Lizard monitoring at the Baring Head block, East Harbour Regional Park, Wellington: December 2013 season

Report prepared for Greater Wellington Regional Council
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Cover photograph: Most of the December 2013 Baring Head lizard monitoring team. Photo credit: Murray Keightley.

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Executive summary

Baring Head is a 284 hectare block of mixed-use land (grazed, scrub and coast) on the Wainuiomata coast that was recently acquired by Greater Wellington Regional Council (GWRC) for the purpose of inclusion into the wider East Harbour Regional Park.

The site is of regional significance for native lizards, with four species being present (Hitchmough *et al.* 2013 threat classifications are listed in brackets): the Raukawa gecko *Woodworthia maculata* (Not Threatened), the northern grass skink *Oligosoma polychroma* Clade 1a (Not Threatened), the copper skink *Oligosoma aeneum* (Not Threatened) and the spotted skink *Oligosoma lineoocellatum* clade 1a (At Risk – Relict).

In 2011, GWRC had expressed an interest in removing stock from the grazed parts of Baring Head, but was concerned about the effect that this could have on the lizard community due to subsequent changes in habitat structure and/or mammal abundance. Due to these concerns, GWRC implemented an occupancy-based quantification of the potential impacts of a change in land management regime (including pest animal control) on the lizard community. Due to numerous captures of ground weta (presumably *Hemiandrus bilobatus*) noted in the 2012 year, we began formal monitoring of this invertebrate in 2013. The sampling design aims to examine both the (1) trend in distribution of lizard species across the five landscape management units present at the Baring Head block and (2) the trend in abundance of lizard species at Baring Head.

Here, we report on the results from the December 2013 monitoring season, compare them with the December 2012 – January 2013 monitoring results, and provide recommendations for the next (December 2014) season of the Baring Head lizard and ground weta monitoring programme.

This year, we captured 112 individual northern grass skinks, 77 Raukawa geckos and 4 copper skinks. No spotted skinks were captured this year. Thirty-three captures of ground weta were made, but individuals were not distinguished. Abundance estimates for northern grass skinks were very similar between the 2012 and 2013 seasons. The estimates from last year for Raukawa geckos were lacking in precision too much to draw any sound conclusion from, although estimated total abundance was fairly similar. In both the 2012 and 2013 years, pitfalls within the River Escarpment land management unit had the highest estimated average abundance, followed by those in the Coastal Escarpment, Coastal, River Flats, with Marine Terrace traps having the lowest estimated occupancy.

We obtained sufficient captures of northern grass skinks, Raukawa geckos and ground weta to estimate occupancy and abundance with reasonable precision across all traps using Royle (2004) N-mixture models in the 2013 year, and for northern grass skinks in the 2012 year. We have distribution and demographic information for Raukawa geckos and northern grass skinks from both the 2012 and 2013 years.

Because the pitfalls were randomly placed far enough apart to be independent, we could probably calculate unbiased estimates for species density and thus total abundance per habitat strata using the estimated superpopulation abundance, estimated home ranges of the species in question and the total area of each habitat strata. Also, because the pitfalls are the same each year, the superpopulation estimates should be directly comparable between years as an indicator of general trends in species abundance and distribution. Therefore, we feel confident that by repeating the current methods for one more season (December 2014) we will be able to obtain data sufficient to form baseline occupancy and abundance data across the entire Baring Head block for northern grass skinks, Raukawa geckos and ground weta.

However, captures of spotted skinks and copper skinks remain sparse. It is recommended that survey effort be intensified for these species, particularly for the spotted skink. One option is placing 30 extra pitfalls (with ≥ 25 m spacing) on the River Escarpment surrounding location of the spotted skink capture made by R. Romijn in 2010. We also recommend that *in lieu* of sufficient captures to estimate abundance and occupancy that we change our baseline criteria for the rare species to focus on other population characteristics until enough animals are captured by the sampling scheme to allow us to estimate occupancy and abundance. These new criteria are: sex ratios, assessment of gravidity in females, location of captures and age structure of the population as a rough indicator of recruitment rates.

Introduction

Baring Head is a 284 hectare block of mixed-use land (grazed, scrub and coast) on the Wainuiomata coast that was recently acquired by the Greater Wellington Regional Council (GWRC) for the purpose of inclusion into the wider East Harbour Regional Park. The site is of regional significance for native lizards (Romijn *et al.* 2012), with four species being present (Hitchmough *et al.* 2013 threat classifications are listed in brackets): the Raukawa gecko[1] *Woodworthia maculata* (Not Threatened), the northern grass skink[2] *Oligosoma polychroma* Clade 1a (Not Threatened), the copper skink *Oligosoma aeneum* (Not Threatened) and the spotted skink *Oligosoma lineoocellatum* clade 1a (At Risk – Relict, qualifiers: conservation dependent, sparse, partial decline[3]).

GWRC has expressed an interest in removing stock from the grazed parts of Baring Head, but is concerned about the effect that this may have on the lizard community due to subsequent changes in habitat structure and/or mammal abundance (Newman 1994, Hoare *et al.* 2007, Knox *et al.* 2012, Norbury *et al.* 2013). Due to these concerns, GWRC implemented an occupancy-based quantification of the potential impacts of a change in land management regime (including pest animal control) on the lizard community. The sampling design aims to examine both the (1) trend in distribution of lizard species across the five landscape management units present at the Baring Head block and (2) the trend in abundance of lizard species at Baring Head. The unit of monitoring is considered to be the relative abundance and distribution of the four lizard species present, in terms of superpopulations of each species. The "superpopulation" is defined as the total number of lizards of each species whose home range overlaps a pitfall trap, making them available for capture (Bell & Herbert 2012, Oppel *et al.* 2013). Upon noting the reasonably frequent presence of ground weta caught in the pitfall traps, these questions have been expanded to this taxon from December 2013 onwards. Because a stratified random sampling scheme was used, observed trends in the superpopulation can be used to infer temporal and spatial trends in the total lizard and weta populations at Baring Head. Collection of baseline data on lizard relative abundance and species distributions has now been completed for two years (first year: December 2012–January 2013, second year: December 2013). Pest control on the block commenced in January 2014, and a third lizard monitoring season is scheduled for December 2014. The data of these three monitoring years (2012, 2013 and 2014) can be compared with future monitoring seasons to ensure lizards are not adversely affected by the change in management regime.

