Island management and commercial sponsorship: the Mercury Islands experience

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CONTENTS

Abstract

A sponsorship agreement between the Department of Conservation and ICI Crop Care Division began in 1990 with the aim of removing introduced mammals (kiore or Pacific rats *Rattus exulans* and rabbits *Oryctolagus cuniculus*) from Stanley (100 ha), Red Mercury (225 ha) and Cuvier (170 ha) Islands. The primary aim of the project was to restore three nearly extinct populations of tuatara (*Sphenodon punctatus*) and to provide safe habitats for other threatened species. The project also enabled three-phase development of methods for aerial application of rodenticides using helicopters, measurement of the effects of aerial applications on possible non-target species including saddlebacks (*Philesternus carunculatus*) and little spotted kiwi (*Apteryx owenii*), and development of ways to minimise non-target and financial costs of such campaigns. The campaigns against mammals were conducted under an Experimental Users Permit. Each of the eradication attempts was successful and the sponsorship agreement was completed ahead of schedule. A census of colour banded saddlebacks on Stanley Island indicated possible 1-5% mortality as a result of the spreading of Talon baits. On both Stanley and Red Mercury Islands five minute bird counts were higher after baits were spread than immediately prior to the campaigns. Negative public reaction to the programme was centred on the potential cultural and scientific importance of kiore. Positive outcomes of the eradication of rabbits and kiore from these islands (total of 495 ha) include direct and indirect benefits to at least 20 species of rare plants, invertebrates, reptiles and birds, as well as increases in the abundance of numerous other species that are now largely or totally restricted to islands.

1. Introduction

The potential for significant improvements in the conservation status of plants and animals on islands, and a seeming inability to take up this challenge on all but very few islands, has long been recognised - and lamented (Merton 1970, 1972).

The advent of the Department of Conservation (DOC) in 1987 unified protection of habitats and species under the same Act (Conservation Act 1987) and raised possibilities for whole ecosystem approaches to management. The Act raised additional opportunities because interpretation of "conservation" includes "protection of natural resources" and protection is defined as "(a) Its restoration to some former state; and (b) Its augmentation, enhancement, or expansion." These principles are clearly applicable to island management.

A breakthrough for management of island ecosystems was achieved in the late 1980s with the first effective eradications of rats from islands (McFadden and Towns 1991, Taylor and Thomas 1989, Taylor and Thomas 1993, Towns 1988,

Veitch and Bell 1990). The potential application of these techniques to restoration of island ecosystems quickly became apparent (Towns 1988, Towns *et al.* 1990). Coincidentally, an approach to Science and Research Division of DOC by a public relations firm then acting for ICI Crop Care Division provided a vehicle to test this potential.

The offer, made in mid 1990, was for DOC to present a proposal for a co-operative conservation programme with ICI Crop Care, in which the Department would have free use of ICI products for rodent eradication on islands. The ICI offer, plus the Department's need to restore islands, thus presented some challenges:

1. How could a programme be developed that would provide for stepwise evaluation of techniques for eradication of rodents from islands?
2. How could such a programme be incorporated into a sponsorship agreement with ICI Crop Care?
3. How could the structures within a newly reorganised Department be exploited to maximum potential in order to present an efficient operation to a large commercial multinational enterprise?

In the following account we describe the agreement developed between ICI and DOC, signed in November 1990 and completed in September 1993, examine the aims defined in the agreement, identify the progress in island management methods made possible through the agreement, and summarise achievements made as a result of the agreement.

2. Development of the sponsorship agreement

2.1 INITIAL CONSULTATION

At the time of writing, most sponsorship agreements that involve significant commitments of funds and/or product are negotiated through the DOC Public Awareness Unit. A proposal was therefore drafted with the Manager (Threatened Species Unit), and involved consultation with the Directors (Species Protection Division and Science and Research), staff and the Regional Conservator (Waikato Conservancy) and staff of Land Protection Division (at that stage responsible for all wild animal control) and the Public Awareness Unit.

The proposal presented to ICI in July 1990 included the following elements (Towns 1990):

1. The project would be centred on three islands in the Mercury Islands Ecological District where many rare species were under threat, recovery plans for some of these species were already in draft, and a strategic view for island management in the district was already being developed (Towns *et al.* 1990).

2. The proposal would be based around progressive development of aerial spread as a means of eradicating rats from islands of > 100 ha; larger than those routinely being attempted at that stage.

3. Development of aerial spread methods would involve progressively larger islands, starting with 100 ha Stanley Island and finishing with 220 ha Red Mercury Island (all island areas based on Atkinson and Taylor (1992)).

4. Field management staff would assist with each operation. As competence with aerial spread improved, scientific staff involvement would decline whereas that of management staff would increase.

5. As efficiencies with aerial spread improved, the per hectare cost of each operation would reduce through increased efficiency of application and reduced need for follow-up applications of rodenticide on the ground.

2.2 KEY POINTS IN THE AGREEMENT

In November 1990, a letter of agreement was signed between DOC and ICI New Zealand. The agreement included the following points:

1. Pacific rat (kiore), *Rattus exulans,* and rabbits, (*Oryctolagus cuniculus*) would be removed from selected Mercury Islands with ICI Talon (brodifacoum) products as the first step towards restoration of tuatara (*Sphenodon punctatus*), bird, plant and insect populations on the islands.

2. ICI would provide DOC with Talon baits free of charge in three phases: (a) In September 1991, 0.5 tonnes Talon 50 WB and 1.5 tonnes Talon 20 P (for use on Stanley Island); (b) in September 1992 0.5 tonnes Talon 50 WB and 1.5 tonnes Talon 20 P (for use on Cuvier Island); (c) in September 1994 0.5 tonnes Talon 50 WB and 3.5 tonnes Talon 20 P (for use on Red Mercury Island).

3. ICI would collaborate with DOC in producing brochures/leaflets detailing achievements through implementation of the programme, and would contribute to signs on islands warning away illegal visitors.

However, the offer was made with some conditions which applied to the proposed field programme:

1. ICI would support only phase one of the agreement (Stanley Island). Commitment of ICI to the remaining two phases would depend on the success of phase one.

