Conservation of kakerori (*Pomarea dimidiata*) in the Cook Islands in 2005/06

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Hugh A. Robertson[1] and Edward K. Saul[2]

[1] Department of Conservation, PO Box 10420, Wellington 6143, New Zealand. Email: hrobertson@doc.govt.nz

[2] Takitumu Conservation Area Project, PO Box 3036, Rarotonga, Cook Islands

ABSTRACT

In 1989, the kakerori (*Pomarea dimidiata*) was one of the ten rarest bird species in the world, with a declining population of just 29 birds in the Takitumu Conservation Area (TCA) of southeastern Rarotonga. As a result of conservation management, the kakerori population rebounded, with up to 300 birds being recorded on Rarotonga and Atiu in 2004/05. The southern Cook Islands was, however, hit by five tropical cyclones over a 4-week period in February–March 2005, and much of the forest on exposed faces, spurs and ridges (traditional kakerori habitat) was severely damaged. The population survived remarkably well, with a minimum of 274 adults known to be alive in the TCA in August 2005. An additional 17 adults were found on Atiu between August 2005 and March 2006. The main casualties of the cyclones on Rarotonga appeared to be young birds (1–3 years old) and very old birds (>20 years old). Because the population on Rarotonga remained well within the management target of 250–300 individuals, rat poisoning was again done fortnightly, as in the previous 2 years. Breeding productivity was exceptionally poor in 2005/06, mainly because of nesting failures or early fledgling deaths caused by abnormally wet conditions during the main fledging periods. Nests were more exposed to the elements because the cyclones had extensively defoliated the canopy. Furthermore, rats were often seen foraging during the day, apparently struggling to find food (few trees were fruiting). Only 22 fledglings were definitely seen in 2005/06; however, some territories were not checked or poorly checked during the breeding season, and some fledglings may have dispersed to better vegetated sites. We recommend that rat control should return to the weekly poisoning regime used during the 1989–2001 recovery phase of the kakerori management programme if the August 2006 census reveals that the population has fallen below 220 birds (a 20% decline from pre-cyclone levels). Otherwise the regime of the sustainable management phase (fortnightly poisoning) should continue.

Keywords: kakerori, *Pomarea dimidiata*, sustainable management, translocation, catastrophe, rat control, Rarotonga, Atiu

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1. Introduction

1.1 KAKERORI

In a review of bird conservation problems in the South Pacific commissioned by the South Pacific Regional Environment Programme (SPREP) and the International Council for Bird Preservation (now BirdLife International), Hay (1986) identified the kakerori, or Rarotonga monarch (*Pomarea dimidiata*), as one of the species most urgently in need of conservation management (Robertson et al. 1994).

The kakerori is a small (22 g) forest passerine, endemic to Rarotonga. Both males and females undergo the same set changes in colouration as they grow older: all yearlings are orange, with a yellow base to the dark bill; all 2-year-olds are orange, with completely dark bills; 3-year-olds are a variable 'mixed' colour, ranging from some females that are blotchy grey and orange, through to some males that are entirely grey; all birds 4 or more years old are entirely grey (Robertson et al. 1993; Robertson & Saul, unpubl. data).

Most 1- and 2-year-old kakerori form loose flocks on the ridge tops, away from occupied territories; however, some join adults as 'helpers' to defend a territory and to raise young. Most territories are in valleys, especially those sheltered from the prevailing southeast trade winds. Adult kakerori are strongly territorial and remain in their territories throughout the year. They breed from October to February, though most eggs are laid in October and early November. They lay 1–2 eggs in a bulky nest, often placed on a forked branch overhanging a creek. Replacement clutches are laid if nests fail, but kakerori usually do not re-lay after successfully fledging young (Saul et al. 1998).

1.2 POPULATION TRENDS BEFORE MANAGEMENT (BEFORE 1989)

In the mid-1800s, kakerori were reported to be common throughout Rarotonga, but by the early 1900s they were thought to have become extinct. In the 1970s, a small population was rediscovered in the rugged interior of the island. David Todd found 21 birds in 1983, and estimated that there were 35–50 birds (David Todd, unpubl. data). A thorough search in 1987 found 38 birds (Robertson et al. 1994), but subsequent annual censuses identified 36 birds in 1988, and then 29 in 1989, thus confirming that the conservation status of kakerori was 'critically endangered' (Collar et al. 1994). At an average rate of population decline of 12% per year, a population viability analysis showed that there was a 50% chance that kakerori would be extinct by 1998, and a 90% chance by 2002 (HAR, unpubl. data).

1.3 RECOVERY PHASE (1989–2001)

Hay & Robertson (1988) identified that ship rats (*Rattus rattus*) were the main predators at nests, and cats (*Felis catus*) were predators of adults and recently-fledged juveniles, and they recommended an experimental recovery programme targeting these predators, supported by scientific study aimed at assessing the effectiveness of this work. The recovery plan was implemented by the Cook Islands Environment Service (Robertson et al. 1994) and ran through to 1995, when it was updated. More emphasis was then placed on the standard wildlife management practice of establishing an 'insurance' population on another island to better secure the species (Saul 1995). In 1996, the management of the recovery programme was passed to the Takitumu Conservation Area (TCA) Co-ordinating Committee. This body comprises representatives of the three customary land-owning families which care for the 155 ha TCA in southeastern Rarotonga, the home of most kakerori (Fig. 1). The TCA was established as part of the South Pacific Biodiversity Conservation Programme with the aim of protecting and enhancing the TCA's biodiversity values, at the same time as generating income for the landowners through the development of a sustainable ecotourism venture.

