Conservation of kakerori (*Pomarea dimidiata*) in the Cook Islands in 2006/07

Hugh A. Robertson and Edward K. Saul

DOC RESEARCH & DEVELOPMENT SERIES 296

Published by
Science & Technical Publishing
Department of Conservation
PO Box 10420, The Terrace
Wellington 6143, New Zealand

DOC Research & Development Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff or external contractors funded by DOC. It comprises reports and short communications that are peer-reviewed.
Individual contributions to the series are first released on the departmental website in pdf form. Hardcopy is printed, bound, and distributed at regular intervals. Titles are also listed in our catalogue on the website, refer www.doc.govt.nz under *Publications*, then *Science & technical*.

ISSN 1176–8886 (hardcopy)
ISSN 1177–9306 (web PDF)
ISBN 978–0–478–14464–2 (hardcopy)
ISBN 978–0–478–14465–9 (web PDF)

This report was prepared for publication by Science & Technical Publishing; editing and layout by Lynette Clelland. Publication was approved by the General Manager, Research & Development Group, Department of Conservation, Wellington, New Zealand.

In the interest of forest conservation, we support paperless electronic publishing. When printing, recycled paper is used wherever possible.

CONTENTS

Conservation of kakerori (*Pomarea dimidiata*) in the Cook Islands in 2006/07

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

[1] Department of Conservation, PO Box 10-420, Wellington, New Zealand
[2] Takitumu Conservation Area Project, PO Box 3036, Rarotonga, Cook Islands

ABSTRACT

In 1989, the kakerori (*Pomarea dimidiata*) was one of the 10 rarest birds in the world with a declining population of just 29 individuals living in forested hill country in the Takitumu Conservation Area (TCA) of south-eastern Rarotonga, Cook Islands. Following 12 years of rat poisoning, the population had increased to 255 birds in August 2001. The programme then shifted from 'species recovery' to 'sustainable management' of the Rarotonga population at 250 to 300 birds. The rat poisoning effort was reduced, and an 'insurance' population was established on Atiu. By August 2004, following the reduction of poisoning from weekly to fortnightly, and the transfer of 30 youngsters to Atiu in 2001–03, there were 281 birds on Rarotonga and 25 on Atiu. The southern Cook Islands were hit by five tropical cyclones in a four-week period in February–March 2005, and forests on Rarotonga were severely damaged. Kakerori survived the storms remarkably well, but the main effect was observed in the following breeding season (2005/06), when nesting success on Rarotonga was exceptionally poor. Reduced canopy cover caused nests to be exposed to abnormally wet conditions, and lack of fruit meant that rats were exceptionally hungry. Only 31 yearlings were known to be alive in August 2006—about half the expected number—and annual mortality of banded birds (25%) was the highest since management began. The kakerori population on Rarotonga fell 8% from 275 birds in August 2005 to a minimum of 254 birds in August 2006. The situation was better on Atiu, with the population growing from about 32 adult birds in 2005/06 to a minimum of 37 adult birds in 2006/07, and an Atiu-bred pair nested successfully for the first time. The 2006/07 breeding season on Rarotonga was moderately successful, with a minimum of 51 fledglings found. Because the 'sustainable management' regime of fortnightly rat poisoning in the TCA was only just adequate in giving protection to adult kakerori, the annual poisoning programme was modified by adding rounds of 'interim' poisoning in April and July 2007 aimed at reducing rat and cat numbers before the breeding season.

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

Robertson, H.A.; Saul, E.K. 2008: Conservation of kakerori (*Pomarea dimidiata*) in the Cook Islands in 2006/07. *DOC Research & Development Series 296*. Department of Conservation, Wellington. 19 p.

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) in the early 1980s, 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 their 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 a few 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 raise young. Most territories are in valleys, especially those sheltered from the prevailing south-east trade winds. Adult kakerori pairs are strongly territorial and remain on their territory 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 bulky nests which are often constructed on forked branches overhanging creeks. 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 as being common throughout the island of 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 individuals in 1983, and estimated that the total population was 35–50 birds (unpubl. report). 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; confirming the conservation status of kakerori as '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 (H. Robertson 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. 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. After 1995, an updated recovery plan (Saul 1995) placed more emphasis on the standard wildlife management practice of establishing an 'insurance' population on another island to better secure the species. 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 south-eastern Rarotonga, the home of most kakerori (Fig. 1). The TCA was established as part of the South Pacific Biodiversity Conservation Programme (Robertson 2000) with the aim of protecting and enhancing the biodiversity values in the area and also 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 was started in one of the four main catchments used by kakerori in the TCA. As a result, the breeding success in this area was much better than in the untreated areas, so the area under protection in the TCA was gradually increased. Since 1992, rats have been poisoned each spring in most of the TCA (Robertson et al. 1998).