2. To ensure that the proposal would not have unforseen effects on non-target species, DOC would provide ICI with protocols to be used in the field, and these protocols would be independently reviewed by ICI's own advisors.

3. This was to be regarded as an experimental use of ICI products and DOC scientific staff would be involved in supervising all new developments.

4. The products would be used in accordance with their label instructions. Should the programme require variations from these instructions, ICI would assist with paperwork and ensure that an experimental use permit was provided.

5. If problems with the products were encountered, ICI Crop Care would be given reasonable opportunity to provide alternative products and formulations.

The agreement also contained conditions that would ensure that DOC acknowledged the involvement of ICI in the programme and enabled ICI to use publicity about the programme in its own publications. However, the agreement was not an attempt to use DOC staff for development of products with commercial application for ICI. For one of the products, Talon 20 P, DOC was the only potential client and the only registered user for aerial applications.

ICI also made the informal request that one of us (DRT) would be their only point of contact in matters relating to the agreement, and that their Product Manager would be the equivalent point of contact in ICI Crop Care.

2.3 OTHER SUPPORT ACTIVITIES

As requested by ICI Crop Care, protocols to mitigate against risk to non-target species were submitted for their approval. Harriers (*Circus approximans*) and moreporks (*Ninox novaeseelandiae*) (through secondary poisoning) and introduced finches (through intake of baits) were identified as the species most at risk. Saddlebacks (*Philesternus carunculatus*) were regarded as being at less risk but could be affected either directly (through baits) or indirectly (via insects containing brodifacoum). The following precautions were accepted by ICI:

1. Trials using non-toxic Talon 20 P baits would be conducted on Stanley Island before the aerial operation was conducted.
2. The rapid breakdown formulation of Talon 20 P would be used (loss of 70% toxicity in 25 mm rainfall).
3. Any dead rats or rabbits would be collected to ensure that they would not be scavenged by birds.
4. Talon 50 WB blocks would be placed under cover to make them less visible to birds.
5. A colour-banded population of saddleback would be monitored throughout the operation.
6. The proposal would be subject to approval of the DOC Animal Ethics Committee.

In the course of the agreement, a Conservation Action Plan for the Mercury Islands Ecological District was completed (Thomson *et al.* 1992). The Action Plan coordinated objectives developed in five Recovery Plans either completed or in draft. Three of these plans, the Whitaker's and robust skink plan (*Cyclodina whitakeri* and *C. alani*) (Towns 1992), the tuatara plan (Cree and Butler 1993) and the kiwi plan (*Apteryx* spp.) (Butler and McLennan 1991) were approved in the course of the sponsorship agreement with ICI. The kiwi plan and the tuatara plan either had already gained sponsorship (kiwi) or had outside financial support for research programmes (tuatara). This support was used to provide logistic assistance for some activities undertaken with ICI products in the Mercury Islands.

3. Study areas

3.1 RESOURCES

The Mercury Islands, and Cuvier Island to their north, were chosen as the focus for this project because: they contain threatened species with high national profiles; have been the subject of projects with a proven record of success; and have provided a testing ground for new conservation methods (Atkinson 1988, Towns *et al.* 1990, McFadden and Towns 1991, McFadden 1992).

The Mercury Islands, 6 km off the Coromandel Peninsula, consist of seven islands ranging in area from 2 to 1860 ha and several small unnamed stacks and islets (Fig. 1). Cuvier Island is 15 km north of Great Mercury Island.

The Mercury Islands are volcanic peaks that were contiguous with the North Island during the last ice age, and became separated from the mainland by rising sea levels between 10 000 and 8 500 years ago. Cuvier Island, which is further offshore, was isolated at least 12 000 years ago.

The Mercury Islands have retained an outstanding array of relict species and communities. These include rare milktree (*Streblus banksii*) forest, the only known habitat of the Middle Island tusked weta (as yet without a scientific name); two rare species of large skink (robust and Whitaker's skink); five populations of tuatara (with inclusion of the Cuvier population), and the largest populations of the rare Pycroft's petrel *(Pterodroma pycrofti).*

However, all of the larger Mercury Islands (> 15 ha) have been modified either by human activities or the effects of introduced mammals associated with humans. By the 19th Century, kiore were apparently established on the larger islands and periodic burning, possibly to ease access for mutton-birding, had destroyed much of the original vegetation. Rabbits were introduced to Stanley and Korapuki Islands at around the turn of the century. Both islands were extensively burned early this century and Red Mercury experienced a major fire in the 1930s (Millener 19.72). The combined effects of predation and habitat destruction from fire and browsing left three populations of tuatara on large islands on the verge of extinction (Cuvier, Red Mercury and Stanley), viable milktrees confined to 13 ha Middle Island, the tusked weta and other large flightless insects highly vulnerable to extinction should there be an invasion by rodents, and lizard communities on most islands severely depleted.

Fortunately, the smaller islands, of which Middle (13 ha) and Green (3 ha) are the most important, have remained relatively unmodified and free of all introduced mammalian predators (Towns *et al.* 1990). In 1986, a successful rabbit and kiore eradication campaign on Korapuki Island began the process of rehabilitating the more modified islands (McFadden and Towns 1991), leading to the reintroduction of Whitaker's skink to Korapuki Island in 1988 (Towns 1994).