Here, we report on the results from the December 2013 season, compare them with the December 2012 – January 2013 monitoring results and provide recommendations for the next (December 2014) season of the Baring Head lizard monitoring programme. Supporting documents and data were provided to the GWRC as supplementary information (available from GWRC upon request).

Methods

In early 2012, we conducted a simulation-based power analysis on common skink and common gecko pitfall trap occupancy data collected over 9 trap-days at Baring Head by Romijn (2011). This study (Herbert & Bell 2012) recommended that seven repeat checks of 200 pitfall traps would give sufficiently precise

[1] In 2014 the NZ Department of Conservation changed the common name of the common gecko (*Woodworthia maculata,* Grey 1845) to the 'Raukawa gecko' after consultation with New Zealand herpetologists.
[2] In 2014 the NZ Department of Conservation changed the common name of the common skink *sensu stricto* (*Oligosoma polychroma* Clade 1, Patterson & Daugherty 1990) to the 'northern grass skink'.
[3] Note that the separation of the spotted skink into separate species is currently contentious. Genetic structure suggesting two clades and five sub-clades was found by Greaves et al. (2007) however only four putative species are recognized in the DOC 2012 reptile threat classification (Hitchmough et al. 2013). Further taxonomic work on this species is currently underway (S. Melzer & G. Patterson, unpub. data).

occupancy data to allow use of occupancy to track abundance and distribution of northern grass skinks and Raukawa geckos over time.

The Baring Head block was divided into five broad management strata: (1) Coastal Platform, (2) Coastal Escarpment, (3) River Escarpment, (4) Marine Terrace, and (5) River Flats. The spatial classification of these management strata followed a pre-existing GIS layer for the block held by GWRC (REGION Y2010 rural layer colour orthophotos). Within these landform strata, we generated 45 random points (40 points for use, plus 5 extra 'back-up' points) to site pitfalls with the caveat that points must be 25 m apart to ensure traps would be spatially independent (traps were considered independent if a lizard could not be caught in two adjacent traps, an assumption based on what is known about the home ranges of the species involved, see Herbert & Bell (2012)). Points falling on the areas with the most difficult terrain (the river escarpment, and the South Coast escarpment) were ground-truthed in September 2012 to determine which points were feasible for use. Points were placed as accurately as possible by use of a hand-held GPS unit (Garmin GPSmap 60CSx). Where the terrain was too difficult or unsafe to place the pitfall at the exact GPS location, the pitfall was positioned at the closest feasible site within 12.5 m of the original location.

Two hundred and six (206) pitfall traps were dug during October and November 2012 and marked with flagging tape in shrubland or with yellow plastic triangles nailed to a wooden peg in pasture. Of these, 202 traps were randomly placed, and a further 4 traps were put in areas thought to provide habitat for copper skinks in order to boost their detection. Each pitfall trap consisted of a 4 litre plastic bucket with sealable lid (Payless Plastics, New Zealand) that had six 4 mm drainage holes drilled in the bottom. A stick was placed in each bucket to enable animals to climb out if the lid was displaced outside the monitoring season. An approximately 30 x 30 cm treated 7 mm plywood or concrete paver cover was placed on top of each closed pitfall. Plywood covers were pinned to the ground and/or weighted down with rocks to prevent them from being blown away. Concrete paver covers were used in pasture areas (Marine Terrace, River Flats and some of the Coastal Escarpment pitfalls) to prevent the pitfalls being trampled by stock. Damaged or missing pitfalls and covers were replaced throughout the study on an as-needed basis.

Over the last two monitoring seasons[4], volunteers, council staff and herpetologists participated in the lizard pitfall monitoring. Volunteers were provided with field protocols and copies of the GWRC (2011) 'Geckos of the Wellington Region' and 'Skinks of the Wellington Region' guides to assist with lizard species identification; they were also asked to take photographs of any lizards encountered. Volunteers accompanied people experienced in lizard field studies until they were confident and sufficiently skilled to work alone.

The summer 2012/2013 monitoring period was run in two blocks; the first four checks were carried out between the 14th and 21st of December 2012 and the last three checks between the 10th and 12th of January (hereafter, the 2012 season). The summer 2013/2014 monitoring period was completed in a single block of eight days spanning between the 6th and 13th of December 2013 (the 2013 season). To satisfy ethical standards, pitfall traps were checked once a day while they were open. On opening each trap, we wiped the sides of the bucket to ensure a clean surface and reduce the chance of lizards being able to climb out. The bottom of each bucket was filled with 1-2 cm layer of vegetation and soil to provide habitat and shelter for lizards caught. Pitfall traps were baited with a piece of tinned pear. We also placed a wet ~5×5 cm piece of sponge in the trap to prevent the inside the pitfall from becoming too dry for lizards. The pear pieces and wet sponges were refreshed whenever the previous one had dried out.

Pitfall traps were checked in order according to set routes so that each trap would be checked at roughly the same time each day to ensure a consistent loading time across traps. We took the following measures from each lizard caught: species, snout-vent length (SVL), total tail length, length of the regenerated portion of tail where present and sex (adult geckos only). We photographed any lizards where species identification was uncertain. During January 2013 and December 2013, individual lizards were identified by writing a

[4] Eleven field staff & volunteers were involved in the December 2013 season and 16 in during the earlier December 2012 and January 2013 seasons.

temporary mark on the dorsal surface using a xylene-free permanent marker pen. From January 2013 onwards, the presence and number of ground weta – most likely[5] *Hemiandrus bilobatus* Ander 1938, (Johns 2001) – caught in the pitfalls was noted.

In order to identify the total number individual northern grass skinks and Raukawa geckos caught during the 2012 season, we used a combination of trap number (with the assumption that skinks did not move between traps), capture date, SVL, tail length, length of regenerated portion of tail and temporary mark (we were only able to consistently temporary mark during the January 2014 checks) to distinguish individuals. Because SVL data only was collected from lizards in the December checks, we allowed a SVL measurement error of ± 3 mm. We are confident that the total number of individual geckos caught in traps is correct, since no trap detected a gecko on more than one occasion, all geckos encountered were measured, and the traps were spaced far enough to minimize the likelihood of geckos moving between traps. The total number of individual northern grass skinks caught is less certain and represents the minimum number of individuals captured. This is because some skinks escaped before enough identifying measurements could be taken (4% of captures), some of the pitfall traps had multiple capture occasions over the one-month capture season and we identified some individual skinks from the same trap with SVLs within ±3 mm of each other. Therefore our estimate for the total number of individual northern grass skinks caught during the 2012 season is likely to be conservative. For the 2013 season, we temporarily marked the dorsal surface of each lizard captured and cross-checked against lizard measurements to distinguish individuals. None of the marks were observed to be partially rubbed off any of the skinks during the study; therefore it is safe to presume that the marks were stable.