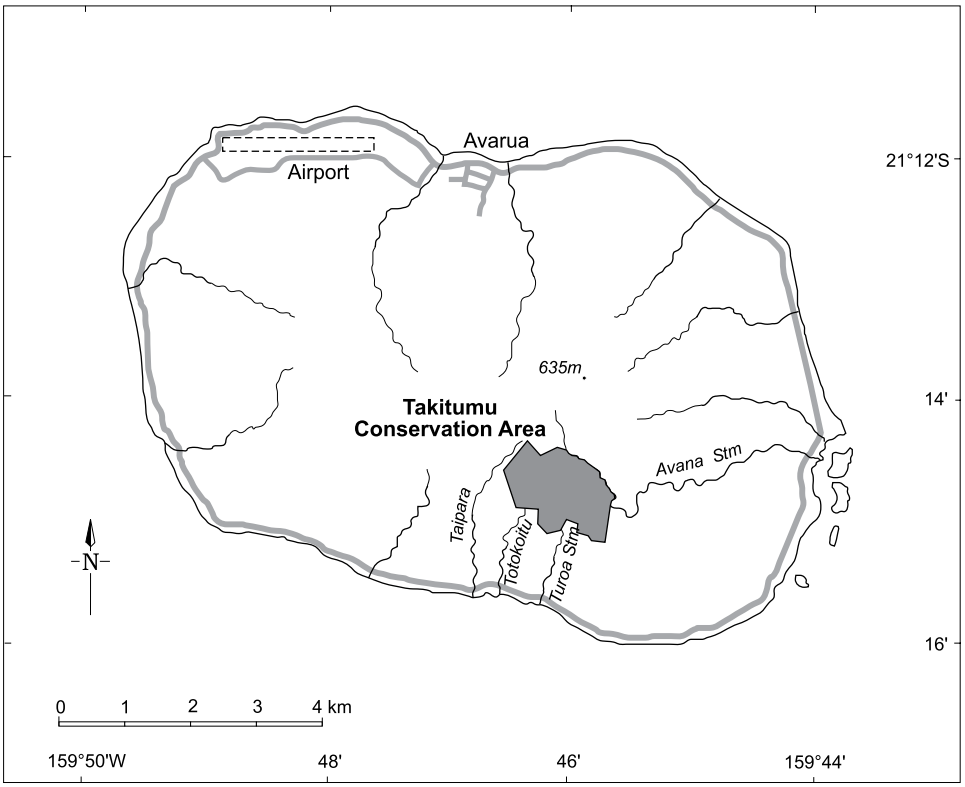


Figure 1. Map of Rarotonga showing the location of the Takitumu Conservation Area.

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. The census is made easier by the adult birds generally remaining in the same territory year after year (Saul et al. 1998). 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' (BirdLife International 2000), one of a very few species to have had their status downgraded as a result of conservation management rather than improved knowledge (Alison Stattersfield, BirdLife International, pers. comm.).

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 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. Following five cyclones in 2005, the Disney Foundation supported a separate assessment in 2005/06 of the effects of these severe storms on kakerori and other threatened birds in the southern Cook Islands, while we continued with the experimental sustainable management programme.

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 36 years since the beginning of satellite monitoring of all cyclones in 1970, de Scally (2008) recorded that an average of 1.6 tropical cyclones (with mean wind speeds ≥34 knots (62 km/h), and strong enough to damage human structures) affected the southern Cook Islands each summer or early autumn. However, between 5 February and 6 March 2005, five tropical cyclones ('Meena', 'Nancy', 'Olaf', 'Percy' and 'Rae') swept through the southern Cook Islands, generally on a northwest to southeast bearing (Fig. 2). Cyclones 'Meena' and 'Nancy' had the greatest impact on Rarotonga, with most of the forest habitat on exposed faces, spurs and ridges of the TCA being severely damaged—large trees were toppled and most trees were extensively defoliated. The kakerori population survived this initial battering remarkably well, with

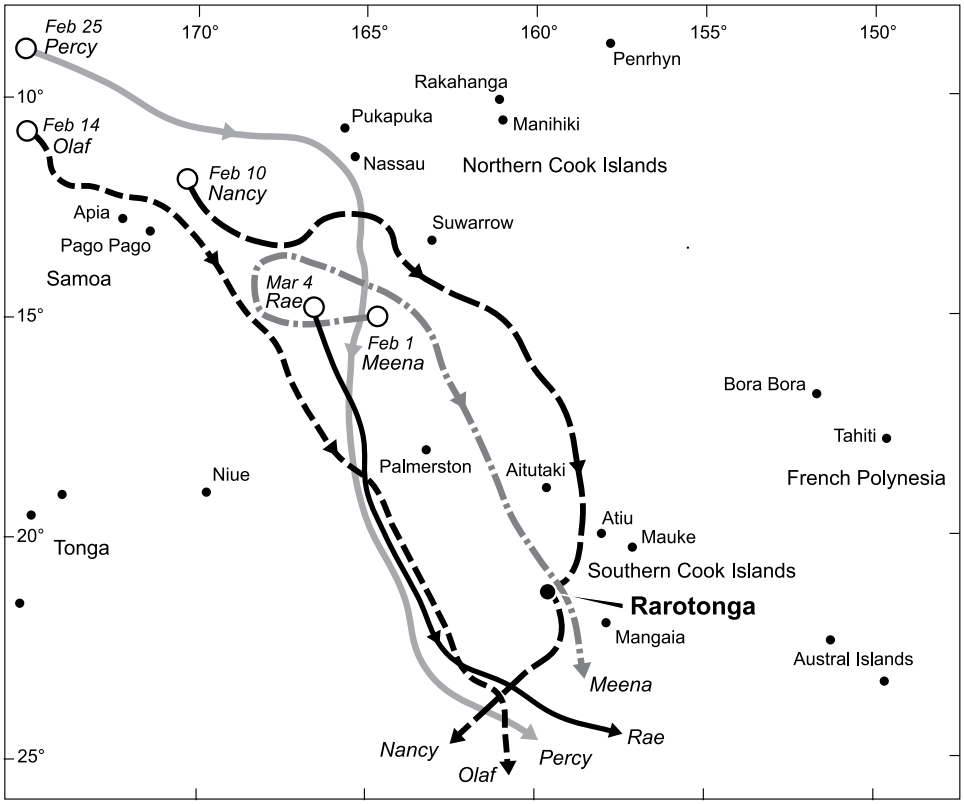


Figure 2. Tracks of the five tropical cyclones that passed through the southern Cook Islands in February and March 2005.

a minimum of 276 adult birds found in the TCA in August 2005, and a bare minimum of 19 adult birds found in the translocated population on Atiu between August 2005 and March 2006 (Robertson & Saul 2007).