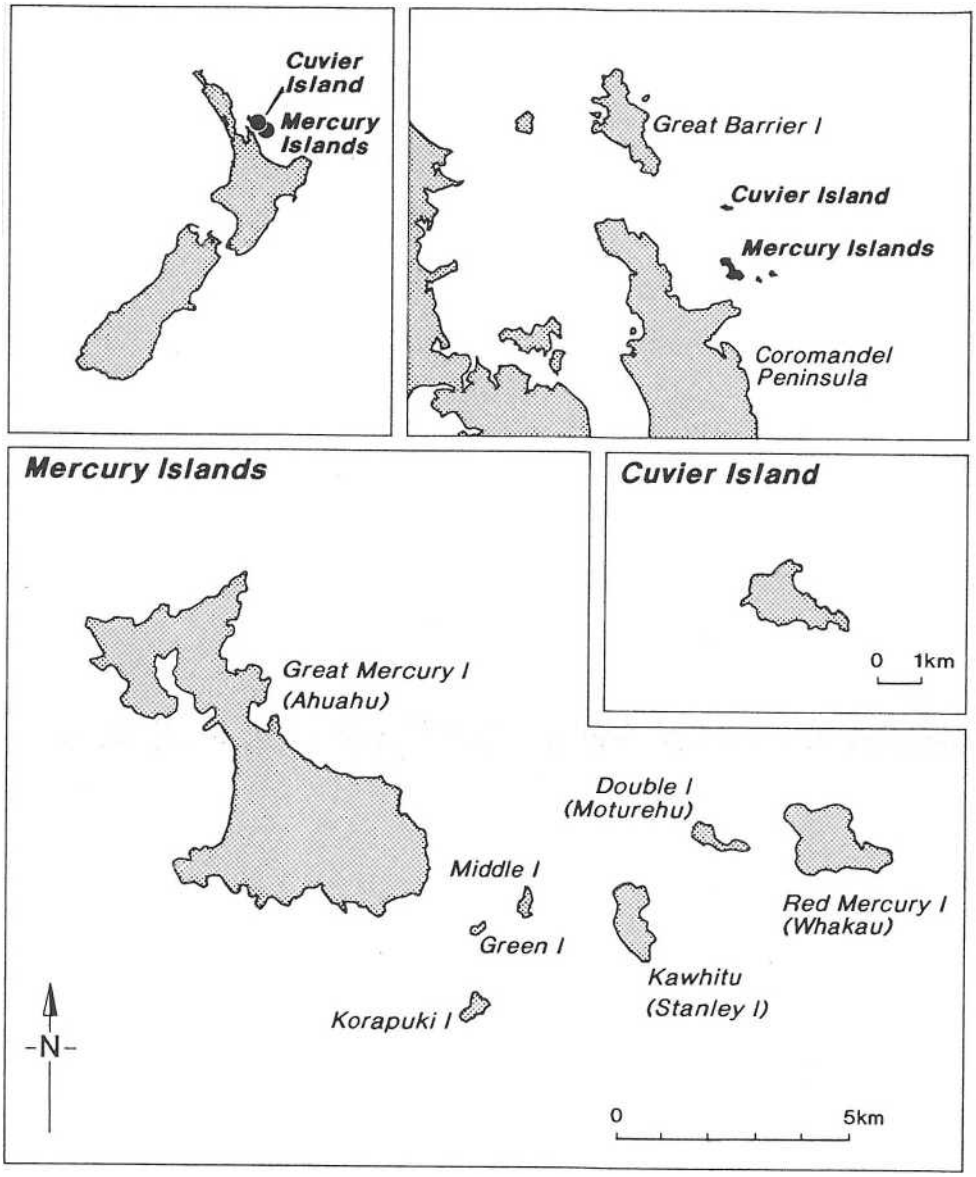

FIGURE 1. POSITION OF CUVIER ISLAND AND THE MERCURY ISLANDS IN RELATION TO NEW ZEALAND AND THE COROMANDEL PENINSULA.

3.1.1 Stanley Island

Like other islands in the Mercury Group, Stanley Island (Kawhitu or Atiu) is a Pliocene - lower Pleistocene landform produced largely by eruptions onto a terrestrial surface in the form of basaltic flows, intrusions, and other formations (Hayward 1986, Hayward and Moore 1972). Cliffs on the northwestern side of the island have a high proportion of laminated pale tuff of rhyolitic origin, possibly from the Miocene centres of Great Mercury or the Coromandel Peninsula. The predominant basalt has resulted in an island that appears somewhat tabular from the sea, with an undulating surface topography rising to 137 m, steep cliffs, and coastal caves and bouldery slopes. There are no permanently flowing streams.

Recent fires and presence of rabbits has led to highly modified vegetation dominated by pohutukawa (*Metrosideros excelsa*) over a subcanopy of mahoe

(*Melicytus ramiflorus*) with very little ground vegetation. Twenty four saddlebacks were introduced to Stanley Island as a conservation measure in 1977, and the population has since expanded to at least 250 birds (Towns *et al.* 1993). However, the island supported a small lizard fauna, with half the number of species found on neighbouring islands free of rats (Towns 1991). A small tuatara population was present (about 20 known animals) that has shown no evidence of breeding either in captivity or in the wild (see Cree and Butler 1993).

3.1.2 Red Mercury Island

Red Mercury Island (225 ha) is the largest of the Mercury Islands in Crown ownership. Like Stanley Island, this predominantly basalt island appears somewhat tabular from the sea, with an undulating surface topography, and steep cliffs. The island has streams that hold permanent water, although these cease flowing during dry periods.

Except for kiore, there are no introduced mammals on the island. Vegetation on the island is distinctive because of the predominance of second-growth species following periodic fires until about 1934 (Lynch *et al.* 1972). Rare vertebrates of particular interest on Red Mercury are a relict population of tuatara, a large population of Pycroft's petrel, saddlebacks, introduced in 1966 (Fogarty and Douglas 1972), and little spotted kiwi (*Apteryx owenii*), introduced in 1983 (Robertson *et al.* 1993).

3.1.3 Cuvier Island

Unlike the Mercury Islands, Cuvier Island is derived from Miocene intrusive volcanic magma that was not erupted but cooled slowly in chambers beneath volcanoes (Hayward 1986). The island has steep coastal cliffs and a narrow, steep pinnacle on the eastern end.

Cuvier Island is one of the few offshore islands where information about the flora and fauna pre-dates major habitat modification after European occupation. The island was purchased from Maori in the 1880s and a lighthouse erected in a 26 ha lighthouse reserve at the eastern end of the island in 1888-1889 (Wright 1981). The lighthouse was serviced by two keepers and their families who farmed the lighthouse reserve for almost 100 years until the light was automated and the families withdrawn in 1981. In 1956, the remainder of the island was purchased by the Crown and in 1957 was declared a reserve for preservation of flora and fauna (Merton 1970).

