



North Island  
*Oligosoma* spp.  
skink recovery plan

2002-2012

THREATENED SPECIES RECOVERY PLAN 48



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.

After preparing a technical report, which was refined by scientists and managers both within and outside the Department, a draft of this plan was sent to the New Zealand Conservation Authority and relevant Conservation Boards for comment. After further refinement, this plan was formally approved by the Central Regional Office in May 2002. A review of this plan is due after 10 years (2012), 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.

The Department acknowledges 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 opportunities for consultation between the Department and the tangata whenua. Departmental Conservancy Kaupapa Atawhai Managers are available to facilitate this dialogue.

A recovery group consisting of people with knowledge of the North Island *Oligosoma* spp., and with an interest in their conservation has been established. The purpose of the North Island *Oligosoma* Recovery Group is to review progress in the implementation of this plan and to recommend to the Department any changes that may be required as management proceeds. Comments and suggestions relating to the conservation of the North Island *Oligosoma* spp. are welcome and should be directed to the recovery group via any office of the Department or to the Biodiversity Recovery Unit.



# North Island *Oligosoma* spp. skink recovery plan

2002-2012

THREATENED SPECIES RECOVERY PLAN 48

David R. Towns, Keri A. Neilson and A. H. (Tony) Whitaker

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# 1. Introduction

The skink genus *Oligosoma* comprises 22 known species, all endemic to the New Zealand region (Patterson & Daugherty 1995; Patterson 1997). *Oligosoma* is separated from the other endemic genus of skinks, *Cyclodina*, on morphological and genetic grounds (Patterson & Daugherty 1995). Members of the two genera also differ in their behaviour. Unlike *Cyclodina*, most *Oligosoma* species are strictly diurnal. The only exceptions are the northern North Island egg-laying skink (*O. suteri*) which is mainly nocturnal and the Three Kings skink (*O. fallai*) which is sometimes nocturnal (R. Parrish, pers. comm.).

The species in *Oligosoma* show great ecological diversity. North Island members range from strictly shoreline inhabitants, such as the egg-laying skink, forest-inhabiting species such as the striped skink (*O. striatum*) that may be at least partly arboreal (Whitaker 1998), through to the common skink (*O. nigriplantare polychroma*) that ranges from coastal rocky shorelines to alpine areas in the central North Island. The North Island fauna (Table 1) includes one species endemic to the

TABLE 1. SUMMARY OF CONSERVATION STATUS OF NORTH ISLAND SPECIES IN THE GENUS *OLIGOSOMA*. DATA ON TAXONOMY FROM PATTERSON & DAUGHERTY (1995), DEPARTMENT OF CONSERVATION (DOC A) PRIORITY RANKING FROM MOLLOY & DAVIS (1994), THREAT CLASSIFICATION LISTINGS (DOC B) FROM HITCHMOUGH (IN PRESS) AND INTERNATIONAL CONSERVATION STATUS FROM IUCN (1996).

COMMON NAME	SCIENTIFIC NAME AND AUTHORITY	DOC A	DOC B	IUCN STATUS
Brown skink	<i>Oligosoma zelandicum</i> (Gray, 1843)	Nil	Not threatened	Nil
Chevron skink	<i>O. bomalonotum</i> (Boulenger, 1906)	A	Nationally endangered	Threatened
Common skink	<i>O. nigriplantare polychroma</i> (Patterson & Daugherty, 1990)	Nil	Not threatened	Nil
Egg-laying (Suter's) skink	<i>O. suteri</i> (Boulenger, 1906)	Nil	Not threatened	Nil
Moko skink	<i>O. moco</i> (Duméril & Bibron, 1839)	Nil	Sparse	Nil
Narrow-bodied skink	<i>O. gracilicorpus</i> (Hardy, 1977)	Ex <sup>1</sup>	Not ranked	Data deficient
Shore skink	<i>O. smithi</i> (Gray, 1845)	Nil	Not threatened	Nil
Small-scaled skink	<i>O. microlepis</i> (Patterson & Daugherty, 1990)	A	Serious decline	Threatened
Speckled skink	<i>O. infrapunctatum</i> (Boulenger, 1887)	Nil	Gradual decline	Lower risk: near threatened
Spotted skink	<i>O. lineocellatum</i> (Duméril & Duméril, 1851)	Nil	Gradual decline	Nil
Striped skink	<i>O. striatum</i> Buller, 1871	A	Data deficient	Threatened
Three Kings (Falla's) skink	<i>O. fallai</i> (McCann, 1955)	C (L) <sup>2</sup>	Range restricted	Lower risk: near threatened

<sup>1</sup> Ex: Presumed extinct

<sup>2</sup> C (L): Category C, Local



Three Kings Islands (*O. fallai*) and a further five species identified in the latest IUCN Red List (IUCN 1996). At least two additional species appear to have undergone serious range declines and are now largely confined to offshore islands.

This is the third recovery plan for North Island skinks in *Oligosoma*. The first plan, for the chevron skink, *Oligosoma bomalonotum*, was a 5-year plan approved in 1993 (Towns & McFadden 1993) and subsequently extended to February 2000. The second plan was developed for the striped skink for 5 years to February 2003 (Whitaker 1998). The present plan was compiled to coincide with expiry of the chevron skink plan. Since the chevron skink and striped skink both inhabit Great Barrier and Little Barrier Islands, and several other species in the genus appear under threat in the North Island, recovery options for all of them have been covered in one 10-year plan. This plan therefore supersedes the striped skink plan, and provides additional objectives for that species. However, most objectives of the striped skink plan are unchanged and are outlined in detail in the original plan.

The present plan reviews the conservation status and recovery actions required in order to improve the conservation status of twelve species in *Oligosoma* found in the North Island and on adjacent offshore islands. The assessments of conservation status include the North Island populations of four species present in the North and South Islands. Inclusion of a wide range of species in the present plan has two purposes. First, because many of the species overlap in geographic range, it should help in identifying where management actions may have multi-species effects. For example, the successful removal of rats from Kapiti Island (1970 ha) and the proposed removal of rats from Little Barrier/Hauturu Island (3083 ha) could have significant conservation benefits for two rare *Oligosoma* species (on Little Barrier Island), and also enable long-term increases in the abundance of a further six species in the genus (both islands combined). Second, it provides an avenue to identify where species are declining and could become rare in the future if actions are not undertaken now. Specific recovery objectives are, however, listed here only for the six rarest species. Of these six species, four inhabit at least one island location where there are no introduced mammals. The two exceptions, chevron skinks and striped skinks, are now affected by introduced mammals throughout their entire range. For this reason, the eradication of kiore (*Rattus exulans*) from Little Barrier Island is identified here as a key step for the protection and recovery of chevron skinks and striped skinks.

Taxonomic nomenclature follows Patterson & Daugherty (1995) and common names follow Molloy & Davis (1994) and Gill & Whitaker (1996). Colour illustrations of all species are provided in the recent 'Penguin guide to New Zealand Wildlife' (DOC 2002).

## 2. Distribution past and present

The geographic ranges of at least six of the North Island species in the genus *Oligosoma* have undergone substantial declines since the arrival of humans in New Zealand. Notes on existing sympatric associations are provided below and are summarised in Table 2. Data for distribution maps were derived from current data in the Amphibian and Reptile Distribution scheme (Pickard & Towns 1988) unless identified otherwise. Localities mentioned in the text are identified in Fig 1.

TABLE 2. SUMMARY OF COMBINATIONS OF EXTANT SPECIES OF NORTH ISLAND *OLIGOSOMA* SKINKS ARRANGED IN APPROXIMATE NORTH-SOUTH SEQUENCE. DOTS IDENTIFY SPECIES THAT CO-EXIST AND SQUARES THOSE THAT OVERLAP IN RANGE.

	THREE KINGS	EGG-LAYING	SHORE	MOKO	CHEVRON	STRIPED	COMMON	BROWN	SMALL-SCALED	SPECKLED	SPOTTED
THREE KINGS		●	●								
EGG-LAYING	●		●	●	■	■					
SHORE	●	●		●	■	■	■			■	
MOKO		●	●		●	●					
CHEVRON		■	■	●		●					
STRIPED		■	■	●	●		●	■		●	
COMMON						●		●	●	●	●
BROWN						■	●			●	●
SMALL-SCALED							●			●	
SPECKLED			■			●	●	●	●		●
SPOTTED							●	●		●	

Figure 1. Species distribution localities mentioned in the text.

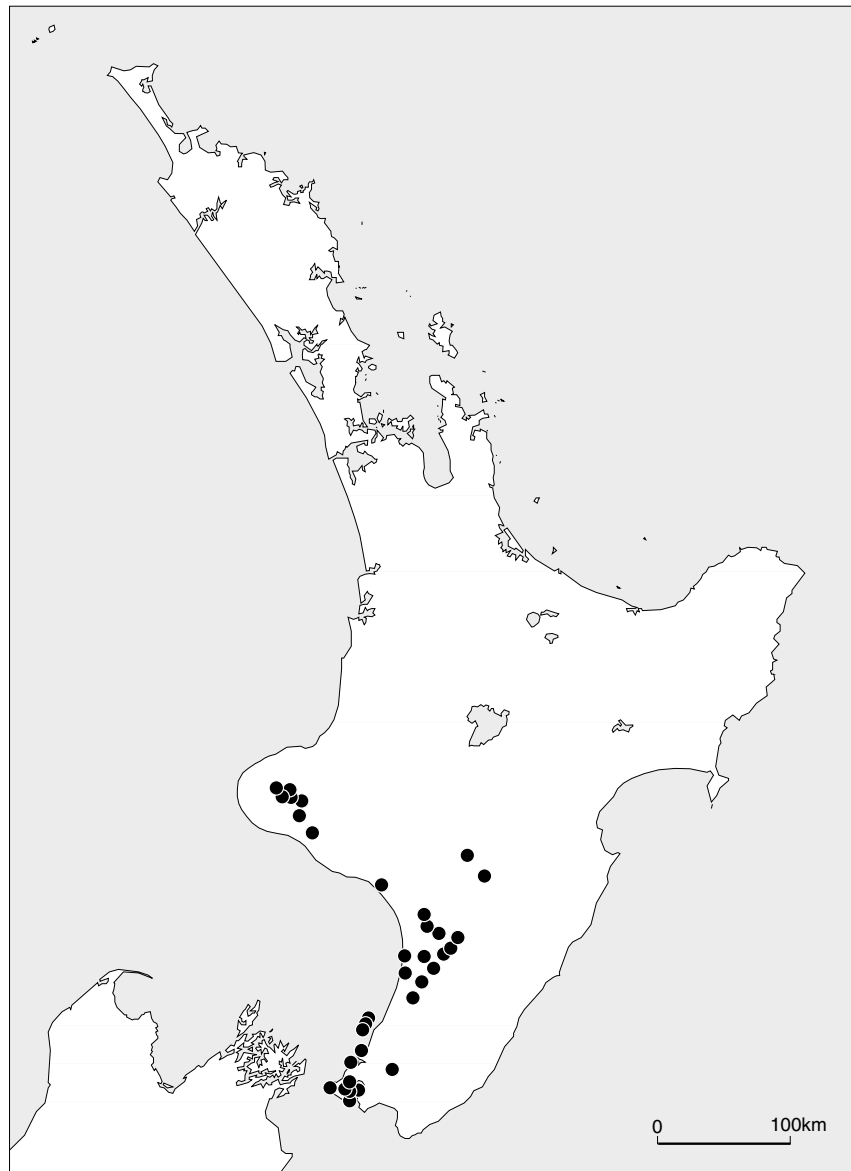


### **Brown skink: *Oligosoma zelandicum***

This species appears to have been widespread over the south-western North Island from Taranaki south, and also on the adjacent offshore islands. Brown skinks are now present in the Taranaki area and the western half of the southern North Island, on Kapiti Island, Mana Island (Fig. 2) and possibly on islands in Wellington Harbour. Brown skinks are also found in the northern and north-western South Island.

Brown skinks frequently co-exist with common skinks (Gill 1976) and at a few localities with spotted skinks. Brown, common, spotted and speckled skinks co-exist in Marlborough Sounds on Stephens Island/Takapourewa and are likely to have once done so in the Wellington area (Towns 1992).

Figure 2. Distribution of populations of brown skink *Oligosoma zelandicum* in the North Island.



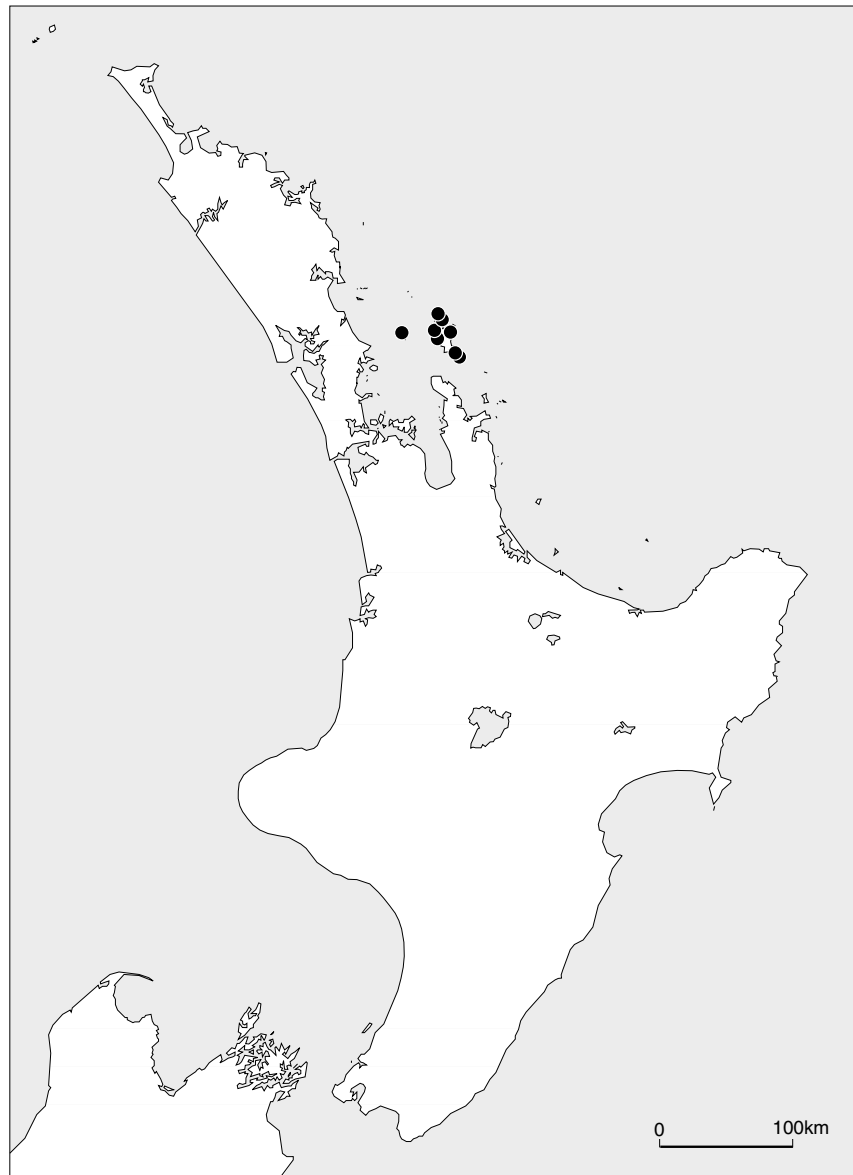
### **Chevron skink: *Oligosoma bomalonotum***

Chevron skinks are at present known only from Great Barrier and Little Barrier Islands. There are anecdotal reports of lizards large enough to have been chevron skinks from the Hokianga area early in the 20th century (see Towns & McFadden 1993), and Worthy (1991) has identified subfossil remains of what may be chevron skinks in cave and sand dune deposits at Waipu and Tokerau Beach (Fig. 1). The present distribution of chevron skinks is consistent with that of other species of lizards once widespread on the mainland and now confined to offshore islands.

On Great Barrier Island, chevron skinks have been recorded from at least 20 sites (catchments) (Towns & McFadden 1993) and a single specimen was captured in a stream bed on northern Little Barrier Island (Fig. 3).

