



# Recent developments in New Zealand herpetofauna research

Abstracts of papers presented at the 15th and  
16th biennial conferences of the Society for  
Research on Amphibians and Reptiles in  
New Zealand

N.J. Nelson and S.N. Keall



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biennial conferences of the Society for Research  
on Amphibians and Reptiles in New Zealand

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## Abstract

Research on New Zealand's amphibians and reptiles is presented at the biennial conference of the Society for Research on Amphibians and Reptiles in New Zealand. This compilation includes abstracts from conferences held in 2013 in Wellington and 2015 in Nelson. The scope of the research presented ranges from species-specific studies to testing new techniques, and in most instances includes application of the research to conservation.

Keywords: amphibians, reptiles, conference abstracts

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# 1. Introduction

Reptiles and amphibians are important components of New Zealand ecosystems, but we are still trying to understand their diversity and know very little about their ecology. The Society for Research on Amphibians and Reptiles in New Zealand (SRARNZ) is made up of researchers, conservation practitioners and amateur herpetologists who are dedicated to understanding more about New Zealand's herpetofauna. Every two years, the Society holds a conference to bring people together to hear about the latest research and celebrate contributions targeted primarily at New Zealand frogs, lizards and tuatara. In 2013, the 15th biennial conference of the Society was held in Silverstream, Hutt Valley, Wellington (Silverstream Retreat; 10-12 February). Fifty people attended a two-day conference to hear full-length presentations from 18 researchers. In 2015, the 16th biennial conference was held in Nelson (Tahuna Conference Centre; 30 January - 1 February). The three-day conference was attended by 65 people and featured full-length presentations from 31 researchers and a day-long symposium celebrating the legacy of Tony Whitaker, an eminent New Zealand herpetologist who died in 2014. Topics covered at the two conferences included species-specific studies on habitat use, dispersal, colour variation and behaviour, immunology and wildlife disease, stress hormone responses, and sex determination. Techniques were evaluated for identifying individuals, monitoring translocations and tracking. We now understand more about effects of island size on preserving genetic diversity and effects of introduced predators on native frogs, as well as including individual growth parameters in population modelling. We are still learning about New Zealand's lizard diversity and biogeography, and the threats associated with invasive herpetofauna. A selection of the abstracts for talks presented at the conferences is included here to allow wider use of the new knowledge and promote the value of the Society for understanding and conserving New Zealand's native herpetofauna. More detail on the research can be obtained by contacting the authors of each abstract directly or from full reports published elsewhere. In particular, a special issue of the *Journal of the Royal Society of New Zealand* (2016) explores the current state of knowledge in areas of investigation to which Tony Whitaker made significant contributions.

## 2. 2013 Conference abstracts

### 2.1 Incorporating individual growth into population models for reptiles

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Sensible management decisions for threatened species require population models, but reliable models are 'data hungry'. Efficient management therefore requires integrating data for multiple populations, but doing so requires an understanding of how vital rates (survival and reproductive) vary among populations. In reptiles, we expect vital rates to be size-dependent, and therefore expect population dynamics to be linked to individual growth rates which are linked to climate. Therefore, a key to modelling multiple reptile populations will be to incorporate individual growth into population models. Reptile population projections are typically made using stage-based models, where the stages are size categories. This approach links population dynamics to individual growth to some extent, in that the stage transition probabilities depend on growth rates. However, the approach is unsatisfactory in that it requires artificial size categories, and does not allow understanding of growth to be directly translated into population dynamics. Plant ecologists have recently developed an 'integral projection approach' that directly links growth to population dynamics without the need for artificial stages. However, this approach does not currently allow for variation in growth rates among individuals, and such individual variation is pronounced in reptiles. We have recently developed a growth-modelling approach that allows for such individual variation as well as a size-based switch in growth trajectory associated with sexual maturation. We are currently attempting to integrate this growth modelling approach into population dynamics using a long-term data set for snapping turtles (*Chelydra serpentina*).

### 2.2 Colour variation and adaptation in a New Zealand lizard

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The occurrence of colour and pattern variation in lizards is often attributed to natural selection (e.g. predator avoidance) and sexual selection (e.g. mate choice). These selective forces can often oppose each other, resulting in a phenotype that reflects a compromise between survival and mating success. The effect of multiple selection pressures on colouration, especially in variable environments, is not well understood. This study investigated the function of colour for both camouflage and intraspecific signalling in a shore skink (*Oligosoma smithi*) population at Tawharanui Regional Park, Auckland. We observed the population's colouration trend over different seasons at the white sand dunes of Tawharanui, and present evidence of colour adaptation in a translocated population at Tiritiri Matangi Island, which has a different habitat (dark sand and rock beach). In 2007 to 2008, we measured morphometrics and photographed skinks and their habitat from both locations. We predicted a correlation between brightness of the habitat and dorsal colouration (visible to predators) but expected no such correlation for ventral body regions (hidden from predators). Preliminary results showed a significant difference in brightness between dorsal and ventral regions, and the results for skinks in both

regions correlating with habitat brightness. There were temporal differences in the brightness of adults between breeding and nonbreeding seasons at Tawharanui. Finally, the brightness of the translocated population was significantly lower than the source population (Tawharanui). These results suggest that shore skinks are capable of adjusting their body brightness to adapt to habitat and, potentially, for intraspecific signalling during mating.

## 2.3 Extreme site fidelity in adult Maud Island frogs over successive decades

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Maud Island frogs *Leiopelma pakeka* (Anura: Leiopelmatidae) are extremely long-lived. Mark-recapture studies on Maud Island from 1976 to 2010 have revealed that some individuals have survived for 35–40 years in two 12 × 12 m lowland forest plots, allowing their movements and home ranges to be investigated over many years of their lives. Given the time scale (decades) that some frogs were present at the study sites, we found that the adult *L. pakeka* studied were highly sedentary, occupying remarkably small individual range areas (mean minimum convex polygon area ± SE = 26.7 ± 2.2 m<sup>2</sup>, 95% kernel density estimate ± SE = 26.7 ± 1.3 m<sup>2</sup>). The mean distances moved between successive range centroids were also very small—on average, *L. pakeka* shifted their ranges only 1.3 m every 10 years, showing an extremely high level of site fidelity over a very long timescale. The mean nearest neighbour distance was 0.63 m (range = 0–3.04 m). The mean ± SE density from 3 years analysed was 0.35 ± 0.05 frogs/m<sup>2</sup> on one plot (grid 1) and 0.88 ± 0.16 frogs/m<sup>2</sup> on the other (grid 2). Mean home range sizes varied by sex and study plot, which may reflect different densities, habitats or physiological requirements. Our long-term results represent some of the smallest, most stable home ranges and most extreme site fidelity known for any vertebrate.