By 1957, wandering stock (cattle, *Bos taurus,* and sheep, *Ovis aries),* introduced in 1889, had damaged the forest vegetation, and cats (*Felis catus*) and goats (*Capra hircus*) were feral. As a result of browsing, the forest vegetation was reduced to an open woodland (mostly of pohutukawa) that lacked an understorey, some previously reported plants were extinct on the island, and scrub on coastal faces was reduced to eroding grassland. Predation, largely by cats, had eliminated previously recorded North Island saddleback, pied tit (*Petroica macrocephala*), tui (*Prosthemadera novaeseelandiae*) and parakeet (*Cyanoramphus novaezelandiae*), burrowing seabirds were reduced to two species breeding on the island (sooty shearwater, *Puffinus griseus* and

grey-faced petrel, *Pterodroma macroptera gouldi*), and tuatara were reduced to seven known individuals (Merton 1970, Bellingham *et al.* 1981, McCallum and Harker 1981).

Eradication of goats was completed in 1961, a new boundary fence for the lighthouse settlement was completed in 1963, excess stock were destroyed, feral cats were removed by 1964 and domestic cats banned from the island from 1970 (Merton 19-0), leaving kiore as the only introduced mammals.

In 1968, saddleback were returned to Cuvier Island (Merton 1970) and red-crowned parakeet were reintroduced in 1974 (Atkinson 1988, Cree and Butler 1993). Stitchbirds *(Notiomystis cincta)* were introduced to Cuvier Island in 1982 (Angehr 1985), but although they bred successfully soon after release, this population appears to be declining to extinction (Atkinson 1988).

3.2 POTENTIAL GAINS

At least 20 species of rare plants, invertebrates, reptiles and birds were identified as likely to benefit either directly or indirectly through the removal of rats (plus rabbits on Stanley) during this programme (Table 1). For some species, successful establishment or re-establishment in the absence of rats would have significant effects on their conservation status. Notable amongst these would be reinstatement of tuatara on Cuvier, Red Mercury and Stanley Islands (Cree and Butler 1993), establishment of Whitaker's skink and robust skink on Stanley and Red Mercury Islands (Towns 1992), the potential establishment of tusked weta on Stanley, Red Mercury or both, and the regeneration of milktree on Stanley Island. Other less rare species that should benefit include Pacific and Duvaucel's geckos (*Hoplodactylus pacificus* and *H. duvaucelii*), Suter's skink (*Oligosoma suteri*) and marbled skink (*Cyclodina oliveri*), ground weta and other large invertebrates such as darkling beetles (*Mimopeus* spp) and giant centipede (*Cormocephalus rubriceps*).

4. Implementation of the agreement

4.1 NEW MANAGEMENT STRUCTURES

Three new elements were added to the Department's management structures in the course of this programme. First, funding for DOC eradication projects on islands was defined within a National Priority Pool (NPP) administered by Species Protection Division (Head Office). Second, to ensure best use of the funds and expertise available, a National Co-ordinator for eradication projects on islands was nominated.

Following from these initiatives a priority list of eradication projects was defined. The National Co-ordinator was also able to ensure that new data and

TABLE 1. SPECIES EITHER UNDER THREAT, UNCOMMON OR ABSENT ON THE MAINLAND, AND LIKELY TO BENEFIT EITHER DIRECTLY OR INDIRECTLY FROM REMOVAL OF INTRODUCED MAMMALS FROM STANLEY, RED MERCURY AND CUVIER ISLANDS.

SPECIES	ISLAND DISTRIBUTION
Plants	
Calystegia marginata	Cuvier
Cook's scurvy grass (*Lepidium oleraceum*)[B]	Previously recorded on Cuvier, now absent
Milktree (*Streblus banksii*)	Previously recorded on Cuvier, now absent, surviving remnant on Stanley
Native cucumber (*Sicyos angulata*)[C]	Stanley, Cuvier
Senecio sp	Cuvier
Shore spurge (*Euphorbia glauca*)	Previously recorded on Cuvier, now absent
Invertebrates	
Middle Island tusked weta[A]	Known from rat free Middle Island (Mercury Islands) only
Cave weta (Rhapidophoridae)	Stanley, possibly Red Mercury and Cuvier
Mimopeus elongatus	Distribution and abundance unclear
M. opaculus	Known in the Mercury Islands only on rat free islands
Giant centipede (*Cormocephalus rubriceps*)	Stanley, possibly Red Mercury and Cuvier
Reptiles	
Tuatara (*Sphenodon p. punctatus*)[B]	Remnant populations on Cuvier, Red Mercury and Stanley
Duvaucel's gecko (*Hoplodactylus duvaucelii*)	Red Mercury, Stanley, extinct on Cuvier?
Marbled skink (*Cyclodina oliveri*)	Red Mercury?, extinct on Stanley, Cuvier
Robust skink (*C. alani*)[B]	Reintroduced to Red Mercury and Stanley following rodent eradication
Whitaker's skink (*C. whitakeri*)[B]	Reintroduced to Red Mercury and Stanley following rodent eradication
Moko skink (*Oligosoma moco*)	Stanley, Red Mercury and Cuvier
Suter's skink (*O. suteri*)	Red Mercury, Cuvier, extinct on Stanley?
Birds	
Diving petrel (*Pelecanoides urinatrix*)	Extremely abundant on rat free islands, present on Stanley and Red Mercury, not breeding on Cuvier
Fluttering shearwater (*Puffinus gavia*)	Very rare on Stanley and Red Mercury, not breeding on Cuvier
Little shearwater (*P. assimilis*)	Breeding on Stanley and Red Mercury, not breeding on Cuvier
Pycroft's petrel (*Pterodroma pycrofti*)	Breeding on Stanley, Red Mercury, not breeding on Cuvier
Little spotted kiwi (*Apteryx owenii*)[B]	Introduced to Red Mercury
Red-crowned kakariki (*Cyanoramphus novaezelandiae*)[C]	Red Mercury, Stanley, reintroduced to Cuvier after removal of cats
North Island saddleback (*Philesturnus c. rufusater*)[C]	Reintroduced to Cuvier, Red Mercury, Stanley
Stitchbird (*Notiomystis cincta*)[B]	Introduced to Cuvier

Categories of threat are based on Molloy and Davis (1994) with Category A identified as having highest priority for conservation action. Data on plant distribution from P. de Lange (pers. comm.), invertebrates from C. Green (pers. comm.), reptiles from Towns (unpublished) and McCallum and Harker (1981), birds from G. Taylor (pers. comm.) and Bellingham *et al.* (1981).

techniques applied in eradication projects at one location produced information that was applied on a national basis to other projects. The three projects identified in the present programme with ICI were thus incorporated into this national strategy.

