Cyclodina spp. skink recovery plan

1999–2004

THREATENED SPECIES RECOVERY PLAN 27

Department of Conservation
Te Papa Atawhai

Recovery Plans

This is one of a series of recovery plans published by the Department of Conservation. Recovery plans are statements of the Department's intentions for the conservation of particular plants and animals for a defined period. In focusing on goals and objectives for management, recovery plans serve to guide the Department in its allocation of resources and to promote discussion amongst a wider section of the interested public.

The Department recognises the valuable contribution of all individuals, groups and organisations participating in this recovery programme. The Department recognises its obligation in terms of section 4 of the Conservation Act 1987 to give effect to the Principles of the Treaty of Waitangi in relation to its business, and the need to take account of the views of the tangata whenua and the application of their values in the conservation of natural resources. While the expression of these values may vary, the recovery planning process provides opportunites for consultation between the Department and the tangata whenua. Departmental Conservancy Kaupapa Atawhai Managers are available to facilitate this dialogue.

After peparing a technical report that was refined by scientists and managers both within and outside the Department, a draft of this plan was sent to relevant Conservation Boards, tangata whenua, and other stakeholders for comment. After further refinement, this plan was formally approved by the Northern Regional General Manager in May 1999. A review of this plan is due after five years (in 2004), or sooner if new information leads to proposals for a significant change in direction. This plan will remain operative until a reviewed plan is in place.

A recovery group consisting of people with knowledge of *Cyclodina* species, and with an interest in their conservation, has been established. The purpose of the Cyclodina Recovery Group is to review progress in the implementation of this plan and to provide advice to the Department. The Department of Conservation will consult with relevent Conservation Boards, tangata whenua and other stakeholders where such consultation will assist with implementation of this plan. Comments and suggestions relating to the conservation of *Cyclodina* species are welcome and should be directed to the recovery group via any office of the Department or to the Biodiversity Recovery Unit.

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1. Introduction

This is the second recovery plan for skinks in *Cyclodina*. The first plan, largely for Whitaker's and robust skink (*Cyclodina whitakeri* and *C. alani*), was approved in 1992 and had a five-year span until May 1997 (Towns 1992a). The present plan reviews the conservation status and recovery actions required for the entire genus of at least eight extant species and sets broad recovery objectives for the next ten years. However, some objectives rely on eradications of pests from islands planned within the next five years. The ten-year goals will be influenced by the success of these eradications. Detailed objectives for five years are therefore provided; at five years a review of the plan is proposed.

The members of *Cyclodina* are endemic to the New Zealand region. The genus includes a higher proportion of rare or threatened species (62%) than any other New Zealand lizard genus (Daugherty et al. 1994). This figure greatly exceeds the proportion (37.5%) of species of *Cyclodina* listed as 'threatened' in the latest IUCN Red List (Baillie and Goombridge 1996), but the IUCN list excludes two undescribed species included by Daugherty et al. in their assessment. A more realistic assessment of status of these species is provided by Molloy and Davis (1994) where one species is identified in Category A (highest priority for conservation action), three in Category B, and one in Category C as a local endemic (L).

In their generic review of the New Zealand skinks (Scincidae), Patterson and Daugherty (1995) found that there were similarities between *Cyclodina* and *Oligosoma*, but high levels of genetic divergence within each genus. They thus supported previous suggestions (e.g. Towns et al. 1985) that these skinks are a more ancient element in the fauna than was previously recognised. The separation of *Cyclodina* from *Oligosoma* on morphological and genetic grounds (Patterson and Daugherty 1995) is also, to some extent, reflected in their behaviour. Most of the *Oligosoma* species are strictly diurnal (there is only one exception). In contrast, the *Cyclodina* species are either nocturnal, crepuscular or can vary in their time active, but, so far as is known, none are strictly diurnal.

Cyclodina shows considerable size divergence between species—the genus includes both the smallest (c. 120 mm) indigenous skink, copper skink (*Cyclodina aenea*), and the largest skink (c. 350 mm), the presumed extinct *C. northlandi*. However, in general, there has apparently been little genetic or morphological divergence within species. For example, no significant genetic divergence was measured in the three populations of Whitaker's skink scattered over 500 km (C.H. Daugherty pers. comm.). An exception is in the marbled skink (*C. oliveri*) species complex, which comprises at least one cryptic species (still to be described) and two morphologically distinctive forms not genetically differentiated (C.H. Daugherty pers. comm.; Appendix 1). The recovery actions proposed below attempt to ensure that future options for management are not foreclosed by existing deficiencies in taxonomic knowledge of the group. The plan therefore identifies, and seeks to maintain, genetic and morphological diversity. This approach follows Baverstock et al. (1993), who recommended that isolated populations without breeding links with other populations of the same species (demes) are the most appropriate units of management for conservation.

This plan has been developed in order to build on gains already made in the conservation of Whitaker's and robust skinks in the first plan, but also to formally include other species in the conservation actions. Inclusion of a wider range of species should also help in identifying where management actions may have multispecies effects. For example, restoration on Mana Island will be of benefit to McGregor's skink (*C. macgregori*), robust skink and possibly also to Whitaker's skink; restoration in the Mercury Islands has been of benefit to Whitaker's skink, robust skink, copper skinks and marbled skink; and restoration in the Hen and Chickens Islands has been for the benefit of ornate skinks (*C. ornata*), copper skinks, an undescribed species and McGregor's skinks. Specific recovery objectives are, however, listed here only for the six rarest species.

The recovery objectives include translocations of populations of skinks to islands from which introduced predators have been removed. These translocations fall within goals for ecosystem restoration identified in Atawhai Ruamano statements, the Strategic Business Plan and conservancy Conservation Management Strategies (see Sections 7 and 8: Options for Future Recovery, and Goals and Objectives). Accounts of terminology used in association with translocations, and how sites have been identified for restoration of *Cyclodina* populations in the course of this plan, are given in Appendix 2.

Taxonomic nomenclature (including tag names) used here follows Daugherty et al. (1994) and common names follow Gill and Whitaker (1996). Maori names attributable to species in *Cyclodina* are not known. Where locations in the text have alternative Maori and English names, both are provided only at first mention, thereafter one name in common use is provided.

2. Past distribution

Species in *Cyclodina* are confined to the North Island and islands immediately offshore. The southernmost populations are near Wellington city; no species in the genus is present on any islands in the Marlborough Sounds.

2.1 *Cyclodina aenea*: COPPER SKINK

Present habitat use and geographic distribution indicates that copper skinks probably occupied a wide geographic, altitudinal and ecological range through most of the North Island and on offshore islands.

2.2 *Cyclodina alani*: ROBUST SKINK

Sand dune, cave and midden deposits indicate that robust skinks inhabited lowland forest throughout much of the North Island, and on offshore islands around the north west, northeast and southwest. There is as yet no evidence that they were present on islands in the Bay of Plenty.

2.3 *Cyclodina macgregori*: MCGREGOR'S SKINK

As with robust skinks, subfossil deposits indicate that McGregor's skink was once widely distributed over the North Island from Northland to Wellington, and also probably on many of the offshore islands (Worthy 1987).

2.4 *Cyclodina northlandi* (PRESUMED EXTINCT)

This species is known only from late Holocene subfossils in caves at two locations in eastern Northland, one near Kaeo and the other near Waipu (Worthy 1991) (Fig. 1). By association with other lizard fossils and terrestrial molluscs, Worthy (1991) concluded that *C. northlandi* was an inhabitant of dense forest with high rainfall and deep litter.

2.5 *Cyclodina oliveri*: MARBLED SKINK

Marbled skinks have been identified only in cave deposits from near Kaeo in Northland. However, their continued presence on islands off the northeastern coast indicates that this species group was probably once widespread from Northland to the northern Bay of Plenty. Whether this distributional range was occupied by a range of species (perhaps including mainland populations of Mokohinau skinks), or one species showing morphological clines remains unknown.

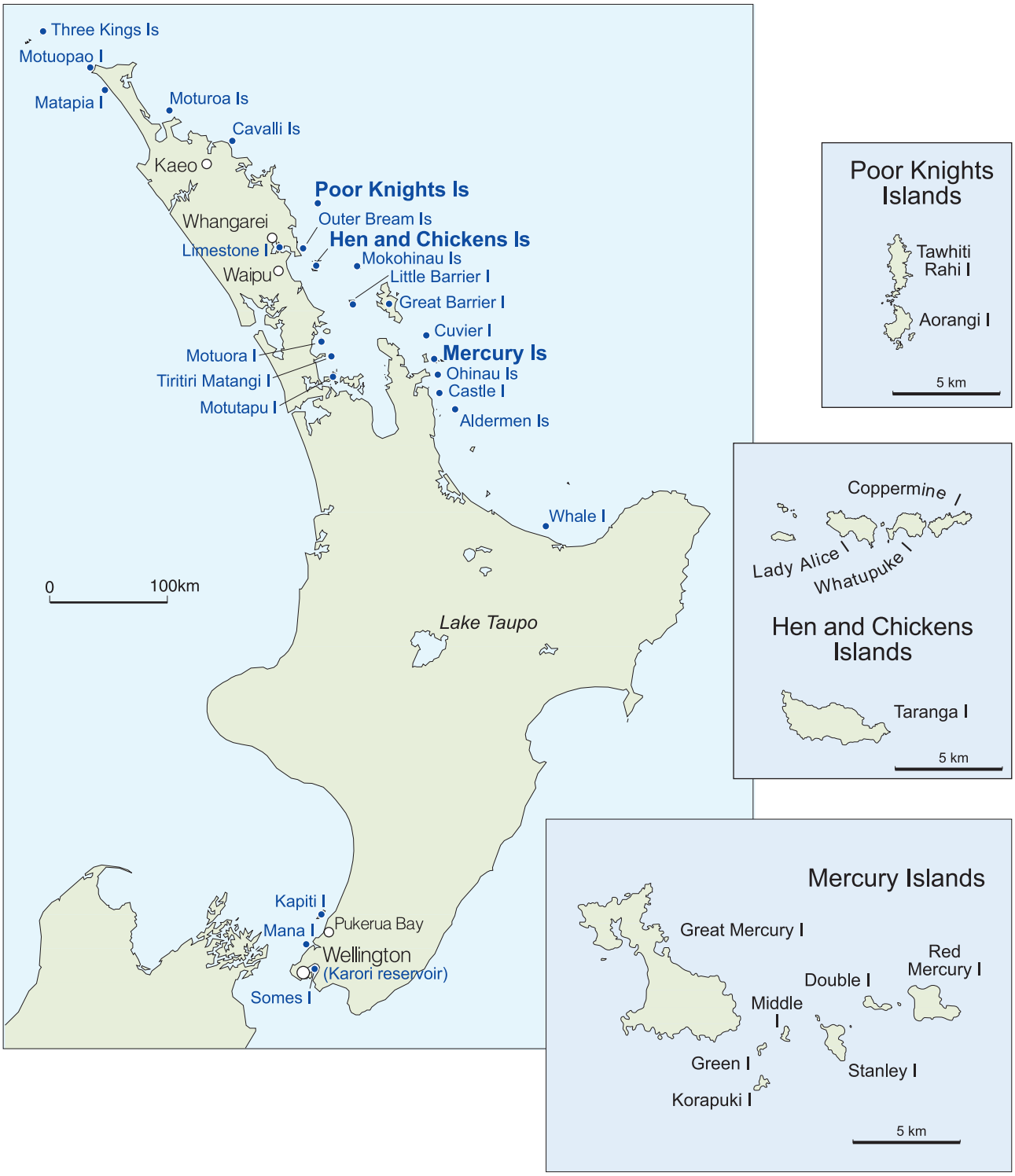


Figure 1. Localities mentioned in the text with inserts for island groups (Is) identified in bold face.

2.5.1 Poor Knights Islands form

Marbled skinks in the Poor Knights Islands are 'larger and more bulky' than those from other islands or island groups (Hardy 1977), but there is no definitive taxonomic or genetic basis for separating them from other populations (Hardy 1977, C.H. Daugherty pers comm.). The distinctively large form is confined to the Poor Knights Islands.

2.5.2 Southern populations

The smaller form of the marbled skink occupied an area from at least the Coromandel Peninsula south to the northern Bay of Plenty and possibly also Little Barrier/Hauturu and Great Barrier/Aotea Islands, islands of the Hauraki Gulf, and adjacent mainland.

2.6 *Cyclodina* n. sp. 1. 'Mokohinau Island and Chicken Islands': MOKOHINAU SKINK

The *Cyclodina* species previously attributed to *C. oliveri* in the Mokohinau Islands and Hen and Chickens is probably a separate species (Daugherty et al. 1994 citing Vos unpublished). The taxon was likely to have been widespread through both island groups and possibly onto the adjacent mainland.

2.7 *Cyclodina* n. sp. 2 'Poor Knights Islands': POOR KNIGHTS SKINK

Hardy (1977) identified several distinctive morphological characteristics of the copper skinks from the Poor Knights Islands. The distinctiveness of this population has been confirmed by genetic studies and separate species status is now proposed (Daugherty et al. 1994 citing Vos unpublished). Even if separate species status is not warranted, this is clearly a highly distinctive form confined to the Poor Knight Islands.

2.8 *Cyclodina ornata*: ORNATE SKINK

Ornate skinks were probably widespread through much of the North Island, at least at lower elevations, and on many offshore islands in the Hauraki Gulf and north of the Coromandel Peninsula.

2.9 *Cyclodina whitakeri*: WHITAKER'S SKINK

Whitaker's skink has a distributional range similar to that for the robust skink but unlike robust skinks has not been found in subfossil deposits or extant populations north of the islands of the Hauraki Gulf.

3. Present distribution

The geographic ranges of many of the species of *Cyclodina* have undergone massive declines since the arrival of humans in New Zealand. Association of lizard remains in Holocene cave deposits from Northland indicates that up to six species of *Cyclodina* once coexisted; more species than for any other section of the North Island herpetofauna (Towns and Daugherty 1994). Such sympatric species diversity no longer exists naturally anywhere in the North Island. Notes on existing sympatric associations are provided below. Data for distribution maps were derived from Pickard and Towns (1988) unless identified otherwise.

3.1 COPPER SKINK

The copper skink is one of the more common and widespread of the New Zealand lizards. The species is widely dispersed in the Wellington and Wairarapa areas but there are few reports from the area between there and the southern shores of Lake Taupo. From Taupo north there are numerous reports from the North Island and offshore islands. The exception is high altitude areas of the central North Island. High altitude areas may be beyond the physiological tolerance of the species but other apparent gaps in range are probably a reflection of relative survey effort (Figure 2, photo 1).

Copper skinks co-exist with McGregor's skinks on Mana Island, with ornate skinks on Kapiti Island, the main North Island and many of the northern offshore islands (except the Mercury Islands) and with marbled skinks on Great Barrier and Little Barrier Islands and in the Aldermen Islands. The highest sympatric diversity of *Cyclodina* skinks is in the Mercury Islands, where copper skinks co-exist with marbled skinks, robust skinks and Whitaker's skinks.

Photo 1. *Cyclodina aenea*: copper skink. A.H. Whitaker.

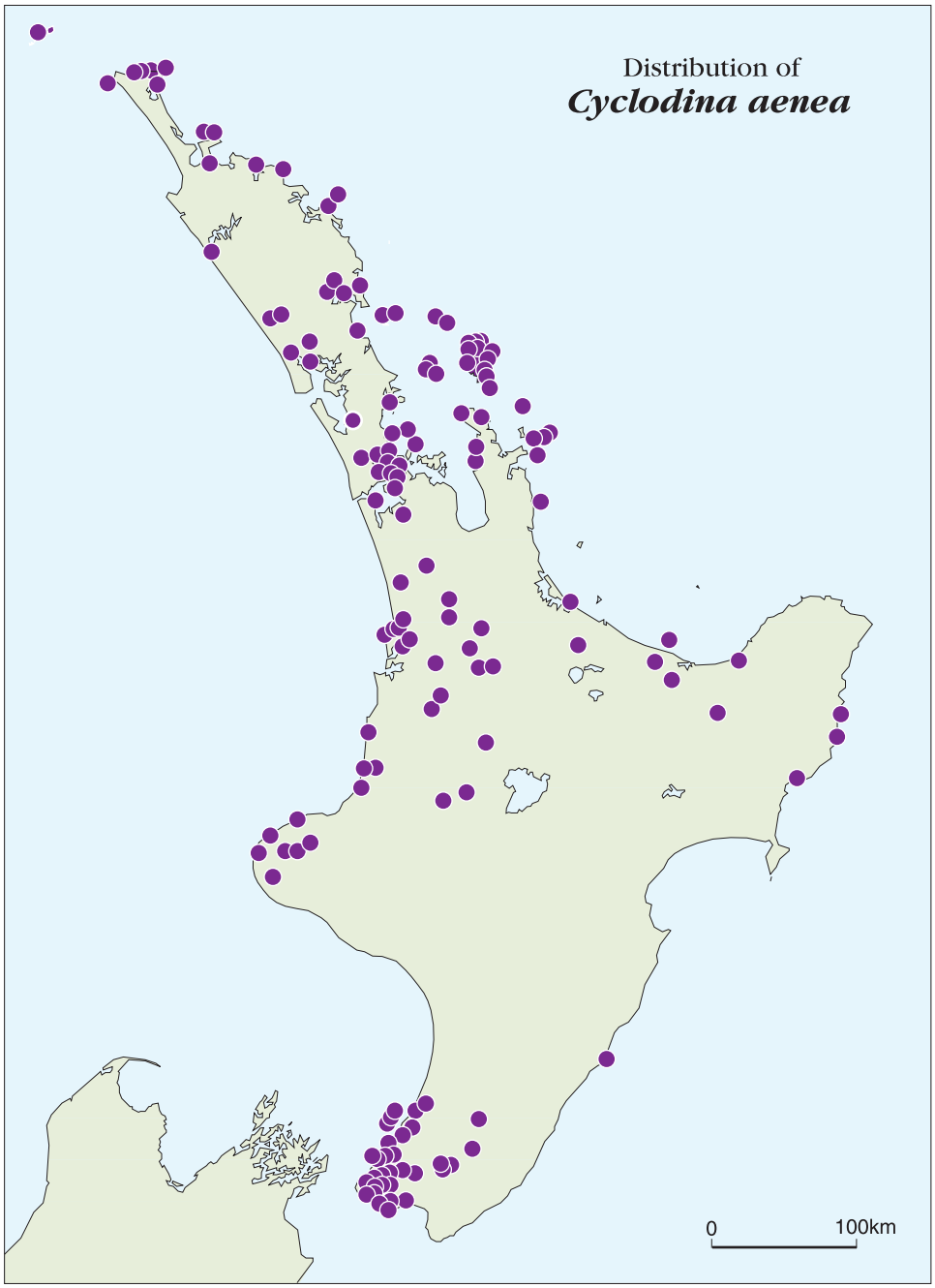


Figure 2. Distribution of populations of the copper skink, *Cyclodina aenea*.

