

# OPERATIONAL WORK UNDERTAKEN TO ERADICATE RATS AND RABBITS IN THE PHOENIX ISLANDS, REPUBLIC OF KIRIBATI, MAY-JUNE 2008



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Frontispiece – a green tinge of *Boerhavia* and other plants returns to Rawaki 18 June 2008, six days after the last rabbits were removed.

## EXECUTIVE SUMMARY

In 2006 a Critical Ecosystem Partnership Fund (CEPF)-funded terrestrial conservation survey of the Phoenix Islands, Kiribati confirmed the global importance of these islands for seabird populations, but it also found that mammalian pests were impacting on threatened seabird species and ecosystems on each of the eight islands (Pierce et al. 2006). The accompanying feasibility study and draft operational plan of focused on the removal of mammalian pests from the three smallest islands – Rawaki (European rabbit), McKean Island (Asian rat) and Birnie Island (Pacific rat). The operational plan was subsequently refined with input from the Government of Kiribati (GoK), NZ Department of Conservation (DOC) via its Island Eradication Advisory Group (IEAG), Conservation International (CI) and the Pacific Invasives Initiative (PII) (Thorsen et al. 2008). Funding was provided by NZAID in 2008 and Pacific Expeditions was contracted to undertake the work with support from GoK, DOC, CI and PII, including help from GoK and DOC staff in the field.

Final planning for the eradications took place in the very short period February-May 2008, during which operational plan changes were incorporated, staff recruited, equipment and supplies purchased, boat prepared and permits and authorizations from GoK and NZ authorities were issued. Training in pest eradication work, biosecurity, monitoring and other capacity building initiatives took place with GoK staff on Kiritimati (Christmas Island, Kiribati) also during this period (Brown and Pierce 2008). All Pest-Off 20R (brodifacoum) bait and most equipment was air- or sea-freighted to Samoa, which was used as the staging area for the pest eradication work, with consumables being purchased in and around Apia.

The pest eradication work on the Phoenix Islands took place during 27 May – 18 June 2008. Rawaki (land area c.46 ha) was the first to be visited and a 25 m grid established for hand-spreading brodifacoum bait. Additional baiting was undertaken around the lagoon edge and island perimeter. A second bait-spread across the island took place two days later. Total bait density was 90.9 kg/ha over the western portion of the island which supported high rabbit densities and 24.5 kg/ha on the eastern portion of lower rabbit densities. Following the second handspread of bait, we departed Rawaki for McKean Island, but our two hunters and pointer dog returned to Rawaki during 9-18 June to kill any surviving rabbits. During 9-12 June 43 rabbits were shot, with many also showing poison symptoms. The hunters saw no live rabbits over the following 6 days, despite systematic day and night searches, including the final two days when the remaining expedition members returned and assisted with surveillance.

McKean Island (c.20.7 ha) was considerably smaller than previously gauged. It was initially visited on 5-7 June when a 25 x 50 m grid was established and bait hand-spread at 25 m intervals on 6 June. Additional bait was spread around the island perimeter and the lagoon edge. We returned to McKean Island on 11-13 June and carried out a second hand-spread of baits on 11 June, and opted to repeat some of this on 12-13 June due to rain-induced damage to bait. Overall bait spread was 80.4 kg/ha in the high density rat area and 35.1 kg/ha in the low density area. In addition plastic bait stations were established at 50 m intervals

across the island and baited during our initial visit. No bait replenishing was needed for the bait stations during the second visit. Many dead and dying rats were seen during this second visit, but the success of the rat eradication will not be determined until at least mid 2009.

Baiting of Birnie Island was to have been attempted between the first and second McKean Island baitings, but on arrival at Birnie Island on 9 June, landing was deemed to be unsafe as there was no safe passage through the reef. Further discussion of feasibility and risks were held on 10 June and this led to the decision to completely abort Birnie Island due to an unacceptably high risk of landing accidents. Following discussions with GoK, the bait intended for Birnie Island was subsequently offloaded Abariringa (Kanton Island) for freighting to Kiritimati (scheduled later in 2008). Discussions were held with the Abariringa village elders on poison safety precautions, biosecurity and overall restoration plans for the Phoenix Islands group.