## 2.4 Following up Duvaucel's gecko (*Hoplodactylus duvaucelii*) on Mana Island: post-translocation monitoring 11–13 years on

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Currently, little is known about the methods and techniques required for successful gecko translocations in New Zealand and internationally. This includes a lack of data on population establishment and the outcomes of past gecko translocations. We surveyed Duvaucel's geckos (*Hoplodactylus duvaucelii*) on Mana Island that originated from a stock of 40 translocated from North Brother Island in 1998—the first significant translocation event for New Zealand geckos. In the first 10 years (1998–2008) since this release, only 26 geckos had been encountered, potentially due to their cryptic nature and relatively slow population growth rate. Since 2009, we have been monitoring the population at the original release location using capture-mark-recapture methods and radio-telemetry studies. We examined population size, body condition, area inhabited, movements, habitat use, population structure and parasite loads. We reported our results to date, which are encouraging for future translocations of Duvaucel's geckos to sanctuaries where introduced mammals have been eradicated.



## 2.5 Effects of behavioural and environmental variation on offspring sex ratios in New Zealand tuatara

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Mechanistic niche models use biophysical ecology, mathematical descriptions of physiology and behaviour to examine an environment from the point-of-view of a single organism's physiological requirements and thermal constraints. The evolution of environmental sex-determining mechanisms (in particular, temperature-dependent sex determination (TSD)) in many reptile species means that biophysical models can inform studies of reptile reproductive ecology and evolution. An important question is whether female nesting behaviour is a potential mechanism for maintaining balanced population sex ratios through periods of climate change. We integrated in situ observations of nesting behaviour with climate data into a mechanistic framework to examine how maternal effects—nest site selection, nesting phenology and nesting migration—in the New Zealand tuatara (*Sphenodon punctatus*) interact with environment to influence soil temperatures in nests. We then calculated embryonic development rates and offspring sex ratios for using a range of current and hypothetical future environmental and behavioural scenarios. Oviposition cues that, in the past, enabled females to choose 'warm' nest sites to maximise offspring fitness may contribute to increases in proportions of male hatchlings during periods of rapid climate warming. A consistently warmer environment may additionally constrain nesting behaviour in female tuatara if temperatures exceed physiological thermal tolerances, thereby limiting the reproductive niche.

## 2.6 Basking behaviour of the Otago/Southland gecko (*Woodworthia* "Otago/Southland") in Eastern Otago

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Shifts in body temperature and behaviour associated with changes in reproductive condition have been well documented in viviparous (live-bearing) lizards, often under laboratory conditions. Yet how viviparous lizards from cold climates (especially nocturnal species) achieve sufficient warmth during pregnancy in the wild is poorly understood. We used time-lapse photography to study the diurnal behaviour of the Otago/Southland gecko *Woodworthia* "Otago/Southland" (formerly of the *Hoplodactylus maculatus* species complex), a viviparous gecko that is often described as nocturnal. In the wild, geckos have rarely been observed basking. However, in the laboratory, pregnant females bask, sometimes elevating their body off the substrate into an 'on-toes' position that has the potential to raise body temperature. Time-lapse photography of wild geckos revealed a complex array of diurnal basking behaviours which could be split into four subcategories: head, whole-abdomen, half-abdomen and 'on-toes'. Early pregnant females basked directly, either completely emerging from retreats or exposing only parts of their body (e.g. half-abdomen) to the sun. Temperature loggers inserted into copper models were used to compare the thermal profiles of two basking positions (direct and 'on-toes') and two in-retreat positions (deep crevice and superficial rock). Models in basking positions experienced higher thermal fluctuations, and consistently reached higher temperatures over the spring recording period compared with models in retreats. These findings suggest that diurnal basking and retreat site

selection may enable females to achieve optimal body temperatures for embryonic development in cool-temperate climates. Further research will address whether basking behaviour varies with retreat type (deep crevice v. superficial slab).

## 2.7 Does the suppression of introduced ship rats (*Rattus rattus*) benefit the endangered Archey's Frog (*Leiopelma archeyi*)?

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The introduced ship rat (*Rattus rattus*) has long been considered a threat to New Zealand's endemic frog fauna (*Leiopelma* spp.). However, little is actually known about the impact of this predator on frog populations. Ship rats prey on the endangered Archey's frog (*L. archeyi*) which is known from only two locations—Coromandel Peninsula and Whareorino Forest—the latter being the stronghold site for the species. A research-by-management study investigating the impact of ship rats on the Whareorino population was carried out from 2003 to 2011 after rat predation events in that population. Since 2003, ongoing ground-based rat control has maintained low rat abundance over 300 ha of frog habitat (treatment site), while rat abundance remained high at a second 300 ha area that received no rat control (non-treatment site). Capture-recapture monitoring completed twice per year using the 'robust design' involved eight sessions per year (four nights each session) spread evenly between four monitoring plots; two each in the treatment and non-treatment areas. Over 12 sessions from 2005 to 2011, 1106 individuals were recorded at treatment plots and 468 individuals at non-treatment plots. We estimated population abundance, survival rate, recruitment rate, proportion of frogs underground (unavailable for capture) and compared population trends between the treatment and non-treatment plots. A declining trend in abundance was observed in the non-treatment plots; however, no trend was evident in the treatment plots. We found no trend in survival estimates for any of the plots (range = 0.53 to 0.76). Total recruitment was higher in the treatment than the non-treatment plots and differed significantly between all plots except the treatment plots ( $p$  values  $\leq 0.017$ ). Population size differed significantly between the treatment and non-treatment plots after monitoring session 1, and continued to diverge thereafter ( $p$  values = 0.4136 or lower). We believe this demonstrates the efficacy of rat control at sustaining and possibly aiding an increase in population size. Evidence also suggests the main effect from high rat abundance may be suppression of recruitment. These results confirm that rat control contributes significantly to maintaining a viable Archey's frog population at Whareorino Forest, and may help guide management of *Leiopelma* species on the Coromandel Peninsula and elsewhere.

## 2.8 Sloop—an automated image retrieval system for matching lizards

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Photo-surveys have been used for monitoring of grand (*Oligosoma grande*) and Otago (*O. ottagense*) skinks for over 10 years, but the photo-matching is time-intensive. Sloop improves the process by using advanced image matching algorithms to present ranked candidate matches of known individuals to a submitted photograph for human confirmation and maintains a database of known individuals, their sighting history and other metadata. The Grand and Otago Skink Recovery Programme is using Sloop to match photo-survey results against a database of known individuals in order to carry out sight-resight estimation of populations. The sighting history built up in Sloop is then exported for analysis using Mark software. There is potential for the system to be rolled out to additional species if they have suitable immutable skin patterns.