Because Rarotonga is the main international arrival point in the Cook Islands, and has the largest human population, its wildlife is most at risk from the accidental or deliberate importation of new avian diseases (e.g. mosquito-borne *Plasmodium* haematozoa, or 'Asian bird-flu') or other new biota (e.g. two cage-escaped crimson rosellas (*Platycercus elegans*) were seen in the TCA in August 2005, and cage-escaped eastern rosellas (*Platycercus eximius*) were seen in the TCA in August 2006). After careful consideration of factors such as island size, 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 if they should ever die out there.

Between August 2001 and August 2003, 30 young kakerori were transferred to Atiu. The transfers appear to have been successful, with breeding recorded in a variety of different habitats (Robertson et al. 2006).

Since the 2003/04 season, the rat poisoning effort in the TCA has been reduced to fortnightly checking and replacement of baits, rather than the weekly regime used during the 'recovery' phase (Robertson & Saul 2005). This reduced programme has saved considerable time and poison compared with the standard regime, yet has still resulted in good numbers of fledglings in 2003/04 and 2004/05 (Robertson & Saul 2005, 2006). There were few fledglings in 2005/06, however, but this was due to the indirect effects of the cyclones in 2005 (Robertson & Saul 2007).

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

2. Objectives in 2006/07

The objectives of the 2006/07 field season were to:

- Conduct the annual pre-breeding 'roll-call' and territory mapping of kakerori on Rarotonga in August 2006.
- Mist-net and colour-band as many kakerori as possible on Rarotonga in August 2006, with the aim of ensuring that > 50% of birds are individually colour-banded.
- Collect feather samples from all birds being handled for a Victoria University of Wellington study of the genetics of a natural population that had passed through a severe bottle-neck.
- Maintain the 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 weekly poisoning used in the 'recovery phase'.
- Compare the breeding success of 20 pairs in territories subject to rat poisoning with 20 pairs in areas without poisoning.
- 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 annual census was carried out over 12 days from 13 to 24 August 2006, but the data was also supplemented by subsequent sightings. The kakerori population on Rarotonga declined 8% from 276 birds in August 2005 to a minimum of 254 birds in August 2006 (Fig. 3). This was the worst annual decline recorded since management began in 1989. However, the population remained well above the 220 bird target we had proposed as a breakpoint at which management would revert to 'recovery mode' with weekly rather than fortnightly rat poisoning (Robertson & Saul 2007).

Of the 155 banded kakerori known to be alive in 2005, 39 (25%) were not found during the 2006 census and were assumed to have died. This annual mortality rate was significantly higher than the 12% average annual mortality recorded between 1989 and 2005 ($\chi^2_1 = 20.4$, $p < 0.001$).

The mortality in 2005/06 was not evenly spread across age cohorts (Table 1). It was especially high among young birds (1–3 years old). In this age group, 20 (30%) of 67 banded birds disappeared. Also, the two remaining > 20-year-old birds disappeared in the 2005/06 season. This followed the death of four of the five oldest birds the previous year (Robertson & Saul 2007). It seems likely that kakerori survival is poor once the birds get to about 20 years old. The four oldest