3.2 ROBUST SKINK

Despite evidence that this species was once widely distributed through the North Island and on offshore islands, the present distribution is highly fragmentary with natural populations confined to six small islands around the northern North Island, the largest of which (Middle Island) is just 13 ha in area. Populations are present on Matapia Island (2 ha), Moturoa Island (9.5 ha), Tatapihi (Groper) Island (3 ha) in the Mokohinau Group, Middle Island and Green Island (4 ha) in the Mercury Group, and Castle Island (3 ha) (Towns 1992a, de Lange et al. 1995).

In addition to these, populations have been translocated to Korapuki Island (18 ha), Stanley Island (100 ha) and Red Mercury Island (225 ha) in the Mercury Group (Towns 1992a, 1994, Towns and Stephens 1997) and Motuopao Island (30 ha) (Parrish and Anderson in press) (Figures 1,3; photo 2).

Subfossil deposits indicate that robust skinks once co-existed with up to six other species of *Cyclodina* in the northern North Island (Towns and Daugherty 1994) and with copper and McGregor's skinks on Mana Island (Towns 1992a). Robust skinks still co-exist with ornate skinks on Matapia Island (Forester and Anderson 1995), with Mokohinau skinks and ornate skinks on Groper Island (de Lange et al. 1995) and with copper, marbled and Whitaker's skinks in the Mercury Islands (Towns 1991).

Photo 2. *Cyclodina alani*: robust skink
E.K. Cameron

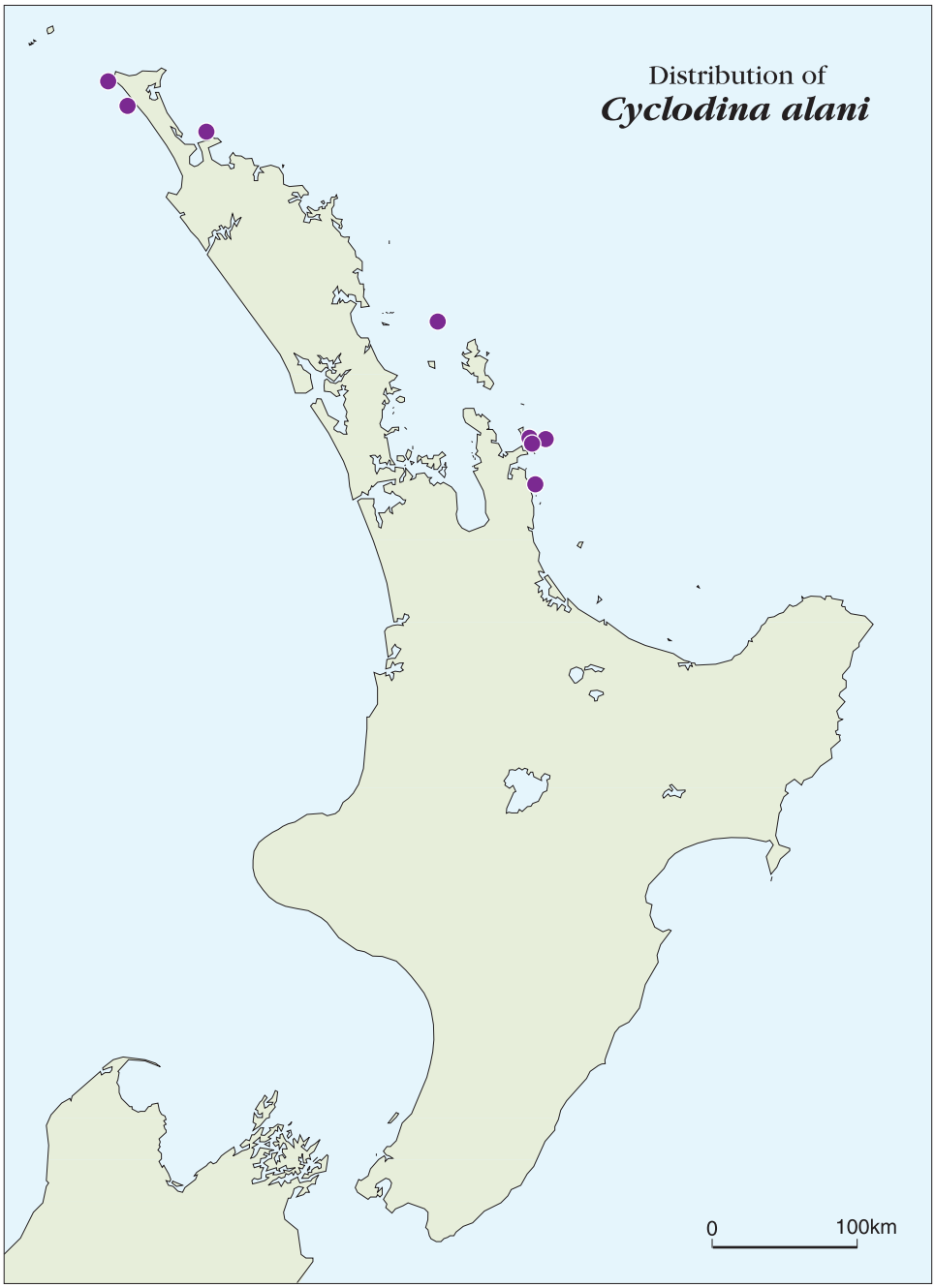


Figure 3. Distribution of populations of robust skink, *Cyclodina alani* (after Towns 1992a, 1994).

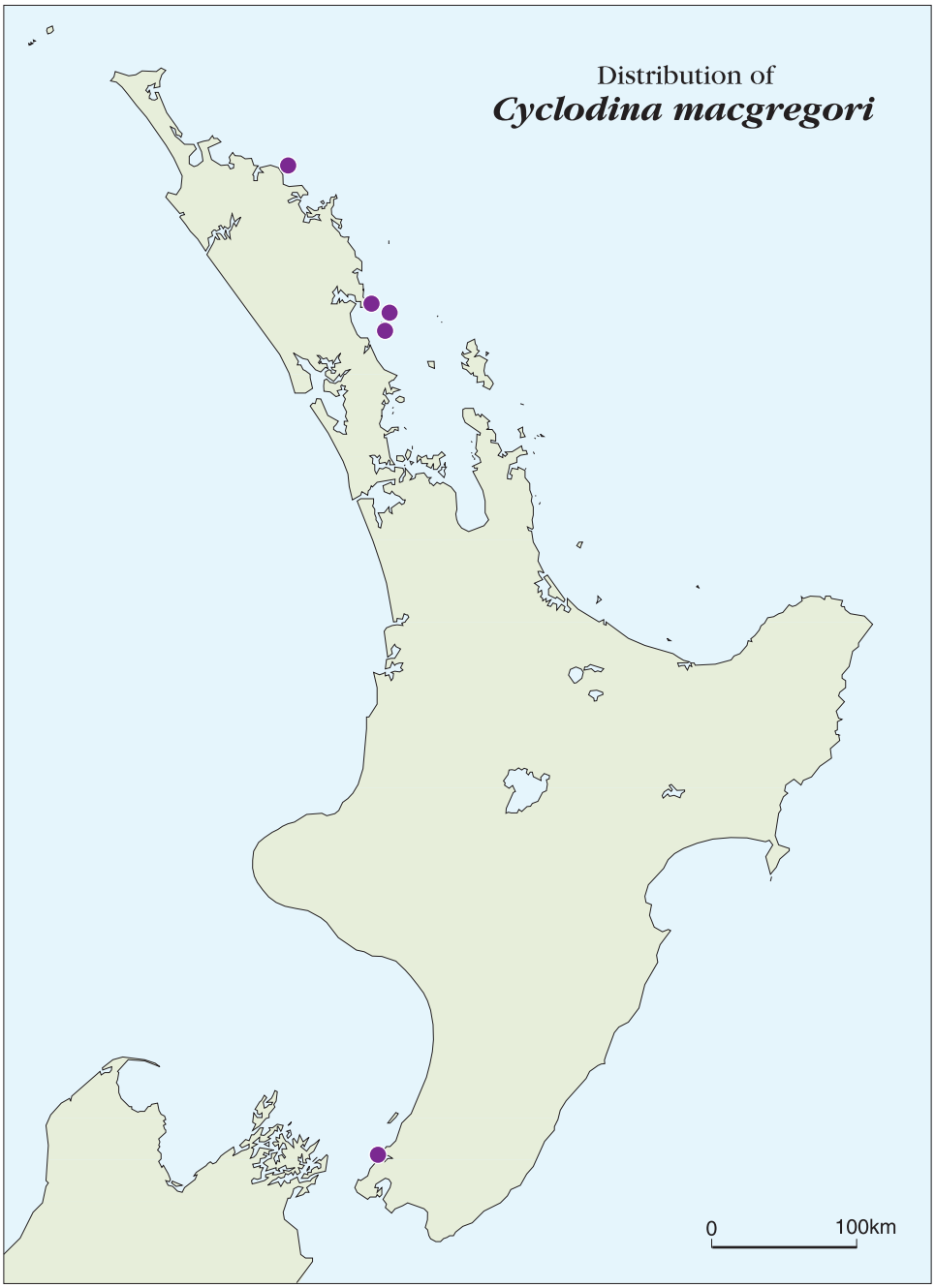
3.3 MCGREGOR'S SKINK

McGregor's skink now has an extremely fragmented distribution, with four populations known over a distance of about 500 km: Motuharakeke Island (6 ha) in the Cavalli Islands, Mauitaha Island (4.5 ha) in the Outer Bream Islands, Sail Rock (2.1 ha) in the Hen and Chickens Islands and Mana Island (217 ha) near Wellington (Figures 1,4; photo 3). A population has been translocated to Lady Alice Island (155 ha).

This species does not co-exist with other members of the genus on Motuharakeke Island or on Sail Rock, but it does co-exist with ornate skinks on Mauitaha Island (R. Parrish pers comm.) and with copper skinks on Mana Island (Newman 1994).

Photo 3. *Cyclodina macgregori*: McGregor's skink. A.H. Whitaker.

Figure 4. Distribution of populations of McGregor's skink, *Cyclodina macgregori*.



3.4 MARBLED SKINK

3.4.1 Poor Knights form

Marbled skinks have been found on six islands, including Tawhiti Rahi (163 ha) and Aorangi (110 ha) in the Poor Knights group (Whitaker 1978). Additional populations may be located on some rock stacks, but it is reasonable to assume that this form occupies most of the available habitat in the group. Other *Cyclodina* species in the group are the undescribed Poor Knights skink and ornate skink.

3.4.2 Southern populations

South of the Mokohinau Islands, marbled skinks have a scattered distribution, with restricted populations on Little Barrier Island, northern Great Barrier Island (Newman and Towns 1985), Middle, Green and possibly Red Mercury Islands (Towns 1972, Whitaker 1978), Old Man Rock (0.7 ha), and on islands in the Aldermen (except Middle Chain) (Whitaker 1978). This species has also been established on Korapuki Island in the Mercury Islands (Figures 1 and 5; photo 4).

Marbled skinks co-exist with ornate skinks and copper skinks only on Great Barrier and Little Barrier Islands. In the Mercury Islands they co-exist with copper, robust and Whitaker's skinks.

3.5 MOKOHINAU SKINK

Five populations of this taxon have now been identified. In the Mokohinau Islands they are present on Stack 'H' and Groper Rock (de Lange et al. 1995) in a combined area of 4 ha. They have not been found on any of the larger islands in the group. In the Chickens, Mokohinau skinks are present on Muriwhenua+Wareware (two islands joined by a boulder spit), Pupuha, and Middle Stack. The largest landmass is Muriwhenua+Wareware (4 ha); all

Photo 4. *Cyclodina oliveri*: marbled skink. E.K. Cameron.

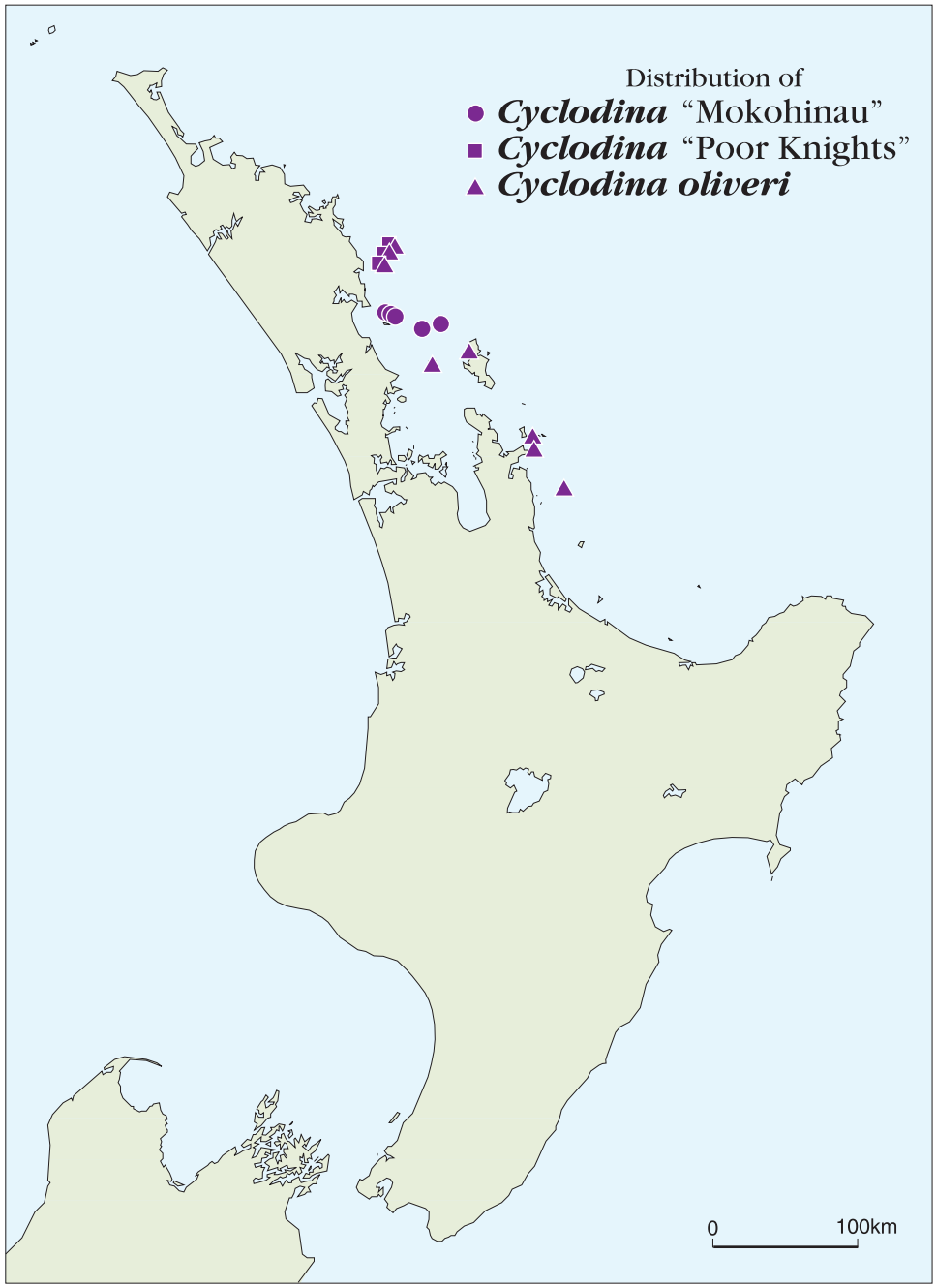


Figure 5. Distribution of populations of marbled skinks *Cyclodina oliveri* (triangles), Mokohinau skinks *Cyclodina* n. sp. 1 (circles), and Poor Knights skinks *Cyclodina* n. sp. 2 (squares).

locations combined total 5.3 ha. No natural populations have been found on any of the larger islands in the Hen and Chickens group, despite extensive suitable habitat, but they have been translocated to Lady Alice Island (155 ha) (Figures 1,5; photo 5).

Mokohinau skinks co-exist with ornate skinks and robust skinks in the Mokohinau Islands (de Lange et al. 1995) but there are no other members of the genus co-existing with Mokohinau skinks in the natural populations in the Marotere/Chickens Islands (Whitaker 1978).

