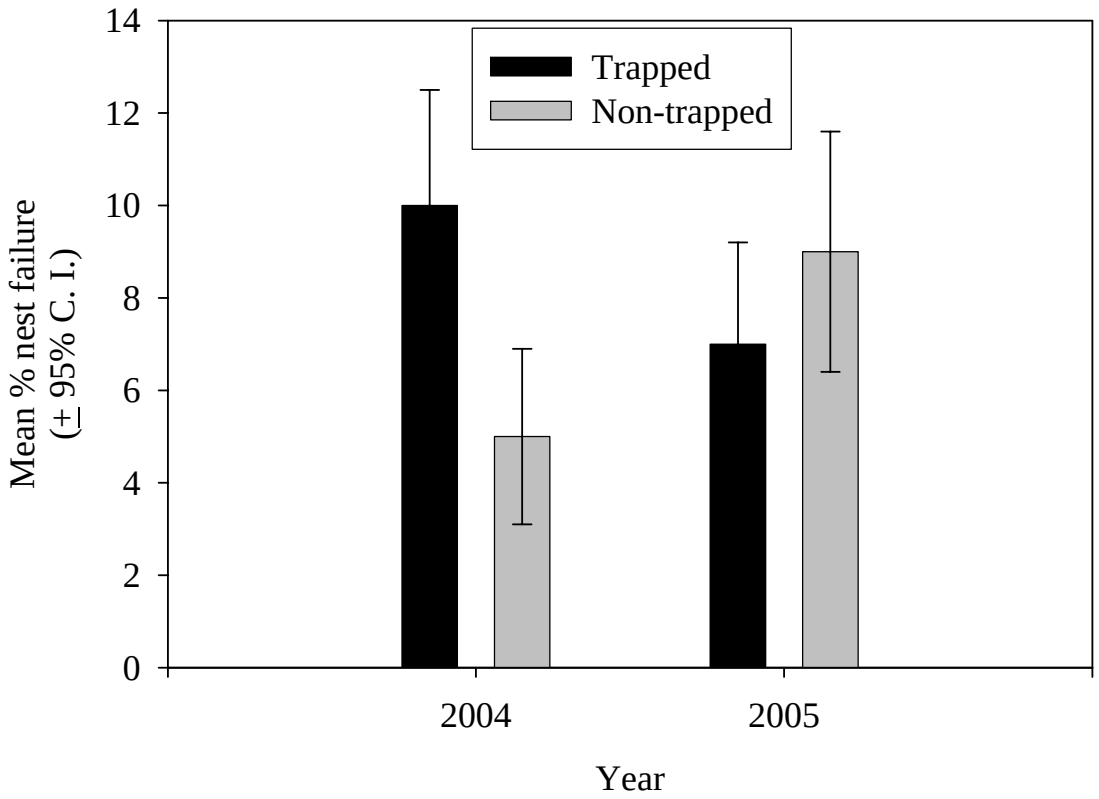
Occupied burrows
280 of 347 marked burrows (81 %) were occupied with nesting birds in 2003-2004 and 253 of the 349 burrows (72 %) were occupied in 2004-2005.

Hatching
In 2004 and 2005 eggs began hatching about the 12th January. The last eggs hatched about the 1st February.

Nest failures
In 2004 seven nests (5%) failed on the non-trapped sites and 15 nests (10%) failed on the trapped sites (Table 1). In 2005 11 nests (9%) failed on the non-trapped sites and 9 nests (7%) failed on the trapped sites (Table 2). There was no significant difference in the failure rate of nests between either year (graph 1).

The eggs were retrieved in most cased and checked for cause of death. In all cases it appears that the eggs were fertile but died during development. This could be due to chilling of the egg or abandonment of the nest (if one of the adults didn't return to relieve the nesting bird for example).

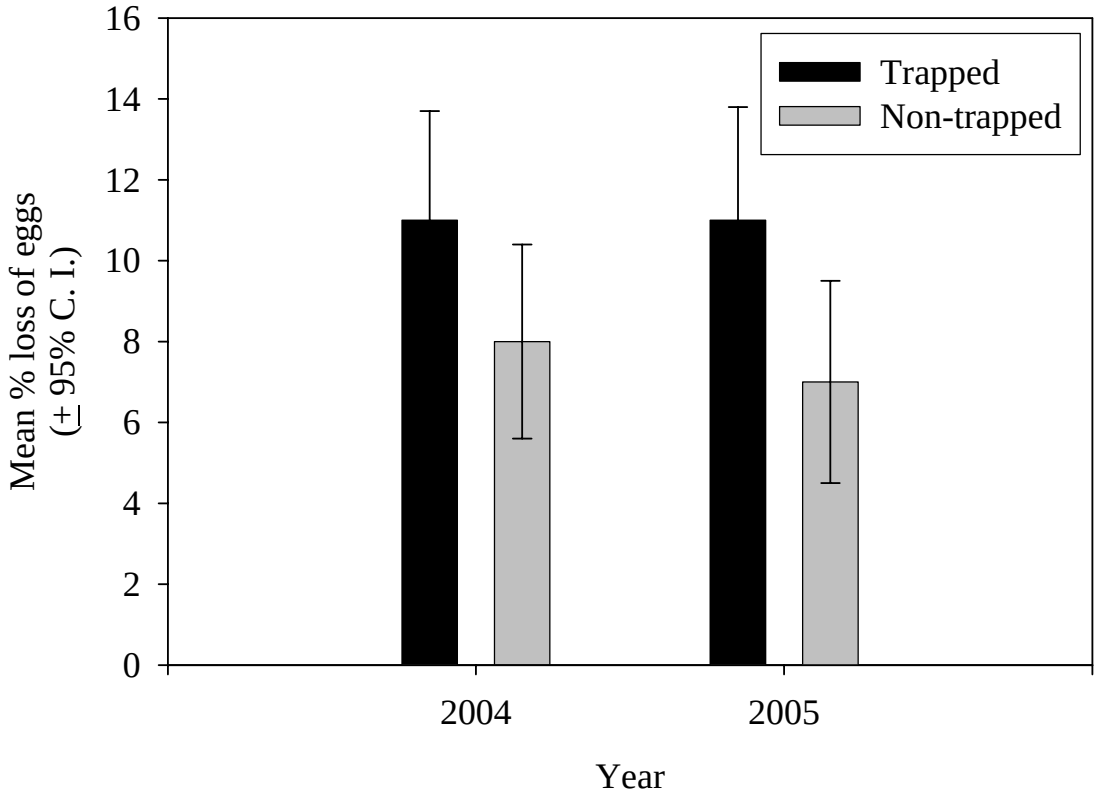
Graph 1.
Percentage of titi nest failures
on rat-trapped and non-trapped sites



Loss of eggs

In 2004 10 eggs (8%) disappeared on the non-trapped sites and 15 nests (11%) disappeared on the non-trapped sites (Table 1). In 2005 8 eggs (7%) disappeared on the non-trapped sites and 14 nests (11%) disappeared on the non-trapped sites (Table 2). There was no significant difference in the rate of egg loss between either year (graph 2). The higher overall rate of egg loss on the rat-trapped sites was due to the higher rate of predation by weka on most of the rat-trapped sites. No control of rats or weka was done during the egg incubation period before hatching in early January. The loss of eggs could have been either due to nest failure and subsequent abandonment by the adults or was, more likely, due to predation by weka.

Graph 2.
Percentage of eggs lost from titi nests
on rat-trapped and non-trapped sites



Loss of chicks

In 2004 nine chicks (8%) were lost on non-trapped sites and 19 chicks (16%) were lost on the rat trapped sites (Table 1). This meant that more chicks were being lost on two of the *trapped* sites than on the non-trapped sites. In 2005, weka were also controlled on all sites and only five chicks (4%) were lost on the trapped sites and 2 chicks (2%) were lost on the non-trapped sites (Table 2). There were significantly fewer chicks lost in 2005 (average = 3%) on all sites compared with 2004 (average = 12% [graph 3]).

Graph 3.
Percentage loss of chicks
on rat-trapped and non-trapped sites

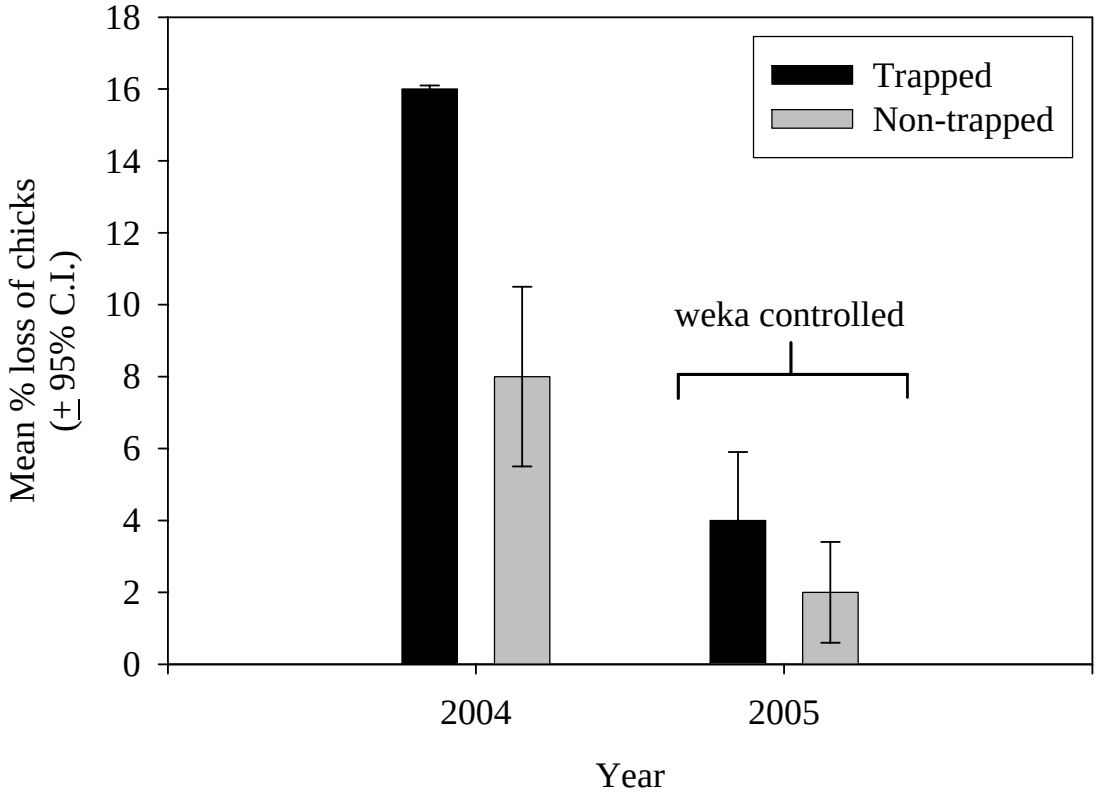


Table 1. Nest failure and loss of eggs or chicks in 2004.

Season	Number of burrows checked	Number occupied with nesting pair	Failed nest	%	Egg lost	% Eggs lost	Chicks lost	% chicks lost	Total losses	%
Non-trapped site	173	135	7	5	10	8	9	8	26	19
Trapped site	174	145	15	10	15	11	19	16	48	33
Mean	173.5	140	11	8	12.5	10	14	12	37.5	27

Table 2. Nest failure and loss of eggs or chicks in 2005 (weka controlled on all sites during early chick phase).

Season	Number of burrows checked	Number occupied with nesting pair	Failed nest	%	Egg lost	% Eggs lost	Chicks lost	% chicks lost	Total losses	%
Non-trapped site	173	120	11	9	8	7	2	2	21	18
Trapped site	176	133	9	7	14	11	5	4	28	21
Mean	174.5	126.5	10	8	11	9	3.5	3	24.5	19

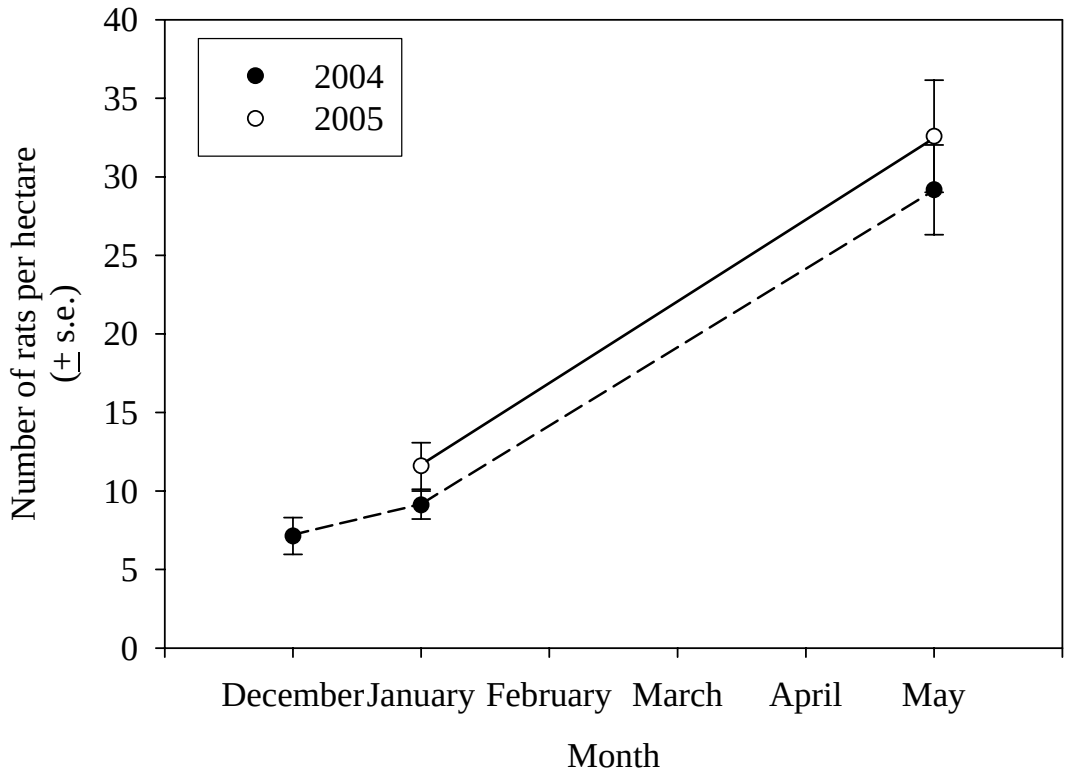
Removal of rats

A total of 2132 rats were trapped over the five trapping sessions on all the trapping grids. Rat numbers were initially high on grids, but numbers caught declined rapidly to average about 3-6 rats caught per day from about day 10 of trapping. From about day 6 most rats caught were probably invading the trapping area from outside the grids. Male ship rats weighed 212 gm (NZ average: 147 gm) and females weighed 190 gm (NZ average: 131 gm). Some rat stomachs had the remains of eggshell and down feathers in them

Density of rats

In both seasons the density of rats increased from around 10-12 rats per hectare in early January to about 25-30 rats per hectare by mid-May (graph 4).

Graph 4
Seasonal change in the density of ship rats
2003-2004 and 2005



Weka removal

A total of 14 weka were removed from all the burrow-scoped sites in 2005. One male weka was found to have a titi chick leg and foot in its stomach.

Discussion

The research in 2004 showed that chicks were being lost on all the burrow-scoped sites regardless of whether they were rat-trapped or not. At the same time, many freshly dead titi chicks were found on most sites, and a few weka were seen to pull titi chicks out of burrows and kill them. So it appeared that weka, not rats, were the main predator on titi. Therefore the second summers work on Taukihepa concentrated on removing rats from three sites as usual plus removal of weka from all six sites, to see if we could reduce the loss of chicks to weka, and therefore highlight any losses of chicks caused by rats.

The second summer of field-work has reinforced the view that the impact of ship rats on titi is minor at the most. The impact of weka, however, is significant. Up to 15% of titi eggs may be being eaten by weka and an average of 12% of titi chicks were being killed by weka. These rates of predation are higher than previously estimated as only the non-trapped sites were used for this analysis last year. The control of just a few weka on each site in 2005 was enough to significantly reduce the loss of chicks.

The impact of weka was highly variable between sites, as some sites had very little loss of eggs or chicks and some had very high loss rates. This variability could be due to lower numbers of weka on some sites (meaning the predation rate could be related to density) or the weka on some sites may not be specialist predators of titi eggs or chicks (meaning the predation may be related to individual behaviour).

The failure rate of nests on the islands was about 10% and did not change significantly between years. Almost all the failed eggs were fertile but had died in the first few weeks. Failure of nests could be due to chilling of the egg for various reasons, like very wet weather for example, or an inexperienced bird not incubating properly, or the death of one of the incubating pair.

Egg losses remained about the same across both summers, also at about 10%. A few of these losses may have been due to a nest failing, but it is probable that most of the losses are due to predation by weka. It is unlikely that 200gm rats would tackle a 900gm incubating titi. Similarly, the pattern of egg loss followed the pattern of chick loss, in that on site where more eggs were lost, more chicks were also lost, which suggests the same cause(s) for the losses. In addition, several opened fresh eggs, with a developed embryo inside, were found on the ground in early January 2005. Most of the rest of the fluid in the egg was gone. The eggs were obviously fertile and had to have been incubated for the embryo to develop. Weka have been seen going down titi burrows regularly and they could easily surprise a sleeping titi, and steal their eggs. Many sleeping adult titi were not woken while burrow-scoping their burrows in January.

Ship rats on the titi islands are about 30% heavier than ship rats on the mainland. They are also in much numbers than on Rakiura. Numbers of rats on Rakiura reach about 3-4 per hectare in most years, whereas rats on the titi islands have minimum numbers of about 6-8 rats per hectare rising to 4-5 X this by late autumn. The increase in numbers ties in with the titi breeding season. Rats only begin to breed in December (after titi

begin nesting) and continue to breed until May (when the last titi chicks leave). Rats on Rakiura, however, breed from mid-autumn to winter. It is obvious that the rats are, at the least, scavenging the numerous dead titi, abandoned eggs and chicks. This is all very high quality food and contributes to the rats' very large size and their substantial increase in numbers while the titi are present. The impact of ship rats on titi was not detectable in this analysis, but it appears to be very minor impact at most. The planned stable-isotope analysis of the various samples from rats, weka and dead titi will further clarify these results.

Acknowledgements

I wish to extend my thanks to the Taukihepa and Rerewhakauopoko birders who made me and my volunteers very welcome and always keen to help. Their work helped to substantially in measuring the affect of rats and weka on titi. I would also like to acknowledge all the Committee members' and manu owners' courage and hospitality in allowing myself and the team onto the islands and their respective manu.

Appendix G-2: Harper Rat Report 2010

Appendix: Harper, G. 2010 Report

Changes in relative abundances among forest birds before and after the eradication of ship rats on Taukihepa Island, Tïtï Islands, New Zealand (Report 2)

DRAFT

Grant Harper

Report prepared for Ka Mate Nga Kiore (Kill the rats) Incorporated Society

April 2010

Introduction

The Taukihepa (Big South Cape Island) ship rat *Rattus rattus* invasion of 1963 is one of the most infamous and well-documented introductions of an exotic species to an island. The ensuing irruption of ship rat numbers led to the extinction of several endemic and native bird species, an endemic bat, a large, ground dwelling weevil and other invertebrate species (Bell 1978).

Taukihepa (900ha) has several million burrowing seabirds on the island, mainly the titi, or sooty shearwater (*Puffinus griseus*) and mottled petrels (*Pterodroma inexpecta*). They breed on the island during the austral summer and the majority migrate to the northern Pacific (mainly the coasts of California, Alaska, Kamchatka, and Japan) during austral winter (Shaffer et al. 2006). Titi are subject to customary harvest by Rakiura Maori.

The breeding success of titi were probably being adversely affected by predation by ship rats during the chick stage. Large petrel species elsewhere were negatively affected by this rat species (Seto & Conant 1996, Jouventin et al. 2003, Igual et al. 2006). The affects of predation on titi by ship rats and weka (*Gallirallus australis*), a large native rail, have only recently been investigated (Harper 2006, Harper 2007).

In July 2006, ship rats were eradicated from Taukihepa and the nearby islands of Pukeweka, Rerewhakauopoko (Solomon) and kiore/Pacific rat *Rattus exulans* were eradicated from Mokonui Island. Funding for the eradication was provided by the *Command* Trustee Council as reparation for mortality of sooty shearwaters during an oil spill off the California coast during September 1998. The spill coincided with the sooty shearwater migration, and assessment data indicated that titi were the species most affected numerically.

Benefits from ship rat eradication were anticipated to extend beyond titi as other native forest birds on the islands were also likely to be adversely affected by ship rat predation (Moors 1983, Brown et al. 1998). Therefore, counts of forest birds were initiated to measure the response in numbers of birds after removing rats. It was expected that this response would be very quick once the adverse effects of predation and competition for food were removed. This is in contrast to measures of the response of titi to the removal of rats, which was not expected to be apparent for six to seven years when 'post-eradication' titi chicks begin to return to breed for the first time.

This is the second report of an ongoing study to record the changes in the relative abundances of forest birds after the removal of ship rats.

Methods

Bird counts were undertaken between March 15 and March 30 in 2006, 2008 and 2010. No counts were carried out in 2007. The counts were carried out in conditions of less than 15 knot winds and at the most, only light precipitation, to reduce the adverse affects of noise. Counts were carried out between 0900 and 1800hrs NZDT. All counts were carried out between the Parata and Parikiore manu inclusive, on the eastern coast of Taukihepa. Thirty-five counts were carried out over 1-3 days.

Counts were carried out under forest cover of 70-100% tupare *(Olearia colensoi*) forest with occasional small patches of *Hebe elliptica* and southern rata (*Metrosideros umbellata*). Sites were selected with groundcover of less than 20% of shield fern and/or water fern.

Two counts methods were used. The principal method involved counting all the birds that entered a 20-m diameter 'vertical cylinder' over a five-minute period. To do this a site was selected and temporary marks (flagging tape in small stakes) were laid out in a 10-m radius from the site. These sites were at least 100-m apart from other counting sites. Each site was located by GPS and weather conditions were noted.

The second method used the standard five-minute count method whereby all individual birds seen or heard from the selected site were counted over a five-minute period. This was a secondary or back-up method, mainly to obtain presence/absence data as a few species (i.e., blackbirds) were less likely to enter the 20-m diameter circle.

The data was analysed using repeated measures ANOVA.

Results

In 2006, 35 sites were sampled from 21 March to 22 March. The count data are in Appendix 1 and the abundances of birds are graphed in Figure 1.

In 2008, 35 counts were undertaken during March 27, 29 and 30. The count data are in Appendix 2.

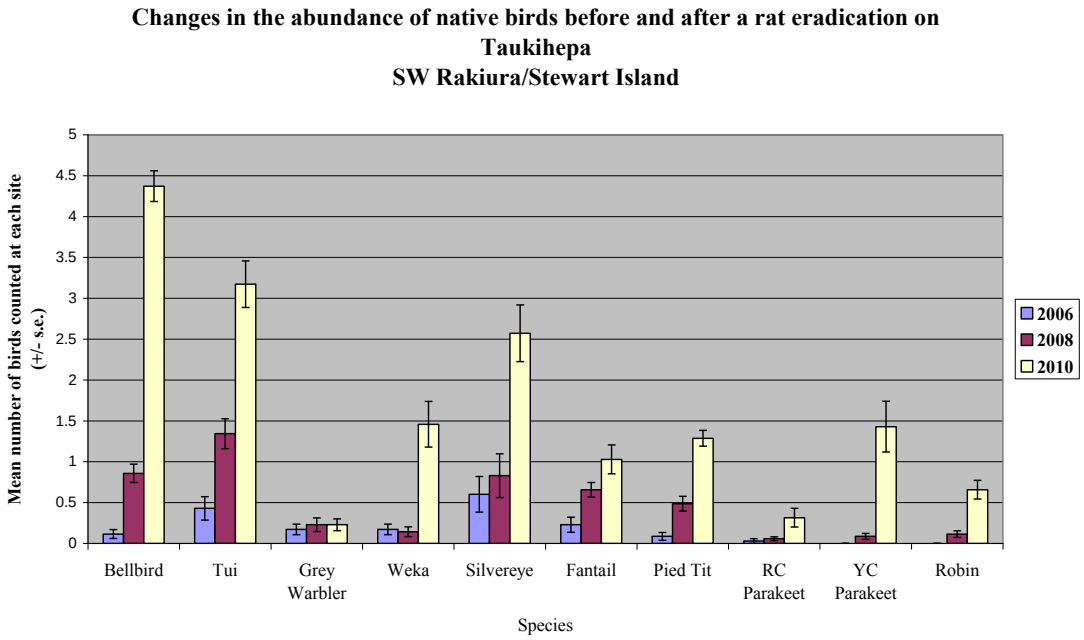
In 2010, 35 counts were carried out on 17 and 18 March. The count data are in Appendix 3 and the abundances of birds are graphed in Figure 1.

Fifteen species were recorded (Appendix 3). Nine native species were recorded in significantly greater abundances in 2010 compared with 2006: weka *Gallirallus australis* ($F_{3,35}$ = 19.2, P = 0.0005), koapara/bellbird *Anthornis melanura* ($F_{3,35}$ = 312.6, P = 0.0005), tui *Prosthermadera novaeseelandiae* ($F_{3,35}$ = 55.3, P = 0.0005), tauhou/silvereye *Zosterops lateralis* ($F_{3,35}$ = 14.3, P = 0.0005), miromiro/pied tit *Petroica macrocephala* ($F_{3,35}$ = 46.3, P = 0.0005), piwakawaka/fantail *Rhipidura fulginosa* ($F_{3,35}$ = 9.3, P = 0.0008), kakariki/yellow-crowned parakeet *Cyanorhamphus auriceps* ($F_{3,35}$ = 19.0, P = 0.0005) kakariki/red-crowned parakeet *Cyanorhamphus novaezelandiae* ($F_{3,35}$ = 5.4, P = 0.007) and toutouwai/Stewart Island robin *Petroica autralis rakiura* ($F_{3,35}$ = 24.8, P = 0.0005).

Of the native species only grey warbler/riroriro *Gerygone igata* had not increased in abundance ($F_{3,35}$ = 0.26, P = 0.77)

Introduced species
Dunnock *Prunella modularis* have increased in abundance since 2006 *(*($F_{3,35}$ = 7.7, P = 0.001) as have blackbirds ($F_{3,35}$ = 3.2, P = 0.05). A few redpolls *Carduelis flammea* were also heard.

Other bird species
On 17 March 2010, a black swan was noted flying into Murderer's Cove at 1030 hrs.



Discussion

The abundances of all native birds, except grey warblers, have continued to increase since the eradication of rats in 2006. In early 2006, silvereye and tui were the most common species recorded, but bellbirds are now the most abundant bird along with tui. Whereas koapara/bellbirds were noticeably uncommon prior to the rat eradication (pers. obs.), they are now fifteen-times as common as they were three and a half years ago.

Although red-crowned parakeet were once the most common parakeet on the island, but still an uncommon bird, they have now been superseded by yellow-crowned parakeets, which were seen or heard on 24 of the 35 count sites. Prior to the rat eradication these parakeets were very rarely heard, let alone seen. Now groups of up to 10 yellow-crowned parakeets are often disturbed feeding in the leaf litter.
Weka have also made a noticeable comeback since the post-eradication count in 2008 and were regularly encountered at count sites and in occasionally groups of up to eight. They are now substantially more common than pre-eradication which suggests that rats were having some impact on their breeding success, which is surprising considering their size and aggressive nature. There was also a noticeable lack of adult dead korure/mottled petrels *Pterodroma inexpecta*. Prior to the rat eradication korure/mottled petrels carcases were commonly found in the steep forest behind Murderer's Cove. This lack of corpses suggests that only a few 'rogue' weka were actively preying on petrels or maybe titi chicks and that the behaviour was learned. The behaviour may reassert itself in future when pressure on weka numbers and food supply may force weka into preying on seabirds again.