The third element was establishment of the network of Kaupapa Atawhai Managers whose responsibilities included liaison between DOC and iwi Maori. The use of this network ensured that iwi were aware of what the Department's activities on islands involved and how this might affect plants and animals that were held in high regard by Maori.

4.2 INVOLVEMENT OF OTHER SPONSORS

The linkage between the programme with ICI, the various recovery plans, and the NPP strategies for eradication progressively provided funds either for logistic support or to help refine methods of bait application. Organisations involved included Dallas and San Diego Zoos, who were funding research related to tuatara recovery, Fay Richwhite, who provided transport of baits to Red Mercury Island, and BNZ, as primary sponsors of the kiwi recovery plan (Table 2).

TABLE 2. ORGANISATIONS AND SECTIONS OF DOC WHO PROVIDED SIGNIFICANT ASSISTANCE ADDITIONAL TO ICI, WAIKATO CONSERVANCY AND SCIENCE AND RESEARCH FUNDS.

LOCATION	ITEM	ASSISTANCE
Stanley Island	Monitoring saddlebacks Invertebrate studies Logistic support (helicopter and boat charters)	Dallas Zoo San Diego Zoo
Red Mercury Island	Monitoring kiwi Logistic support (helicopter hire and free transport)	Bank of New Zealand Fay Richwhite San Diego Zoo
Cuvier Island	Development of helicopter use with spreader and GPS	NPP (DOC: Species Protection Division)

4.3 CHANGES IN SEQUENCE

To best make use of these additional funds, ICI agreed to a change in sequence of phases two and three of the agreement (Red Mercury Island substituted for Cuvier). This change was made at the request of Head Office of DOC to test the effects of Talon 20 P on the Red Mercury Island little spotted kiwi population as possible casualties if a similar aerial operation was conducted on Kapiti Island.

4.4 RESEARCH OBJECTIVES

By incorporating information needs in the protocols developed to minimise risk to non-target species, involvement of the various recovery plans, inclusion of

several sponsors in addition to ICI, and co-ordination with NPP, the following inter-related research objectives were developed (primary funding agency in parentheses):

1. Methods for eradication of kiore and rabbits from islands using aerial spread of baits (ICI, NPP, San Diego Zoo).
2. Tests for non-target effects of Talon 20 P on a colour banded population of saddlebacks (Dallas Zoo).
3. Tests for non-target effects of Talon 20 P on kiwi fitted with transmitters (BNZ).
4. Response of invertebrates on an island inhabited by tuatara following removal of rats and rabbits (Dallas Zoo).
5. Long term and short term effects of brodifacoum in soils, invertebrates and birds (DOC Science and Research, Landcare Research).

5. Results

5.1 LICENSING IN RELATION TO ERADICATIONS

At the beginning of the programme, Talon 20 P was licensed only for use by ground laying against rabbits. In phase one, the primary target species on Stanley was rabbits. The product licensed for use against rats, Talon 50 WB, was therefore provided by ICI for use against kiore should it be needed. Because the Talon 20 P was to be spread from the air, the product was re-licensed for use by DOC for aerial application against rabbits on offshore islands that lack livestock.

For subsequent applications, where the primary target was kiore, the Department was issued an Experimental Use Permit with a revised product label approved by the Pesticides Board.

Throughout the programme one of us (DRT) acted as Scientific Co-ordinator and the main link with ICI Crop Care. All of the eradication campaigns were supervised by I. McFadden (Science and Research Division), who was also National Co-ordinator for NPP-funded eradication projects on islands (a position established after the Red Mercury Island project). Project Leaders were designated by Waikato Conservancy for the Red Mercury and Cuvier projects (P. Thomson).

5.2 ERADICATIONS

5.2.1 Stanley Island

An air drop of 1.75 tonnes Talon 20 P was carried out on Stanley Island on 25 September 1991 using a monsoon bucket beneath a squirrel helicopter (average spread 17 kg/ha). Talon 50 WB (100 kg) was spread by hand between 22-29 October 1991 (Towns *et al.* 1993).

No live rats or rabbits were seen beyond four days after the air drop. Intensive follow-up monitoring using traps, passive indicators (apple, candles and soap) for nine months failed to reveal the presence of rats or rabbits, and subsequent less intensive checks over two years has shown the island to be clear of both species.

Apparently both rats and rabbits were eradicated with the single aerial spread of Talon 20 P. This was the first multiple pest eradication recorded as a single operation on a New Zealand island, and the first time that rabbits had been removed without the need for following operations with firearms. The cost of the operation was estimated as $366/ha if costed at commercial rates.

Given that Talon 50 WB was spread against rats, the possibility that at least part of the population succumbed to the ground application could not be discounted. The use of Talon 20 P as the primary agent against rats was therefore the focus of the Red Mercury Island operation.

5.2.2 Red Mercury Island

The aim of the Red Mercury Island operation was to improve the efficiency of spread of the Talon 20 P baits and minimise the use of Talon 50 VbB. However, problems were encountered with consistency of non-toxic pellets used to calibrate the bait spreader mechanism proposed for trials on Red Mercury. A modified monsoon bucket was therefore used in this operation.

The aerial spread of 3.5 tonnes Talon 20 P was conducted on 21 September 1992 (average spread 15 kg/ha). A malfunction with the monsoon bucket caused by baits of variable size led to suspicions of uneven bait coverage over part of the island. Potential gaps were covered by a ground application of Talon 50 WB (100 kg) (Towns *et al.* 1994). The island has been subjected to intensive trapping and monitoring and no sign of rats has been seen. The cost of the rodent eradication part of work on Red Mercury island was estimated as $190/ha.