3.6 POOR KNIGHTS SKINK

This species has been located on the four largest islands in the Poor Knights group and two of the smaller stacks (Whitaker 1978) (Figure 1, 5). Additional populations might be located on some of the smaller rock stacks, but present indications are that the Poor Knights skink occupies most of the available habitat in the Poor Knights group. The species co-exists with marbled skinks on at least four Poor Knights islands and with ornate skinks on Aorangi Island.

Photo 5. *Cyclodina* sp. 'Mokohinau' A.H. Whitaker.

Photo 6. *Cyclodina ornata*: ornate skink. A.H. Whitaker.

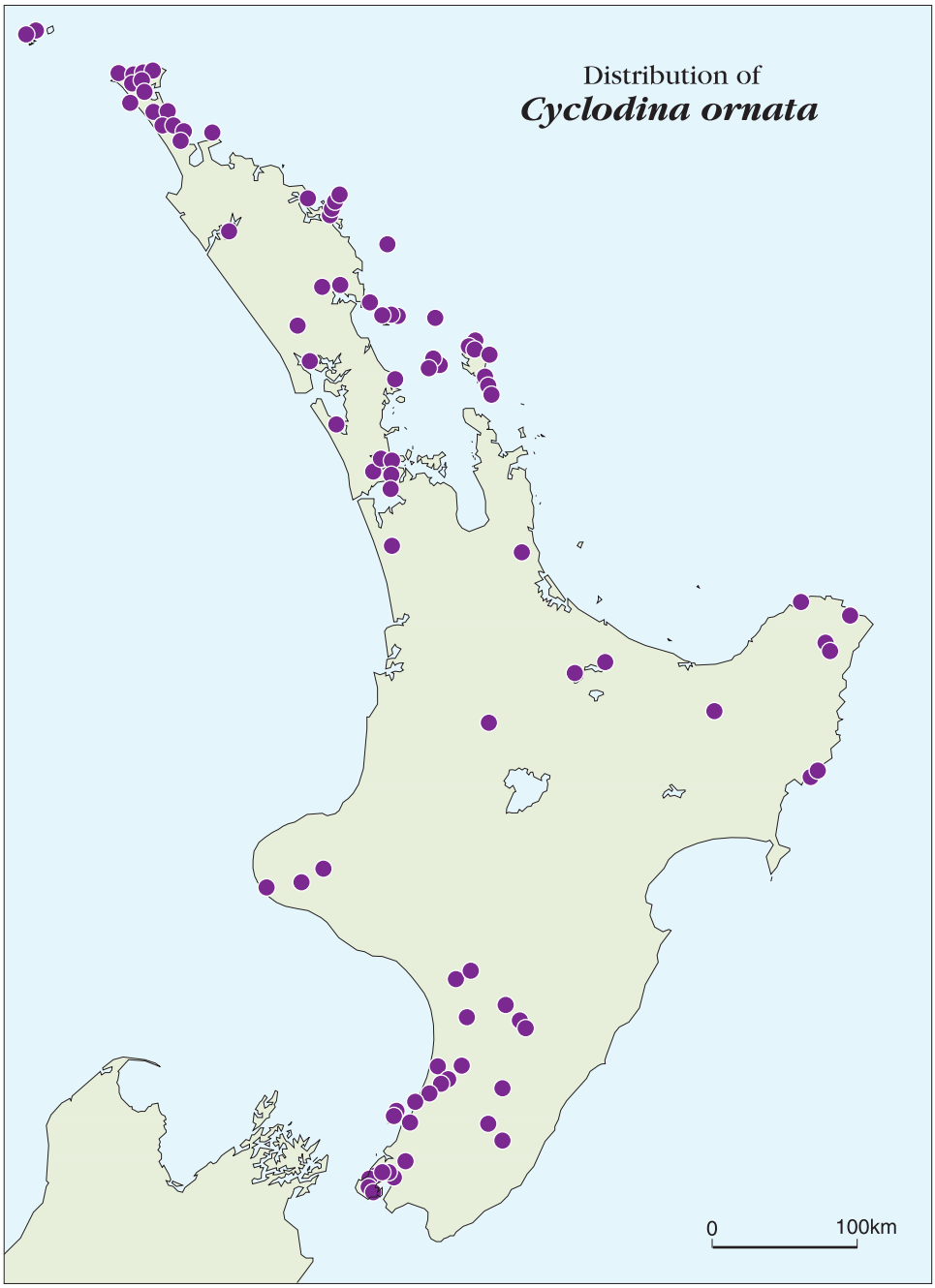


Figure 6. Distribution of populations of the ornate skink, *Cyclodina ornata*.

3.7 ORNATE SKINK

Ornate skinks are found at scattered localities from the Three Kings Islands in the north, on selected offshore islands, and throughout much of the North Island as far south as Wellington. The species is widespread on Great Barrier Island (e.g. Newman and Towns 1985), but has not been recorded from the Coromandel Peninsula (Pickard and Towns 1988) nor on any of the islands to the east of Coromandel Peninsula and in the Bay of Plenty (Figure 6, photo 6).

Ornate skinks co-exist widely with copper skinks, and at selected localities with robust skinks, Mokohinau skinks, McGregor's skinks (Outer Bream Islands) Poor Knights skinks and marbled skinks (Great Barrier and Little Barrier Islands). Ornate skinks are not known to co-exist with Whitaker's skinks in extant populations, but identification of Whitaker's skinks in midden deposits on Motutapu Island suggests that the two species once co-existed in at least a few locations (Towns and Ballantine 1993).

3.8 WHITAKER'S SKINK

The scattered relictual distribution of Whitaker's skink follows a similar pattern to that for McGregor's skink, with natural populations only on Middle Island (Mercury Islands), Castle Island (off the Coromandel Peninsula) and on the North Island at Pukerua Bay near Wellington (Figures 1,7; photo 7).

The species is now also established in the Mercury Islands on Korapuki Island and has also been translocated to Stanley and Red Mercury Islands.

Whitaker's skinks co-exist with copper skinks and/or robust skinks at two sites and on Middle Island with copper, robust and marbled skinks.

Photo 7. *Cyclodina whitakeri*: Whitaker's skink. E.K. Cameron.

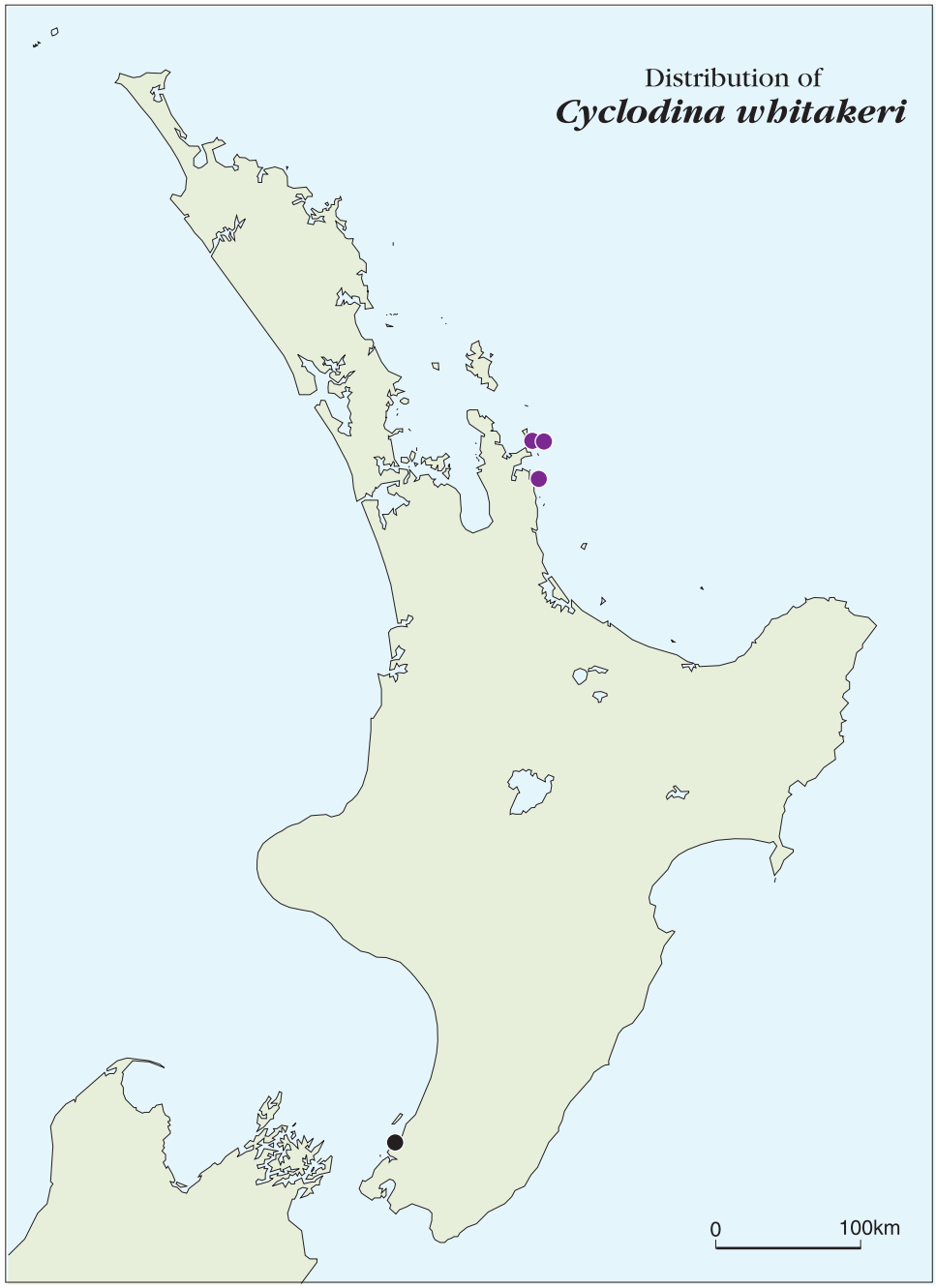


Figure 7. Distribution of populations of Whitaker's skink, *Cyclodina whitakeri* (after Towns 1992a).

4. Threats and conservation status

Comparisons between the relict distribution of many species in this genus and the present distribution of introduced mammalian predators, coupled with experimental manipulations of predator populations, indicate that most (if not all) species in this genus are sensitive to predation (e.g. Whitaker 1978, Worthy 1987, Towns and Daugherty 1994). This assertion is supported by:

- Increases in capture frequency of copper skinks following removal of kiore (*Rattus exulans*) in the Mercury Islands (Towns 1994).
- Establishment of Whitaker's skinks, robust skinks and marbled skinks on islands from which kiore have been removed (a test of the alternative hypothesis that the skinks were detrimentally affected by habitat quality) (Towns 1994 and unpublished data).
- Recorded predation of Whitaker's skinks by weasels (*Mustela nivalis*) (Miskelly 1997).
- Increased capture frequencies of ornate skinks when kiore are controlled or removed in the Marotere Islands (Towns and Parrish unpublished data).
- Shifts in distribution, demography and capture frequency of McGregor's skinks following the irruption, then removal, of mice (*Mus musculus*) from Mana Island (Newman 1994).

Conservation ratings have been determined for several species in the genus. Those species listed by the IUCN (Baillie and Goombridge 1996) are all in the 'vulnerable' category, i.e. threatened species not critically endangered or endangered, but facing a high risk of extinction in the wild in the medium term. Criteria assigned to New Zealand species include 'D', where populations are very small or restricted; '1', where populations may number less than 1000 individuals; and '2' , where the area occupied is acutely restricted (Mace and Stuart 1994). However, the IUCN criteria are applied only to species formally described. A broader view of species and range of criteria is used in the priority ranking system of Molloy and Davis (1994) where species of *Cyclodina* are ranked A (highest priority) through C (lowest priority) (Table 1).

4.1 COPPER SKINK

This species appears to be sensitive to predation by rodents, with capture frequencies depressed during irruptions of mice on Mana Island and at Pukerua Bay (Newman 1994, Towns and Elliott 1996). However, their local abundance and widespread distribution indicates that copper skinks are not under threat.

Copper skinks are not ranked on current conservation priority lists.

TABLE 1. SUMMARY OF TAXONOMIC RELATIONSHIPS AND CONSERVATION STATUS OF SPECIES IN *Cyclodina*. DATA ON TAXONOMY FROM HARDY (1977), C.H. DAUGHERTY (PERS. COMM.), CONSERVATION PRIORITIES FROM MOLLOY AND DAVIS (1994) AND IUCN CONSERVATION STATUS FROM BAILLIE AND GOOMBRIDGE (1996).

TAXONOMIC CATEGORY	MOLLOY AND DAVIS CATEGORY	IUCN CATEGORY
Copper skink group		
Copper skink: *C. aenea* Girard	Nil	Nil
Poor Knights skink: *Cyclodina* n.sp.2	C (L)	Nil
Robust skink: *C. alani* (Robb)	B	Threatened
McGregor's skink: *C. macgregori* (Robb)	B	Threatened
Marbled skink group		
Poor Knights marbled skink: *C. oliveri* (McCann)	Nil	Nil
Southern marbled skink: *C. oliveri*	Nil	Nil
Mokohinau skink: *Cyclodina* n.sp.1	A	Nil
Northland skink: *C. northlandi* Worthy	Ex[1]	Nil
Ornate skink: *C. ornata* (Gray)	Nil	Nil
Whitaker's skink: *C. whitakeri* Hardy	B	Threatened

[1]Presumed extinct

4.2 ROBUST SKINK

The reduction in range of all populations of robust skinks to locations free of introduced mammalian predators is an indicator of the sensitivity of this species to predation (Towns and Daugherty 1994). The remaining six natural populations are on small islands, only three of which are gazetted reserves on public land where access can be controlled. One of the two locations in Maori ownership—Matapia Island—is, however, protected by extreme inaccessibility.

Robust skink is presently ranked as **Threatened** (VU D1+2) by IUCN (Baillie and Goombridge 1996) and as **Category B** in Molloy and Davis (1994).

4.3 MCGREGOR'S SKINK

Like the robust skink, this species was until recently restricted only to islands free of introduced mammalian predators other than mice. The northern-most population, on the Cavalli Islands, is on land in Maori ownership; the remaining three populations are on public land.

McGregor's skink is ranked as **Threatened** (VU D2) by IUCN (Baillie and Goombridge 1996) and as **Category B** in Molloy and Davis (1994).

4.4 MARBLED SKINK

Marbled skinks follow a similar distribution pattern to other species of *Cyclodina* vulnerable to introduced predators: of 16 known populations on islands only two (Great Barrier and Little Barrier) co-exist with introduced mammals. The populations on Great Barrier and Little Barrier Islands are both confined to deep boulder banks consistent with habitat displacement due to predator pressure (Newman and Towns 1985, T. Greene pers. comm.).

4.4.1 Poor Knights form

Because all of the islands in the Poor Knights group are less than 500 m apart, each island is vulnerable to the arrival of Norway rats (*Rattus norvegicus*) or ship rats (*R. rattus*) on any other island. If not intercepted early, an invasion of either one of these species could result in the loss of this distinctive marbled skink population.

4.4.2 Southern populations

These populations are under less threat than those on the Poor Knights Islands because the 10 populations are scattered over a wide geographic range. However, their relative vulnerability might increase proportionally if later studies (for example on the Great Barrier and Little Barrier Island populations) indicate further divergence within the group.

Marbled skinks are not ranked on current conservation priority lists.

4.5 MOKOHINAU SKINK

None of the five scattered islands occupied by this species is larger than 4 ha, so all natural populations are vulnerable to disturbance (either natural or human-induced). In addition, the populations in the Mokohinau Islands can be distinguished from those in the Marotere Islands (C.H. Daugherty pers. comm.). If the Marotere and Mokohinau populations are treated as two separate groups, the two small Mokohinau populations should be regarded as highly vulnerable to disturbance.

This taxon is not ranked by the IUCN, but is ranked **Category A** in Molloy and Davis (1994).

4.6 POOR KNIGHTS SKINK

Like the Poor Knights form of the marbled skink, this species is highly vulnerable to invasions of rats.

The species is not ranked by IUCN, but is ranked **Category C (L)** in Molloy and Davis (1994).

4.7 ORNATE SKINK

Porter (1987) regards the present distribution of ornate skinks on the North Island as consistent with a species confined to refuge habitats following habitat destruction and disturbance by introduced predators. The response of ornate skinks to removal of rats from the Marotere Islands supports this view. However, the species is still widespread and has not undergone the dramatic declines recorded elsewhere in the genus.

Ornate skinks are not currently ranked on any conservation priority lists.

4.8 WHITAKER'S SKINK

All three natural populations of Whitaker's skink should be regarded as highly vulnerable to disturbance. The largest population, on Middle Island, is in an area of relatively sheltered waters heavily used for recreational and commercial fishing and diving. There is therefore an attendant risk of an escape of rodents onto the island through illegal landings. The population on Castle Island is not on gazetted public land, and the tiny population at Pukerua Bay is under constant threat from fire and introduced predators (Towns and Elliott 1996).

Whitaker's skink is presently ranked as **Threatened** (VU D1+2) by IUCN (Baillie and Goombridge 1996) and as **Category B** in Molloy and Davis (1994).

5. Ecology of species in *Cyclodina*

5.1 COPPER SKINK

Copper skinks may be crepuscular or diurnal (Porter 1987). Before the arrival of Maori, this species may have been most abundant in marginal or ecotonal habitats such as forest perimeters, scrubland (Porter 1987), and coastal scrub (Towns and Elliott 1996). They now use a wide range of habitats including long grass, compost heaps, urban gardens, native forest, open rocky sites and coastal habitats (Porter 1987, Towns 1992b, Towns 1994, Towns and Elliott 1996). Copper skinks may also have benefited from reduction in the range of larger *Cyclodina* species (Porter 1987). This suggestion is supported in the Mercury Islands, where copper skinks are rare on Middle Island in the presence of other species of *Cyclodina*, but have become abundant on Korapuki Island following the eradication of rats and rabbits and in the absence (until recently) of other members of the genus (Towns 1994).