This year we used Royle (2004) N-mixture models (see Donovan & Hines 2007 for a "plain English" guide to implementing these models) on the lizard count data in program PRESENCE version 5.8 (Hines 2006) to estimate both site occupancy and abundance of northern grass skinks, Raukawa geckos and ground weta. This model differs from the standard occupancy modelling used last year (MacKenzie et al. 2002) as data on the number of animals caught each day is incorporated, rather than using a detection history of presence / absence. We did not use weather covariates in modelling this year's data because last year we found that a fully time-dependent model explained variation in the data set better than any combination of the weather covariates used (minimum daily temperature, maximum daily temperature and rainfall in the previous 24 hours; Herbert *et al.* 2013b). We also re-analysed the data for the northern grass skink and Raukawa gecko data from the previous 2012 season, using the Royle (2004) models. Six northern grass skinks of neonate size (young of the year; SVL ≤ 30 mm) were captured in January 2013, indicating that the population was not closed to births during the summer 2012/2013 monitoring period; therefore these captures were excluded from the data set. Pitfall site variables (aspect, slope, physiography and vegetation) are currently being collected for input into future analysis of the data.

Results

Summary of trap effort for December 2013

The total survey effort for the December 2013 monitoring season was 1,432 trap-days with 205 traps run this year. Traps CE28 and CE20 were missing, but CE28 was put in this year. A few pitfalls on the river flats were damaged and thus reinstalled – buckets RF32 and RF43 were dented, RF05 and RF06 were flooded and the pitfall was missing altogether at RF34. Many of the pitfalls were difficult to find on the first day due to them being overgrown or due to the flagged route being damaged, these were opened on the 2nd day (8/12/2013) and were checked six times – CE12, RE26, RE41, RE29.

[5] The identification of the ground weta to species level needs to be checked, using live specimens during the next survey (December 2014).

Summary of lizard and ground weta captures for December 2013

The number of captures of northern grass skinks was slightly lower, and the naive occupancy of pitfall traps was markedly lower in the summer 2013 season compared to the previous season (Table 1). Both captures and naive occupancy of copper skinks increased this year (Table 1). There was a marked increase in Raukawa gecko captures; however naive occupancy was quite similar (Table 1). The presence of gravid females was noted for both of these species.

The four copper skinks were all adults (54 - 61 mm SVL) and were all caught in River Escarpment traps between 7 and 10 December 2013 (Fig. 4). None were noted to be gravid. Three of these traps had also caught northern grass skinks, and two had caught both northern grass skinks and Raukawa geckos.

Thirty-three captures of weta were made during the December 2013 capture period in 7.8% of the traps (Table 1).

The locations of captures of each species are provided in the supplementary information (available from GWRC upon request). ARDS cards have been submitted to the Department of Conservation by EcoGecko Consultants Limited for the lizards found during the 2012 and 2013 surveys.

Table 1. Summary of captures in the summer 2013 and 2012 seasons

Measure	**Species**	**Season**	
		Dec 2012 – Jan 2013	**Dec 2013**
Number of captures (capture rate in captures per trap-day)	Copper skink	1 (0.001)	4 (0.003)
	Northern grass skink	166 (0.118)	133 (0.093)
	Raukawa gecko	16 (0.011)	94 (0.066)
	Ground weta	NA	33 (0.023)
Naive occupancy as % of pitfall traps that caught ≥ individual (# occupied traps)	Copper skink	0.5% (1)	2.0% (4)
	Northern grass skink	27.1% (55)	14.1% (29)
	Raukawa gecko	5.4% (11)	7.3% (15)
	Ground weta	NA*	7.8% (16)
Number of individuals captured (number of recaptures)	Copper skink	1 (0)	4 (0)
	Northern grass skink	116 (50)**	112 (21)
	Raukawa gecko	16 (0)	77 (22)
	Ground weta	NA	NA
Trap-days		1,410	1,432

* Data was only collected in Jan 2013 so not comparable with December 2013 data
** Likely to be an underestimate.

We originally assumed that the proportion of traps occupied by a lizard or ground weta on a given day would increase across the trapping period, and this did appear to be generally true for Raukawa geckos and weta. However, the proportion of traps capturing a northern grass skink peaked at day 4 (Fig. 1a). The detection probability of each individual lizard or weta, *r*, as estimated by the Royle (2004) N-mixture models (see further on in the results) followed a similar trend, but individual detectability was highest in Raukawa geckos (Fig. 1b).

The size distribution of northern grass skinks captured in traps was similar to the December 2012/January 2013 season, but with the noticeable absence of juvenile skinks (SVL < 30 mm, Fig. 2). Most (85.4%) Raukawa geckos[6] and northern grass skinks[7] (94.7%) captured were of adult size (Figs. 2 & 3). One neonate (young-of-the-year) sized Raukawa gecko (SVL = 29 mm) was captured, indicating that birthing in this species may have just begun around the time of the surveys.

(a)

(b)