The primary aim to complete the task on Red Mercury using Talon 20 P was not fully met. However, Talon 20 P was the only bait used over at least 70% of the island, demonstrating its potential as an effective agent against rats. The final phase, Cuvier Island, therefore focused on the use of Talon 20 P alone.

5.2.3 Cuvier Island

In addition to developing the most efficient methods of spreading Talon 20 P, the Cuvier operation also intended to set out unequivocal lines of response and responsibility in the event that the follow-up use of Talon 50 WB might be required (Towns *et al.* 1995).

By ensuring that non-toxic trial baits were from the same batch as toxic baits, a spreader mechanism was tested and calibrated using baits identical to those being applied on the island. The aerial spread of 2.5 tonnes of Talon 20 P was carried out in 1.4 hours of flying time on 7 September 1993. No Talon 50 WB was used. The island has been intensively checked four times over nine months and there has been no confirmed sign of kiore. The cost of the operation was estimated as $181/ha.

5.3 RESEARCH ON NON-TARGET SPECIES

Research on non target species was conducted on Stanley and Red Mercury Islands. The species composition on Cuvier Island was similar to the other two islands and did not warrant any of the research being repeated.

On Stanley Island, monitoring focused on saddlebacks as being the native species with greatest potential risk. Bait trials with wild birds on the island indicated that levels of acceptance of the baits would be low. Careful searches of Stanley Island one month after the aerial spread of baits produced the following species that possibly died after ingesting poison: five saddlebacks, three chaffinches *(Fringilla coelebs),* three blackbirds *(Turdus merula),* two house sparrows *(Passer domesticus)* and one morepork. If brodifacoum had been the cause of death, all species other than the morepork were likely to have died after ingesting the pellets. However, most carcasses were too decomposed to provide traces of brodifacoum, which was identified in only one sparrow and one blackbird.

Estimates of mortality of saddlebacks over the period baits were present were 1-5%, with an annual mortality estimated as 17.4%. This latter figure was not significantly different from annual mortalities recorded during years previous to the eradication campaign against rabbits and rats (Towns *et al. 1993).*

A wider range of studies of non target effects of brodifacoum on Red Mercury Island were conducted after little spotted kiwi showed little attraction to the baits in captivity. None of the nine kiwi equipped with transmitters and followed for six weeks after the aerial spread of baits showed any ill effects of the baits or transmitters, kiwi call frequencies counted before and after the air drop were not significantly different, and five minute bird counts indicated that species potentially at risk of poisoning from Talon (blackbirds, kakariki *Cyanoramphus novaezelandiae,* and saddlebacks) were more frequently encountered six months after the operation than immediately before it (Robertson *et al. 1993).*

Five blackbirds and one saddleback were found dead after the aerial spread of baits. The saddleback and two blackbirds tested contained lethal doses of brodifacoum. Samples of water, soil and invertebrates conducted during and after the aerial spread of baits only revealed brodifacoum in one sample of invertebrates (slugs) obtained two days after the operation. However, six blackbirds captured live eight months after the spread of baits all contained traces of brodifacoum in the liver (Towns *et al.* 1994).

No dead birds could be found after the operation on Cuvier Island.

5.4 INFORMATION TRANSFER

The cost in time and operating funds incurred by Science and Research Division was, as anticipated, highest in the Stanley Island phase of the programme. Subsequently, the scientific involvement declined as Conservancy staff increased logistic support (such as monitoring for rat sign), became more directly involved in the aerial operation, and efficiencies were made in monitoring effectiveness of bait spread (Fig. 2).

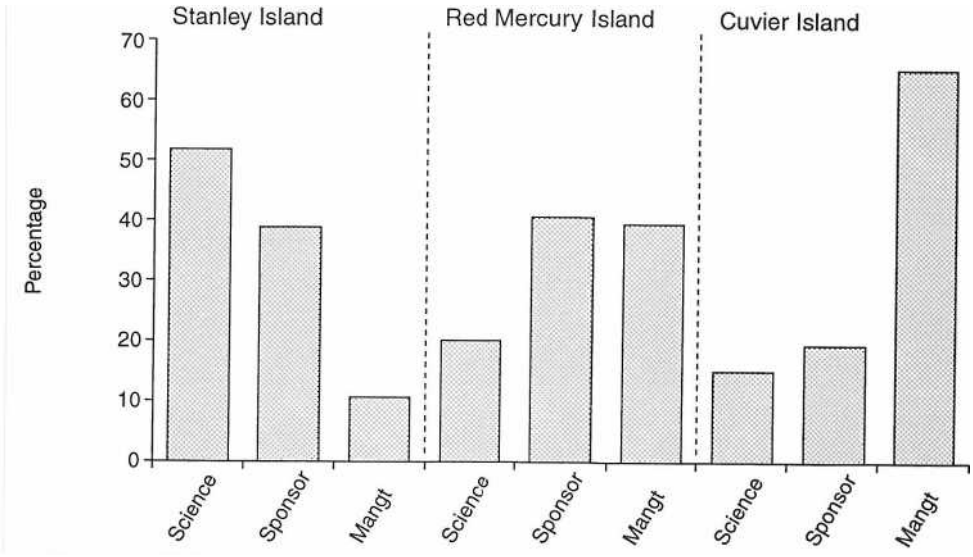

FIGURE 2. RELATIVE CONTRIBUTION OF SCIENCE AND RESEARCH (DOC), SPONSORS AND DOC FIELD CENTRE AND CONSERVANCY STAFF (MANGT) TO COST OF THE ERADICATION CAMPAIGNS BETWEEN 1991 (STANLEY ISLAND) AND 1993 (CUVIER ISLAND) BASED ON COSTS IDENTIFIED IN TOWNS *ET AL.* (1993, 1994, 1995). NOTE THE ONLY SPONSOR INVOLVED ON CUVIER ISLAND WAS ICI CROP CARE (BAITS).