In spring 1989, an experimental programme of rat poisoning and nest protection started in one of the four main catchments used by kakerori. The breeding success there was much better than in the untreated areas, and so the area under protection was gradually increased. Since 1992, rats have been poisoned each spring in most of the TCA (Robertson et al. 1998).

The effectiveness of predator control has been measured by recording annual breeding productivity in protected and unprotected areas (Robertson et al. 1998; Saul et al. 1998), recording the annual survivorship of individually colour-banded kakerori and undertaking an annual pre-breeding census each August.

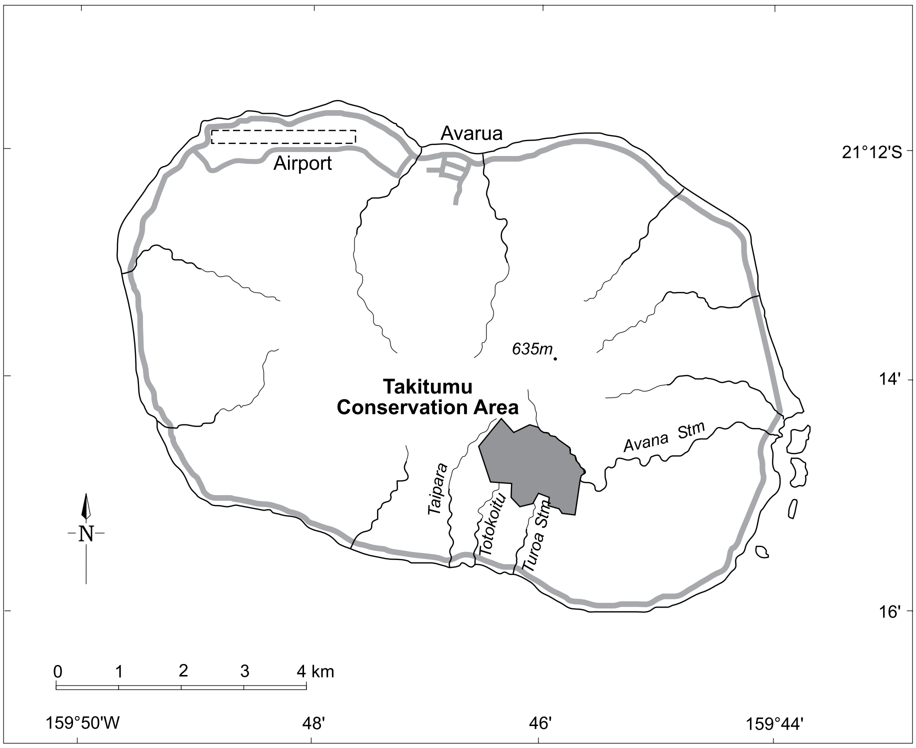

Figure 1. Map of Rarotonga showing the location of the Takitumu Conservation Area.

The census is made easier by the adult birds generally remaining in the same territory year after year (Saul et al. 1998), and the progressive changes in colouration of kakerori during their first 4 years of life (Robertson et al. 1993) improve estimates of the identity and survival of unbanded birds.

During this recovery phase, the population of kakerori increased at an average rate of 20% per year, from 29 birds in August 1989 to 255 in August 2001. In 2000, BirdLife International downgraded the threat ranking of kakerori from 'critically endangered' to 'endangered' (Stattersfield et al. 2000), one of a very few species to have been downgraded as a result of conservation management rather than improved knowledge (A.J. Stattersfield, BirdLife International, pers. comm. 2002).

1.4 SUSTAINABLE MANAGEMENT PHASE (SINCE 2001)

With funding support from the Avifauna Programme of SPREP, and then the Pacific Initiatives for the Environment (a programme of the New Zealand Agency for International Development), the emphasis of management in the TCA shifted from the recovery of kakerori to a programme aimed at sustaining the population on Rarotonga. Since spring 2001, the key work during this phase has been two-fold: firstly, the experimental reduction in rat poisoning effort in the TCA to a level where recruitment of kakerori more-or-less balances annual mortality and so maintains the population at 250–300 birds and, secondly, the establishment of a secure insurance population away from Rarotonga (Robertson & Saul 2004).

A population of 250–300 birds on Rarotonga, while small by international standards, is probably sufficiently large to withstand normal demographic perturbations and maintain adequate genetic diversity, given that the population passed through a bottleneck of just 13 females alive in 1989. Nevertheless, this population, occupying less than 200 ha on one island, is at significant risk of substantial decline or extirpation from a major catastrophic event.