5.2 ROBUST SKINK

Robust skinks are strongly nocturnal and live under rocks, or in seabird burrows, tree stumps and fallen logs, generally in well vegetated areas where there are accumulations of leaf litter. They can also occupy coastal areas as long as there is a dense cover of vegetation. Studies on cutaneous water loss by robust skinks (A. Cree, C.H. Daugherty and D.R. Towns unpublished) indicated an unusually high propensity to lose water through the skin. Robust skinks may use damp environments such as crevices, bird burrows, rotting logs and closely matted vegetation as retreats in order to minimise this evaporative loss.

5.3 MCGREGOR'S SKINK

This species is apparently active in the early morning and late evening in coastal scrub or forest, often in areas heavily burrowed by seabirds (Robb 1986). At two sites—Sail Island and Mana Island—the lizards are present in bouldery areas where they are insulated from extremes of temperature and where moisture levels remain high (Newman 1994). In view of symptoms of heat stress displayed by the animals when handled (Newman 1994), McGregor's skinks may be prone to high rates of cutaneous water loss.

5.4 MARBLED SKINK

5.4.1 Poor Knights form

Marbled skinks were recorded as abundant on four of the five larger islands in the Poor Knights group (Whitaker 1978), where they forage at night in forest wherever there is leaf litter. Occasionally they appear during the day to forage under conditions of low light intensity (A.H. Whitaker pers. comm.), but usually they spend the day underneath logs and stones or in petrel burrows (Whitaker 1968).

5.4.2 Southern populations

Marbled skinks in the Mercury and Aldermen Islands appear to be largely nocturnal (Hardy 1977) but they may also forage during the day (Robb 1986). They are found most frequently in forest, but can occupy areas of low scrub on small islands densely inhabited by burrowing seabirds.

5.5 MOKOHINAU SKINK

In the Mokohinau Islands the Stack 'H' population was regarded as abundant by Whitaker (1978), but only two adults have been found on Tatapihi (Groper) Island (de Lange et al. 1995). At both localities the extent of shrubby vegetation cover available for these lizards is extremely limited. However, both islands are heavily burrowed by diving petrels (*Pelecanoides urinatrix*), the burrows of which may form an important refuge for the lizards. In the Marotere Islands these skinks are present amongst boulders under low scrub and *Muehlenbeckia*, but they also inhabit areas densely burrowed by small seabirds, including fluttering shearwaters (*Puffinus gavia*).

5.6 POOR KNIGHTS SKINK

Whitaker (1968) found this species to be crepuscular, but occasionally active by day and most common where there was ground cover near flax and scrub. Population densities were assessed as low (Whitaker 1968), with overall encounter rates identified as 'frequent' (Whitaker 1978).

5.7 ORNATE SKINK

Porter (1987) found that ornate skinks may be diurnal, but trapping programmes elsewhere in forest (e.g. Marotere Islands and Great Barrier Island) suggest that ornate skinks are either crepuscular or nocturnal (Towns unpublished data). The species may therefore have flexible activity periods. Before the arrival of Maori in New Zealand, ornate skinks may have been occupants of forest areas, rock piles and other areas of stable thermal character, but have since become largely confined to habitat refuges providing the right microhabitat features and protection from predation (Porter 1987).

5.8 WHITAKER'S SKINK

This species is crepuscular/nocturnal, often being most active soon after dark. Whitaker's skinks forage within seabird burrow complexes and boulder banks, emerging onto the surface infrequently (Towns and Elliott 1996). Captures in the Mercury Islands and at Pukerua Bay indicate that the species is active over a narrow temperature range of 14–22 °C (Towns 1994, Towns and Elliott 1996), and occupies sites where relative humidity is high (near saturation). These habits are consistent with reported high rates of cutaneous water loss (A. Cree, C.H. Daugherty and D.R. Towns pers comm.). Productivity of female Whitaker's skinks appears to be amongst the lowest recorded in the genus, but this may be offset by females living for up to 20 years (Towns 1994 and unpublished data).

6. Species recovery to date

The previous recovery plan provides detailed objectives only for Whitaker's and robust skinks (Towns 1992a). However, there have been recovery actions undertaken for other members of the genus under objectives identified in Conservation Management Strategies and Conservation Action Plans. These actions are reviewed under sections 6.1 to 6.3 below.

6.1. GOAL AND OBJECTIVES OF THE FIRST RECOVERY PLAN

The goal of the first plan was: '*To maintain and enhance existing populations of Whitaker's and robust skink, and to improve their conservation status by establishment of at least three new populations of both species by the year 2000.*' The goal was to focus on ecological restoration, especially in the Mercury Islands Ecological District, and include a community approach to enhancement of invertebrates, lizards and tuatara (Towns 1992a, p. 17).

This goal was supported by eight objectives. These are identified below with an assessment of their progress.

6.1.1 Eradicate rodents from large islands

Required development of techniques for effective use of rodenticide on islands of greater than 50 ha.

Status:

Introduced rodents, kiore (*Rattus exulans*) have now been successfully removed from all of the public lands in the Mercury Islands Ecological District, including Red Mercury Island (225 ha) (Towns et al. 1993, 1994, 1995). This has increased the area of islands freed from introduced predators from 50 ha when the plan was drafted to 556 ha now. The objective has been completed.

Identified outcomes:

- Release invertebrates from predation by kiore (see invertebrate project below).
- Provide large islands with habitat suitable for Whitaker's and robust skinks. Stanley Island was declared rabbit- and rodent-free in 1993 and Red Mercury Island rodent-free in 1994.

6.1.2 Determine strategies for translocation and monitoring of Whitaker's and robust skinks

Status:

This objective is ongoing.

A five-year study of translocation methods began in 1993. The study has identified successful breeding and an expanding population of Whitaker's skinks on Korapuki Island. There has been no need to add additional Whitaker's skinks from Middle Island to this population.

Identified outcomes:

- Protocols for translocation and monitoring of rare lizards. These have been developed and are being tested with a range of species (e.g. Towns 1994).
- Establishment of new populations of robust skink on Korapuki Island and Double Island. Robust skinks from Green Island were translocated to Korapuki Island in 1992/93. This group has been closely monitored, but it is too early to claim that they are established on Korapuki Island.
- Whitaker's and robust skink translocations to Double Island have been put on hold (to allow for possible management of tusked weta), but once rodents were removed, both species were translocated to Red Mercury Island (November 1994 to March 1995) and to Stanley Island (November 1995).

6.1.3 Determine rate and form of invertebrate recovery, and role as food sources for lizards

Status:

This objective is ongoing, and has received funding through special Threatened Species allocations starting in 1995.

Identified outcomes:

- Identify community structure of invertebrates. Extensive collections of litter invertebrates have been obtained, and some analyses have been conducted.
- Deficiencies in invertebrate communities identified and remedied. A new project releasing Auckland tree weta (*Hemideina thoracica*) from Double Island onto Korapuki Island is identifying methods for re-establishment of invertebrates.

6.1.4 Determine vulnerability of Whitaker's and robust skinks to extinction

This project was to have tested in the field the results of laboratory studies on vulnerability of rare *Cyclodina* species to evaporative water loss.

Status:

Identified in the recovery plan as of low priority. Not undertaken.

6.1.5 Maintain captive populations of Whitaker's and robust skinks

Required establishment of viable breeding populations of Whitaker's and robust skinks in captivity for later release in the wild. Identified in the recovery plan as an option for the Pukerua Bay population of Whitaker's skinks where the animals are in low numbers and vulnerable to disturbance.

Identified outcomes:

- Whitaker's skinks in captivity. There is no self sustaining population in captivity. To date, lack of certainty over future locations for new populations of Pukerua Bay Whitaker's skinks has meant there has been no incentive to proceed with captive breeding.
- Robust skinks in captivity. There are three populations of robust skinks originating from Castle Island and Moturoa Island in captivity. The Motuora population is at least self-sustaining.

6.1.6 Protect populations on land outside Crown control

Required to establish dialogue with iwi Maori over management partnerships on Matapia Island and Moturoa Island (Northland), and clarification of the tenure of Castle Island (Waikato).

Status:
Ongoing.

Identified outcomes:
- Dialogue with Maori tribal authorities in Northland. Has resulted in co-operation over management of the robust skink population on Matapia Island, but has yet to make progress with iwi over access to Moturoa Island.
- Restoration in Ohinau Islands. A close working relationship has developed between Ngati Hei and Waikato Conservancy, but restoration of the islands for rare reptiles is not regarded as a high priority.
- Protection of Castle Island. This was identified as a high priority task to be achieved within two years. There has been little progress so far and this may have implications for future projects in other locations (e.g. robust skinks for Mana Island).

6.1.7 Management of populations of Whitaker's skink at Pukerua Bay

Required provision of management regime for the Crown reserve, an administration agreement with Porirua City Council over a Council paper road that covers much of the skink habitat, a co-management agreement so that the Council and Crown reserves are managed compatibly, and gazettal of the Crown reserve.

Status:
Ongoing.

Identified outcomes:
- Management strategy for Pukerua Bay. This site is now identified as a 'Key Place' in the Wellington Conservancy Conservation Management Strategy (CMS) (1996).
- Administration agreement with Porirua City Council. No formal agreements.
- Reserve category and gazettal. The Crown area is now designated as Scientific Reserve.
- Account of management options for resident lizard community. Provided by Towns (1992b) and in published form by Towns and Elliott (1996).

6.1.8 Promote public interest in recovery of Whitaker's and robust skink and in community restoration

Proposed fostering interest in the Pukerua Bay reserve by establishing a network of local guardians, linkage between recovery of Whitaker's and robust skinks and recovery of tuatara, and involvement of public in restoration in the Mercury Islands Ecological District.

Status:
Ongoing.

Identified outcomes:

- Pukerua Bay local interest and guardians. A network of guardians is yet to be promoted.
- Linkage with tuatara recovery. Successfully used in the Mercury Islands where a sponsorship agreement with ICI Crop Care Division to rescue declining tuatara populations moved towards ecological restoration as the main goal. This project has received coverage from television and a wide range of printed media (Towns and Stephens 1997).
- Involvement of public in restoration of Mercury Islands Ecological District. This has included tours of iwi to the islands and a series of successful guided tours to Stanley Island as part of the Waikato Conservancy Summer Programme. The summer programmes have since been terminated.

6.2. OTHER MANAGEMENT

Removal of introduced predators from islands other than those identified in previous recovery plan, and additional research, has enabled the following initiatives for species in *Cyclodina*:

- Confirmation of the successful removal of mice from Mana Island and subsequent increased capture frequency of McGregor's skink.
- Research on the identity and relative abundance of predators of lizards at Pukerua Bay.
- Translocation of 25 marbled skinks from Green Island to Korapuki Island in 1992–1993 as part of the research project on translocation protocols. This population is now successfully breeding.
- Translocation of 30 Mokohinau skinks from Muriwhenua Island to Lady Alice Island. This project began in March 1997 and was completed in March 1998.
- Translocation of 30 robust skinks from Matapia Island to Motuopao Island in May 1997 as part of a restoration project for the island following the removal of kiore in 1990.
- Translocation of 39 McGregor's skinks from Sail Rock to Lady Alice Island. This project began in December 1997 and was completed in March 1998 as part of the planned restoration of islands from which kiore have been removed in Taranga Ecological District.
- Discovery of a hitherto unknown population of robust skinks on Tatapihi (Groper) Island in the Mokohinau Islands (de Lange et al. 1995).
- Initiation of predator control at Pukerua Bay in 1998.

6.3 SUMMARY OF MANAGEMENT AND RESEARCH TO DATE

- The rodent eradication targets identified in the original recovery plan were not only exceeded in the Mercury Islands, they have provided the springboard for many other successful campaigns within the known range of these species (see Options for Future Recovery below).
- The goal of establishing three new populations each of Whitaker's skink and robust skink may have been met; Whitaker's and robust skinks now are present on Korapuki, Stanley and Red Mercury Islands. However, research on the Korapuki Island populations has shown that the intrinsic rate of increase in these lizards is so low, it may be several years yet before successful establishment of all of these populations can be determined.
- Achievement of the original goal was estimated to increase the potential area occupied for each species over that known in 1988 by 990% for Whitaker's skink and 570% for robust skink. However, by including translocations to Red Mercury and Motuopao Islands, the target reached exceeds the preferred option and is close to the 10 year goal of 2500% for Whitaker's skink and 1275% for robust skink.

7. Options for future recovery

The goals identified in Atawhai Ruamano Conservation 2000 (Anon. 1993) present a particular challenge for species recovery programmes: single species management is not just viewed as recovery of the species. 'The aim is for restoration of the species within its ecosystem.' The Strategic Business Plan (Anon. 1998) identifies two 'key steps' that relate to species recovery: (1) '... policies and plans that integrate species protection and ecosystem conservation work...' and (2) '... restoration of high priority offshore and mainland island ecosystems and advancing recovery programmes for threatened species in accordance with an integrated approach to management ...' (p. 10). There are at present more opportunities for attaining these ideals on islands, where many pest organisms can be removed, than on the mainland, where at best they can be controlled for restricted periods and areas. Since the present recovery plan for *Cyclodina* is largely island based, it provides an opportunity to examine the following implications of species management in the context of ecosystem restoration:

- The identification of species combinations that have been lost but can be re-established through ecological restoration. An example is the release of McGregor's skink on Lady Alice Island, where it will be the only population of the species sympatric with Mokohinau skink.
- The identification and reinstatement of processes of interaction (such as natural predation) that may have been lost, and which under single species goals might have been controlled to maximise the biomass of the threatened species. One example is a proposal to reintroduce tuatara to Korapuki Island, even though they are likely to be natural predators of Whitaker's and robust skinks (Thomson et al. (1997) unpublished Conservation Action Plan for Mercury Islands Ecological District).
- Reduced need to spread threatened species widely to minimise risk, but an increased need to minimise risks that may locally affect whole ecosystems. An example is the need to carefully manage risks of rodent invasion in the Poor Knights Islands to protect a distinctive local form and an endemic species of *Cyclodina*.

Campaigns against introduced predators (especially rodents) provide unprecedented potential for increased abundance of *Cyclodina* species resident on islands, as well as enabling significant expansions into their former range for species confined to small relict populations. Locations therefore included in recovery options are Mana Island, Kapiti Island, islands in the Hauraki Gulf and the Marotere Islands.

Options for recovery are developed below separately for the rarer species or unusual forms in *Cyclodina* and summarised in Table 2.

TABLE 2. SUMMARY OF PREFERRED (FIVE YEAR) OPTIONS FOR RECOVERY OF RARE SPECIES OF *Cyclodina* WITH LINKAGE TO RELEVANT OBJECTIVES IN SECTION 8. I = ISLAND, Is = ISLANDS.

SPECIES	PREFERRED OPTION	TEN YEAR GOAL	RELEVANT OBJECTIVES
Robust skink	• Protection of Castle I population. • Restoration in Ohinau Is. • Monitoring translocations. • Pest prevention. • Translocation to Mana I, Marotere I. • Restoration plan, Mokohinau Is. • Plan for reintroduction to Cuvier I (if appropriate).	• Reintroduce to Double I. • Reintroduce to Tiritiri Matangi, Motuora I. • Plan for reintroduction to Hen I and Little Barrier I after removal of kiore. • Plan for reintroduction to Kapiti Island.	1,2,3,5,6,8.9,10,11,12
McGregor's skink	• Pest prevention. • Reintroduction to Lady Alice I, Whatupuke I. • Plan for reintroduction to Kapiti I. • Assess Cavelli Is for new sites.	• Plan for reintroduction to Hen I, Little Barrier I, after removal of kiore. • Plan for eradication of kiore from Motukawanui I.	1,2,8,9,11
Marbled skink	• Pest prevention • Monitor translocations. • Establish identity of Great Barrier I and Little Barrier I populations. • Plan for reintroduction to Cuvier I, Stanley I, Middle Chain I. • Survey Red Mercury I. • Plan for removal of kiore from Little Barrier I.	• Reintroduce to Tiritiri Matangi, Motuora Is. • Reintroduce to Double I.	1,2,8,9,11
Mokohinau skink	• Reintroduce to Whatupuke I, Coppermine I. • Reintroduce to one other Mokohinau Is.	• Plan for reintroduction to Hen I following removal of kiore. • Reintroduce to additional Mokohinau Is.	1,2,3,5,6,8,11
Poor Knights skink	• Pest prevention. • Survey.		1,8
Whitaker's skink	• Protection of Castle I population • Restoration of Ohinau Is. • Monitor translocations. • Pest prevention. • Manage Pukerua Bay. • Translocate to Mana I. • Plan for reintroduction to Cuvier I (if appropriate).	• Reintroduce to Double I. • Reintroduce to Tiritiri Matangi I, Motuora I. • Assess Kapiti I, Somes/Matiu I.	1,3,6,7,8,9,10,11,12

7.1 ROBUST SKINK

Option 1

Do nothing more than is identified in the previous recovery plan. This would:

- Require continued efforts to locate owner(s) and protect Castle Island.
- Maintain relationships with Ngati Hei with a view to eventual restoration of robust skinks and other herpetofauna in the Ohinau Islands.
- Require periodic (at five-year intervals) assessments of the status of released populations on Korapuki, Stanley and Red Mercury Islands.
- Require pest prevention measures maintained for all locations.
- Enable continued expansion of the new Korapuki, Stanley and Red Mercury Island populations.