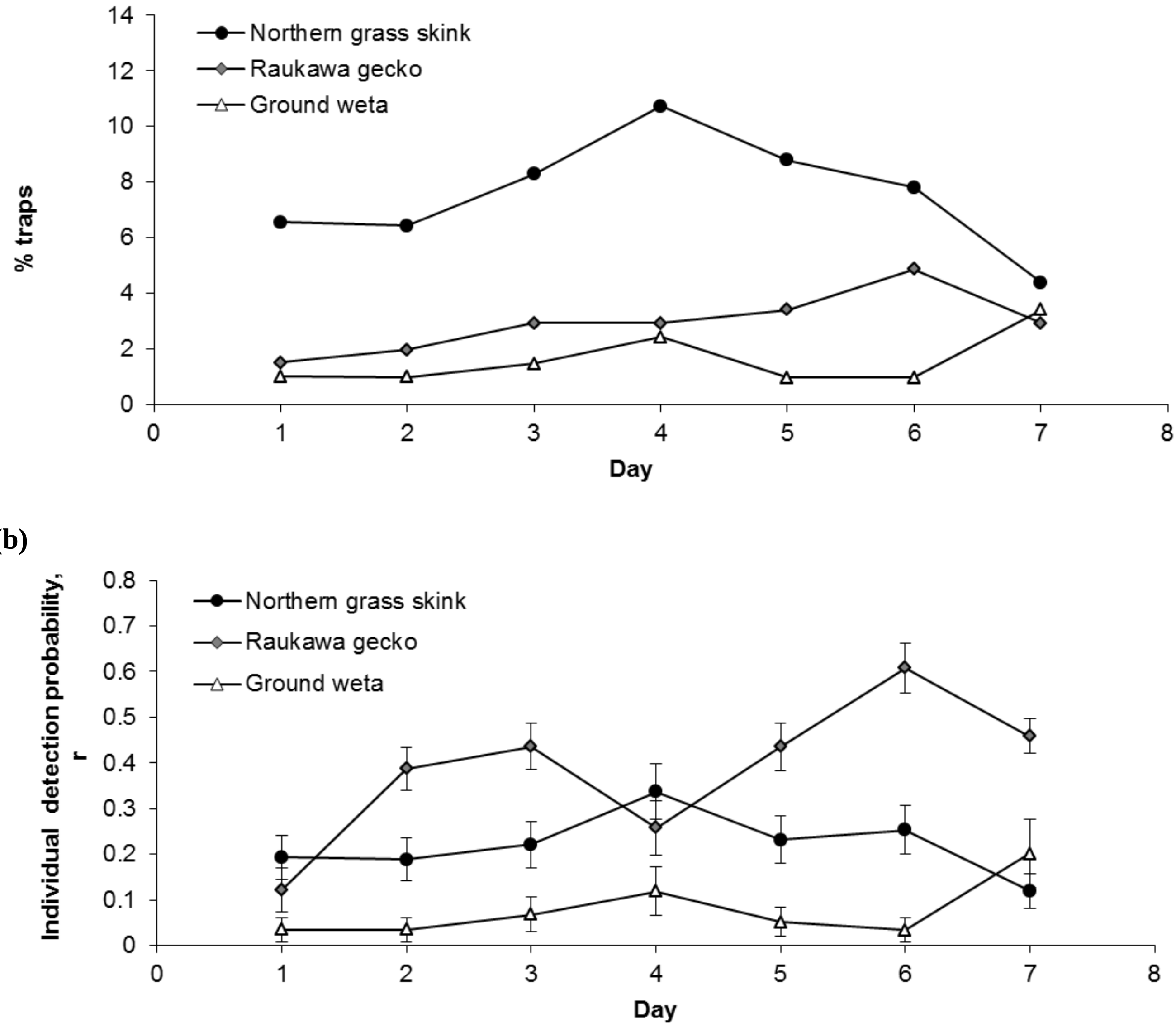

Figure 1. (a) Observed species detection rates (% of traps with ≥ 1 individual caught) and **(b)** estimated individual detection probability, *r*, in pitfall traps by survey day during the December 2013 monitoring season with error bars being ± 1 standard error.

[6] Here we used SVL ≥ 52.5 mm assuming an even sex ratio of geckos sized between 50 mm (minimum size of adult females) and 55 mm (minimum size of adult males) after Whitaker (1982).
[7] SVL ≥ 41 mm after Spencer et al. (1988).

(a)