The most obvious risk is from a severe tropical cyclone passing over or close to Rarotonga. In the 14 years between 1969 and 1983, Thompson (1986) recorded that an average of 1.4 tropical cyclones (with mean wind speeds >33 knots (61 km/h), and strong enough to damage human structures) affected the southern Cook Islands each summer or early autumn. Five of the 19 tropical cyclones were classified as hurricanes, with mean wind speeds of >63 knots (117 km/h), and they were usually accompanied by great destruction. Between 5 February and 6 March 2005, five tropical cyclones ('Meena', 'Nancy', 'Olaf', 'Percy' and 'Rae'), including four that reached hurricane force at some stage, swept through the southern Cook Islands, generally on a northwest to southeast bearing (Fig. 2). This was the highest number of cyclones ever recorded in a single season in the Cook Islands, and cyclone 'Percy' recorded the lowest barometric pressure (900 hPa) ever measured in the South Pacific (Ngari 2005).

Hurricane-force 'Meena' passed to the east of Rarotonga on 5 and 6 February 2005, with maximum sustained winds on Rarotonga of 46 knots (85 km/h) and gusts of 64 knots (119 km/h), 107 mm of rain, and serious sea-surge damage. Hurricane-force 'Nancy' passed close to Atiu in the early hours of 15 February and uprooted many trees, and then it continued southwards until turning westward to hit Rarotonga that afternoon, before moving away only slowly to the south and southwest. The accompanying 53 knot (98 km/h) winds with gusts to 88 knots (163 km/h) on flat land (but probably much stronger in the hills) on Rarotonga caused severe damage to trees on southward-facing slopes, spurs and ridgelines within the TCA. Luckily, this cyclone, which had earlier been classified as a Category 2 hurricane (sustained winds of 84–96 knots), had weakened to tropical storm force by the time it reached Rarotonga, otherwise the damage would have been considerably worse. Hurricane-force 'Olaf' passed to the west of Rarotonga on 17 February and caused more heavy rain and serious sea-surge damage, but the winds on Rarotonga reached only tropical storm force at 38 knots (70 km/h) with gusts to 51 knots (95 km/h). Hurricane-force 'Percy' and cyclone 'Rae' passed to the west of Rarotonga on 3 March and 6 March, respectively, and again both were accompanied by rain, strong winds (> 30 knots, 56 km/h) and storm surges.

Because Rarotonga is the main international arrival point for, and has the largest human population in, the Cook Islands its wildlife is most at risk from the accidental or deliberate importation of new avian diseases (e.g. mosquito-borne haematozoa of *Plasmodium* sp., or 'Asian bird-flu') or other new biota (e.g. two cage-escaped crimson rosellas (*Platycercus elegans*)

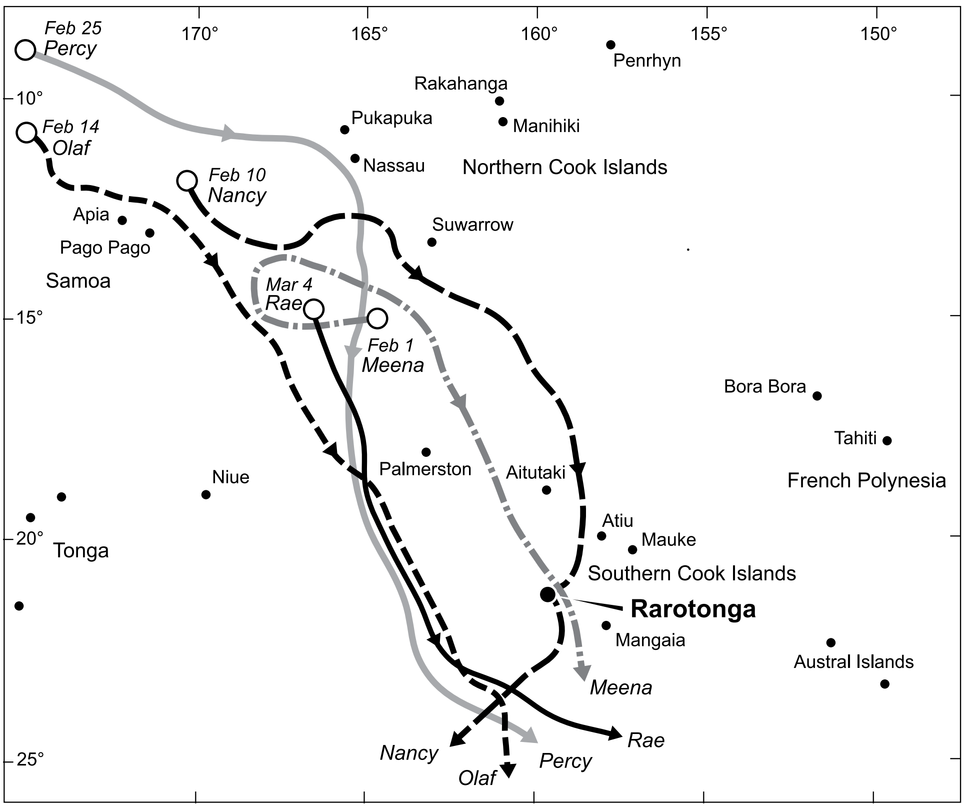

Figure 2. Tracks of the five tropical cyclones that passed through the southern Cook Islands in February and March 2005.

were seen in the TCA in August 2005 by Ed Saul and Diana Dombroski). After careful consideration of factors, such as island size and topography, habitat availability, predators, competitors, disease risk and community attitudes, Atiu was chosen as the best island for the establishment of an insurance population (Robertson et al. 2006). If successful, this second population should lower the risk of extinction of kakerori, and allow birds to be returned to Rarotonga should they ever die out there.