## 2.9 Origin and diversification of myobatrachid frogs

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The Family Myobatrachidae (22 genera, 120+ species) is endemic to the Australo-Papuan region, comprising 57% of the Australian frog fauna and displaying more diversity in reproductive strategies than any other major frog clade. The higher-level relationships among myobatrachid genera and the relationships of myobatrachids to other frog groups have been the subject of considerable dispute. We have assembled tissues from every described species of Myobatrachid (including several extinct species) and multiple outgroups, representing seven major frog clades. Using a large molecular dataset, the first comprehensive molecular phylogeny for all Myobatrachid frogs was developed. The phylogeny can be used to address a series of questions concerning the origin, diversification and biogeography of Myobatrachidae in the southern hemisphere.

## 2.10 Comparing the dispersal of jewelled geckos (*Naultinus gemmeus*) from ‘hard-release’ and ‘soft-release’ translocations

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This study has since been published in the journal *Animal Conservation* as a full article. With permission from the journal, the abstract is reproduced here. The citation is as follows:

Knox, C.D.; Monks, J.M. 2014: Penning prior to release decreases post-translocation dispersal of jewelled geckos. *Animal Conservation* 17: 18–26.

Translocation is an essential conservation tool often used to re-establish reptile populations following anthropogenic extirpation, but is not always successful. One factor potentially limiting success is dispersal of individuals from the release site immediately after translocation and consequent non-overlap of ranges. ‘Penning’ involves the use of an enclosure to restrict dispersal of translocated animals for a pre-determined period of time, with the aim of habituating animals to the release site so that they will establish a breeding population. We evaluated the utility of penning for limiting post-translocation dispersal of jewelled geckos (*Naultinus gemmeus*) by simultaneously tracking 19 geckos that had either been translocated into a pen for 9–10 months prior to the pen’s removal ( $n = 10$ ) or were translocated to a nearby site with no physical barrier to dispersal ( $n = 9$ ) over a three-week period. The area occupied by penned geckos did not increase following removal of their pen, despite suitable habitat being available outside the pen area. In contrast, un-penned geckos moved distances of up to 40 m outside of their release area, and effectively increased the area that they were occupying as a group 4.4-fold over the three-week period. We suspect that when *Naultinus* geckos are released without time in a pen some individuals may disperse too far to contribute to a breeding population and, consequently, the likelihood of population establishment and rate of population growth may be diminished. Our hypothesis is supported by a survey we conducted the following summer in which all four adult female geckos found at the penned site were gravid, but neither of the females resighted at the un-penned site were gravid. We believe that the potential advantages of penning (e.g. restricting initial dispersal, increased ease of monitoring) may outweigh the disadvantages (e.g. cost) for many herpetofauna translocations.

## 2.11 The influence of temperature on corticosterone secretion in tuatara (*Sphenodon punctatus*)

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Glucocorticoids (GCs) are steroid hormones secreted from adrenal tissues in all vertebrates. Short-term increases in GC levels (‘stress response’) are observed in individuals exposed to challenging stimuli. These increases influence change in behaviour and physiology to help individuals cope with environmental challenges. Corticosterone (CORT) is the primary GC hormone in reptiles, including tuatara (*Sphenodon punctatus*). Baseline CORT secretion in tuatara is relatively low and in accordance with other vertebrate species, a ‘stress response’ to capture/restraint is detected. Although variation in baseline and ‘stress-response’ CORT secretion in tuatara exists, studies examining patterns of CORT secretion and influential factors are limited. The influence of body temperature (T<sub>b</sub>) on CORT is unclear, with studies either suggesting or questioning a significant relationship. In this study we examined: 1) relationships between T<sub>b</sub> and baseline CORT; 2) relationships between T<sub>b</sub> and ‘stress-response’ CORT; and 3) results from experimental manipulations of temperature on ‘stress-response’ CORT in gravid female, non-gravid female and male tuatara. We confirmed gravid females have significantly higher baseline plasma CORT concentrations than non-gravid females and males, suggesting increased CORT secretion in females during the nesting season. T<sub>b</sub> was not significantly different between groups, suggesting that increased T<sub>b</sub> is not driving the elevation in CORT observed in gravid females. However, significant positive relationships between T<sub>b</sub> and baseline CORT (in gravid females only) and T<sub>b</sub> and ‘stress-response’ CORT (in all groups) were observed. Controlled experiments investigated the influence of T<sub>b</sub> on ‘stress-response’ CORT secretion and results contribute to the interpretation and direction of future CORT studies.

## 2.12 The ecological and immunological relationships between *Salmonella* and tuatara

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The transmission and expression of disease in wild animal populations is a complex interaction of host, pathogen and environmental factors. We investigated spatiotemporal dynamics of *Salmonella* in an island ecosystem and selected one species—tuatara (*Sphenodon punctatus*)—for in-depth immunological analyses. Salmonellosis is an important zoonotic disease resulting in significant morbidity and mortality in populations of wild reptiles, birds and mammals throughout the world. We found that tuatara are exposed to *Salmonella* in their burrow environments and through contact with infected prey. However, *Salmonella* has not been isolated from over 600 cloacal swabs from wild and captive tuatara. This raises the question of whether tuatara are innately resistant to *Salmonella*. To investigate this hypothesis we examined aspects of both innate and adaptive immune responses in tuatara serum. Immune measurements included in vitro antimicrobial activity of serum and antibody recognition of bacterial antigens. We developed flow cytometry assays to investigate antibody recognition of bacterial antigens by tuatara serum and demonstrated that tuatara possess antibodies which recognise *Salmonella* antigens. Assays were also established to determine the anti-microbial activity of tuatara serum and we compared this activity with that of a number of other reptilian and mammalian species. The anti-microbial activity of tuatara serum was approximately 6-fold higher than donkey or mouse sera, but showed similar activity to the other reptilian species tested. This is the first report of both anti-*Salmonella* antigens and active anti-microbial activity in tuatara serum. Understanding disease-host dynamics plays a vital role in the management and health of captive and wild tuatara.

## 2.13 Evaluating footprint tracking tunnels as a detection and monitoring tool for New Zealand lizards

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Our knowledge of many of New Zealand's cryptic lizard taxa is limited by a lack of reliable monitoring methods. Footprint tracking tunnels have been used to index small mammal populations in New Zealand for several decades. Recent improvements in the ink formulation used on tracking cards have made this technique more suitable for detecting lizards. However, the utility of footprint tracking for detecting a range of lizard species and for producing reliable indices of abundance is unknown. We (1) evaluated whether clear footprints could be obtained for a range of lizard species, (2) investigated whether prints could be identified to species level (using footprint measurements) for two similar-sized gecko species, and (3) conducted a pilot study investigating the relationship between indices obtained from footprint tracking and from pitfall trapping. In a trial using captive- and wild-sourced lizards (four skink and eight gecko species) from the South Island, we found that all skink prints were indistinct or obscure, but obtained clear, measurable prints for all gecko species. We were able to discriminate between the two gecko species for which we had a large sample (*Naultinus gemmeus* and *Woodworthia*

“Otago/Southland”) based on footprint measurements (the best model correctly assigned *N. gemmeus* 96.1% of the time). Indices of abundance derived from footprint tracking and pitfall trapping for lizards on Korapuki Island were comparable for skinks, but not for geckos. Further research is required to evaluate the utility of footprint tracking for identification of a range of New Zealand lizard species and the utility of the technique for monitoring lizard populations.