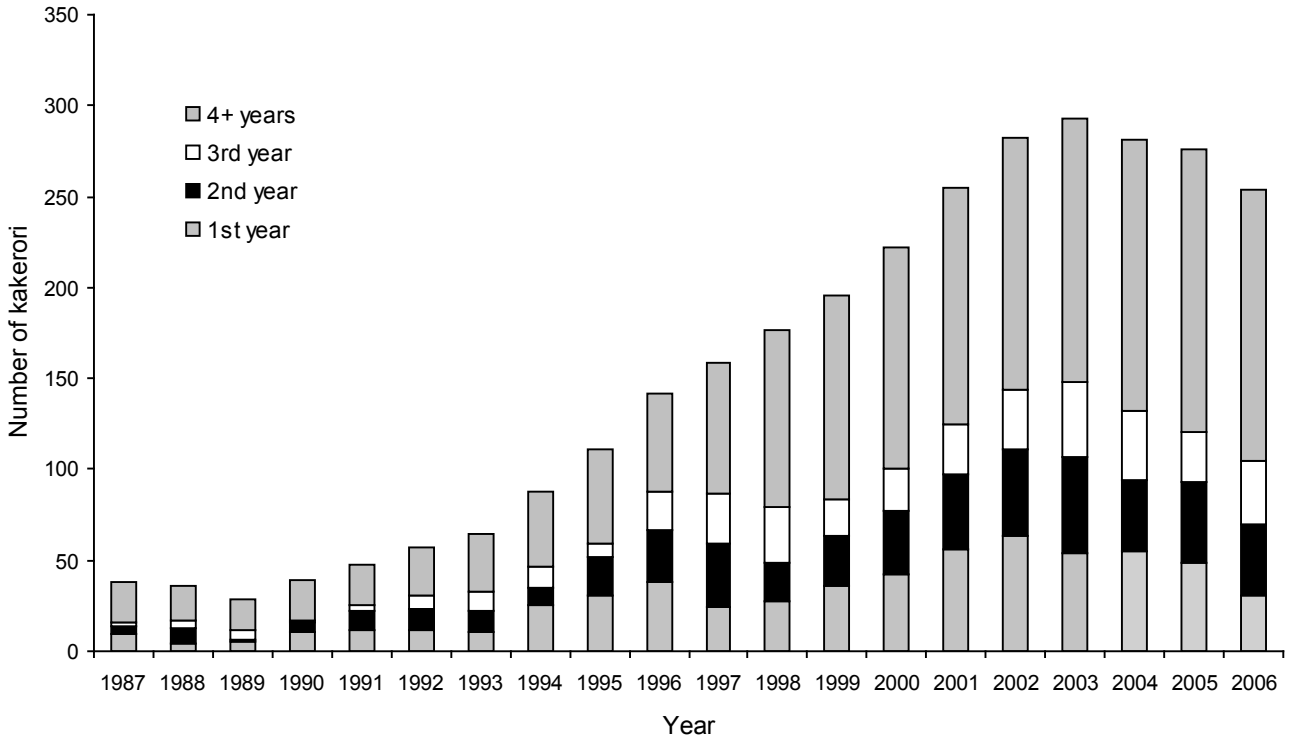


Figure 3. Annual pre-breeding census of kakerori, 1987 to 2006.

TABLE 1. ANNUAL MORTALITY OF DIFFERENT COHORTS OF KAKERORI IN THE PERIOD 1989–2005 AND IN 2005/06. NOTE HIGH MORTALITY OF 1–3-YEAR-OLD BIRDS AND ≥ 20-YEAR-OLD BIRDS IN 2005/06.

AGE	1989/05		2005/06	
(YEARS)	n	% MORTALITY	n	% MORTALITY
1	183	16	25	36
2	189	14	27	19
3	175	10	15	40
4	160	13	12	17
5–9	492	11	41	20
10–14	184	13	25	28
15–19	65	8	8	0
20+	16	31	2	100
Total	1464		155	

birds alive in August 2006 (two males and two females) were yearlings when the recovery programme started in 1987, so were 20 years old in 2006. The overall annual survival rate (s) of banded kakerori since management started in 1989 now stands at 86.6%, equivalent to a life expectancy [L = 1/(1–s)] of 7.5 years.

As usual, banded males survived slightly better (79%) than females (68%). The overall annual survival of banded males since management began in 1989 is now 87.7%, so they have a life expectancy of 8.1 years, compared with an annual survival of 85.0% and life expectancy of 6.6 years for banded females.

In August 2006, only 31 yearlings were added to the population, which was the lowest number of recruits since 1997, and about half of the 49–63 recorded in each

of the 4 years since management changed in 2001. Much of this poor recruitment can be attributed to the after-effects of the 2005 cyclones, particularly the still-sparse canopy cover which afforded nests little protection from the abnormally heavy rains experienced during the 2005/06 breeding season (Robertson & Saul 2007). In addition, rats were seen to be particularly hungry in spring 2005 because their usual fruit supplies had failed, and they were frequently observed foraging during daylight, and feeding on unripe green berries (Robertson & Saul (2007).

Territory mapping revealed that the distribution of kakerori in August 2006 remained similar to that recorded in 2005/06.

3.2 MIST NETTING AND COLOUR BANDING

With assistance from Mathew Chan, we set mist-nets each day during the census, usually when yearlings were encountered, but sometimes in traditional catching sites or where birds were having territorial disputes. In August 2006, catches were lower than usual, partly the result of reduced catching effort, but the birds also proved very elusive, and no large flocks or 'clubs' of young birds were found. We caught and individually colour-banded only ten new birds: six (21%) of the 29 yearlings, three 2-year-olds and a 7-year old, and recaptured two banded birds. The new captures and resightings of banded birds brought the total number of colour-banded birds on Rarotonga to 127, or 50% of the population. The small number of birds banded in August 2006 reversed the recent trend of increasing the percentage of banded birds in the TCA following its low point of 45% in August 2003 after 30 banded youngsters were transferred to Atiu between 2001 and 2003 rather than being released back into the TCA. The focus of colour-banding over the next few years should be to raise the proportion of colour-banded birds to > 50%, to help improve the accuracy of our population estimates.

3.3 GENETIC RESEARCH

The kakerori population passed through a severe genetic bottleneck in 1989 when numbers fell to 29 birds—16 males and 13 females. This is one of the smallest bottlenecks reported in a declining population of wild birds before conservation management reversed the decline. Mauritius kestrel (*Falco punctatus*) declined to only four wild birds (Jones et al. 1995) and the Chatham Islands black robin (*Petroica traversi*) declined to five birds (Butler & Merton 1992), but both species have recovered to several hundred birds, like the kakerori. These severe bottlenecks generally lead to a loss of genetic diversity, because small populations are subject to greater genetic drift, and increased probabilities of inbreeding (Allendorf & Luikart 2007). The Chatham Islands black robin has proven to have very low levels of genetic diversity compared with other related species (Ardern & Lambert 1997). A more frequently reported cause of genetic bottleneck arises during translocations to new sites, or the natural establishment of a new population from a small number of founders, where the founders are assumed to be drawn randomly from a large interbreeding population. A study by Mathew Chan of Victoria University will compare the genetic diversity of kakerori

with other bird populations which have developed from artificial bottlenecks associated with translocations where the numbers of founding birds were similar to those of kakerori in 1989.