The self-reintroduced robins have done well since their arrival on the island and were seen at 20 of the 35 count stations. This species should continue to increase in abundance for some time. Increases in the abundances of fantail and pied tit were also recorded which is not surprising as invertebrate numbers improve post rat eradication. Grey warbler continue to remain uncommon and will probably not increase much. On other islands without rats grey warbler are not particularly common, mainly due to competition from species like pied tit and bellbird.

It is expected that the increases recorded cannot continue to rise due to restrictions in habitat availability and competitive interactions between species and individuals. Another count in 2012 should note a levelling out in the mean number of individuals in all the species recorded at the sites.

Conclusion

The numbers of native birds on Taukihepa has continued to burgeon since the eradication of rats, which gives some indication of the density of birds present before rats arrived. It is likely that the growth in bird populations should level off shortly as competition between species begins to impede population growth. An additional count in 2012 should record this likely change in growth trend. In future, instead of rat predation severely restricting bird numbers, more natural limits to growth will assert themselves, namely fewer births and more deaths due to limited food supply. Normally in these situations of populations growing at the rate we have seen, there is often an 'overshoot' in numbers and a crash in the population before population return to equilibrium with the habitat and other species present. Eventually species' populations will level off around an optimum for the tüpare habitat. Whether we have reached that yet is to be seen. A complicating factor for some species will be the reintroduction of tïeke/saddleback, a species that will likely compete with some of the other species present. It has been very heartening and most surprising watching the incredible increase in abundances of native birds on the island since the eradication, which has certainly exceeded my expectations.

Acknowledgements

The Ka Mate Nga Kiore (Kill the rats) Incorporated Society and the Command Trustee Council provided the funding for this research. Hannah Nevins of Oikonos initiated the project and assisted with planning. Ron Bull and his whanau, once again, were supremely helpful and welcoming during my time on the island and the crew of the "Shangri La" got us onto the island. The Department of Conservation, Nelson/Marlborough Conservancy, provided for my time on the island at no charge.

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Appendix G-3: Harper, 2007

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Wildlife Research, 2007, 34, 443–453

Detecting predation of a burrow-nesting seabird by two introduced predators, using stable isotopes, dietary analysis and experimental removals

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Abstract. Burrowing seabirds are vulnerable to extirpation by introduced predators such as rats, but much evidence of predation is circumstantial. On Taukihepa, an island off southern New Zealand, two possible predators exist with sooty shearwaters (*Puffinus griseus*): the weka (*Gallirallus australis*), a large rail, and the ship rat (*Rattus rattus*), both introduced to the island. It was expected that chick predation would be principally by weka, the much larger of the two predators. To measure losses of sooty shearwater chicks to weka or rats, nests were monitored with burrow-scopes at six sites in the summers of 2003–04 and 2004–05. In three of the sites rats were removed on 4-ha grids by trapping. In the other three sites rats were not trapped. In addition, weka were removed from all six sites in 2005. Concurrent diet analysis of weka and rat stomachs was undertaken as well as stable isotopic analysis ($\delta^{13}C$, $\delta^{15}N$) of samples from rats and weka. These were compared with possible prey items including sooty shearwaters. Additional stable isotope samples were taken from Pacific rats (*Rattus exulans*), a small rat species present with weka and sooty shearwaters on nearby Moginui Island. Weka diet comprised ~40% of bird remains by volume and calculations using Isosource, an isotopic source portioning model, estimated sooty shearwaters contributed 59% (range: 15–71%) of weka diet during the sooty shearwater chick-raising period. Ship rats, in contrast, had very depleted $\delta^{13}C$ isotope signatures compared with sooty shearwaters and bird remains contributed <9% of diet by volume, with Isosource calculations suggesting that ship rats consumed more passerine birds (mean: 30%; range 5–51%) than sooty shearwaters (mean 24%; range: 0–44%). In both summers, more chicks were lost on sites from which rats had been removed than on control sites. When weka were removed in 2005, fewer chicks were lost than in 2004 and significantly fewer weka-killed chicks were found on weka-removal sites than on non-removal sites. Weka were the principal predator of sooty shearwater chicks, depredating an estimated 9.9% of nests. Combining several techniques quantified the loss and identified the principal predator of a seabird in decline.

Introduction

Burrowing seabird populations are particularly vulnerable to introduced predators (Moors and Atkinson 1984), and this is especially true on islands. When mammalian predators, such as rats (*Rattus* spp.) or domestic cats (*Felis catus*), are introduced to islands, resident populations of seabirds invariably decline or go extinct (Atkinson 1985; Burger and Gochfeld 1994). Non-native avian predators introduced to islands can also kill seabirds. An example is on subantarctic Macquarie Island, where the weka (*Gallirallus australis*, ~750 g), an omnivorous rail endemic to New Zealand, was introduced in 1872, and the ship rat (*Rattus rattus*) in early 1900s (Taylor 1979). Weka, ship rats and cats, introduced *c.* 1810, have been recorded preying on the numerous seabird species present, resulting in populations of smaller seabirds disappearing from the island (Brothers 1984).

In some instances, seabird populations persist on islands where exotic predators have been introduced. On some of the Titi Islands in southern New Zealand, burrowing sooty shearwaters, or titi, breed in large numbers despite the presence of ship rats, which were introduced in 1963 (Bell 1978), and weka, introduced early in the 20th century (Miskelly 1987) and also implicated as predators of sooty shearwaters (Imber 1975; Brothers 1984). The abundance of sooty shearwaters is declining worldwide, which has been variously attributed to climate change, drift-netting, and predation by introduced mammals (Lyver *et al.* 1999, 2000; Scofield and Christie 2002; Uhlmann *et al.* 2005). Predation by ship rats on eggs and small chicks is inferred in sooty shearwater populations elsewhere and in other similar-sized burrowing petrels (Lane 1962; Harris 1970; Grant *et al.* 1981; Thibault 1995). Imber (1975) suggested, however, that nesting petrels are only likely to be extirpated if the maximum weight of a rat predator is about the same as, or exceeds, the average adult weight of the petrel species. Similarly, Major *et al.* (2006) concluded that Norway rats (*Rattus norvegicus*, 170 g) caused deaths in least auklet (*Aethis pusilla*) chicks (adult weight 84 g), rather than adults or eggs, but principally through disturbance of the adults and subsequent exposure of chicks rather than predation. Sooty shearwaters weigh ~800 g and male ship rats ~200 g (Heather and Robertson 1996; Innes 2005), so the inferences for predation of this species are equivocal. However, like other petrels (Imber *et al.* 2003), sooty shearwater chicks are most vulnerable just after the brief

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guard stage, when chicks weigh 90–150 g (Richdale 1945), because foraging adults are increasingly absent (Richdale 1945). So it was possible that rats would depredate sooty shearwater chicks in the first week or two after hatching. The magnitude of loss of sooty shearwater chicks from introduced predators on offshore islands is unknown, however, because egg or chick depredation has not been measured.

As direct observations of predation are rare, effects of rats on seabirds are often inferred from observations of chick remains or emptied nests (Brothers 1984; Brooke 1995; Seto and Conant 1996; Major and Jones 2005) and, increasingly, from ratios of the stable isotopes of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) (Hobson *et al.* 1999; Drever *et al.* 2000; Major *et al.* 2007). Hobson *et al.* (1999) suggested combining stomach content analysis and stable isotopes to clarify the nature of introduced predators' effects on seabirds. Subsequently, Stapp (2002) used both techniques to investigate the impact of ship rats on seabirds, but was unable to establish whether rats killed or simply scavenged seabirds. Scavenging yields very similar stomach contents and stable isotope values as predation (Stapp. 2002). Differential nesting success between sites where rats were present or removed can be used to measure the effect of rats on seabirds (Seto and Conant 1996; Thibault 1995; Bried and Jouventin 1999). Invariably, nesting success was higher where rats were extirpated or reduced to low densities. In light of these findings, a predator-removal and non-removal experiment was established on Taukihepa, in concert with gut samples and stable isotope analysis. Comparing breeding success of sooty shearwaters on sites where predators were present or removed would provide the level of loss attributable to predators. Stable isotope samples from Pacific rats (*Rattus exulans*) on an island with sooty shearwaters were also sought, to provide comparative data from a small predator less likely to kill a large shearwater.

The objectives of the study were to quantify the loss of sooty shearwater chicks and eggs, and to identify the principal predator responsible for any losses. As both rat species were smaller than sooty shearwaters it was expected that the weka was likely to be the principal predator.

Methods

Study sites

Taukihepa, or Big South Cape Island (797 ha, 47°14′S, 169°25′E), lies ~2 km south-west of Stewart Island/Rakiura, New Zealand (Fig. 1). It is the largest island in the southern Titi Islands, so named because of dense populations of titi or sooty shearwaters that breed there over the austral summer and autumn. Soils are derived from peat and are highly modified in the upper horizons by massive mixing and addition of marine-derived nutrients from the burrowing of titi (Hawke and Newman 2005). The climate is wet (1400 mm), with over 250 rain days (>0.1 mm) spread throughout the year. The mean annual temperature is 10.3°C (Sansom 1984). Strong winds are normal. A detailed description of the habitat on the islands is given by Johnston (1982).

Pacific rats were trapped on nearby Moginui or Big Moggy Island (68 ha) (Fig. 1). Moginui has very similar rocks, soils, climate, and forest to Taukihepa. Moginui slopes upward from the east to high cliffs in the west, and Pacific rats, weka and sooty shearwaters were present.

Assessing nesting success

Burrows in six sites on Taukihepa were randomly selected in December 2003 (Fig. 1). The sites were a minimum of 400 m apart to maintain the independence of individual predators. Within each site we used an infrared burrowscope (Lyver *et al.* 1998) to select between 36 and 51 burrows occupied by sooty shearwaters incubating eggs. Nests were initially checked once or twice in early December. To record hatching success and chick survival, burrows were then examined before eggs hatched in mid-January, and observations then repeated every three days until mid-February. By this time the chicks were assumed to be large enough (~400 g) to defend themselves from rats. Nest failures were recorded when eggs did not hatch but were still present. The burrows were examined again in March to record any further losses. The process was repeated between December 2004 and March 2005.

Statistical analysis of each measure of nest failure, egg loss and chick loss was carried out using an ANOVA, where the reproductive measure equalled the year plus treatment results. Replicates were the site and year combination (n = 12) and year

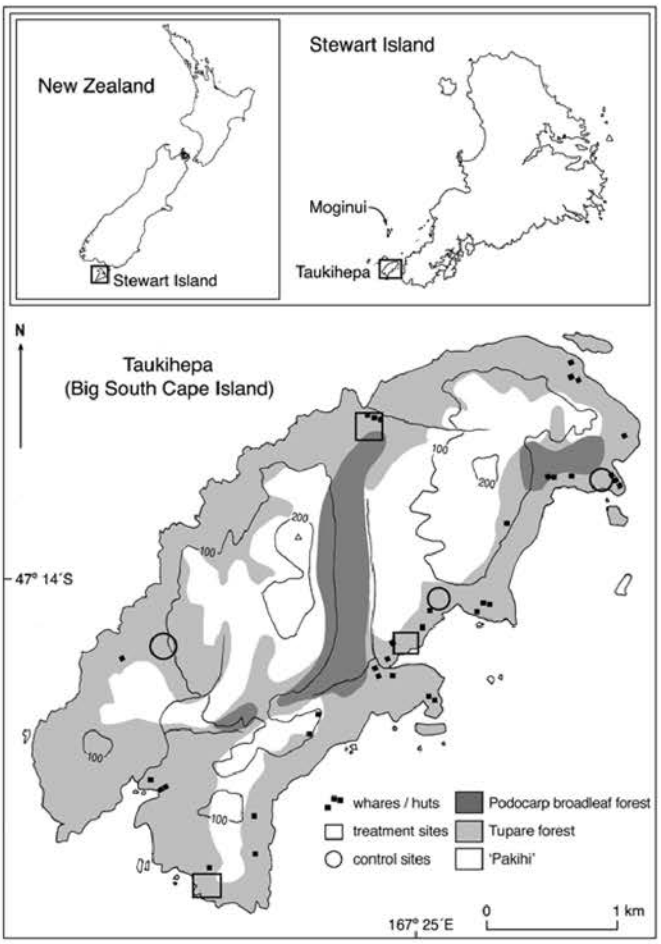

Fig. 1. The location of treatment (rat-trapped) and control (non-trapped) sites on Taukihepa and location of Moginui and the southern Titi Islands, south-west New Zealand.

and treatment were explanatory variables. Percentage losses were square-root transformed before analysis.

Predator removals

Rats were trapped and removed from three treatment sites out of the six monitoring areas situated across the island (Fig. 1). A compass and fabric measuring tape were used to establish the traps on grids. The location of the corners of the 200 m by 200 m (4 ha) grids were recorded by Global Positioning System (GPS) using a Garmin Etrex. Trapping grids consisted of 85 'Victor'™ snap-traps, in a grid of seven traps at 33-m intervals on 13 alternate offset rows 16 m apart. The traps were baited with a mixture of rolled oats and peanut butter and secured with wire stakes under 12-mm galvanised mesh covers. Traps were set when they were put out and operated continuously for the following 4–5 weeks.

To obtain stable isotope samples from Pacific rats on Moginui, a trapping grid of 49 traps under mesh covers was established on the northern end on 16 March 2005 and run for five days. The 100 m by 100 m (1 ha) grid consisted of seven rows 15 m apart, each of seven traps at 15-m intervals. The numbers of traps used was limited by transport restrictions.

Traps were checked every morning, and all rats removed and processed on the day of capture, following Cunningham and Moors (1996). Muscle samples for stable isotopic analysis were taken from the left hind leg.

Within- and between-season measures of chick losses due to weka were made during the study period. Sooty shearwater chicks found with the distinctive injuries caused by weka (Harper 2006) were collected on the six monitoring sites and on tracks between monitoring sites (Fig. 1) in January and February 2004 and 2005. Search effort for dead chicks was approximately equal on the monitoring sites and tracks each year. In January and February 2005, in addition to rat removals on three sites, any weka found on all six monitoring sites were removed. Weka were killed immediately by pithing. Each weka was measured, sexed and weighed and the crop and a pectoral muscle sample were removed for dietary and stable isotopic analysis, respectively.

Diet analysis

Stomachs from rats and crops from weka removed from experimental sites were later analysed. Each stomach or crop was stored in a vial in 75% ethanol. A subsample of rat stomach samples from January 2005 was used to compare rat and weka diets for the same period. Birds were identified mainly by feather and shell remains, and some bones. Insects were identified from exoskeleton remains. Plant material, including leaves, seed or fruit, were recorded. For rats, bait ingested from traps was also recorded. Results were recorded in two ways: (1) frequency of occurrence (percentage of guts containing a prey item), and (2) estimated volume of food items. Two methods were used, because the former does not take into account prey weight and its relative contribution to daily food intake. The frequency-of-occurrence method has been used in many studies of rat or weka diet (Carroll 1963; Gales 1982; Brothers and Skira 1984; Moors 1985) and is therefore useful for comparisons.

Muscle tissue samples from ship rat, Pacific rat, and weka were stored frozen in a propane freezer and transferred later to a laboratory freezer. Additional possible diet items, including pectoral muscle from freshly dead sooty shearwater adults and chicks, invertebrates, and plant material were obtained opportunistically. Although this sampling was not random, major diet items of rats and weka were chosen.

Stable isotope analysis

Samples were analysed for stable isotope ratios by Iso-Trace New Zealand Ltd, Dunedin. Samples were freeze-dried and ground into a powder, then lipids were extracted using a chloroform–methanol rinse. Isotope ratios ($^{13}C/^{12}C$ and $^{15}N/^{14}N$) were measured using isotope ratio mass spectrometry (IRMS; Hydra® 20/20 mass spectrometer). Stable isotopes are expressed in δ notation (in parts per thousand; per mil; ‰) as follows:

$$\delta X(‰) = 1000 \times (R_{sample} - R_{standard}) / R_{standard}$$

where X is the ratio of ^{15}N to ^{14}N or ^{13}C to ^{12}C and R is the ratio $^{15}N/^{14}N$ or $^{13}C/^{12}C$ as measured for the samples and relevant standards (atmospheric N_2, VPDB, respectively). The notations ($\delta^{13}C$ and $\delta^{15}N$) refer to the enrichment (positive values) or depletion (negative values) relative to these standards. Measurement errors are shown in Table 2. Turnover time for muscle tissue is ~4 weeks (Tieszen *et al.* 1983), so the ratios reflect the diet during the period before death.

The possible percentage contribution of several potential prey items to rat or weka diet was estimated using the mean isotopic values of prey in the computer program Isosource (Phillips *et al.* 2005). The calculation involved pairs of carbon and nitrogen isotopic signatures being compared with all other isotopic pairs of possible prey, in an iterative model, as possible solutions to the observed predator's isotopic signature. Appropriate diet-tissue fractionation values between prey and consumer were selected for the model. For weka, values of +1.9‰ and +3.1‰ for $\delta^{13}C$ and $\delta^{15}N$ respectively were applied to possible prey items to estimate fractionation to consumer tissue. These values were derived from pectoral muscle of dunlin (*Calidris alpina pacifica*) (Ogden *et al.* 2004). Potential prey items for rats had fractionation values of +0.5‰ for $\delta^{13}C$ and +3.0‰ for $\delta^{15}N$ applied using values from gerbil (*Meriones unguiculatus*) muscle tissue (Tieszen *et al.* 1983). The stable isotope values for muscle of weka and ship rats are listed in Table 2. Uncertainty in the source contribution estimates due to measurement error and sample variability can be included in the Isosource model by choosing tolerance values. The tolerance value and source increment value were set at 0.1‰ and 1‰ respectively. Results were graphed as a mean value with maximum and minimum range values. Comparisons of the results were made with the percentage contribution of prey to predator diet as assessed from stomach or crop samples.

Results

Sooty shearwater nesting success

Of 347 marked burrows, 280 (81%) were occupied by nesting birds in 2003–04 and 253 of 349 burrows (72%) in 2004–05. In both 2004 and 2005 eggs began hatching on ~12 January. The last eggs hatched on ~1 February.

In 2004, seven nests failed on control sites and 15 failed on treatment sites (Fig. 2*a*). In 2005, 11 nests failed on control sites and nine on treatment sites. There was no significant treatment

effect over both years ($F = 3.67$, $P = 0.09$). There was also no significant difference between years ($F = 0.02$, $P = 0.9$) or treatment sites ($F = 0.25$, $P = 0.63$). Most eggs from failed nests were retrieved and checked for cause of death and all appeared to have been fertile but died during development.

In 2004, 15 eggs disappeared on the treatment sites and 10 disappeared on the control sites (Fig. 2*b*). In 2005, 14 eggs disappeared on the treatment sites and eight disappeared on the control sites. There was no significant treatment effect over both years ($F = 1.14$, $P = 0.32$). Similarly, there was no significant difference in egg loss between years ($F = 0.81$, $P = 0.39$) or treatment sites ($F = 3.24$, $P = 0.11$).

Predator removals

In total, 2132 ship rats were trapped over the five trapping sessions on all the trapping grids. Rat captures were initially high, but captures declined rapidly to average about one rat or less trapped per hectare from about the fifth day of trapping. From about then most trapped rats were likely invading the trapping area from outside the grids. Fifteen weka were removed from the six burrow-scoped sites (mean number of weka removed: 2.5, s.e. 0.62). The mean density of radio-tracked weka on Taukihepa was estimated at 0.76 ha^{-1} (s.e. 0.07) in tupare forest (Cunninghame 2006), which yielded an approximate density of 3.04 weka on the 4-ha grid sites.

The percentage loss of chicks was not significantly affected by treatment over both years ($F = 0.01$, $P = 0.97$) or significantly different between treatment sites ($F = 1.21$, $P = 0.3$). However, there was a difference between years that approached significance ($F = 4.83$, $P = 0.06$). There was a substantially smaller percentage of chicks lost in 2005, on the control and treatment sites combined, than in 2004 (Fig. 2*c*.). In 2004 more chicks were lost on treatment sites (19) than the nine lost on the control sites. In contrast, when weka were removed from both treatment and control sites in 2005, only five chicks were lost on the treatment sites and two on the control sites. In addition, ~60% fewer weka-killed chicks ($n = 13$) were found on weka-controlled sites in 2005 than in 2004 ($n = 29$). However, on tracks with no weka control in 2005, more weka-killed chicks were found ($n = 9$) than in 2004 ($n = 4$). This was a significant departure from homogeneity ($\chi^2 = 4.57$, d.f. =1, $P = 0.033$).

Diet analysis

Crop samples from 15 weka were analysed. Although insects occurred more often in weka diet than did bird remains, insects and bird remains contributed approximately the same (38.8% and 39.6% respectively) to diet by volume (Fig. 3*a*). Fruit or seeds were the next most common diet items. Two crops, from separate sites, were full of sooty shearwater chick remains, including skin, feathers and a foot in each.

Rat diets in January 2005 consisted mainly of insect and plant remains by either volume or occurrence (Fig. 3*b*). Bait was recorded in the results but normally would not be present. Bird remains, including meat and down feathers, constituted only 8.7% of rat diet by volume and occurred 11 times in 60 rat stomachs. This included three cases where eggshell was recorded. Insects occurred more often than the other diet items, but contributed a similar amount, by volume, to rat diet as plant material. There was no significant departure from homogeneity for the

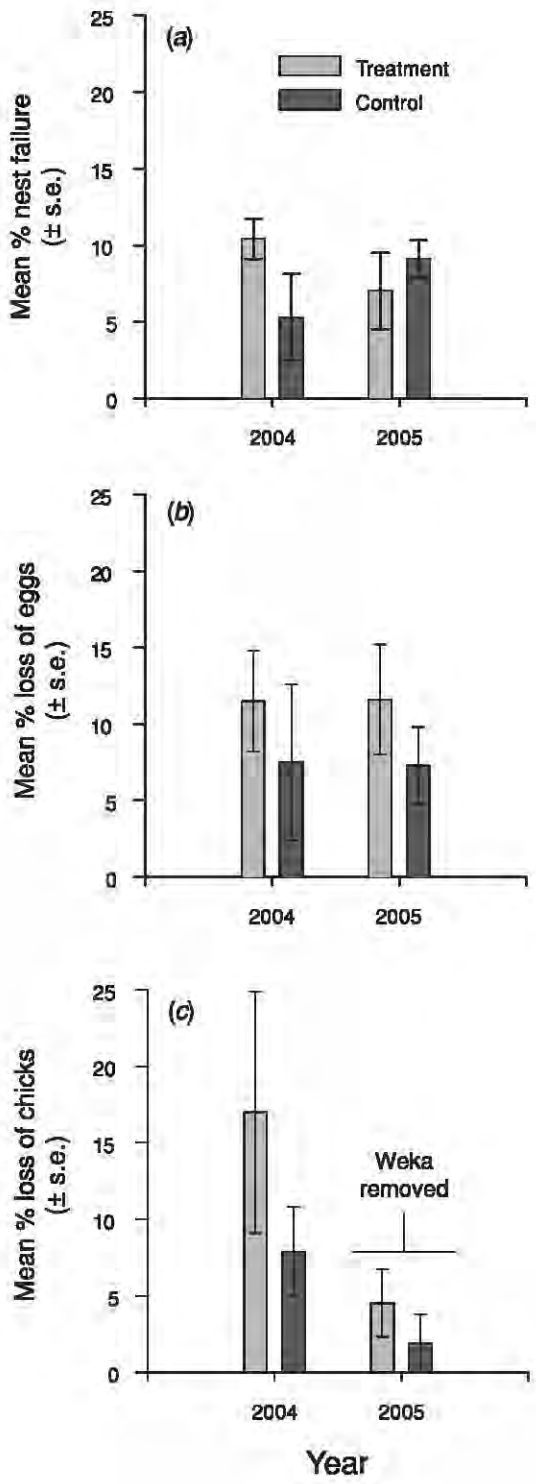

Fig. 2. (*a*). Estimated failure rate (%) of sooty shearwater nests on six sites on Taukihepa, summer 2004 ($n = 280$ occupied burrows) and 2005 ($n = 253$ occupied burrows). (*b*). Estimated loss of sooty shearwater eggs (%) from burrows on six sites with ship rats and weka were present on Taukihepa, summer 2004 ($n = 258$ burrows with incubated eggs) and 2005 ($n = 233$ burrows with incubated eggs). (*c*). Estimated loss of sooty shearwater chicks (%) from burrows at three treatment sites (ship rats removed) and three control sites (ship rats present) on Taukihepa, summer 2004 ($n = 233$ burrows with eggs remaining) and 2005 ($n = 213$ burrows with eggs remaining). Weka were present in 2004 but removed in 2005.

Table 1. Results of statistical analysis, using Mann–Whitney U-tests, to determine comparative differences in the stable-nitrogen and -carbon signatures of muscle tissue collected from ship rats, Pacific rats, weka and sooty shearwater chicks and adults on Taukihepa and Moginui, 2005
Statistically significant values are indicated: *, P ≤ 0.05; **, P ≤ 0.01

		Sooty shearwater (Taukihepa) (*n* = 5)		Ship rat (Taukihepa)		Pacific rat (Moginui)		Weka (Taukihepa)	
		$\delta^{15}N$	$\delta^{13}C$	$\delta^{15}N$	$\delta^{13}C$	$\delta^{15}N$	$\delta^{13}C$	$\delta^{15}N$	$\delta^{13}C$
Ship rat (Taukihepa) (*n* = 11)	U	1.0	44.0						
	P	>0.01**	0.06						
Pacific rat (Moginui) (*n* = 4)	U	0.0	12.0	40.5	61.0				
	P	0.01*	0.62	0.45	>0.01**				
Weka (Taukihepa) (*n* = 7)	U	2.5	18.5	66.5	68.5				
	P	0.01*	0.87	0.01*	>0.01**				
Weka (Moginui) (*n* = 2)	U	–	–	–	–	8.0	8.0	4.0	13.0
Weka (Moginui) (*n* = 2)	*P*	–	–	–	–	0.06	0.06	0.38	0.08

seasonal occurrence of plant or insect items in rat diet in January and May of 2004 and 2005 (plants: $\chi^2 = 0.62$, d.f. =1, $P = 0.43$; insects: $\chi^2 = 0.02$, d.f. =1, $P = 0.89$). However, there was a significant departure from homogeneity for bird remains ($\chi^2 = 4.35$, d.f. =1, $P = 0.04$). Fewer bird remains were found in rat stomachs in January 2005 than in January 2004, and much more in May 2005 than the corresponding month in 2004.

Stable isotope analysis

The mean isotopic values of weka, ship rats, Pacific rats and possible diet items are shown in Fig. 4, (details in Table 2), with statistical comparisons between the possible predators and sooty shearwaters in Table 1. $\delta^{13}C$ and $\delta^{15}N$ values were obtained from 11 ship rat and four Pacific rat muscle samples for Taukihepa and Moginui respectively. Seven weka muscle samples from Taukihepa were analysed for stable isotope ratios and two from Moginui. Three muscle samples were obtained from adult sooty shearwaters and two from chicks. The isotopic values for sooty shearwater adults and chicks were combined for the analyses. Replicate measurements of internal laboratory standards (EDTA-OAS) indicated measurement values of –0.9 (±0.3) for $\delta^{15}N$ and –38.3 (±0.03) for $\delta^{13}C$.