Non-target and biosecurity concerns that were pre-assessed included excessive consumption of bait by hermit crabs, possible deaths of bristle-thighed curlews and other waders, possible disturbance to frigatebirds, and potential for introducing foreign biota. Crab densities were lower than recorded in 2006 and did not impact significantly on bait consumption. Some bristle-thighed curlews, Pacific golden plover and ruddy turnstones were seen consuming poison baits directly, and carcasses of the former two species were subsequently found, all indicating that additional precautions will need to be taken in the future when these and other waders are present in significant numbers. Precautions to minimize disturbance to nesting frigatebirds were successful. Biosecurity breaches of the expedition were minimized by checking for invertebrates in particular at the source (Apia), at boat loading time, aboard the boat, and prior to landing.

Some simple baseline monitoring was established at Rawaki and McKean Islands involving vegetation maps, vegetation photopoints, and establishing seabird indices of abundance. These monitoring tasks are easily repeatable and can be used by GoK staff to monitor (the hopefully positive) responses of biota on the targeted islands. In the case of seabird fly-ons, an island's health can be determined by counting sensitive indicator species from a moored boat, and therefore presents no biosecurity risk or safety concerns associated with going ashore.

There were many capacity building benefits to GoK staff during this work on Kiritimati and Phoenix Islands. These focused on four main areas - improved understanding of invasive species impacts on biota, improved capacity to plan and undertake eradications, how to go about biosecurity work, and establishing and maintaining biota monitoring programmes. Other aspects were addressed at lower levels, e.g. data management (Kiritimati) and community discussions (Abariringa). All of the above would benefit from further targeted input.

Future biodiversity restoration in Kiribati should combine priority restoration objectives with capacity building, expanding on the current work. There are clear and important restoration opportunities in the Phoenix Islands in the form

of the large semi-pristine ecosystems of Enderbury Island and Orona; restoration of Enderbury Island (by removing Pacific rats) should be extended to include Birnie Island, particularly if Enderbury Island is baited aurally, and biosecurity stepped up throughout Kiribati. Meanwhile at Kiritimati, a capacity building and educational focus is needed to bring about more sustainable management of seabirds and the endemic warbler, the Bokikokiko, as well as working to improve biosecurity at all of the Phoenix and Line Islands.

## ACKNOWLEDGEMENTS

This project has been supported by many agencies and individuals dating back to 2005 when plans were developed for the 2006 conservation survey of the Phoenix Islands. After the 2006 survey, many people helped plan the 2008 pest eradications, with key help coming from the following:

### Kiribati

Tukabu Teroroko, Director of the Phoenix Islands Protected Area (PIPA) Office, facilitated the processing of permits and authorisations, and provided ongoing updates for Ministry of Environment, Lands and Agriculture Development (MELAD) staff and eradication planners alike; Directors Tererei Abete-Reema (Environment) and Kinaai Kairo (Agriculture) and their staff particularly Nenenteiti Teariki-Ruata and Aata Binoka provided ongoing support; Iotita Kuarawete of Kiribati Police authorised the firearm permits; MELAD Secretary Tebwe Ietaake provided ongoing support from the early 2007 planning stages of the project; Puta Tofinga authorised the 2006 surveys in which Aobure Teatata and Tiare Etei participated; other key individuals during the Kiribati planning period were Sue Taei and James Atherton (CI) and Greg Stone (New England Aquarium), all of whom assisted with funding for this project. Craig Rickett of the NZ High Commission in Tarawa provided ongoing high level support for the eradication project.

### New Zealand

Andrew Bignell, Mike Donaghue and Greg Sherley (DOC) assisted with early project development in 2007. Advice on project operational design was provided by the Island Eradication Advisory Group and several other individuals. Quality poison bait was provided by Animal Control Products, Wanganui, and we appreciate the tolerance of Bill Simmons to the abrupt changes in transport methods. Popular Pets (particularly Ann Smith) arranged the safe journey for Sako to and from Samoa, while Wendy Newsham at MAF helped overcome the last minute paperwork for exit and entry permits with NZ Biosecurity, and Michelle Wood at Ministry of Foreign Affairs and Trade achieved the same for firearms and ammunition. Trevor Duxfield at Fliway assisted with many items of “difficult” cargo within New Zealand and between New Zealand and Samoa. Jan Crisp at House of Travel landed us all on schedule. Steven Thorpe (Auckland University) identified invertebrates collected during the expedition. Vince Kerr (DOC) helped with mapping.