Option 2

As in Option 1, but in addition, proceed with proposed translocations to islands cleared of rodents as follows:

- Undertake planned reintroduction to Mana Island from Castle Island within two years.
- Develop five-year plan for translocation to at least one other island in the Mokohinau Group from which rats have been removed.
- Establish the species on at least one island in the Marotere Group (probably Lady Alice or Coppermine) within five years of removal of kiore.

Option 3

As in Option 2, but:

- Continue with planned release on Double Island, following establishment of tusked weta.
- Plan for translocations to Hen/Taranga Island and Little Barrier Island depending on approval to remove kiore.
- Proceed with translocation to Tiritiri Matangi Island and/or Motuora Island as identified in restoration plans (Hawley 1997a,b), but following assessment of the impacts of ground-dwelling birds (pukeko, *Porphyrio porphyrio*; takahe, *P. mantelli;* and kiwi, *Apteryx* spp.). This may be a long-term option that requires development of dense plant cover as protection from birds.
- Assess the practicality of reintroducing robust skinks to Kapiti Island in the presence of weka (*Gallirallus australis*).

Preferred option

The option chosen for the first five years of this plan is Option 2. This option would increase the number of populations from six (as at the beginning of the previous plan) to at least 12 and extend the area occupied from c. 39 ha in 1992 to at least 700 ha of potential habitat by 2005. Option 3 provides realistic long-term goals that could be met within 10 years of acceptance of this plan, but depends partly on successful removal of kiore and other rodents from large islands with difficult terrain.

7.2 MCGREGOR'S SKINK

Option 1

Do nothing more. This would:

- Maintain the number of populations at four, one of which is not in public ownership.
- Recognise that the species will continue to extend its range into suitable habitat on Mana Island for many decades. This is provided that other wildlife management activities do not jeopardise the population (e.g. Atkinson 1990, 1991, Miskelly 1999).
- Require periodic (five-yearly intervals) assessments of the population released on Lady Alice Island in 1998.
- Require continued effective pest prevention measures are maintained at all localities on public land.
- Leave the Motuharakeke population at risk of disturbance.

Option 2

As in Option 1, but in addition, proceed with proposed translocations to islands cleared of rodents as follows:

- Release on Whatupuke Island within five years once removal of kiore from Coppermine Island (a potential source of kiore reinvasion) is confirmed.
- Assess the practicality of translocation from Mana Island to Kapiti Island in the presence of weka and following surveys for any surviving resident populations of McGregor's skink on Kapiti Island.
- Assess additional islands in the Cavalli Group as future locations.

Option 3

As in Option 2, but:

- Plan for translocations to Hen Island and Little Barrier Island following removal of kiore.
- Plan for eradication of kiore from Motukawanui Island (Cavalli Islands) as a prelude for restoration including McGregor's skinks from Motuharakeke Island.

Preferred option

The option chosen for the first five years of this plan is Option 2. This option would increase the number of populations from four to at least six (some of which could become very large) and extend the area occupied from 230 ha to at least 480 ha of potential habitat. Option 3 provides realistic long-term goals that could be met within 10 years of acceptance of this plan, but depends on removal of kiore from large islands with difficult terrain (Hen Island and Little Barrier Island) and removal of kiore from one island not at present identified as a priority in the Northland Conservancy CMS (1995) (Motukawanui).

7.3 MARBLED SKINK

Option 1

Do nothing more. This would:

- Leave identity of the Great Barrier Island and Little Barrier Island populations unclear.
- Require continued maintenance of pest prevention measures on island Nature Reserves in the Poor Knights Islands, Mercury Islands and Aldermen Islands.
- Enable continued expansion of marbled skinks on Korapuki and Red Mercury Islands (if resident on the latter). For expansion to be confirmed, periodic population monitoring will be required.

Option 2

As in Option 1, but confirm identity of all populations and proceed with translocations to islands cleared of rodents as follows:

- Undertake genetic studies to clarify the identity of populations on Great Barrier and Little Barrier Islands.
- Release on Cuvier Island if future surveys fail to reveal their presence.
- Translocate from Middle Island to Stanley Island in the Mercury group if future surveys fail to reveal their presence.
- Translocate from a selected island(s) in the Aldermen to Middle Chain Island if future surveys fail to reveal their presence on Middle Chain Island.
- Survey to investigate the presence of a resident population on Red Mercury Island.
- Plan for removal of kiore from Little Barrier Island.

Option 3

As in Option 2, but:

- Translocate to Tiritiri Matangi and/or Motuora Islands as identified in restoration plans (Hawley 1997a,b) and subject to studies on the effects of ground feeding birds.
- Translocate to Double Island following establishment of tusked weta and if future surveys fail to reveal the presence of a resident population.

Preferred option

The option chosen for first five years of this plan is Option 2. This option would add at least four populations of marbled skinks to islands within their historic range. Option 3 is a realistic long-term goal which could be met within 10 years of acceptance of this plan.

7.4 MOKOHINAU SKINK

Option 1

Do nothing more. This would:

- Require periodic (five-yearly intervals) assessments of the population released on Lady Alice Island.
- Enable continued expansion of the species on Lady Alice Island for many decades.
- Leave the two small populations in the Mokohinau Islands highly vulnerable to disturbance.

Option 2

As for Option 1, but:

- Release on Whatupuke and Coppermine Islands once eradication of kiore from Coppermine is confirmed (within five years).
- Commence translocation from either Stack 'H' or Tatapihi Island to at least one other island in the Mokohinau Islands if future surveys fail to reveal their presence on the host island.

Option 3

As for Option 2, but:

- Remove kiore from Hen Island to allow for establishment of rare *Cyclodina* species including Mokohinau skink.
- Establish on all available islands in Mokohinau Group, including Fanal Island (once freed of kiore).

Preferred option

The option chosen for the first five years of this plan is Option 2. This option would require development of a restoration plan for the Mokohinau Islands and some innovations applied to translocation of restricted populations of lizards in that group. The option would increase the area occupied from at total of 9.3 ha to at least 340 ha. Option 3 is the ideal long-term option. However, given the small lizard population base in the Mokohinau Islands, this option may take several decades to reach completion.

7.5 POOR KNIGHTS SKINK

Option 1

Do nothing more. This would require:

- Regular surveillance of the islands and maintenance of pest prevention measures.
- Surveys to assess status (abundance) in the islands.

Option 2

As in Option 1, but:

- Locate a suitable additional island group and establish a second group of populations.

Preferred option

The option chosen for this plan is Option 1. This species is apparently endemic to the Poor Knights Islands, where it occupies its entire historic geographic range. Translocation to other islands is not consistent with the ecosystem goals identified in Atawhai Ruamano. Furthermore, the closely related copper skink is already resident on potential islands in the area and could interact (including hybridise) with the Poor Knights species. It will be necessary to accept that this will always be a relatively rare species and threats to the islands will need to be managed accordingly.

7.6 WHITAKER'S SKINK

Option 1

- Do nothing more than is identified in the previous recovery plan. This would:
- Require continued efforts to locate owner(s) and protect Castle Island.
- Maintain relationships with Ngati Hei with a view to eventual restoration of Whitaker's skinks and other herpetofauna in the Ohinau Islands.
- Require periodic (at five-year intervals) assessments of the status of populations released on Korapuki, Stanley and Red Mercury Islands.
- Require pest prevention measures maintained for all locations.
- Enable continued expansion of the new Korapuki, Stanley and Red Mercury Island populations.
- Manage the population at Pukerua Bay.

Option 2

As in Option 1, but in addition, proceed with the proposed translocations from Pukerua Bay to Mana Island as outlined by Miskelly 1999.

Option 3

As in Option 2, but:

- Continue with planned release on Double Island, following establishment of tusked weta.
- Proceed with translocation to Tiritiri Matangi Island and/or Motuora Island as identified in restoration plans (Hawley 1997a,b), but following assessment of the impacts of ground-dwelling birds (pukeko, takahe and kiwi). This may be a long-term option that requires development of dense plant cover as protection from birds.
- Assess the practicality of releasing Whitaker's skinks on Kapiti Island in the presence of weka, but depending on whether future surveys reveal the skinks' presence.
- Assess possibility of eventual translocation from the Pukerua Bay population to Somes/Matiu Island in Wellington harbour.

Preferred option

The option chosen for the first five years of this plan is Option 2. This option would increase the number of populations from three (as in 1988) to at least seven and extend the area occupied from c. 20 ha in 1988 to at least 500 ha by 2005. Option 3 provides realistic long-term goals that could be met within 10 years of acceptance of this plan, but depends on results of test of effects of weka on lizards on Kapiti Island.

8. Goal and objectives

8.1 LONG-TERM GOAL

The long-term (50 year) goal of this recovery programme is to improve the international conservation (IUCN) status of all threatened (and Category A) species to 'near threatened (lower risk)' or better. For this goal to be met it will be necessary to: maintain the endemic forms and species of *Cyclodina* within their historic range, enhance all identifiable genetic stocks of species now confined to islands, and re-establish on the mainland at least one self-sustaining population of each of the species previously present on the mainland but now confined to islands.

The following objectives are compiled from the preferred (five-year) option for the six rarest species. If met, these objectives would work towards the long-term goal by: enhancing existing populations, re-establishing lost populations and re-creating lost species assemblages of species in *Cyclodina* within their known geographic range as summarised in Table 3. The objectives are largely based on public land. New initiatives on private land, where they are compatible with these objectives, would be viewed as optional additions to those outlined here. Research support required for each objective is identified in the summary in parentheses.

8.2 SUMMARY OF OBJECTIVES FOR THE DURATION OF THIS PLAN

Objectives are listed in order of priority.

1. Maintain all existing populations on islands either naturally free or cleared of introduced predators.

(*Development of new baits, lures and bait dispensers to minimise non-target effects, but maximise potential to intercept arriving pests.*)

2. Eradicate rodents from selected large islands of significance to *Cyclodina* skinks.

(Determine responses of resident lizards to predator removal from large and species-rich islands.)

3. Assess the success of existing releases of *Cyclodina* skinks.

(*Determine ideal population size and composition for lizard translocations; undertake genetic studies on variation in released populations.*)

4. Determine identity of isolated populations.

(*Genetic studies of marbled skinks and other isolated populations in the genus.*)

5. Develop a restoration plan for the Mokohinau Islands.

6. Restore *Cyclodina* populations to at least two additional islands within their natural range.

(*Assess the potential for detrimental interactions between species pairs no longer co-existing*.)

TABLE 3. COMBINATIONS OF *Cyclodina* SPECIES LIKELY TO RESULT FROM RESTORATION ACTIVITIES PROPOSED IN THIS PLAN. NOTE, EXISTING COMBINATIONS ON ISLANDS WHERE PROTECTION IS THE ONLY GOAL (e.g. POOR KNIGHTS) ARE EXCLUDED. SPECIES MARKED 'r' ARE RESIDENT; 'i', ALREADY RELEASED. DISTRIBUTION DATA FROM HITCHMOUGH (1979), MCCALLUM (1980), MCCALLUM & HARKER (1981), PARRISH & PIERCE (1993), PICKARD & TOWNS (1988), TOWNS (1991, UNPUBLISHED DATA), WHITAKER (1978).

	C. aenea	*C. alani*	*C. macgregori*	*C. oliveri*	*C.* n.sp.1	*C. ornata*	*C. whitakeri*
Motuopao	r	i					
[1]Motukawanui	r	?				r ?	
[2]Limestone	r						
Lady Alice	r	?	i		i	r	
[2]Whatupuke	r	?				r	
[3]Coppermine	r		?			r	
[1]Hen	r					r	
[2]Mokohinau Is	r	r				r	
[3]Fanal	r ?						
[1]Little Barrier	r			r		r	
[2]Tiritiri Matangi	r						
[2]Motuora	r						
[2]Cuvier	r	?					?
Korapuki	r	i		i			i
Stanley	r	i					i
Red Mercury	r	i		r?			i
Double	r						
[2]Middle Chain	r ?						
[2]Whale	r						
[3]Kapiti	r					r	
[2]Somes/Matiu	r						?
[2]Mana	r		r			?	

[1] Rodents still present.

[2] Rodents removed, restoration of reptiles about to begin/recently began.

[3] Eradication campaign against rodents recently completed.

7. Manage the mainland population of Whitaker's skink at Pukerua Bay.

(*Management of predator guilds.*)

8. Survey for additional populations of rare species of *Cyclodina*.

9. Promote protection and/or restoration of rare species of *Cyclodina* on islands off the public estate.

10. Determine effects of ground-dwelling predatory birds on rare species of *Cyclodina.*

(*Determine the effects of ground-feeding birds on lizards*.)

11. Promote public interest in the recovery of *Cyclodina* skinks and in ecological restoration.

12. Maintain populations of selected species in captivity for eventual release into the wild.

8.2.1 Objective 1

Maintain all existing populations on islands either naturally free or cleared of introduced predators.

Explanation

Until recently, almost all populations of the rarest species in the genus were confined to islands which had not been reached by introduced predatory mammals. Over the last 10 years, introduced rodents have been removed from at least 24 islands (total area c. 3470 ha) within the range of *Cyclodina*. Two additional campaigns (total 182 ha) are now in the two-year post-eradication assessment phase. Almost all of these eradications were conducted with conservation of rare reptiles as one primary aim. Protection of this investment requires regular surveillance, measures against accidental arrival of rodents via landings by the public, and contingencies against arrival of pests through shipwrecks. These measures are of particular importance in the Three Kings Islands and Poor Knights Islands, where there are endemic or distinctive populations of *Cyclodina*.

This objective is supported by Section 5.4, Northland CMS (1995), 'Animal Pests', Auckland CMS (1995), and Section 20, Wellington CMS (1996).

Action

- Permanent bait stations against rodents at all likely landing sites.
- Regular (at least six-monthly) monitoring of bait stations and replacement of baits.
- Advocacy at suitable locations (e.g. local boating clubs) to ensure that the vulnerability of islands to the spread of rodents is understood.
- Development of new baits, lures and bait dispensers to minimise non-target effects, but maximise potential to intercept arriving pests.
- Establish contingencies to deal with accidental invasions of predatory mammals.

Key Personnel

DOC Northland, Auckland, Waikato, Bay of Plenty, Wellington, Science Technology and Information Services.

8.2.2 Objective 2

Eradicate rodents from selected large islands of significance to Cyclodina *skinks.*

Explanation

Eradication of kiore from three large islands would have a major impact on the status of four of the rarer species of *Cyclodina.* These eradications would also require significant expenditure. However, the technology required has been tested elsewhere on large islands (e.g. Kapiti), so it is conceivable that at least one of the proposed eradications could be completed within the life of this plan. The islands proposed are Motukawanui (380 ha), Hen (500 ha) and Little Barrier Island (3083 ha). The highest priority island is Little Barrier, which has the largest fauna of lizards (13 species) known for any New Zealand island, and of the three islands listed above, the largest number of resident species of threatened reptiles. These comprise tuatara (*Sphenodon punctatus*), chevron skink (*Oligosoma homalonotum*), and striped skink (*O. striatum*). There is also a resident population of marbled skink. Survey and trapping programmes for lizards indicate that most forest species are present at very low densities (K. Neilson, pers comm.).

Removal of kiore would allow natural expansion of tuatara, threatened species of lizards, and the three resident species in *Cyclodina*. It would also provide a unique opportunity to measure how a complex lizard assemblage recovers following the removal of an introduced predator. Two additional species—robust skink and McGregor's skink—were probably once also present on Little Barrier Island. Establishment of these two species would provide the closest available approximation to lizard assemblages now lost from Northland (e.g. Towns and Daugherty 1994), while also providing sufficient habitat for them to form very large populations.

This objective is supported by the tuatara recovery plan (Cree and Butler 1993); Section 4.11, Implementation step 2, Northland CMS (1995), and by Key Area 3 (Little Barrier Island) Implementation step 3.7.6, Auckland CMS (1995).

Action

- Undertake negotiations with Ngatiwai prior to planning for removal of kiore from Little Barrier Island and investigate possibility for removal of kiore from Hen Island.
- Plan and obtain funding for removal of kiore from Little Barrier Island within five years and develop a research project on the response of resident lizards to removal of kiore.
- Investigate possibility of removal of kiore from Motukawanui Island.

Key Personnel

DOC Northland, Auckland, Science Technology and Information Services.

8.2.3 Objective 3

Assess the success of existing releases of Cyclodina *skinks.*

Explanation

An ongoing research project is developing and refining translocation protocols for lizards and developing criteria for success. Because of the low productivity of female *Cyclodina* skinks and hence low annual rates of population expansion (Towns 1994), successful establishment of new populations of Whitaker's and robust skinks may take up to 10 years to be identified. All releases have been based on the assumption that a minimal number of animals is available to start new populations. Consequently, a maximum of about 30 individuals has been used. However, in the first years after release up to 40% of the lizards are lost from the population (Towns unpublished data). This, combined with the small released population, may mean that the remaining successful breeding group may be small, lack a significant proportion of the genetic variability of the parent population and could possibly become inbred.

Genetic techniques are now available to test whether there is evidence of bottleneck or inbreeding problems with released populations of lizards. They would usefully indicate whether the size, demography and sex ratio combination of release populations is at the optimum level for long-term survival.

Action

- Complete existing research project on lizard translocations on Korapuki Island in the Mercury Islands within five years.
- Obtain funds to have genetic studies undertaken on variation in released populations.
- Undertake periodic (probably five-yearly) monitoring of released populations of robust and Whitaker's skinks in the Mercury Islands (Stanley and Red Mercury Islands), robust skinks on Motuopao Island, and Mokohinau and McGregor's skinks on Lady Alice Island.