Between August 2001 and August 2003, 30 young kakerori were transferred to Atiu. The early indications are that the transfers have been successful, with successful breeding recorded in a variety of different habitats, and a minimum of 15 birds was found in May–June 2004 (Robertson et al. 2006).

In the 2003/04 season, the rat poisoning effort in the TCA was reduced to fortnightly checking and replacement of baits, rather than the weekly regime used during the recovery phase (Robertson & Saul 2005). This reduced programme was repeated in 2004/05 and 2005/06 because it saved considerable time and poison compared with the standard regime, yet still resulted in good numbers of fledglings (Robertson & Saul 2005).

This report outlines the monitoring and management programme in the fourth season of the sustainable management phase on Rarotonga.

2. Objectives in 2005/06

The objectives of the 2005/06 field season were to:

- Conduct the annual pre-breeding 'roll-call' and territory mapping of kakerori on Rarotonga in August 2005.
- Mist-net and colour-band as many kakerori as possible on Rarotonga in August 2005, with the aim of ensuring that > 50% of birds were individually colour-banded (between 2001 and 2003, this ratio had dropped below 50% because 30 banded youngsters were transferred to Atiu).
- Compare survival and disappearance rates of bagged and unbagged baits to see whether problems with unbagged baits going mouldy can be overcome.
- Maintain the new annual rat poisoning effort by replacing the single bait in each bait station fortnightly in the Turoa, Totokoitu and Lower Avana Valleys, and around the perimeter of these three valleys, if the kakerori population is > 220 birds. Otherwise revert to the weekly poisoning regime used in the recovery phase.
- Compare the breeding success of 20 pairs in territories subject to poisoning with that of 20 pairs in areas without the rat poisoning regime.
- Monitor the survival and breeding of kakerori on Atiu.
- Report results back to the Cook Islands community.

3. Methods, results and discussion

3.1 KAKERORI CENSUS ON RAROTONGA

The kakerori population on Rarotonga declined by 2.5%, from 281 birds in August 2004 to a minimum of 274 birds in August 2005 (Fig. 3). This was the worst annual decline recorded since management began in 1989; however, the impact of the cyclones was much less than we had feared. The population remained well above the 220 bird target we had proposed as a limit below which we would revert to recovery mode management in 2005/06 (Robertson & Saul 2006), and also remained within the target range of 250–300 birds.

Of the 150 banded kakerori known to be alive in August 2004, 35 (23%) were not found during the August 2005 census and were assumed to have died. This was much higher than the 11% annual mortality rate recorded between 1989 and 2004. The mortality in 2004/05 was not evenly spread across age cohorts (Table 1); it was especially high among young adults (1–3 years old), in which 18 (31%) of 58 banded birds disappeared, and among very old birds, in which four (80%) of the five birds aged over 20 years disappeared this season. The only survivor from this latter group was a female that was 24.5+ years old, which is now the oldest kakerori known. This bird was banded by Rod Hay and Gerald McCormack in June 1984 as a grey (4+-year-old) bird and so must have hatched earlier than February 1981. The overall annual survival rate (s) of banded kakerori since management started in 1989 now stands at 87.9%, equivalent to a life expectancy (L = 1/(1–s)) of 8.3 years.