Table 2. Stable–nitrogen ($\delta^{15}N$) and –carbon isotope ($\delta^{13}C$) values of muscle tissue of rats and weka, and sooty shearwater muscle tissue and possible terrestrial prey values from Taukihepa and Moginui Islands

Sample	*n*	$\delta^{15}N$ (±0.3%)		$\delta^{13}C$ (±0.03%)	
		Mean	s.e.	Mean	s.e.
Ship rat (Taukihepa)	11	14.66	0.58	–22.76	0.23
Pacific rat (Moginui)	4	14.85	0.53	–22.05	0.17
Weka (Taukihepa)	7	12	0.53	–21.8	0.28
Weka (Moginui)	2	12.6	0.20	–20.35	0.25
Sooty shearwater chick	2	10.35	0.95	–21.1	1.10
Sooty shearwater adult	3	9.53	0.43	–21.5	0.82
Spider	1	14.3	–	–24.4	–
Grass (*Poa tennantiana*)	1	13.7	–	–27.8	–
Amphipod	3	10.27	0.30	–24.87	0.37
Weta (Orthoptera)	1	8.6	–	–25.7	–
Tupare (*Brachyglottis colensoi*)	5	8.5	1.06	–27.28	0.88
Beetle	2	8.5	1.80	–23.65	0.65
Fern (*Histiopteris incisca*)	3	3.87	0.73	–28.77	1.14
Rata (*Metrosideros umbellata*)	1	–3.9	–	–25.1	–

All the possible predators were significantly more enriched in $\delta^{15}N$ than sooty shearwaters. Sooty shearwaters were not significantly more enriched in $\delta^{13}C$ than Taukihepa weka or Pacific rats, but were close to being significantly more enriched than ship rats.

When compared with ship rats, weka sampled on Taukihepa in January were significantly depleted in $\delta^{15}N$, but were significantly more enriched in $\delta^{13}C$. Similarly, weka on Moginui in mid-March were depleted in $\delta^{15}N$ in comparison with Pacific rats, but the difference was not statistically significant, possibly due to the small sample sizes involved. Weka on Moginui were also approaching significance in enrichment of $\delta^{13}C$ when compared with Pacific rats. Ship rats sampled on Taukihepa in January did not have significantly different $\delta^{15}N$ values than Pacific rats but Pacific rats were significantly more enriched in $\delta^{13}C$. There was no significant difference in the $\delta^{15}N$ values between weka from Taukihepa and Moginui, but differences between $\delta^{13}C$ values approached statistical significance.

There was no significant difference between seasonal values of both $\delta^{15}N$ and $\delta^{13}C$ from ship rats trapped in December, February and May ($\delta^{15}N$: Kruskal–Wallis test statistic = 4.35, d.f. = 2, $P = 0.11$; $\delta^{13}C$: Kruskal–Wallis test statistic = 0.39, d.f. = 2, $P = 0.82$).

Of the other possible diet items the spider sample was enriched in $\delta^{15}N$, comparable with both rat species, but was slightly depleted in $\delta^{13}C$. The other invertebrates sampled had similar $\delta^{15}N$ values to sooty shearwaters but were relatively depleted in $\delta^{13}C$. Of the plant samples the single grass stalk base (*Poa tennantiana*) had similar $\delta^{15}N$ enrichment as the rat species but was less enriched in $\delta^{13}C$. The tupare petioles, which were known to be eaten by rats (pers. obs.), were depleted in both $\delta^{15}N$ and $\delta^{13}C$ relative to rats. The sole sample of rata, of a seed pod, was taken from shrubland on the edge of pakihi, some 10 m from the nearest sooty shearwater burrows. This sample was very depleted in $\delta^{15}N$ compared with all other samples, but was more enriched in $\delta^{13}C$ than other plants.

The isotopic ratios of feathers from two passerines, tomtit (*Petroica macrocephala*) and thrush (*Turdus philomelos*), were included in Fig. 4 (J. Newman, unpubl. data). These small birds exist on seabird islands, the Snares, some 90 km south of Taukihepa, with a similarly dense colony of sooty shearwaters. The Snares are a similar size to Moginui Island and are covered in the same *Olearia* forest. These passerines feed on a mix of

invertebrates and fruit, and provided useful comparative values for rats and weka, with similarly omnivorous diets. In both cases the birds were more enriched in $\delta^{15}N$ than either rats or weka, and thrush were more enriched in $\delta^{13}C$ than the rats.

The results of the Isosource model are presented in Fig. 5. Sooty shearwaters were estimated to contribute a mean of 59% (range: 15–71%) to weka diet in summer, with invertebrates comprising a large portion of the remainder of their diet. Ship rats relied more on small passerines (range: 5–51%; mean: 30%) than sooty shearwaters (0–44%; 24%), with a mix of invertebrates and plant material forming the remainder of summer diet.

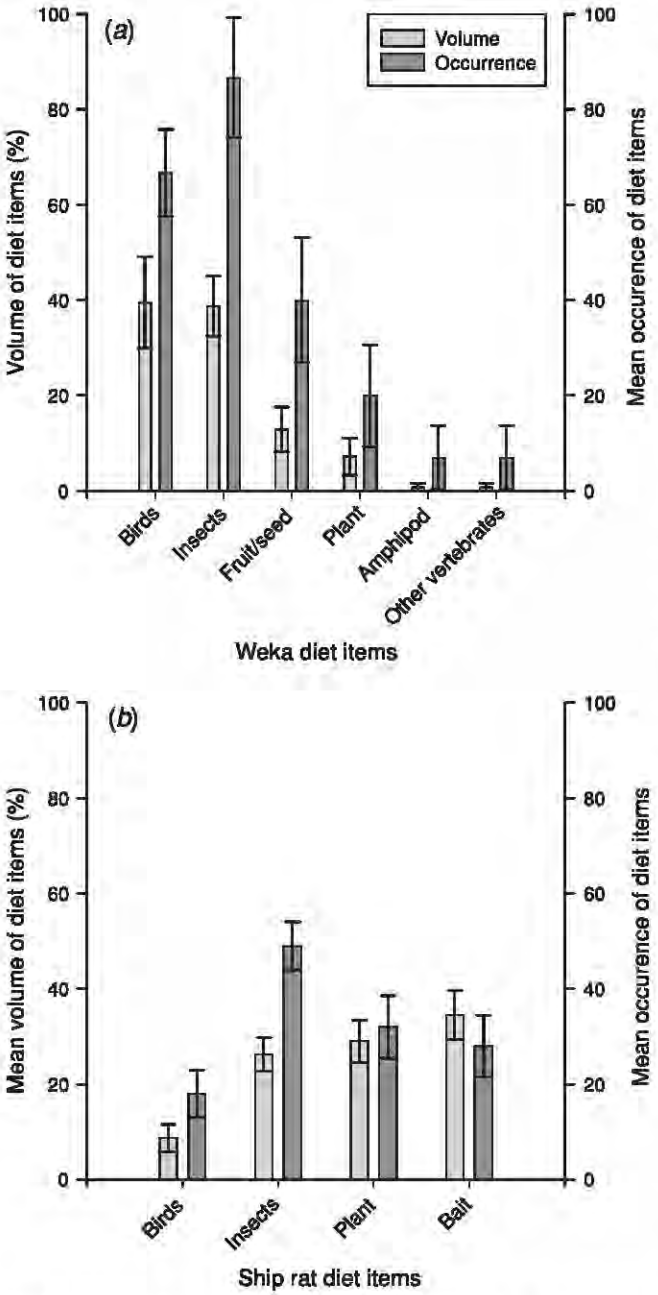

Fig. 3. (*a*). Diet items recorded in stomachs of 60 ship rats on Taukihepa, summer 2005. Items recorded by estimated volume and occurrence in stomachs (±s.e.). (*b*) Diet items recorded in crops of 15 weka on Taukihepa, summer 2005. Items recorded by estimated volume and occurrence in crops (±s.e.).

Discussion

Nest predators of sooty shearwaters

The hypothesis that weka were principal predators of sooty shearwater chicks was strongly supported by the results of this study. Weka probably also depredated eggs, whereas ship rats scavenged the sooty shearwater remains left by weka. Combining three different, but complimentary, techniques provided more conclusive results than was possible using one or even two methods. Although weka had been observed killing titi chicks (Harper 2006), these observations, in themselves, did not prove that weka were the principal predators. Inferred predation of large burrowing seabirds by ship rats on islands elsewhere, along with the stomach analysis presented here, could have led to a conclusion that ship rats also depredated sooty shearwater chicks and eggs. Similarly, relying on stable isotope analysis alone would not have revealed weka predation, as results are sometimes counterintuitive. For example, animals feeding on plants on seabird islands often have more enriched $\delta^{15}N$ signatures than the same species feeding at higher trophic levels (Stapp *et al.* 1999; Drever *et al.* 2000).

Experimental removal of predators

The removal of weka provided the strongest evidence for their effect on nesting success of sooty shearwaters, even though the result was probably confounded by unrelated yearly variation in reproductive success of sooty shearwaters. Despite this likely variation, a substantial reduction in weka density on treatment and control sites in 2005 reduced sooty shearwater chick losses by 75% compared with 2004. There was also a decline in the number of dead chicks found on treatment and control sites whereas the number of dead chicks increased where weka control was absent. This large reduction in chick losses was unlikely to be entirely due to a difference in reproductive success, especially as nest failure and egg loss changed little between years. However, several natural deaths are likely in these figures (Warham 1996), which means the recorded chick losses are not entirely attributable to weka. Indeed, the mean chick loss on the treatment site in 2005 could be assumed to be natural, as predators were almost entirely absent. In this instance, the difference in chick losses on treatment sites between 2004 (17.0% ± s.e. 7.9) and 2005 (4.5% ± s.e. 2.2) which could be attributable to weka would therefore be ~12%. Additionally, if rats are assumed to be largely benign, then control sites could be added to the same equation, which would yield a mean percentage loss of chicks to weka predation of 9.9% (±s.e. 3.5).

The removal of rats on treatment sites in each summer yielded no discernible change in chick losses. More chicks were lost at sites where rats had been removed compared with control sites in both years, which was skewed by large losses on a single site. These asymmetric loss rates may result from different predation pressure between sites by only a few 'rogue' weka apparently 'keyed into' killing titi chicks. Brothers and Skira (1984) suggested that only few individual weka killed burrowing

petrels on Macquarie Island and Cunninghame (2006) recorded one radio-tagged male weka on Taukihepa killing titi chicks more often than other radio-tagged individuals. More dead titi chicks were also found in the territory of this weka than in other weka home ranges (Cunninghame 2006). Body parts of titi chicks in some weka crops show that titi chicks formed a large portion of the diet for at least some weka in late summer and early autumn.

Stable isotope analysis

The stable isotope signature of weka was also much closer to that of sooty shearwaters than were the two signatures of either rat species. The $\delta^{13}C$ values of weka and sooty shearwaters were very close, which would be expected if weka were feeding on sooty shearwaters, as there is only ~1% enrichment of $\delta^{13}C$ between predator and prey (Stapp *et al.* 1999; Kelly 2000). However, Taukihepa weka were enriched only 2.5‰ and 1.7‰ in $\delta^{15}N$ over sooty shearwater adults and chicks respectively, less than the possible 3.3‰ enrichment expected if weka were feeding exclusively on sooty shearwaters (Robbins *et al.* 2005). The omnivorous foraging of weka would be expected to reduce their $\delta^{15}N$ signature relative to a diet based solely on seabirds. Stable isotopic analysis showed that Titi Island weka were ingesting significantly more marine-derived diet items than were rats, and were also more enriched in $\delta^{13}C$ than a single weka sample from mainland New Zealand. Moginui weka were more enriched in $\delta^{13}C$ than Taukihepa weka, by 3.1‰ and 2.3‰ compared with sooty shearwater adults and chicks respectively. This may be due to sampling occurring some 4–6 weeks later on Moginui. Longer exposure to titi chicks as prey was likely to lead to enrichment of $\delta^{13}C$ in weka.

The Isosource calculations supported the diet analysis results. The use of stable isotopes in these calculations also provided a longer period for evidence of the prey source, as turnover time for muscle tissue is ~4 weeks (Dalerum and Angerbjörn 2005). For example, although diet analysis revealed that both weka and rats consumed birds, the Isosource program suggested that sooty shearwaters contributed much more to weka diet than to rat diet, and the reverse was apparent for small passerines (Fig. 5). Similarly, the relatively low consumption of plant material relative to invertebrates in weka diet was repeated in the Isosource results. The inclusion of fruit (*Coprosma* spp. in particular) may have improved the model for weka, as these fruits contributed to weka diet on Taukihepa. Indeed, the higher consumption rates of sooty shearwater recorded by Isosource for both weka and ship rats when compared with the gut analyses was probably due to two factors. One factor is likely to have been that fewer prey items were sampled than the predators actually consumed. Another factor is that multiple source mixing models tend to overestimate proportions of rarely consumed food items and underestimate abundant food items (Rosing *et al.* 1998). As such, the Isosource model provided indices of prey items consumed rather than actual values.

Interactions between weka and ship rats

Weka did not appear to be a significant predator of rats on Taukihepa. Very few possible mammal remains were found in weka crops and $\delta^{15}N$ values of weka were significantly depleted compared with ship rats, whereas the $\delta^{15}N$ values of weka eating rats should have been relatively enriched. In contrast, ship rats comprised a significant portion of weka diet on Macquarie Island (Brothers and Skira 1984).

Predation by ship rats and pacific rats

Ship rats were not the principal cause of chick loss in sooty shearwaters. Even when ship rats were reduced to very low densities on treatment sites losses of chicks continued at an overall higher rate of loss than control sites The lack of seasonal variation in the isotopic values of samples supported this conclusion. If sooty shearwater adults or chicks were being killed by rats, enrichment of $\delta^{13}C$ in rat tissue in February and May was likely, but not recorded. Stable isotope analysis did reveal that ship rats and Pacific rats were ingesting a similar mix of food at a significantly higher trophic level than weka, which was

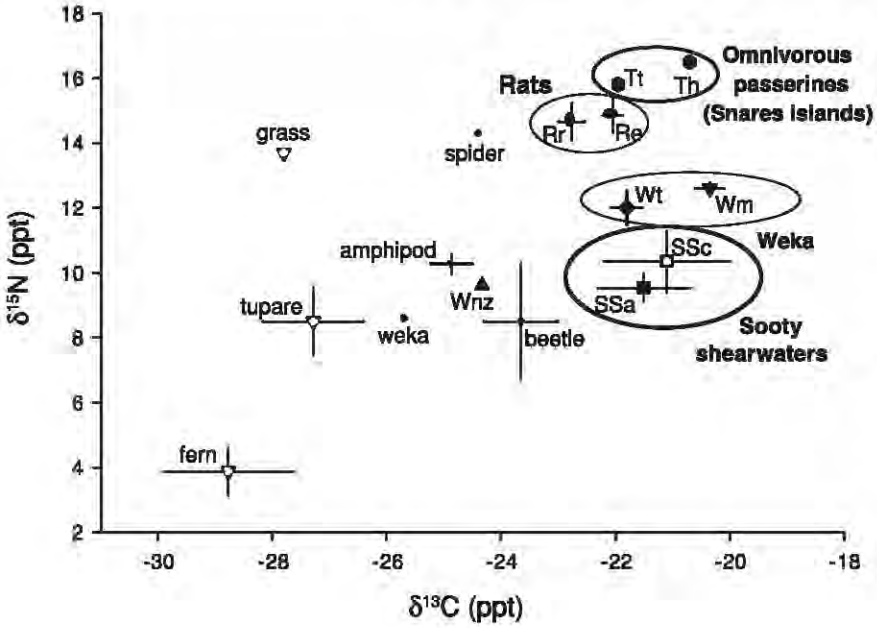

Fig. 4. Stable-nitrogen and -carbon isotope values of muscle tissue of rats and weka with possible terrestrial prey and sooty shearwater muscle tissue values from Taukihepa in summer 2005 and Moginui Islands in early autumn 2005. Values are means ± 95% confidence intervals and are corrected for fractionation. Included are single stable isotope values of feathers from passerines from Snares Islands. SSa = Sooty shearwater adult, SSc = Sooty shearwater chick, Wt = Weka from Taukihepa, Wm = Weka from Moginui, Wnz = Weka from New Zealand mainland, Rr = Ship rat (Taukihepa), Re = Pacific rat (Moginui), Tt = Snares Island tomtit, Th = thrush (Snares Islands).

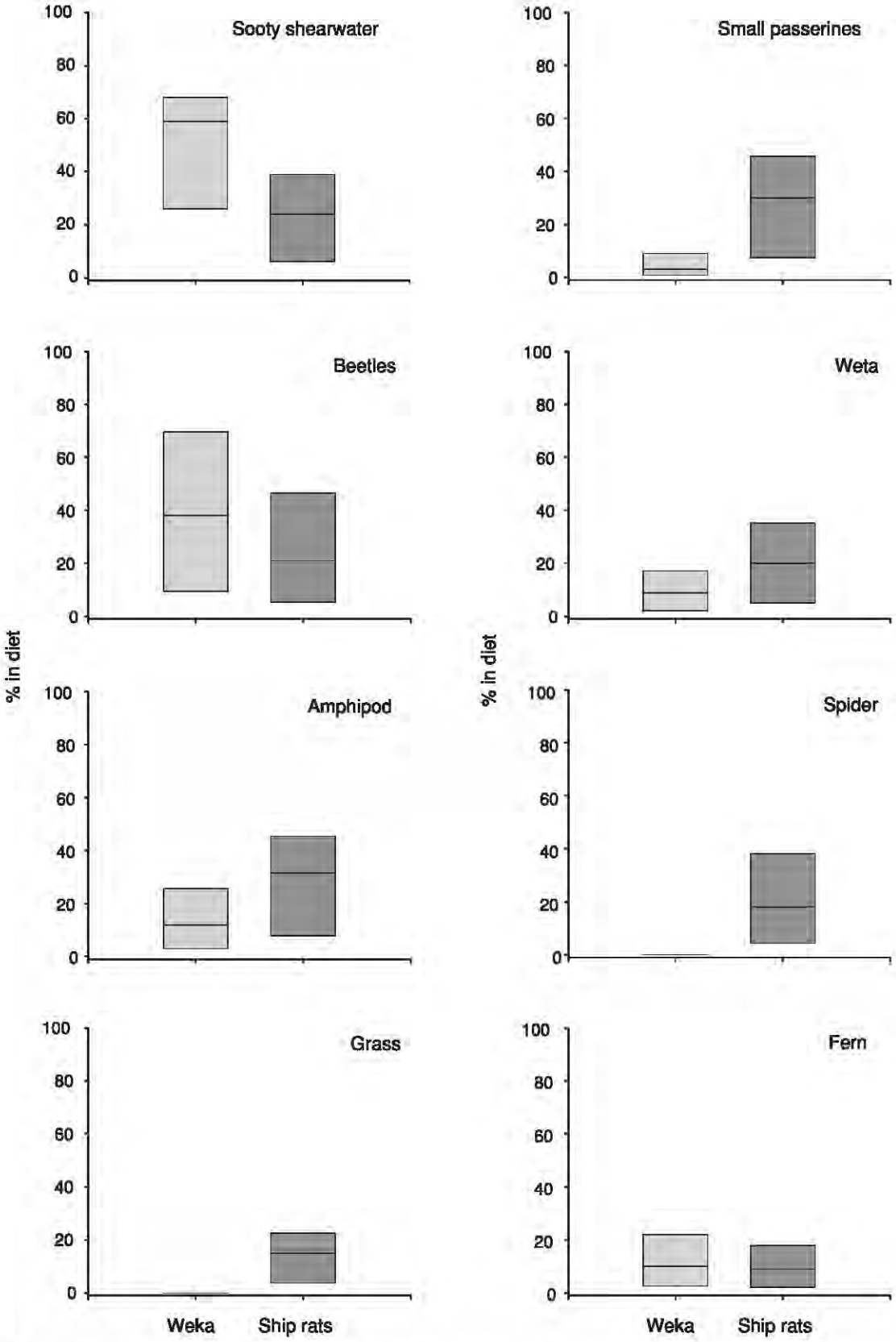

Fig. 5. Possible percentage contribution of prey to weka and ship rat diet as calculated using stable-nitrogen and -carbon isotope values of potential prey items in the Isosource program. Possible percentage contributions are presented as means and ranges. The stable isotope values of potential prey items are in Table 2.

initially surprising as diet analysis showed that weka were eating proportionally more birds as prey than rats. However, the Isosource calculations suggested that rats were consuming more passerines, which had higher $\delta^{15}N$ values than sooty shearwaters (Fig. 4), and which further confirms ship rats as predators of small passerines (Innes 2005). Although Pacific rats had very similar $\delta^{15}N$ enrichment to ship rats, they were even less likely to kill titi chicks because Pacific rats are small (Imber 1975). In addition, if rats were eating more plant-based prey items from grasses, seeds for example, then this would enrich rats' observed $\delta^{15}N$ values, but would not result in enrichment of $\delta^{13}C$ (Stapp *et al.* 1999). Similarly, mice (*Peromyscus keeni*) and voles (*Microtus townsendii*) on a seabird island in British Columbia, which fed on terrestrial plants and insects, had higher $\delta^{15}N$ values than mice feeding largely on seabird eggs (Drever *et al.* 2000). The similarly enriched $\delta^{15}N$ values for both rat species, a spider and the Snares Islands passerines imply at least two, possibly complementary, nutrient pathways for marine N to accumulate in omnivores on seabird islands. One would be via plants fertilised by guano and seabird remains and another through invertebrates, which have fed on guano, guano-fertilised plants, or seabird remains (Hawke and Newman 2005), which suggests that the pathways are complex. Pacific rats were significantly more enriched in $\delta^{13}C$ than ship rats, possibly for the same reasons that Moginui weka were enriched compared with Taukihepa weka. The lack of seasonal variation in the $\delta^{13}C$ values for ship rats tends to argue against this conclusion, however, and suggests that the small size of Moginui may increase exposure of plants there to marine spray, or that weka and Pacific rats had a slightly more marine-derived diet. Sampling of probable diet items at Moginui would have possibly assisted the analysis.

Nest failure and hatching success in sooty shearwaters

Nesting failure was highly variable, with no obvious pattern between treatment or control sites, or between years. This suggests that weka or rats did not affect nesting success, especially as these predators were controlled only during the last 1–2 weeks of incubation. Brothers (1984) also noted abandoned sooty shearwater eggs on Macquarie Island untouched by ship rats for up to a month. Egg failures in Procellariidae most likely result from egg chilling or nest abandonment, if one of the adults did not return to relieve the nesting bird, for example (Warham 1996). Comparisons with later egg and chick-loss patterns suggest that nest failures occur because of environmental factors affecting the breeding success of sooty shearwaters rather than through predation. In fact, the mean percentage nest failure rate over the control and treatment sites over two years was 7.9% (±1.16 s.e.), which was generally lower than that of many other procellariids (Warham 1996). It is unlikely that research activity unduly affected nesting success, because nests were checked once only early in the nesting stage, and then adult attendance only was checked again immediately before hatching.

In contrast to the variable nesting success, a repeated pattern of higher losses of eggs occurred on treatment sites which closely matched the pattern of chick losses. Egg loss may have been due to nesting failure and subsequent abandonment by the adult, but this is unlikely as some abandoned eggs should have been found later when burrowscoping. This loss pattern adds to the suggestion that weka will steal eggs from occupied nests (St Clair and St Clair 1992; Harper 2006).

Nesting success during the egg and early chick stage appeared to be comparatively high despite predation over the two breeding seasons. The little data available from breeding colonies where predators were absent or controlled suggested that ~59–68% of sooty shearwater chicks survived the egg and small chick stage (Jones *et al.* 2003). This result is actually slightly lower than the 65–80% of chicks that survived on Taukihepa, where predation occurred. At colonies where predators such as mustelids (*Mustela* spp.), feral cats and Norway rats were present, fewer than 44% of chicks survived to the end of the small chick stage (Jones *et al.* 2003). These data, although limited, suggest that productivity on Taukihepa is high, with a comparatively small impact by weka. The mean hatching success of sooty shearwaters on Taukihepa of 83.2% (±1.67 s.e.), which was higher than on predator-free Snares (58%: Warham *et al.* 1982), or short-tailed shearwaters in Tasmania (70%: Norman 1985), supports this conclusion. The reduced nesting success on predator-free islands may be a density-dependence effect, possibly through increased interference (Warham 1996), as burrow density is significantly higher on Snares (1.38 burrows m^{-2} (s.e. 0.06): D. Scott, pers. comm.) than Taukihepa (0.43 burrows m^{-2} (s.e. 0.04): J. Newman, pers. comm.), assuming that burrow occupancy is similar.

Despite the lack of evidence for an effect of ship rats on the breeding success of sooty shearwaters, there is anecdotal information that rat irruptions can reduce breeding success of sooty shearwaters immediately after rats invade an island. Extremely poor titi harvesting seasons on three islands apparently coincided with irruptions of ship rats (Drummond 1910; Anonymous 1934; Newman 2006), with one (Newman 2006) noting that the concurrent harvest had been 'typical' on an adjacent island 150 m away without rats. Harvest of sooty shearwaters returned to normal despite the continuing, but lower, rat density. This suggests that the extremely high rat densities and concomitant food shortages during the peak and initial decline phases of an irruption result in increasingly desperate foraging for rodents as recorded in irruptions elsewhere (Ylönen *et al.* 2002; Harper 2005). This risky feeding behaviour could conceivably result in rats killing chicks much heavier than themselves. Rat irruptions on the Titi Islands appear to have occurred only once during the invasion stage as no reccurrence of a rat irruption coupled with extremely poor chick survival has been reported on these islands. This may be due to an apparent lack of other multiannual high-energy food pulses, such as seed-masting tree species (Harper 2005).

Combining methods to detect principal predators

When two or more predators are present with prey, these results suggest caution in attributing most of the predation to one or other species. Even in this case a lack of predation by ship rats was not unequivocally shown, and possibly occurred at low levels but remained undetected. However, the use of complementary techniques did clarify the magnitude of predation that occurred, highlighted the principal predator responsible and showed the degree to which weka and ship rats relied on sooty shearwater chicks as prey or as scavenged food. Similar multiple-source approaches can be used to elucidate other more

complex predator–prey relationships. When resources are limited this approach could be particularly useful for revealing which specific predator to concentrate on for control or eradication when they threaten the survival of native species.

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Appendix H-1: Baseline Shearwater Monitoring Report, 2005

Baseline status of Tītī (sooty shearwater, *Puffinus griseus*) populations on islands around Rakiura/Stewart Island prior to the eradication of rats (*Rattus* spp.) from four selected islands.

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October 2005

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Confidentiality disclaimer:

This report was prepared by the Kia Mau Te Tītī Mo Ake Tōnu Atu (*Keep the Tītī forever)* Research Team (hereinafter referred to as the Tītī Team) for the Ka Mate Ngā Kiore Incorporated Society (KMNK) and the command trustees. It summarises a significant amount of confidential information collected from surveys of 30 manu (harvest areas) from 16 different Tītī Islands. The intention is to use this data as a baseline from which the efficacy of the planned rat eradication (planned for July 2006) can be quantified in five to seven years time. In order to maintain the anonymity of the manu owners all references to the individual islands and manu have been removed from this report, however the raw data and associated information including detailed notes on how to relocate all of the transects on each manu is being held by the Tītī Team at the Department of Zoology. This information will be released to the approved resurvey team upon request to enable them to relocate and check each manu.