### Samoa

Francois Martell and Sue Taei, with their CI team, greatly assisted in the planning for arrival of personnel and equipment in Apia, and with our many last minute requirements prior to our departure to the PIPA (this included Sue's impromptu guided street tour to point out Apia's best hardware and grocery stores!). CI also hosted a most enjoyable departure dinner. Ray Betham (Betham Freight Services Ltd) assisted with clearing Samoa Customs and Agriculture for all bait, equipment and Sako. Makalio Ioane took some of the pressure off in Apia by transporting 3 tonnes of bait to Tokelau via the MV Tokelau.

#### Cook Islands and RV Bounty Bay

Ulamila Wragg passed on messages to the expedition and provided a watchful eye on the weather map from the Cook Islands. Asaeli, Jone and Soko crewed the RV Bounty Bay and provided expert support for the project at sea and ashore, always in great humour.

#### Hawaii and Alaska

Angela Kay Kepler (Pacific Wide Consulting Ltd) provided past data from the PIPA; Wally Johnson, Lee Tibbitts and Eric VanderWerf provided information on curlew and golden plover migration and behaviour.

## 1.0 BACKGROUND

The Phoenix Islands (Figure 1) are one of three island groups comprising the Republic of Kiribati and are centred on 3 degrees south latitude and 170 degrees west longitude in the central Pacific Ocean. Owing to their remoteness and a harsh environment they are little visited by people and only one of the islands (Abariringa or Kanton) is currently inhabited and by a small number of families. The vegetation and terrestrial habitats of most of the islands are in a near pristine condition and nineteen species of seabirds breed at the Group, including several globally important populations.

The exceptionally high biodiversity values of the islands are reflected in many international designations including:

- Establishment of the PIPA in 2006, extended in area in 2008 to become the world's largest declared Marine Protected Area,
- a proposed UNESCO World Heritage Site,
- an important 'Hotspot' and 'Key Biodiversity Area' (Area #133) identified in Conservation International's Polynesia-Micronesia Ecosystem Profile,
- an Important Bird Area (IBA) identified by BirdLife International Pacific,
- A high priority in Kiribati's National Biodiversity Strategy & Action Plan (NBSAP).

A key feature of the terrestrial environment is the number and diversity of seabirds. Petrels, tropicbirds, boobies, frigatebirds and terns collectively are estimated to have numbered in the millions during the 1960s (Garnett 1983). In 2006 the Government of Kiribati in partnership with CI/CEPF, DOC and PII undertook a terrestrial conservation survey to update the 1960s data on

indigenous and invasive biota (Pierce et al. 2006). The 2006 survey identified that the 19 species of seabirds found in the 1960s were all still present, including the endangered Phoenix petrel, the white-throated storm petrel (classified as Vulnerable) and other declining populations of petrel species, together with globally important populations of frigatebirds and booby species and blue noddies.

However, the 2006 survey also revealed that mammalian pests (rats, rabbits and cats) were impacting heavily on birds on all islands. On Rawaki, rabbits, which have been present for over a century, were destroying the nests, nesting habitat and ecosystem generally. On McKean Island, Asian rats had recently arrived (c.2001-02) and had all but eliminated the sensitive procellariiform (tubenoses – petrels, shearwaters, storm-petrels) and tern species that had been common in the 1960s. Most other islands also had experienced greatly depleted seabird diversity and abundance reflecting a long history of pest presence. Thus, despite the presence of excellent feeding areas in the PIPA, there were no predator-free breeding areas.

The 2006 conservation survey identified an urgent need to eradicate pests from the islands including:

- Rawaki – eradicate rabbits in order to secure populations of Phoenix petrels, storm-petrels, ternlets and many others
- McKean Island – eradicate Asian rats to enable recovery of recently depleted populations of sensitive species (procellariiforms and terns)
- Birnie Island – eradicate Pacific rats to enable recolonisation of sensitive species from Rawaki, which should occur quickly given the close proximity of the islands.