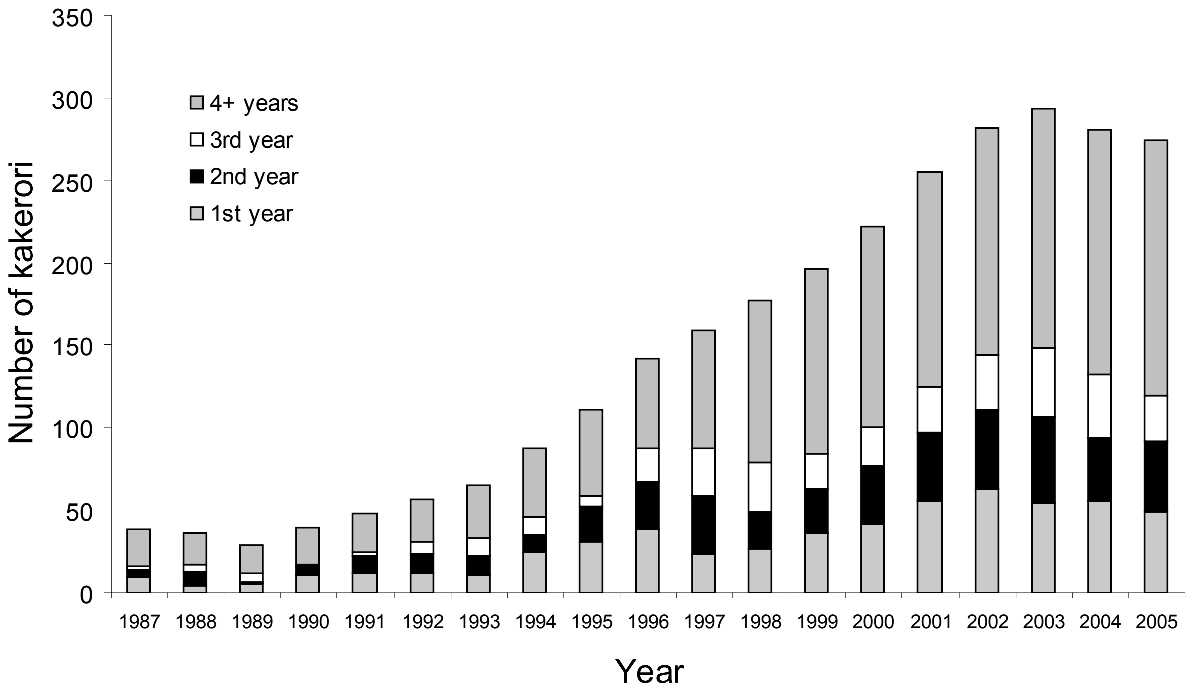

Figure 3. Annual pre-breeding census of kakerori, 1987 to 2005.

TABLE 1 MORTALITY RATES OF BANDED KAKERORI OF DIFFERENT AGES IN 1989–2004 COMPARED WITH 2004/05.

AGE	1989–2004		2004–2005	
(YEARS)	*n*	MORTALITY (%)	*n*	MORTALITY (%)
1	157	12	27	37
2	173	13	16	25
3	160	8	15	27
4	147	13	13	15
5–9	447	11	45	13
10–14	167	12	17	18
15–19	56	7	9	11
20+	11	9	5	80

In August 2005, at least 49 yearlings were recruited into the population out of the 59 fledglings recorded in summer 2004/05 (Robertson & Saul 2006). This 83% recruitment was similar to the c. 80% recruitment recorded in most previous years; however, the first-year survival was probably much less than observed, because the cyclones in early 2005 blocked most tracks and curtailed the fledgling search, and so the 59 counted must be treated as a very conservative estimate (Robertson & Saul 2006). As stated previously, the ridge-top habitats favoured by fledglings (Sanders et al. 1996) took a severe battering and many trees were toppled or denuded of foliage, and so the surprising result was that so many fledglings managed to survive the cyclones.

The territory mapping revealed that the distribution of kakerori remained similar to that recorded in 2004/05, except that some territories close to ridgelines were not occupied, and some territories centred on denuded south-facing slopes had shifted to include better vegetated valley floors or northern slopes that were more sheltered during the cyclones. The longest known movement of a kakerori on Rarotonga was recorded this year: a yearling female from a side valley (LA 7) well down the main Avana Valley had paired with a bird in a side valley (Tu 6) of the Turoa Valley, 2.05 km away from where she was banded.

3.2 MIST-NETTING AND COLOUR-BANDING

With assistance from Diana Dombroski, we set mist-nets on most days during the August 2005 census and caught a total of 42 different kakerori. One bird had been marked with butt-bands as a yearling in 1987 but had lost one of its two colour bands, and we were able to re-band it with the type of band in use since 1988 (wrap-around bands). We individually colour-banded 41 new birds: 25 (51%) of the 49 yearlings, nine 2-year-olds, three 3-year-olds, and four older (grey) birds. These new captures brought the total number of colour-banded birds on Rarotonga up to 156, or 57% of the population. This excellent sample of banded birds helped to continue the recent trend of increasing the percentage of banded birds in the TCA from the time it got as low as 45% (in 2003) when 30 youngsters were transferred to Atiu rather than being released back into the TCA. The focus of colour-banding over the next few years should be to try to raise this percentage to over 60%, and so help to improve the accuracy of population estimates.

3.3 RAT POISON PRESENTATION EXPERIMENT

Because most uneaten baits become mouldy and hence unpalatable to rats each fortnight, we carried out a brief experiment to see whether the baits would survive better inside plastic bags, as presented in Tahiti for protection of Tahiti monarchs (*Pomarea nigra*), and whether rats found these baits to be as acceptable as ordinary unbagged baits.

On 24 August 2005, one 18-g Talon® waxy block bait (active ingredient brodifacoum) was placed in each of 13 zip-lock plastic bags (62 mm × 75 mm), and then bagged and unbagged baits were alternately placed in 26 bait stations in the Turoa Valley. After 1 week, 11 of the 13 bagged baits remained whereas only three unbagged baits remained (Fisher exact test, $P = 0.002$). All missing baits were replaced to restore the initial sample size. A week later, rats had overcome their initial reluctance to take baits from plastic bags and had eaten 8 of the 13 bagged baits compared with 10 of the 13 unbagged baits, and there was no significant difference between the number of bagged and unbagged baits taken over a fortnight (Fisher exact test, $P = 0.34$; ns). The remaining bagged baits appeared to be in good condition, whereas the 3 unbagged baits that had been exposed to the elements for a fortnight had started to deteriorate. Because of the initial reluctance to take baits in plastic bags, which may have been even more pronounced had unbagged baits not been available in alternate stations for the rats to learn that the baits were edible, we decided that during the kakerori breeding season unbagged baits should continue to be used. We, however, decided that during the final bait round, just before Christmas, a single bagged bait should be placed in each bait station so that any surviving or immigrant rats would be exposed to poison over the next few months.