Abstract

In 2003 the Rakiura birding community, together with support from Oikonos Ecosystem Knowledge (a Californian non-profit organization) and the Tītī Research Team from the University of Otago successfully secured $US 467,000 from the Command Trustee Council in order to remediate damage to sooty shearwater (*Puffinus griseus*) caused by an oil spill from the T/V Command off the Californian coast. The proposed method of remediation was the eradication of rats from four Tītī Islands (Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui) by aerial bait drop. A significant component of this successful funding bid was a monitoring program to demonstrate restoration success. This research was included so that the effectiveness of the remediation, in terms of recovery to the sooty shearwater population, could be quantified and reported back to the Command trustees. This report details the completion of stage one of the monitoring program; the baseline monitoring carried out by the Tītī Research Team on behalf of the Ka Mate Ngā Kiore.

Background

Damage to sooty shearwater caused by the Command oil spill

The T/V *Command* oil spill occurred off the Californian coast on 26 September 1998, just prior to the migration of sooty shearwater (Tītī, Muttonbird, *Puffinus griseus*) back to southern hemisphere nesting colonies. Sooty shearwaters were the second most frequent species among oiled birds recovered and were by far the most abundant species counted during aerial surveys at the time of the spill and within the spill area[1]. During recovery efforts, survey personnel recovered a dead, oiled sooty shearwater at Seaside Beach, Monterey Bay (#Z-38660). This individual was banded as it entered a nesting burrow the previous year on Whenua Hou Island, New Zealand. This confirmed damage directly linked to the New Zealand shearwater population. This notable recovery along with 11 additional shearwaters recovered on beach surveys provides sufficient evidence that the *Command* Spill negatively impacted this trans-Pacific migrating seabird.

No mortality estimates were calculated for the sooty shearwater in the *Command* Trustees Bird Injury Report. However, Moller *et al.* (2002) used similar methods to those applied to common murre (*Uria aalge*) by the Trustees, to estimate sooty shearwater mortality. The probable estimates indicated that around 15,591 shearwaters[2] were killed during the Command spill compared with 1,490 murres (Boyce and Hampton, 2002). Sooty shearwaters were therefore probably the most numerically affected species. Loss of production of chicks because of the death of their parents in the spill would mean that 20,265 fewer tītī were in the population by the 2002/03 breeding season (time of mitigation proposal) because of the spill[3]. Furthermore, as this event occurred just prior to the pre-breeding migration, adults exposed to a sub-lethal level of spilled oil may have suffered undocumented compromised reproductive output during the 1998/99 nesting season.

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[1] At-sea densities of 11 – 346 birds km^{-2} were reported by Boyce and Hampton (2002).
[2] The estimate ranged from 1,489 – 29,606 birds killed in the Command spill.
[3] This calculation incorporates the lost production from 1998/99 to 2002/03 and the natural mortality of the missing adults had they not been killed by the spill.

Impact of Introduced Predators on Shearwaters

The most easily reversed detrimental impact to New Zealand tītī breeding populations is predation by introduced predators. Three species of rat (*Rattus* spp.), stoats (*Mustela erminea*), ferrets (*M. furo*) and feral house cats (*Felis catus*) were introduced to New Zealand 125 - 200 years ago and now kill both tītī adults and chicks at mainland colonies[4]. Other introduced species such as brushtail possums, pigs, and deer, cattle and dogs are more than likely to have impacted on mainland seabird colonies, however the effects of these predators on seabird populations are less well documented.

Predator control on mainland colonies of New Zealand would bring only temporary relief because predators re-invade cleared areas every year. Also, predator control on the mainland could only restore small numbers of tītī because theses colonies have dwindled to few breeding pairs[5]. Eradication of predators on islands was considered a more efficient strategy, providing a permanent refuge of breeding habitat for shearwaters as well as other native flora and fauna. The large, dense breeding colonies around Rakiura Island offered the best, most feasible prospects for the *Command* Trustee Council to repair the injury to tītī caused by the spill as quickly as possible. Therefore the sooty shearwater restoration project selected this option to mitigate the impacts of the oil spill.

Three rat species are present on the Tītī Islands (*Rattus rattus, R. exulans,* and *R. noveicus*). Kiore[6] (*R. exulans*) were first introduced to some breeding islands by Māori several centuries ago. Ship rats (*R. rattus*) were introduced to some islands following European settlement although only reached some islands comparatively recently (e.g. they irrupted on Taukihepa during the 1960s with rat infested fishing boats thought to be the most likely source of this invasion). Norway rats (*R. norveicus*) are important predators of tītī on mainland colonies and until recently on Campbell Island, but are not

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[4] Hamilton & Moller (1995), Lyver (2000).
[5] Hamilton *et al.* (1997).
[6] Also known as the Polynesian rat, kimoa or Pacific rat.

known to be very widespread on the Tītī Islands. The most potentially serious threat to tītī eggs and chicks was thought to be posed by the ship rat and the smaller kiore[7]. Rats probably kill some eggs but their main impact is thought to be predation of young chicks just after the 'guard stage' when both parents must leave the chick unattended in order to forage for themselves and their chick. Direct action to eliminate predation of tītī by introduced rats at breeding colonies was considered to provide the greatest and most certain return to tītī populations and damaged island ecosystems.

Selection of islands for rat eradication

The 'Big South Cape Islands' (Taukihepa, Pukeweka and Rerewhakaupoko) were the natural choice for restoration by eradication of ship rats. Taukihepa is the single largest island (939 ha) where tītī breed where rats are present. The island group is sufficiently far from the Rakiura mainland that rats could not re-invade naturally. Currently about 47% of the total area of sooty shearwater breeding ground in New Zealand is infested with rats[8]. If eradication of ship rats from the Big South Cape Islands can be achieved, only 20% of breeding ground will remain rat infested. The additional removal of kiore from Mokonui, the next largest island remaining with rats, would result in only about 14% of all tītī breeding area still having rats present.

Monitoring for mitigation success: an essential component of the mitigation process.

Eradication of rats on the Big South Cape Islands and Mokonui was considered by the *Command* trustee Council the most appropriate way to repair the oil spill injury sustained by sooty shearwaters. Since the *Command* trustees are required to demonstrate that all mitigation funds have been wisely used a monitoring plan was an essential component of this restoration programme. Determining the success, or otherwise of the restoration effort for repairing injury levels necessitates quantifying the number of individual sooty

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[7] Kiore were once considered to be predominantly vegetarian, but more recent diet studies show it to be omnivorous (Atkinson & Moller 1990).

[8] This calculation assumes that half of Taukihepa has '*manu*' (burrowed breeding grounds), ignores the very small mainland colonies, Solanders and Campbell Island colonies, but includes the Snares.

shearwaters entering the population after eradication, that would otherwise have been depredated by rats.

Sooty shearwater population recovery in response to rat eradication will be slow due to the species' long lifespan (up to ~ 40 years), low reproductive rate (1 chick per year) and delayed maturity (age of first breeding 5 -6 years). Hence measurement of restoration success will only be achieved over a long time period (10 to 20 years). Preliminary predictions of success can be achieved by constructing mathematical models of sooty shearwater population dynamics. The impacts of rat predation on sooty shearwater reproductive output have already been assessed on Taukihepa and reproductive parameters in models can now be modified to determine the effects of rat eradication can by comparing simulations of population growth in the presence and absence of rats.

Although mathematical models allow a rapid assessment of potential outcomes of restoration actions, mitigation success can only be measured with certainty by independently validating model predictions. Population recovery in response to rat eradication will be assessed using a BACI design (before-after-control-impact design) to measure population abundance before and after rat eradication on Taukihepa and Mokonui (impact sites) and islands with and without rats (control sites). A survey of the area of Taukihepa covered in sooty shearwater breeding area has been accomplished and will allow the measured change in population abundance to be applied to the population size to give the predicted number of extra shearwaters resulting from eradication that will replace the estimated oil spill mortalities.

The purpose of this report

This report informs relevant parties involved in the sooty shearwater restoration programme of the results of baseline (before) sampling which will ultimately be used to detect the response of sooty shearwaters to rat eradication. Specific aims of the report are to provide:

i) details of the design of the baseline survey of sooty shearwater abundance undertaken during the 2004/05 breeding season;

ii) a summary of baseline data collected during the 2004/05 survey; and

iii) necessary information to maximise the efficiency and outcomes of the repeat survey to be undertaken in the 2013/14 breeding season by those appointed by the Ka Mate Ngā Kiore Committee.

Study Design

The research effort to measure the effect of rat eradication on sooty shearwater populations follows a BACI (before-after-control-impact) design. Rate of population change on islands targeted for eradication before and after rat eradication (impact sites) will be compared to change on islands with rats that have not been eradicated, and islands where rats are not present over the entire study period (control sites). If rats are impacting sooty shearwater populations we will expect to see an increased population growth rate relative to those observed at either type of control site (rats present, rats absent).

The Kia Mau Te Tītī Mo Ake Tōnu Atu research team has visited 30 manu on 16 Tītī Islands to determine sooty shearwater abundance and density. Fortunately these manu comprise a mixture of impact sites and both forms of control site. Additional effort has been undertaken on Whenua Hou, The Snares and Putauhinu, where trends in abundance have been monitored for nine years. Permanent stakes have been left at either end of transects established during first visits to sites, allowing repeat sampling to measure changes in population abundance. Data that the research team has collated from harvested sites are confidential to the individual birders on those manu and data from non-harvested sites are confidential to the research project. All parties have kindly offered to share this data with the *Command* restoration program for the purpose of measuring its success.

One-off visits to manu as part of the Kia Mau Te Tītī Mo Ake Tōnu Atu research project have occurred over the last six sooty shearwater breeding seasons. It is therefore unreasonable to suggest that surveys at the start of this sampling period would represent a suitable baseline survey to estimate the impact of rat predation. Any site that had been surveyed prior to the 2003/04 breeding season was resurveyed in 2004/05. In Addition to to long-term monitoring sites, two new manu were included as part of the baseline survey for the Command restoration program.

Two parameters were used as indicators of shearwater abundance, burrow entrance density (number of burrow entrances per m^2) and burrow occupancy (number of active nests among burrows in a transect). Because considerably more effort is required to measure burrow occupancy than burrow entrance density, logistic constraints on the research team resulted in only the latter being measured at resurveyed sites. However, burrow occupancy was still measured at long-term monitoring sites and at the two new manu surveys. If burrow density provides an accurate index of population size then this parameter alone could be used to measure rate of population change. However the measurement of most relevance to estimating restoration success is chick density (burrow entrance density multiplied by burrow occupancy). When visits to manu have occurred in the last three breeding seasons (2002/03 – 2004/05) we suggest that burrow occupancy measurements should be used for a baseline estimate of chick density. We deem burrow occupancy measurements during visits before these seasons to be less reliable and suggest that they are used with appropriate caution when calculating baseline chick density.

Survey Methodology

When manu or islands were first visited by the research team the survey area was usually divided into roughly equal sized sections. Transects were then randomly positioned within each section. A meter long stake made of right-angled aluminium with a number stamped into the top was placed at the start of each transect. A centreline was then run out along another randomly chosen compass bearing until the first 20 burrows within 1 m (2 m on Whenua Hou) on either side of the centre line tape had been found. A second numbered stake was driven in on the centre line at the point perpendicular to the 20th burrow entrance found (Figure 1). The distance along the centre line was measured in meters and multiplied by 2-m (the width of the transect) to get the overall area of the transect.

We needed a careful rule to decide whether or not each entrance fell within or outside the transect (or circular plot). Imagine a pen stuck vertically into the very middle of the entrance hole as tight up against the roof of the tunnel as possible. If that pen fell on or just within the 1-m line across the transect it was counted as in. The hole was ignored if it fell just a fraction outside the line (Figure 2).

We then used a 'burrowscope' to explore the burrows from all 20 of the entrance holes in the transect. Sometimes the tunnels branched and we then recorded it as two, or more, separate burrows even though they originated from the same entrance hole. We recorded whether or not we saw a chick, egg, adult or nothing within it. Often we could not reach the very end of the burrow because roots, rocks, mud, twists and turns blocked the way forward. Whenever the full extent of the burrow could not be prospected, we recorded the burrow contents as 'unknown'.

In the case of sites that were being resurveyed in the 2004/05 breeding season attempts were made to locate the aluminium stakes positioned at either end of the transect. If this was achieved a centre line tape was extended between the stakes and all entrances within 1 m of the line, between the stakes, were recorded. On several occasions only one end of

the stake was located. At these transects the centre line was extended on the original bearing for the original distance, with all entrances within 1m either side of the centre line counted.

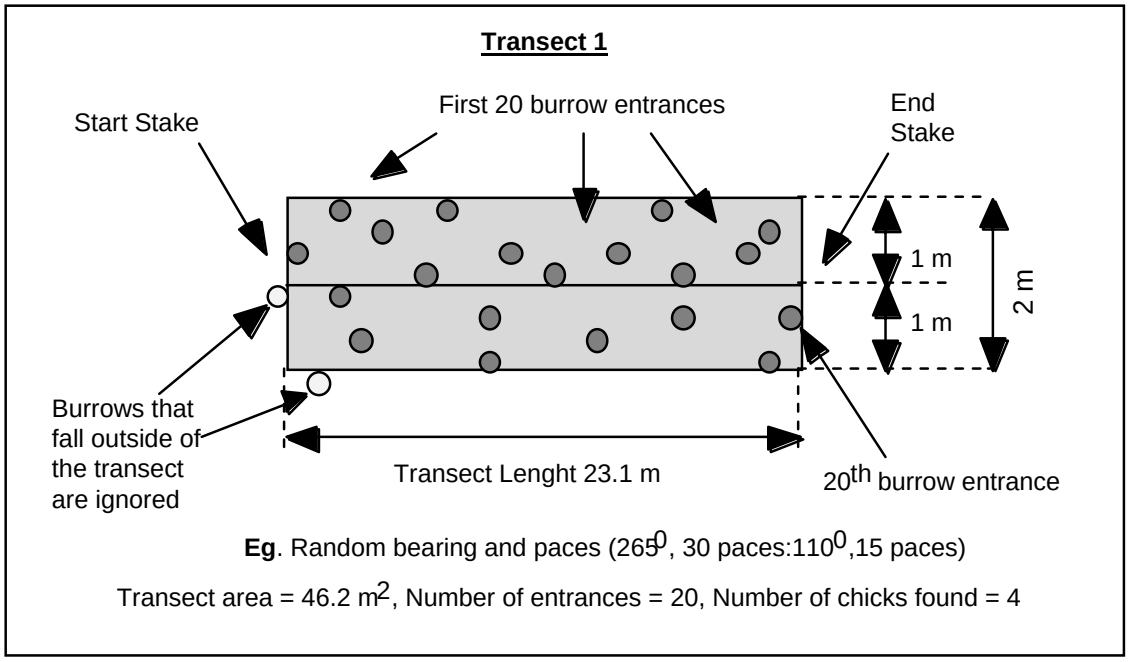

Figure 1. The layout of how each transect was sampled. Circles indicate burrow entrances located within (filled) and outside (open) of the transect.

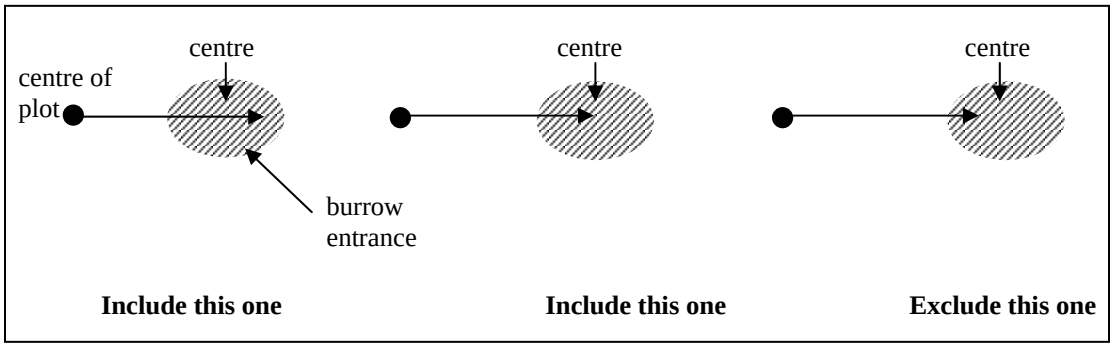

Figure 2. The rule to decide whether or not an entrance hole is within or outside the transect or circular plot.

Estimates of Population Abundance

Parameters relevant to the measurement of sooty shearwater population abundance were as follows:

Burrow density (*BD*) was calculated as:

$$BD = \frac{E}{\left[A + A/\left(E - 0.5\right)\right]}$$

Where *E* is the number of entrances within the transect and *A* is the area of the transect. The area of the transect was adjusted (using the formula in the denominator of the equation above) because the end of the transect was originally established at the point where the 20_{th} entrance was encountered, which underestimates density slightly.

Sooty shearwater burrow systems are often complex with two or more burrows frequently diverging from a single burrow entrance (Hamilton 2000). Consequently burrow systems can consist of several individual burrows which can each be considered solved or unsolved after being prospected with the burrowscope. Individual burrows were classified as "solved" if either a chick was detected and/or the end of the burrow was reached. "unsolved" burrows were those where the end was not reached with the burrowscope due to unfavourable burrow geometry and obstructions such as puddles, roots and adult birds (McKechnie 2004). Solved entrances were those for which all burrows diverging were solved with the burrowscope. The "improved" method of estimating occupancy takes into account the potential of occupants being present in burrows beyond the point to which the burrowscope prospected, and provides a more accurate index of actual occupancy (McKechnie 2004).

Occupancy per burrow entrance (*O*) was calculated as:

$$O = \frac{SB}{SE} \times \frac{C}{S}$$

Where *SB* is the number of solved burrows diverging from solved entrances (*SE*), *C* is the number of chicks and *S* is the number of solved burrows (irrespective of whether they came from solved or unsolved entrances).

Results of the baseline survey

Study areas were resurveyed on 15 manu on 11 different tītī islands to establish burrow entrance density in 2005. Transects at two new manu were established and three manu visited in the 2003/04 breeding season were not visited this season but are considered baseline estimates for the purpose of measuring restoration success. An additional manu in 2003/04 and three in the 2004/05 season had burrow entrance density determined using circular plots (an alternative method of estimating burrow entrance density) and can be considered baseline samples if the resurvey team is prepared to visit them and repeat the circular plot sampling method at the end of the monitoring period. Long-term monitoring sites at Whenua Hou, The Snares and Putauhinu (six manu) were also resurveyed as was Tuhawaiki Island off the Catlins coast. A total of 26 sites were surveyed among the three treatment classes, impact (n = 9), rat-absent control (13), rat-present control (n = 4; Table 1). Because we were not able to control factors such as the number of islands infested with rats, this is an unbalanced design with unequal numbers of samples in each treatment, however, without setting up many entirely new sampling sites a balanced design was considered unachievable.

Table 1. Number of study sites established on islands among the three treatment classes.

Island	Rats to be Eradicated (Impact)	Rats Present (Control)	Rats Absent (Control)
Putauhinu[a]			6
Whenua Hou[a]			1
The Snares			1
Putauhinu Nugget 4[a,b]			1
Timore			1
Joss's [c]		1	
Tia [c]		2	
Ernest [d]		1	
Bench [e]	1		
Pikomamakanui			1
Pohowaitai			1
Pukaweka [c]	1		
Betsy			1
Mokonui [e]	1		
Taukihepa [c,f]	6		
Total Harvested	8	4	3
Total Non-harvested [g]	1	0	10
Overall Total	**9**	**4**	**13**

[a] Kiore were eradicated from Putauhinu and it's nuggets in 1997 and from Whenua Hou in 1998.

[b] Putauhinu Nuggets 2, 3 and 8 could also be resurveyed although no permanent transects are established on these islands so comparisons would consist of data obtained using circular plots.

[c] Ship rats present (*Rattus rattus*)

[d] Norway rats present (*R. Norveicus*)

[e] Polynesian rats present (*R. exulans*). Rats were eradicated from Bench Is. in June/July 2005.

[f] One extra manu on Taukihepa has no permanent transects established but could be added if circular plots are utilised to estimate burrow density.

[g] Tuhawaiki Island could be added as another rat-absent control if funding allows this island to be resurveyed in the future.

Transects at sites being resurveyed were re-found using a combination of location maps, GPS (Global Positioning Systems) using fixes recorded during the original survey, and previous experience when one or more members of the resurvey team had visited the island during the original survey. Despite this combination of approaches re-locating transects was often difficult with the proportion found when resurveying a manu varying between 43 and 100% and a total of 146 of the original 175 transects found (83%). These losses can probably be attributed to either the transect no longer being present at the site (destroyed by windfalls, or removed etc.) or the transect simply not being found. Loss of transects has significantly affected the potential sample sizes for a before and after comparison of sooty shearwater population abundance. If a similar proportion of these "re-found" transects is likely to be detected during the "after" phase of the mitigation study then about 70% of the original sample size (123 of 175) of transects will remain. However, we can still expect to find about 83% of transects at the long-term monitoring sites and those manu that had transects established during the 2003/04 and 2004/05 seasons. These figures could potentially be more severe than predicted because a) fewer members of the future resurvey field team are likely to have been present during original surveys and b) a longer interval will occur between the before and after phases of the mitigation study than occurred between transect establishment and the 2005 resurvey.

Measurements of sooty shearwater population abundance including burrow entrance density, burrow occupancy and chick density on the respective islands and manu are given in Table 2. These are the values that data from resurveys will be compared to when estimating the impacts of rat eradication on sooty shearwater populations.

Table 2. Mean sooty shearwater abundance ± SE (*n*) during baseline estimates at all study sites, where *n* is the number of transects surveyed in each experimental class.

Experimental Class	Entrance Density	Occupancy	Chick Density
Impact (rats eradicated)	0.51 ± 0.02 (108)	0.35 ± 0.03 (57)	0.18 ± 0.02 (57)
Control (rats present)	0.40 ± 0.03 (39)	0.45 ± 0.06 (10)	0.17 ± 0.05 (10)
Control (rats absent)	0.71 ± 0.03 (154)	0.46 ± 0.01 (119)	0.33 ± 0.02(119)

Note: all rat species were grouped into one category in the table above due to uncertainty in their relative effects on sooty shearwater productivity. The results of ongoing research will provide the necessary information on these effects which will be accounted for by using more complex statistical procedures when the second survey of abundance is completed after eradication.

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Appendix H-2: Predation Impact Report, Dillingham et al. 2007

A model-based assessment of the impact of predator control on populations of Tītī (sooty shearwaters; *Puffinus griseus*)

Peter Dillingham, Sam McKechnie, Grant Harper, David Fletcher and Henrik Moller

Report prepared for Ka Mate Ngā Kiore (Kill the Rats) Incorporated Society

28 February 2007

Disclaimer

This is a draft report and may not represent final estimates

Executive Summary

Predation of tītī eggs and chicks by rats and weka was estimated to be 20% in an experiment performed on Taukihepa and Rerewhakaupoko islands. It was estimated that predator control performed in 2006 at Taukihepa, Rerewhakaupoko, Pukaweka, and Mokonui islands could have a substantial impact on the size of tītī populations, depending on the success of the predator control. Ten years after predator control, it is estimated that there will be an additional:

- 67,000 birds if 50% of predators were killed initially
- 450,000 birds if 90% of predators were killed initially
- 1.6 million birds if 100% of predators were killed and there is no re-colonization
- 14,000 birds as a minimum (the lower 95% CI of the 50% of predators killed initially scenario with a decreasing population trend in the baseline case)

An estimated 16,000 tītī were killed in the oil spill. Even in pessimistic scenarios, the probability that predator control resulted in at least 16,000 additional birds is >95%. In moderate and optimistic scenarios, the probability of recovery is nearly 100%.

Many of the additional birds after ten years are relatively young, especially when higher levels of eradication occur. However, the probability that predator control resulted in at least 16,000 additional *adult* birds in moderate and optimistic scenarios is still nearly 100%, while it reduces to c. 75% if only half of the predators are eradicated.

The benefits of predator control should continue well beyond the 10 years simulated, providing environmental conditions do not change drastically, or density dependent regulation of the population sets in. If current harvest levels are having a detrimental effect on tītī populations then strategies for minimising impacts may be sought by the harvesting community. Additional predator control may be an approach to this that is acceptable to the harvesting community and practical on other Tītī Islands. Although high variation in predation rates between sites and limitations in the study design made separating the relative contributions of rats and weka difficult it appears that

weka predation was substantial. However, the benefits of further weka control on other islands should be weighted against any potential harm to the conservation status of this threatened species. By way of contrast, although the predation of tītī chicks by rats may be relatively minor, the benefits or removing this introduced species to wider island ecosystem health are likely to be considerable.

Introduction

Tītī (sooty shearwaters; *Puffinus griseus*) are a medium sized (~ 850 g) burrow nesting petrel that breed in dense colonies on islands around southern New Zealand, Tasmania and South America (Warham and Wilson 1982; Heather and Robertson 1996; Reyes-Arriagada et al. 2006). They breed during the Austral summer with the majority of the population migrating to the northern Pacific during winter (Shaffer et al. 2006). Populations on the Tītī Islands around Rakiura, New Zealand are the subject of a large-scale customary harvest by Rakiura Māori (Wilson 1979; Stevens 2006). Many islands in this group have been exposed to invasions by introduced predators, most notably the establishment of ship rats (black rat; *Rattus rattus*) on Taukihepa (Big South Cape Island) in the 1960's, which caused the extinction of several bird, insect and mammal species (Bell 1978). The influence of introduced predators on sooty shearwater population dynamics on these islands has only recently been investigated (Harper 2006; Harper submitted). However, seabirds appear to be particularly vulnerable to novel predators given their lack of behavioural adaptations to avoid predation (Moors and Atkinson 1984) and their life history traits which are sensitive to elevated mortality rates (Hunter et al. 2000; Saether and Bakke 2000; Cuthbert et al. 2002; Hunter and Caswell 2005). This is reflected by the increasing evidence of negative effects of introduced predators on several closely related species (Seto and Conant 1996; Imber et al. 2000; Imber et al. 2003; Jones 2003; Jouventin et al. 2003; Igual et al. 2006).

The suite of introduced predators that sooty shearwaters are exposed to varies between individual Tītī Islands and is probably determined by introduction history and proximity to mainland Rakiura, which hosts a diverse community of predators with differing swimming abilities (Harper 2002). Impacts of the different rat species on sooty shearwaters probably varies widely. Kiore (pacific rats; *Rattus exulans*) are known to reduce breeding success of small petrel species (Booth et al. 1996) but are unlikely to be able to open sooty shearwater eggs or depredate chicks. Predation rates of seabirds by ship rats is better quantified and moderate to severe mortality of the nesting stage has been reported in a range of species (Seto and Conant 1996; Jouventin et al. 2003; Igual et al. 2006), including those larger than sooty shearwaters (Jouventin et al. 2003). Norway rats (brown rats; *Rattus norvegicus*) are present on

several near-shore Tītī Islands, and although their impacts are perhaps the most severe of the three species (Harper 2002), they are absent from the islands that are the focus of this study. Weka (*Gallirallus australis*), a rail species native to Rakiura and the New Zealand mainland, were introduced to many Tītī Islands as a food source for humans. They are active predators of a range of seabirds including sooty shearwaters (St. Clair and St. Clair 1992; Imber et al. 2003; Harper 2006).