## 2.14 Habitat use and movement patterns of southern North Island forest gecko (*Mokopirirakau* “Southern North Island”) at Otari-Wilton’s Bush, Wellington

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This study has since been published in the *New Zealand Journal of Zoology* as a full article and is not reproduced here. The citation is as follows:

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## 2.15 Does island size matter for preserving genetic variation in small lizards?

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Genetic diversity is important for the fitness of animal populations, with reduced genetic diversity resulting in reduced immune responses and reproductive success. In New Zealand, habitat loss and predation by introduced mammals has caused extinctions of many native lizard species from the mainland habitats, with many now only found on offshore islands where mammalian predators have been removed. Some of these island reserves are very small and may only support small populations. Small and isolated populations often face the risk of reduced genetic diversity due to higher levels of inbreeding. In this study we have used 10 microsatellite markers to compare the genetic diversity of common gecko (*Woodworthia maculata*) populations between mainland and 11 islands of different sizes ranging from 0.98 ha (Aeroplane Island) to 1970 ha (Kapiti Island). We discussed whether island size has consequences for genetic diversity in common geckos and management implications for island populations and assessed the effects of past mammalian presence on the genetic diversity of common geckos.

## 3. 2015 Conference abstracts

### 3.1 Prey camouflage and colour pattern variation in heterogeneous habitats

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The success of visual camouflage depends on how well an animal blends into its background, thus concealing its presence from potential predators or prey. However, optimising background-matching is challenging in heterogeneous habitats. Many species exhibit substantial colour pattern variation, and in a prey species such as the shore skink (*Oligosoma smithi*), it is unclear whether individuals match particular components of the habitat, or if colour patterns represent a compromise for the different habitat used. Here, we quantify colour pattern variation in the highly variable shore skink, the skinks' habitat use and colour-matching to their background. We recorded achromatic (i.e. brightness) and pattern variations (scored according to pattern complexity) of body and background within a shore skink population. Results show that body pattern types and their brightness are distributed according to habitat complexity and brightness, indicating a camouflage function for colour patterns in this species. However, the habitat use and level of background-matching in brightness differed for each pattern type. This suggests that the population consists of colour patterns that are well matched and less matched to their backgrounds. Our study demonstrates that camouflage efficiency can vary for different colour pattern variants within a population occupying heterogeneous habitats.

### 3.2 Archey's frog, *Leiopelma archeyi* in the Coromandel Ranges—how has it fared since its population crash over 1996–2001?

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Internationally, Archey's frog (*Leiopelma archeyi*) is of high conservation concern, leading the EDGE list of the world's most evolutionarily distinct and globally threatened amphibians and listed as Critically Endangered on the IUCN Red List of Threatened Species. Under the New Zealand Threat Classification System, *L. archeyi* is ranked as Nationally Vulnerable. Given this, it is timely to review data emerging from a long-term demographic study of the species at Tapu Ridge, Coromandel Ranges, where annual population estimates have been made since 1984. Over 1996–2002 this study revealed a large population decline (88%), but fortunately numbers did not continue to decline rapidly, as was once feared, although population estimates have remained relatively low and have not returned to former levels. We also report on changes in methods of individual identification used at Tapu, on chytridiomycosis infection in *L. archeyi* there, and on transect surveys of both *L. archeyi* and Hochstetter's frog (*L. hochstetteri*) elsewhere in the region. There is still cause for concern for the future of *L. archeyi*, given recognition of such agents of decline as disease, invasive predators, habitat disturbance and climate change.

### 3.3 Patterns of locomotion in leiopelmatid frogs: a peek into the night-life of the earliest frogs

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Several morphological, genetic and behavioural characteristics show that frogs in the Family Leiopelmatidae (*Ascaphus* and *Leiopelma*) are the most primitive living anurans. In addition, the phylogenetic relationships within the leiopelmatids indicate that the basal species (*Ascaphus montanus*, *Leiopelma hochstetteri*) are stream dwellers, while the other species are mainly terrestrial. Similar to most other frogs, leiopelmatids launch into the air with bilateral limb extension, but unlike other frogs, they do not extend their arms to control landing and essentially ‘crash land’. To better understand this first step in the evolution of frog jumping, we studied locomotor behaviour in the field of three species of *Leiopelma* and one species of *Ascaphus*. The goal was to quantify the types of locomotion and other movements used by these frogs to determine how frequently they ‘crash land’ in nature. We recorded locomotor movements of individuals from four species (*A. montanus*, *L. archeyi*, *L. hochstetteri*, *L. pakeka*). Individuals were located at night in their natural habitats and observed with focal animal observations and infrared video recordings for 60 minutes per individual (30 individuals per species). The results showed that walking is the primary mode of locomotion in leiopelmatids. There was considerable overlap in behavioural repertoires of the two stream species, as both were observed to jump on land and into the water. In contrast, the terrestrial species rarely jumped, but differed in walking frequency and other behaviours that reveal differences in the nature of their sit-and-wait feeding strategies related to habitat differences in their terrestrial niches. Thus, we were able to quantify shifts in locomotor repertoires that are associated with the evolutionary transition to terrestrial niches.

### 3.4 PAWS: a novel technology for lizard detection and monitoring

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The ability to accurately monitor lizard populations and detect cryptic species is a critical component of lizard management and biodiversity monitoring. Given the typically small population size and secretive behaviour of lizards, it is particularly important that monitoring techniques provide a high probability of detection for a range of species in a range of habitats. In addition, monitoring methods should be robust, repeatable, simple and cost effective. The PAWS (Print Acquisition for Wildlife Surveillance) system has been designed as a field tool for distinguishing and recording different animal species interacting with a long-life device. The aim of this device is to improve detection and monitoring for species of concern, whilst reducing labour costs and the need for data interpretation. This tool was developed to passively detect mammalian pests, but has recently been applied to herpetofauna in New Zealand and Australia. Captive trials have demonstrated that it is possible to distinguish between lizard species based on characteristics such as foot and body dimensions and with a bigger dataset it will be possible to improve the accuracy of detection significantly. Recent advances include higher-resolution surfaces, mini camera modules, remote download potential and user-friendly software to increase applications of this tool and extend its use to the wider community. We conclude that used alone, or in parallel with other field methods, the PAWS device is a promising tool for lizard monitoring.