5.5 RESULTS OF ADVOCACY/PUBLICITY

The programme was introduced to the public by production of a brochure by ICI and DOC. The brochure was for distribution to local businesses and interest groups at the formal launch of the agreement. The launch of the sponsorship agreement on Stanley Island was publicised with newspaper and television coverage. Feature articles that related to the project, especially to the benefits likely to be gained by tuatara, were printed in the New Zealand Herald (28 November 1990), Waikato Times (3 August 1991) and Hauraki Herald (18 April 1992). In total, 11 significant newspaper articles (> 5 cm column length) were published about the Mercury. Islands programme, of which seven (total 362 cm column length) made specific mention of ICI Crop Care as primary sponsor. The latter seven articles comprised 81 cm in a national daily paper (New Zealand Herald), 281 cm in local papers with circulation in the Waikato and Coromandel areas, and 59 cm in a Maori publication, Kia Hiwa Ra. This analysis excludes media coverage outside northern New Zealand (where clippings were not accessible) and also excludes short articles (< 5 cm) published in the New Zealand Herald announcing that the aerial spread of baits had been undertaken. A Waikato Conservancy. summer programme in January and February 1993 included guided day trips to Stanley Island in which the values of the islands and the importance of the eradication campaigns were outlined.

The Stanley Island operation also featured on a large format calender produced by ICI Public Health (UK). The calender, produced for 1993, had international circulation.

5.6 UNFORSEEN PROBLEMS: THE KIORE ISSUE

The positive media coverage of conservation gains on islands provoked one area of negative response generated largely from academic staff of the University of Auckland uncomfortable with the removal of kiore from islands. The issues were debated on radio, television, and in the printed media. Except for an article by Kidson (1992), the comments did not refer specifically to the Mercury Islands programme. Various university staff were quoted in the media as claiming that because kiore were regarded as taonga (treasures) by Maori, DOC should "put a moratorium on eradication to prevent its extinction" (Jones 1992a), that there should be broader consultation with Maori people (Jones 1992b), that failure to do so was "culturally insensitive" at best (Townsend 1993), that the case for kiore damaging indigenous plants and animals was either "fairly circumstantial" or, in the case of damage to tuatara, "not proven" (Jones 1992a). It was also claimed that DOC has an "ecological fundamentalist attitude" to introduced species (Kidson 1992).

Few printed articles mentioned the high level of consultation with iwi before any of the eradications were undertaken, the scientific evidence in peer-reviewed publications on the effects of kiore on indigenous species, that after ship rats (*Rattus rattus*) and Norway rats (*R. norvegicus*), kiore are the world's third most widely distributed species of rat (Wodzici and Taylor 1984) and that their eradication in New Zealand, let alone elsewhere in the Pacific and Asia, is not possible or even contemplated. On the contrary, the issue became identified as a cultural controversy (Dickison 1992). The only attempt at an investigative view by the media of the role of kiore in Maori culture, and evidence of their effects on island ecosystems, was by Dickison (1992) who concluded that a supposed clash of cultures was really a clash between one introduced animal regarded by some as a taonga and its indigenous prey - also regarded as taonga. This therefore amounted to a clash between priorities (Dickison 1992).

All media debate (newspapers, radio and television) over the appropriateness of removing kiore from islands was directed to DOC Head Office and handled by the Manager, Threatened Species Unit. Suggestions that the case for eradication of kiore should be justified in a more public way (Jones 1992b) were accepted. The Director, Species Protection Division, undertook to produce a position statement on kiore that outlined the effects they have on indigenous species, identified criteria that could be used for removal of kiore, specified locations where their removal met these criteria and identified locations from which their removal is unlikely. The first draft of the statement was released in August 1994.

6. Discussion

6.1 SUPPORT FROM INFRASTRUCTURE

The use of sponsorship to support conservation efforts by a Government agency in New Zealand is a relatively new innovation. Some very large sponsorship partnerships exist. For example, the kakapo recovery plan is partly funded by sponsorship. The whole plan was estimated as requiring $2.3 m over five years (Powlesland 1989). However, there has not previously been opportunity to objectively assess either the value of sponsorship at the completion of an agreement, or how the Department has performed in partnerships of this kind. The relatively short-term agreement with ICI Crop Care therefore presents a rare opportunity to identify what DOC gained from the relationship, how information gained was transferred to management actions, and how the management structures coped both with new opportunities and unforseen events.

The unforseen issues that arose over kiore in the course of the programme added a new dimension to a scientific project (development of rat eradication techniques): a test of the ability of the Department to respond to challenges about how its priorities for conservation are derived. The agreement with ICI and both the positive and negative effects of publicity that this involved called on integrated responses from Science and Research Division, Waikato Conservancy management, advocacy and Kaupapa Atawhai staff, and Head Office support through co-ordination and policy development.

The effectiveness of these responses is best judged by the results of the agreement with ICI Crop Care: all three phases of the agreement were completed as planned, all identified objectives were met, the total cost to ICI was about $10 000 less than was budgeted for through reduced use of Talon 50 WB (Towns *et al.* 1995), and the agreement was completed one year ahead of schedule. Without such effective support of the programme from within DOC, the agreement probably would not have gone beyond phase one (Stanley Island).

Additional measures of the value of the public relations and the effectiveness of the Department's infrastructure would best have been obtained by measuring public attitudes to conservation in the communities on the Coromandel peninsula adjacent to the Mercury Islands. Such assessments, which would need to have been obtained periodically as the three phases of this agreement were completed, were beyond the scope of this project.

6.2 EFFICIENCY GAINS

At commencement of the programme, removal of rodents from islands of more than 100 ha had already been achieved, but at considerable cost. For example, the removal of rats and rabbits from 173 ha Whale Island required repeated use of a range of toxins culminating in applications of compound 1080 and Talon 20

P over two years (Jansen 1993). The eradication of mice (*Mus musculus*) from Mana Island has not been costed accurately, but estimated total costs of labour and materials exceeded $100 000 (i.e., at least $500/ha) (D. Merton pers. comm.). The first attempts at eradicating rats from small islands cost over $1000/ha (Taylor and Thomas 1989, McFadden and Towns 1991).

Improvements in the efficiency of eradication campaigns in the course of the Mercury Islands programme can be measured in several ways, including: gross cost of each phase, quantities of toxin used, number of non-target organisms affected, and speed of transfer of expertise gained into other operations.