On Great Barrier Island, chevron skinks occupy the same forest areas as striped skinks. Chevron skinks also overlap in range (but not habitat) with egg-laying skinks, moko skinks and shore skinks.

Figure 3. Distribution of populations of chevron skink *Oligosoma bomalonotum*.

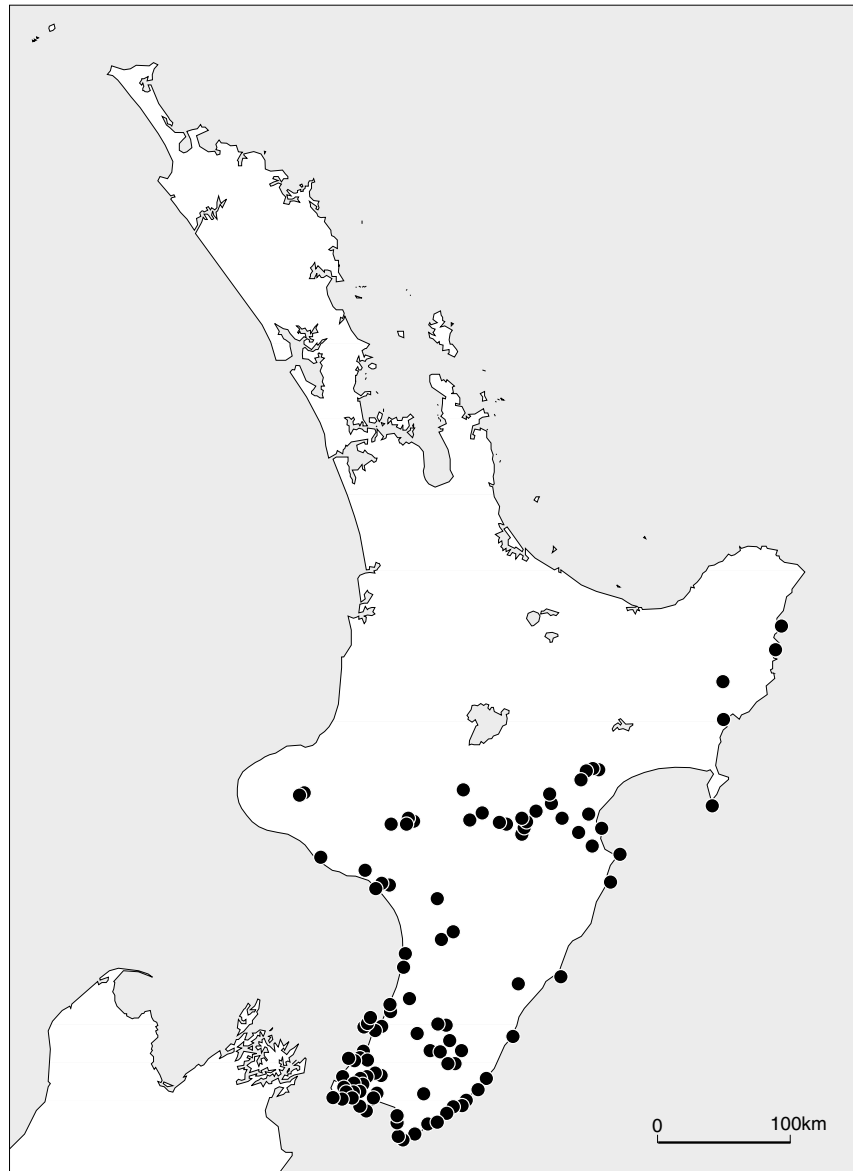


**Common skink: *Oligosoma nigriplantare polychroma***

Common skinks are widely distributed over the southern half of the North Island and throughout much of the South Island (Patterson & Daugherty 1990). In the North Island, the species ranges from the coast to high-altitude tussock grasslands (Fig. 4). A second subspecies, *O. nigriplantare nigriplantare*, is widespread through the smaller Chatham Islands (Hardy 1977).

In the North Island, common skinks co-exist with brown, spotted, speckled, striped and small-scaled skinks (Patterson & Daugherty 1990; Whitaker 1991, 1997).

Figure 4. Distribution of populations of common skink *Oligosoma nigriplantare polychroma* in the North Island.

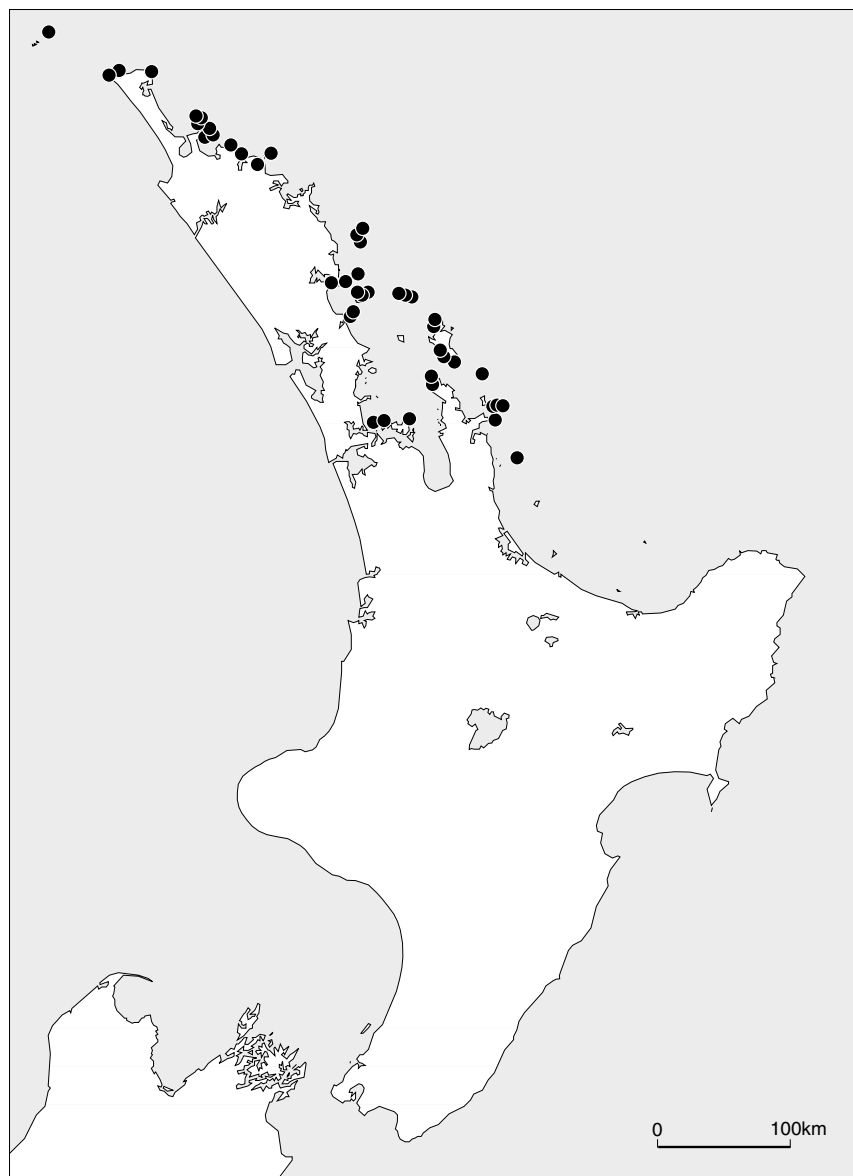


### Egg-laying skink: *Oligosoma suteri*

The present distribution of egg-laying skinks indicates that they were probably once associated with hard shorelines from the Coromandel Peninsula north, and on offshore islands over the same geographic range. The species is now largely confined to islands off northern and north-eastern North Island where 49 populations have been identified from the Three Kings Islands to the Aldermen Islands (Towns 1991; D. Towns, R. Parrish and I. Westbrooke unpubl. data). Only three mainland populations are known: two in northern Northland and one on the Coromandel Peninsula (Fig. 5).

Egg-laying skinks co-exist with shore skinks and moko skinks on most islands. In addition to these, egg-laying skinks co-exist with Three Kings skinks on the Three Kings Islands, and overlap in range with striped and chevron skinks on Great Barrier and Little Barrier Islands.

Figure 5. Distribution of populations of egg-laying skink *Oligosoma suteri*.

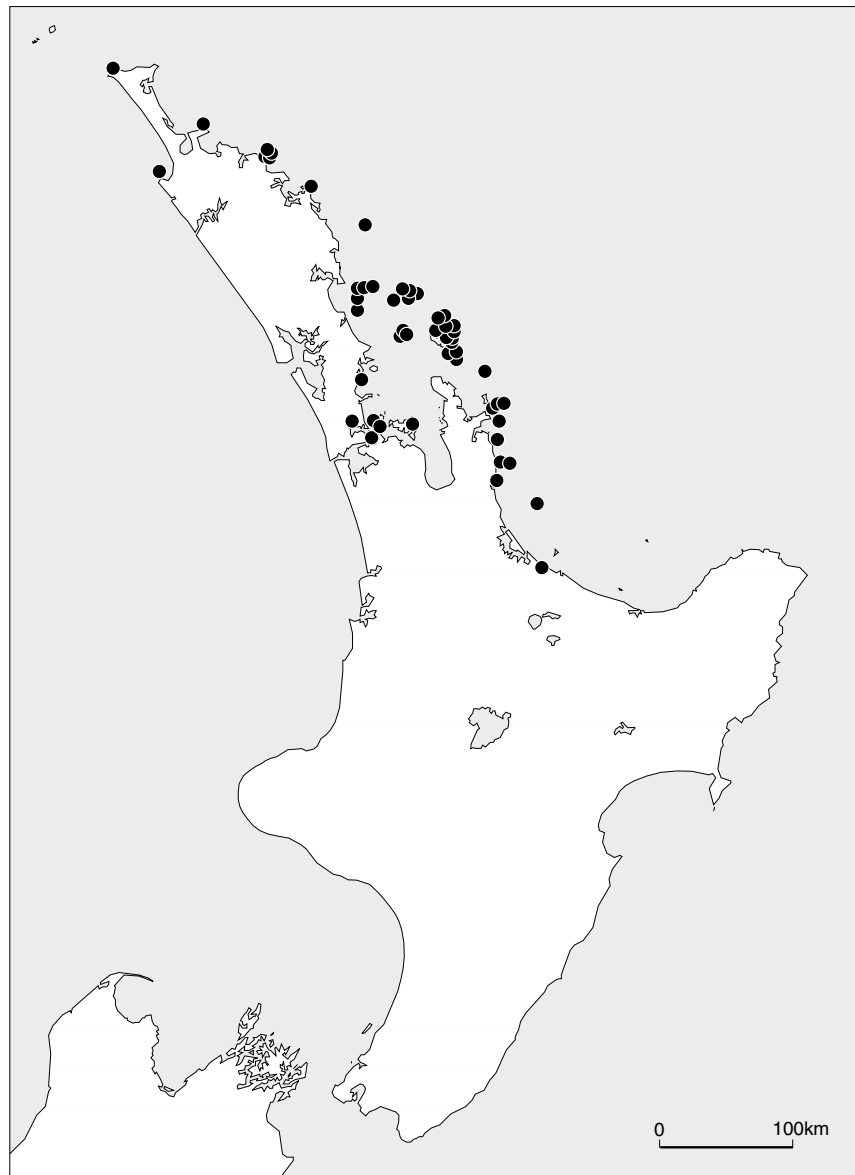


### **Moko skink: *Oligosoma moco***

Their present fragmented distribution indicates that moko skinks were once widespread on most offshore islands and in coastal areas in the North Island from the Bay of Plenty north. Like egg-laying skinks, moko skinks are now found almost solely on offshore islands (at least 33) ranging from Motuopao Island to Mayor Island (Tuhua) in the Bay of Plenty (Fig. 6). Fewer than five mainland populations have been identified.

The range of sympatric species in the genus is the same as for egg-laying skinks except that there are no confirmed reports of moko skinks on the Three Kings Islands (R. Parrish, pers comm.).

Figure 6. Distribution of populations of moko skink *Oligosoma moco*.





### Narrow-bodied skink: *Oligosoma gracilicorpus*

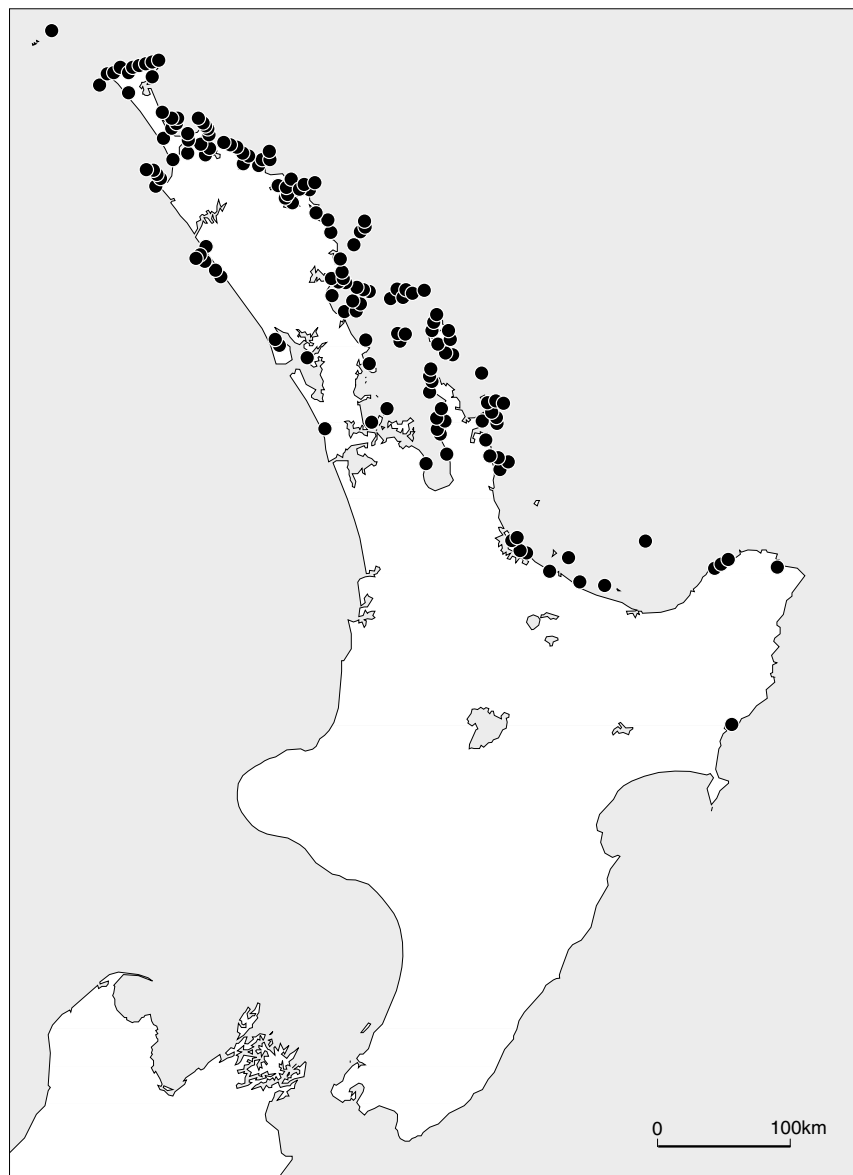
The only locality data for the single known specimen of this species is 'Hokianga'.

### Shore skink: *Oligosoma smithi*

Shore skinks are the most widely distributed species of *Oligosoma* in the northern North Island. At least 79 island populations have been identified and the species also occupies at least 50 locations on the mainland. Populations range from the Three Kings Islands to near Auckland on the west coast and to Gisborne on the East Coast (Fig. 7).

The range of species in the genus coexisting with shore skinks is the same as for egg-laying skinks, although shore skinks overlap in general range (without co-existing) with speckled skinks in the southern Bay of Plenty and also with common skinks near Gisborne.

Figure 7. Distribution of populations of shore skink *Oligosoma smithi*.