### 3.5 Modelled microclimate surfaces predict nest site suitability and hatchling sex ratios for tuatara under climate change

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Quantitative data on habitat suitability are becoming progressively more important to reintroduction biology, both for identification of appropriate release sites and for post-translocation monitoring. For oviparous reptiles with temperature-dependent sex determination (TSD), an effective definition of habitat suitability includes the thermal suitability of release sites both for completion of embryonic development and, over the long term, for maintenance of balanced population sex ratios. We used a spatially explicit, mechanistic microclimate model and a biophysical model of embryonic development to locate suitable nesting sites and predict offspring sex ratios for tuatara on two latitudinally and environmentally distinct New Zealand islands under current and projected climate scenarios. Our results show that a scenario conforming to the maximum predicted magnitude of local, seasonal climate warming could result in heavily male-biased hatchling sex ratios on both islands over the next 100 years. We argue that spatially explicit data on thermal suitability for incubation and sex determination should be considered critical, not only to conservation but also in planning and monitoring of translocated populations of tuatara and other species with TSD.

### 3.6 Letting go of the living fossil label: two hundred years of studies on tuatara

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Recently I completed a substantial book about tuatara (*Sphenodon punctatus*), the last of the rhynchocephalian reptiles. This is the first major compilation for decades on this species of international significance. In this talk, I address two aspects. First, in keeping with the theme of the symposium, I summarise the contribution that the late Tony Whitaker made to tuatara research, including the valuable assistance he gave to completing this book. Second, I summarise a major theme of the book: that, contrary to common usage, tuatara are not usefully considered as a living fossil. I condense evidence from studies by many people across many disciplines to argue that tuatara are best considered as a modern reptile, with a challenging composite of derived features as well as features retained from ancient lepidosaurian ancestors. Some features of tuatara, especially those connected with life history, have parallels among New Zealand geckos and probably evolved in both lineages in response to local climates.

### 3.7 Slithering away: a decade of mammalian predator trapping has not resulted in recovery of native skink populations

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Protection of indigenous lizard populations from introduced mammalian predators on the mainland is a major conservation challenge in New Zealand. The Rotoiti Nature Recovery Project (RNRP) was established within the Nelson Lakes National Park in 1997 as a Department of Conservation 'mainland island'. In 2001, the control area was increased to include the habitat of the indigenous common (*Oligosoma polychroma*), speckled (*O. infrapunctatum*) and spotted (*O. lineocellatum*) skinks. We monitored these populations within the RNRP using live capture pit-fall traps during 2002–2013. Over this 10-year period, both common and speckled skink populations decreased significantly. Few spotted skinks were found, and where present they appear to be in decline. In 2010, we expanded the project to compare skink populations inside the park with those on neighbouring farms that did not have mammalian predator control. In addition, we were able to compare the present lizard population at Lake Station with previous research. For common skinks, the proportion of females to males and the body size of females caught since the 1970s has decreased. A comparison of catch rates at Lake Station between this study and a similar one in 1995 showed that all species have decreased in abundance, with the largest change seen for speckled and spotted skinks. It appears that skink populations inside and outside the RNRP are in decline and the level of mammalian predator control currently occurring in the RNRP is insufficient to protect or allow recovery of the skink populations.

### 3.8 Assessing the feasibility of translocating Hochstetter's frogs to Orokonui Ecosanctuary

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Management tools such as translocations may be necessary for populations inhabiting modified environments, especially in established exotic pine plantations that will require eventual removal. Identifying suitable habitat and determining the physiological consequences of environmental temperatures in novel areas are just two components necessary for herpetofauna translocations. Identifying suitable habitat is often challenging, as target species tend to be cryptic, threatened and inhabit largely modified areas. Furthermore, whilst conservation physiology is developing, temperature relations are still unknown for many species. We attempted to address these issues in a population of *Leiopelma hochstetteri* (Hochstetter's frog) with the prospect of potentially translocating individuals prior to the onset of pine harvesting. We investigated resource selection in populations inhabiting Torere Forest (Bay of Plenty) and predicted habitat suitability in a potential translocation site at Orokonui Ecosanctuary (Dunedin). Considering the South Island is considerably cooler than the areas they currently occupy, we also investigated thermal preference and the effects of cooler temperatures on gut retention times and body weight of captive frogs. Our results suggest that frogs are strongly associated with cobble rocks and logs, but not gravel. Based on these findings, habitat was considered suitable at Orokonui. At 6–7.5 °C, gut retention times and body weights of captive frogs increased, but no digestion of slaters occurred. Crickets

were digested, however. Preferred temperatures mainly ranged between 15 and 21°C, although these are conservative estimates, as frogs may have selected higher temperatures given the opportunity. Despite suitable habitat identified in Orokonui, the effects of cool temperatures on Hochstetter's frogs warrants further investigation.

### 3.9 Estimating the predation rate of an introduced mammal on two of the world's most endangered amphibians using molecular diet analysis

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Molecular analysis of predation is a rapidly growing field used to study complex trophic interactions and detect the presence of endangered taxa as prey in order to manage their conservation. The evidence to date of introduced mammals negatively impacting New Zealand's native frogs (*Leiopelma* spp.) is largely circumstantial. One species often implicated in the decline of native frogs is the ship rat (*Rattus rattus*). The aim of this study was to utilise DNA-based diet analysis to provide estimates of the predation rate of ship rats on frogs in New Zealand. Ship rat stomach samples were collected through kill-trapping from study sites inhabited by Archey's frog (*Leiopelma archeyi*) and Hochstetter's frog (*Leiopelma hochstetteri*). Rat stomach contents were subject to analysis using species-specific DNA primers. Six out of 161 stomach samples (3.73%) tested positive for the presence of frogs as prey. Using previously reported prey detectability half-lives and a predation rate model, minimum predation rate estimates varied from 0.07 to 0.3 Archey's frogs/rat/night and 0.01 to 0.05 Hochstetter's frogs/rat/night. This is the first time that DNA-based diet analysis has been used to measure the impacts of predators on amphibians and the first time that *Leiopelma* spp. have been detected in introduced mammal stomach contents. The information obtained in this study can be used to directly inform predator control management decisions in the light of protecting these endangered species and can be viewed as a case study for other conservationists researching the impacts of introduced fauna on native amphibians.