Key Personnel

DOC Northland, Waikato, Science Technology and Information Services, outside agency for genetic studies.

8.2.4 Objective 4

Determine identity of isolated populations.

Explanation

A cryptic species present in the Mokohinau and Marotere Islands has been identified from the marbled skink group of species (Daugherty et al. 1994), but the analysis did not include populations from Little Barrier and Great Barrier Islands. The identity of these populations thus remains unclear. Understanding the identity of these populations is required when assessing source populations for translocations of marbled skinks to the inner Hauraki Gulf islands.

Some *Cyclodina* populations that have been geographically isolated for long periods have shown either species-level divergence, distinctive morphology, or genetic divergence. Examples are the endemic undescribed species related to copper skinks in the Poor Knights Islands, morphologically distinctive marbled

skinks in the Poor Knights Islands and a genetically distinctive population of an undescribed species in the Mokohinau and Marotere Islands (C.H. Daugherty pers. comm.). This variation raises the possibility that long-isolated populations of other species in the genus have undergone similar divergence. Possibilities include the robust skinks of the Mokohinau Islands, and the ornate skinks of the Poor Knights, Mokohinau and Three Kings Islands.

Determining the identity of these isolated populations may have implications for conservation priorities in the various islands. This will require genetic studies, but their extent may be limited in the short term by the availability of animals. The studies can, however, be ranked in priority order, with identity of the Little Barrier and Great Barrier Island populations of greatest urgency, and studies of ornate skinks lowest priority.

Action

Encourage studies of genetic identity of marbled skinks and other isolated populations in the genus.

Key Personnel

DOC Science Technology and Information Services, Northland, Auckland, outside research agencies.

8.2.5 Objective 5

Develop a restoration plan for the Mokohinau Islands.

Explanation

Kiore were eradicated from the Mokohinau Islands (except Fanal) in 1990. One of the justifications for the project was to protect rare invertebrates and lizards in the group (McFadden and Greene 1994). Eradication of kiore has removed the risk of further spread of rats through the group. However, the two populations of Mokohinau skink, and the single population of robust skink and ornate skink, remain vulnerable to other forms of disturbance such as fire or severe drought. This risk would be greatly reduced if these relict populations were incorporated into a comprehensive ecological restoration plan for the whole group (see Key Area 2, Implementation step 2.7.6, Auckland CMS, 1995). The plan would need to be supported by proposals for translocations of three species of *Cyclodina*: the undescribed species, ornate skinks and robust skinks. For each species, options for translocation to other islands may include captive breeding to obtain sufficiently large groups for release, or the use of 'trickle' feed releases of small groups of wild individuals.

Action

- Compile a restoration plan for the Mokohinau Islands.
- Assess options for management of populations of *Cyclodina* skinks.
- Commence releases of *Cyclodina* skinks within five years subject to surveys (see Objective 8).

Key Personnel

DOC Auckland.

8.2.6 Objective 6

Restore Cyclodina *populations to at least two additional islands within their natural range.*

Explanation

Conservation of marbled skink, McGregor's skink, Mokohinau skink, robust skink, and Whitaker's skink is largely based on releases of these species to islands in their historic range from which introduced predators have been removed. These need to account for the optimum-sized populations for release into new habitats as well as potential detrimental effects on source populations (see Appendix 2).

The restoration of lizard assemblages on islands in some cases will result in species combinations that are identifiable from scattered subfossil deposits, but not found in existing communities (see Appendix 3). It is not possible to predict the long-term outcome of reinstating combinations such as McGregor's skink and Whitaker's skink on Mana Island and McGregor's skink and Mokohinau skink in the Marotere Islands. In the short-term, care with establishing new populations at distant locations on the same island will overcome this problem. In the medium-term, trial releases where species are able to interact may provide the best test of whether there are likely to be long-term detrimental effects of one species on the other.

Some translocations proposed here involve species where small parent populations are confined to fragile habitats. This problem presents particular challenges in the Mokohinau Islands. Trials elsewhere, either through captive breeding, or through the slow release of small numbers of individuals by 'trickle feed', may provide solutions to these problems. For example, releases of small numbers of Whitaker's skinks on Mana Island should provide data applicable to the Mokohinau Islands.

Action

- Complete translocation of Mokohinau skinks from Muriwhenua to at least one other island in the Marotere Islands (in addition to Lady Alice Island) once removal of kiore is confirmed.
- Develop methods for release of small populations of skinks confined to fragile habitats in the Mokohinau Islands.
- Complete translocation of McGregor's skinks from Sail Island to at least one other island in the Marotere Islands (in addition to Lady Alice Island) once kiore are removed.
- Release robust skinks from Moturoa Island onto a selected island in the Marotere group subject to agreements with local iwi.
- Plan for translocation of marbled skinks to Cuvier Island if surveys confirm their absence.
- Determine suitability of Cuvier Island for Whitaker's and robust skinks through analysis of midden deposits.
- Translocate marbled skinks from Middle Island to Stanley Island if surveys confirm their absence; and to Middle Chain Island from elsewhere in the Aldermen group.
- Reintroduce robust skinks to Mana Island from Castle Island subject to negotiations between Waikato Conservancy and iwi.
- Release Whitaker's skinks from Pukerua Bay onto Mana Island subject to sufficient animals being located and a risk assessment of the potential effects of ground feeding birds (e.g. takahe and pukeko) on Mana Island.

Key personnel
DOC Northland, Auckland, Waikato, Wellington, Science Technology and Information Services.

8.2.7 Objective 7

Manage the mainland population of Whitaker's skink at Pukerua Bay so that presently unused habitat refuges become occupied by the species.

Explanation
Pukerua Bay is the only mainland location occupied by the larger species of *Cyclodina*. An area of 12.3 ha has been purchased and is now gazetted as Scientific Reserve. However, the Whitaker's skink population is concentrated near to or on a Porirua City Council paper road on the seaward side of the reserve. There is also a Porirua City Council reserve immediately adjacent to the Scientific Reserve, and it includes considerable habitat either suitable for, or occupied by, Whitaker's skinks.

Both areas are infested by mice, and there are populations of hedgehogs, weasels and stoats (C. Miskelly pers comm.); the reserve is also doubtless visited by domestic and feral cats and ferrets. Passive management of the mouse problem was proposed by Towns (1992b) through replanting of native shrubs and flax to discourage seeding of rank grass.

Management of these two adjacent reserves would benefit from a collaborative agreement with Porirua City, public guardians against collecting of lizards and illegal fires, and public involvement in ecosystem restoration through planting of native coastal vegetation and weed and wild animal control (see p. 77 Wellington CMS 1996).

Action
- Establish working relationship with Porirua City Council over management of Pukerua Bay Scientific Reserve and the council lands on its boundaries.
- Undertake management actions identified in Wellington Conservancy CMS (1996).
- Undertake predator control at Pukerua Bay and assess response by resident lizards.

Key Personnel
DOC Wellington.

8.2.8 Objective 8

Survey for additional populations of rare species of Cyclodina.

Explanation
A number of small islands naturally free of introduced mammals have not been adequately surveyed for rare *Cyclodina* skinks. Some of these islands are off the public estate. Others are administered by DOC, but are rarely visited because they are small and/or have difficult access. However, there are increasing examples of species discovered in tiny habitat refuges on small islands. The discovery of robust skinks on Groper (Tatapihi) Island is the most recent example.

Examples of islands free of rodents which may yield rare species include islands in the Moturoa and Cavalli groups (Maori-owned) and Motukokako (Piercy)

Island (Maori-owned) in Northland Conservancy, Wooded Island (off Tiritiri Matangi Island) in Auckland Conservancy and rodent-free islands in the Ohinau group (Maori-owned) in Waikato Conservancy.

In addition, some pest eradications may allow the natural recovery and spread of hitherto unknown populations of rare *Cyclodina* skinks. Examples worth investigating include Mokohinau skinks on Lizard Island in the Mokohinau Group (McCallum 1986) and Whitaker's or McGregor's skinks on Kapiti Island.

Action

- Survey small rodent-free islands for populations of rare species of *Cyclodina*.
- Survey large islands (such as Kapiti) for relict populations of rare *Cyclodina* skinks.

Key personnel

DOC Northland, Auckland, Waikato, Wellington.

8.2.9 Objective 9

Promote protection and/or restoration of rare species of Cyclodina *on islands off the public estate.*

Explanation

Key populations of rare *Cyclodina* skinks inhabit land off the public estate. These include robust skinks on Matapia and Moturoa Islands and McGregor's skinks on Motuharakeke Island (all Maori land) in Northland Conservancy, and robust and Whitaker's skinks on Castle Island (Customary Maori Land) in Waikato Conservancy. The population of robust skinks on Matapia Island has already been used for translocation to Motuopao Island, the Moturoa populations would logically form the basis for releases in the Marotere Islands, and the Castle Island population could be used for translocations to Mana Island. In addition, if kiore were removed from Motukawanui Island, neighbouring Motuharakeke Island should be used as a source of McGregor's skinks. These actions require high levels of dialogue with iwi and a clear expression of the Department's goals and capabilities for species recovery and restoration.

In addition, restoration on privately owned islands, and islands under Maori ownership is being undertaken or is planned in Northland and Waikato Conservancies. These activities could complement recovery goals identified here, but it may be necessary to identify whether they should have lower priority for Departmental resources than projects already approved on public land.

Action

- Where appropriate, seek protection of land off the public estate where populations of rare *Cyclodina* skinks are present.
- Maintain dialogue with iwi Maori, especially where restoration proposals potentially include populations under tribal control or, alternatively, restoration on Maori land requiring populations on public land.
- Seek clarification of ownership and formal protection of Castle Island.

Key Personnel

DOC Northland, Waikato.

8.2.10 Objective 10

Determine effects of ground-dwelling predatory birds on rare species of Cyclodina.

Explanation

Several islands have had mammalian predators removed, but retain populations of either self-introduced or intentionally-introduced native birds that might have significant effects on recovery of the lizards. For example, since the eradication of kiore from Red Mercury Island, robust skinks have been released in the presence of little spotted kiwi. With the removal of mice from Mana Island, McGregor's skinks are expected to extend their range beyond the boulder strands presently occupied and spread into regenerating forest and scrub. However, takahe have been introduced to the island and there is a large self-introduced population of pukeko whose effects on the skinks are unknown (see also Atkinson 1990). Kapiti Island is proposed in this plan as a possible location for Whitaker's, robust and McGregor's skinks, but there is a large resident population of little spotted kiwi (*Apteryx owenii*) and an expanding population of weka. Similarly, *Cyclodina* skinks are proposed for release onto Tiritiri Matangi Island, already inhabited by pukeko, takahe and kiwi, and to Motuora Island, which has a large population of pukeko (Hawley 1997 a,b).

The risks posed by these actions should be assessed and will help with determining the combinations and sequence of species released onto restored islands. (see also Appendix 2).

Comparative studies of survivorship of robust skinks could be undertaken on Red Mercury Island in the Mercury Group. This could benefit from ongoing studies on rate of expansion of little spotted kiwi on Red Mercury Island and be linked with the rate of recovery of robust skinks on neighbouring Stanley Island, where kiwi have not been introduced. Studies using weka exclosures have commenced on Kapiti Island (C. Miskelly pers. comm.). In addition to enabling risk assessment for island restoration programmes, such studies should help with assessing the potential for lizard recovery on large islands such as Little Barrier Island where there is a large resident population of kiwi.

Action

- Undertake studies to determine the effects of ground-feeding birds on *Cyclodina* skinks.
- Compare survival and productivity of Whitaker's and robust skinks on Red Mercury Island (little spotted kiwi present) with Stanley Island (kiwi absent).

Key Personnel

DOC Science Technology and Information Services, DOC Waikato, Wellington.

8.2.11 Objective 11

Promote public interest in the recovery of Cyclodina *skinks and in ecological restoration.*

Explanation

Much of the recovery of species such as Whitaker's and robust skinks has in the past been focused on Nature Reserves where public access is strictly limited. Nonetheless, some restoration work at these sites has been conducted with involvement of local iwi. Elsewhere, the Scientific Reserve at Pukerua Bay is close to an urban area and there are proposals to reintroduce species of *Cyclodina* to Mana, Tiritiri Matangi and Motuora Islands, where there is open public access. Species management projects at such locations provide opportunities to demonstrate the uniqueness of the New Zealand lizard fauna and also provide flagship species for promoting the value of ecological restoration.

Previous successful guided visits to the Mercury Islands have demonstrated the level of public interest in the islands. The value of continuing these, at least periodically, should be assessed.

Action

- Develop partnerships with iwi when implementing ecological restoration.
- Promote public interest in New Zealand lizards and in habitat restoration.
- Promote values of the Pukerua Bay Scientific Reserve and encourage community-based projects for reserve restoration and surveillance.
- Encourage the Supporters of Tiritiri Matangi Inc and the Motuora Restoration Society to apply strategies for restoration that include *Cyclodina* skinks.
- Investigate prospects for future public visits to the Mercury Islands and Cuvier Island as a means of promoting successful island restoration.

Key personnel

DOC Auckland, Waikato and Wellington.

8.2.12 Objective 12

Maintain populations of selected species in captivity for eventual release into the wild.

Explanation

Establishment of new populations of some species in *Cyclodina* may need to be attempted with small numbers of wild animals taken into captivity and the number for release boosted by captive husbandry. Particular examples where this approach may be required are the Mokohinau and robust skinks from the Mokohinau Islands. There are also circumstances where the skinks may need to be held in captivity for a considerable period as numbers caught are gradually expanded to an ideal population size. This may be the most effective approach for Whitaker's skinks from Pukerua Bay because of the low capture rates in this population (e.g. Towns and Elliott 1996).

To date, there has been patchy success with breeding *Cyclodina* in captivity. For example, there is no self-sustaining population of Whitaker's skinks in captivity. On the other hand, there has been success with breeding of robust

skinks. The performance of captive-raised populations in the wild is unknown. There are possibilities that skinks raised in captivity will show poorer survivorship when released than those born in the wild. They may also have been exposed to diseases that could have a devastating effect on resident lizard species on the host island. These possibilities could be tested using a species such as robust skink where there has been success with breeding in captivity. Existing robust skinks in captivity from one of the northern populations could form the basis for trial releases on islands such as Tiritiri Matangi or Motuora Island.

Overall, however, the use of captive breeding for this plan should be viewed on a case-by-case basis specifically for the establishment of new populations where direct translocations from wild populations cannot be undertaken.

Action

- Assess feasibility of trial releases of captive-bred robust skinks on Tiritiri Matangi Island subject to comprehensive surveys of the resident lizard fauna on Tiritiri Matangi and Wooded Island and assessments of the effects of predatory birds.
- Determine origins and suitability of robust skinks in captivity for a trial release into the wild.
- If a suitable population exists, determine disease screening and quarantine requirements.

Key Personnel

DOC Auckland, Biodiversity Recovery Unit, Captive Breeding Co-ordinator.

8.2.13 Long-term objective

One of the long-term goals stated for this plan was to: '*Re-establish on the mainland at least one self-sustaining population of each of the species previously present on the mainland but now confined to islands'.*

Explanation

One species—Whitaker's skink—has survived at Pukerua Bay, so this goal should be met if the Pukerua Bay site is appropriately managed. Other species now confined to islands include marbled skinks, Mokohinau skink, robust skink and McGregor's skinks.

Present attempts by the Department at intensive ecosystem management (the 'Mainland Islands' approach) have identified the levels of intensity of pest control and cost of maintaining areas for avifauna. The next step would be to target this approach at reptiles. Some resident mainland species may respond to the projects aimed at birds; ornate skinks and copper skinks may be worth monitoring in some locations. However, for the larger species with low female productivity, near-zero predator density will need to be obtained and sustained. For this approach to succeed, sites may need to have boundaries that minimise potential reinvasion by predators. Forested peninsulas have potential for this, particularly if it is possible to fence the landward boundary against most introduced mammals.

One example of possible location for sustained zero-density management of predators is Bream Head, a rugged area of coastal broadleaf forest on a peninsula adjacent to the Marotere Islands, only about 500 m from a population of McGregor's skinks in the Outer Bream Islands, and within the previous range of robust skinks.

An example of a forest area where a fence against predator reinvasion is under construction is Karori Reservoir in Wellington. Mainland populations of rare species of *Cyclodina* could be established at such sites, but the long-term viability of such populations would need to be assured.

Action

- Identify intensive ecosystem management sites that may enable reintroductions of *Cyclodina* skinks.
- Investigate strategies for intensive predator control to near-zero density for indefinite periods.
- Investigate feasibility of establishment of rare *Cyclodina* skinks within habitat isolates protected by predator exclusion fences (e.g. Karori Reservoir).

Key Personnel

DOC Northland, Auckland, Waikato, Wellington.

9. Work plan

The following work plan (Table 4) identifies priority tasks by conservancy and species. Some tasks, such as surveying for new populations, although not identified here, should be conducted as and when opportunities arise.

TABLE 4. SUMMARY OF PRIORITY TASKS (SHADED) BY CONSERVANCY, LOCATION AND SPECIES, WITH RELEVANT OBJECTIVES IN PARENTHESES (WITH OBJECTIVES NUMBERED IN PRIORITY ORDER). I = ISLAND, Is = ISLANDS.