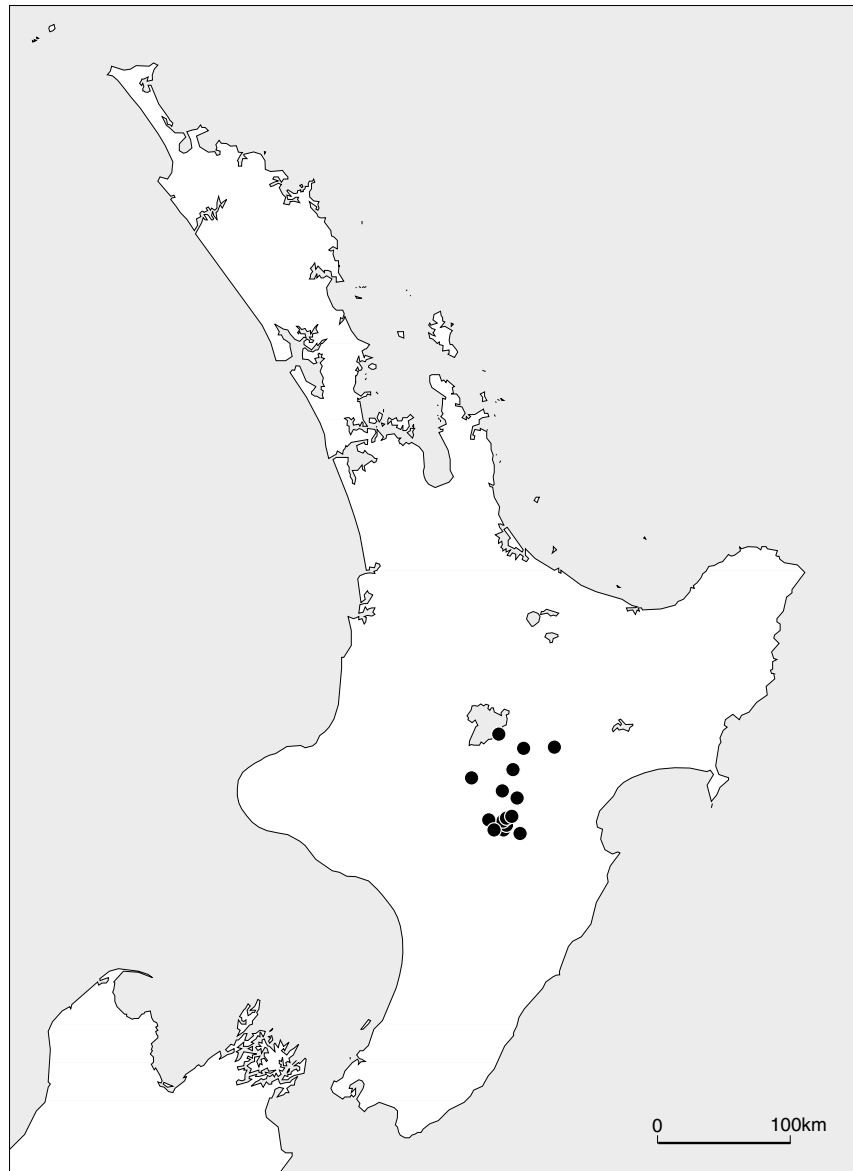


### Small-scaled skink: *Oligosoma microlepis*

The small-scaled skink is known from a few widely scattered localities from the southern Te Urewera district, through the Kaimanawa Range to the northern Ruahine Range, as well as from Motutaiko Island in Lake Taupo (Whitaker 1991, 1997; Hutchinson 1992, 1993) (Fig. 8). This distribution, and the habitat they occupy, suggests the species may once have been widely distributed in the eastern and central North Island, including the Taupo Basin, and perhaps further north or south along the axial ranges.

Small-scaled skinks co-exist with common skinks at several sites and are sympatric with speckled skink in the upper Rangitikei Catchment.

Figure 8. Distribution of populations of small-scaled skink *Oligosoma microlepis*.

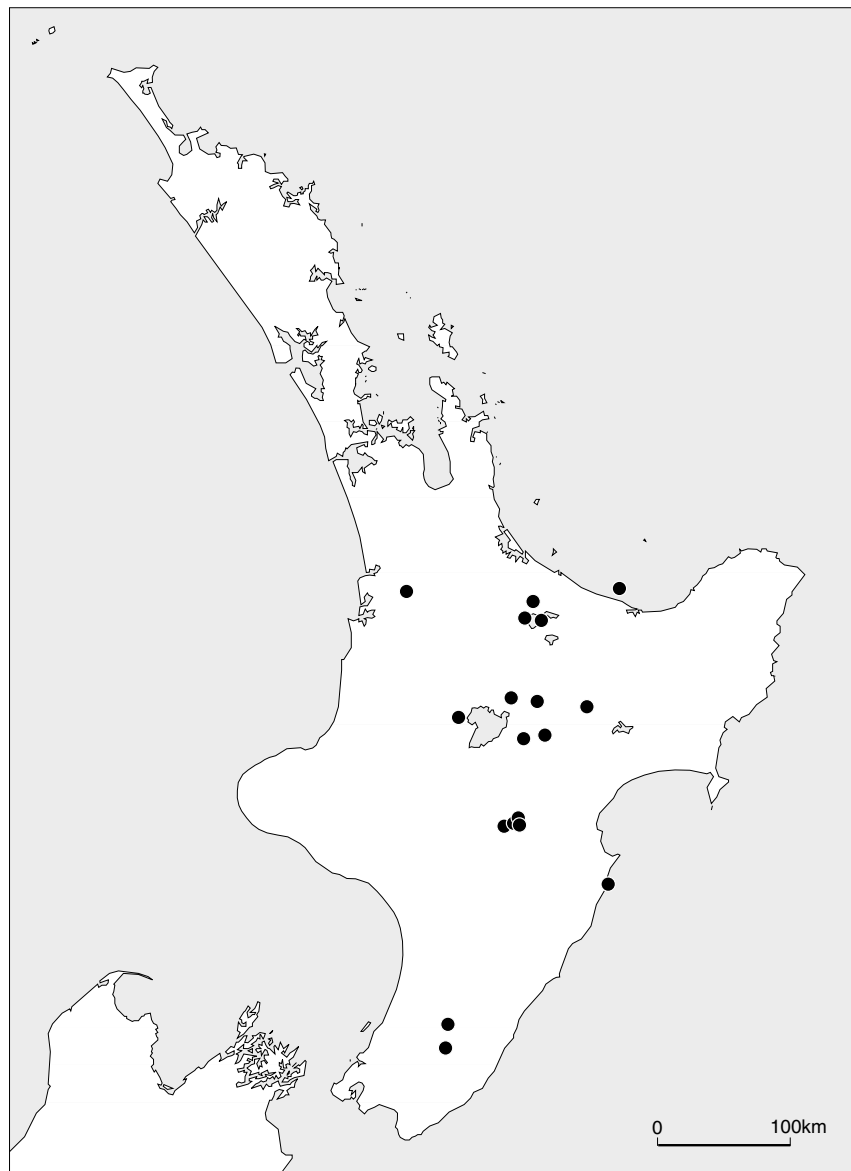


### Speckled skink: *Oligosoma infrapunctatum*

Speckled skinks have a scattered distribution indicating that they may once have been widely distributed through the North Island. Subfossil remains have been identified in caves as far north as Waipu (Worthy 1991), and existing records indicate that the species may have occupied inland areas up to 800 m above sea level. The species is widespread and relatively common on the Volcanic Plateau between Pureora, Taupo, Rotorua and through the Murupara/Galatea/Rangitaiki Plains region. There are outlying sites west of Hamilton, in Hawke's Bay, in the upper Rangitikei catchment, between Patea and Wanganui, and a few sites in the Wairarapa. On the Rangitaiki Plains, sites are in the range 700–750 m elevation (see Whitaker 1991, 1997). There are two island populations: on Moutohora (Whale) Island off Whakatane and Mokoia Island in Lake Rotorua. The Moutohora population appears to be the stronghold for the species in the North Island (Fig. 9). South Island populations are confined to the north-western part of the island (Pickard & Towns 1988).

The range of species of *Oligosoma* that coexist with speckled skinks in the North Island is the same as for common skinks.

Figure 9. Distribution of populations of speckled skink *Oligosoma infrapunctatum* in the North Island.

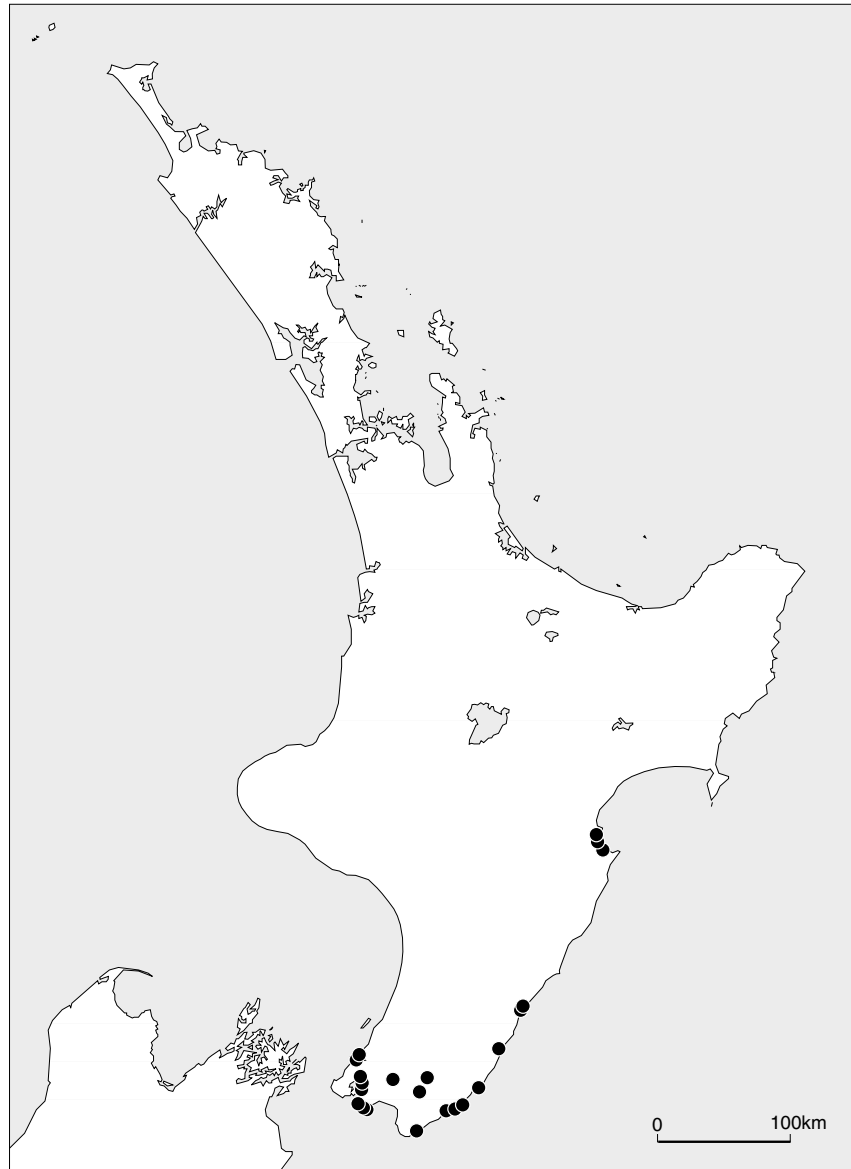


### Spotted skink: *Oligosoma lineocellatum*

Spotted skinks also have a scattered distribution indicating that they may once have been widespread in lowland areas of the southern North Island south of Hawke Bay. Spotted skinks are known from about 10 sites on the mainland North Island from Napier, the Wairarapa and Wellington areas (Fig. 10). The species is also found on islands in Wellington Harbour (Miskelly 1999), on islands in the Marlborough Sounds and is widespread in the eastern South Island (Pickard & Towns 1988).

In the North Island, spotted skinks coexist with brown, speckled and common skinks.

Figure 10. Distribution of populations of spotted skink *Oligosoma lineocellatum* in the North Island.

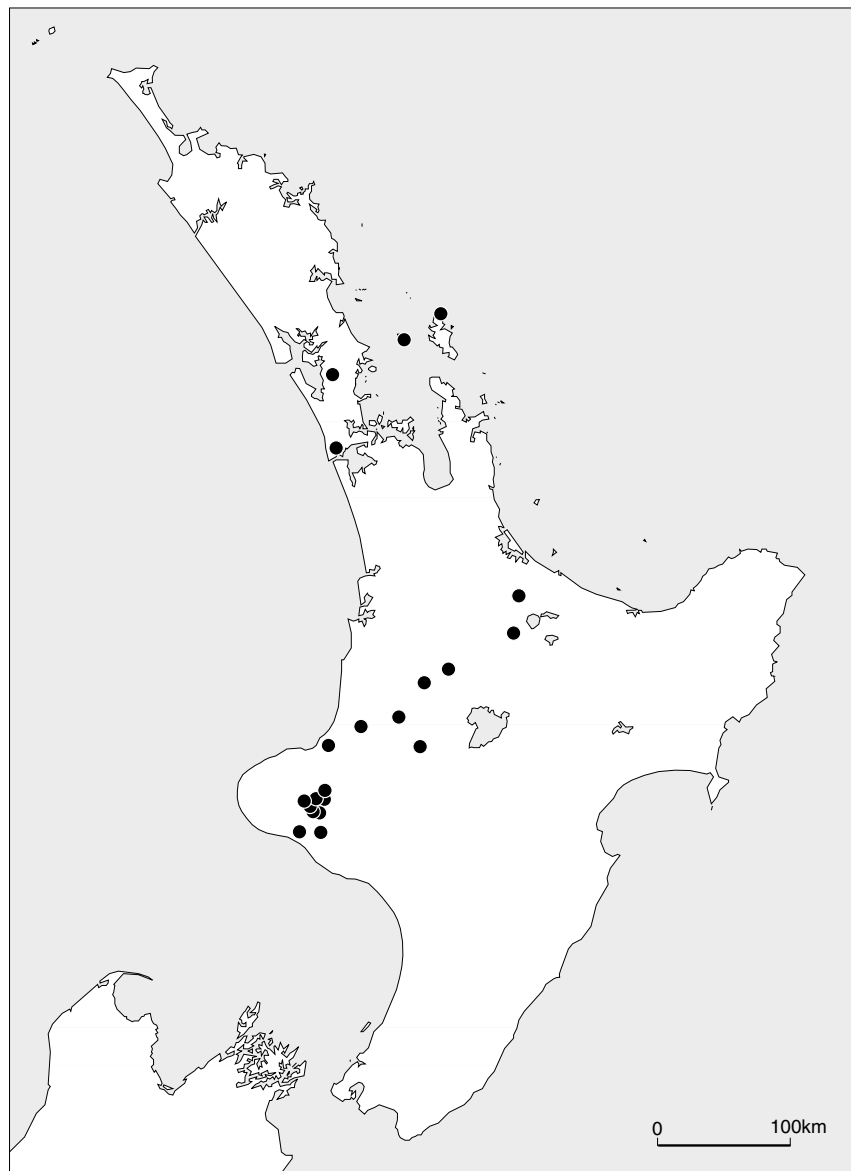


### Striped skink: *Oligosoma striatum*

The scattered localities of striped skinks indicate that the species was widely distributed, perhaps once over much of the North Island from Taranaki north to at least the Kaipara area of Northland. The species has been reported in recent times from up to 40 locations from Northland, Great Barrier and Little Barrier Islands, Bay of Plenty, Waikato and South Taranaki (Fig. 11). However, about 35% of these records are for individuals whose identity cannot be confirmed and at locations not precisely known (Whitaker 1998 and references therein).

The range of species of *Oligosoma* that coexist with striped skinks is the same as for chevron skinks except that striped skinks also coexist with common skinks and speckled skinks, and overlap in range with brown skinks.

Figure 11. Distribution of populations of striped skink *Oligosoma striatum*.