In July 2006 ship rats were eradicated from Taukihepa, Pukaweka and Rerewhakaupoko (Solomon Island), and kiore were eradicated from Mokonui Island. Attempts were also made to eradicate weka after the rat eradication programme. Funding was provided by the *Command* Trustee Council as repatriation for the mortality of sooty shearwaters suffered during an oil spill from the T/V *Command* off the Californian coast. The spill coincided with the sooty shearwater migration in September 1998, and there was evidence that it was the species most affected numerically, with an estimated mortality of 15,591 birds. There is a paucity of natural predators on these islands, and those that are present (brown skua; *Catharacta skua*, australasian harrier; *Circus approximans*) are at very low abundance, so losses to these species are negligible at the population level. Thus, if rats and weka were successfully eradicated, there would be essentially no predation, breeding success should increase, and a corresponding increase in the annual population growth rate (λ) could be estimated. If partial removal of predators or re-colonization occurred, then the impact would be short-term, corresponding to a birth-pulse event.

This study involves three components designed to at least partially estimate the impact of predator control on tītī population sizes. First, an experimental manipulation of rat and weka levels is used to quantify predation rates. Next, reasonable predation scenarios corresponding to differing levels of predator control are established. Finally, a generic seabird population model is extended to allow for changes in predation rates. From this, we are able to assess the likely response of the tītī population to control or eradication of rats and/or weka; the resulting changes in population size, and the likelihood of the repatriation of the oil spill mortality within ten years.

Predation experiment

Study Area

Taukihepa (Big South Cape Island; 790 ha, 47°14' S, 167°25' E) lies c. 2 km southwest of southern Rakiura (Stewart Island) and is the largest of the 36 Tītī Islands. Pukaweka (2 ha) is located immediately north of Taukihepa with a channel of approximately 50 m separating the islands. Another channel of a similar width further north separates Pukaweka from Rerewhakaupoko (Solomon Island; 21 ha). These three islands are close enough that dispersal by rats and weka between them is likely to be common (Coutts 2005; Blackburn 1964), making them an ecologically connected unit. Mokonui (Big Moggy Island; 66 ha) is located 7 km north of Taukihepa. Before the eradication operation weka were present on all four islands, having been introduced as a human food source in the early 20th Century (Miskelly 1987). Ship rats became established on Taukihepa, Rerewhakaupoko and Pukaweka in about 1963 (Bell 1978) and kiore probably became established only on Mokonui about 1400-1500 with advent of muttonbirding (Holdaway 1999). A detailed description of the habitat on the islands is given by Johnston (1982).

Design of Predation Experiment

Predation of sooty shearwater nests was investigated by experimentally removing rats from square plots (4 ha) of sooty shearwater breeding habitat and comparing breeding success with control sites (Harper, submitted). Six and two plots were randomly selected in November 2003 on Taukihepa and Rerewhakaupoko respectively. The sites were a minimum of 400 m apart to maintain the independence of individual predators. Within each site we used an infra-red burrowscope (Lyver et al. 1998) to select between 36 and 51 burrows occupied by sooty shearwaters incubating eggs. We individually identified burrows using plastic, cattle ear-tags pinned to the entrance. Nests were initially checked once between 28 November and 2 December 2003 and again between 13 and 16 January 2004 just prior to hatching. We then checked each nest every three days until between 8 and 11 February to monitor their fate. Each nest was then checked once between 18 and 21 March.

We removed ship rats from three and one randomly selected study sites on Taukihepa and Rerewhakaupoko respectively. The trapping grids consisted of 85 "Victor"™ snap-traps, in a grid of seven traps at 33 m intervals on 13 alternate offset rows 16 m apart. Trapping was undertaken between 14 January and 12 February 2005. We baited traps with a mixture of rolled oats and peanut butter and checked each trap (and removed any rats caught) daily over the entire trapping period. Capture rates quickly dropped away from initially high levels and after several nights of trapping captures were largely restricted to the perimeter of the grid.

Methods undertaken in the 2004/05 breeding season were identical except that only the six plots (rats were controlled on three plots) on Taukihepa were monitored. In addition, all weka observed in any plot in January and February were removed using trapping and snaring, and although their populations were much reduced, total eradication of weka on the plots was never achieved. Dates of monitoring the plots in the 2004/05 breeding season were; once between 14 and 17 December, rechecked between 10 and 14 January, monitored every three days until between 12 and 14 February, and then one final check between 20 and 22 March. Rat trapping was undertaken between 10 January and 16 February.

Statistical methods

The predator control experiment allows the assessment of predation, natural mortality, and breeding success rates under treatment and no treatment combinations of rat and weka control. Due to natural site-to-site variation in predation levels and year-to-year variation in natural mortality rates, this experiment is best at estimating the effect of weka control on predation rates, although natural mortality rates and the effect of rat control are also estimated. Further, a baseline predation rate may be estimated for use in the population modelling portion of this analysis.

Breeding success is a combination of egg success (hatching or not) and chick success to fledging. Eggs may either fail through natural mortality or through predation; otherwise they 'survive' to hatching, while chicks generally survive unless predated upon. Thus, the distribution of survivals or breeding successes, natural failures, and predation failures may be thought of as a multinomial process based on the number of

nests observed (N), and survival or breeding success (c), observed predation (p_o), and observed natural mortality (n_o) probabilities that sum to one. The underlying predation and natural mortality rates, or the expected rates in the absence of the other, are somewhat greater than the observed rates, as predation (p) and natural mortality (n) compete with each other. That is, an egg or chick that fails in one manner is not available to fail in the other. Breeding success is then the absence of mortality, and can be calculated as

$$c = (1-p)(1-n) \tag{1}$$

Natural mortality occurs during the egg cycle but generally not during the chick cycle. Recognizing this, if we assume that egg and chick predation rates are approximately equivalent (as supported by data), and that egg and natural mortalities occur during the same time frame without assignment bias, then the observed mortality rates can be related to the underlying rates by

$$\begin{aligned} n_o &\approx n - np/4 \\ p_o &\approx p - 3np/4 \end{aligned} \tag{2}$$

For example, if there was a 20% probability of predation and a 10% probability of natural mortality (in the absence of the other), then the overall breeding success rate is expected to be $c = (1-p)(1-n) = 0.72$, while the observed predation rate is expected to be $p_o = p - 3np/4 = 0.185$ and the observed natural mortality rate is expected to be $n_o = n - np/4 = 0.095$.

Combining this, the counts of nests at each site that successfully fledge a chick (x_c), fail naturally (x_n), or are predated (x_p) follow a multinomial distribution

$$\vec{X} \sim Multinomial(\vec{p}, N) \tag{3}$$

where $\vec{X} = \left(x_c, x_n, x_p\right)$, $\vec{p} = \left((1-p)(1-n), n - np/4,\ p - 3np/4\right)$, and N is the number of nests.

We wished to model p and n based on treatments (rat control, weka control) while adjusting for site-to-site (s) and year-to-year (y) variation. It was thought that predation intensity varies across sites due to differences in site accessibility and predator density, so a random effect for site (η_s) was included in the model, as were rat and weka effects. The inclusion of a site effect was also important to avoid dependence problems from pseudo-replication, as each site was monitored twice (2004 and 2005). The weka treatment effect is confounded with time, and other possible explanations for any observed effect may exist. However, the most likely source of any change in predation rates is the reduction in the number of predators rather than any other variable. Thus, we modelled

$$\text{logit}(p_s) = \eta_s - \beta_R I_R - \beta_W I_W + \beta_{RW} I_{RW} \tag{4}$$

where β_R is the main-effects rat control effect, I_R is an indicator variable for (0) no rat control or (1) rat control, β_W is the main-effects weka effect, I_W is an indicator variable for (0) no weka control or (1) weka control, β_{RW} is the rat-weka interaction effect, and $I_{RW} = I_R I_W$. Further, prior distributions for the model were

$$\eta_s \sim N(\mu_s, \sigma_s^2),\ \mu_s \sim N(0,100),\ 1/\sigma_s^2 \sim Gamma(0.01, 0.01),$$

$$\beta_R \sim N^+(0,100),\ \beta_W \sim N^+(0,100),\ \beta_{RW} \sim N(0,100),$$

where N^+ signifies a positive-censored normal distribution. This restriction was put in place for the main rat and weka treatment effects, as it was assumed that predator control could only have a beneficial effect on breeding success. We also tested a main-effects model, where $\beta_{RW} = 0$, for ease of interpretation and possible improvement in precision. In this model,

$$\text{logit}(p_s) = \eta_s - \beta_R I_R - \beta_W I_W \tag{5}$$

The underlying natural mortality rates ($n_{s,y}$) were modelled to allow for potential year-to-year (y) and site-to-site (s) variation. Thus, the underlying natural mortality rate was modelled as

$$\text{logit}(n_{s,y}) = \zeta_s + \omega_y \tag{6}$$

with prior distributions

$$\zeta_s \sim N(0,100),\ \omega_y \sim N(\mu_\omega, \sigma_\omega^2),\ \mu_\omega \sim N(0,100),\ 1/\sigma_\omega^2 \sim Gamma(0.01, 0.01)$$

The long-term expected natural mortality (n_L) is then

$$\text{logit}(n_L) \approx \mu_\omega \tag{7}$$

The breeding success model was developed using a Bayesian framework with non-informative priors using WinBUGS. A burn-in phase of 10,000 iterations was used followed by 50,000 samples. This level of sampling allowed the Monte Carlo errors to be negligible relative to the parameter standard errors. Model fit was assessed using the Bayesian p-value (Gelman et al. 1996, Brooks et al. 2000), using the Freeman-Tukey statistic (Freeman and Tukey 1950) to measure discrepancy. Bayesian p-values close to 0.5 represent good fits and values near 0 or 1 represent poor fits. In assessing whether to use the interaction (Eq. 4) or the main-effects (Eq. 5) predation model, we used the deviance information criterion (DIC; Spiegelhalter et al. 2002), as well as examining the confidence interval for the interaction term β_{RW}.

Because monitoring for this study began after egg-laying, the observations are contingent upon survival to the beginning of the monitoring process. Also, chicks were monitored for just shy of 60 days after hatching. However, they are not fully fledged for approximately 100 days. Thus, there may be additional predation beyond that observed during the experimental period, and predation rates estimated from this data represent a lower bound. It is likely that rat predation of sooty shearwater chicks occurs predominantly during the post-guard phase of the nesting period, as was observed with kiore predation on related species (Imber et al. 2003), after the chick is left in the burrow and before the chick becomes too large and aggressive to be preyed upon by the rat. As the monitoring period covered the vulnerable stage of the nesting cycle there is unlikely to be additional rat predation. However, it is conceivable that predation by weka continued past the end of monitoring. The predation rate likely declines over the course of the chick stage as the chicks grow and are better able to protect themselves from predators, and the most accessible chicks are removed. Predation rates for the late-chick stage are unknown. The amount of bias in the

predation estimate may be derived by first estimating daily predation rates during the chick-phase (p_d) as $p_d \approx 1-(1-p/2)^{60}$. If the daily predation rate post-monitoring (p_p) is a constant fraction of the rate during monitoring (i.e. $p_p = kp_d$ for some k), then the actual predation during the chick-phase would be $p_c \approx p/2+\left[1-\left(1-kp_d\right)^{40}\right]$, the total predation would be $p^* \approx p+\left[1-\left(1-kp_d\right)^{40}\right]$, and the bias in the estimate would be

$$p-p^* \approx 1-\left(1-kp_d\right)^{40} \tag{8}$$

Some data were collected regarding the time of predation throughout the monitoring process. These allow a qualitative assessment of plausible values for k and the bias term $p-p^*$.

Predation scenarios

To estimate the impact of predator control on predation, models for predator population growth and for the relationship between predator levels and predation need to be developed. In this study, an absence of data requires simple models. In particular, while weka growth rates in optimal conditions are reasonably well quantified using the methods of Niel and Lebreton (2005), similar approaches for studying optimal growth rates in rats appear to be more variable (Blueweiss et al. 1978), while the impact of density-dependence on growth for either species is not quantified. Finally, while it is reasonable to assume that predator levels and predation are positively correlated, there was no data to describe the relationship beyond that.

Both rat and weka populations have the ability to grow relatively quickly (Blueweiss et al. 1978, Niel and Lebreton 2005). In particular, in the circumstance of predator control, it is likely that post-control conditions may be near-optimal as any density-dependent effects would be minimal. Niel and Lebreton (2005) describe an approach to estimating the maximum growth rates for birds requiring only estimates of adult survival and age of first breeding. For weka, these are approximately 85-90% and 1 year (Tony Beauchamp, pers. comm.) respectively, suggesting that the population may grow by 30%-40% annually. Less information was available for rats, but field

observations suggest that increasing by an order of magnitude or more within a year is feasible.

With no data to support a particular functional response between predator control rates and predation, and minimal data to support growth rates of predators, we made three simplifying assumptions:

(1) Current predator levels are at the predator carrying capacity (k_p)

(2) Predator levels (N_p) increase by 35% each year until reaching carrying capacity

(3) Predation rates (r_p) are calculated as $r_p = N_p / k_p$.

Under these assumptions, we considered three predator control scenarios as well a baseline scenario:

(0) No reduction in predation for comparative purposes

(1) An initial 50% reduction in predator levels, representing partial success in eradication,

(2) An initial 90% reduction in predator levels, representing a generally successful but not complete eradication, and

(3) A 100% reduction in predator levels, with no re-colonization for at least ten years representing a successful eradication.

Combining the assumptions with the three control scenarios results may be characterized as (1) moderately reduced predation for two years, (2) substantially reduced predation for four years followed by moderate reduction for a further four years, and (3) the elimination of predation. This represents a reasonable range of possible outcomes, with the first scenario being most likely if rat predation is an important factor and control is not ongoing or complete.

Population model

Under the scenarios listed above, we wished to assess the impact of predator control on the change in the population size after ten years. We did this using a generic life-cycle for a seabird population model (Figure 1). The model is stage-based and assumes a post-breeding census. It involves four stages: chicks (C), juveniles (J),

prebreeders (P) and adults (A). Juveniles are defined as birds that are at least one year of age and have yet to return to the colony. Prebreeders are birds that have returned to the colony but have yet to attempt to breed. Adults are birds that have had at least one breeding attempt. We define an immigrant to be a prebreeder that was not born at the colony, and a recent immigrant to be one that has just become a prebreeder.

The model involves the following parameters:

b	probability that an adult is breeding
c	probability that an egg becomes a fledgling
g_{JP}	probability that a juvenile that is alive becomes a prebreeder
g_{PA}	probability that a prebreeder that is alive becomes an adult
$f^{(I)}$	number of recent immigrants divided by number of prebreeders in previous year
$\phi^{(C)}$	probability that a chick survives the coming year
$\phi^{(J)}$	probability that a juvenile survives the coming year
$\phi^{(P)}$	probability that a prebreeder survives the coming year
$\phi^{(A)}$	probability that an adult survives the coming year

The projection matrix corresponding to the model is

$$A = \begin{bmatrix} 0 & 0 & 0 & bc\phi^{(A)} \\ \phi^{(C)} & (1-g_{JP})\phi^{(J)} & 0 & 0 \\ 0 & g_{JP}\phi^{(J)} & (1-g_{PA})\phi^{(P)} + f^{(I)} & 0 \\ 0 & 0 & g_{PA}\phi^{(P)} & \phi^{(A)} \end{bmatrix} \tag{9}$$

Note that

- There is some choice as to the definition of the immigration rate $f^{(I)}$. The definition we use here implicitly assumes that the number of immigrants is scaled by the number of adults in the population in the previous year. By using this definition we are modelling immigration as being equivalent to an increase in the effective survival rate of adults. It is clearly possible that factors other than the number of adults in the population last year might affect the number of immigrants.

- The survival rates $\phi^{(J)}$ and $\phi^{(A)}$ are "local" in the sense that the corresponding mortality rates may include permanent emigration. We could specify a separate first-year survival rate, but this is very difficult to estimate for species such as tītī, that spend the first few years of life away from their natal colony.

All the parameters, apart from g_{JP}, g_{PA} and $f^{(I)}$, may be estimated directly from data or may be available in literature. In estimating the "graduation rates" g_{JP} and g_{PA}, we make use of the variable stage-duration method (Caswell 2001). Thus we have

$$g_{JP} \approx \frac{1}{\mu_J} \exp\left\{ -\frac{1}{2} \ln\left(\frac{\lambda}{\phi^{(J)}} \right) \left(\mu_J - \frac{\sigma_J^2}{\mu_J} \right) \right\} \tag{10}$$

where μ_J and σ_J are the mean and standard deviation of the time spent in the juvenile stage and λ is the population growth rate predicted from the model. Likewise, we have

$$g_{PA} \approx \frac{1}{\mu_P} \exp\left\{ -\frac{1}{2} \ln\left(\frac{\lambda}{\phi^{(P)}} \right) \left(\mu_P - \frac{\sigma_P^2}{\mu_P} \right) \right\} \tag{11}$$

where μ_P and σ_P are the mean and standard deviation of the time spent in the prebreeder stage. As λ is an output of the model, we need to provide an initial value for λ (such as $\lambda = 1$) in order to produce initial estimates for g_{JP} and g_{PA}. We can then estimate $f^{(I)}$ using the methods of Peery et al. (2006) and the population model is fully specified. This leads to a new value for λ, which in turn provides new estimates for g_{JP} and g_{PA}, and the process continues until convergence (Caswell, 2001).

Use of a deterministic population model to estimate graduation rates involves the assumption that the population growth rate does not vary with time. Thus we define the population growth rate to be

$$\lambda = \lambda_{t+1} = \frac{N_{t+1}}{N_t} \tag{12}$$

where N_t is the population size in year t, and the equation is assumed to hold for any value of t. In addition, the population size (N_t) may be treated as a the magnitude of vector of stage-specific populations $\vec{\theta}_t = \left(\theta_t^{(C)}, \theta_t^{(J)}, \theta_t^{(P)}, \theta_t^{(A)} \right)$, where the entries represent the chick, juvenile, prebreeder, and adult population sizes in the *t*th year, so

$$N_t = \theta_t^{(C)} + \theta_t^{(J)} + \theta_t^{(P)} + \theta_t^{(A)} \tag{13}$$

The proportion of birds in each stage $\vec{P}_t = \left(P_t^{(C)}, P_t^{(J)}, P_t^{(P)}, P_t^{(A)}\right)$ is then

$$\vec{P}_t = \vec{\theta}_t / N_t \tag{14}$$

The growth rate (λ) may be estimated by the dominant eigenvalue of the population projection matrix, while the corresponding eigenvector is used to estimate $\vec{P}_t$ (Caswell 2001). In some cases it may be important to include stochastic elements, such as temporal or spatial variation in survival, in order to obtain an unbiased estimate of λ. In practice, if this variation is not large then deterministic models may suffice. In particular, other model assumptions often have greater influence on the estimate of λ, and the deterministic assumption may have relatively little impact.

In general, estimating the initial population size and stage distribution (N_0, $\vec{\theta}_0$) is potentially difficult for seabirds, as typically only a few states are observable. We derived a population estimate based on estimates of the number of chicks ($\hat{\theta}^{(C)}$) summed over the four locations. Using the number of chicks as a somewhat conservative estimate of the number of breeding pairs, as well as the probability that an adult is breeding (b) and the proportion of the population that are adults ($P^{(A)}$), the population size can be estimated as

$$N_0 \approx 2\theta^{(C)} / \left(bP^{(A)}\right) \tag{15}$$

Next, predation affects the model parameter c, or breeding success. The earlier definition of breeding success can be expanded to include a harvest rate (h), in addition to natural mortality and predation. Assuming that these rates are independent,

$$c = (1-n)(1-p)(1-h) \tag{16}$$

We note that observed rates of mortality will be somewhat lower than the underlying mortality rates, as an egg or chick that perishes in one manner is then unavailable to perish in the others.

Various predation scenarios correspond to changing p through ten years, or $p = (p_1, p_2, \ldots, p_{10})$. From this, breeding success parameters are calculated as $c = (c_1, c_2, \ldots, c_{10})$ where $c_i = (1-n)(1-p_i)(1-h)$. This method can be easily adjusted to accommodate changing harvest rates through time or changing natural mortality rates. Keeping other parameter values fixed, this generates ten projection matrices $A_1, \ldots, A_{10}$, where

$$A_i = \begin{bmatrix} 0 & 0 & 0 & bc_i\phi^{(A)} \\ \phi^{(C)} & (1-g_{JP})\phi^{(J)} & 0 & 0 \\ 0 & g_{JP}\phi^{(J)} & (1-g_{PA})\phi^{(P)} + f^{(I)} & 0 \\ 0 & 0 & g_{PA}\phi^{(P)} & \phi^{(A)} \end{bmatrix} \tag{17}$$

The population size after *t* years under predation scenario *j* is then estimated as

$$\vec{\theta}_t^{(j)} = \left(\prod_{i=1}^{t} A_i \right) \vec{\theta}_0 \tag{18}$$

Thus, $N_{10}^{(0)}$ is the ten-year population estimate assuming no predator control, $N_{10}^{(1)}$ corresponds to the 10-year population estimate under scenario 1 (50% initial reduction in predation), and so forth. Further, with the deterministic assumption and no changes in predation rates, the baseline estimate may be simplified to

$$N_{10}^{(0)} = \lambda^{10} N_0 \tag{19}$$

The ten-year impact of predator control in the *j*th scenario may then be assessed as

$$I_{10}^{(j)} = N_{10}^{(j)} - N_{10}^{(0)} \tag{20}$$

In order to estimate the accuracy of this estimate, a simulation based method was used. The algorithm used was:

(1) Generate 10,000 values for b, n, p, h, $f^{(I)}$, $\phi^{(C)}$, $\phi^{(J)}$, $\phi^{(P)}$, and $\phi^{(A)}$ from a logit-normal distribution (Mead 1965) given mean values and standard errors. Using the logit-normal constrains parameter values between 0 and 1, as is appropriate for

probabilities. The delta-method (Casella and Berger 2002) was used to approximately preserve means and standard errors when performing the logistic transformation. We also generated 10,000 values for μ_J, σ_J, μ_P, and σ_P from normal distributions given mean values and standard errors, constraining the values to be at least 1 and standard deviations to be at least 0.1 (e.g. we constrained them to be within plausible ranges). The baseline breeding success value (c) is calculated from n, p, and h using Eq. 16. Finally, we generated 10,000 values for the number of chicks ($\theta_0^{(C)}$) from a uniform distribution based on population survey means and standard errors. Implicit in these parameter draws is the assumption that parameter estimates are uncorrelated. If there are known correlations in estimates, they may be incorporated at this step.

(2) For each of the 10,000 parameter draws, we estimated g_{JP} and g_{PA} and built the corresponding projection matrix. From this, the stable stage-distribution under the baseline case of no predator control was calculated, providing the proportional stable stage-distribution $\vec{P}_0$ for all scenarios. Combining this with the number of chicks ($\theta_0^{(C)}$), breeding success (c), the probability of breeding (b) and Eq. 15, the initial population size (N_0) is estimated. Further, the missing portions of the population vector are estimated using the relationship $\vec{\theta}_t = \vec{P}_0 N_0$ (see Eq. 14). Further, λ for the baseline case was estimated from the dominant eigenvector and $\hat{N}_{10}^{(0)} = \hat{\lambda}^{10}\hat{N}_0$ from Eq. 19.

(3) For each predator control scenario, generate $A_1, \ldots, A_{10}$, estimating $\vec{\theta}_t^{(j)}$ from Eq. 18 and $N_t^{(j)}$ from Eq. 13.

(4) Calculate $I_{10}^{(j)} = N_{10}^{(j)} - N_{10}^{(0)}$. From the resulting distribution, the mean, standard error, and confidence intervals are estimated in a straightforward manner.

The impact of predator control ($I_{10}^{(j)}$) is positively correlated with the baseline estimate of λ. That implies that the greatest impact of predator control happens when

it is least necessary. For this reason, we also estimated the ten-year impact of predator control restricted to parameter sets that result in population decline (i.e. the baseline $\lambda < 1$), denoted $I_d^{(j)}$. Also, because the impact of the oil spill was estimated to be c. 16,000 mortalities, we wished to estimate the probability that predator control resulted in at least 16,000 additional birds, or

$$P_R^{(j)} = \Pr\left(I_{10}^{(j)} > 16,000\right) \tag{21}$$

We are also able to provide an estimate of the current total population size (chicks through adults) supported by these islands using Eq. 15.

We also wish to note that error (especially bias) in parameter estimates may substantially affect $N_{10}^{(j)}$ and $N_{10}^{(0)}$. However, because any bias in parameter estimates propagates to both $N_{10}^{(j)}$ and $N_{10}^{(0)}$, the impact of parameter bias on $I_{10}^{(j)}$ is greatly reduced. That is, while we may have difficulty assessing future population trends, our ability to assess the difference in those trends is considerably better. This allows us to assess the impact of different levels of predation with considerably more confidence than we could assess future population trends.

Parameter estimates

Parameters for the population model fall into five broad categories: (1) reproductive, (2) stage transition, (3) immigration, and (4) survival rates, as well as estimates of (5) population size. In some cases, direct estimates are available from data, while in other cases estimates are less robust. Values used are summarized in Tables 1 & 2.

Important reproductive rates are the proportion breeding (b) and breeding success (c). Breeding success is determined by the chick harvest rate (h), natural mortality (n), and predation (p). For the proportion breeding, we used an estimate from Fisher Island and assumed a standard error of 0.05, while the chick harvest rate was assumed to be 0.16 ($se = 0.02$; Newman et al. submitted). The predation experiment provided estimates of natural mortality from Eq. 6 of $n = 0.11$ and the baseline predation rate (i.e. no predator control) from Eq. 5. In addition, we considered an estimate of natural mortality of $n = 0.26$ ($se = 0.05$) over a longer time series at

Whenua Hou (Newman et al., submitted). Combining these, we assumed that natural mortality at the four islands averaged approximately $n = 0.2$ ($se \approx 0.1$).

The stage duration for juveniles was estimated at $\mu_J = 5.0$ and $\sigma_J = 1.1$ using data from Taiaroa Head and The Snares. Estimates from the short-tailed shearwater (*Puffinus tenuirostris*) were used for the prebreeder stage duration ($\mu_P = 2.9$; Bradley et al. 1999). We assumed that $\sigma_P = 1.1$ and inflated the standard error to 0.4. The graduation rates were estimated using the iterative methods described in Eq.'s 10 and 11 within the full population model. Immigration rates are difficult to quantify but are on the order of $f^{(I)} = 0.3$. Due to our uncertainty in this estimate, we assumed a large standard error of 0.1.

Survival rates, especially adult survival, are generally the most important components in population models for long-lived, slow-reproducing species. For this analysis, survival rates were taken from Taiaroa Head, The Snares, and Whenua Hou, ranging from 0.89 to 0.97. Noting that the birds on Taiaroa Head were subject to predation by stoats, cats, and ferrets, we assumed a median value of 0.95 based on the other two locations and inflated the standard error to 0.03 to account for the extra uncertainty induced by using non area-specific estimates. There were two estimates of juvenile survival available; once again, we chose an average value ($\phi^{(J)} = 0.7$) and assumed an inflated standard error of 0.04. First year or chick survival was assumed to have the same mean and standard error (although still considered as a separate parameter). There was no prebreeder survival estimate available, and it was assumed to be somewhat higher than juvenile survival, with $\phi^{(P)} = 0.8$ with a standard error of 0.05. Adult survival varied substantially across locations (Table 1). For the purposes of this assessment, we assumed adult survival of $\phi^{(A)} = 0.95$ with a standard error of 0.03.