In addition the 2006 conservation survey recommended that the larger islands should also be restored:

- Enderbury Island - restoration of this large ecosystem by eradicating Pacific rat will ultimately support millions of seabirds of at least 18 species
- Orona – cat eradication (and rats if present)
- Manra, Nikumaroro, Abariringa – ideally pest-free status of the entire group should be a goal for PIPA restoration.

These recommendations support the draft PIPA management plan being developed by the PIPA office. Meanwhile, New Zealand agencies (PII, NZAID and DOC through the Minister of Conservation) also indicated a desire to provide financial and further technical support and assistance from New Zealand.

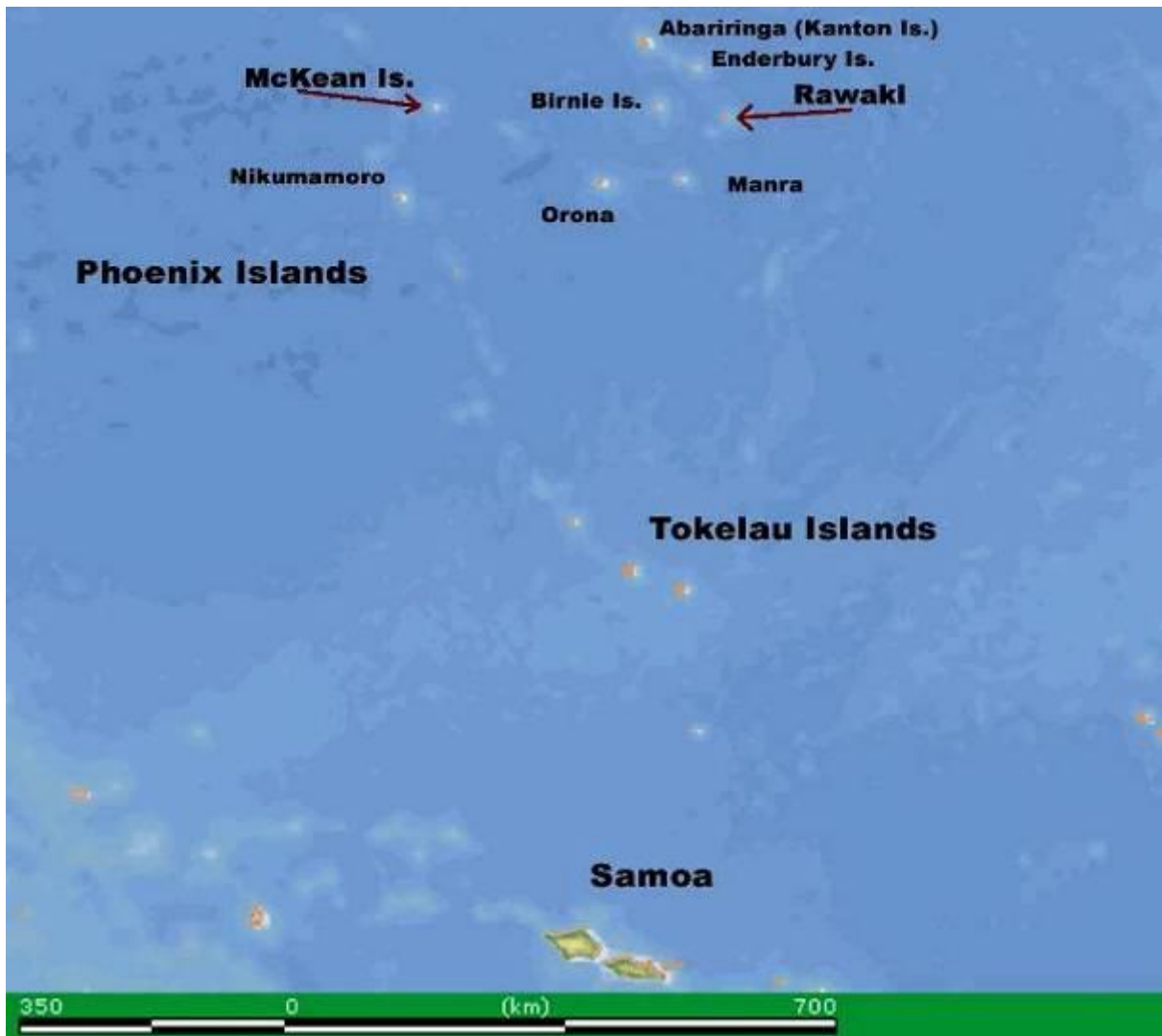


Figure 1 – Location of target islands in the Phoenix Islands.