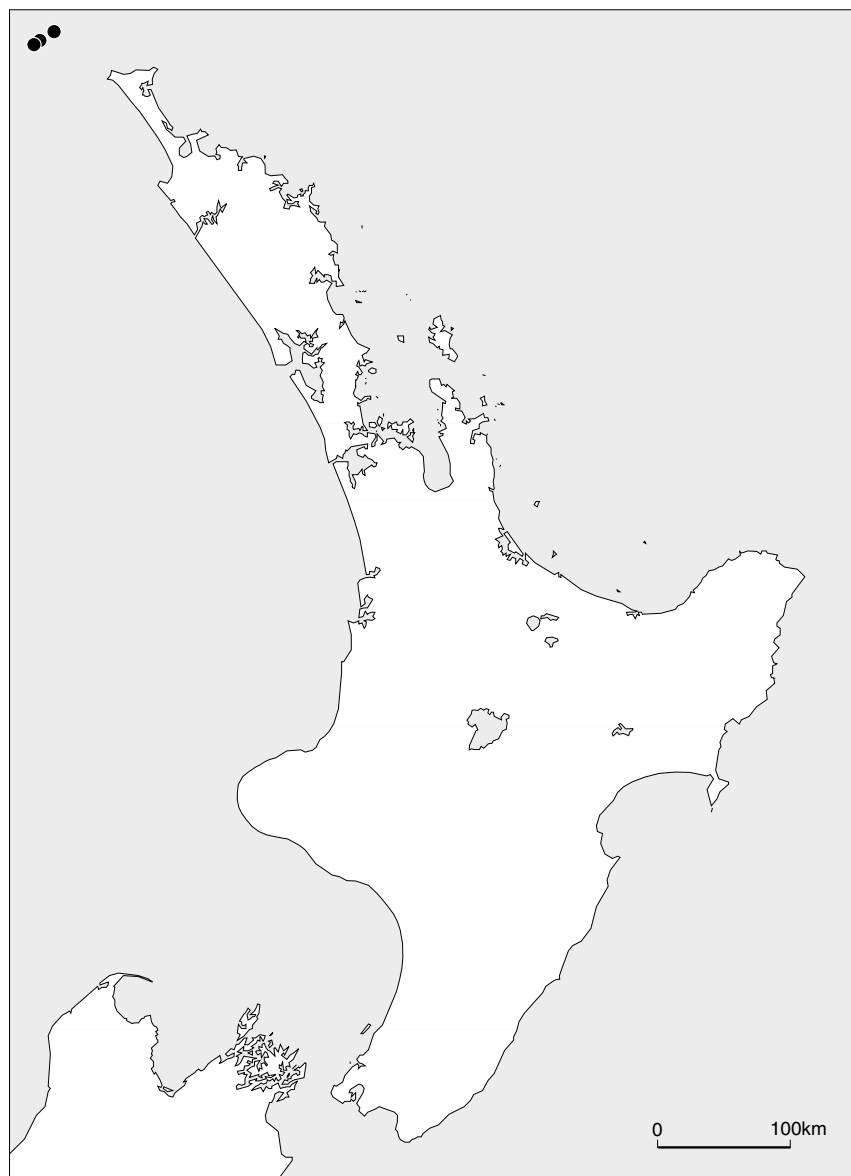
### Three Kings skink: *Oligosoma fallai*

The Three Kings skink is presumed to be endemic to Three Kings Group, where it inhabits at least seven islands and islets (Fig. 12). Subfossil remains from Northland suggested by Worthy (1991) as possibly from Three Kings skinks were associated by size, not the result of definitive identification.

The largest of the islands inhabited by the Three Kings skink, Great King (408 ha), was heavily modified during Maori occupation. The vegetation cover was further modified by goats, which were removed in 1946. Whether these changes had detrimental effects on the skinks remains unknown. Today, the species is abundant on each of the islands inhabited (R. Parrish, pers. comm.) and thus still occupies its entire known historic range.

Three Kings skinks co-exist with egg-laying skinks and shore skinks throughout the group.

Figure 12. Distribution of populations of Three Kings skink *Oligosoma fallai*.



### 3. Threats and conservation status

At least half of the North Island species in *Oligosoma* are sensitive to predation. This is indicated by comparisons between the present fragmentary distribution of species such as chevron skink, egg-laying skink and moko skink and the present distribution of introduced mammalian and avian predators, coupled with experimental manipulations of predator populations. Supporting data are provided by:

- Substantial increases in capture frequency of shore skinks at some locations following removal of kiore (*Rattus exulans*) in the Mercury Islands (Towns 1996).
- Increases in capture frequency of egg-laying skinks in the Chickens Islands following removal of kiore (D.Towns and R. Parrish unpubl. data), and the rapid establishment of a translocated population of egg-laying skinks on Korapuki Island after the removal of kiore (indicating their previous absence was not related to habitat quality) (Towns & Ferreira 2001).
- The discovery of brown skinks on Mana Island following the removal of mice (*Mus musculus*) (Miskelly 1999) and increases in their capture frequency following the removal of weka (*Gallirallus australis*) from Te Kakaho Island in the Marlborough Sounds (Brown 1997; Rufaut & Clearwater 1997).
- Increases in capture frequency of spotted skinks following the removal of weka from Te Kakaho Island, and weka and kiore from the adjacent Nukuwaiata Island (Brown 1997).
- Increases in the abundance of moko skinks on Red Mercury Island after the removal of kiore (D.Towns and G.T. Ussher unpubl. data).
- The discovery of speckled skinks on Mokoia Island following the removal of rats (Owen 1997).

The IUCN (1996) lists several New Zealand species of *Oligosoma* as 'threatened', with categories within threatened ranging from 'data deficient' to 'vulnerable' (VU). The latter category covers threatened species not critically endangered or endangered, but facing a high risk of extinction in the wild in the medium term. Within VU are two groups (B and D) relevant to New Zealand species (IUCN 1994):

'B', species with an area of occupancy less than 2000 km<sup>2</sup>; and further subdivided into:

- '1': populations severely fragmented or in <10 locations.
- '2': populations with continuing decline likely in area of occupancy ('b'); area, extent, and/or quality of habitat ('c'); and number of locations or subpopulations ('d').

'D', species with populations that are very small or restricted; and further subdivided into:

- '1': populations numbering less than 1000 individuals.
- '2': area occupied is acutely restricted.

IUCN conservation ratings have been determined for six North Island species of *Oligosoma*. Five of these species were also included in the Department of Conservation priority ranking system (Molloy & Davis 1994). Six species (Table 1) are ranked between gradual decline and nationally endangered under the New Zealand threat classification system (Molloy *et al.* 2001; Hitchmough in press).

### **Brown skink**

Although brown skinks appear to be sensitive to predation by rodents and weka, they do use highly modified habitats (below) and are abundant at some localities, so their long-term survival does not appear to be under threat.

Brown skinks are not ranked on any conservation priority lists.

### **Chevron skink**

Chevron skinks appear to persist on Great Barrier Island in the presence of three species of rodents, feral cats and pigs. However, the skinks are rarely encountered, with the highest capture rates less than 0.25/100 trap-days (Towns & McFadden 1993; K. Neilson unpubl. data). On Great Barrier Island, some of the most readily observed populations are on private land in forest remnants associated with the most built-up areas. However, the long-term viability of these populations in the presence of wild populations of introduced predators as well as domestic cats and dogs remains unclear.

Only a single individual has been seen on Little Barrier Island despite specific surveys and >20,000 trap-days of effort (Whitaker 1993, 1995; Gibbs 1996; K. Neilson unpubl. data). This lack of success indicates that chevron skinks have not undergone any measurable recovery since the removal of cats from Little Barrier Island (cf. Towns & McFadden 1993). Therefore, chevron skinks appear more detrimentally affected by the continued presence of kiore on Little Barrier Island, than by kiore and a range of other predators on Great Barrier Island. Whether there are significant differences in the abundance and effects of rodents on these two islands is unknown.

Chevron skinks are ranked as **threatened** (VU D2) by IUCN (1996), as **Category A** in Molloy & Davis (1994) and as **nationally endangered** by Hitchmough (in press).

### **Common skink**

This species is widespread and at some locations may be very abundant. For example, Towns and Elliott (1996) estimated densities of common skinks at about 5,000/ha at a mainland coastal site. The species also uses highly modified sites. Common skinks cannot be regarded as under threat and are not ranked on any conservation priority lists. However, the Chatham Islands subspecies is listed as **range restricted** (Hitchmough in press).

### **Egg-laying skink**

Although now largely confined to islands, resident populations of egg-laying skinks are probably expanding their range on at least 10 islands following the removal of introduced predators (kiore), and on Korapuki Island, following the skinks' reintroduction (Towns *et al.* 2001). With additional eradications for predators either planned, or to be confirmed, there is potential for substantial increases in the range and abundance of the species within many of the island groups occupied.

Egg-laying skinks are not ranked on any conservation priority lists.



### **Moko skink**

Like egg-laying skinks, moko skinks are likely to be increasing in abundance on at least 18 islands following the removal of kiore (Towns *et al.* 2001). They may benefit further from additional eradication campaigns under way or planned such as a campaign to eradicate kiore and Norway rats (*Rattus norvegicus*) from Mayor Island (Hunt & Williams 2000). On the mainland, at least one population on the North Shore of Auckland City was probably destroyed by housing developments in the late 1980s.

Moko skinks are not ranked on any published conservation priority lists, but are classified as **sparse** (Hitchmough in press) due to historic declines on the mainland North Island.

### **Narrow-bodied skink**

The single specimen assigned to this species is in poor condition and it is therefore difficult to determine whether the species is valid (see Towns & McFadden 1993). Modern genetic methods may enable resolution of the affinities of the narrow-bodied skink. However, even if a valid species, the narrow-bodied skink is presumed to be extinct (Daugherty *et al.* 1994).

The species is listed as **data deficient** by IUCN (1996) but is not listed in Molloy & Davis (1994) or Hitchmough (in press).

### **Shore skink**

There are anecdotal reports of the decline or disappearance of some mainland populations of shore skinks, especially those near popular resort areas on the Coromandel Peninsula and near Mt Maunganui. On the other hand, the species responds rapidly to removal of predators from some islands. It inhabits most islands occupied by egg-laying and moko skinks, and like those species is likely to benefit from rodent removal from at least 18 islands.

Shore skinks are not ranked on any conservation priority lists.

### **Small-scaled skink**

All known populations of small-scaled skinks are small and isolated, and the habitats used are patchily distributed. The widespread modification of the upper Rangitikei River Catchment and the Rangitaiki Plains through agricultural development probably increase the risk to populations in those regions; populations in the Kaimanawa Range are at less risk of habitat modification but are still exposed to introduced predators. The current status of the small-scaled skink population on Motutaiko Island is unknown because of difficulties over access to the island but the skinks there are presumably benefiting from the absence of introduced predators.

Small-scaled skinks are listed as **threatened** (VU B1+2bcd) by IUCN (1996), as **Category A** in Molloy & Davis (1994) and as **serious decline** in Hitchmough (in press).

## Speckled skink

This species appears sensitive to predation, but is quite secretive and inhabits densely-vegetated areas where it may not readily be observed. Attempts at locating historic populations in the Wairarapa area have not been successful (C. Miskelly, DOC, pers. comm.), suggesting declines in populations inhabiting some of the more modified areas. However, the recent discovery of scattered populations in the Taupo region indicates that speckled skinks can persist in farmland for a time (Whitaker 1997). Hitherto unknown populations have been located recently in Pureora Forest in the course of possum and predator control operations and there are anecdotal reports of significant increases in abundance of speckled skinks on Moutohora Island following the eradication of Norway rats in 1986 (Anon. 1999). A population was recently located on Mokoia Island in Lake Rotorua after a successful eradication campaign against Norway rats, although mice are still present (Owen 1997). Weka were released on Mokoia Island as a conservation measure in the 1950s (Owen 1997) and these may affect abundance of the Mokoia speckled skink population (see Brown (1997) and Rufaut & Clearwater (1997) for effects of weka on lizards).

Speckled skinks are listed as **lower risk: near threatened** by IUCN (1996), have medium-high priority in Wellington Conservancy (Anon. 1996), but are not ranked in Molloy & Davis (1994). The species is classified as **gradual decline** in Hitchmough (in press) because of the recent loss of North Island populations.

## Spotted skink

Spotted skinks are still found at scattered localities in the southern and eastern North Island. These skinks are apparently sensitive to predation, with documented declines near urban areas in the South Island (Freeman 1997b), and rapid responses by spotted skinks to removal of weka from islands (Brown 1997; Rufaut & Clearwater 1997). There are anecdotal reports of increases in their abundance, with densities of up to 8000/ha recorded (Neill 1997), following the removal of ship rats from Matiu/Somes Island.

Spotted skinks are identified as having medium-high conservation priority in Wellington Conservancy (Anon. 1996) but are not ranked by IUCN or Molloy & Davis (1994). The species is classified as **gradual decline** in Hitchmough (in press) because of the recent loss of North Island populations.

## Striped skink

Striped skinks appear to mainly inhabit forested areas, although some of the best-known populations have been in the remnant stumps and logs after forest has been cleared for farming (Robb 1986; Whitaker 1994). The species has in the past doubtless been affected by forest clearance (Whitaker 1998), by the decay and clearance of logs and stumps in pasture (Robb 1986), and also by heavy collecting of some populations before full protection was provided for this and other lizard species (Whitaker 1998). The very low frequency of sightings in forest (Whitaker 1998) may reflect the species' habitat use (see below). A detailed assessment of threats is provided by Whitaker (1998).

Striped skinks are listed as **threatened** (VU B1+2bcd) by IUCN (1996), as **Category A** in Molloy & Davis (1994) and as **data deficient** in Hitchmough (in press) because none have been found in their natural habitat for the last 5 years.

### Three Kings skink

This species inhabits scrub and forest in the Three Kings Islands. Potential threats to the populations include catastrophic climatic events and the escape of introduced predators onto the islands. Given the long isolation of these islands, estimated to be at least 2 million years by Hayward (1986), and likely climatic variations over such a period, climatic change is less of a risk than introduction of predators. Because some of the Three Kings Islands are in close proximity (<1 km), introduced predators (such as Norway rats) could swim between them.

Three Kings skinks are ranked as **lower risk: near threatened** by IUCN (1996), **Category C (Local)** in Molloy & Davis (1994) and **range restricted** in Hitchmough (in press).

## 4. Ecology of North Island species in *Oligosoma*

Most North Island members of *Oligosoma* are diurnal and many are heliothermic (sun-basking). Brief accounts of the ecology of each species are provided below, with additional details and relevant references for each species in Table 3.

### Brown skink

This small species of less than 75 mm snout-vent length (SVL) is distinguished by a distinctive orange or red ventral surface, and (usually) continuous pale stripes down the outer forelimbs (Townes 1988). The species uses a range of habitats from coastal shrub vegetation, to rough farmland, and overgrown gardens, derelict farm buildings and forested areas. On Mt Taranaki they have been found in sub-alpine shrubland. Brown skinks seem to use sites with higher moisture levels than common skinks, where the two co-exist (Gill 1976; East *et al.* 1995; Townes & Elliott 1996). The skinks feed on a wide range of small invertebrates (mostly 5 mm or less in length) and produce at least three offspring in January (Gill 1976).

### Chevron skink

Chevron skinks are the longest of the New Zealand lizards (SVL to >140 mm) and are named for the distinctive chevron-shaped markings on the dorsal surface. They also have a pale teardrop-shaped spot below the eyes and distinctive dark markings under the chin (Townes 1988). Only about 150 individuals have ever been seen. Most sightings have been along streams (Townes & McFadden 1993), although those most closely associated with water have predominantly been immature animals (K. Neilson unpubl. data). Adults have occasionally been seen on roads, inside the walls of derelict buildings, in culverts and even in plumbing systems such as wastewater pipes. Recent evidence suggests that adults are at least partly arboreal (K. Neilson unpubl. data).

Chevron skinks feed on invertebrates including small land snails, spiders and beetle larvae (K. Neilson unpubl. data). Up to eight offspring are produced in late summer-early autumn (February-March).