Estimates of Sooty Shearwater Population Size

Estimates of the number of chicks on Taukihepa, Pukaweka, Rerewhakaupoko, and Mokonui islands are summarized in Table 2 and are based on estimates from Newman et al. (submitted). These values were summed to estimate the total number of chicks

at 1.16 million ($se = 240,000$) just prior to harvest and provides a conservative estimate of the number of breeding pairs. Combining this with other parameter estimates and Eq. 15 allowed us to estimate the total population size.

Results

Predation and natural mortality rates

There were clear differences in observed predation and survival rates between sites. Examining the unadjusted data and combining egg and chick predation, observed predation rates averaged 17% and ranged from 4-40% in 2004; after partial weka control in 2005 observed predation decreased to an average of 12% due to an apparent decrease in chick predation, and ranged from 3-25%. The average predation rate was somewhat higher in the rat treatment sites; however, this was primarily due to one location with very high predation. In general, there was a high level of site-to-site variability in predation rates. The level of site-to-site and year-to-year variation in observed natural mortality was relatively small, with natural mortality averaging 8% and ranging from 2-16%.

In modelling the mortality rates, there was no indication of a need for an interaction term ($\Delta DIC = 1.0$, $\beta_{RW} = -0.2$; $se = 0.5$), the model fit was reasonable (Bayesian p-value $= 0.61$) and Eq. 5 was used to model predation rates. With a limited time-frame for the experiment, the long-term natural mortality rate estimated by Eq. 6 was not very precise due primarily to uncertainty in the level of year-to-year variation, and was $\hat{n}_L = 0.11$ ($se = 0.12$). Predation rates without any predator control will be at least $\hat{p} = 0.21$ ($se = 0.07$; 95% CI 0.11-0.38), plus any bias correction that may result from the limited monitoring period. Most of the predation of chicks occurred early in the post-guard phase, supporting the theory that larger chicks are better able to defend themselves from predators and that daily predation rates in the post-monitoring period are substantially reduced. If daily predation rates were decreased by a factor of four (e.g. $k = 0.25$), the bias was estimated using Eq. 8 and was relatively small $p - p^* \approx -0.02$. For the purposes of the population model, no bias correction was included.

The study design made it difficult to assess the impact of rat control on predation rates ($\beta_R = 0.43$; $\sigma_{\beta_R} = 0.40$; $CV > 0.9$). Rat control, restricted in the model to be at least minimally beneficial, was estimated to decrease the odds of predation by 30%, may have little or no effect on reducing predation, or may result in nearly an 80% decrease in the odds of predation ($OR = 0.69$; 95% CI: 0.23-0.99). A future experiment following a before-after control-impact design would have a better opportunity to assess this. Weka control was confounded with year, as all locations were controlled in 2005 and none in 2004. Assuming that this confounded effect is due to weka control, the level of control performed during the experiment resulted in improved precision ($\beta_W = 0.57$; $\sigma_{\beta_W} = 0.25$) compared to the estimated rat control effect. Weka control at the unregulated levels of this experiment decreased the odds of predation by over 40% ($OR = 0.58$; 95% CI: 0.34-0.90).

Population model

Equation 15 suggests a total population of 8 million birds (95% CI: 5 to 12 million birds) at the four islands in this study. With such a large population, even small improvements in parameter values may have large impacts. By reducing predation, we estimate that the population size in ten years will be at least 14,000 birds greater than it would have been without predator control, even in pessimistic scenarios. With the high level of uncertainty in portions of this model, it is conceivable that predator control could result in over a million additional birds within ten years if eradication is successful. The benefit of successful eradication is estimated at 1.6 million additional birds (95% CI: 500,000 to 4.3 million), more than twenty times the benefit from the 50% eradication scenario (67,000 additional birds; 95% CI: 18,000 to 166,000), and over four times the benefit of the 90% eradication scenario (450,000 additional birds; 95% CI: 130,000 to 1.1 million). These results are summarized in Table 3.

With the numerous sources of variability in this study, the assessment of the population growth rate was not very accurate, with $\hat{\lambda} = 1.02$ ($se = 0.05$). The estimated impact of predator control is reduced somewhat if the population is decreasing. In these circumstances, successful eradication would result in 1.1 million

additional birds (95% CI: 370,000 to 2.3 million), the 90% eradication scenario would result in 310,000 additional birds (95% CI: 100,000 to 690,000), and 50% eradication would generate an additional 46,000 birds (95% CI: 14,000 to 105,000).

The probability of producing at least 16,000 additional birds is $P_R^{(j)} > 0.95$ in all scenarios, and nearly one in the 90% or 100% eradication scenarios. A large portion of the difference between the scenarios is the continued increase in breeding success in later years in the scenarios with good or complete eradication. This leads to a large difference in the number of young birds between the different scenarios, with smaller differences in the number of adults.

Limiting the results to the increased number of adult birds, it is expected that successful eradication would result in 590,000 additional adult birds (95% CI: 190,000 to 1.4 million), the 90% eradication scenario would result in 180,000 additional adult birds (95% CI: 55,000 to 410,000), and 50% eradication would generate an additional 27,000 adult birds (95% CI: 8,000 to 65,000) after ten years. For the 90% or 100% eradication scenarios, the probability of at least 16,000 additional adult birds is nearly 100%, while this decreases to c. 75% if only half of the birds are eradicated.

Discussion

Predation of tītī nests by introduced predators

The predation experiment demonstrates the high levels of predation of sooty shearwater eggs and chicks that occurred on the islands monitored. However, high variation in predation rates between sites and limitations in the study design make separating the relative contributions of rats and weka difficult. This study was unable to determine if predation by rats was minimal or large. Regular observations of active weka predation on these islands (Harper 2006) and evidence of a reduction in predation when weka were partially controlled in the second breeding season suggests that weka predation is substantial. While the weka treatment is confounded with year, the most likely explanation for the observed difference is the weka control rather than

a confounding factor, especially given that natural mortality remained relatively constant between years.

There was relatively little variation observed in natural mortality rates in the two years of this study or across study sites, while predation rates varied greatly. While the study included sites on only two islands for two years and clearly cannot fully assess spatial/temporal variation, it does suggest that predation rates in some locations and years are the primary limiting factor on breeding success (beyond any level of human harvest). In several sites (4 of 8) prior to weka control, predation rates were 20% or higher, with a model-adjusted average of c. 20%. Due to the high level of site-to-site variation, similar experiments in the future may prefer a before-after control-impact design, so that each site acts as its own spatial control while the inclusion of control sites throughout the experiment also elicits information on temporal variation.

Simulating the impacts of predation

The difficulty in differentiating between rat and weka predation makes modelling the implications of the rat eradication on tītī dynamics problematic. However, in practice modelling the two forms of predation separately will only be necessary if either species remains, post-eradication attempts, or reinvades any of these islands over the time period simulated (10 years), or for predicting the impacts of predation on tītī on other islands where rats or weka occur singularly. Providing that no rats survived the poison drop in 2006, and that follow-up control of weka occurs on Mokonui and Taukihepa in the 2007 harvesting season (this control has already been undertaken on Pukaweka and Rerewhakaupoko), then this scenario is presumably the most likely. The benefits to the tītī population should continue well beyond the 10 years simulated, providing environmental conditions do not change drastically, or density dependent regulation of the population sets in.

Several other scenarios were used to simulate partially successful eradications or reinvasion of the islands. In all cases, even short-term predator control resulted in repatriation of the oil-spill injury within the simulated time period, given our population model. However, several simplifying assumptions regarding predation

response to predator levels and predator growth rates were made. Estimates provided are conditional on the model being accurate or reasonably so. While we tried to incorporate realistic levels of uncertainty in parameter estimates, assumptions regarding predator population growth rates, current status, and the relationship between predator density and predation may be overly simplistic. Furthermore, we grouped the four islands together for simplicity. If there are differences in eradication success or reinvasion between islands then our predictions may be biased to some degree. Island specific modelling of post-poisoning weka control is ongoing.

Prospects for reducing predator impacts

Of great concern to many people is the sustainability of the customary tītī harvest. The impact of current harvest levels is currently unknown and is the focus of ongoing research (Moller et al. 2006). If harvesting is having a detrimental effect on tītī populations then strategies for minimising impacts may be sought by the harvesting community. At the same time, these strategies must allow for the cultural and economic needs gained from the harvest. As the estimated predation is greater than the estimated customary harvest level, one approach to mitigating harvest could be through predator control. While many islands are already predator-free, eliminating predators on other islands could result in a continuance of the customary harvest, and may be preferable to other potential mitigations.

Benefits to tītī populations must also be compared to any impact on the species being removed so we suggest that any future weka control be done with a thorough understanding of their wider conservation status. Weka control is a contentious issue, as they are threatened and a taonga species for Māori. Estimates of rat predation were not precise enough to adequately quantify the improvement that may result from rat control alone. However, removing introduced rats from these islands is almost certain to have a broad range of ecosystem benefits (e.g. Atkinson 1985) with no known detrimental effect beyond any short term sideffects of the eradication itself (such as killing of non target species) and the cost of any ongoing quarantine measures.

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Table 1. Summary of parameter estimates used in the population model. When multiple estimates were available, they are listed as well as the value used in the population model.

Parameter	Symbol	Location	Estimate	SE
Breeding and mortality				
Proportion Adults Breeding	b	Fisher Island	0.69	0.05
Natural Mortality	n	Model value	0.20	0.10
		Taukihepa	0.11	0.11
		Whenua Hou	0.26	0.05
Predation	p	Taukihepa	0.21	0.07
Harvest Rate	h	Four Islands	0.16	0.02
Survival				
First year survival from fleging	$\phi^{(C)}$	None	0.70	0.06
Juvenile Survival	$\phi^{(J)}$	Model value	0.70	0.04
		Tairoa Head	0.73	0.02
		The Snares	0.66	0.02
Prebreeder Survival	$\phi^{(P)}$	None	0.80	0.05
Adult Survival	$\phi^{(A)}$	Model value	0.95	0.03
		Tairoa Head	0.89	0.02
		The Snares	0.93	0.02
		Whenua Hou	0.97	0.02
Stage duration and immigration				
Mean Time as a Juvenile	μ_J	Tairoa Head & The Snares	5.0	0.2
SD Time as a Juvenile	σ_J	Tairoa Head & The Snares	1.1	0.1
Juvenile - Prebreeder Rate	g_{JP}	Model estimate	0.082	0.014
Mean Time as a Prebreeder	μ_P	Short-taileds	2.9	0.2
SD Time as a Prebreeder	σ_P	Short-taileds	1.1	0.2
Prebreeder to Adult Rate	g_{PA}	Model estimate	0.26	0.04
Immigration Rate	$f^{J(I)}$	Assumed	0.30	0.10

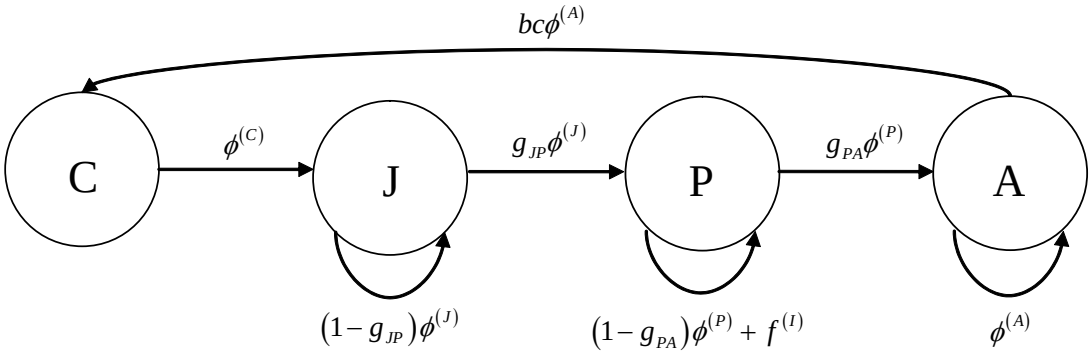
Table 2. Estimated number of chicks (from Newman et al. submitted).

Location	**Number of Chicks**	**SE**
Taukihepa	807,000	236,000
Pukaweka & Rerewhakauopoko	62,000	28,000
Mokonui	291,000	27,000
Total	1,160,000	240,000

Table 3. Estimated impact after ten years of predator control.

Eradication	Additional birds	SE	95% CI
50%	70,000	39,000	18,000 - 166,000
90%	450,000	260,000	100,000 - 690,000
100%	1.6 million	1.1 million	370,000 - 2.3 million

Figure 1. Life cycle for a tītī population model, with four stages: chick (C), juvenile (J), prebreeder (P) and adult (A).



Appendix I: Insect and Invertebrate Survey Report, Edwards 2008

Taukihepa/Big South Cape Island: Invertebrate investigation March 2008

E. Edwards, Department of Conservation, June 2008

View from top of Taukihepa across to southern Stewart Island, &, some of the fauna.

"When we were there in 1968 the canopy of the Olearia forest at night was alive with rats and the only large beetles on the forest floor were a carabid and a tenebrionid, both smelly when picked up. We found no Hadramphus *or* Anagotus *weevil adults. There were no signs* of Hadramphus *larvae around the root masses of* Stilbocarpa *and only old evidence of one* Anagotus *workings, in* Drachophyllum *... The moderately-sized (12 -15mm) weevil* Cuneopterus *was not uncommon under large logs, and that was about it for the macrofauna really. From what I know now from work on rat free Breaksea I., before rats got to Taukihepa the Olearia and teteaweka branches would have had larval workings in the outer sapwood just a rats gnaw through the bark, and the foliage would have concealed countless adults."* (J.S. Dugdale comment 2008)

Context

This investigation was invited by iwi of Taukihepa following an interesting history which includes the ecosystem disrupting effect of ship rats that arrived in the early 1960,s and subsequent restoration effort of removing the rats in the winter of 2006. Moths, beetles and other insects inhabiting the island are documented and, comments about their significance or the impact of rats on them are discussed.

The weather was mild with westerly winds having little effect in the region of Murderers Cove. The first of two evenings was calm, warm and low cloud with slightly misty periods. The second evening was partly cloudy and cooler. Light trapping attracted a good number of moths and also drew many colonial seabirds some of which landed at the light –particularly in the misty conditions. Using light trapping, hand collecting and including old records, 76 invertebrate taxa are noted (appendix 1). These include 54 moth species, twelve beetles and 10 other taxa.

Mutttonbird forest (puheretaiko-tupare –*Brachyglottis reinoldii-Olearia colensoi* var. *grandis*)

Habitats

Deep peaty soils with abundant seabird burrows surround the cove. Within the region of Murderers Cove a range of vegetation and habitats occur including coastal fringing teteaweka (*Olearia oporina*) forest, coastal cliff and crevice turf/*Poa astonii*/herb community, Punui (*Stilbocarpa lyallii*) community, mutttonbird forest (puheretaiko-tupare –*Brachyglottis reinoldii-Olearia colensoi* var. *grandis*) and hardwood-podocarp forest.

Coastal fringing teteaweka (*Olearia oporina*) forest, &, coastal cliff and crevice turf/*Poa astonii*/herb community

Patch of Punui *Stilbocarpa lyallii* former habitat of giant punui weevil *Hadramphus stilbocarpae*. Feeding damage shown on the right is seasonal from early to mid summer and from moth larvae –unfortunately not weevils.

Feature insects

Rakiura ghost moth

Of note at the time of sampling was the abundance of the large Rakiura endemic ghost moth *Aoraia insularis*. Males were abundant while females are flightless and are not well known. Taukihepa is the Type Locality from which this moth is described and Whenua Hou is the only other known locality.

The large strikingly coloured moths with plumose antennae are males of the Rakiura endemic ghost moth *Aoraia insularis*. Moths that feed on ferns, hardwood trees, *Hebe elliptica*, mosses and leaf litter are also represented.

Extinct giant weevils

Punui giant weevil *Hadramphus stilbocarpae* were first described from Big South Cape – Taukihepa and are known on Snares Islands and a few rodent free islands in Fiordland. These weevils would have been present in a number of places in Southland and Stewart Island a few hundred years ago when kiore and ship rats were not present. When the ship rat plague occurred at Taukihepa these weevils were clearly at risk on the island and appear to have gone extinct. During the survey in 2008, Punui plant patches have been searched for this weevil but none have been found. Another search should be done in 2010 to allow more time for any possible remnant population of these weevils to grow and be detected. If no giant weevils can be found in 2010, it may be worth considering a beetle transfer.

Another giant weevil *Anagotus* species is known from coastal Teteaweka round Fiordland Islands. No examples of this beetle were discovered in searches either. To know more about the history of this weevil and other beetles and native snails it would be possible to do professional archaeological analysis of soil deposits at bluff and cave sites on the island.

Australian immigrants

In the weeks prior to the survey, It appears that the weather has carried numerous insects across the Tasman Sea from Australia to Taukihepa. This is shown by finding many

examples of the moths *Agrotis ipsilon aneituma* and *Spoladea recurvalis* and the southern most record ever of a semi-tropical *Anomis* species moth. These last two are certainly not able to breed here.

Big tough leaf rollers
The leaf roller moth *Planotortrix puffini* has caterpillars that are capable of tying the large thick leathery leaves of puheretaiko –*Brachyglottis reinoldii* together with silk and also eats these leaves. This is quite a feat for such a small insect. Another related leaf roller moth *Ctenopseustis herana* is common with larvae on a range of trees and ferns. Most tree ferns showed the larval damage on some fronds where part of the leaf crumples often spiralling upwards in a mess which occurs when the frond keeps growing after being tied with silk.

Traill's ground beetle
Traill's ground beetle *Mecodema trailli* is named for Traill a pioneer naturalist of Stewart Island. This large beetle is among many insects and some snails that are found only in the region of Stewart Island and some outlying islands but it is one of few invertebrates that are also found at Motupohue/Bluff Hill which has the same, geology, soils and vegetation as Rakiura.

Rodent responses
The vegetation and insects have been released from the sustained predator, scavenger and herbivore effect of ship rats for almost two years. In this situation moths, beetles and other invertebrates respond. The response has not been assessed for Taukihepa but it is likely that the two cave weta species that were abundant in the 2008 survey (see appendix notes) were less abundant when rats were present.

The abundance of ground beetles, large bodied spiders, Rakiura ghost moth, Rakiura carnivorous snail *Rhytida australis*, ground weta *Hemiandrus* species (not seen in 2008 survey), Helm's stag beetle *Geodorcus helmsi* and cave weta are all expected to increase and maintain higher densities in the absence of rats and mice.

Recommendations for invertebrates
With rats and mice absent, prevent new arrivals of these rodents or other exotic invertebrates and plants.

During 2010 (or some later date) search specifically for Punui giant weevil *Hadramphus stilbocarpae*. This was one of the icon animals that has likely been lost along with the reported bat and birds. If the beetle is not found, an assessment for recolonisation could be considered.

Of lesser priority but still of significance for the region, carry out a professional archaeological investigation of soil deposits at bluff and cave sites on the island. This may provide information about human occupation but would be targeted at historical information on large bodied snails, beetles and weta as well as birds and bats. It may be possible for example, that Herekopare weta *Dienacrida carinata* once existed on Taukihepa. This kind of information for the weta or other insects and birds would have consequences for management of both the species and islands in the region.

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Teno pai to Ron Bull and his whanau for encouragement and hot stove. John Dugdale, Peter Johns and Brian Patrick supplied great historical accounts and insect records.

Appendix 1.

Inventory of moths and some other invertebrates from Taukihepa/ Big South Cape Island, April 2008

All invertebrates noted from Murderers Cove 20 -40 metres above sea level with few exceptions noted. A few records of roaches, flies, weta and some beetles were forward to me by Peter Johns who visited the Island in 1964, 1968 and 1969 with a number of Insect experts. This data is shown in comments.

Taxon	**Comments**
Beetles -Coleoptera	
Family Carabidae -predator ground beetles	
Mecodema trailli	Trail's ground beetle, a large predacious ground beetle endemic to Rakiura region. Named for Roy Trail of Stewart Island
Mecodema trailli	Big South Cape Island, Puwai Bay,10-30,24.viii.64,Johns, PM; Bell BD,logs,,
Family Cerambycidae -longhorn beetles	
Prionoplus reticularis	Huhu beetle, Larvae bore in dead wood
Family Curculionidae -weevils	
Anagotis species	Teteaweka weevil. Not recorded but associated with *Olearia oporina* teteaweka coastal muttonbird scrub in Fiordland and likely Rakiura region. Would be vulnerable to ship rat predation where these are present.
Hadramphus stilbocarpae	Punui weevil/knobbled weevil, larvae bore in puni *Stilbocarpa lyalli* roots & adults eat the leaves. Taukihepa is the Type Locality for this rare giant beetle species that most likely became extinct on the island during ship rat plagues of the 1960's. It was not rediscovered in this survey
sp. 1	*sp. 1, wood/bark boring weevil, abundant in muttonbird scrub*
sp. 2	*sp. 1, wood/bark boring weevil, abundant in muttonbird scrub*
Family Lucanidae -stag beetles	
Geodorcus helmsi	Helm's stag beetle, widespread in forests but currently rare in the region of Murderers Cove. This long lived and large soil wood dwelling beetle is probably reduced in numbers when rats or mice are present.
Mitophyllus parrianus	Parry's stag beetle,larvae bore in wood
Family Oedemeridae -blister beetles/lax beetles	
Thelyphassa lineata	*Striped lax beetle, larvae in rotting wood in forests*
Family Staphylinidae -rove beetles	
Creophilus oculatus	Devil's coachhorse, a common carrion feeding rove beetle. These beetles are a more obvious part of a fauna that make good use of the few birds that die on land.
Family Tenebrionidae -darkling beetles	
Pseudhelops capitalis	Big South Cape Island (no other data),,-.ii.69,Townsend, JI,at night
	Big South Cape Island (no other data),,16.ii.69,McBurney, J,on Dracophyllum longifolium
Zeadelium australe	Big South Cape Island, Puwai Bay,10-30,21.viii.64,Johns, PM,coastal Olearia, at night

Taxon	**Comments**
Hempitera –Cicada, aphids,	**honey scale and bugs**
Family Cicadidae -cicada	
Kikihia sp. 'murihiku' (Charles Fleming)	Noted in 1968 (J.S. Dugdale)
Kikihia subalpina	Noted in 1968 (J.S. Dugdale)
Moths -Lepidoptera	
Family Batrachedridae -micro moths	
Batrachedra arenosella	found at Murderers Cove and 80 m asl.
Family Geometridae -looper caterpillar moths	
Chalastra pellurgata	A fern looper, Larvae eat tree ferns
Chloroclystis filata	Australian plug, an Australian species
Chloroclystis inductata	Flower plug, larvae polyphagous on flowers
Declana leptomera	Spotted manuka moth, larvae eat vareous shrubs
Epicyme rubropunctaria	Heath looper, Inhabits heaths
Homodotis falcata	Larvae eat litter
Ischalis fortunata	Zigzag fern looper, larvae eat *Polysticum* sheild ferns
Pasiphila charybdis	Larvae eat coastal hebe *Hebe elliptica*
Phrissogonus testulata	
Pseudocoremia rudisata	Tree daisy looper, larvae feed on *Olearia* spp. (*Olearia colensoi*)
Pseudocoremia suavis	Common forest looper, larvae polyphageous, found 180 metres in podocarp-hardwood forest
Xyridacma alectoraria	Fivefinger looper, larvae eat *Pseudopanax* five finger
Xyridacma veronicae	Large hebe looper, Larvae on *hebe* spp.
Family Hepialidae -ghost moths	
Aoriaia insularis	Rakiura ghost moth, only known from Whenua Hou and Taukihepa/Big South Cape. Taukihepa is the Type Locality. Females not known but almost certainly flightless. This may have increased in abundance with rat removal.
Family Noctuidae -owlet moths	
Agrotis ipsilon aneituma	Greasy cutworm, common travelling from Australia and also established NZ
Aletia longstaffi	Larvae eat Inaka *Dracophyllum* spp. and herbs
Anomis sp. *(?flava)*	vagrant from Australia. Southern most record for New Zealand
Graphania mutans	Common garden owlet, polyphageous
Graphania plena	Green carpet owlet, polyphageous
Graphania sp.	un-named from Rakiura region -Solander only other known locality. (Det. B Patrick)
Meterana ochthistis	An owlet
Meterana stipata	Mottled brown owlet, larvae eat Pohuehue *Muehlenbeckia australis*
Tmetolophota purdi	Orange astelia wainscot, larvae eat *Astelia fragrans*
Family Oecophoridae -litter moths	
Gymnobathra tholodella	Larvae inhabit litter, found at Murderers Cove and 140 metres asl.
Phaeosaces aptocrypta(?)	
Tingena sp. (?*undescribed*)	
Trachypepla anastrella	
Family Plutellidae -cabbage moths	
Plutella xylostella	Diamondback moth, larvae eat cruciferae
Family Psychidae -bagmoths	
Rathamictis sp. (southern South Is.)	A small bag moth, inhabits sooty mould -tree trunks

Taxon	**Comments**
Family Pyralidae -snout moths	
Diplopseustis perieresalis	
Eudonia feredayi	Inhabits open areas of short vegetation, found Murderers Cove and 220 metres asl.
Eudonia leptalea	Inhabits open areas
Eudonia octophora	Inhabits wetland with rushes
Eudonia philerga	Inhabits rocky areas
Spoladea recurvalis	vagrant from Australia, beet webworm
Musotima nitidalis	Golden brown fern moth, common Aust. & NZ, larvae eat ferns
Scoparia autumna	
Scoparia minusculalis	Larvae eat understorey mosses
Family Tineidae cloths moths	
Monopis ethelella	sheeps wool moth, larvae eat fir or feathers
Proterodesma byrsopola	found at Murderers Cove and 140 m asl.
Sagephora phortegella	
Tinea atmogramma	
Family Tortricidae leafrollers	
Apoctena persecta (Meyrick)	Larvae eat *Coprosma foetidissima, Recorded by J.S Dugdale 1968*
Catamacta gavisana	Larvae polypgeous eat *Myrsine australis* and other understorey trees/shrubs
Ctenopseustis filicis	Larvae eat tree ferns. The rusty brown colour is characteristic
Ctenopseustis herana	Larvae polyphageous on most trees/shrubs and ferns like Blechnum 'black spot' (sensu Hugh Wilson); another South & Stewart Island endemic. The larva ties leaves into a crumpled mess, in which it lives
Cydia succedana	Gorse pod moth, an introduced biocontrol agent. This species is highly dispersible.
Ericodesma melanosperma	Larvae eat *Dracophyllum longifolium* Recorded by J.S Dugdale 1968
Eurythecta siriana	
Planotortrix octo	Larvae polyphageous on broadleaved trees e.g., *Coprosma lucida, Metrosideros, Griselinia.* The caterpillar ties the leaves flat together like a sandwich, in which it lives.
Planotortrix puffini	larvae eat *Brachyglottis reinoldii*, *Olearia oporina, O. colensoi var grandis, O. angustifolia and Celmisia lindsayi at Nuggets. Recorded by J.S Dugdale 1968*
Pyrgotis sp. *plagiatana s.l.*	Painted wedge, polyphageous on shrubs and likely on *Hebe elliptica,* note from J. S. Dugdale: This is like the Open Bay Is WD entity, which in turn is like the Auckland & Campbell population Salmon & Bradley called *Epagoge parallela.* It was synonymised with *plagiatana* (Dugdale 1971:1 66, Auckland Is Lepidoptera)
Roaches -Blattodea	
Family Blattellidae	
Parellipsidion pachycercum	A native roach, Puwai Bay,10-30,24.viii.64,Johns, PM,logs,,
	Puwai Bay,10-30,-.-.65,Bell, BD,,,
	Puwai Bay,10-30,22.viii.64,Johns, PM,treetrunks, Olearia, night,,
	Puwai Bay,10-30,30.viii.64,Johns, PM,rocks, supralittoral, night,,
Flies -Diptera	
Family Coelopidae -seaweed flies	
Chaetocoelopa littoralis	Hairy kelp fly