3.4 RAT POISONING

Because the August 2005 census showed that the kakerori population had withstood the cyclones better than expected, we continued with the fortnightly poisoning regime introduced in 2003/04. The same regime of poisoning in all three of the main valleys used for breeding, and around their perimeters (Robertson & Saul 2005, 2006), was continued this year.

One 18-g Talon® bait was placed in each of 428 bait stations (a 50-cm tube of unperforated 'Novacoil' drainpipe) placed 50 m apart on a 22-km network of tracks in the TCA, starting between 12 and 20 September. Because of the need to clear tracks of cyclone debris and windfalls, three lines (Turoa, Totokoitu and Outer) started about a week later than usual, and one line (Lower Avana) was first baited about a fortnight later than usual. Bait take was recorded fortnightly, and all missing baits were replaced.

Because baits quickly became mouldy (and therefore unattractive to rats) in the warm humid conditions on Rarotonga, all uneaten baits were replaced each fortnight.

The pattern of bait take was similar between the three valleys, and on their perimeters (Fig. 4) but, as noted in the 3 previous years, bait take in the Totokoitu Valley was higher than on the other lines until the very end of the poisoning period. In 2005, bait take was significantly higher over the whole season than in the previous 2 years (Wilcoxon matched pairs signed-ranks test on fortnightly bait take, $z = 2.22$, $P = 0.026$), with 22 of the 28 fortnightly takes over the four lines being higher in 2005 than in comparable fortnights in 2003 and 2004 combined. This result was not unexpected given that rats were apparently struggling to find enough food—we saw rats every day during the August 2005 census, whereas usually no rats (or just one) was seen during daylight. We also encountered many dead rats in August, before any poison had been laid. The actual density of rats was high, but not exceptionally high because few rats were seen at night and bait take was initially below 100%. The bait take dropped slightly as the season progressed, but never reached the 36% fortnightly take that equates to the 20% weekly target we aimed for during the recovery phase.

The reduced baiting regime used in 2005/06 took 4 person days per fortnight, compared with 7 days per fortnight for the weekly regime used in the recovery phase, a reduction of 43%. A total of 38 kg of bait was taken by rats in 2005/06, compared with 35 kg in 2004/05 and 39 kg in 2003/04, and 52 kg in the last year of standard weekly baiting in 2001/02 (Robertson & Saul 2006). Allowing for another 12 kg of baits used to replace uneaten mouldy baits, and to leave in plastic bags in bait stations at the end of the

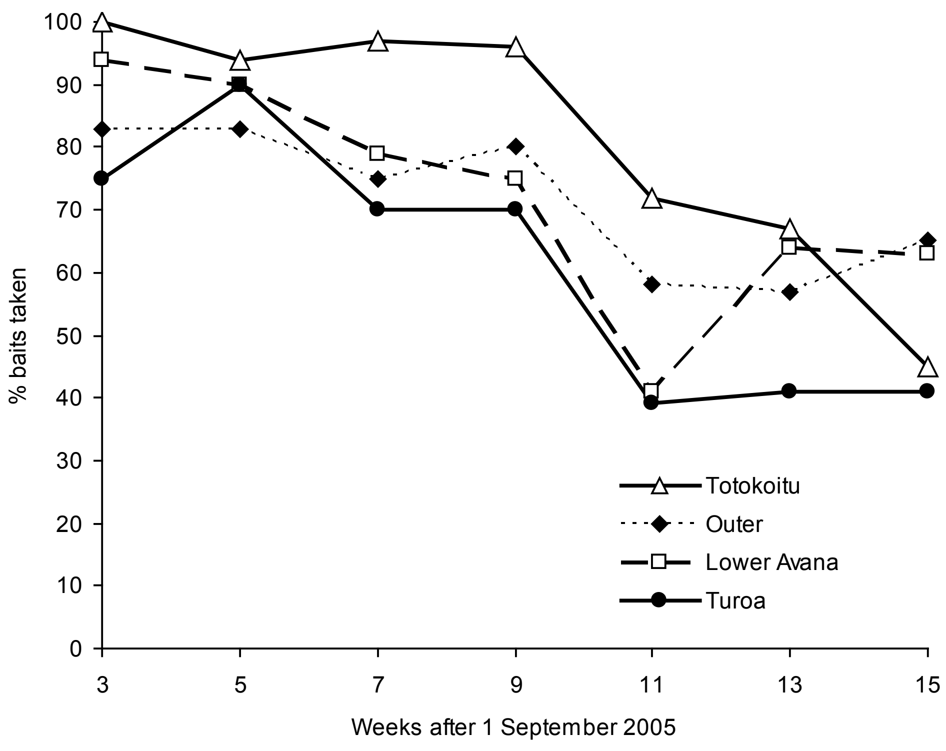

Figure 4. Bait removed by rats per fortnight in the Totokoitu, Lower Avana and Turoa Valleys, and around their perimeter (Outer), in late 2005.

poisoning season, the 50 kg of baits used in 2005/06 was only 16% of the 304 kg used over the same geographical area during the peak year of baiting (1991), when three baits were placed in each bait station (rather than one, as at present) for most of the season, and bait station density was greater (Robertson et al. 1998).