### 3.10 Inbreeding depression in a captive population of Otago skinks (*Oligosoma otagense*)

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Small populations can suffer reduced population growth as a consequence of inbreeding. To inform management of threatened species, realistic rates of inbreeding depression should be incorporated into population models. We studied a captive population of Otago skinks (*Oligosoma otagense*), an endemic lizard species for which ongoing survival is dependent on intensive management. The captive population is used as a source of reintroduction stock for this species, but it is highly inbred. We modelled the effects of inbreeding on individual survival using a mixed effects Cox proportional hazards approach, allowing us to estimate the strength of inbreeding depression (the lethal equivalents) acting on lifetime survival probability. Our results indicated a trend between increasing individual inbreeding coefficient and decreasing

lifetime survival rates, similar to other studies of inbreeding depression in captivity. However, the estimated number of lethal equivalents acting on this population up until the mean survival time ranged from -0.48 to 7.95 per diploid genome, indicating this trend was not statistically significant. Inbreeding depression is often less severe in captivity due to relaxed selection pressure (e.g. a lack of predators and natural parasites), stable environmental conditions and reduced intraspecific competition. Therefore, conservation managers should treat the estimated number of lethal equivalents from this study as a conservative minimum estimate of inbreeding depression, as inbreeding may have stronger negative effects on individual survival in a wild setting. We recommend that population viability analyses used to specify future conservation actions for this species take rates of inbreeding into account, particularly when modelling reintroduction actions.

### **3.11 An overview of New Zealand gecko taxonomy**

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The New Zealand geckos are an old endemic, monophyletic radiation of more than 40 species, many still undescribed. The phylogeny published by Nielsen et al. (2011) contained some surprises. The New Zealand and New Caledonian Diplodactylinae gecko radiations are not sister groups as previously hypothesised. Each is independently derived, with different sister clades in Australia, where all the more distant immediate outgroups are also found. The estimated date for the basal split within New Zealand is 24.4 mya (range 15.5–33.8), but at least two different-sized gecko taxa are present in the 16–19 mya Saint Bathans fauna. The New Zealand radiation contains seven distinct clades which we have recognised as genera. The high taxonomic and ecological diversity of the group is extremely unusual for a temperate landmass. Additional discoveries remain likely, and further taxonomic splitting of some of the proposed species is likely in future.

### **3.12 Lizard biogeography: driven by history or ecology?**

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Species distributions are driven by a combination of history and species biology, including dispersal ability and ecological tolerance. Biogeographers have traditionally looked for concordant patterns of distribution and often hypothesised that these are the result of shared history. If this is the correct explanation, then the phylogenetic divergence events underlying these shared distribution patterns should be roughly congruent in time. Skinks and geckos have been present in New Zealand for more than 20 million years, giving ample time for geological and climate change events to have affected their distributions, and each represents a radiation of tens of species from a single founder population. They are relatively poor dispersers, and therefore appear to be an ideal group for the detection of the effects of history on distribution. However, when phylogenetic divergence across shared distribution boundaries is compared between taxa, there is no pattern of shared history—divergence depths across the same boundaries vary enormously.

### 3.13 How do juvenile tuatara perform following translocation to a cool southern ecosanctuary? A comparison between three source groups

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Anthropogenic climate change is predicted to be a major cause of species extinctions. Translocations to thermally suitable locations can restore populations experiencing the effects of climate change. Tuatara (*Sphenodon punctatus*) have international significance as the last survivor of the rhynchocephalian reptiles. Once widespread throughout New Zealand, tuatara now occur naturally on 32 islands in the north of the country, where the survival of at least one population is threatened by climate change. Here we studied the translocation of juvenile tuatara from three groups (wild-caught from a warmer climate, head-started from a warmer climate and head-started from the local climate) to a mainland site (Orokonui Ecosanctuary) on the South Island. This is the first translocation of tuatara to a site substantially south of, and thus cooler than, the current range of tuatara, but within the past latitudinal range. We compared growth rates, body condition and survival for the three groups, focusing on the first 5 months following release. All groups showed a small decrease in body condition, although wild-caught juveniles grew faster than head-started individuals. Survival of all groups was high (96.4–100% over the first summer; at least 57.7–66.7% after the first winter). Our results suggest that juvenile tuatara, irrespective of group, perform similarly following release, and that either wild-caught or head-started juveniles could be used as founders for future translocations. Further monitoring is needed to compare the relative contributions of wild-caught versus head-started founders to the establishment of a self-sustaining population, which might take longer in the cooler southern climate of the ecosanctuary.

### 3.14 Amphibian intruders: anthropogenic disease pathways and the risk of chytridiomycosis

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Chytridiomycosis caused by the fungus *Batrachochytrium dendrobatidis* (Bd), was first identified in New Zealand in the late 1990s. Globally, chytridiomycosis has had a devastating effect on numerous genera within the class amphibia. In New Zealand, the rapid decline of the Archey's frog *Leiopelma archeyi* has been linked to chytridiomycosis. It has been suggested that the pet trade was the source of Bd's introduction into the wild in New Zealand. However, an introduction of unwanted organisms through illegal or accidental importation provides another possible disease pathway. From 2001 until his death in 2014, Tony Whitaker held the MPI collection of 244 illegally or accidentally imported amphibians. Each specimen in the collection has been identified to the family level, with most identified to the species level. The origin of each animal and their method of entry into New Zealand is also recorded, as is the date and whether the individual was alive or dead when found. The collection contains several species that are known

carriers of the Bd fungus. These specimens, along with the recorded data, provide a valuable opportunity to assess disease risk in relation to the anthropogenic movement of Bd across New Zealand's borders. The current project looks at the presence of Bd in the MPI collection with the aim of determining the frequency and, ultimately, the risk of Bd being introduced via anthropogenic movement of unwanted exotic amphibians.

### 3.15 Legal protection of New Zealand's reptiles and amphibians

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All species of reptiles and amphibians that naturally occur in New Zealand are fully protected under the Wildlife Act (1953). However, this has only been the case since 1996. Full protection for all indigenous species of herpetofauna took more than a century to achieve, starting with a partially successful attempt to protect tuatara (*Sphenodon punctatus*) in 1895, and has involved twelve separate pieces of legislation. The reasons for protection being sought for various reptile and amphibian species can be found in archived correspondence and reports from the Colonial Secretary's Office, Internal Affairs (including the Wildlife Service), Marine Department, Ministry of Fisheries (now Ministry of Primary Industries), and the Department of Conservation. Key agencies and individuals involved in seeking protection for New Zealand's herpetofauna included the Australasian Society for the Advancement of Science, the Philosophical Institute of Canterbury, Harold Hamilton (Dominion Museum), Katie Pickmere, Gilbert Archey (Auckland Institute and Museum), Joan Robb (Auckland University) and Tony Whitaker. Whitaker's involvement began in 1969 when he was on the staff of the Animal Ecology Division of the Department of Scientific & Industrial Research, and continued through to 1996, when he was editor of SRARNZ Notes. This presentation will summarise the most significant events in the history of legal protection of New Zealand's herpetofauna, and pitfalls encountered or created over the past 120 years.