YEAR:	1	2	3	4	5	>5
Northland: General						
Pest prevention (1)						
Pest removal (2)						
Robust skink						
Motuopao I monitoring (3)						
Lady Alice I translocation (3)						
Coppermine I translocation (6)						
McGregor's skink						
Lady Alice I monitoring (3)						
Whatupuke I translocation (6)						
Hen I translocation (6)						
Mokohinau skink						
Lady Alice I monitoring (3)						
Whatupuke I translocation (6)						
Coppermine I translocation (6)						
Auckland: General						
Pest prevention (1)						
Pest removal (Little Barrier I) (2)						
Mokohinau plan (5)						

Surveys (8)						
Robust skink						
Translocations (6)						
Marbled skink						
Little, Great Barrier Is identity (4)						
McGregor's skink						
Translocations (6)						
Mokohinau skink						
Mokohinau I translocations (6)						
Whitaker's skink						
Translocations (6)						
Waikato: General						
Pest prevention (1)						
Pest removal (off public land)						
Robust skink						
Castle I protection (9)						
Mercury Is monitoring (3)						
Cuvier I translocation (6)						
Double I translocation (6)						
Wellington: General						
Pest prevention (1)						
Pukerua Bay management (7)						
Robust skink						
Mana I tranlocation (6)						
Kapiti I translocation (6)						
Whitaker's skink						
Mana I translocation (6)						
Kapiti I surveys (8)						

10. Research priorities

For the work plan to be effectively implemented, it will need to be supported by research in the following areas:

Topics are listed in order of priority.

10.1 DEVELOP NEW BAITS, LURES AND BAIT DISPENSERS TO MINIMISE NON-TARGET EFFECTS, BUT MAXIMISE POTENTIAL TO INTERCEPT ARRIVING PESTS

10.1.1 Explanation

Present products used in permanent bait stations, and the bait stations themselves, were largely developed for agricultural use. When used on islands, the baits can have undesirable non-target effects, are attacked by insects, and degrade in high-humidity environments. Moreover, on islands free of rodents, the high density and diversity of potential food items may make detection and elimination of invading rodents extremely difficult.

A project comparing the relative effectiveness of these commercially available products is now under way at Landcare Research using funds provided by DOC. However, there is a need to develop new strategies and products to guard against introduced mammals (especially rodents) reaching offshore islands.

An extension of this approach would be the development of products for use against mustelids and rodents on islands within the swimming range of these species from the mainland. Successful interception of reinvading predators would make available many other islands for reptile conservation (e.g. Bay of Islands, inner Hauraki Gulf Islands, inshore islands around the Coromandel Peninsula).

10.2 RESPONSES OF RESIDENT LIZARDS TO PREDATOR REMOVAL FROM LARGE ISLANDS

10.2.1 Explanation

Present studies on the responses of lizards once predators have been removed have been based on small islands (<200 ha) with depleted lizard faunas. If kiore are to be removed from Little Barrier Island (Objective 2), there would be a unique opportunity to measure the response of resident species (including marbled skinks), and to incorporate these responses in restoration models for the island.

10.3 RESEARCH ON LIZARD TRANSLOCATIONS INCLUDING GENETIC STUDIES ON VARIATION IN RELEASED POPULATIONS

10.3.1 Explanation

Research on the 'ideal' population size and structure of release populations is under way (see also Appendix 2.). However, the potential for detrimental effects through loss of genetic information in the course of translocations has not been studied in New Zealand reptiles, is poorly known elsewhere, but could have implications for the long-term viability of new populations (Dodd and Seigel 1991). Techniques are now available that should enable such studies using small amounts of tissue (e.g. individual toes).

10.4 STUDIES OF THE IDENTITY OF MARBLED SKINKS AND OTHER ISOLATED POPULATIONS IN THE GENUS

10.4.1 Explanation

Some members of *Cyclodina* show evidence of allopatric speciation. For example, the Poor Knights skink appears to be derived from isolated forms of the copper skink (Hardy 1977). There are also cryptic species, such as the Mokohinau skinks which are difficult to separate morphologically from marbled skinks (Daugherty et al. 1994). Divergences such as these may be apparent in other long-isolated populations. At present, the marbled skinks of Little Barrier and Great Barrier Islands are of unclear affinities (see Objective 4). But in addition to these, the isolated populations of ornate and robust skinks of the Mokohinau Islands and the ornate skinks of the Three Kings and Poor Knights Islands, could show significant divergence from other populations.

10.5 DETERMINE THE EFFECTS OF GROUND-FEEDING BIRDS ON LIZARDS

10.5.1 Explanation

Present studies of the survival of translocated populations of Whitaker's skinks have demonstrated the high vulnerability of this species to adult predation. Computer models indicate that losses of adults that exceed 5% per annum could cause new populations to collapse (Towns 1994).

Before unrestricted releases of the larger species of *Cyclodina* are undertaken, it will be necessary to ensure that ground-feeding birds on some islands do not pose a significant threat to new populations. Studies measuring the possible effects of weka (plus kiwi) on Kapiti Island are now underway. However, there may be significant risks posed by pukeko and takahe on some other islands.

10.6 POTENTIAL FOR DETRIMENTAL INTERACTIONS BETWEEN SPECIES PAIRS NO LONGER CO-EXISTING

10.6.1 Explanation

On some islands, reinstatement of lost species assemblages is proposed. One example is release of Whitaker's skinks onto Mana Island, which is already inhabited by McGregor's skinks. The latter species is larger than Whitaker's skinks, and reputed to be particularly aggressive. There is a need to undertake trials that will determine the long-term effects of interactions between such species. The results of such trials could affect later restoration goals, such as the possible release of Whitaker's skinks and McGregor's skinks on Kapiti Island, but also the releases of McGregor's skinks and Mokohinau skinks in the Hen and Chickens Islands.

10.7 DEVELOPMENT OF METHODS FOR INTENSIVE MANAGEMENT OF PREDATORS ON THE MAINLAND

10.7.1 Explanation

The long-term goal of this plan is for re-establishment on the mainland of species now confined to islands. For this to be possible, it will be necessary to assess levels of predation that can be sustained by these species, and the cost-effectiveness of maintaining predator numbers at these levels.

In the short term, there is a pressing need to manage predator guilds at Pukerua Bay. Because of the proximity of the Pukerua Bay township to the Scientific Reserve, some commonly-used control methods (such as rodenticide in bait stations) may involve significant risks (for example to domestic cats through secondary poisoning) and these could affect public relationships with the local community. These risks need to be assessed and minimised.

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12. References

Anon. 1993: Atawhai Ruamano Conservation 2000 Discussion Document 2. Wellington, New Zealand Department of Conservation.

Anon. 1998: Restoring the dawn chorus. Department of Conservation Strategic Business Plan 1998–2002. Wellington, New Zealand Department of Conservation.

Atkinson, I.A.E. 1990: Ecological restoration on islands: prerequisites for success. In: Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. Eds. Ecological restoration of New Zealand islands. Department of Conservation *Conservation sciences publication no. 2*: 73–90.

Atkinson, I.A.E. 1991: A re-appraisal of the conservation value of Mana Island. DSIR Land Resources Technical Record 64. Lower Hutt, Department of Scientific and Industrial Research.

Baillie, J; Goombridge, B. 1996: IUCN List of Threatened Animals. Gland, IUCN and Conservation International.

Baverstock, P.R.; Joseph, L; Degnan, S. 1993: Units of management in biological conservation. In: Moritz, C.; Kikkawa, J. Eds. Conservation Biology in Australia and Oceania. Chipping Norton, Surrey Beatty & Sons. Pp. 287–293.

Conservation Management Strategy for Wellington 1996–2005. Wellington Conservancy Conservation Management Planning Series No. 2. Wellington, Department of Conservation.

Conservation Management Strategy for Auckland 1995–2005. Auckland Conservancy Conservation Management Planning Series No 2. Auckland, Department of Conservation.

Conservation Management Strategy for Taitokerau Northland 1995 (Draft). Northland Conservancy Management Planning Series No. 1. Whangarei, Department of Conservation.

Cree, A.; Butler, D. 1993: Tuatara recovery plan (*Sphenodon* spp.). Threatened Species Recovery Plan Series No. 9. Wellington, Department of Conservation.

Daugherty, C.H.; Patterson, G.B.; Hitchmough, R.A. 1994: Taxonomic and conservation review of the New Zealand herpetofauna. *New Zealand journal of zoology 21*: 317–323.

de Lange, P.J.; Cameron, E.K.; Taylor, G.A. 1995: Flora and fauna of Tatapihi (Groper) Island, Mokohinau Islands. *Tane 35*: 69–94.

Dodd, K.; Seigal, R.A. 1991: Relocation, repatriation and translocation of amphibians and reptiles: are they conservation strategies that work? *Herpetologica 47*: 336–350.

Forester, L.J.; Anderson, P.J. 1995: Vascular plants, vegetation and wildlife of Matapia Island, Far North New Zealand. *Tane 34*: 39–50.

Gill, B.J.; Whitaker, A.H. 1996: New Zealand frogs and reptiles. Auckland, David Bateman.

Hardy, G.S. 1977. The New Zealand Scincidae (Reptilia: Lacertilia): a taxonomic and zoogeographic study. *New Zealand journal of zoology 4*: 221–325.

Hawley, J. 1997a: Tiritiri Matangi working plan. Auckland, Department of Conservation.

Hawley, J. 1997b: Motuora restoration working plan. Auckland, Department of Conservation.

Hitchmough, R.A. 1979: Lizards observed during a visit to the Cavalli Islands, December 1978 to January 1979. *Tane 25*: 119–124.

Mace, G.; Stuart, S. 1994: Draft IUCN Red List categories, version 2.2. *Species 21–22*: 13–24.

McCallum, J. 1980: Reptiles of the northern Mokohinau Group. *Tane 26*: 53–59.

McCallum, J. 1986: Evidence of predation by kiore upon lizards from the Mokohinau Islands. *New Zealand journal of ecology 9*: 83–87

McCallum, J.; Harker, F.R. 1981: Reptiles of Cuvier Island. *Tane 27*: 17–22.

McFadden, I.; Greene, T. 1994: Using brodifacoum to eradicate kiore (*Rattus exulans*) from Burgess Island and the Knights Group of the Mokohinau Islands. Department of Conservation *Science and research series No. 70.*

Miskelly, C.M. 1997: Whitaker's skink *Cyclodina whitakeri* eaten by a weasel *Mustela nivalis.* Department of Conservation *Conservation Advisory Science Notes No. 146.*

Miskelly, C. 1999: Mana Island Ecological Restoration Plan. 149 p. Wellington, Department of Conservation.

Molloy, J.; Davis, A. 1994: Setting priorities for the conservation of New Zealand's threatened plants and animals. (Second edition collated by C. Tisdall). Wellington, Department of Conservation.

Newman, D.G. 1994: Effects of a mouse, *Mus musculus,* eradication programme and habitat change on lizard populations on Mana Island, New Zealand, with special reference to McGregor's skink, *Cyclodina macgregori. New Zealand journal of zoology 21*: 443–456.

Newman, D.G.; Towns, D.R. 1985: A survey of the herpetofauna of the northern and southern blocks, Great Barrier Island, New Zealand. *Journal of the Royal Society of New Zealand 15*: 279–287.

Parrish, G.R.; Anderson, P.J. in press: Lizard transfers from Matapia Island to Motuopao Island, Northland, New Zealand and observations on other fauna. *Tane 37*.

Parrish, G.R.; Pierce, R.J. 1993: Reptiles of Motuopao Island, Northland, New Zealand. *Tane 34*: 53–58.

Patterson, G.B.; Daugherty, C.H. 1995: Reinstatement of the genus *Oligosoma* (Reptilia: Lacertilia: Scincidae). *Journal of the Royal Society of New Zealand 25*: 327–331.

Pickard, C.R.; Towns, D.R. 1988: Atlas of the amphibians and reptiles of New Zealand. Department of Conservation *Conservation sciences publication number 1.*

Porter, R. 1987: An ecological comparison of two *Cyclodina* skinks (Reptilia; Lacertilia) in Auckland, New Zealand. *New Zealand journal of zoology 14*: 493–507.

Robb, J. 1986: New Zealand amphibians and reptiles in colour (second edition). Auckland, Collins.

Towns, D.R. 1972: The reptiles of Red Mercury Island. *Tane 18*: 95–105.

Towns, D.R. 1991: Response of lizard assemblages in the Mercury Islands, New Zealand, to removal of an introduced rodent: the kiore (*Rattus exulans*). *Journal of the Royal Society of New Zealand 21*: 119–136.

Towns, D.R. 1992a: Recovery plan for Whitaker's and robust skink. *Threatened Species Unit Recovery Plan Series No. 3*. Department of Conservation, Wellington.

Towns, D.R. 1992b: Distribution and abundance of lizards at Pukerua Bay, Wellington: implications for reserve management. Department of Conservation *Science and research internal report no. 125.* Wellington,

Towns, D.R. 1994: The role of ecological restoration in the conservation of Whitaker's skink (*Cyclodina whitakeri*), a rare New Zealand lizard (Lacertilia: Scincidae). *New Zealand journal of zoology 21*: 457–471.

Towns, D.R.; Ballantine, W.J. 1993: Conservation and restoration of New Zealand island ecosystems. *Trends in ecology and evolution 8*: 452–457.

Towns, D.R.; Daugherty, C.H. 1994: Patterns of range contractions and extinctions in the New Zealand herpetofauna following human colonisation. *New Zealand journal of zoology 21*: 325–339.

Towns, D.R.; Elliott, G.P. 1996: Effects of habitat structure on distribution and abundance of lizards at Pukerua Bay, Wellington, New Zealand. *New Zealand journal of ecology 20*: 191–206.

Towns, D.R.; Stephens, T. 1997: Island management and commercial sponsorship: the Mercury Islands experience. Department of Conservation *Science and research series 103.*

Towns, D.R.; Daugherty, C.H.; Newman, D.G. 1985: An overview of the ecological biogeography of the New Zealand lizards (Gekkonidae, Scincidae). In: Grigg, G.; Shine, R.; Ehmann, H. Eds. Biology of Australasian frogs and reptiles. Chipping Norton, Surrey Beatty. Pp. 107–115.

Towns, D.R.; McFadden, I.; Lovegrove, T. 1993: Offshore islands co-operative conservation project with ICI Crop Care Division: Phase One (Stanley Island). Department of Conservation *Science and research internal report no. 138*.

Towns, D.R.; McFadden, I.; Thomson, P.; Robertson, H.; Colbourne, R: 1994. Offshore islands co-operative conservation project with ICI Crop Care Division: Phase Two (Red Mercury Island). Department of Conservation *Science and research internal report no. 142.*

Towns, D.R.; McFadden, I.; Thomson, P. 1995: Offshore islands co-operative conservation project with ICI Crop Care Division: Phase Three (Cuvier Island). Department of Conservation *Science and research internal report no. 150*.

Whitaker, A.H. 1968: The lizards of the Poor Knights Islands, New Zealand. *New Zealand journal of science 11*: 623–651.

Whitaker, A.H. 1978: The effects of rodents on reptiles and amphibians. In: Dingwall, P.R.; Atkinson, I.A.E.; Hay, C. Eds. The ecology and control of rodents in New Zealand Nature Reserves. Wellington. Department of Lands and Survey Information Series No. 4. Pp. 75–86.

Worthy, T.H. 1987: Osteological observations on the larger species of the skink *Cyclodina* and the subfossil occurrence of these and the gecko *Hoplodactylus duvaucelii* in the North Island, New Zealand. *New Zealand journal of zoology 14*: 219–229.

Worthy, T.H. 1991: Fossil skink bones from Northland, New Zealand, and description of a new species of *Cyclodina*, Scincidae. *Journal of the Royal Society of New Zealand 21*: 329–348.

Appendix 1

TAXONOMIC NOTES

There has at times been considerable debate over identity and correct nomenclature in *Cyclodina*. Since 1977, most authors have followed the generic revision of Hardy (1977). More recent taxonomic lists (e.g. Daugherty et al. 1994) have, however, not addressed some issues raised subsequently to Hardy's review. At present there are unresolved issues involving marbled skinks and ornate/copper skinks. Genetic studies, yet to be completed and published, should help clarify some of the issues summarised below.

Marbled skinks

According to Hardy (1977), marbled skinks are a single variable species distributed from the Poor Knights Islands to the Aldermen. He did not accept the previous description by Robb (1975) of separate species status for the southern-most populations (Mercury Islands and Aldermen). Subsequent to Hardy's review, Robb (1986) retained her original distinction between the Poor Knights and Hen and Chickens populations, which she assigned to *Cyclodina oliveri* and those in the Aldermen, which she assigned to *C. pachysomaticum*. This latter taxon, which was discounted by Hardy (1977), seems to have been ignored by workers since 1986.

Genetic studies do not support separation of the Poor Knights and Aldermen populations, but have identified a cryptic species in the Mokohinau Islands and Marotere Islands (C.H. Daugherty pers. comm.).

The breakdown of populations thus appears to be as follows:

- The Poor Knights form which reaches over 100 mm SVL (snout-vent length) is the largest and is thus morphologically distinguishable from the rest. These are predominantly nocturnal.
- The Mokohinau Island and Marotere Islands form which reaches up to about 85 mm SVL, is smaller than the Poor Knights form, and according to Robb (1986) is also nocturnal. Captures in the Marotere Islands using pitfall traps also indicate that this species is active at night (Towns and Parrish unpublished data).
- The southern (Mercury Island and Aldermen) populations (assigned by Robb to *pachysomaticum*) are equivalent in size to those in the Mokohinau and Marotere Islands, but these are active either during the day (Robb 1986) or at night/ during the late afternoon (Towns unpublished capture data).

There is considerable scope for detailed morphological, genetic and behavioural studies in this group, and for these studies to be extended to include populations on Little Barrier and Great Barrier Islands. The confusion over the taxonomic identity of the various populations has implications for some restoration proposals. For example, if marbled skinks are included in the projects on the inner Hauraki Gulf islands, it is unclear at present whether Little Barrier Island or Mercury Island populations would be the most appropriate source. Given the degree of genetic and morphological diversity in this group, it would be dangerous to assume that the Mercury Island and Little Barrier Island populations are the same taxon.