TABLE 3. SUMMARY OF SELECTED BIOLOGICAL CHARACTERISTICS OF NORTH ISLAND SPECIES IN *OLIGOSOMA*. SIZE AS MAXIMUM SNOUT-VENT LENGTH (SVL); DENSITY FIGURES ARE FOR THE RANGE FROM MINIMUM TO MAXIMUM RECORDED.

SPECIES	SVL (mm)	HABITAT	DENSITY (per ha)	REFERENCES
Brown skink	73	Coastal shrubland (especially vineland) to forest; moist sites	1477	Gill (1976), Hardy (1977), East <i>et al.</i> (1995), Towns & Elliott (1996)
Chevron skink	146	Forest, especially along streams		Ogle (1981), Newman & Towns (1985), Robb (1986), Towns & McFadden (1993), K. Neilson (unpubl. data)
Common skink	69	Coastal, open sites, vineland and shrubland especially in dry sites, also grassland, riverbeds, sub-alpine	15-4919	Gill (1976), Hardy (1977), Patterson & Daugherty (1990), Patterson (1992), East <i>et al.</i> (1995), Towns & Elliott (1996), Freeman (1997a)
Egg-laying skink	126	Coastal, rocky beaches and shore platforms	1483-130,000	Towns (1975a, 1975b), Hardy (1977), Whitaker (1968a, 1968b), R. Parrish (pers. comm.)
Moko skink	72	Grasslands to open forest	2152	Whitaker (1968b), Robb (1986)
Shore skink	80	Open shorelines (bouldery beaches and rock platforms), dunes to shrubland	2224-2718	Whitaker (1968b), Towns (1975b, 1991, 1996)
Small-scaled skink	70	Rock and bouldery areas; river beds screes, outcrops and cliffs	Localised densities of up to 2/m <sup>2</sup>	Patterson & Daugherty (1990), Gill & Whitaker (1996), Whitaker (1991)
Speckled skink	106	Grassland through shrubland and forest	-	Hardy (1977), Robb (1986), East <i>et al.</i> (1995)
Spotted skink	1111	Open grassy areas, shrubland dunes, boulder beaches, rocky coasts, flaxlands, vinelands, tussock grassland; coastal to alpine areas	1000-8000	Hardy (1977), Robb (1986), East <i>et al.</i> (1995), Freeman (1997b), Neill (1997)
Striped skink	76	Logs in pasture to tall forest	-	Hardy (1977), Whitaker (1998)
Three Kings skink	142	Coastal, wave platforms, ground-cover, scrub and forest	-	Hardy (1977), Robb (1986), R. Parrish (pers. comm.)

<sup>1</sup> This record from Hardy (1977) is larger than any others reported; the generally accepted maximum size is <95 mm SVL

### Common skink

Common skinks are relatively small lizards (SVL <70 mm). The species is extremely variable in colour, with colour patterns reflecting the wide range of habitats occupied. At coastal sites, where they inhabit rocky beaches, they may be almost jet black, but in native grasslands, they may have well defined stripes on the body and

legs (Patterson & Daugherty 1990). Other areas inhabited include urban areas and farmland, usually in more open and drier areas than occupied by brown skinks (Gill 1976). They feed on a wide range of invertebrates and some fruit (Patterson 1992). The mean number of offspring is 3.8, produced in summer (January to February) (Patterson & Daugherty 1990).

### **Egg-laying skink**

This species is amongst the larger of the *Oligosoma* species, with adults exceeding 100 mm SVL, although maximum size appears to vary with location (Towns 1975a). Egg-laying skinks are strictly coastal lizards, extending their range further into the intertidal zone than any other northern species (Towns 1975b). Colour varies from black to mottled grey, and habitats range from beneath rotting seaweed on rocky beaches to hard-rock coastlines and low coastal vegetation (D. R. Towns unpubl. data). The skinks forage at night either amongst boulders, on the surface of rocks and decaying seaweed, or in rock pools (Whitaker 1968a; D.R. Towns unpubl. data). On islands where there are introduced predators, the skinks become confined to rocky beaches. On suitable beaches egg-laying skinks may reach average densities of 10–13/m<sup>2</sup> (Whitaker 1974; Towns 1975b). Egg-laying skinks feed on a wide range of coastal invertebrates, but especially the amphipods around decaying vegetation (Towns 1975b) and on carrion in seabird colonies (A.H. Whitaker unpubl. data). An average of 3.7 eggs per female are laid communally under rocks embedded in soil (Whitaker 1968b) during December, and hatch in autumn (March to April) (Towns 1975a).

### **Moko skink**

Moko skinks are small (<75 mm SVL), brown-coloured skinks distinctively marked with double pale stripes down the body and tail, and a pale stripe down the limbs. These skinks inhabit coastal to forested areas, usually where there is vegetation cover. They can be particularly common amongst long grass and flax, often basking on logs or wood or vegetation exposed to sunlight. Nothing is known of the diet or litter size of this species (Whitaker 1968b; Robb 1986).

### **Narrow-bodied skink**

This skink of 97 mm SVL was originally attributed by McCann (1955) to *Oligosoma bomalonotum* (chevron skink). However, on the grounds that it was probably a juvenile, Hardy (1977) described it as a separate species. Later examination of the specimen indicated that it is an adult male (Towns & McFadden 1993) within the size range found in chevron skinks. However, definitive identification has so far been impossible because the specimen has become bleached in preservative. There is no information with the specimen to indicate the precise locality (other than 'Hokianga') or the circumstances in which it was collected.

### **Shore skink**

These coastal inhabitants vary in size and colour depending on location and habitat. Most populations comprise lizards < 70 mm SVL. Shore skinks range from the marginal vegetation and rocky areas near the storm line on beaches—following the receding tides to forage—to open grassy areas and seabird burrows near the coast.

They often bask in the open, and feed on a wide range of invertebrates (Robb 1986), carrion and broken eggs in seabird colonies, and the fruit of coastal plants such as taupata (*Coprosma repens*) and kawakawa (*Macropiper excelsum*) (Whitaker 1987). Young are born in summer to early autumn (January–March); mean litter size is 2.2 (D.R. Towns unpubl. data).

### **Small-scaled skink**

These small skinks (<70 mm SVL) are distinguished from species of similar general appearance (common skink, speckled skink and brown skink) by the high number of mid-body scales (>36, mean = 42). Small-scaled skinks inhabit rocky areas such as screes, boulder tumbles, outcrops and cliff-faces in the central North Island ranges (Whitaker 1991, 1997).

Two or three offspring are born from late January to early March (Patterson & Daugherty 1990). Little is known about the biology of this species except that they actively forage during the day.

### **Speckled skink**

This species has pale flecking on the dorsal surface of the body and tail, but an important diagnostic feature is its yellow ventral surface, often flecked with black along the entire length (Towns 1988). Populations vary in size from a maximum SVL of 75 mm to 106 mm depending on location. Speckled skinks range from native grasslands to shrubby areas and forest, and from coastal sites on islands to inland areas (East *et al.* 1995; Whitaker 1997). At some locations they are associated with petrel burrows (Robb 1986). Nothing is known of the diet or litter size of this species.

### **Spotted skink**

The spotted skink is named after distinctive pale green spots edged with black along the dorsal body and tail. It is one of the larger species in the genus, reaching approximately 95 mm SVL and inhabits open areas and shrubland from near sea level to the sub-alpine zone (Gill & Whitaker 1996). The skinks appear to avoid heavily forested areas (East *et al.* 1995). Diet comprises a broad range of invertebrates, carrion and occasionally nectar (A.H. Whitaker unpubl. data) and up to four young are born in late summer–early autumn (February–March) (Robb 1986).

### **Striped skink**

These are relatively small skinks (usually <75 mm SVL). In forest areas they live in or under logs or litter on the forest floor, and may be at least partly arboreal as they have been found on larger trees inhabiting epiphytes, and cracks and crevices in trunks and limbs, as high as the forest canopy. In farmland they often inhabit rotting logs and rank vegetation. The areas occupied are frequently damp or swampy, and they seem to bask less than other members of the genus (Whitaker 1998). They are susceptible to very high rates of evaporative water loss compared to congeners (Neilson in press) and therefore habitat use is likely to be restricted to moist habitats. Striped skinks are active for long periods during the day and also have

periods of activity during the night, particularly during wet conditions (K. Neilson and B. Goetz unpubl. data).

Diet of wild populations is unclear. Litter size ranges from three to eight (Whitaker 1998), with the young born in January to February (Robb 1986).

### **Three Kings skink**

This species is one of the largest New Zealand skinks, with adults reaching over 140 mm SVL. The lizards inhabit forest areas, scrub and low-growing ground cover where they feed on invertebrates, fruits of shrubs and the spilled regurgitations of sea birds. Capture frequencies are much higher in scrub than in forest, indicating that numbers may decline somewhat on Great King Island as the forest continues to regenerate. Three Kings skinks are diurnal for much of the year, but can at times become nocturnal (R. Parrish pers. comm.). At least four young are born in summer (January to February) (Robb 1986).

## **5. Past conservation effort**

Previous recovery plans provide detailed objectives for chevron and striped skinks (Towns & McFadden 1993; Whitaker 1998). 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 below.

### **5.1 GOAL AND OBJECTIVES OF CHEVRON SKINK PLAN**

The long-term goal of the original chevron skink recovery plan was to: 'Maintain and enhance existing populations of chevron skink on Little Barrier and Great Barrier Islands and to improve their conservation status from endangered to rare through habitat management on Great Barrier Island by the year 2000.'

This was to be achieved through the following core activities:

- Improvement of quality of stream catchments on Great Barrier Island through targeted wild animal control.
- Reduction of the threats to existing habitats by strong advocacy for the conservation values of Great Barrier Island.
- Reduced predation of native wildlife by reduction in cat numbers (the latter a very long-term objective).

These were supported by seven 5-year and three long-term (period undefined) objectives. A summary of progress with these is provided below.

#### **Establish and maintain a pest prevention campaign**

Required reduction of the vulnerability of Great Barrier Island to the introduction of potential pest species by publicising the need for measures to prevent the introduction of Norway rats, possums and mustelids.

*Status: ongoing, but at much lower intensity.*

Intensive 2-year project completed, involving preparation of public relations displays, posters and brochures, talks or lectures to residents and at schools, liaison with Auckland City and Auckland Regional Councils and Great Barrier Island Community Board.

*Identified outcomes:*

- Increased public awareness of conservation values.
- Immediate reporting of escape of suspected pests (e.g. mustelid false alarms).
- Maintenance of mustelid-, possum- and Norway rat-free status of Great Barrier Island.

### **Establish partnerships with local authorities and local land owners**

Wild animal control and reserve management is complicated by a range of Crown and local authorities with protected land and overlapping responsibilities.

*Status: ongoing.*

*Outcomes*

Excellent initiatives from Community Board regarding cat control, but also good relationships and complementary objectives developing between DOC, Auckland Regional Council and Auckland City Council (especially for pest prevention (above) and co-ordinated approach to goat control).

### **Survey Little Barrier Island for chevron skinks**

Following the capture of a juvenile chevron skink on Little Barrier Island, survey potential sites for additional populations.

*Status: completed.*

*Outcomes*

Despite three intensive surveys and over 20,000 trap-days effort, no further specimens have been located. However, the traps were successful in capturing a striped skink (previously unreported on the island). Capture rates of all lizards on Little Barrier Island are very low (K. Neilson unpubl. data) suggesting that kiore are having a significant impact on all forest species.

### **Determine how habitats are used by chevron skinks on Great Barrier Island**

*Status: ongoing.*

This is now well funded and has a full-time staff member assigned to it (KN). Studies are based around intensive study at Tryphena (started in 1997), predator management trials (started in 1998/89) and evaporative water loss studies (completed in 1999).



## **Eradicate goats and pigs from selected areas on Great Barrier Island**

Outstanding forest habitat at Te Paparahi, with a particularly diverse herpetofauna, was under threat from very large numbers of feral goats.

*Status: ongoing.*

### *Outcomes*

This has gone far beyond the objectives of the plan, with goat numbers now reduced to undetectable levels over the northern third of the island; an area much larger than anticipated in the plan. Pigs remain a problem because of locally high densities on some parts of the island.

## **Promote public interest and involvement in the recovery of chevron skink**

This objective was directed at the Auckland public and specifically involved liaison with Auckland Zoo.

*Status: ongoing.*

A working relationship with Auckland Zoo has included: construction of facilities with DOC funding assistance, salvage, rehabilitation and release of chevron skinks caught by cats, use of chevron skinks at the zoo for trials of field methods, and an agreement between DOC and the zoo regarding the plans for the captive population.

## **Define long-term objectives for land management**

Required the definition of specific management goals for DOC land.

*Status: ongoing.*

Management goals are defined in the completed Conservation Management Strategy for Auckland Conservancy (Anon. 1995). More specific objectives are being developed in a Conservation Action Plan for the island.

## **Long-term objectives**

Three long-term objectives were identified in the chevron skink plan:

- Determine habitat use on Little Barrier Island (amended from the original by agreement, see p. 21 of the chevron skink plan).
- Wild animal control at the southern end of Great Barrier Island.
- Investigate sterilisation and control of cats.

The first of these has not been possible because no further chevron skinks were located on Little Barrier Island. This objective has been deferred.

Although there has been little wild animal control in southern Great Barrier (little of which is under DOC control), goat eradication from the island now seems feasible and is being planned jointly between DOC and the Auckland Regional Council. This campaign is likely to commence within 5 years.

Sterilisation and control of cats is an initiative undertaken by the Great Barrier Community Board, which has instigated an intensive public relations programme and is providing 50% subsidy for sterilisation of domestic cats. This objective is ongoing.

## 5.2 GOAL AND OBJECTIVES OF STRIPED SKINK PLAN

The long-term goal of the striped skink plan was to: 'Ensure the survival in perpetuity of striped skinks in their natural habitat at a number of sites throughout their range, including at the limits of their distribution.' Measures of success included an improvement of the species' conservation status on either IUCN or DOC criteria (Whitaker 1998).

Six objectives were presented in the striped skink plan. At the time of writing, the striped skink plan had been operational for 4 years, during which time efforts were focused on the first objective (below) through laboratory studies of evaporative water loss and the fourth objective (below).

### **Data on those aspects of the species' habitat and habits required to determine distribution and abundance**

Studies of evaporative water loss have been carried out on striped skinks and compared with three other species. Results indicate that striped skinks are unable to quickly alter rates of water loss through the skin in response to drying conditions. Striped skinks also appear to have the highest mass-specific evaporative water loss of the species tested (Neilson in press).

A captive-based study on daily activity patterns and arboreal tendencies has recently been completed.

### **Initiate an advocacy programme for striped skinks**

To date progress with this objective has been almost exclusively in Wanganui Conservancy. Regular publicity about striped skinks in local papers has been successful in soliciting reports of individuals and salvages of injured animals. Pamphlets and posters have been produced in order to generate public awareness in other conservancies where striped skinks are found. Meetings have been held with landowners in Taranaki and these have been largely successful, with populations on private land continuing to be monitored.

The remaining five objectives of the striped skink plan are included here under 'Objectives'. Whitaker (1998) provides the detailed justifications for these objectives.

## 5.3 OTHER MANAGEMENT

Removal of introduced predators from islands, predator control on the mainland and activities other than those identified as the primary focus for the chevron and striped skink plans, have enabled the following (likely) improvements in populations of *Oligosoma* skinks:

- Removal of kiore from north-eastern islands has benefited at least 10 resident populations of egg-laying skinks, 18 populations of moko skinks and 18 populations of shore skinks (see Towns *et al.* 2001).
- Successful translocation of egg-laying skinks to Korapuki Island (Mercury Islands) (Towns & Ferreira 2001).
- The discovery of hitherto unknown populations of speckled and small-scaled skinks in the central North Island, and speckled skinks in south Taranaki, resulting in improved conservation status and greatly extending the ranges of both species.
- Removal of Norway rats from Mokoia Island (in Lake Rotorua) and subsequent discovery of speckled skinks (Owen 1997).
- Removal of Norway rats from Moutohora Island, of benefit to resident speckled skinks (Anon. 1999).
- Removal of Norway rats from Motu-o-Kura (south of Napier), of benefit to common skinks (Adams 1997).
- Removal of kiore and Norway rats from Kapiti Island, allowing expansion of resident populations of brown skinks and common skinks.
- Removal of ship rats from Matiu/Somes Island, allowing increases in abundance of common skinks and spotted skinks.
- Removal of mice from Mana Island led to the subsequent discovery of brown skinks and is allowing increases in abundance of brown skink and common skink populations (Miskelly 1999).
- Translocation of spotted skinks to Mana Island (Griffiths 1999).