Taxon	**Comments**
Family Tipulidae -craneflies	
Tipulidae,Limnophilella serotina	A long legged cranefly species, Big South Cape Island, North Peak,222,10.ii.69,Eyles, AC,sweep moor,,
	Big South Cape Island, North Peak,222,11.ii.69,Eyles, AC,,,
Tipulidae,Molophilus jenseni	A long legged cranefly species, Big South Cape Is, Murderers Cove,,26.viii.64,Johns, PM,ferns, etc,,
Weta & grasshoppers -Orthoptera	
Family Anostostomatidae -weta	
Hemiandrus zzsaxatilis n. sp. (Peter Johns)	A southern ground weta species, Likely to have decreased in abundance in the presence of ship rats. Not found during 2008 visit. Big South Cape Island (no other data),,12.xi.68,Watt, JC,under logs,,
Hemiandrus zzsaxatilis n. sp. (Peter Johns)	Big South Cape Island, North Peak,222,10.ii.69,Eyles, AC,under tussock,,
Hemiandrus zzsaxatilis n. sp. (Peter Johns)	Big South Cape Island, northeast end,,13.ix.68,Dugdale, JS,at night,,
Hemiandrus zzsaxatilis n. sp. (Peter Johns)	Big South Cape Island, northeast end,,9-14.ii.69,Townsend, JI; McBurney, AJ,at night,,
Hemiandrus zzsaxatilis n. sp. (Peter Johns)	Big South Cape Island, Patupahe Bay,,16.ii.69,Townsend, JI,ex Poa clump,,
Hemiandrus zzsaxatilis n. sp. (Peter Johns)	Big South Cape Island, Puwai Bay,10-30,22.viii.64,Johns, PM,coastal Olearia, at night,,
Family Raphidophoridae -cave weta	
Species 1.	An orange cave weta species common at night in forest (2008)
Species 2.	A dark grey cave weta species in forest (2008)
Centipedes -Chilopoda Geophilomorpha	
Family Chilenophilidae	
Tasmanophilus spenceri	A native centipede, Murderers Cove,,26.viii.64,Johns, PM,logs,,
Tasmanophilus spenceri	Puwai Bay,10-30,21.viii.64,Johns, PM; Bell BD,logs,2 tubes,

Appendix J: Nevins et al. 2009

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Forum

International and cross-cultural management in conservation of migratory species

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We live in an age defined by global access to information. This has rapidly increased the scale of our ecological and social awareness (e.g., fair trade movement) and helped us to identify ecological problems and conservation solutions beyond the typical scale of traditional knowledge (i.e., the foraging range of a human group) or political jurisdictions (i.e., state or national boundaries). For the first time, we can comprehend and accumulate biological knowledge for species on the scale of ocean basins (Prince et al. 1992; Burger & Shaffer 2008). Coincident with this knowledge has been the awareness of the global human footprint and some of its consequences, such as, resource over-exploitation, habitat degradation, and species extinctions. Presently, however, we have a mis-match between the scales at which management frameworks operate (local, regional, national) and the scales at which ecosystems or their components exist (Crowder et al. 2006). Significant conservation actions must be made at appropriate scales (ocean basin, continental) for migratory species, particularly when these resources (e.g., blue fin tuna) are subject to extraction by entities with a variety of national and international allegiances (Block et al. 1995).

Geopolitical boundaries arbitrarily delineate sub-populations and hinder effective management and understanding of these species. This is particularly true for far-ranging or migratory species, where foraging, moulting, or nesting ranges can be widely dispersed. Knowledge about habitat connectivity among neotropical migratory songbirds and butterflies that breed in nearctic (North America) and winter in the neotropics (Central and South America) has led to the recognition of flyways or migratory corridors and the development of international conservation consortiums. In 1990, the "Partners in Flight/Compañeros en Vuelo/Partenaires d'Envo", an international conservation programme, was formed in response to growing knowledge of wintering area habitat loss and concerns about population declines. Such international programmes can address conservation issues at the appropriate (and in some cases, global) ecological scale and can be used as models for species not covered by such conservation initiatives.

The *Kia Mau te Tītī mo Ake Tōnu Atu* (Keep the Tītī Forever) project exemplifies a cross-cultural collaboration of scientists and Māori community members to inform co-management of an important seabird resource (Moller et al. 2009a,b). Building upon this established partnership, we initiated the Rakiura Tītī Islands Restoration Project, an international collaboration between a United States non-profit conservation organisation, University of Otago scientists, and Rakiura Māori, with support from New Zealand conservation managers. Our shared resource, taonga tītī (the treasured sooty shearwater, *Puffinus griseus*), brought us together and

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facilitated an effective international partnership with the common goal of restoring damages to the New Zealand sooty shearwater population suffered as a result of the *T/V Command* oil spill off central California, United States in 1998 (Anon. 2004).

Pan-Pacific shearwaters face anthropogenic threats throughout their migratory range both on land (e.g., habitat disturbance, invasive species predation, over-harvesting) and at sea (e.g. oil spills, fishery bycatch, marine pollution, climate change; Croxall et al. 1984). Based on this knowledge, the New Zealand and United States scientists, with *iwi* (tribal) support, proposed to the Command Oil Spill Trustee Council the removal of invasive predators (rats and weka) on nesting islands in the Southern Hemisphere. This was determined to be the best action to restore the equivalent shearwater losses from the oil spill, ensure multi-species benefits to important island ecosystems, and provide the greatest long-term conservation success.

Setting an empowering new precedent, the Command Oil Spill Trustee Council approved this international restoration project in 2003. This decision faced intense scrutiny and public criticism for allocating funds to be spent outside of the United States, where the perceived damages had occurred; however, despite strong opposition, the science-based assessment of threats to the population remained valid and the request for international stakeholder involvement was justified.

Throughout this experience of getting the project approved we found the greatest hurdle to conservation solutions for this migratory species was expanding the scale of the bureaucratic framework to seek and include indigenous stakeholders. And yet, without *iwi* participation, this conservation action would not have been possible. Coordinated knowledge or establishment of a "community of learning" (Robson et al. 2009 this issue) and the regular inclusion of indigenous and non-indigenous peoples who benefit from shared resources will be required to make shared conservation gains in the future (Allen et al. 2009 this issue). In the marine biome, this problem is magnified as resource management and extraction are overseen by fishery management councils (which are industry-based) and international commissions and national treaty boards, such as the North American Free Trade Agreement or NAFTA (politically-based). It is rare to see inclusion of indigenous or scientific stakeholders.

Recent efforts to include a broader international approach to migratory marine species conservation has been planned and implemented through the Commission for Environmental Cooperation (CEC) supported in large part by NAFTA. Identified marine icons—the migratory leatherback sea turtles (*Dermochelys coriacea*) and pink-footed shearwaters (*Puffinus creatopus*)—illustrate the problem with defining even the scope of conservation and management action based on geo-political boundaries rather than ecologically meaningful boundaries. For example, these turtles are limited to nesting on islands in Papua New Guinea while the shearwaters are restricted to several small islands in Chile—both countries which are; (1) not part of the NAFTA tri-national group (United States, Canada, Mexico), (2) arguably the only places where significant conservation actions maybe accomplished, and (3) home to indigenous peoples who have a significant stake in conservation outcomes and resource use but have not been included (but see Anon. 2007).

We need to increase the scale of these "communities of learning" to include all stakeholders in future conservation work. At the same time we can not underestimate the strength and value of indigenous knowledge streams which involve time scales not often encompassed in modern Western science (Wehi et al. 2009 this issue). For example, Lyver et al. (1999) provided an example of how Māori sooty shearwater chick harvest records were used to develop powerful predictors of future oceanographic change. Further, interviews with local inhabitants on Bougainville Island suggest that leatherback turtle numbers had declined within the last 30–50 years (Kinch et al. 2009). Temporal scales of understanding can be greatly increased with the inclusion of traditional knowledge in our assessment of conservation issues and solutions.

In this new age of information, we must look to global co-management approaches to match the ecological scales of conservation issues we aim to solve. Because we desire to sustain natural resources which ultimately will sustain us, our *tamariki* (children), and our *mokopuna* (grandchildren), we will benefit by incorporating new approaches and more complete international and cross-cultural partnerships to understand and conserve our natural world.

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Appendix K: McClelland et al. 2011

The Rakiura Tītī Islands Restoration Project: community action to eradicate *Rattus rattus* and *Rattus exulans* for ecological restoration and cultural wellbeing

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Abstract In 2003, a non-profit group, Ka Mate Nga Kiore, was set up to oversee the restoration of four Māori-owned islands off the south coast of Stewart Island, New Zealand. The first step in the restoration was to eradicate ship rats (*Rattus rattus)* from three islands and Pacific rats (*R. exulans)* from another. The eradication was funded by the *Command Oil Spill Trustee Council* which managed the mitigation money from an oil spill off the Californian coast in 1998. The funding was coordinated via *Oikonos Ecosystem Knowledge*, a non-profit USA group primarily involved in seabird research and restoration. The project was primarily to benefit sooty shearwater (*Puffinus griseus*) and to sustain a culturally important customary harvest of their chicks by Rakiura Māori. However, like all island eradications, a wide range of other species also benefited from the removal of rats. The New Zealand Department of Conservation provided technical advice and assistance for the planning and implementation of the eradication programme. This paper describes how, with appropriate funding, community and technical support, rodent eradications can be achieved on private islands. In this case, a range of institutions and individuals joined to achieve a common goal that highlighted a significant international conservation action. We urge that more international and local-community-led restoration projects be initiated in the future.

Keywords: Ship rats, kiore, sooty shearwater restoration, muttonbirding, *Puffinus griseus,* international and local community collaboration

INTRODUCTION

Approximately 21 million sooty shearwater (*Puffinus griseus*) form breeding colonies in New Zealand (Newman *et al.* 2009), mostly (53%) on the 35 'Tītī Islands ('Muttonbird Islands) around Rakiura (Stewart Island) in southern New Zealand (Fig. 1). The indigenous people of southern New Zealand are Rakiura Māori, who own these islands and have a legal right to harvest the near-fledgling chicks, which they call 'tītī' or 'muttonbirds'. Tītī harvesting is a fundamental part of being Rakiura Māori (Moller *et al.* 2009), an important source of income (Wilson 1979), spiritual inspiration (Lyver and Moller 2010) for the birding families, and a nationally important example of *kaitiakitanga* (Māori conservation management) and environmental co-management in action (Moller *et al.* 2000; Stevens 2006). Sustaining the abundance of sooty shearwaters is therefore a fundamentally important goal of the Rakiura Māori community.

On 26 September 1998, the tanker vessel "*Command*" released approximately 3000 gallons (11,356 litres) of oil off the California coast (Anon. 2004). Thousands of seabirds were killed by the spill, including between 2 and 32 thousand (median estimate 15,500) sooty shearwaters (Moller *et al.* 2003). One of eleven sooty shearwaters recovered on beaches during the spill had been banded by an Otago University research team on Whenua Hou/ Codfish Island off the north west coast of Rakiura (Stewart Island). This individual provided the required nexus to allow for mitigation funds to recover damaged natural resources under a consent decree signed by the guilty party and the US multi agency Command Spill Trustee Council. The banding programme was part of *Kia Mau Te Tītī Mo Ake Tōnu Atu* / "Keep the Tītī forever", a 14-year study into the productivity of the species and the sustainability of the muttonbird harvest (Moller 1996; Moller *et al.* 2009).

Oikonos Ecosystem Knowledge, an American non-profit research group, recognised this event as an unprecedented opportunity for *Command* mitigation funds to repair the oil spill injury to sooty shearwater populations in New Zealand. The eradication of introduced predators on New Zealand islands containing colonies of sooty shearwaters was considered the most effective way to repair the oil spill injury and also provide substantial additional multi-species benefits.

This paper describes how the funds from the oil spill, with community and technical support, enabled rodent eradications to be achieved on private islands. We also outline how institutions and individuals collaborated to achieve a significant international conservation action.

STUDY SITES

Four islands were chosen as a priority for rodent eradication, based on their importance for birding (the taking of muttonbirds)(Newman *et al.* 2008, 2009), historical significance, conservation potential, and the feasibility and cost effectiveness for predator eradication. These were Taukihepa / Big south Cape (939 ha), Rerewhakaupoko/ Solomon (30 ha), Pukeweka (3 ha), and Mokonui / Big Moggy (86 ha) (Fig. 1).

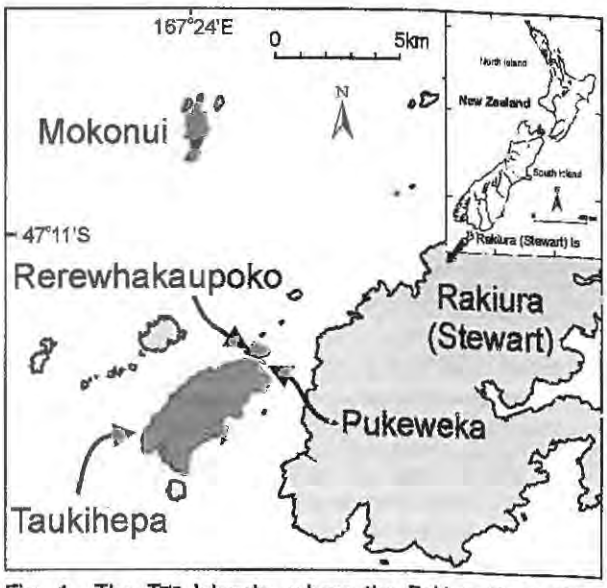

Fig. 1 The Tītī Islands, where the Rakiura Restoration Project research and rat eradication took place in 2006.

Pages 451-454 In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). 2011. Island invasives: eradication and management. IUCN, Gland, Switzerland.

The Taukihepa group (Taukihepa, Pukeweka and Rerewhakaupoko) had been historically recognised as one of New Zealand's ecological jewels as the last refuge for several species of birds and the greater short-tailed bat (*Mystacina robusta*) before ship rats (*Rattus rattus*) invaded the group in 1963. The rats caused extinction of Stead's bush wren (*Xenicus longipes variabilis*) and Stewart Island snipe (*Coenocorypha aucklandica iredalei*), and perhaps also the greater short-tailed bat, and potentially the local extinction of an unknown number of species of birds, lizards, and invertebrates (Bell 1978; Ramsay 1978). It is particularly poignant that the Rakiura Restoration Project targeted rats on the Taukihepa group because it was the 1964 rat irruption and ensuing ecological disaster - more than any other event in New Zealand - that triggered widespread realisation of the ecological impacts of introduced rodents and the need for their eradication from islands (Dingwall et al. 1978).These three islands were effectively treated as one landmass during the eradication because the rat populations can easily swim between them.

The eradication of Pacific rats (kiore: *Rattus exulans*) from Mokonui, which is approximately 5 km to the west of Taukihepa, was included in the project during the early stages of planning at the request of its beneficial owners. This extension imposed only a minimal increase in planning and implementation costs, yet promised significant ecological gains because of its relatively large size.

THE PROJECT

Funding

The bid to eradicate rats from the Tītī Islands was prepared by scientists assisting the joint Oikonos-Rakiura Tītī Islands Administering Body (Moller *et al.* 2003). This successful bid to the *Command* Trustee Council provided US$513,000 for restoration including: rat eradication (70% of expenditure); scientific monitoring of outcomes (10%); reporting and administration (10%); educational video about the project (5%); and initiating community-level quarantine programmes after the rats were removed (4%).

Community Involvement

The Tītī Islands are managed under two different management committees, membership of which is based upon the history of each island. Once eradication funding had been secured, in order to facilitate the two committees working together, and effectively to provide a sub-committee which could focus on the eradication, a NZ non-profit incorporated society was formed. This group could act on behalf of the islands' owners, communicate independently with Oikonos and the Command Trustee Council, and feed back to the committees as required. The community called this group *Kā Mate Ngā Kiore* (KMNK), which loosely translated means "death to the rats". KMNK's main tasks were to: 1) link the various parties involved in the planning and operational aspects of the project with the thousands of owners of the islands; 2) keep all parties informed of progress; and 3) get a consensus on approvals from the owners for relevant actions when required. KMNK also coordinated the involvement of birders in the operational aspects of the project, which were guided by New Zealand's Department of Conservation (DOC).

Understandably, some of the American public opposed the transfer of reparation funds to New Zealand. However, the Tītī project was seen by the Trustee Council as an important part of mitigating the impact of the oil spill. The *Command Trustee Council* had confidence to support investment outside the USA because: 1) a comprehensive ecological research programme had already developed methods and collected some of pre-eradication baseline data, which built confidence in adequate documentation of repair to the oil spill injury; and 2) a research team (*Kia Mau Te Tītī Mo Ake Tōnu Atu*) had population parameter estimates on hand to demonstrate the size of the injury to sooty shearwaters and to simulate prospects for recovery.

Accountability and security of funding streams was paramount. One of KMNK's roles was to financially manage the project within New Zealand, contracting in assistance as required and ensuring that the required reporting was completed. *Oikonos* was actively involved in project management and became the liaison between USA and New Zealand entities. Effectively, a trusted local US agent oversaw funding, while the KMNK performed a similar and crucial role in New Zealand for operations and community involvement.

Planning the eradication

Planning for the eradication started in 2003 when KMNK obtained the final mandate from the islands' owners to make any decisions required to carry out the eradication. This was crucial as it was impractical to go back to all the owners every time a decision was required. In 2004, a Memorandum of Understanding (MOU) was drawn up between DOC and KMNK so that the roles and responsibilities of the two groups concerning preparation for the eradication were clearly defined (DOC 2004). The MOU recognised DOC's international expertise in rodent eradications. Technically, the eradication was considered by DOC to be relatively straightforward. However, the large number of owners of the islands, and the fact that the islands are inhabited for up to two and a half months a year, added novel complications. The trust and guidance of KMNK therefore became fundamentally important for the success of this project. KMNK also ensured that all cultural and spiritual concerns were considered. These included: 1) a blessing ceremony prior to the eradication to keep the operators safe and ask for overall success of the venture; and 2) ensuring that ancestral guardians of the islands understood the need to break a traditional *rāhui* (prohibition) that normally bans all muttonbirders from visiting the islands except during the late fledging stage. The *rāhui* protects habitat and minimises disturbance to the adults' breeding attempts (Moller and Lyver 2010).

The eradication was originally planned for the winter of 2005. However, planning and financial hold-ups delayed the operation for a year. KMNK and the *Command Trustees* agreed that it was important to not rush the eradication operation. In 2006, a contract for service was signed by DOC and KMNK for the bait drop (DOC 2006a). This replaced the MOU and detailed the roles of the two parties for the eradication itself. We believe that clear MOUs between community representatives and government agencies or researchers are essential to allow co-ordination of diverse contributions, all of which are needed for the success of the overall endeavour. In general, investment of time and resources to allow extensive communication between stakeholders slows the process down, but the multi-stakeholder buy-in to the overall goal is thereby more solid and lasting. Local knowledge of the community was also essential for putting the eradication plan into action. DOC prepared the applications for all the legal consents required, although they were applied for and issued to KMNK. This simplified the consultation process because KMNK had direct contacts with most of the affected parties and were in a better position to convince them of the benefits of the project, whereas DOC had the legal and technical experience required to obtain the consents for the release of poison bait into the environment. A significant concern for New Zealand public opposition to aerial poison baiting was addressed by having DOC manage the overall consents process.

Operational work

A detailed operational plan was developed by DOC in consultation with KMNK to ensure that all details were covered and everybody knew their roles when bait was being spread (DOC 2006b). The bait was 10 mm diameter cereal bait pellets (Pestoff 20R) containing 20 ppm brodifacoum in 25 kg bags loaded into 1.2 m^3 plywood "pods" used previously on Campbell Island (McClelland 2011). The pods were loaded on to a local charter vessel and transported to Taukihepa where they were unloaded by helicopter and placed in covered rows at a sheltered site. To ensure that pods remained water tight, their condition was monitored by an experienced contractor who was accompanied by muttonbirders from the island. The pods were flown to a preselected open location near the top of the island on the day of the bait drop. The bait loading team consisted of DOC staff, experienced contractors and volunteer local birders, with a dedicated site manager to oversee loading and safety.

The eradication followed the standard procedures developed in New Zealand over the proceeding 20 years: two aerial drops of 8 kg ha^{-1} and then 4 kg ha^{-1} (e.g., Broome 2009). Helicopters carrying underslung spreader buckets spread bait in an 80 m wide swath. Overlapping dispersal (50% for the first drop and 25% for the second) minimised the chances of gaps and two additional swaths were spread around the coast as this is recognised as a habitat typically with increased densities of rats (Taylor and Thomas 1989).

Ground baiting

More than 100 buildings are distributed around the islands, primarily near the coast. These include sleeping quarters, workhouses, and storage sheds used during the muttonbirding season. Bait was spread by helicopter over each entire island, including over buildings. However, buildings could still have provided refuges for the rats where they could obtain shelter and food and not be exposed to the bait. KMNK coordinated approximately 40 volunteer birders to go to the island on the day of the first drop and place bait in aluminium dishes in cavities within all buildings. This was a major undertaking and could not have been coordinated without local knowledge and approvals for entry into the buildings.

All water collection systems on the buildings had been disconnected during the previous birding season. After sufficient rain had fallen to clear any bait off roofs, KMNK then arranged for a team of birders to return to the island in November to reconnect the water systems so that tanks were replenished with drinking water by the time the community returned next March for the 2007 birding season.

Public outreach

As the project was recognised as being nationally significant, KMNK worked with the media, papers and television, to get coverage whenever possible. A video, recording the whole project, was produced by South Coast Productions and KMNK to highlight the cultural significance of the project as well as its technical aspects (Asher 2007). Oikonos provided updated information via The Rakiura Tītī Restoration Project webpage (http://www.oikonos.org/projects/titi.htm).

Outcome monitoring

Informal post-eradication rat monitoring was carried out by the birders, who are active around the island during both day and night for up to 75 days of the year while harvesting the muttonbirds (McKechnie *et al.* 2010). The many buildings should also have acted as attractants for any remaining rats hence, aiding in their detection. Although the monitoring was extensive, it was not formalised, there was no training, and no attempt was made to record where people had been, so there could potentially have been gaps in the coverage. We therefore waited for three years (three muttonbirding seasons) without rat sign before declaring the operation a success in June 2009. There was still no sign of rats during the March–May 2010 birding season.

The funding agency required any repair to the impacted population to be quantified. Monitoring plots were established so that a 'Before-After-Control-Impact' design (Stewart-Oaten *et al.* 1986) can eventually be used to assess to what extent rat eradication triggers increased sooty shearwater abundance. However, the median age at first breeding of sooty shearwaters is approximately 7.8 years (Fletcher *et al.* subm.), so it will be at least 2014 before initial effects of the eradication on recruitment can be detected.

Monitoring of other species has been opportunistic. The removal of the rats has allowed the recovery of terrestrial bird species including Stewart Island robin (*Petroica australis rakiura*) and fernbirds (*Bowdleria punctata*), which naturally re-established from neighbouring predator free islands. However the ongoing presence of weka (*Galliralus australis*), a large predatory rail that was introduced to the island in the early 1900s as a food source, has hindered recovery of smaller ground nesting birds, burrowing seabirds, lizards, and larger invertebrates. KMNK would like to remove weka from the islands, but currently lack the resources to do so.

Biosecurity programmes

Ongoing ecosystem and threatened species recovery depends on heightened biosecurity now the eradication is complete. Each March and April, a wide variety of vessels transfer large quantities of food-stuffs and equipment to the islands. No formal quarantine programmes existed before the eradication project. The *Command Trustee Council* and KMNK team were anxious to lock-in the benefits of the rat eradication by minimising the chances of rats re-invading by accidental transport to the islands.

New quarantine measures are focused primarily at pre-departure points and in transit because catching rodents once they reach the islands is considered unlikely. Measures include producing and disseminating posters, calendars, and other 'promotional' material all emphasising the importance of quarantine: giving presentations at 'permit' days (important pre-season administrative meetings for muttonbirders); a short film about the eradication itself, including the importance of quarantine has been produced by KMNK.

DISCUSSION

This project involved a diverse range of organisations and groups, which shows that adequate funding and the right technical advice enables private groups to carry out eradications on their own land. Direct involvement and community "ownership" of environmental management is seen as key in building 'environmentality' (Agrawal 2005) and commitment to 'Adaptive Co-management' (Berkes and Turner 2006) for long-term restoration and sustainable use of wildlife (Stephenson and Moller 2009).

The project could not have been carried out by any one of these groups without assistance from the others. *Oikonos* initiated the project and had the required understanding of the American mitigation process to convince the *Command Trustee Council* that the project was worth funding; Otago University had banded the bird that proved the vital link to the funding in the first place and had the ability to carry out the research required by the funders; DOC had the required expertise to plan and carry out the eradication; KMNK drove the whole project and co-ordinated the community

of island owners. KMNK were given DOC's Conservation award in 2007 for the effective manner in which they performed this crucial role to make the project a success.

KMNK are now working with DOC to reintroduce some species of birds which were previously present on the islands. Tīeke / South Island saddlebacks (*Philesturnus carunculatus carunculatus*) will be reintroduced to Taukihepa in March 2010. The return of this sub species is especially significant as they were saved from extinction after rats invaded Taukihepa by the transfer of 36 individuals to two nearby islands (Atkinson and Bell 1973; Bell 1978). Having charismatic and culturally important species such as tīeke on the island for the first time in over a generation, should emphasise to the birders the ecological impact the rats had and encourage the owners to maintain the quarantine standards required to keep rodents off the islands.

CONCLUSIONS

The eradication of rats from the Taukihepa group is a locally and internationally significant conservation event, brought to completion by private landowners, a NZ government department, a university and a US-based international non-profit working together. Participation in the restoration project, and the goal to get rid of the rats, has been enormously appreciated by the muttonbirding community. The project is also the first time that mitigation money from an oil spill off the American coast has been spent away from the USA. This sets an important precedent in recognising that negative environmental events, such as oil spills, in one part of the world can have significant impacts on another nation many thousands of kilometres away. Agencies and countries need to work together to get the best possible results for the available money and recognise that the movements of seabirds across political boundaries and jurisdictions are ultimately irrelevant from an ecological point of view (MacLeod *et al.* 2008; Nevins *et al.* 2009).

ACKNOWLEDGEMENTS

We would like to thank the *Command* Trustee Council *and* Oikonos, and the muttonbirders of the Tītī Islands, particularly the birders of Taukihepa, Pukeweka, Rerewhakaupoko and Mokonui. Without them this project would not have been possible. SouthCoast Productions contributed significant support into documenting this environmental conservation success story for future generations of conservationists.