We collected feather samples from all 12 kakerori handled in August 2006. Because of poor productivity in 2005/06, it was planned to collect further samples in August 2007 to achieve a reasonable sample size (40+).

3.4 RAT POISONING

Because the August 2006 census showed that the kakerori population was still above the 220 bird threshold we had set (Robertson & Saul 2007), we continued with the fortnightly poisoning regime throughout the TCA rather than returning to weekly poisoning as used during the 'recovery phase' (1989–2001). The same three main valleys, and around their perimeter (Robertson & Saul 2006, 2007), were again treated in 2006/07.

One 18-g Talon® (active ingredient 0.05% brodifacoum) waxy block bait was placed in each of 428 bait stations (50-cm tubes of un-perforated 'Novacoil' drainpipe) placed 50 m apart on a 22-km network of tracks in the TCA. Baiting started between 28 and 31 August 2006, a fortnight earlier than usual, and up to three weeks earlier than in 2005, when cyclone debris had to be cleared from some bait lines. 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, and the old baits removed from the TCA.

The pattern of bait take was similar between the three valleys, and on their perimeters (Fig. 4) but, as noted in the three previous years, poison bait take in the Totokoitu Valley was generally higher than on the other lines. In 2006, bait take was much higher over the whole season (81%) than in the four previous years (Fig. 5) of fortnightly poisoning (range 56–70%), and only one fortnightly bait round (Lower Avana in December) reached the 36% fortnightly take which is equivalent to the 20% weekly target we aimed for during the recovery phase. Although rats were rarely observed in daylight during the August 2006 census or during baiting, abundant fruit on trees recovering from the effects of the cyclones meant that there was no shortage of food available to them.

The baiting regime used in 2006/07 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%. Because the baits were laid out a fortnight earlier than usual and baiting finished a fortnight later than usual, and rats were numerous throughout the season, far more baits (54 kg) were taken by rats in 2006/07 compared with the 35–39 kg taken in the same seasons since 2002 (Robertson & Saul 2006). However, even allowing for an additional 15 kg of baits used to replace uneaten mouldy baits, the 69 kg of baits used in 2006/07 was still only 23% 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).

Figure 4. Fortnightly bait removal by rats in the Totokoitu, Lower Avana and Turoa Valleys, and around their perimeter (Outer) in late 2006.

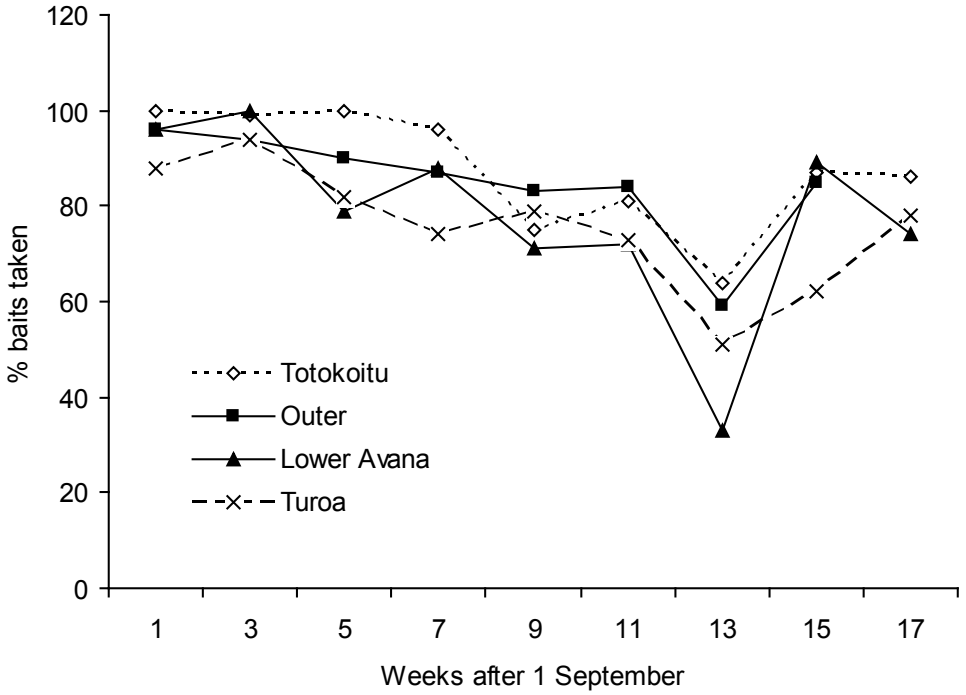
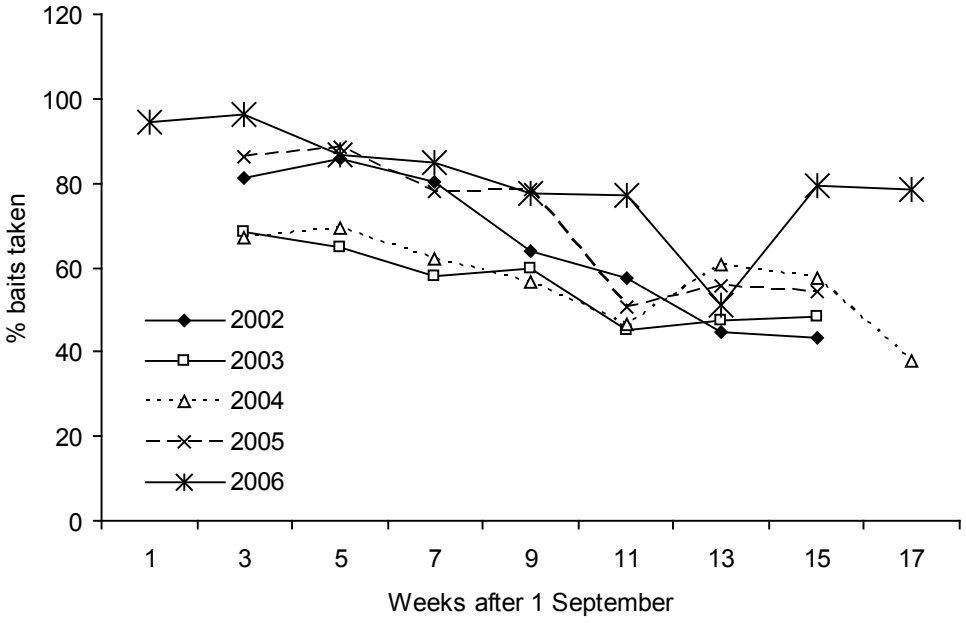