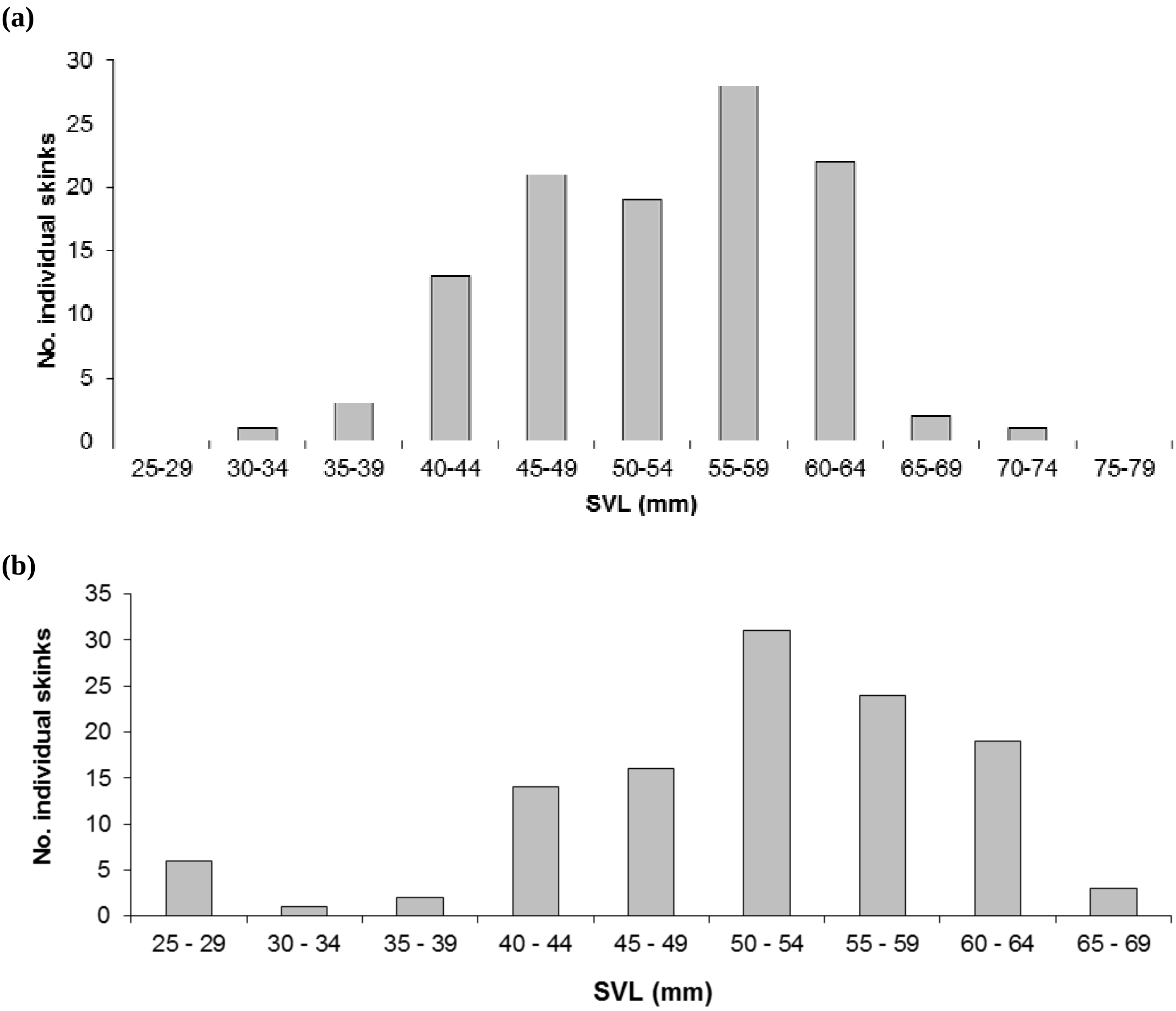

Figure 2. (a) Snout-vent lengths (SVL) of individual northern grass skinks captured in pitfall traps at Baring Head December 2013 season. N skinks = 110 (2 escaped before measure). **(b)** SVLs of apparent individual (arbitrary identification of individuals by tag, morphology and capture history) northern grass skinks captured in pitfall traps at Baring Head summer 2012/2013 season. N skinks = 116.

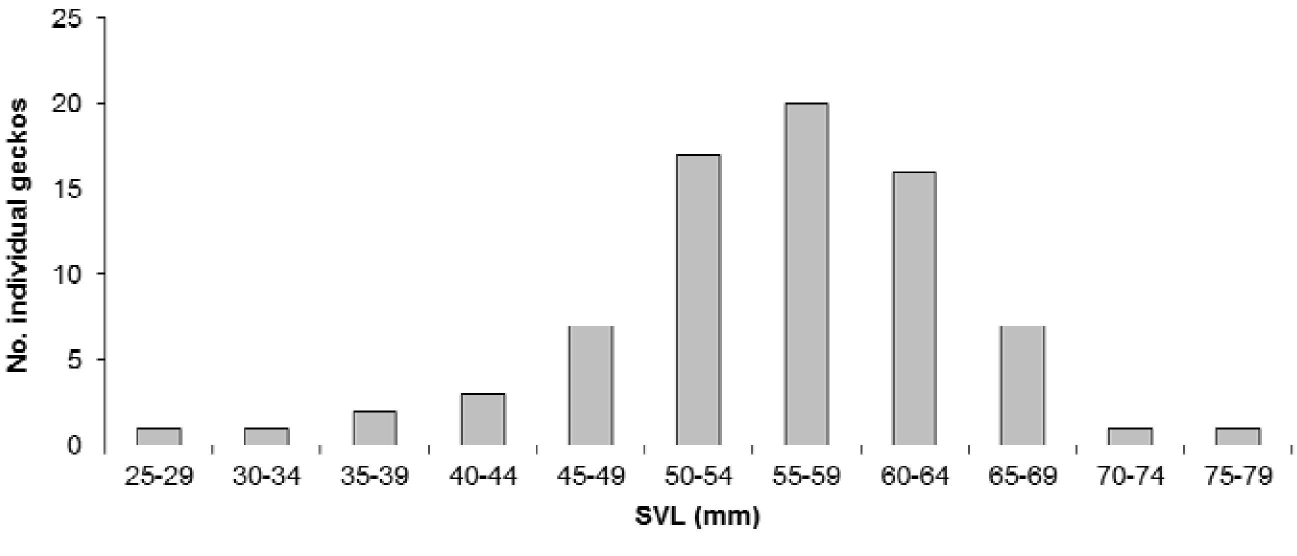

Figure 3. Snout-vent lengths (SVL) of individual Raukawa geckos captured in pitfall traps at Baring Head December 2013 season. N geckos = 76 (1 escaped before measure).

Lizard and ground weta pitfall occupancy

For northern grass skinks, Raukawa geckos and ground weta, the best model was one which incorporated habitat strata into estimation of both the average abundance (λ) and detection probability of individuals (*r*) and had a fully time-dependent *r* (Table 2). Abundance estimates for northern grass skinks were very similar between the 2012 and 2013 seasons (Table 3). The estimates from last year for Raukawa geckos were lacking in precision too much to draw any sound conclusion from (i.e. the coefficient of variation[8] was close to 50%; Table 3). As for occupancy last year, pitfalls within the River Escarpment strata had the highest estimated average abundance, followed by those in the Coastal Escarpment, Coastal, River Flats, with Marine Terrace traps having the lowest estimated occupancy (Fig. 4).

Table 2. List of models tried for estimation of occupancy, mean abundance (λ) and individual detection probability (*r*) of northern grass skinks, Raukawa geckos and ground weta in pitfall traps at Baring Head for the December 2012 and December 2013 seasons (note, no weta data for 2012). “time” = fully time-dependent model, “hab” = habitat strata.

December 2012 / January 2013					
Model	**AIC**	**ΔAIC**	**AIC weight**	**Model likelihood**	**N. parameters**
Northern grass skinks *Oligosoma polychroma* Clade 1a					
λ (hab), r(hab+time)	839.95		1.000	1.0000	13
λ (.), r(time)	883.46	43.51	0.000	0.0000	12
λ (hab), r(hab)	892.52	52.57	0.000	0.0000	2
λ (.), r(.)	942.19	102.24	0.000	0.0000	2
Raukawa geckos *Woodworthia maculata*					
λ (hab), r(hab+time)	168.32		0.7385	1.0000	13
λ (hab), r(hab)	170.41	2.09	0.2597	0.3517	2
λ (.), r(.)	180.47	12.15	0.0017	0.0023	2
λ (.), r(time)	186.38	18.06	0.0001	0.0001	12
December 2013					
Model	**AIC**	**ΔAIC**	**AIC weight**	**Model likelihood**	**N. parameters**
Northern grass skinks *Oligosoma polychroma* Clade 1a					
λ (hab), r(hab+time)	796.32		0.999	1.0000	9
λ (hab), r(hab)	810.20	13.88	0.001	0.0010	2
λ (.), r(time)	822.78	26.46	0.000	0.0000	8
λ (.), r(.)	825.13	28.81	0.000	0.0000	2
Raukawa geckos *Woodworthia maculata*					
λ (hab), r(hab+time)	504.98		0.9994	1.0000	9
λ (hab), r(hab)	519.71	14.73	0.0006	0.0006	2
λ (.), r(time)	573.13	68.15	0.0000	0.0000	8
λ (.), r(.)	585.69	80.71	0.0000	0.0000	2
Ground weta *Hemiandrus* sp.					
λ (hab), r(hab+time)	292.95		0.9979	1.0000	9
λ (.), r(time)	305.51	12.56	0.0019	0.0019	8
λ (.), r(.)	310.18	17.23	0.0002	0.0002	2
λ (hab), r(hab)	316.34	23.39	0.0000	0.0000	2

[8] The coefficient of variation is a measure of the precision of the estimate, it is simply the standard error of the estimate divided by the estimate itself (and multiplied by 100 to express as a percentage). We consider a CV of < 30% to represent an acceptable level of precision.