By completion of the present programme, the cost per hectare had halved from $366/ha on Stanley Island to $181/ha on Cuvier Island (although the Stanley Island operation involved both rabbits and rats). Part of the reduction in cost was accounted for by reductions in the quantity and type of baits used. This involved a reduction in amount spread from 17 kg/ha on Stanley Island to 15 kg/ha on Red Mercury and Cuvier Island, but also a change from the use of up to 100 kg of the more persistent and toxic Talon 50 WB on both Stanley and Red Mercury to exclusive use of Talon 20 P on Cuvier Island. Further cost reductions are possible; a successful campaign on Tiritiri Matangi Island used Talon 20 P at a rate of only 10 kg/ha (C.R. Witch, pers. comm.).

Associated with the volumes and type of baits used, the number of birds apparently killed by brodifacoum decreased from 14 on Stanley Island to six on Red Mercury and none on Cuvier.

As the programme developed, awareness of its value in developing techniques applicable elsewhere was coupled with changes in the way priorities for funding were set in DOC. Consequently, funds for logistic support sought from sponsors declined from a maximum of $9200 on Stanley Island to nil on Cuvier Island, where all logistic support was met through DOC funds (NPP island eradication funds). Techniques developed in the Mercury Islands that were rapidly applied elsewhere by DOC included a DOC-funded project against kiore on 26 ha Middle Chain Island (Aldermen Islands), undertaken simultaneously with the project on Red Mercury Island, and two large operations against kiore (102 ha Whatapuke Island and 196 ha Tiritiri Matangi Island), successfully completed within two months of the campaign on Cuvier Island. Results and expertise gained from these projects are now being applied to projects for eradication of rats from very large islands such as Codfish Island (1396 ha) and Kapiti Island (1970 ha).

6.3 RESEARCH GAINS

During the programme, useful new information was gained either directly or indirectly about behaviour in the field of anticoagulants such as brodifacoum and its potential effects on non-target species. Previous to this programme, Talon 20 P had not been used against rabbits in forested environments, and attempts at using it to eradicate rabbits on islands (such as Round Island, Mauritius) had not been completely successful (Merton 1987).

Protocols developed for this programme predicting rapid disintegration of Talon 20 P in rain (thus minimising non-target effects) were confirmed. Talon 20 P

baits were rarely found when islands were checked four weeks after their aerial spread. On the other hand, fears that brodifacoum ingested by insects could cause secondary poisoning in insectivorous birds (Wright and Eason 1991) were not confirmed in the Mercury Islands. On the contrary, field data suggested that dead birds containing brodifacoum most likely obtained it from fresh baits, rather than through accumulation of toxins from invertebrates or soils. This has now been confirmed from soil and invertebrate samples in the Mercury Islands and in laboratory trials (D. Morgan, pers. comm.). Insectivorous and ground feeding bird populations monitored during the programme showed no significant increases in mortality over the course of each campaign. However, the presence of traces of brodifacoum in blackbird samples eight months after the spread of baits confirms the long persistence of sublethal doses of brodifacoum in vertebrates (Laas *et al.* 1985). Nonetheless, blackbirds and saddlebacks (both likely to take some baits) were more frequently encountered after the operations than previous to them (Towns *et al.* 1993, Robertson *et al.* 1993).

6.4 CONSERVATION GAINS

The removal of goats and rabbits from 150 ha Round Island in Mauritius has been hailed as a conservation success story with elimination of threats to ten species of threatened plants, six species of endangered reptiles and one species of rare seabird (Merton 1987).

The gains made through removal of kiore and rabbits from the three islands covered in the present programme rival the Round Island success. Previous to this programme, the largest continental island (contiguous with the mainland during the last ice age) free of introduced rats around northern New Zealand was 32 ha Ruamahuanui Island (Aldermen Islands). The Mercury Islands project removed introduced problem mammals from 495 ha of island habitat at a gross cost of $109 096 and provided direct or indirect benefits for at least 20 species of rare plants, invertebrates, reptiles and birds. In addition, however, there are demonstrated benefits to an abundance of resident species previously affected by the presence of introduced mammals. Included amongst species to benefit are five species of lizards, some of which are now rarely encountered on the mainland. Potential changes in lizard abundance can be extrapolated from Korapuki Island (also in the Mercury Group), where, since removal of kiore and rabbits in 1986, lizard relative abundance at some sites increased 30-fold (Towns 1991, 1994) and at least 10 species of large flightless invertebrates not recorded while kiore were present (Hicks *et al.* 1975) have since reappeared (C. Green, pers comm.). Some of these, including three species of cockroaches, a species of carabid beetle and a cave weta, have become common in many areas. On Cuvier Island, a number of regionally threatened species of plants have already benefitted from removal of goats. Included amongst these are parapara (*Pisonia brunonianum*) and coastal maire (*Nestegis apetala*), which are both now abundant on the island. At least seven additional regionally threatened plant species should benefit from the removal of mammals, and a further four locally distributed endangered plants could be established there now that rats have been removed (P. de Lange pers. comm.).

Most importantly, however, natural regeneration and restoration is now possible on three large islands (>100 ha) for a lowland coastal plant/invertebrate/reptile/seabird system reduced to a few small continental islands around northern New Zealand. Because the islands included in this programme are so large by comparison with islands naturally free of rodents, it is difficult to predict how removal of rabbits and rats will ultimately affect the structure of their biotic communities. However, it is reasonable to expect both rapid changes and previously unrecorded interactions between species. These changes will be accelerated by restoration objectives proposed for the group, the first stage of which was translocation of Whitaker's and robust skinks to Red Mercury Island (late 1994-early 1995) and Stanley Island (late 1995); and the second stage, which will involve the return of tuatara now held in captivity (Cree and Butler 1993).

In future, the islands included in the programme with ICI and other sponsors are most likely to be viewed for their pivotal importance in conservation of rare species and the restoration of hitherto modified island systems. However, the additional importance of these islands in learning how to develop partnerships with industry and iwi, effective use of DOC's administrative and priority setting mechanisms, and development of the techniques for island management, should not be forgotten.

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