Figure 5. Fortnightly pattern of bait removal in the TCA in 2006 compared with the previous four years.



To try to increase the survival of adult and fledgling kakerori by reducing rat and cat numbers before the breeding season, a programme of 'interim poisoning' was carried out in April 2007 and July 2007. This involved placing a single bait in each of the 428 bait stations each baiting round.

The entire annual rat poisoning programme, with the additional 'interim poisoning', took 44 person days and used 82 kg of bait.

3.5 BREEDING SUCCESS

Breeding success appeared to be moderate in the TCA in the 2006/07 season, with a total of 51 fledglings found. This is fewer than the 60–70 seen in most years since the sustainable management phase started in 2000/01, but more than double the number detected the previous year. The weather in 2006/07 was quite benign, with mean temperatures slightly warmer than usual, and it was also much drier than usual on Rarotonga throughout the 2006/07 breeding season. Only 715 mm of rain (66% of normal) fell at Rarotonga Airport from 1 September to 28 February (NZ Climate Digest). No tropical storms were experienced in the Cook Islands during the 2006/07 cyclone season. The canopy had partially recovered from the damage caused by the five cyclones in 2005, but nests continued to have relatively poor protection from rainfall. This abnormal exposure to the elements, combined with high numbers of rats (see above), probably counter-balanced the good weather conditions to result in only moderate breeding success. It is possible, however, 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 2006/07 will be obtained during the August 2007 census.

3.6 ATIU MONITORING

George Matearíki 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 10 colour-banded youngsters in August 2001. A further 10 banded birds were released in August 2002, and the final 10 birds were released in August 2003 (Robertson et al. 2006).

Checks on the Atiu population by Doug, Ian and John Flux and Merryl Park in August 2006, by George Matearíki throughout the breeding season, and by Ed Saul and Lynda Nia in March 2007, revealed a minimum of 48 birds: 37 adults and 11 fledglings (Fig. 6). This was probably an underestimate of the true population because only a small part of the 900-ha forested 'makatea' belt around the island was searched due to the difficult terrain, and several pairs were not checked for fledglings until well after the breeding season.

A minimum of 15 of the 30 kakerori transferred to Atiu in 2001–03 were known to be alive in 2007, including one near the Rising Sun Tumanu whose band combination was not determined. Several other grey (3+ year-old) birds were seen or reported in new places this year, and these may include more of the original colour-banded birds.

There were 15 pairs (including at least three island-bred pairs, and at least three others with one island-bred partner), two grey singletons and seven orange birds (1- and 2-year-olds), two associated with pairs, and five in a small 'club' near Te Pa. In 2006/07, at least seven pairs raised fledglings, including an Atiu-bred pair, near Ake.

The good survival of released birds, together with the good productivity on the island, indicates that the population is becoming well established despite