## 2.0 PROJECT PLANNING

### 2.1 General project planning

Planning for the 2008 pest eradications began in 2006 (Table 2.1) with the completion of a feasibility study and draft operational plan as part of the report to CEPF (Pierce et al. 2006). Wishing to take the pest eradication recommendations to the next stage, the PIPA hosted Pierce at one of the steering committee meetings and follow-up meetings at Tarawa in March 2007 along with Sue Tai (CI) and Greg Stone (NEAQ), the latter of whom funded Pierce's involvement. Outcomes of this were:

- Support from the Directors and PIPA for a three island pest eradication package – Rawaki, McKean and Birnie Islands
- An indication of the role of the GoK in the proposed eradications, including provision of permits and GoK technical staff to help with the eradications

- Identification of permits that GoK would need to provide for the work
- Identification of the key facilitation role of Tukabu Teroroko as head of PIPA
- A draft bid to NZAID was completed spanning pest eradication, capacity building and biosecurity
- A biosecurity protocol for the PIPA was drafted and finalized soon after
- Input to the draft PIPA Management Plan.

Table 2.1 - Timetable of key planning events for PIPA pest eradications

| Date          | Agencies              | Activities  |
|---------------|-----------------------|---|
| <b>2006</b>   |                       |   |
| 14 Apr-10 May | PE, DOC, CI, GoK, PII | Completion of terrestrial conservation survey       |
| Jun           | PE, CI, DOC, PII      | Completion of report and feasibility study          |
| <b>2007</b>   |                       |   |
| Feb           | PE, GoK, DOC, NEAq    | PIPA meetings in Wellington                         |
| 19-28 Mar     | PE, GoK, NEAq, CI     | Meetings in Tarawa - management planning            |
| 28-30 Mar     | PE, CI                | Draft eradication bid prepared                      |
| May-Dec       | DOC, NZAID, PII       | Progression of eradication bid for funding by NZAID |
| <b>2008</b>   |                       |   |
| 1 Feb         | DOC, PE, PII          | Contract signed between PE and DOC                  |
| Feb           | DOC                   | Rabbit bait trials                                  |
| Feb-April     | PE, DOC, GoK, PII     | Planning for CXI training and PIPA eradications     |
| 17-23 Apr     | PE, GOK               | Training at Kiritimati                              |
| 19-23 May     | PE, GoK, CI           | Staging in Samoa                                    |
| 23 May-20 Jun | PE, GoK, DOC          | Eradications  |

Note: CI = Conservation International, DOC = NZ Department of Conservation, GoK = Government of Kiribati, NEAq = New England Aquarium, NZAID = NZ Aid, PE = Pacific Expeditions Ltd, PII = Pacific Invasives Initiative,

Discussions between DOC and NZAID continued throughout the remainder of 2007 with Keith Broome being appointed Project Manager for DOC in late 2007 and Ray Pierce Project provisional leader for Pacific Expeditions Ltd. A contract between DOC and Pacific Expeditions (PE) was signed in February 2008 following the latter's successful tender. Funds first became available to PE in March 2008 following invoicing to DOC (with receipts of expenses). A total of five PE invoices were presented in March-June 2008 and paid 5-15 days after invoicing.

Project allocation and actual expenditure are provided in Table 2.2. Although the project was under spent as a whole, some over expenditure occurred in the areas of dog travel/quarantine and customs brokerage in Apia. In addition to the costs shown here, there was significant salary time donated by DOC, PE, PII and GoK staff involved. The true cost of this time not charged to the project is in the order of an additional NZ\$100k.

Table 2.2 – Budget allocation and expenditure (NZ\$)

| Item  | Budget  | Actual  |
|---|---------|---------|
| Administration                                  | 55,000  | 10,667* |
| Planning incl trials, airfares, bait, equipment | 101,000 | 104,533 |
| Workshop costs                                  | 35,000  | 27,369  |
| Contract – boat charter, salaries               | 162,000 | 196,419 |
| Total   | 353,000 | 338,988 |

\* contingency expenditure shown where the costs fell

## 2.2 Operational planning and advice

This draft operational plan of 2006 became the basis for planning the eradications. It was finalized in April 2008 (Thorsen et al. 2008) following input from the IEAG, PII and operational team members.