#### 5.4 SUMMARY OF MANAGEMENT AND RESEARCH CONDUCTED THROUGH RECOVERY PLANS

- An intensive 2-year advocacy project regarding pest prevention on Great Barrier Island has been completed.
- Surveys for chevron skinks have been completed on Little Barrier Island. Although no new populations were located, striped skinks were discovered on the island.
- Intensive studies on habitat use of chevron skinks on Great Barrier Island are near completion, and being based around intensive study at Tryphena and a new predator management initiative.
- Local eradication of goats on Great Barrier Island has gone far beyond the objectives of the plan, with the zero density area much larger than anticipated.
- Local authorities, through the Auckland City Council (Auckland Zoo) and Great Barrier Island Community Board, assisted with several new initiatives aimed at raising public awareness and reducing risks to chevron skinks. These have included a programme for sterilisation and control of cats funded by the local authorities.
- Field surveys and observations of behaviour of wild striped skink populations are being conducted by DOC staff in Taranaki.
- A successful survey of indigenous logging at Waitaanga (northern Taranaki) resulted in the discovery of striped skinks at canopy height.
- Laboratory studies of evaporative water loss by chevron skinks and striped skinks have now been completed.

- Captive-based research is comparing striped skink activity and arboreal tendencies with those of the brown skink.

Recent intensification of work on chevron skinks has enabled completion of several objectives in the chevron skink plan. A few new locations inhabited by chevron skinks have been found on Great Barrier Island. None of the achievements have been sufficient to realise the long-term goal of the plan: an improvement of the conservation status of the species by the year 2000.

## 6. Options for future recovery

The DOC Statement of Intent (Anon. 2001) includes the following strategic directions for terrestrial natural heritage relevant to this plan: (1) ‘Target species management work to maintain representative populations sufficient for their long-term security...’ (2) ‘Work with landowners, communities and associate agencies to protect important natural ecosystems and habitats and indigenous flora and fauna.’ These present particular opportunities for *Oligosoma* skinks on islands, where many pest organisms can be removed, but also at selected sites on the mainland, where pests can be controlled. However, the costs and benefits for such ‘mainland island’ pest control approaches to lizard conservation have yet to be demonstrated (Towns *et al.* 2001). The proposed removal of kiore from Little Barrier Island presents special opportunities—not just for striped skinks (Whitaker 1998)—but also for chevron skinks. These two rare species form part of the largest resident assemblage of North Island *Oligosoma* skinks (five species) that can be managed through introduced predator eradication, as well as opportunities for expansion of tuatara (Gaze 2001) and species in *Cyclodina* (Towns 1999).

Options for recovery are developed separately below, for the rarer species of North Island *Oligosoma* and summarised with links to objectives in Table 4.

### **Chevron skink**

#### *Option 1*

Do nothing more than is currently funded. This would allow for continued research for at least 3 years, and some further goat control, following which both would cease. This option would:

- Maintain a low-level pest prevention campaign on Great Barrier Island.
- Provide data on habitat use, vulnerability to predation, and cost-effectiveness of rodent control.
- Lead to possible gradual decline and eventual loss of chevron skinks from Little Barrier Island.
- Lead to gradual decline of chevron skinks on Great Barrier Island, through habitat loss resulting from urbanisation around Tryphena, through predation by introduced mammals, plus further habitat degradation and predation by pigs.
- Extend the area in which goats are controlled, but if control is not maintained, re-invasion of areas where goats were previously removed.

## Option 2

Complete intensive research on habitat use and maintain pest prevention campaign as in Option 1, but in addition:

- Continue goat control on Great Barrier Island in order to maintain near zero density on public land.

TABLE 4. SUMMARY OF PREFERRED (5-YEAR) OPTIONS FOR RECOVERY OF RARE SPECIES OF *OLIGOSOMA* WITH LINKAGE TO RELEVANT OBJECTIVES (CHAPTER 8).

SPECIES	PREFERRED OPTION	10-YEAR GOAL	RELEVANT OBJECTIVES
Chevron skink	Obtain data on habitat use, cost-effectiveness of predator control. Continue goat control on Great Barrier Island. Eradicate kiore from Little Barrier Island. Monitor lizard abundance in chevron skink habitats on Little Barrier Island. Determine ecological effects of localised cat control on Great Barrier Island.	Eradicate goats from Great Barrier Island. Establish 'mainland island' site on Great Barrier Island. Undertake localised pig control. Sterilise domestic cats and control feral cats.	2,3,4,8,10,11,13,14
Small-scaled skink	Obtain data on distribution, habitat use, relative abundance, and threats. Determine impact of livestock on habitat patches in farmland. Determine impact of introduced mammalian predators. Conduct advocacy with landowners for protection of small habitat patches.	Assess cost-effectiveness of predator and livestock management around key sites.	6,7,9,10,13
Speckled skink	Survey historic and potential new locations. Eradicate mice from Mokoia Island. Restore population(s) on appropriate islands after removal of rodents. Establish new populations in the Karori Wildlife Sanctuary.	Assess cost-effectiveness of predator management on the mainland.	1,7,10,12,13
Spotted skink	Survey historic and potential new locations. Restore population(s) on appropriate islands after removal of rodents.	Establish new populations in the Karori Wildlife Sanctuary. Assess cost-effectiveness of predator management on the mainland.	1,7,10,12,13
Striped skink	Continue goat control on Great Barrier Island. Eradicate kiore from Little Barrier Island. Monitor lizard abundance on Little Barrier Island. Determine status on Great Barrier Island and mainland. Undertake advocacy for protection off public land. Undertake studies in captivity.	Eradicate goats from Great Barrier Island. Establish 'mainland island' site on Great Barrier Island. Undertake localised pig control on Great Barrier Island. Sterilise domestic cats and control feral cats on Great Barrier Island. Investigate effectiveness of management within existing 'mainland island sites'. Protect and enhance some sites in pastoral areas.	2,4,5,7,8,9,10,11,13,14
Three Kings skink	Install and maintain bait stations against rodents. Survey for distribution.		1,13

- Eradicate kiore from Little Barrier Island within 5 years.
- Continue to monitor lizard abundance in chevron skink habitats on Little Barrier Island before and after kiore removal.
- Determine ecological effects of localised cat control on abundance of intermediate predators (rodents) on Great Barrier Island.

### *Option 3*

As in Option 2, but in addition:

- Complete the eradication of goats from Great Barrier Island.
- Establish an intensively managed 'mainland island' site on Great Barrier Island (probably Te Paparahi), from which introduced pests are identified, controlled to low density or removed.
- Undertake localised pig control on Great Barrier Island to near zero density in high-quality forest habitats occupied by chevron skinks.
- Maintain campaigns for the sterilisation of domestic cats and reduce effects of feral cats on Great Barrier Island.

### *Option 4*

As in Option 3, but locate a suitable island or islands and establish additional populations of the species.

### *Preferred option*

The option chosen for the duration of this plan is Option 3. Some actions may take up to 10 years to be achieved and are listed in Table 4. This option would secure the Little Barrier Island population against all introduced predators, provide a basis for comparison with predator-control studies on Great Barrier Island, improve habitat quality on Great Barrier Island through removal of goats and control of pigs, and enable locations for, and effects of, control of feral cats to be determined. Option 4 is not recommended at present because it is unclear what habitats might be required on small islands if chevron skinks are to survive there in the long term. Furthermore, option 4 may not be consistent with the ecosystem management goals identified for DOC in Atawhai Ruamano (Anon. 1993).

## **Small-scaled skink**

### *Option 1*

Do nothing. This would result in:

- Continued decline and disappearance of populations on farmland through fragmentation and habitat degradation.
- Likely decline and possible loss of populations in natural habitats through ongoing exposure to introduced predators.
- Stabilisation of population on Motutaiko Island provided predator-free status can be maintained.

### *Option 2*

More accurate determination of the conservation status through surveying and research to better understand:

- The distribution, habitat, relative abundance, and threats.
- The impact of livestock on habitat patches in farmland.
- The impact of introduced mammalian predators.

But in addition:

- Depending on the results of the above, commence advocacy programmes with landowners in order to protect small habitat patches on private land.

### *Option 3*

As in Option 2, but additionally an assessment of the cost-effectiveness of predator and livestock management at some sites in order to provide measurable recovery of small-scaled skinks.

### *Preferred option*

The preferred option over the first 5 years of the plan is Option 2. However, as localised management could also benefit speckled skinks and common skinks, the cost effectiveness of Option 3 should be tested within 5–10 years.

## **Speckled skink**

### *Option 1*

Do nothing. This would result in:

- Eventual stabilisation of a large population on Moutohora Island in forested areas and burrows in extensive seabird colonies.
- Possible maintenance of some scattered mainland populations on DOC land in areas intensively managed as ‘mainland island’ sites.
- Likely decline and disappearance of mainland populations in modified habitats (especially those in farmland) and near urban areas through increased predation and loss of cover.

### *Option 2*

Relatively low-level surveying and some remedial action against the effects of predators would require:

- Surveys of potential new locations in the North Island and at sites where the species has been recorded in the past.
- Eradication of mice from Mokoia Island within the next 5 years.
- Restoration of population(s) on appropriate islands such as Motu-o-Kura (East Coast) and Kapiti Island (Wellington) from which rodents have been removed.
- Protection of island populations from invasions of mammalian predators.
- Establish new populations on the mainland in the Karori Wildlife Sanctuary (depending on the results of surveys after removal of predators).

### *Option 3*

As in Option 2, but in addition:

- Assessment of the cost-effectiveness of management of predators at mainland sites in order to provide measurable responses by speckled skinks.

### *Preferred option*

The preferred option over the first 5 years of the plan is Option 2. However, as localised predator management may be of benefit to more than one species of *Oligosoma*, cost effectiveness of such an approach (Option 3) should be tested within 5–10 years.

## **Spotted skink**

### *Option 1*

Do nothing. This would result in:

- Expanding populations on Matiu/Somes and (potentially) Mana Islands, though both will eventually become confined to coastal and shrubland sites as reforestation of the islands proceeds.
- Stabilisation of populations on Mokopuna and Makaro/Ward Islands (Wellington Harbour).
- Likely decline and disappearance of mainland populations in modified habitats (especially those in farmland and near urban areas) through increased predation.

### *Option 2*

Relatively low-level surveying and some remedial action against the effects of predators would require:

- Surveys of potential new locations in the North Island and at sites where the species has been recorded in the past.
- Restoration to other islands within their former range from which rats have been removed e.g. Motu-o-Kura Island, Kapiti Island and its outlying islands (depending on the results of further surveys).

### *Option 3*

As in Option 2, but in addition:

- Establish a new population on the mainland in the Karori Wildlife Sanctuary at open sites along fence lines and fire breaks following the establishment of speckled skinks.
- Assessment of the cost-effectiveness of management of predators at mainland sites in order to provide measurable responses by spotted skinks.

### *Preferred option*

The preferred option over the first 5 years of the plan is Option 2. However, as localised predator management may be of benefit to more than one species of *Oligosoma*, cost-effectiveness of such an approach (Option 3) should be tested within 5-10 years.

## **Striped skink**

The seven original options for striped skink management are condensed below to reflect likely outcomes of the existing recovery plan (Whitaker 1998), but also to encompass options developed for sympatric species.

### *Option 1*

Do nothing more than is currently funded. This would allow for writing up of laboratory research already conducted, some further goat control in the skinks' habitat on Great Barrier Island, predator management trials in forest habitats (developed for chevron skinks), and short-term pest management in 'mainland islands'. After this, all work would cease. This option would:

- Conduct a small-scale rodent control operation campaign on Great Barrier Island for approximately 5 years.



- Provide data on physiological constraints on microhabitat use.
- Provide data on daily activity rhythms, climatic effects on activity, and behaviour (including basking and arboreal tendencies) using captive animals.
- Lead to possible gradual decline and eventual loss of striped skinks from Little Barrier Island and Great Barrier Island.
- Extend the area in which goats are controlled on Great Barrier Island, but if control is not maintained, re-invasion of areas where goats were previously removed.
- Lead to eventual loss of populations in pasture on the mainland as habitat pockets are destroyed or degraded.
- Lead to reversal of habitat improvements through herbivore and predator control, long-term degradation of forest habitats on the mainland occupied by striped skinks, and the possible eventual loss of mainland populations through exposure to introduced predators.

### *Option 2*

Complete research on activity and arboreal tendencies and maintain pest prevention campaign for Great Barrier Island as in Option 1, but addition:

- Continue control of goats and plan for their total eradication from Great Barrier Island.
- Eradicate kiore from Little Barrier Island within 5 years.
- Monitor lizard abundance in striped skink habitats (forest) on Little Barrier Island before and after kiore removal.
- Determine conservation status of striped skink throughout its range through surveys and habitat use studies in 'mainland island' sites where striped skinks have been recorded.
- Undertake an advocacy campaign for protection of striped skink populations off public land, including those in exotic vegetation.

### *Option 3*

As in Option 2, but in addition:

- Complete the eradication of goats from Great Barrier Island.
- Establish an intensively managed 'mainland island' site on Great Barrier Island (probably Te Paparahi), from which pigs are removed and in which predator control may be undertaken.
- Investigate the cost-effectiveness of managing striped skinks within existing 'mainland island' sites (e.g. Waipapa Ecological Area) on the North Island
- Undertake localised pig control to near zero density in high-quality forest habitats occupied by striped skinks on Great Barrier Island.
- Maintain campaign for sterilisation of domestic cats and reduce effects of feral cats on Great Barrier Island.
- Protect and enhance some mainland sites where striped skinks inhabit pastoral environments.

### *Option 4*

As in Option 3, but locate a suitable island or islands and establish additional populations of the species.

### *Preferred option*

The option chosen for the duration of this plan is Option 3. Some actions may take

up to 10 years to be achieved and are listed as such in Table 4. This option would secure the Little Barrier Island population against all introduced predators, provide a basis for comparison with predator control studies on Great Barrier Island, and improve habitat quality on Great Barrier Island through removal of goats. The level of protection and enhancement of mainland sites in Option 3 would depend on success with habitat enhancement in 'mainland island' forest sites, and determination of conservation status throughout the range of the species. Option 4 is not recommended at present because it is unclear what habitats might be required on offshore islands if striped skinks are to survive there in the long term. Furthermore, Option 4 may not be consistent with the ecosystem management goals identified for DOC in Atawhai Ruamano (Anon. 1993).

### **Three Kings skink**

#### *Option 1*

Do no more. This would mean:

- No further threat mitigation activities against potential pests invading the Three Kings Islands.
- No further surveys throughout the group to determine the distribution and abundance of the species.

#### *Option 2*

- Maintain 6-monthly surveillance, and install and check bait stations against rodents in the Three Kings Islands.
- Survey islands in the group to determine the distribution of Three Kings skinks.

#### *Option 3*

As in Option 2, but also locate another island group and establish additional populations of the species.

#### *Preferred option*

The option chosen for this plan is Option 2. This species is apparently endemic to the Three Kings Islands, where it occupies its entire presumed historic geographic range. Translocation to other islands (Option 3) is not consistent with the strategic ecosystem goals identified for DOC in Atawhai Ruamano (Anon. 1993).

## 7. Long-term recovery 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 species of *Oligosoma* within their historic range and enhance all identifiable genetic stocks of the species.

## 8. Objectives and work plan

The following objectives are compiled from the preferred (5-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 assemblages of species in *Oligosoma* within their known geographic range within a work plan summarised in Table 5. Research support required for each objective is identified in the following summary in parentheses.