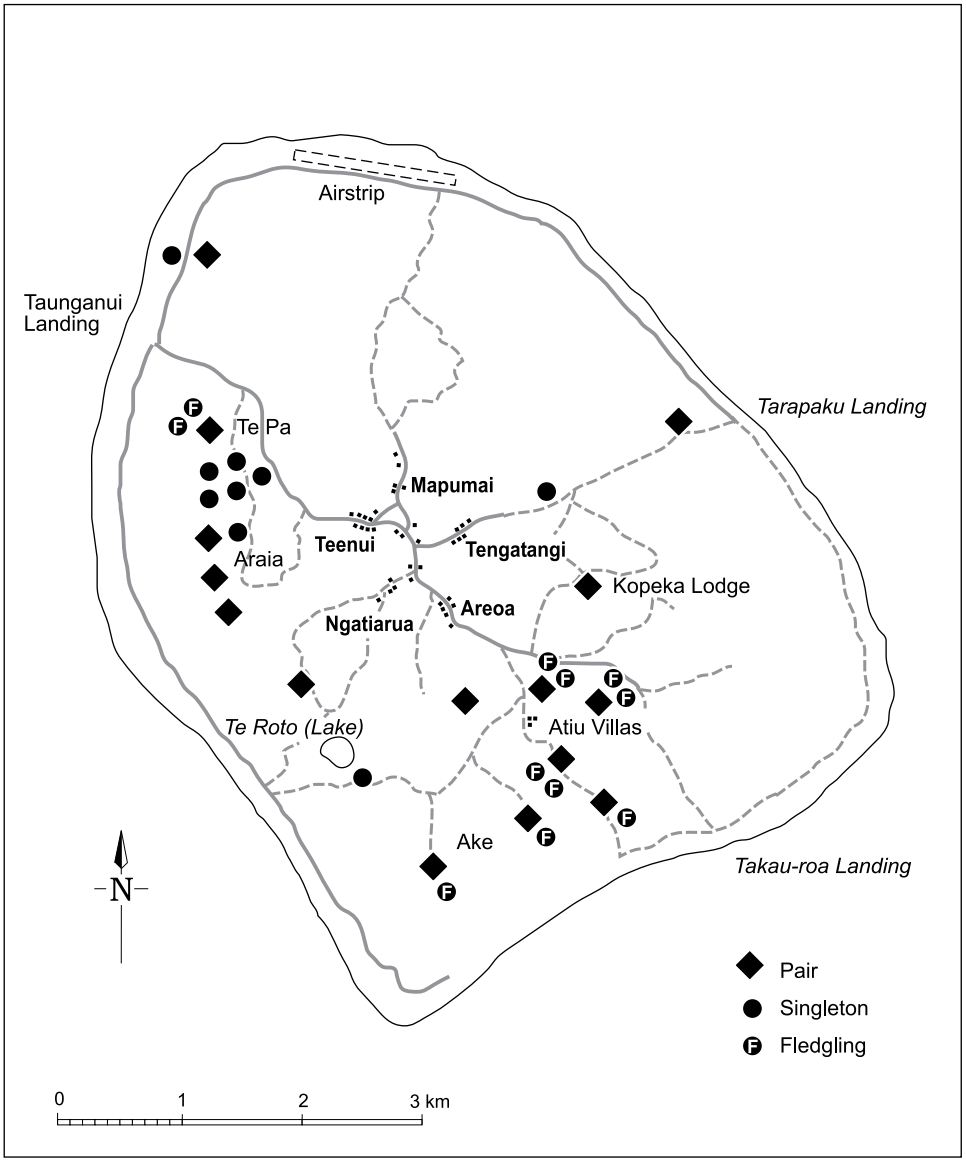


Figure 6. Map of Atiu showing the locations of the 48 kakerori (37 adults and 11 fledglings) seen or reported in 2006/07.

having to co-exist with kiore and cats, and without *Aerobryopsis* moss, their main nesting material on Rarotonga. Pairs have now bred successfully in vastly different habitat types on Atiu, including inland riverine forest, makatea forest, and leeward coastal forest (Robertson et al. 2006).

3.7 ADVOCACY

We have continued to work closely with the TCA Project team, and their ecotourism business. The TCA Project hosted numerous ecotourists during the 2006/07 year. However, more importantly, it continued to showcase the kakerori and conservation work in the TCA to many local school pupils as part of their school curriculum. We were involved in the production of a TV programme '*Te Ora Matarau*' which has already been screened on Cook Islands Television at least three times.

4. Conclusions and recommendations

The 2001/02 season marked a major turning point in the Kakerori Recovery Programme, from a project focussed on 'species recovery' to one aimed at 'sustainability' of the population. A key element of this shift has been the experimental reduction in management effort on Rarotonga to find a regime which allows the kakerori population to be maintained at 250–300 individuals and also enables the programme to be economically sustainable for the TCA Project to run in the long term.

The five cyclones that hit Rarotonga in late summer 2005 had the potential to be catastrophic for kakerori and to reverse many years of hard work; however, the birds survived relatively well, albeit at the lowest survival rate we had recorded at the time since management began in 1989. The most important effect of the cyclones was not felt until the 2005/06 breeding season, when the reduction of canopy cover meant that nests were particularly exposed to the heavy and persistent rain encountered that season and starving rats also had a major impact on breeding success. The 2006/07 breeding season was only moderately successful, with the beneficial effects of benign weather conditions being counter-balanced by nests still being exposed to the elements and high numbers of rats throughout the breeding season. As a result of poor recruitment, and the highest rate of adult mortality recorded since 1989, the population of kakerori on Rarotonga declined over the 2005/06 and 2006/07 breeding seasons to 254 birds, which was just above the lower limit of our target range of 250–300 birds. We recommend to the TCA Project team that if the kakerori population falls to below 250 birds, an increase in poisoning effort is warranted. This would take the form of weekly poisoning until bait take drops below 50% on a bait line, and then reverting to fortnightly poisoning thereafter. We recommend that the yearly poisoning rounds start in the last week of August or the first week of September to ensure that rat numbers are reduced before breeding starts in October. We also recommend that unbagged baits continue to be used during the breeding season; however, a single bagged bait (in a 90 mm × 60 mm clear zip-lock bag; Robertson & Saul 2007) should be placed in each bait station on the final bait-round of the season (near Christmas) and in both rounds of 'interim poisoning' in April and July, so that any surviving or immigrant rats are exposed to toxin in palatable baits during the non-breeding season.

Because the benefit of poisoning has been clearly established, and because the cost of monitoring of nesting success in poisoned and unpoisoned areas is substantial, we recommend that nest monitoring be discontinued. From November onwards each year, an attempt should be made to record the number of fledglings in all territories to provide an estimate of overall productivity.