### Deviations from Operational Plan

This operation, on the whole, followed the Operational Plan. Two major deviations from this plan occurred as noted below.

- 3 tonnes of bait (plus water and diesel) were shipped to the Tokelau Islands due to safety concerns around loading of the RV Bounty Bay. It was subsequently collected by the RV Bounty Bay on 1 June.
- No eradication was attempted on Birnie Island. This was due to landing being more difficult than realized during the 2006 visit because of the absence of a well defined channel through the reef and an abundance of sharp rocks in potential landing areas. Brief consideration was given to floating bait ashore and a team swimming ashore. This idea was abandoned due to safety concerns. Some members of the team did swim ashore on this island and confirmed that Pacific rat (*Rattus exulans*) was present with the capture of a pregnant female.

### Island and habitat areas

Maps of the operational areas, island substrates and vegetation types were completed during the operational work (refer Sections 3 and 4). The original 2006 land area calculation for Rawaki was c. 58 ha, but our 2008 GPS mapping suggested that the land area was 45.7 ha. The land area calculated for McKean Island in 2006 was c.49 ha, but in reality the land area was much smaller, our GPS mapping suggesting 20.7 ha.

## 2.3 Permits, freight and brokerage

### GoK

Tukabu Teroroko, with the cooperation of the GoK departments, provided the following permits in early 2008:

- PIPA research permit for entering the PIPA
- Dept Agriculture import permit for taking brodifacoum and magtoxin to Phoenix Islands

- Dept Agriculture permit for importing a trained rabbit dog. Subsequently NZ MAF requested GoK to provide an additional list of conditions of import into Kiribati, which they did
- Police permit for importing firearms and ammunition. Later, following a change in amount of ammunition being brought from New Zealand, an email authority for variation was provided by the Kiribati Police.

During the expedition and by telephone Tukabu arranged two permit variations:

- Unused bait to be freighted from Kanton to Kiritimati
- Export of dead birds to New Zealand for toxin analyses.

### New Zealand

The New Zealand permitting process was generally more complex and time-consuming than that of Kiribati. Permits were provided for:

- Firearm export and import via Ministry of Foreign Affairs and Trade (MFAT). These permits were provided within 3 weeks. Subsequently they needed to be updated due to changed ammunition quantities, but this was straight-forward
- Requirements for the transport of ammunition (hazardous goods) both within New Zealand and internationally were confusing and advice varied. Complex calculations of explosive potential were required for our ammunition.
- Magtoxin (also hazardous goods) was not permitted to travel by airliner to Apia and needed to be freighted by sea and only fortuitously caught up with the expedition via the MV Tokelau in the Tokelau Islands
- Brodifacoum export by sea freight was dealt with directly by Animal Control Products with no significant problems
- A permit for dog export and import was eventually provided by NZ Ministry of Agriculture and Forestry with assistance from Canterbury Quarantine Services. A delay was caused initially by a concern of “no conditions” being provided by the GoK import permit. Later when GoK provided generic conditions intended for dogs in the inhabited islands of Gilbert and Line Islands, our dog failed to meet these on two counts (desexed and rabies injections) and MAF initially refused to grant the permit. This conundrum was not resolved until a few days before the expedition departed
- Banding permit and bands from DoC in order to band Phoenix petrels and white-throated storm-petrels
- Import of dead birds from Kiribati to New Zealand for analyses required prior completion of import license application to Biosecurity New Zealand or using authority of existing license-holder (pending).

### Apia

We used Betham Freight Services for freight brokerage at our staging area in Apia. All aspects of freight handling, freight storage, firearms and ammunition delivery to the Police, dog delivery to and from the RV Bounty Bay, etc proceeded steadily and with no issues, although no quote could be obtained in advance and costs were greater than anticipated.