Table 3. Model estimates, 95% confidence intervals and estimate precision of derived parameters; occupancy and super-population abundance across all pitfall traps for Raukawa geckos, northern grass skinks and ground weta. CV: the coefficient of variation = standard error (estimate) / estimate; we consider a CV < 30% to represent an acceptable level of precision.

Species	Parameter	Estimate	95% confidence interval	CV (%)
December 2012 / January 2013				
Raukawa gecko	Occupancy	0.5577	0.1664 - 0.9742	49.52483
	Abundance	167.24	37.31 - 749.61	76.53671
Northern grass skink	Occupancy	0.5621	0.5103 - 0.61543	4.785625
	Abundance	169.30	146.34 - 195.86	7.436503
December 2013				
Raukawa gecko	Occupancy	0.5019	0.4359 - 0.5719	6.933652
	Abundance	142.89	117.39 - 173.94	10.02869
Northern grass skink	Occupancy	0.5625	0.5111 - 0.6151	4.728889
	Abundance	169.45	146.71 - 195.71	7.353202
Ground weta	Occupancy	0.4813	0.3452 - 0.6385	15.83212
	Abundance	134.56	86.80 - 208.60	22.3692

(a)

(b)

(c)

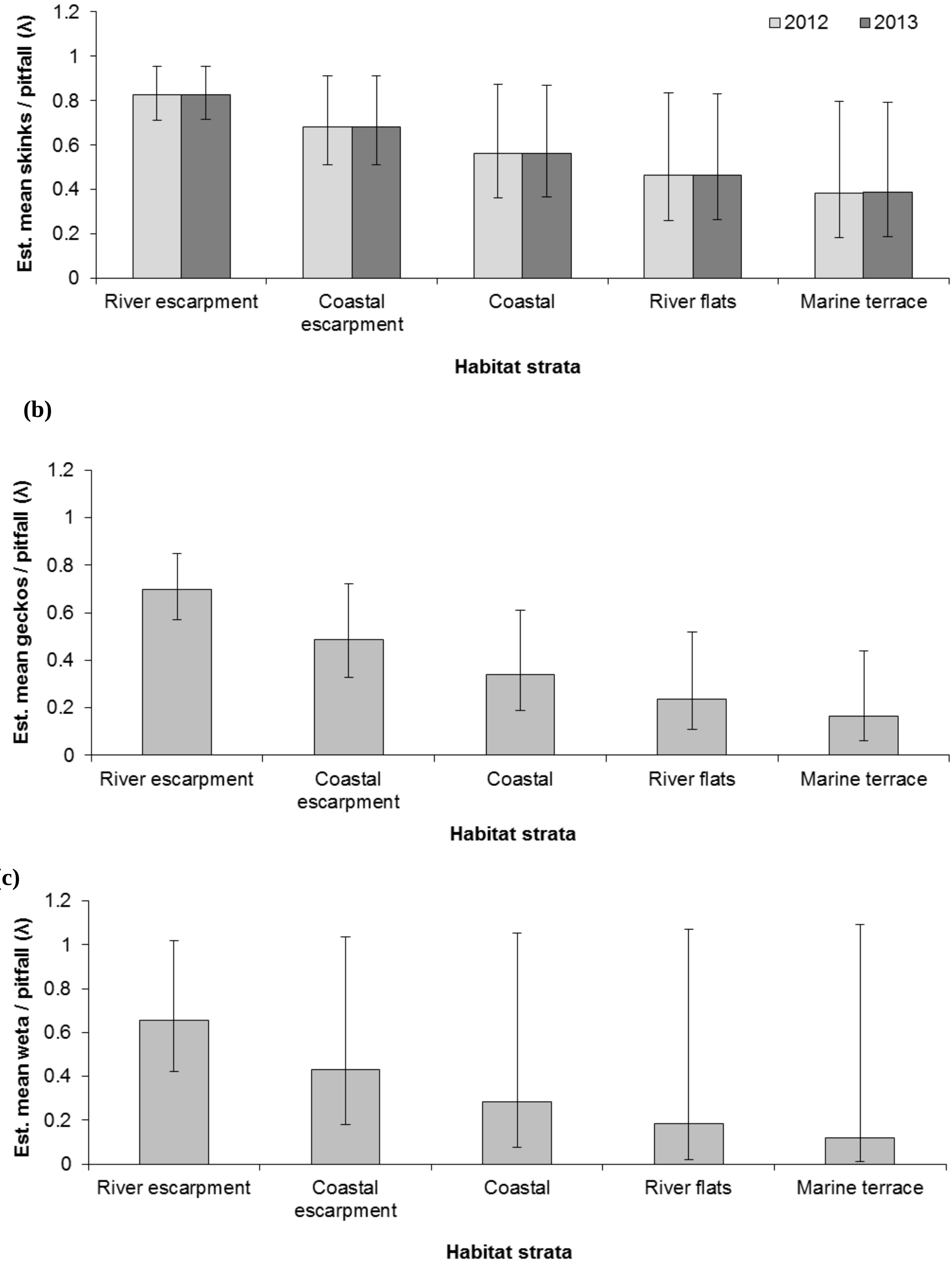

Figure 4. Average estimated abundance per pitfall, λ, of **(a)** northern grass skinks *Oligosoma polychroma* Clade 1a for each landform stratum for the 2012 and 2013 seasons and **(b)** Raukawa geckos *Woodworthia maculata* and **(c)** ground weta *Hemiandrus* sp. for each habitat stratum for the 2013 seasons. Error bars represent the 95% confidence intervals. The label above each bar is the estimated λ value. The 2012 season values are not displayed for Raukawa geckos, as their precision was extremely low.