3.5 BREEDING SUCCESS

Breeding success appeared to be exceptionally poor in the TCA in the 2005/06 season; however, the combination of very poor weather, inexperienced volunteers and an injury to Ed Saul meant that nest checks were less frequent than in previous years. A total of only 22 fledglings was found during the season, which was less than half the number detected in any year since the sustainable management phase started in 2000/01, and was the lowest number of fledglings recorded since 1992, when there were only 57 adult kakerori in the population. It was exceptionally wet in the 2005/06 breeding season, especially at crucial times when most fledglings were produced. From the 1 : 1.6 ratio of rainfall recorded at Rarotonga Airport (299 mm) and at the former meteorological station at Totokoitu, and the greater rainfall in the TCA than at Totokoitu, we estimated that well over 500 mm of rain fell in the TCA in November 2006. In January–February 2006, we estimated that over 800 mm of rain fell in the TCA, with rain falling virtually every day—at Rarotonga Airport, on the dry side of the island, there were only 10 'dry' (< 0.1 mm rain) days in these 2 months combined (NIWA, unpubl. data). We suspect that many nests failed, or fledglings died before they could be detected, because of the persistent wet weather. The canopy damage caused by the five cyclones meant that nests generally had poor protection from rainfall. This abnormal exposure to the elements, combined with high numbers of especially hungry rats, probably accounted for the exceptionally poor breeding success. It is, however, possible that some fledglings dispersed to sheltered valleys away from the areas covered by our nest and fledgling checks, because the usual ridge top habitats occupied by fledglings (Sanders et al. 1996) were still recovering from the cyclones. The best measure of productivity in 2005/06 will be obtained during the August 2006 census.

An unusual feature of the breeding season was that at least one pair of kakerori laid eggs in mid-May 2006, at least 3 months after the any recorded nest (Saul et al. 1998), and produced a very late fledgling in June 2006.

3.6 ATIU MONITORING

George Mateariki and Ed Saul, with help from the local community (especially Enuamanu School pupils) and visiting ornithologists, have monitored kakerori on Atiu since the first release of ten youngsters in August 2001.

Checks on the Atiu population by Ralph and Mary Powlesland in August 2005, by George Mateariki through the breeding season, and by Ed Saul in March 2006 revealed that at least 17 of the 30 kakerori transferred to Atiu in 2001–2003 were alive, as were a pair of yearlings and five fledglings (Fig. 5), despite the damage caused to the forests of Atiu by tropical cyclones 'Meena' and 'Nancy'.

The total of 24 birds in 2005/06 was probably an underestimate of the population because, although most of the inland valleys had been searched systematically, only a small part of the 900-ha forested 'makatea' belt around the island had been visited because the terrain is very difficult to traverse. Two of the 17 transferred birds seen in 2005/06 had not been seen since they were released in 2001–2003, thus indicating that our estimates are conservative.

The good survival of released birds, and the moderate productivity on the island, indicate that the population is becoming established despite having to live with kiore and cats, and without the moss *Aerobryopsis* sp., their main nesting material on Rarotonga. Pairs have bred successfully in vastly different habitat types on Atiu, including inland riverine forest, makatea forest and leeward coastal forest (Robertson et al. 2006).