### 3.16 Future prospects for reproductive technologies in New Zealand reptiles and amphibians

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Reproductive technologies are valuable tools for understanding species-specific reproductive mechanisms. Modern techniques have been used for managing wildlife ex situ and even contributed to in situ conservation. In New Zealand, a small suite of reproductive technologies have been developed in reptiles and amphibians to date. Urinary metabolite measures to non-invasively assign gender of individuals or understand seasonal reproductive hormone profiles have been used in monomorphic leiopelmatid frogs, and faecal extracts from *Oligosoma ottagense* and *Oligosoma grande* are now available for similar analyses. Given corticosterone metabolites can also be measured this way, there is the opportunity to extend this technology to monitoring stress. A method for routine sperm collection and assessment has been developed for *Oligosoma maccanni* as a model species for threatened skinks. This method could be used to confirm the identity of males and detect problems with sperm quality in other species. These procedures underpin development of assisted breeding techniques such as liquid- and frozen-storage of sperm and artificial insemination/fertilisation. In the longer term, genetic resource banks of germplasm could be established as a valuable bet-hedging strategy to safeguard species-level

genetic variation. These techniques will increase our knowledge of native reptile and amphibian reproduction and offer much promise as tools to enhance the production of offspring of desired genetic make-up for in situ recovery and secure genetic repositories for future restoration needs. Given funding will always be a challenge, though, a critical evaluation of reproductive technologies that could most usefully help understand threats, management actions or implement safeguards is strongly recommended to guide future research directions.

### 3.17 Environmental control of delivery date and resulting juvenile fitness in a cool-climate viviparous gecko

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Examining the effects of temperature on thermally sensitive species is essential to understanding their physiology and ecology. Here we compare the effects of basking opportunity and night temperature on birth date in a viviparous lizard (*Woodworthia* “Otago/Southland”) with flexible reproductive frequency. We also test the effects of birth date on offspring fitness. We hypothesised that females exposed to high basking opportunity and night temperature would deliver their offspring before winter, whereas females exposed to low basking opportunity and night temperature would deliver after winter; and that offspring born after winter would have greater fitness than those born before winter. Females were collected in late pregnancy and housed under one of four regimes allowing either high or low basking opportunity (6.5h/d or 5h/d) and high or low night temperature (14°C or 11°C). Births occurred significantly earlier ( $p = 0.035$ ) in females with high basking opportunity than in those with low basking opportunity, whilst night temperature was not significant. Offspring born before winter were heavier at birth than those born after winter (controlling for maternal weight). Otago/Southland geckos exhibit a remarkable degree of reproductive plasticity depending on thermal conditions, though parturition cues for the species have not previously been studied. As climate warming is predicted over the coming years, reproductive frequency may be affected in biennial populations of this species and, potentially, other endemic viviparous lizards. Although more research is needed to clarify cues for parturition, these results offer insight into ecological consequences of climate warming for *W.* “Otago/Southland”.

### 3.18 An overview of New Zealand skink taxonomy

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For its size and climate, New Zealand has a surprisingly large number of skink species. New species are continuously being described either through discoveries in the wild or because genetic techniques have become much more powerful in the last two decades. These techniques have highlighted the number of cryptic species (species almost identical in morphology but sometimes widely different genetically) in New Zealand. They have also pushed back the time of arrival of skinks in New Zealand to the late Oligocene/early Miocene, which is much earlier than was hypothesized even a few years ago. Skinks have colonised almost every terrestrial habitat available and despite the conservatism of their body form have adapted to these diverse habitats in myriad subtle ways.

### 3.19 How does the reproductive frequency of the Otago/Southland gecko (*Woodworthia* “Otago/Southland”) vary with environmental and operative temperature?

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In some viviparous lizard species, females in warmer environments may reproduce annually, whereas those experiencing colder conditions may reproduce only biennially. This less-frequent reproduction may occur because low temperatures slow embryonic development rate and/or because females delay parturition until a more favourable time of year. Variation in reproductive frequency occurs within the *Woodworthia* gecko genus, and laboratory studies show that in the Otago/Southland gecko (*W.* “Otago/Southland”), gestation length is a plastic trait that changes in response to temperature. However, spatial variation in reproductive frequency within this species has not been investigated in the field. In early spring and again in late summer, we palpated  $\geq 20$  adult female geckos at each of seven sites in eastern Otago (elevation 61–1022 m asl). Operative temperature was measured using copper models placed for 4 weeks in midsummer. We obtained weather data from NIWA’s interpolated Virtual Climate Network, choosing stations  $\leq 4$  km from each site. We investigated how inferred reproductive frequency varied with operative temperature, environmental temperature and solar radiation. We found that variation in reproductive frequency was best explained by operative temperature, with annually reproducing populations occurring at sites with higher mean daily maximum, mean daytime and mean 24 hour operative temperatures. Females that can achieve consistent, sufficiently high body temperatures are able to complete pregnancy within 1 year, whereas those that cannot instead exhibit prolonged gestation lengths. We use threshold temperatures to consider whether climate change may cause biennially reproducing populations to switch to annual reproduction in the near future.

### 3.20 Prevalence of the bacteria *Salmonella* and *Campylobacter* in translocated populations of an endemic New Zealand reptile, the tuatara (*Sphenodon punctatus*)

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Tuatara (*Sphenodon punctatus*) are New Zealand endemic, cold-adapted reptiles and the sole extant representatives of the order Rhynchocephalia. Once widespread throughout New Zealand, the introduction of mammalian predators resulted in their extirpation from the mainland and restriction to isolated, predator-free offshore islands. Translocations to extend the range of tuatara have been essential to their conservation. In October 2012, a series of unprecedented large-scale translocations moved 220 adult tuatara from Stephens Island in the Cook Strait to four North Island sanctuaries. It is unknown how movement outside of their ecological region and the associated changes in climate might affect these animals and their susceptibility to potentially harmful bacteria. *Salmonella* and *Campylobacter* are enteric, commensal bacteria and



*Salmonella* is potentially pathogenic. Results of previous attempts to detect *Salmonella* in tuatara were negative, suggesting that they may be innately resistant or that their low body temperatures may not support bacterial proliferation. Similarly, *Campylobacter* prevalence in tuatara was found to be low. To investigate post-translocation prevalence, cloacal swabs were taken from animals at each site and analysed using selective culturing, serotyping, DNA extraction, and PCR. During the first year of sampling, *Salmonella saintpaul* was identified in a translocated individual, indicating that tuatara can carry these bacteria. Preliminary *Campylobacter* PCR results suggest that prevalence across sampled populations could range between 53% and 100%, indicating that this bacterium could be considered a common commensal in tuatara. Further analyses are currently underway and a final set of samples will be obtained and analysed in Autumn 2015.