Discussion

Patterns in lizard occupancy & abundance

This year we obtained sufficient captures of northern grass skinks, Raukawa geckos and ground weta to estimate occupancy and abundance with reasonable precision across all traps using a Royle (2004) N-mixture model. It is of note that the numbers for abundance represent estimates of the number of individuals within the superpopulation only, that is the number of skinks, geckos or weta whose home range overlaps a pitfall, thus has a chance of being captured by one (see Herbert & Bell 2012 for further discussion of this).

Because the pitfalls were randomly placed far enough apart to be independent, we could probably calculate unbiased estimates for species density and thus total abundance per habitat strata using the estimated superpopulation abundance, estimated home ranges of the species in question (Whitaker 1982, Bannock 1998, Porter 1982) and the total area of each habitat strata. Also, because the pitfalls are the same each year, the superpopulation estimates should be directly comparable between years as an indicator of general trends in species abundance and distribution.

The checks were completed within 8 days this year; therefore it is probably safe to assume population closure, particularly due to the absence of neonate-sized northern grass skinks and near-absence of neonate Raukawa geckos. While the number of pitfalls capturing Raukawa geckos is still quite low, it appears that each individual has a high probability of detection by the pitfalls, indeed higher than northern grass skinks, which appear to be more abundant. This is consistent with our modelling of the pitfall data collected by R. Romijn (2011), where we also found that Raukawa geckos generally had a higher detection probability than northern grass skinks at Baring Head (Herbert & Bell 2012). Unfortunately the number of captures of Raukawa geckos in the 2012 season was not high enough to obtain precise measures of abundance or occupancy; therefore the results presented for this species in December 2012 should not be depended upon, although they are likely unbiased. Collection of ground weta for the December 2012 season data began in January 2013 (3 pitfall checks) so this data could not be compared to the subsequent December 2013 season (7 checks). However, abundance and occupancy were calculated for northern grass skinks for both the 2012 and 2013 seasons and appear to be very similar, indicating a stable trend in both estimated occupancy and abundance across these two summers. This was a notable result, supporting the importance of using a statistical method that accounts for detection probability, since we noticed that the number of traps that this species was detected in had decreased in the 2013 season in comparison with the previous season. The capture rate of copper skinks was higher this year, but still not high enough to estimate occupancy and abundance.

No spotted skinks, and few copper skinks, were detected during this years' survey which is of concern given the extensive sustained trapping effort over two years. This likely indicates continued low abundances of the spotted and copper skinks at Baring Head (Romijn 2011, Herbert *et al*. 2013b). Large pitfall traps are a proven method for capturing both of these skink species (e.g. Bannock 1998, Romijn 2010) but Duncan (1999) suggests that spotted skinks are less trappable compared to speckled skinks (*Oligosoma infrapunctatum*) as they spend less time active, may escape from traps more frequently and show a heightened wariness that may contribute to trap-shyness. Porter (1987) reported that they found pitfall traps inefficient for capture of ornate and copper skinks. Pear, however, is the preferred bait by spotted skinks (Duncan 1999). We therefore recommend that survey effort for spotted skinks at Baring Head be intensified by adding 30 further pitfall traps to the area where a spotted skink was captured in 2010 (see supplementary information). Triple-layered Onduline stacks (e.g. Lettink & Cree 2007) as the pitfall cover could be used to maximise spotted and copper skink capture probabilities (as long as experienced surveyors are used to capture them), since Onduline would be able to detect non-active skinks and pitfall traps would be able to detect actively foraging skinks. We recommend that any new pitfall traps be placed at least 25 m away from established traps so that all traps can be run at the same time but remain spatially independent[9]. Direct searches of the area where spotted skinks were previously found is another possibility, but would need to be done after the pitfall surveys are completed so as not to affect lizard behaviour during the pitfall trap capture period. We consider January to March as the best time to do this.

The commencement of a predator control programme at Baring Head (consisting of DOC-200 traps) in January 2014 may allow the residual spotted and copper skink populations to increase to an abundance sufficient to become more detectable by the current lizard monitoring programme. Rediscovery of formerly sparse species at a site has happened in other locations after the advent of pest control programmes (e.g. Duvaucel's gecko on south-eastern Great Barrier Island (J. Gilbert pers. comm.), brown skinks on Mana Island and Raukawa geckos on Tiritiri Matangi Island (Romijn et al. 2012). Because of the low capture rates of the locally rarer spotted and copper skinks, we cannot currently estimate site occupancy or abundance of these species using the sampling scheme for Raukawa geckos and northern grass skinks. Therefore, we suggest that alternative criteria for assessing population health of spotted and copper skinks be used until enough captures can be made to assess site occupancy and abundance. Suggested alternative criteria are: sex ratios and the proportion of juvenile and neonate skinks (converted from SVL data) of captured skinks, assessment of gravidity in adult females by palpation, and capture locations to indicate temporal changes in observed distribution at Baring Head. Because we have an adequate means of monitoring abundance, distribution and demography for the two more common lizard species, we feel sex ratios need only be collected from the rarer species *in lieu* of any other population information. Generally a decrease in the proportion of neonates or deviation in sex ratio from 1:1 within the breeding season, especially over subsequent years could be taken as an early warning sign that the population abundance is likely to decrease and/or their range across Baring Head to become more restricted (Herbert et al. 2014). This type of assessment would be best done just prior to the birthing season when we carry out the pitfall checks and again during the birthing season (January – February for copper skinks and February to March spotted skinks; Robb (1980), Porter (1987)) to allow neonate skinks to be captured for assessment of continued breeding. Sexing skinks and assessing gravidity by palpation does require the involvement of highly trained staff as inaccurate conclusions and/or harm to skinks is a risk of using these methods. However, copper and spotted skinks have only been encountered within the River Escarpment land management unit, which is only checked by experienced staff.