### 8.1 SUMMARY OF OBJECTIVES FOR THE DURATION OF THIS PLAN

*Objectives are listed in priority order:*

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 Little Barrier Island to protect chevron and striped skinks.
3. Determine how habitats are used by chevron skinks on Great Barrier Island.  
(Radio telemetry and 'mark-recapture' of chevron skinks.)
4. Determine effectiveness of intensive predator control for conservation of chevron skinks and other lizard species on Great Barrier Island.  
(Investigation of cost-effectiveness of localised intensive predator (cat and rat) control at selected sites on Great Barrier Island.)
5. Determine how habitats are used by striped skinks.  
(Study populations—especially those in captivity—to determine activity patterns, thermal preferences, arboreal tendencies and susceptibility for water loss.)
6. Determine how habitats are used by small-scaled skinks.  
(Study populations in modified and unmodified habitats and investigate the effects of fragmentation of populations.)
7. Assess the threats, needs and conservation status of striped, small-scaled, speckled and spotted skinks.  
(Determine effects of introduced predators and livestock on skink populations.)

TABLE 5. SUMMARY OF PRIORITY TASKS BY CONSERVANCY, SPECIES AND LOCATION. OBJECTIVES IN PARENTHESES; LEVEL OF EFFORT: BLACK = HIGH; GREY = MODERATE.

	YEAR					
	1	2	3	4	5	>5
<b>NORTHLAND</b>						
<b>Three Kings skink</b>						
Pest prevention (1)	Black	Black	Black	Black	Black	Black
Survey (13)	Grey	Grey				
<b>Striped skink</b>						
Threats and conservation status (7)	Grey	Grey	Grey	Grey	Grey	Grey
<b>AUCKLAND</b>						
<b>Chevron and striped skinks</b>						
Eradicate kiore, Little Barrier (2)			Black	Black	Black	
Control of pigs/goats, Great Barrier (8)	Black	Black	Black	Black	Black	Black
Develop advocacy programmes (10)	Grey	Grey	Grey	Grey	Grey	Grey
Response of lizards to kiore removal (11)	Black	Black	Black	Black	Black	Black
Manage populations in captivity (14)	Black	Black	Grey	Grey	Grey	Grey
<b>Chevron skink</b>						
Determine habitat use (3)	Black	Black				
Effectiveness of predator control (4)	Black	Black				
<b>Striped skink</b>						
Threats and conservation status (7)					Black	Black
<b>WAIKATO</b>						
<b>Speckled and striped skink</b>						
Threats and conservation status (7)			Black	Black	Black	Black
Potential for management on mainland (9)			Black	Black	Black	Black
Develop advocacy programmes (10)	Grey	Grey	Grey	Grey	Grey	Grey
<b>BAY OF PLENTY</b>						
<b>Speckled skink</b>						
Pest prevention (1)	Black	Black	Black	Black	Black	Black
<b>Small-scaled, speckled and striped skinks</b>						
Threats and conservation status (7)	Black	Black	Black	Black	Black	Black
<b>EAST COAST/HAWKES BAY</b>						
<b>Small-scaled, speckled and spotted skinks</b>						
Threats and conservation status (7)	Black	Black	Black	Black	Black	Black
Develop advocacy programmes (10)	Grey	Grey	Grey	Grey	Grey	Grey
<b>Speckled and spotted skinks</b>						
Restore within their natural range (12)	Grey	Grey	Grey	Grey	Grey	Grey
<b>TONGARIRO-TAUPO</b>						
<b>Small-scaled skink</b>						
Determine habitat use (6)			Black	Black		
Threats and conservation status (7)	Black	Black	Black			
Develop advocacy programmes (10)	Black	Black	Grey	Grey	Grey	Grey
<b>WANGANUI</b>						
<b>Striped skink</b>						
Determine habitat use (5)	Black	Black	Black	Grey	Grey	Grey
Manage populations in captivity (14)	Black	Black	Grey	Grey	Grey	Grey
<b>Small-scaled, speckled and striped skinks</b>						
Determine habitat use (6)		Black	Black	Black	Black	Black
Threats and conservation status (7)	Black	Black	Black			
Potential for management on mainland (9)			Black	Black	Black	Black
Develop advocacy programmes (10)	Black	Black	Grey	Grey	Grey	Grey
<b>WELLINGTON</b>						
<b>Speckled and spotted skinks</b>						
Pest prevention (1)	Black	Black	Black	Black	Black	Black
Potential for management on mainland (9)	Grey	Grey	Grey	Grey	Grey	Grey
Restore within their natural range (12)	Grey	Grey	Grey	Grey	Grey	Grey

8. Eradicate pigs and goats from selected areas on Great Barrier Island and establish at least one intensive management site.  
(Determine effects of pigs on plants and terrestrial fauna; investigate feasibility of extensive pest management of predators such as rodents and cats.)
9. Investigate potential for management of striped skinks and small-scaled skinks in at least one intensively managed site on the mainland.  
(Investigation of cost-effectiveness of localised intensive predator control at selected sites on the mainland.)
10. Develop advocacy programmes to protect populations of skinks either on or off public land.
11. Determine response of terrestrial lizards, especially chevron and striped skinks, to removal of kiore from Little Barrier Island.  
(Set up standard monitoring sites and methods to determine effects of kiore removal on resident lizards.)
12. Restore *Oligosoma* populations within their natural range.
13. Determine identity of species with fragmented or isolated populations.  
(Undertake genetic studies.)
14. Manage a small population of striped skinks and chevron skinks in captivity primarily for research, but as appropriate, to assist with advocacy.  
(Undertake studies of reproductive biology and ecological physiology.)

## 8.2 WORK PLAN

### **Objective 1: Maintain all existing populations on islands either naturally free or cleared of introduced predators**

#### *Explanation*

All populations of the Three Kings skink are confined to islands that are free of introduced predatory mammals. Over the last 10 years, introduced rodents have been removed from at least 25 islands (total area ca. 3400 ha) within the range of North Island *Oligosoma*. One additional island (Fanal) is now regarded as rat-free. Many eradications were conducted with conservation of rare reptiles as the 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 particularly important in the Three Kings Islands, not just for endemic species of *Oligosoma*, but also for an endemic undescribed gecko in *Hoplodactylus* (Daugherty *et al.* 1994).

This objective is supported by Section 5.4, Northland CMS (1995), 'Animal Pests', Auckland CMS (1995), 'Islands management' Bay of Plenty CMS (1997) and Section 20, Wellington CMS (1996).

#### *Action*

- Establish and maintain permanent bait stations against rodents at all likely landing sites.
- Undertake regular (at least 6-monthly) monitoring of bait stations and replacement of baits.
- Encourage the 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.
- Develop and enforce protocols for visitors to islands to eliminate the risk of accidental invasion of pest species.

#### *Performance measures*

- Installation of bait stations on islands without rodents and regular (6-monthly) renewal of baits and monitoring for rodent sign.
- Established contingency plans and stocks of traps and baits for use in the event of the invasion of predatory mammals.
- Established 'island care' protocols used by all visitors to islands without rodents.
- Maintenance of the rodent-free status of islands.

#### *Key Personnel*

DOC Northland, Auckland, Waikato, Bay of Plenty, Wellington; Science Technology and Information Services (STIS).

## **Objective 2: Eradicate rodents from Little Barrier Island to protect chevron and striped skinks**

#### *Explanation*

Eradication of kiore from Little Barrier Island (3083 ha) should have a major impact on the status of two of the rarest species in *Oligosoma*. Little Barrier Island has the largest fauna of reptiles (14 species) known for any New Zealand island. The fauna includes tuatara (*Sphenodon punctatus*) as well as chevron skinks, striped skinks and marbled skinks (*Cyclodina oliveri*). Survey and trapping programmes for lizards indicate that most forest species are present at very low densities (K. Neilson unpubl. data.).

Removal of kiore would allow natural expansion of tuatara and most species of terrestrial lizards while also providing sufficient habitat for them to form very large populations.

This objective is linked to Objective 10 and is supported by the tuatara recovery plan (Gaze 2001); the *Cyclodina* skink recovery plan (Towns 1999) and by Key Area 3 (Little Barrier Island) Implementation Step 3.7.6, Auckland Conservation Management Strategy (1995) and Objective 1.1.4 in the DOC Strategic Business Plan (1998).

#### *Action*

- Undertake negotiations with Ngatiwai prior to planning for removal of kiore from Little Barrier Island.
- Remove kiore from Little Barrier Island within 5 years (includes 2 years to confirm success).

#### *Performance measures*

- Completion of a Co-operative Conservation Management agreement for Little Barrier Island with Ngatiwai. The plan should recognise the need to reduce threats to rare species of lizards.
- Removal of kiore from Little Barrier Island within 5 years.

#### *Key Personnel*

DOC Auckland.

### **Objective 3: Determine how habitats are used by chevron skinks on Great Barrier Island**

#### *Explanation*

Great Barrier Island is still the stronghold for chevron skinks. Whether this would remain the case if kiore are removed from Little Barrier Island is unclear. However, there is an apparent association between chevron skinks and moist habitats such as streams (Towns & McFadden 1993); such environments are far more widespread on Great Barrier Island than on Little Barrier Island.

Studies of habitat use by chevron skinks using radio telemetry are near completion on Great Barrier Island. Laboratory studies of evaporative water loss have also been undertaken and support the hypothesis that there is a physiological need for the moist environments such as leaf aggregations, rotting logs and stream beds with which the species is commonly associated.

#### *Action*

Complete current studies of habitat use by chevron skinks on Great Barrier Island within 2 years and review further information needs required for management of the species on Great Barrier Island.

#### *Performance measures*

- Habitat use predicted through information linking behaviour in the wild with physiological studies in captivity.
- Improved capture and telemetry methods.

#### *Key Personnel*

DOC Auckland; Science and Research Unit, STIS.

### **Objective 4: Determine effectiveness of intensive predator control for conservation of chevron skinks and other lizard species on Great Barrier Island**

#### *Explanation*

Eradication of predators has been the method of choice for restoration of lizard populations on islands. However, on very large islands and on the mainland, eradication is unlikely to be possible. The effectiveness of intensive control—rather than eradication—of pests has been demonstrated for forest birds (e.g. Innes *et al.* 1999), but its cost-effectiveness for lizards remains unknown. Great Barrier Island is an ideal location to carry out such studies because of its diverse fauna of lizards, including chevron and striped skink, and the absence of mustelids and Norway rats. These studies should also identify whether pest control is likely to provide a sustainable option on the mainland with a larger suite of predators.

#### *Action*

Continue existing studies examining cost-effectiveness of predator control for chevron skinks and other lizard species on Great Barrier Island. Within 3 years review whether further information is required.

### *Performance measures*

- Reduced densities of rodents in predetermined areas for at least 3 years.
- Measurements of the demographic and behavioural responses of chevron skinks and other resident lizard species when predator densities are reduced.
- Assessment of the feasibility, costs and benefits of localised predator control to a level providing measurable benefits to lizards.

### *Key personnel*

DOC Auckland; DOC Science and Research Unit, STIS.

## **Objective 5: Determine how habitats are used by striped skinks**

### *Explanation*

Management options for striped skinks will remain unclear until optimum habitats, and the way these are used, are determined. The scattered data at present available indicates that striped skinks may be (at least) partly arboreal inhabitants of lowland podocarp-hardwood forest dominated by tawa (*Beilschmiedia tawa*). Present proposals include clarification of these data through laboratory studies and observations of captive and wild skinks to determine thermal requirements, behaviour, activity patterns and evaporative water loss (Whitaker 1998).

### *Action*

Continue with research on aspects of the biology of striped skinks, focusing on:

- Activity periods (daily and seasonal) and thermal requirements under laboratory conditions.
- Comparative studies of behaviour, including thermal requirements and arboreal tendencies, using captive animals.
- Comparative field studies with sympatric species including chevron skink, brown skink and speckled skink (sympatric in parts of the range of striped skinks).

### *Performance measures*

- Habitat use in the wild predicted through information linking behaviour with physiological studies in captivity.
- Improved capture and survey methods.

### *Key personnel*

DOC Science and Research Unit, STIS; outside research agencies.

## **Objective 6: Determine how habitats are used by small-scaled skinks**

### *Explanation*

At present small-scaled skinks are only known from widely scattered locations ranging from small areas of rocky scree in pasture to screes, bluffs and outcrops in relatively unmodified areas. All of the sites are less than one hectare in size. Management options for small-scaled skinks will remain unclear until optimum habitats, and the way these are used, are determined. At present nothing is known about attributes of habitats that enable the lizards to survive in modified areas, the



long-term prospects for these relict populations, and whether the skinks are able to disperse between scattered habitats.

#### *Action*

Undertake research on the biology of small-scaled skinks, focusing on:

- Habitat use, diet and population densities in a range of environments (modified to relatively unmodified).
- Population viability in modified and unmodified habitats.
- Levels of dispersal between adjacent populations and potential effects of isolation.

#### *Performance measures*

- Improved advocacy and management of populations, especially those in modified habitats.
- Improved survey methods based on an understanding of habitat use and habitat availability.

#### *Key personnel*

DOC Science and Research Unit, STIS; outside research agencies.

### **Objective 7: Assess the threats, needs and conservation status of striped, small-scaled, speckled and spotted skinks**

#### *Explanation*

The conservation status of four species of *Oligosoma* should be clarified with surveys of known populations. Surveys have recently been completed for small-scaled skinks (Whitaker 1991, 1997; Hutchinson 1992). Striped skinks are the highest priority for future surveys (Whitaker 1998) but they present particular challenges because appropriate survey methods have yet to be devised. Resolution of such issues may hinge on the information about habitat use raised in Objectives 5 and 6. Surveys for speckled and spotted skinks could be conducted on an opportunistic basis with the particular aim of determining the limits of distribution, and the status of, and threats to, known populations on the mainland North Island.

#### *Action*

- Survey for small-scaled, speckled and spotted skinks, and for striped skinks once key information on habitat use is available.
- Investigate reports of the species provided by DOC staff and the public to determine the status of existing populations (e.g. stable, declining, or increasing).
- Identify needs for management action such as predator control (see Whitaker 1998).

#### *Performance measures*

- Improved knowledge of the distribution and status of small-scaled, striped, speckled and spotted skinks throughout their North Island range.
- Effective management of selected populations with measured increases in abundance.

### *Key personnel*

DOC Conservancy staff: Auckland, Waikato, Bay of Plenty, Tongariro/Taupo, Wanganui, East Coast/Hawke's Bay, Wellington; Science and Research Unit, STIS.

## **Objective 8: Eradicate pigs and goats from selected areas on Great Barrier Island and establish at least one intensive management site**

### *Explanation*

On Great Barrier Island, pigs feed intensively along stream margins occupied by chevron skinks. Pigs are known to be predators of lizards (Thomson & Challies 1988) and they often leave extensive areas of turned, loosened soil prone to erosion during floods. Goats greatly influence composition of the understorey and, like pigs, may accelerate soil erosion (Newman & Towns 1985). Localised eradication of pigs and goats was proposed in the previous chevron skink plan (Towns & McFadden 1993). However, although intensive pig control has yet to be conducted, total eradication of goats from Great Barrier Island now seems feasible. Management of other introduced mammals is also feasible and a potential intensive management site has been proposed at Te Paparahi at the northern end of the island.

### *Action*

- Continue with existing partnerships with Auckland City Council and the Great Barrier Island Community Board with a view to eradicate goats within 10 years.
- Undertake localised intensive control of pigs and measure costs/benefits to forest systems.
- Establish an intensively managed site (probably at Te Paparahi) where all introduced mammalian pests will be controlled.

### *Performance measures*

- Plan for the eradication of goats from Great Barrier Island.
- Until eradication plan implemented, maintenance of near zero densities of goats already achieved.
- Improved understanding of the effects of pigs on forest ecosystems on Great Barrier Island.
- Intensively managed site developed at Te Paparahi.

### *Key personnel*

DOC Auckland; Science and Research Unit, STIS; outside research agencies.

## **Objective 9: Investigate potential for management of small-scaled and striped skinks in at least one intensively managed site on the mainland for each species**

### *Explanation*

Intensive management of forest areas has successfully improved prospects for birds—such as kokako—declining on the mainland (e.g. Innes *et al.* 1999). Depending on the results of trials on Great Barrier Island (see Objective 4), the cost-effectiveness of this approach should be assessed on the mainland.