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Appendix L-1: Hester et al. 2004, International Albatross and Petrel Conference- Abstract

2004 International Albatross and Petrels Conference, Montevideo, Uruguay

Oral Presentation, Conservation Policies and International Initiatives

Rakiura tïtï restoration: mitigation of injury from an oil spill in U.S. waters by eradication of rats from *Puffinus griseus* breeding colonies in New Zealand

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[3] Ka Mate Nga Kiore, New Zealand
[4] University of Otago, Zoology Department, Dunedin, New Zealand

We present an encouraging example of international and cross-cultural collaboration to mitigate the effects of an oil spill on a trans-equatorial migratory procellarid, *Puffinus griseus* (Sooty Shearwater, Tïtï). In the United States, several laws (The Clean Water Act, CERCLA and OPA) have created federal and state departments that exist to support mitigation of marine species injured by oil spills in U.S. waters. Migratory seabirds are often injured in greatest proportions by coastal oil spills. U.S. trustee agencies and the legal documents that guide the use of mitigation monies have recently begun to recognize the importance of restoration efforts outside the spill area for injured migratory species. Participation of international trustees (i.e. bird harvesters, non-U.S. resource agencies) and seabird biologists throughout the process (injury assessment, legal activities, restoration project planning) is needed to wisely target mitigation efforts and funding. We discuss the Rakiura Tïtï Restoration Project that seeks to repair injury to Sooty Shearwaters caused by the T/V *Command* oil spill in 1998 off the central coast of California by eradication of introduced rats from breeding colonies on four southern islands of New Zealand.

Appendix L-2: Nevins et al. 2006, Society for Conservation Biology - Abstract

Appendix: Society for Conservation Biology – Abstract
20th Annual Meeting, Conservation without Boarders, San Jose, CA 2006

Oral Presentation

Nevins, Hannah, Michelle Hester, Ka Mate Nga Kiore, Henrik Moller, Charlene Andrade, Pete McClelland and Josh Adams

Oikonos Ecosystem Knowledge, P.O. Box 979, Bolinas, CA 94924, USA (HN, MH) michelle@oikonos.org; Ka Mate Nga Kiore Incorporated Society, P.O. Box 47, Te Anau, New Zealand (PH); U.S. Fish and Wildlife Service, 2800 Cottage Way, Sacramento CA (CA); Department of Conservation, Invercargill, NZ (PM); University of Otago, Dunedin, NZ (HM, JA)

The Rakiura TitiRestoration Project: Mitigation of the Command oil spill injury by eradication of rats from Sooty Shearwater breeding colonies in New Zealand

We present an example of international and cross-cultural collaboration to mitigate the effects of an oil spill on a trans-equatorial migratory seabird, the Sooty Shearwater *Puffinus griseus* called *titi* by the Rakiura Maori, indigenous people of southern New Zealand. Migratory seabirds face a multitude of human-related threats when at sea (e.g., marine pollution, fishery bycatch) and at their nesting islands (e.g., habitat disturbance and non-native mammalian predators). In September 1998, an estimated 1,400 to 15,000 shearwaters were killed in coastal Californian waters during their non-breeding migration by oil leaked from the negligent T/V CommandThe Rakiura Titi Restoration Project seeks to repair the oil spill injury by eradicating invasive non-native rats *Rattus* spp. from four breeding islands in NZ: Taukihepa (939 ha), Rerewhakaupoko (86 ha), Mokonui (30 ha), and Pukeweka (3 ha). This restoration project is co-managed by US trustee council and guided by Rakiura Maori who are the *kaitiaki* (environmental guardians) of this *taonga* (treasured) species. Rakiura Maori value titi for their cultural, economic, and spiritual importance. Because titi are ecologically important as a keystone species in the titi island ecosystem, this project is expected to result in multi-species benefits to endemic insects, native birds and plants.

Contact: Hannah Nevins, Oikonos Ecosystem Knowledge, P.O. Box 1103, Aptos, CA 95001 USA, hannah@oikonos.org, 011-831-427-2540

Topic areas: Ecosystem-specific conservation (island conservation); conservation of migratory taxa (seabirds); Non-native invasive species

Appendix M: Newman et al. 2011, World Seabird Conference - Abstract

2010 1st World Seabird Conference, Sept. 7-10, Victoria, Canada

ABSTRACT [poster presentation]

Jamie Newman*, Hannah Nevins, Josh Adams, Michelle Hester, Henrik Moller, Pete McClelland, Penny Hutchins, Robert Coote and Morry Trow

Rakiura Sooty Shearwater Restoration Project: a case study of trans-Pacific conservation for a migratory seabird

In the austral winter of 2006, four islands in southern New Zealand, dominated by large colonies of sooty shearwaters (*Puffinus griseus*), were successfully cleared of introduced rats. Although the eradication itself was comparatively straightforward, the event was of note for the following three reasons. Firstly, the eradication was funded by the *Command Oil Spill Trustee Council* which is an American organisation managing the mitigation funds from a major oil spill off the Californian coast in 1998. This transfer of funding and effort to the other side of the Pacific sets a new precedent, recognising the fact that the conservation ecology of highly migratory seabird species such as these spans geo-polictical borders. Secondly, the islands are privately owned by Raikura Māori and are culturally important because of the customary harvest of sooty shearwater (*Puffinus griseus*) chicks that takes place on them each year. The restoration project is community-led and involves local, governmental, and international stakeholders. Thirdly, the removal of rats from these islands is particularly poignant because they include the Taukihepa / Big South Cape group, which was made internationally famous by the invasions and subsequent eruption of ship rats (*Rattus rattus*) in the 1960's. This tragic event led to the direct extinction of two terrestrial bird species and only last minute rescue efforts saved one more. It was a graphic demonstration of the damage inflicted by introduced predators on naïve flora and fauna. Our paper will describe the eradication process, including the research and monitoring component of the project and report on the ecological responses of the islands to date. This includes preliminary predictions of the increase in sooty shearwaters due to the eradication and the wider ecological significance of restoring seabirds in coastal island ecosystems.

Community Quarantine & Outreach

Appendix N: Rakiura Tïtï Islands Rodent Quarantine Contingency Plan, KMNK, 2005

Rakiura Tïtï Islands Rodent Contingency Plan

Ka Mate Nga Kiore Inc

July 2005

Introduction

This Contingency Plan has been prepared by Ka Mate Nga Kiore Inc and applies to all rodent free Titi islands adjacent to the coast of Stewart Island. It is included as an Appendix to the Rakiura Titi Islands Rodent Quarantine Strategy, also produced by Ka Mate Nga Kiore Inc, and should be read in conjunction with that Strategy.

It is important to stress here that ***contingency action is viewed by Ka Mate Nga Kiore Inc as the last resort: vigilant quarantine precautions are the first and best means of preventing a rodent invasion.*** However, even the best quarantine strategy cannot prevent unforeseen circumstances occurring – a ship wreck for example. This Plan has been prepared with such circumstances in mind, and to satisfy obligations to the Command Trustee Council – a major funder of rodent eradications from several Titi Islands.

Definitions

Contingency Plan – describes actions to be undertaken if a rodent is seen or thought to be present on any rodent-free Titi Island.

Quarantine Strategy – describes actions and procedures to prevent any rodent arriving on any rodent-free Titi Island.

"Prevention is better than cure."

Purpose of this Plan

The purpose of this Contingency Plan is to provide guidance to initiate a prompt first response to any sighting, or suspicion that a rodent has evaded quarantine procedures and is present on any rodent-free Titi Island. Contingency measures prescribed here are intended to be in effect only until the Department of Conservation can initiate action as per its own Island Contingency Plan.

Contingency Plan Actions

- Prepare contingency kits prior to the start of each birding season. Each kit should contain the following:
  - approx 6kg of 'Talon' rat bait (e.g. ½ of a 12.5kg bucket)
  - 25 bait stations and pegs
  - 25 rat snap traps
  - 25 mouse snap traps
  - 25 trap covers and pegs
  - flagging tape (for marking trap and bait station locations)
  - 1 small jar peanut butter & approx 200gm rolled oats (trap bait)
  - plastic bags (for storing any rodent caught)
  - 2 x notebooks & pencils
  - laminated instruction sheets (see below).
- At the start of each birding season position kits at helicopter fuel dump sites. As it is impossible to predict where the kits might be needed, fuel dump sites are considered to be the best locations to store them.
- At the end of each season return all kits to the mainland so they can be checked and replenished as necessary.
- 'Talon' has a shelf life and a fresh batch should be taken down each season. 'Talon' that has been left sitting for a number of years may not be as effective or palatable as it should be if needed. Old 'Talon' not used could be distributed and used around wharves and packing areas as per the Quarantine Strategy.
- Trap bait also has a shelf life and fresh bait should be taken down each season.
- Ensure that as many people as possible know about the purpose and whereabouts of the Contingency Kits by providing information at hui and permit days.

Instructions

(a laminated copy of these instructions should be kept in each Contingency Kit)

This Contingency Kit should contain

- approx 6kg of 'Talon' rat bait (e.g. ½ of a 12.5kg bucket)
- 25 bait stations and pegs
- 25 rat snap traps
- 25 mouse snap traps
- 25 trap covers and pegs
- flagging tape (for marking trap and bait station locations)
- 1 small jar peanut butter & approx 200gm rolled oats (trap bait)
- plastic bags (for storing any rodent caught)
- 2 x notebooks & pencils

If any rodent (rat or mouse) is seen on any rodent free island, or if there is evidence that a rodent might be there (e.g. droppings, chew marks amongst supplies or in huts) then ***it is essential that you do the following immediately***:

1. **Call DOC** – either ask Meri Leask to pass on a message, or call directly. Tell them what has been seen or found, where it was seen/found and who saw/found it.

Contacts are:

Pete McClelland
Programme Manager Outlying Islands
Southern Islands Area
Work phone 03 214 7525
Home phone 03 231 3465

Andy Roberts
Area Manager
Southern Islands Area
Work phone 03 2147512
Home phone 03 217 8960

Duty Officer
Department of Conservation
Phone 03 2144589 (this number may be answered by an after-hours service, who will then connect to the Duty Officer, or by the Receptionist if during office hours)

The Department of Conservation has its own Island Contingency Plan and will respond to any rodent invasion, and has the resources to do so. You may be asked to set up traps and bait stations in the area where the rodent was seen

or thought to be, and to maintain them until DOC has time to put its own Island Contingency Plan into action. This should only take 1-2 days.

2. If setting up traps and bait stations:
   - Set them at 25-50m intervals in the bush, closer around huts and buildings.
   - Use two Talon baits in each poison bait station – this way you know how many baits were put out, and when checking will know immediately if any have been taken.
   - Peg bait stations and trap covers to the ground, and secure traps firmly – especially if weka are present.
   - Mix peanut butter and rolled oats together until you can roll it into smooth balls – not too sticky & not too crumbly. Use this to bait rat and mouse traps.
   - Use the flagging tape to clearly mark trap and bait station locations.
   - Check traps and bait stations daily until told otherwise.
   - If you catch a rodent, note where it was caught and put it in a bag and keep it so that the species can be identified. It will also provide other information such as sex, age, and whether or not it is a breeding animal. This information will help DOC in planning an appropriate response.
   - If Talon bait is disappearing, note which bait stations it is disappearing from.

Appendix O: Quarantine Materials – Brochure

pest-free *titi Islands*

Take extra care when you are –

- packing at home
- travelling by boat
- using helicopters
- unpacking at the islands
- travelling between islands

kia mau te titi mo ake tonu atu

Keep the titi forever

Ka Mate Nga Kiore Inc.

Department of Conservation
Te Papa Atawhai

Command Trustee Council

Oikonos Ecosystem Knowledge

Kia ora all birders!

These are steps you can take to reduce the risk of introducing rodents and other pests to the Titi Islands.

Packing at home

- Pack gear as close to departure as possible.
- Set snap-traps or lay poison baits (e.g. Talon, Storm) around the area you intend to use for packing.
- Pack foodstuffs into clean plastic or wooden containers (e.g. fish bins, plastic barrels with screw-on lids, plywood crates) that can be sealed and are rodent-proof. Use the 'Little Finger' rule. Cardboard boxes, canvas, or other soft material bags are not suitable.
- Once food is packed into a container, seal it immediately and ensure it remains sealed until being opened on the island.
- Take special care when packing food supplies.
- Only take vegetables that have been washed and are free of dirt, insects, snails etc.
- Ensure personal gear and clothing (e.g. socks, pockets, soles of footwear, tents) are free from dirt, seeds etc.
- Inspect gear that may be used infrequently (e.g. tents, packs, old mattresses) for sign of rodents, dirt, invertebrates, etc.

Travelling by boat

- Place poison-bait stations on board for several days prior to departure. Even the cleanest and most well-maintained boat can harbour transient rats and mice.
- Install rodent guards on mooring lines.
- Shut doors at night and inspect decks before departure for evidence of rodents.
- Aim to leave port during daylight hours when rodents and insects are less active.
- Pack building materials and large items (e.g. generators, mattresses) as close to departure as possible. Check for dirt, invertebrates, etc. before transporting.

Photo: DOC

- Plan to travel direct to the island: stop-overs increase the risk of rodents coming aboard.

Using helicopters

- Use clean fadges, free of dirt, seeds or leaf litter.
- Place a few poison baits in fadges and pack just prior to transporting your gear.

Unpacking at the islands

- For extra care, unpack all gear inside with doors and windows closed. Watch for rodents!

Travelling between islands

- Take care when travelling between islands. Follow the guidelines above to ensure that pests are not transported from one island to another.

Early warning signs of pests

Early detection of the arrival of plant and animal pests is important.

Rodents can be detected from signs which include:

- Carcasses or remains of predated species or eggshell
- Anything with obvious 'gnaw' marks, e.g. soap, wax
- Droppings
- Burrowing or digging activity
- Sightings

If you believe a new pest has arrived on a titi Island, the Department of Conservation can help with:

- Identification of the pest species and provide recommendations for the control and/or eradication.

Remember

Keeping the Islands pest free will only work if individuals take responsibility for themselves and their gear. Rats and mice can fit through very small gaps which many people would consider too small to allow their access.

'Little Finger Rule'

If the tip of the little finger up to the end of the fingernail can, even with force, be pushed through a hole in a container, then it is **not** rodent-proof.

For further information contact;

Department of Conservation,
33 Don Street, Invercargill
phone; (03) 214 4589
or
Ka Mate Nga Kiore Inc.
P O Box 743, Invercargill.

Cover photo:
Darren Scott

Published by
Department of
Conservation
P O Box 743
Invercargill
2005

pest-free
Titi Island

Department of Conservation
Te Papa Atawhai

Ka Mate Nga Kiore In
Command Trustee C
Oikonos Ecosystem

Whakapuaka

iata a Io Te Atua
pō, ko te ao, tāna ko Te Ao Mārama, ka heke iho ko
riki ki te whai ao.
nei tātou, ngā whakatupuranga kua waihotia ki muri,
itiaki mō ngā taonga kua mahue ki muri, kei runga i
outere e hora nei i te Moana Tāpokapoka ā Tāwhaki,
Ara a Kewa e marohiroh e Rakiura e!

he realms of night evolved the present world of activity
ht. These goods descended into this world and provided
ands and treasures in the region of rakiura (being the
s of the titi and other taonga). It is us who are the
endants who have the responsibility to protect the
s and the treasures that are spread about Te Moana
xapoka a Tāwhaki and Te Ara a Kewa that lie there
ng under the glowing skies of Rakiura.

Introduction

nanagement of the Titi Islands, and the relationship of
ra Māori to these islands, are the nearest living example
gatiratanga being exercised according to traditional
ms and practices, and as guaranteed by the Treaty
itangi.

iti Islands are a wahi taonga – resources that sustain
and are culturally and historically important to the
ra Māori of Kai Tahu.
ctivities associated with these islands identify the
onal customs and practices that existed prior to
pean contact. (Adapted from *Te Whakatau Kaupapa o Murihiku*)

ate Nga Kiore Inc. (including representatives from the
ra Titi Islands Committee and Administering Body),
ne Department of Conservation recognise the
tance of the Titi Islands being pest free. The eradication
s from several islands has been made possible, in
through funding by the Command Trustee Council and
articipation of Oikonos Ecosystem Knowledge. This
ort is gratefully acknowledged.

rochure is a pro-active, educational tool to help you
tect these islands from the introduction of rodents
ther unwanted plants and animals.

Tieke/saddleback

Puvui/Stilbocarpa

Photos: DOC

Jonnie Pennicott releases Snares Islands snipe on Putauhinu.
16 April 2005
Photo: DOC

Pests include

- Rodents (rats and mice)
- Plants (seeds or propagative material)
- Invertebrates (insects, bugs, snails, slugs, mites, and their eggs and larvae)
- Plant and animal diseases (carried in soil, on vegetables or via pets etc.)
- Fungi (spores, mould etc. growing on most substances, including foodstuffs)
- Pets (dogs, cats, etc.)

It only takes one person to overlook basic precautions and everyone loses. Everybody can gain or everybody can lose.

Kotahi te kakama
One is aware of the surroundings

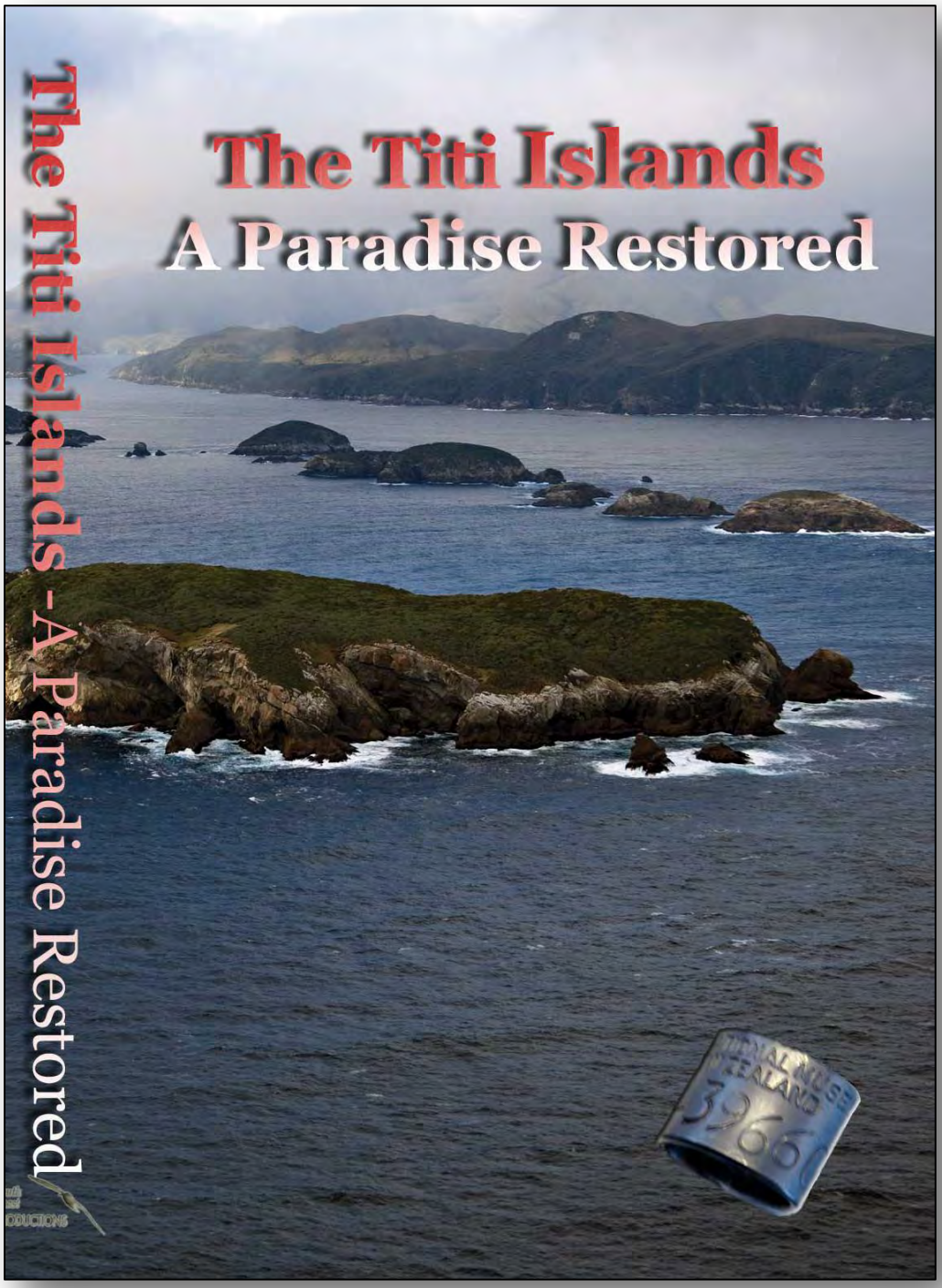
Ka ora te mauri
The surroundings would mature

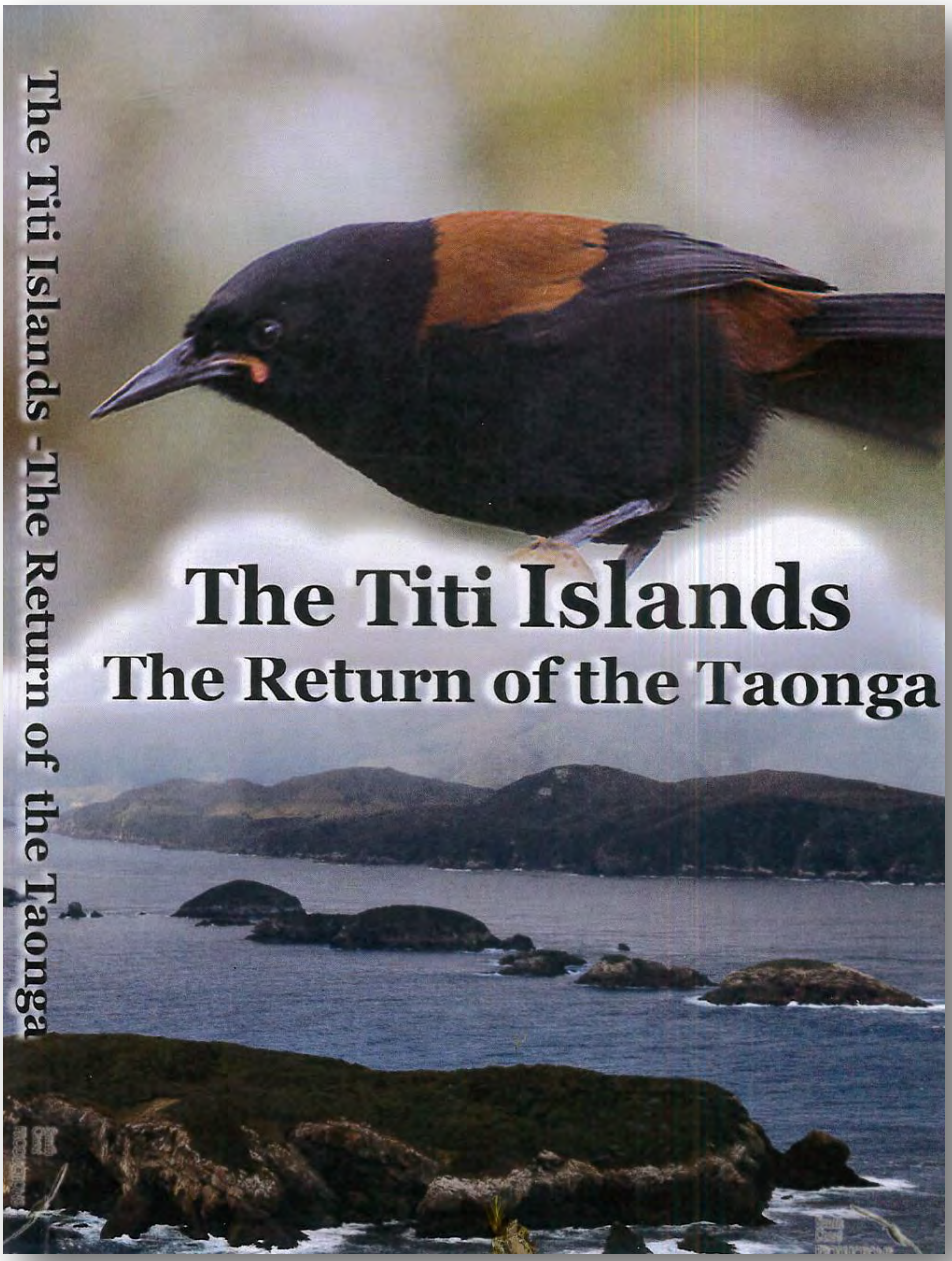
Kotahi te Ngoikore
One who is unaware of the surroundings

Ka mate te mauri
The surroundings will suffer

Appendix P: Documentary DVD Covers, “The Tïtï Islands: Paradise Restored”

Appendix R: Cover of two documentaries created and produced by SouthCoast Productions, Te Anau, NZ to document the success of the Rakiura Titi Islands Project. Free copies were made for educational purposes and additional copies are sold to support ongoing quarantine measures.





The Titi Islands -The Return of the Taonga

Appendix Q: Outreach Materials – Tïtï Times article, 2006

Tītī times

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KIA MAU TE TĪTĪ MO AKE TŌNU ATU

number 13 May 2004

in this issue

Karaka of the hakawai

Feature creature page 12

Tītī whakapapa

Research pages 8–9

Flying with a legend

Bill Black profile pages 10–11

Rat eradication ready to roll

This issue of the *Tītī Times* is infested with rats.

Don't worry, we haven't gone mad about the little critters, but with the proposed eradication of Taukihepa, Rerewhakaupoko, Pukeweka and Mokinui looking increasingly likely (see page 14) we thought it would be a good opportunity to cover some of the history of the tītī islands rat invasion as well as bringing you up to date on the latest developments and plans to get rid of them.

In this issue you can read:

- An interview with Norman York, including his memories of when rats first appeared on Taukihepa in the early 1960s and how hard everyone tried to get rid of them. Page 6–7
- A 1965 letter to birders from the 'Big South Cape Birders Rat Control Committee' to battle the rat invasion. Page 16
- Jane Davis describe the removal of kiore from Putauhinu and how much better the island is now the rats have gone. Page 4–5
- A report on the rat eradication hui held at Murihiku marae in October this year. Page 14

Plus lots more of our usual mix of news and views relating to tītī and birding.

Lets kill the rats!

Funding almost secure – keep your fingers crossed!

In the last Issue (*Tītī Times* 12) we reported on an oil spill by the T.V. *Command* off the California coast in 1998 that killed many seabirds, including tītī from New Zealand. The US government caught and prosecuted the guilty company and set up a fund for environmental restoration. Two helpful American researchers and, the Tītī Research Team applied on behalf of Rakiura Māori for restoration funds to help repair the damage to tītī caused by this spill by eradicating rats from more tītī islands.

The 'Rakiura Tītī Restoration Project' bid got over its first hurdle last year – it was one of a handful of over thirty applications to be short–listed for potential funding. It is very important to note that although this funding is certain, we can't yet say for sure that the oil spill funds will be available until the application passes a final public notification phase in March 2004.

But some groundwork is need urgently if rats are to eradicated as soon as possible once funds are secured – it is going to be a very tight schedule and a busy time for all involved. Keep your fingers and toes crossed that you get the money!

JN