A search for spotted skinks records in the Department of Conservation BioWeb *Herpetofauna* database revealed a paucity of spotted skink locations on the greater Wellington mainland (compared to more common lizard species in the Wellington region). In total, there are 60 location records in the greater Wellington region made between 1963 and 2007, but few of these records are current (i.e. made in the last 10 years)[10]. We therefore feel that a survey for this species across the greater Wellington regionwould be desirable to determine the current status of this species and its' populations on the Wellington mainland[11]. Because of the apparently fragmented distribution of spotted skinks on the mainland, local extinction of populations that are isolated would likely represent a higher risk of loss of genetic variation within this species than for a more ubiquitously distributed species. We consider intensified survey effort for spotted skinks this to be important since, while not endangered, it is known that spotted skinks are adversely affected by introduced mammalian predators (Duncan 1999) and have a lower reproductive rate than smaller skinks (Spencer et al. 1998). Additionally, the maintenance of this species' national threat status is considered to be dependent upon continuation of current conservation management actions at localities

[9] That is, to ensure the two sampling schemes don't interfere with each other by capturing the same lizards. This is important since the extra traps would not be randomly placed therefore should not be included in the data analysis for the sampling programme for Raukawa geckos and northern grass skinks.

[10] This paucity in recent results could be partially attributable to non-reporting of location results to the database.

[11] Both survey of new sites and resurvey of sites with historical records of spotted skink presence. Data collection could include distribution, population structure to determine whether the population is breeding or not and tissue sampling for investigation into genetic structure across the regions since populations are likely to be highly fragmented. Survey effort could probably be optimised during the planning phase by carrying out habitat modelling to predict likelihood of spotted skink occurrence prior to survey.

where it is known to exist (Townsend *et al.* 2008, Hitchmough *et al.* 2013). Baring Head is recognised as a significant site for this species on the North Island mainland and is the only GWRC-owned land in which this species is found (Greaves *et al.* 2007, Romijn *et al.* 2012). Further surveys for this species, particularly along the Wairarapa Coast, are recommended by Romijn *et* al. (2012), and we feel that more collecting more information on the status of spotted skinks in the Wellington region would better inform decisions about the level of management needed for the Baring Head population.

Examination of index data obtained from rodent and other small mammal tracking tunnel transects run at Baring Head by GWRC indicate that both rat and mustelid numbers have remained consistently low since November 2011 at the site. However, numbers of hedgehogs – a significant lizard predator (Jones *et al.* 2013) – have increased to a very high level (peaking at 83% in February 2012, November 2012 and February 2014 (GWRC unpublished data). There also appeared to be an irruption in mouse numbers between May and November 2012, which has since subsided (GWRC unpublished data). Since Norbury *et al.* (2013) noted that exotic pasture grasslands supported more invasive pests, especially during higher grass seeding and/or pastoral land retirement, it is critical to understand the ability of the current pest control programme in suppressing numbers of various pest species during irruptions of pest populations in response to land management. We strongly recommend that both multi-species pest control (including suppression of irruptions of mouse abundance) as well as lizard monitoring using the current programme be sustained over the long term. Lizard monitoring could be changed to every second to third year after the baseline data collection has been completed.

Suggested major changes / updates to field protocols next year

Field logistics ran fairly smoothly this year, and the data collected in this study was of good quality for statistical analysis. However, there are a few recommended changes to the protocol, as follows:

Lizard marking for Mt+1. We have recently had success with a double-marking system (numbered xylene-free ventral marking and photographic identification) for Waitaha geckos (*W.* cf. *brunnea*). In that study, no more than 1.5% of geckos lost their temporary marks within a 21-day capture period repeated over two seasons of monitoring effort (Herbert *et al.* 2013a & 2014). This scheme actually saves lizard processing time since recaptured geckos do not need to be measured again, and it is thought that writing a number should not take any extra skill or time compared to simply placing a random mark on the animals While temporary marks were not noticed to rub off skinks at Baring Head, we have had problems with this in two South Island populations of grass skink species (*O.* aff. *polychroma* clade 5 and McCann's skink *O. maccanni*; C. Knox & S. Herbert pers. obs.). In order to reduce issues with this, we suggest measurement of all northern grass skinks upon both first capture and recapture, unless the mark remains clearly identifiable at the time of recapture. We have recently started developing a simple means of numerically assistance for the identification of most likely matches between sets of individual identifications in large spreadsheet data sets from closed populations (assuming no growth or tail breaks within the monitoring period), based upon the minimum sum squared difference between pairs of SVL, total tail length and length of the regenerated portion of the tail. This technique effectively enables large numbers of individuals to be more quickly sorted and may also reduce the human error involved with matching measurements across large numbers of individuals.

Collection of habitat variables. The GIS-based stratification of landscape management units was based on landform and future landscape management units in relation to pest animal control to reflect the main question that this surveying programme hopes to answer: "how does the distribution and abundance of lizard (and ground weta) species change over time in response to changes in management of the different landscape units"? As such, while most pitfalls in a unit will be surrounded by habitat that is fairly characteristic of that unit, we have noticed that there are some pitfalls that are surrounded by habitat more similar to that of another unit. Therefore the current stratification of pitfalls does not represent habitat features that may affect lizard and weta species distribution. However, the current scheme of habitat classification of the pitfalls does seem to adequately account for variation in detection probability and occupancy for northern grass skinks (see goodness of fit testing in Herbert *et al.* 2013b). Collection of habitat variables for each pitfall is now underway (aspect, slope, physiography and vegetation) are currently being collected for input into future analysis of the data, which will likely improve the precision of the estimates as well as provide a baseline against which habitat changes can be documented.

Possibly no need to include weather covariates in the occupancy / abundance models. Upon examination of the detection of species and individuals from this season and the modelling of weather covariates from last year (Herbert *et al.* 2013b), it appears that the variation in detection probability is not adequately accounted for by using weather covariates alone, as it seems that detection of at least Raukawa geckos and ground weta increases over the sampling period. This perhaps indicates a positive behavioural response (i.e. 'trap happiness') to the bait or refuge supplied by the traps. It may be that Raukawa geckos and ground weta take time to locate a trap, or that they learn that the baited traps are a source of food. This does not appear to be the case for northern grass skinks, where species detection peaked at day 4 and individual detection probability stayed fairly constant over the sampling period (with a shallow peak at day 4). Also for the purposes of this monitoring programme we are not particularly interested in the correlation between weather and detection probability, rather they are 'nuisance' variables. Therefore it is probably better to use a fully time-dependent, or possibly a linear or quadratic function of time to model this variation instead of weather covariates.

More detailed planning for next year's field protocols and logistics can be found in the supplementary information provided to GWRC along with this report. Supporting material updated since December 2013 is also given in the supplementary information, but for material that did not need updating, please refer to Herbert *et al.* 2013b.

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