### *Action*

- Encourage monitoring of changes in lizard density at ‘mainland island’ sites inhabited by striped skinks and habitat patches inhabited by small-scaled skinks.
- Investigate the responses of discrete populations of striped and small-scaled skinks to intensive control of predators and determine the cost-effectiveness of this approach in the long term.

### *Performance measure*

- Assessment of the feasibility, costs and benefits of localised predator control to a level providing measurable benefits to lizards.

### *Key personnel*

DOC Bay of Plenty, Waikato, Wanganui; Science and Research Unit, STIS.

## **Objective 10: Develop advocacy programmes to protect populations of skinks either on or off public land.**

### *Explanation*

The eradication of pests from islands has provided numerous locations where species of *Oligosoma* skinks are returning to their former abundance. Maintaining these locations free of introduced predators requires effective interception measures (Objective 1) but also a supportive public, well informed about the risks of unwanted species on islands.

On the mainland—and on Great Barrier Island—issues more frequently involve protection of isolated populations of lizards on land not administered by DOC. The most frequent sightings of chevron skinks on Great Barrier Island have been in a stream catchment draining private land. Likewise, the most frequently observed striped skink populations in eastern Taranaki have been amongst rotting logs or remnants of exotic vegetation on private farmland (Whitaker 1998).

Support for protection of skinks in isolated habitat refuges requires innovative advocacy, close liaison between DOC field staff and local communities, and input by the Department into district land-use plans and other mechanisms for protection of indigenous fauna.

### *Action*

- Provide island care brochures to local boating communities to identify the risks of pests and the need to respect Nature Reserves.
- Publish and distribute fact sheets about species of skinks that inhabit private land.
- Encourage control of pests on private land and advocate for control and neutering of cats.
- Encourage maintenance of habitat patches on private land.
- Establish links with community groups as a means of maintaining exchanges of information about projects involving species listed in this plan.
- Investigate and develop collaborative approaches with private landowners, hapu/iwi and local government agencies for the control of pests and protection of habitats occupied by species of *Oligosoma* on land not in public ownership.

- Develop partnerships with Ngati Rehua and interested community groups in order to establish an intensively managed site at Te Paparahi on northern Great Barrier Island.

#### *Performance measures*

- Appropriate brochures and fact sheets produced and distributed.
- Increased proportion of neutered domestic cats on Great Barrier Island.
- Representative sites or habitats occupied by rare species of *Oligosoma* on private land are identified on District Plans or protected by other regulations promulgated through Local Authorities, and protected in the long term from destruction.
- Partnership agreement that leads to establishment of an intensively managed site at Te Paparahi.

#### *Key Personnel*

DOC staff, North Island conservancies.

### **Objective 11: Determine response of terrestrial lizards, especially chevron and striped skink, to removal of kiore from Little Barrier Island**

#### *Explanation*

The removal of kiore from Little Barrier Island could enable a substantial increase in the abundance of both striped and chevron skinks as well as other resident species of lizard. Should the numbers of striped and chevron skinks increase as expected, the conservation status of both species would be subject to review. However, this review will not be possible without data on the rate of increase and extent of available habitat for the species on Little Barrier Island.

#### *Action*

- Set up permanent trap lines or grids that can be used to assess lizard abundance before and after the campaign against kiore on Little Barrier Island.
- Undertake assessments of habitat use and availability for chevron and striped skinks using comparative data (for chevron skinks) from Great Barrier Island.
- Provide models for likely rates of population increase and test these against wild populations on Little Barrier Island.

#### *Performance measure*

- Understanding the effects of kiore on resident lizard species on Little Barrier Island.

#### *Key Personnel*

DOC Science and Research Unit, STIS; DOC Auckland.

## **Objective 12: Restore *Oligosoma* populations within their natural range**

### *Explanation*

Conservation of species in *Oligosoma* can be achieved largely by protection and enhancement of resident populations. However, there are islands around the central, eastern and southern North Island where speckled and spotted skinks could be restored following the removal of introduced rodents. Examples include Mokoia Island in Lake Rotorua, Motu-o-Kura south of Napier and Kapiti Island near Wellington. Intensive surveys of these islands is required before translocations are planned to ensure that there are no resident populations that survived at low densities.

### *Action*

- Eradicate mice from Mokoia Island.
- Identify islands suitable for the reintroduction of speckled and spotted skinks.

### *Performance measures*

- Removal of all rodent species from Mokoia Island.
- Successful establishment of speckled and spotted skinks on islands from which introduced predators have been removed.

### *Key personnel*

DOC Bay of Plenty, East Coast/Hawke's Bay, Wellington.

## **Objective 13: Determine identity of species with fragmented or isolated populations**

### *Explanation*

Some lizard populations that have been geographically isolated for long periods have shown species level divergence, distinctive morphology, or genetic divergence. For example, evolution of the Three Kings skink in the Three Kings Islands raises the possibility that long-isolated populations of other species in *Oligosoma* have undergone similar divergence.

Modern genetic techniques using mtDNA can be used to resolve the identity of isolated *Oligosoma* populations and to determine phylogenetic relationships and fine-scale evolutionary patterns within the genus. Such methods also raise the possibility of determining the affinities of the single specimen of the narrow-bodied skink (*Oligosoma gracilicorpus*) and should definitively determine whether it is an existing extant species (see Towns & McFadden 1993).

### *Action*

- Encourage studies of genetic identity of narrow-bodied skink, isolated populations in *Oligosoma*, and species whose affinities remain unclear (e.g. striped skinks: Whitaker 1998).

### *Performance measure*

- Understanding the genetic identity of isolated populations within species.
- Determination of the taxonomic relationships of species whose identity or affinities remain unclear.

### *Key Personnel*

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

## **Objective 14: Manage small populations of chevron skinks and striped skinks in captivity primarily for research, but as appropriate, to assist with advocacy**

### *Explanation*

Most of the chevron skinks at present in captivity are held at Auckland Zoo and have been rescued either damaged by vehicles or salvaged from predators (e.g. cats, kingfishers) on Great Barrier Island. The exception is a single chevron skink captured on Little Barrier Island and held at the DOC field base on the island. Salvage of chevron skinks has been highly successful with all rescued animals surviving at least a year in captivity.

Striped skinks are held at the National Wildlife Centre, Mt Bruce and Ti Point Reptile Park, Leigh. There is scope for continued study of the behaviour, physiology and reproductive biology of chevron and striped skinks. However, expanding populations of these species in captivity are not pivotal to this plan. Indeed, the Little Barrier Island chevron skink should be released once eradication of kiore has been completed. Similarly, the development of successful treatments for salvaged chevron skinks at Auckland Zoo have enabled damaged animals to be treated and released on Great Barrier Island.

There is now a need to plan for the size of chevron skink and striped skink populations held in captivity, and to determine the number and role of any offspring produced in captivity. These issues, and protocols for rehabilitation of chevron skinks rescued on Great Barrier Island, would be most appropriately covered in a captive management plan.

### *Action*

- Maintain small populations of striped skinks and chevron skinks as long as is required for research and advocacy.
- Develop a resource kit for treatment and release of damaged chevron skinks on Great Barrier Island.
- Develop management plans for chevron skinks and striped skinks held in captivity.

### *Performance measures*

- Populations of chevron skinks and striped skinks maintained in captivity for as long as they are required as part of the research and advocacy objectives identified in this plan.
- Management plans for the chevron skinks and striped skinks held in captivity.
- Successful rehabilitation of salvaged chevron skinks on Great Barrier Island using resource kits based on successful treatments on the mainland.

### *Key personnel*

DOC Auckland, Wanganui; Science and Research Unit, STIS; National Wildlife Centre; Auckland Zoo; Ti Point Reptile Park.

# 9. 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.

## 1. **Develop new baits, lures and bait dispensers to minimise non-target effects, but maximise potential to intercept arriving pests**

### *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.

Two relevant projects are under way at Landcare Research using funds provided by DOC:

- Comparisons of the relative effectiveness of commercially available products.
- A strategic approach to the development of 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 re-invading 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).

## 2. **Radio telemetry and ‘mark-recapture’ of chevron and striped skinks**

### *Explanation*

Radio-telemetry is proving to be extremely useful in providing information on habitat use in adult chevron skinks. To date it has allowed radio-tracking of individuals for up to 11 days. However, presently available transmitter technology restricts the use of transmitters to adult and sub-adult chevron skinks because the transmitters are too heavy for juveniles and smaller lizards such as striped skinks. The development of lighter transmitters would aid in answering habitat use questions in these smaller lizards.

Toe-clipping restrictions by iwi on some of the northern islands have meant that alternative methods for recognising recaptured individuals have had to be explored. Currently the ventral surface of all chevron skinks captured is being photographed for comparisons of chin markings between individuals. The validity of this method is yet to be confirmed as it is unknown whether these markings change over time. This system also becomes laborious as capture numbers increase. In order to more confidently and easily identify recaptured chevron skink, and striped skinks on islands where toe-clipping is not allowed, the development of a technique for long-term identification using non-invasive marking is required.

Methods for the detection of striped skinks in the wild are urgently required.

**3. Investigation of cost-effectiveness of localised intensive predator (cat and rat) control at selected sites on Great Barrier Island**

*Explanation*

A project examining the effects of localised rodent and cat control on populations of chevron skinks and other lizards on Great Barrier Island received funding in 1998. The first year of this project involved intensive surveying for suitable treatment and non-treatment locations to carry out the study. These have now been selected and following 1 year of pre-treatment data collection and trapping commenced in November 2000. Predator control will be carried out for 6 months per year until at least April 2004. Lizard populations will be surveyed every summer throughout this time to detect changes in population size, structure and habitat use. It is intended that at the completion of this work, it will be possible to make recommendations on the cost-effectiveness of carrying out predator control to benefit lizard populations over a larger area.

**4. Carry out research—especially with captive animals—to determine activity patterns, thermal preferences, tendencies for water loss, and reproductive output**

*Explanation*

Because chevron and striped skinks have proved so elusive, much information on constraints on the animals in the wild must be derived from studies of animals in captivity and in the laboratory. Populations of both species are now being held for this purpose.

Studies of evaporative water loss by chevron and striped skinks have now been completed (DOC, Science and Research Unit). The habitat use of chevron skinks revealed by radio-telemetry has shown that they may remain hidden within living or dead tree trunks for considerable periods (K. Neilson unpubl. data). These habits have implications for body temperature regulation and metabolic capacity. If chevron skinks remain as elusive as they have to date, physiological studies of animals under laboratory conditions may provide the best mechanism for determining constraints on habitat use in the wild. Similarly, studies of the reproductive output of chevron skinks in captivity may provide the only means of determining the capacity of the species to respond to management in the wild.

There is also need for more work on some aspects of the behaviour of striped skinks, especially arboreal tendencies and basking behaviour as both influence capacity to locate the skinks in the wild. Further details are provided in Objective 5.

**5. Study populations of small-scaled skinks in modified and unmodified habitats and investigate the effects of fragmentation of populations**

*Explanation*

There have been no studies of the ecology of small-scaled skinks, little is known about their habitat use and nothing is known about their productivity and hence capacity to respond to management where populations inhabit modified habitats.



In addition, the known locations occupied are small and some populations are separated by many kilometres. The long-term implications for these isolated populations need study which could be undertaken using modern genetic techniques. For further details see Objectives 6 and 13 and research project 8 (below).

**6. Determine effects of pigs on plants and terrestrial fauna; investigate feasibility of extensive pest management of predators such as rodents and cats**

*Explanation*

Feral pigs are widespread on Great Barrier Island and there is considerable resistance by sections of the local community to their control. To date, the ecological effects of wild pigs in New Zealand remain poorly known (Atkinson 2001) and it is therefore difficult to justify intensive control on the basis of existing evidence.

Studies of the direct and indirect effects of pigs on the terrestrial fauna (especially amphibians and reptiles) of Great Barrier Island are necessary. The cost-effectiveness of controlling pigs to predetermined densities should also be investigated.

Proposals to intensively manage all introduced pest mammals at selected sites on Great Barrier Island (e.g. Te Paparahi) will also require tests of the feasibility of managing rodents and cats over a large area. The management will need to be reflected in positive responses from species such as chevron and striped skinks.

**7. Set up standard monitoring sites and methods to determine effects of kiore removal from Little Barrier Island on resident lizards**

*Explanation*

The rate and type of response of chevron and striped skinks to removal of kiore from Little Barrier Island cannot be predicted at present. Studies of other species of skinks show that responses to rodent removal may be rapid at some locations and slow at others depending on the quality of available habitats. In addition, at some locations lizards may show behavioural changes that make them more easily caught after removal of kiore. If the long-term benefits of removal of kiore are to be demonstrated for chevron and striped skinks, monitoring of populations on Little Barrier Island should be undertaken before and after kiore removal.

Pitfall trapping has been carried out in selected forest catchments on Little Barrier Island since 1993. Trap numbers at three sites run during January 1999 ranged from 10 to 22. Pitfall trapping in boulder beach areas has also been carried out sporadically with capture rates much higher than in the forested areas.

In order to improve the usefulness of data collected on Little Barrier, permanent trap lines need to be set up in chosen locations. Ideally a range of different habitats should be trapped, with replicate trap lines in each habitat. This would involve placement of a much greater number of traps than is currently set up on the island. Traps should be run each summer up to and following the proposed removal of kiore from the island.

## 8. Undertake genetic studies

### *Explanation*

The plan proposes to enhance all genetic stocks of the species included as part of the long-term recovery goal. However, the genetic identity of isolated populations of most species is poorly known. Identity of these populations should be determined on an opportunistic basis, with the gathering of small tissue samples such as sloughed skin integrated into periodic surveys and the results published within the life of this plan.

## 10. Review date

This plan sets detailed objectives for 10 years from the date of approval and broad recovery objectives for an additional 5 years. A review of the plan at 5 years from approval would enable fine-tuning of the longer-term (10-year) objectives.

## 11. Acknowledgements

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# Published recovery plans

NUMBER	SPECIES	YEAR APPROVED
47	Tuatara	2001
46	Chatham Island fantail, Chatham Island tomtit and Chatham Island warbler	2001
45	Forbes' parakeet and Chatham Island red-crowned parakeet	2001
44	New Zealand shore plover	2001
43	Chatham Island shag and Pitt Island shag	2001
42	Chatham Island mollymawk, northern royal albatross, Pacific mollymawk	2001
41	Chatham Island tui	2001
40	Black robin	2001
39	Parea	2001
38	Chatham Island oystercatcher	2001
37	Chatham petrel	2001
36	Chatham Island taiko	2001
35	Hoiho	2001
34	Pygmy button daisy	2001
33	<i>Hebe cupressoides</i>	2000
32*	Inland <i>Lepidium</i>	2000
31*	<i>Muehlenbeckia astonii</i>	2000
30*	North Island kokako	1999
29*	Weka	1999
28	<i>Pittosporum patulum</i>	1999
27	<i>Cyclodina</i> skinks	1999
26	Coastal cresses	1999
25	Threatened weta	1998
24*	Striped skink	1998
23	Fairy tern	1997
22	Blue duck	1997
21	Kakapo	1996
20	Stitchbird	1996
19*	Brown teal	1996
18*	Native frogs	1996
17	New Zealand (Hooker's) sea lion	1995
16*	<i>Dactylanthus taylorii</i>	1995
15*	Bat (peka peka)	1995
14	Otago and grand skinks	1995
13*	Giant land snail	1995
12*	Takahe	1994
11	South Island saddleback	1994
10*	New Zealand dotterel	1993
9*	Tuatara	1993
8	Kowhai ngutukaka	1993
7*	Subantarctic teal	1993
6*	Mohua (yellowhead)	1993
5	Chevron skink	1993
4	Black stilt	1993
3*	Whitaker's and robust skinks	1992
2	Kiwi	1991
1*	North Island kokako	1991
-*	Yellow-eyed penguin	1991

\* Out of print. In-print issues are available from DOC Science Publishing, Science & Research Unit, P.O. Box 10-420, Wellington.