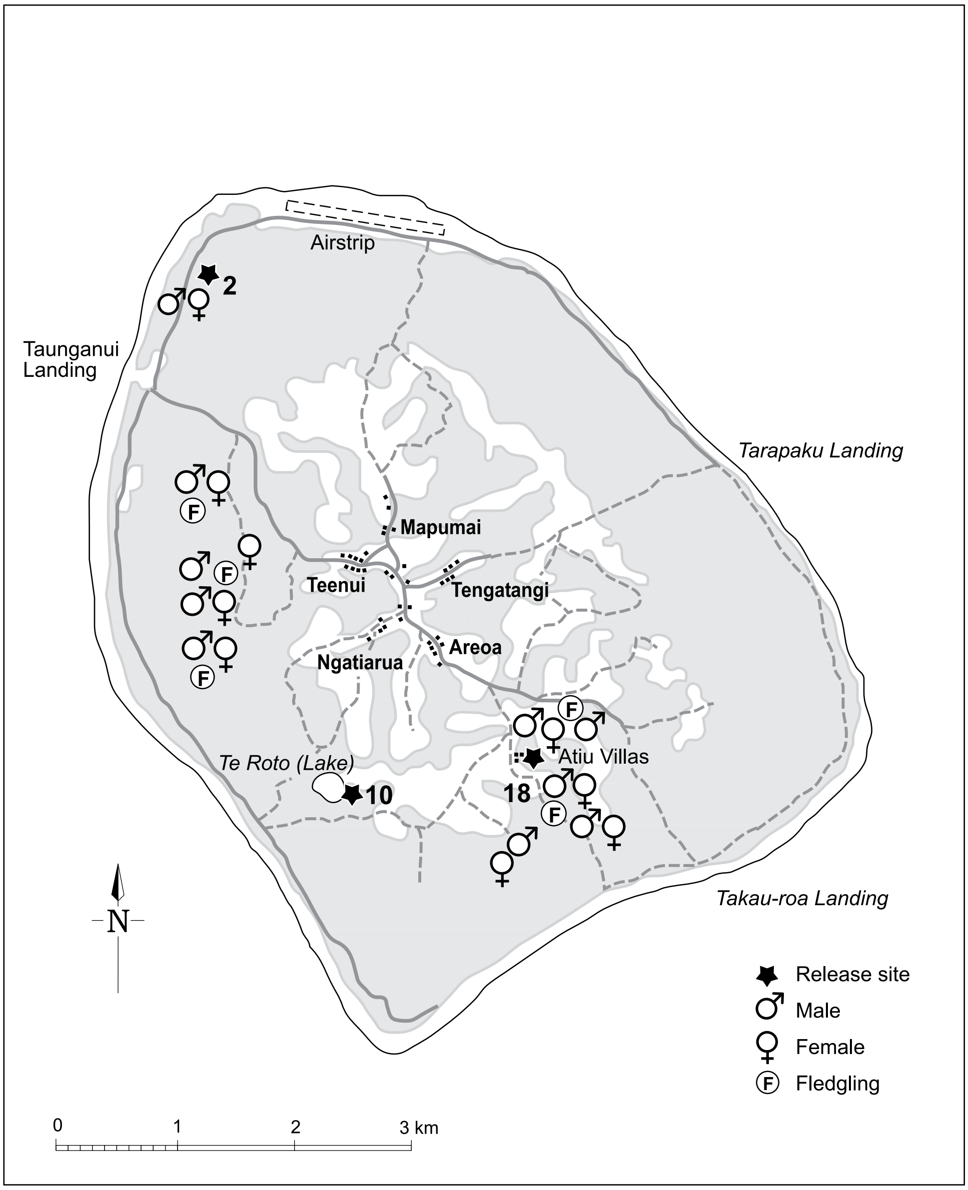

Figure 5. Map of Atiu showing the locations of kakerori seen in 2005/06.

3.7 ADVOCACY

We continued to work very closely with the committee of land-owning families who run the TCA Project, and assisted with its ecotourism business. We were interviewed by the *Cook Island News* newspaper about the August census results, the success of the breeding season and the monitoring of birds on Atiu before and after the cyclones. A four-page colour newsletter, *Kakerori Karanga*, was produced by Adam Isaacs for the TCA and distributed widely in the local community.

The TCA Project hosted numerous ecotourists during the year, but more importantly showcased the kakerori and conservation work in the TCA to many local school pupils as part of their school curriculum.

4. Conclusions and recommendations

The 2001/02 season marked a major turning point in the Kakerori Recovery Programme, from one principally aimed at recovery of the population to one aimed at sustainability. A key element of this shift has been the experimental reduction in management effort on Rarotonga, to find a regime that not only maintains the kakerori population at 250–300 individuals, but that also enables the programme to be economically sustainable for the TCA Project in the long term.

The five cyclones that hit Rarotonga in late summer 2005 had the potential to be catastrophic for kakerori and reverse many years of hard work; however, the birds survived relatively well, albeit at the lowest survival rate recorded since management began in 1989. Perhaps the most important effect of the cyclones was not seen until the following breeding season, when the general widespread reduction of canopy cover meant that nests were particularly exposed to the heavy and persistent rain encountered in November 2005 and January–February 2006.

At the start of the season, rat numbers were high and they also seemed to be exceptionally hungry judging by our numerous daytime encounters with them.

We believe that the fortnightly poisoning regime is adequate to maintain good breeding productivity in normal circumstances; however, the combined effects of the cyclones on the habitat and rat population dynamics, and unusually heavy rainfall at crucial stages in the 2005/06 breeding season, meant that the kakerori population probably declined this year. We recommend that if less than 220 birds are detected in the August 2006 census (a 20% decline from the pre-cyclone population), then a return to a weekly poisoning regime is warranted, but if there are more than 220 birds, then fortnightly poisoning should continue. In 2005/06, the poisoning of rats started at least a fortnight later than usual due to the need to clear cyclone debris from tracks, and so we recommend that the poisoning regime should start in late August or early September 2006. We also recommend that unbagged baits continue to be used during the breeding season. However, a single bagged bait should be placed in each bait station on the final bait round of the season (near Christmas), so that any surviving or immigrant rats are exposed to toxin in palatable baits well into the New Year.

In the 2006/07 breeding season, all breeding attempts of a pre-selected sample of 20 pairs should be monitored closely in each of the poisoned and the unpoisoned areas. During January and February 2007, an attempt should be made to record the number of fledglings in all territories to provide an estimate of overall productivity in 2006/07.

The other main element in the shift to sustainable management of kakerori on Rarotonga was the establishment of an insurance population on Atiu, which would survive should some environmental catastrophe strike Rarotonga. The transfers are now complete, and there is no immediate need to transfer more kakerori to Atiu, given that this population seems to be becoming well established and apparently came through tropical cyclones 'Meena' and 'Nancy' better than the population on Rarotonga. We recommend that thorough searches for banded and unbanded birds continue as opportunities arise, and that all records of kakerori on Atiu should be collated by the TCA Project team.

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