In addition to a reduced (fortnightly) baiting regime, the other main element in the shift to 'sustainable' management of kakerori on Rarotonga was the establishment of an 'insurance' population on Atiu, in case some environmental catastrophe strikes Rarotonga. Transfers of kakerori to Atiu were completed in 2003, and there is no immediate need for more birds to be transferred, because the Atiu population is becoming very well established. However, genetic theory suggests that one new founder is needed every generation to maintain genetic

diversity in this 'insurance' population (Allendorf & Luikart 2007). This will require 2–3 birds to be transferred from Rarotonga to Atiu about every 6–7 years. We recommend that thorough searches for banded and unbanded birds on Atiu continue as opportunities arise, concentrating especially on determining the identity of the two 'new' pairs (at Tarapaku Landing and Kopeka Lodge Road), the pair in the gully south of Atiu Villas, and the banded singleton seen near the Rising Sun Tumunu. All records of kakerori on Atiu should continue to be collated by the TCA Project team.

5. Acknowledgements

The Global Environment Facility Small Grants programme supported the research and management efforts on Rarotonga in 2006/07 and, together with Euan Smith of Air Rarotonga, helped to cover the costs of monitoring kakerori on Atiu. The TCA Project paid for poison baits and improvements to the accommodation for volunteers.

Lynda Nia and Ian Karika of the TCA Project provided invaluable field assistance throughout the year with track maintenance, rat-poisoning and the monitoring of nesting attempts for much of the field season on Rarotonga.

The Department of Conservation, New Zealand, allowed Hugh Robertson to take special leave on pay to assist with the census in August 2006. Phil Battley, Matthew Chan and Sue Moore helped with the annual census and mist-netting on Rarotonga.

George Matearíki continued to monitor kakerori on Atiu throughout the season. Doug, Ian and John Flux and Merryl Park provided notes of birds seen on Atiu in August 2006. Lynda Nia helped with the post-breeding monitoring survey in March 2007.

Ian Karika, manager of the TCA Project, assisted in many ways throughout the year with technical support, fund-raising, and providing additional accommodation at the field base for the volunteers.

Chris Edkins drew the maps, and Lynette Clelland, Ralph Powlesland, and Greg Sherley improved the manuscript.

6. References

Allendorf, F.W.; Luikart, G. 2007: Conservation and the genetics of populations. Blackwell Publishing, Carlton.

Ardern, S.L.; Lambert, D.M. 1997: Is the black robin in genetic peril? *Molecular Ecology 6*: 21–28.

BirdLife International 2000: Threatened birds of the world. Birdlife International, Cambridge and Lynx Edicions, Barcelona.

Butler, D.; Merton, D. 1992: The black robin. Oxford University Press, Auckland.

Collar, N.J.; Crosby, M.J.; Stattersfield, A.J. 1994: Birds to watch 2: the world list of threatened birds. BirdLife International, Cambridge.

de Scally, F.A. 2008: Historical tropical cyclone activity and impacts in the Cook Islands. *Pacific Science 62*: 443–460.

Hay, J.R. 1986: Bird conservation in the Pacific Islands. *Study report No. 7*. International Council for Bird Preservation, Cambridge.

Hay, J.R.; Robertson, H.A. 1988: Ecology of kakerori (*Pomarea dimidiata*)—a draft recovery plan. Ecology Division Report. Ecology Division, DSIR, Lower Hutt.

Jones, C.G.; Heck, W.; Lewis, R.E.; Mungroo, Y.; Slade, G.; Cade, T. 1995: The restoration of the Mauritius Kestrel *Falco punctatus* population. *Ibis 137*: S173–S180.

Robertson, H.A. 2000: Conservation of kakerori (*Pomarea dimidiata*), Rarotonga. *Conservation Advisory Notes 272*. Department of Conservation, Wellington.

Robertson, H.A.; Hay, J.R.; Saul, E.K. 1993: Age and sex determination of kakerori *Pomarea dimidiata*. *Notornis 40*: 179–187.

Robertson, H.A.; Hay, J.R.; Saul, E.K.; McCormack, G.V. 1994: Recovery of the kakerori: an endangered forest bird of the Cook Islands. *Conservation Biology 8*: 1078–1086.

Robertson, H.A.; Karika, I.; Saul, E.K. 2006: Translocation of Rarotonga monarchs *Pomarea dimidiata* within the southern Cook Islands. *Bird Conservation International 16*: 197–215.

Robertson, H.A.; Saul, E.K. 2005: Conservation of kakerori (*Pomarea dimidiata*) in the Cook Islands in 2003/04. *DOC Research & Development Series 207*. Department of Conservation, Wellington.

Robertson, H.A.; Saul, E.K. 2006: Conservation of kakerori (*Pomarea dimidiata*) in the Cook Islands in 2004/05. *DOC Research & Development Series 246*. Department of Conservation, Wellington.

Robertson, H.A.; Saul, E.K. 2007: Conservation of kakerori (*Pomarea dimidiata*) in the Cook Islands in 2005/06. *DOC Research & Development Series 285*. Department of Conservation, Wellington.

Robertson, H.A.; Saul, E.K.; Tiraa, A. 1998: Rat control in Rarotonga: some lessons for mainland islands in New Zealand. *Ecological Management 6*: 1–12.

Sanders, K.H.; Minot, E.O.; Fordham, R.A. 1996: Juvenile dispersion and use of habitat by the endangered kakerori *Pomarea dimidiata* (Monarchinae) on Rarotonga. *Pacific Conservation Biology 2*: 167–176.

Saul, E.K. 1995. Towards 2000: a management plan for the kakerori's next 5 years. *Unpubl. Report*. Cook Islands Environment Service, Rarotonga.

Saul, E.K.; Robertson, H.A.; Tiraa, A. 1998: Breeding biology of the kakerori (*Pomarea dimidiata*) on Rarotonga, Cook Islands. *Notornis 45*: 255–269.