Ornate and copper skinks

Analyses of the origins of species names for ornate and copper skinks were published simultaneously by Robb (1977) and Hardy (1977), with different conclusions. Robb (1986) contends that the species name *aenea* has been incorrectly applied and that the validity of a previously used species name, *pseudornata*, is the correct name for ornate skinks. These issues require re-examination and clarification.

References

Daugherty, C.H.; Patterson, G.B.; Hitchmough, R.A. 1994: Taxonomic and conservation review of the New Zealand herpetofauna. *New Zealand journal of zoology 21*: 317–323.

Hardy, G.S. 1977: The New Zealand Scincidae (Reptilia: Lacertilia): a taxonomic and zoogeographic study. *New Zealand journal of zoology 4*: 221–325.

Hutchinson, M.N.; Donnellan, S.C.; Baverstock, P.R.; Krieg, M.: Simms, S.; Burgin, S. 1990: Immunological relationships and generic revision of the Australian lizards assigned to the genus *Leiolopisma* (Scincidae: Lygosominae). *Australian journal of zoology 38*: 535–554.

Robb, J. 1975: Two new skinks of the genus *Leiolopisma* from New Zealand. *Koninklijke Nederlandse Akademie van Wetenschappen, series C 78*: 477–484.

Robb, J. 1977: A revision of the synonymy of three species of leiolopismid skinks from New Zealand. *Bulletin of the British museum of natural history (Zoology) 31*: 303–310.

Robb, J. 1986: New Zealand amphibians and reptiles in colour (second edition). Auckland, Collins.

Appendix 2

TERMINOLOGY, SITES AND GUIDELINES FOR TRANSLOCATION AND RELEASE OF *Cyclodina* SKINKS

The recovery of *Cyclodina* skinks in the present plan relies largely on the eradication of pests from islands and establishment of the skinks in restored habitats. These restoration goals raise a number of conceptual and practical issues outlined below.

Terminology

Where the previous presence of a species now absent can be confirmed at a location by historic or palaeoecological evidence (e.g. old museum specimens, subfossil remains), their re-establishment at that location is referred to here as a reintroduction (see IUCN 1987). In the absence of direct evidence, the likelihood of previous presence of a species varies, and populations established at such locations are referred to here as a release or translocation.

Sites

Despite the absence of direct evidence, there are some locations (especially islands) with a history of modification where species were almost certainly once present judging by their abundance on neighbouring islands lacking similar disturbance (Category 1 in Appendix Table A2.1). There are also locations where previous presence is highly likely (Category 2, Appendix Table A2.1), but without the high level of probability found in Category 1. All translocations proposed for this plan are either reintroductions or fall into Categories 1 and 2.

At a small number of locations (Category 3) the previous presence of key lizard species is difficult to determine at present. Decisions on whether such locations should be included in translocations can await palaeoecological studies (such as the examination of material in midden sites).

Finally, a number of islands naturally free of introduced predators lack key species in *Cyclodina* although their presence might have been expected (Category 4). The plan does not propose releases of lizards to these locations, nor to any others (such as some small islands) where the absence of key species appears to be the result of natural phenomena (see Department of Conservation Translocation Guidelines).

Translocation group

So far, translocations of *Cyclodina* skinks have been based on three principles, each of which may benefit from further testing (see Towns et al. 1990):

1. The distance over which species are moved has been kept to a minimum largely due to restoration goals identified for particular island groups. However, there are the practical advantages. For example, physiological studies have revealed unusual cutaneous water loss problems (A. Cree, C.H. Daugherty and D.R. Towns unpublished), and the very narrow thermal range

over which some species are active (e.g. Towns 1994, Towns and Elliott 1996). Short-distance transfers should ensure the best possible match of local climates. An added advantage with short-distance transfers is that the animals are able to be kept in captivity for the shortest possible time.

2. Translocations have predominantly been direct ('hard') transfers of wild-caught animals. Coupled with the short distance moved, this method has the least risk of introducing foreign diseases. Also, hard transfers do not require the construction of holding facilities elsewhere. The proportional survival of lizards bred in captivity and released into the wild remains unknown.

The group used has usually been about 30 individuals. Trials are at present under way investigating the relative success of different proportions of juveniles, males and females. However, the Whitaker's skink population has successfully established on Korapuki Island following random captures of adults (1:1 sex ratio) and juveniles. The group size chosen is a compromise between the ideal population (which, for example with native frogs *Leiopelma* sp. has been up to 300 (D. Newman pers comm.)), the potential to significantly affect the parent population, and the need to avoid a small, inbred translocated group. Present indications are that populations of more than 20 should reflect most of the genetic variation of the parent group (Craig 1991 and references therein). This assertion requires validation for lizards (see Research Priorities).

Criteria for success

For the large *Cyclodina* species, reproductive rates are so low that considerable expensive monitoring could be involved in determining when the population has successfully established. Based on the assumption that a successful translocation is one where the released population is at least self-sustaining (Dodd and Seigal 1991), monitoring of species with low productivity could be reduced to meet the following targets:

1. Five years after release. Locate the released population and determine whether there are new individuals present. This will identify whether the released population survived and is breeding. It will likely be too early to determine whether the population is expanding.
2. Ten years after release. Attempt to capture at least as many lizards as were released and identify the proportion of new versus original animals. This is the clearest measure of whether the population is self-sustaining (births are replacing deaths and the population is at least stable).
3. Fifteen years after release. Intensive surveys to determine either rate of expansion of the released group, or to identify whether the population is self-sustaining (if this was not possible previously).

Additional issues arise as a result of the above three suggestions:

Location. It is essential that the exact location of the release site is known so that subsequent surveys are concentrated where there are the greatest chances of success.

Identification. In order to identify the proportion of new births in a population, the animals originally released must be individually identifiable. There are only two choices as to how this can be done. Either the animals will need individually coded toe clips or each released animal will need to be photographed so that

identifying marks can be located later. Some iwi do not allow toeclipping to be used in their rohe, in which case photography is the only choice. However, it is a choice yet to be extensively field tested.

Over-exploitation. Because of low productivity, newly established populations of large *Cyclodina* cannot themselves be used as a basis for further translocations until many years after release. Present indications are that it may be up to 20 years before 30 individuals could be taken out of a new population without placing the newly established group at risk. As a corollary, the original wild populations will continue to be the main source of animals for translocations—at least for the term of this plan.

References

Craig, J. 1991. Are small populations viable? *Acta XX congressus internationalis ornithologici* : 2546–2552.

Dodd, K.; Seigal, R.A. 1991. Relocation, repatriation and translocation of amphibians and reptiles: are they conservation strategies that work? *Herpetologica 47*: 336–350.

IUCN. 1987. The IUCN statement on translocation of living organisms. IUCN Gland, Switzerland.

Towns, D.R. 1994. The role of ecological restoration in the conservation of Whitaker's skink (*Cyclodina whitakeri*), a rare New Zealand lizard (Lacertilia: Scincidae). *New Zealand journal of zoology 21*: 457–471.

Towns, D.R.; Elliott, G. P. 1996. Effects of habitat structure on distribution and abundance of lizards and Pukerua Bay, Wellington, New Zealand. *New Zealand journal of ecology 20*: 191–206.

Towns, D.R.; Daugherty, C.H.; Cromarty, P.L. 1990. Protocols for translocation of organisms to islands. In: Towns, D.R.; Daugherty, C.H.; Atkinson, I.A.E. Eds. Ecological restoration of New Zealand islands. *Conservation sciences publication no. 2*: 240–254.

TABLE A2.1. DISTRIBUTION OF RARE SPECIES OF *Cyclodina* PROPOSED FOR TRANSLOCATIONS RELATIVE TO POTENTIAL FUTURE LOCATIONS FOR NEW POPULATIONS.

Category 1. Recorded from at least one previously interconnected island(s) group(s) but now absent from remainder of the listed islands:

Species	Island group
Robust skink	Moturoa Islands, Mokohinau Islands, inner Hauraki Gulf islands[1], Mercury Islands, Mercury Bay Islands, Mana Island[1]
McGregor's skink	Cavalli Islands, Hen and Chickens Islands, Bream Islands, Mana Island
Mokohinau Skink	Mokohinau Islands, Hen and Chicken Islands
Marbled skink (southern)	Great and Little Barrier Islands[2], Mercury Islands, Mercury Bay islands, Alderman Islands
Whitaker's skink	Inner Hauraki Gulf Islands[1], Mercury Islands, Mercury Bay islands

Category 2. Recorded from the adjacent mainland or island groups of similar origin, but now absent from the listed localities:

Species	Island group
Robust skink	Motuopao Island, Cavalli Islands, Hen and Chickens Islands, Little Barrier Island, Kapiti Island group, Somes/Matiu Island
McGregor's skink	Little Barrier Island, Kapiti Island group, Somes/Matiu Island
Marbled skink (southern)	Inner Hauraki Gulf islands, Cuvier Island
Whitaker's skink	Mana Island, Kapiti Island group, Somes/Matiu Island

Category 3. Likely past presence unclear because of unusual geological origins of listed site; not known from sites of similar origin:

Species	Island group
Robust skink,	Cuvier Island
Whitaker's skink	Cuvier Island

Category 4. Absent despite suitable habitats, including islands without introduced predators:

Species	Island group
Robust skink	Aldermen Islands, islands of the Bay of Plenty
McGregor's skink	Islands north of Cavalli Islands, Inner Hauraki Gulf islands, Coromandel islands, Bay of Plenty islands
Marbled skink (southern)	Islands south of Aldermen Islands
Whitaker's skink	Islands north of inner Hauraki Gulf, Aldermen Islands, Bay of Plenty islands

[1] Subfossil remains only.

[2] Identity to be confirmed.

Appendix 3

POSSIBLE TIMELINES AND PRIORITIES FOR THE TRANSLOCATIONS OF *Cyclodina* SKINKS

Most source populations of the rare species in *Cyclodina* will, in the next two to three decades, only be available from relatively fragile or sensitive island and mainland sites. The situation will change when new island populations are available as a further source of populations for restoration (see Appendix 2).

It is therefore important to rank translocation proposals to ensure that:

- Host populations are not detrimentally affected by translocations.
- Fragile ecosystems are not adversely affected by translocations.
- Restoration activities are developed using realistic timeframes.

Most proposals can be divided into categories of risk. There is a risk of failure due to small population sizes such as in the trickle feed approach advocated for some locations. However, this risk is independent of risks involving the locations themselves.

If choices have to be made, it is suggested that for the life of this plan highest priority sites should have the lowest risk of failure due to uncontrollable events. At low risk sites the following should be minimal:

- Predation: few avian predators; reptile predators such as tuatara and larger species of lizards either absent, present in low density, or can be isolated (through releases away from the threats).
- Maintenance: costs minimal and likely confined to pest reinvasion prevention measures.
- Security: high due to designation (e.g. Nature Reserve), accessibility, levels of surveillance, low public use.

As a corollary, the following sites represent greater risk even though they may now be free of introduced mammalian predators:

- Predation: presence of many avian predators and/or high densities of reptile predators.
- Maintenance: risks due to predation can be reduced by control of predator density or use of exclosures, but this requires ongoing expenditure (risk is lowered if the expenditure is short term, but raised if indefinite).
- Security: low due to accessibility, significant risk to habitat damage or of animals being accidentally or deliberately disturbed (risk is reduced if public can be restricted to certain areas, or escorted while present, but raised if access is unrestricted and uncontrolled).

The problems raised by the second category of locations may be reduced over time through greater understanding of the success of translocations in category one, or as the number of animals available increases.

The timelines for translocations provided in Table A3.1 reflect a risk analysis using the above criteria as well as the priority order of objectives in this plan. The priority levels identified below relate only to management actions required over the next five years.

TABLE A3.1. PROPOSED TIMES FROM APPROVAL OF PLAN FOR COMMENCEMENT OF TRANSLOCATIONS OF *Cyclodina* SPECIES IDENTIFIED AS PART OF THIS PLAN. SPECIES MARKED 'r' ARE RESIDENT; 'i', ALREADY RELEASED.

	C. aenea	*C. alani*	*C. macgregori*	*C. oliveri*	*C.* n.sp.1	*C. ornata*	*C. whitakeri*
Motuopao	r	i, 1997				> 10 y	
[1]Motukawanui	r	?	< 10 y			r ?	
[2]Limestone	r					< 10 y	
Lady Alice	r	> 5 y	i, 1997–98		i, 1997–98	r	
[2]Whatupuke	r		< 2 y		< 2 y	r	
[3]Coppermine	r	< 3 y			< 3 y	r	
[1]Hen	r	< 10 y	< 10 y		< 10 y	r	
[2]Mokohinau Is	r	< 5 y			< 5 y		
[1]Fanal							
[1]Little Barrier	r	< 10 y	< 10 y	r		r	
[2]Tiritiri Matangi	r	< 10 y					< 10 y
[2]Motuora	r	< 10 y					< 10 y
[2]Cuvier	r			< 10 y			
Korapuki	r	i, 1992–93		i, 1992–93			i, 1988
Stanley	r	i, 1995					i, 1995
Red Mercury	r	i, 1994–95		r?			i, 1994,95
Double	r	< 10 y					< 10 y
[2]Middle Chain	r ?			< 5 y			
[2]Whale	r						
[3]Kapiti	r	< 10 y	< 10 y			r	< 10 y
[2]Somes/Matiu	r					< 10 y	?
[2]Mana	r	< 2 y	r			?	< 2 y

[1] Rodents still present.

[2] Rodents removed, restoration of reptiles about to begin.

[3] Eradication campaign against rodents recently completed.

Motuopao Island

Reintroduction of robust skinks completed. Inclusion of the ornate skinks from Matapia or the adjacent mainland would complete the assemblage of species of *Cyclodina* from Matapia. Survey for translocated robust skinks required at year five. *Low priority over next five years, thereafter high priority.*

Motukawanui Island

Cannot proceed until kiore are removed. Could include eventual releases of robust skinks. *Low priority over next five years, thereafter high priority.*

Limestone Island

High public use. Restoration proposals include ornate skinks. *Low priority.*

Lady Alice Island

First translocations of Mokohinau skinks and McGregor's skinks completed in March 1998. Could also include robust skinks in the long term. Some post-release monitoring under way.

Whatupuke Island

Priority site for McGregor's skink and Mokohinau skink. Could also include robust skink in the long term. At risk of reinvasion by kiore from Coppermine Island until a campaign on the latter is completed in 1999. *Low priority until kiore absence confirmed, thereafter high priority.*

Coppermine Island

Priority site for mokohinau skink and robust skink. Could also include McGregor's skink (depending on how they interact with Mokohinau skinks). A campaign against kiore is due for completion in 1999. *Low priority until kiore absence confirmed, thereafter high priority.*

Hen Island

Cannot proceed until kiore are removed. Could include eventual releases of McGregor's, Mokohinau and robust skinks. *Low priority over next five years, thereafter high priority.*

Mokohinau Islands

Range of land use issues involved. Restoration plan should address risks by location. Critical to future survival of Mokohinau skinks and local populations of robust and ornate skinks. *High priority.*

Fanal Island

Removal of kiore attempted in 1997. Needs assessment of success of the campaign, and could then be included in restoration plan for the group. *Low priority until kiore absence confirmed, thereafter high priority.*

Little Barrier Island

Cannot proceed until kiore are removed. Resident marbled skinks, could include eventual releases of McGregor's and robust skinks. *Low priority over next five years, thereafter high priority.*

Tiritiri Matangi Island

High levels of public visitation, possible risk from ground-feeding birds, needs trial releases of more common species to assess potential problems of predation and security. Possible site for marbled, robust and Whitaker's skinks. *Low priority over next five years, then reassess.*

Motuora Island

High levels of public visitation, possible risk from ground feeding birds, needs trial releases of more common species to assess potential problems of predation and security. Possible site for marbled, robust and Whitaker's skinks. *Low priority over next five years, then reassess.*

Cuvier Island

Possible low levels of future public visitation. Probable site for marbled skinks and possible site for robust and Whitaker's skinks. Needs surveys (including midden analysis) and a restoration plan. *Moderate priority.*

Korapuki Island

Reintroductions completed and now being monitored.

Stanley Island

Reintroductions of robust and Whitaker's skinks completed. Possible future site for marbled skinks. Needs surveys and a restoration plan. *Moderate priority.*

Red Mercury Island

Reintroductions of robust and Whitaker's skinks completed. Possible resident marbled skinks (Towns (1972) as "*Leiolopisma aeneum"*). Needs surveys and a restoration plan. *High priority.*

Double Island

Possible future site for robust, marbled and Whitaker's skinks. Needs restoration plan. *Low priority.*

Middle Chain Island

Future site for marbled skinks. Needs survey and restoration plan. *Medium priority.*

Motouhora/Whale Island

Not recommended for future translocations of *Cyclodina* skinks. This could change if other species of *Cyclodina* are located on nearby islands.

Kapiti Island and adjacent islands

Possible future site for robust, McGregor's and Whitaker's skinks. Needs results of surveys for resident lizards, risk assessment of effects of ground feeding birds. Low public visitation. *Low priority over next five years, then reassess.*

Somes/Matiu Island

High levels of public visitation. Possible future site for ornate skinks. *Low priority.*

Mana Island

Moderate levels of public visitation. Planned site for Whitaker's skink from Pukerua Bay (where there are severe predation threats), and robust skinks from Castle Island. Needs risk assessment of effects of ground-feeding birds (pukeko and takahe). Potential for interaction with McGregor's skinks (in long term). High risk, but other options are limited. *High priority*.