### 3.21 Small-scale movements and microhabitat selection of a native New Zealand frog

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New Zealand native frogs are classified as threatened both nationally and internationally. All four extant species have suffered major range reductions and are now restricted to a few islands in the Marlborough Sounds and parts of the North Island mainland. Studying the spatial behaviour of amphibians helps us understand how they interact with the landscape and enables the identification of habitat features that are essential for their persistence. However, little is known about nightly movement patterns in *Leiopelma* species. The aim of this study is to investigate small-scale movements of a terrestrial species, *Leiopelma pakeka*, in its natural environment. For this purpose, non-toxic Dayglo fluorescent powders were applied to 60 randomly selected frogs during their putative breeding and non-breeding seasons in order to track their movements throughout the night. Irrespective of season, males and females moved similar distances during the night and there was no correlation between total distance moved and size (SVL) of frogs. However, total distance moved was significantly higher during the breeding season, independent of the sex of the frog. Neither temperature nor humidity had an effect on distances moved by females or males, but there were differences in the distances moved by individuals. Microhabitat selection differed from random and between seasons. Knowledge of the spatial behaviour of this frog species will improve our understanding of its habitat requirements, enabling more effective captive husbandry and better assessment of the appropriateness of translocation sites, informing and aiding the conservation management of *Leiopelma* species.

### 3.22 Strategising for the eradication of the plague skink, *Lampropholis delicata* from Great Barrier Island (Aotea Island), New Zealand

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The plague skink, *Lampropholis delicata*, is an oviparous lizard species native to Australia that has become an invasive pest species across a range of locations including most of the Hawaiian Archipelago, Lord Howe Island and New Zealand. As understanding of direct impacts of the skink on local lizard communities or ecological processes is limited, serious concerns remain regarding their impacts, particularly given the high levels of abundance they are known to achieve locally. Auckland Council responded to an incursion on Great Barrier Island (Aotea Island) in 2013 that has led to development and testing of interception and detection methods. These actions preceded a joint effort to establish an ‘eradication by research’ programme to remove the skink from Great Barrier Island. This effort also represents the first structured attempt at eradicating a small terrestrial invasive lizard globally. The programme has pioneered the testing of insect sticky traps as a method for eradicating small terrestrial lizards. The process has highlighted a lack of fundamental knowledge about appropriate tools, detection and interception methods necessary for successful eradication. Additionally, the process has emphasised a lack of mechanisms within resource management and biosecurity agencies that can ensure appropriate and timely responses to such incursions.

### 3.23 Climate change and Archey’s frogs—preliminary analyses

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The purpose of this research is to determine the most appropriate translocation areas for Archey’s frog that will best provide long-term protection from climate change. I use the current occurrence and corresponding climate data for Archey’s frog to construct a bioclimate model of the current climate-envelope (in terms of the minimum and maximum range for four climate variables) to predict where the species might have been at the last glacial maxima and might be in the future. Archey’s frog current distribution was strongly correlated to refugia of the last glacial maximum. Modelling based on very small future increases (1°C) in mean annual temperature indicated the Coromandel Peninsula stronghold population did not fall within the preferred climate range for Archey’s frog. Under the worse-case scenario of a future 3.5°C increase in temperature, both current stronghold populations fell outside the current climate envelope. Suitable translocation sites, in a climate-sense are very limited over New Zealand’s North Island and fall well outside apparent refugia for Archey’s frogs. Archey’s frogs are vulnerable to climate change; even modest temperature increases are likely to threaten current strong-hold sites. The correlation between refugia and current distribution indicates a long-association with current sites that must be integrated into the decision-making on appropriate translocation sites. Sites suitable for this species are south of current strongholds and thus outside the historic known range for the species, necessitating a change in DOCs current translocation-best practice in a climate change context.

### 3.24 **A new invasive amphibian: informing survey and eradication techniques for exotic alpine newts (*Ichthyosaura alpestris*) in New Zealand**

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The eradication of exotic vertebrates in New Zealand is most often associated with removal of species that directly affect our native fauna and flora; most notably introduced mammals. However, a range of other established exotic vertebrates such as reptiles and amphibians have received little or no attention despite growing concerns over their potential impacts on indigenous herpetofauna (e.g. the spread of *Batrachochytrium dendrobatidis* (chytrid fungus), predation pressure, and competitive exclusion). Here we document the establishment of New Zealand's most recent exotic amphibian, the alpine newt (*Ichthyosaura alpestris*), and outline a Ministry for Primary Industries (MPI) biosecurity response aimed at species eradication. In July 2013, three alpine newts were detected on private property in the southern Coromandel. A rapid assessment, followed by delimiting surveys, confirmed the presence of a large established population and preliminary risk assessments considered the newts to be a significant threat to nearby populations of indigenous frogs—as vectors of the pathogenic chytrid fungus. Anecdotal and biological evidence suggest the incursion is potentially more than a decade old. As a result, MPI declared the species an 'Unwanted Organism' and initiated a 3-5-year eradication response. To date, the eradication has been challenged by the detectability of individual newts, the reproductive and behavioural biology of the newts, complex habitat features, a requirement for novel and innovative search and trapping techniques, investigation and compliance issues, land access, public interest, project confidentiality and resource limitations. However, a large collaborative effort between MPI, the Department of Conservation, specialist consultants and contractors, district councils and university research associates has allowed the eradication to progress significantly over the response's first year in practice, with more than 2044 newts removed from the environment to date.

### 3.25 **Habitat preferences of *Oligosoma* “Whirinaki” within Bream Head Scenic Reserve, Whangarei, Northland, New Zealand**

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Predator control is increasingly being undertaken to maintain and restore lizard populations around New Zealand. The Bream Head Scenic Reserve in Whangarei, Northland, is one such site and after three years of intensive predator control a distinctive and as yet undescribed lizard taxon with morphological similarities to the Whirinaki skink (*Oligosoma* “Whirinaki”)

was detected. In January, 2014 we investigated the habitat preferences and area of occupancy of *O. "Whirinaki"* in Bream Head Scenic Reserve through a funnel trapping study. Sixty-four traps were installed in an approximate 10 m grid and habitat data were collected at all trap sites prior to commencement of trapping. Twenty-three individual skinks were caught, including males, gravid females and juveniles; 17 incidental sightings were also recorded, including two observed climbing trees. Skinks preferred 'low scrub' rather than 'low broadleaf' and 'tall broadleaf' forest. Their specific microhabitat preferences were not determined but inference suggests that incidental radiation (sunlight) intensity could be important for predicting their presence. Their area of occupancy (100% minimum convex polygon) was estimated to be 1.8 ha, although this may be an overestimate due to a large area within the polygon being apparently unoccupied. Anecdotally, the trajectory of the population appears to be increasing because of pest control. At present, *O. "Whirinaki"* is classified Data Deficient under the New Zealand Threat Classification System, but it could fit within Nationally Vulnerable (A(3)) or Nationally Critical, depending on the interpretation of the area of occupancy polygon. This has significant implications for the future conservation management of the species.