## 2.4 Training

In April 2008 Derek Brown and Ray Pierce visited Kiritimati for a week and workshopped with GoK staff from Conservation, Agriculture, Police and Linnix. The following aspects were covered at the workshop:

- Biodiversity values and threats at PIPA and Kiritimati
- Strategic approaches to protection – biosecurity and eradications
- Important roles of GoK staff at Kiritimati
- Eradication skills particularly compass lines, grid set-up, bait spreading
- Bird surveys - counting methods, bird handling, data sheets
- Plant surveys – species lists and photo-points
- Inter-island biosecurity – cargo checks at ports, ant surveys
- Lagoon-islands biosecurity – inspection methods for small boats
- Safety, particularly around toxins
- Working with data, graphing results.

Particular emphasis was placed on field activities that would be needed at PIPA and elsewhere in the future. Refer Brown and Pierce (2008) for a report on this workshop.

## 2.5 Project planning - lessons learned

The overall structure of this project is ideal in theory because it has excellent international and internal planners and technical support. However, the lateness in achieving project approval (and consequently the contract) led to a bottleneck of activities that needed to be achieved in four months from early February to early May 2008. It is a testament to all of the operational team that the expedition departed within 2 days of the original scheduled departure date and operational work was achieved on two of the three target islands with no injuries sustained. A great deal was learnt about how and how not to go about international shipment of goods, including ‘difficult’ items such as bait, firearms, ammunition, dogs and fumigants (refer Sections 3 and 4). This will stand the project planners in good stead for future operations.

Suggested improvements for Pacific eradications include:

- Settle contracts at least 6 months in advance of planned eradications
- Provide a significant payment (e.g. 70% of the total) to the contractor when the contract is signed and the balance on reporting
- Determine boat needs and other expedition requirements at an early stage
- Determine permit and freight process and timetables at an early stage for “difficult cargo” at least 6 months in advance
- Be persistent in insisting on financial quotes from freight brokers and quarantine offices.

## 3.0 RAWAKI RABBIT ERADICATION

### 3.1 Summary of operational activities and timetable

- Target pest: European rabbit
- Rabbit densities estimated by transect
- Pest-Off 20R (brodifacoum) bait hand-spread in two pulses 2 days apart
- The hand-spreads were from 25 m intervals on pre-established grid
- First hand-spread baiting density was 56.9 kg/ha in high rabbit density areas and 12.7 kg/ha in low rabbit density areas
- Second hand-spread baiting density was 34 kg/ha in high rabbit density area and 11.8 kg/ha in low density areas
- Supplementary bait spread was undertaken around the perimeter of the island and the edge of the lagoon, and separate baiting in the frigatebird colony
- Operators departed the island after the second bait spread and two hunters and dog returned 8 days later
- 43 rabbits were shot using .22 rifles over the following 4 days with dawn, dusk and night (spotlighting) being the hunting periods targeted
- Dawn and dusk observations, spotlighting and dogging continued for another 6 days after the final rabbit was shot with no further live rabbits being detected.

#### Daily log Rawaki

May 26th – RV Bounty Bay arrives at Rawaki shortly after dark

27th – ferried ashore people, bait, field equipment and supplies

28th – laid out 25 m x 25 m bait grid

29th – first bait application 1810 kg in high target bait density area, 130 kg in low target bait density area

30th – further bait application around the coast and frigate bird colony. Rabbits seen eating bait

31<sup>st</sup> – bait monitoring

June 1st – second bait application 1080 kg in high target bait density area, 120 kg in low target bait density area

2nd – first rabbit found dead

3rd – several rabbits found dead, others clearly affected by poison.

4th – all expedition members departed Rawaki for McKean Island

June 9<sup>th</sup> – Rabbit team (Derek, Lance and Sako) return to Rawaki – 31 rabbits shot

June 10<sup>th</sup> – 9 rabbits shot

June 11th – 1 rabbit shot

June 12th – 2 rabbits shot

June 13th–16<sup>th</sup> - no sign of live rabbits on Rawaki

June 16<sup>th</sup> - full team returns to Rawaki, up to 9 observers doing night spotlight searches and dusk and dawn searches, no sign of live rabbits

June 17<sup>th</sup> – intensive night spotlight searches and dusk and dawn searches, no sign of live rabbits

June 18th – intensive dawn searches, no sign of live rabbits. Team departs Rawaki for Apia

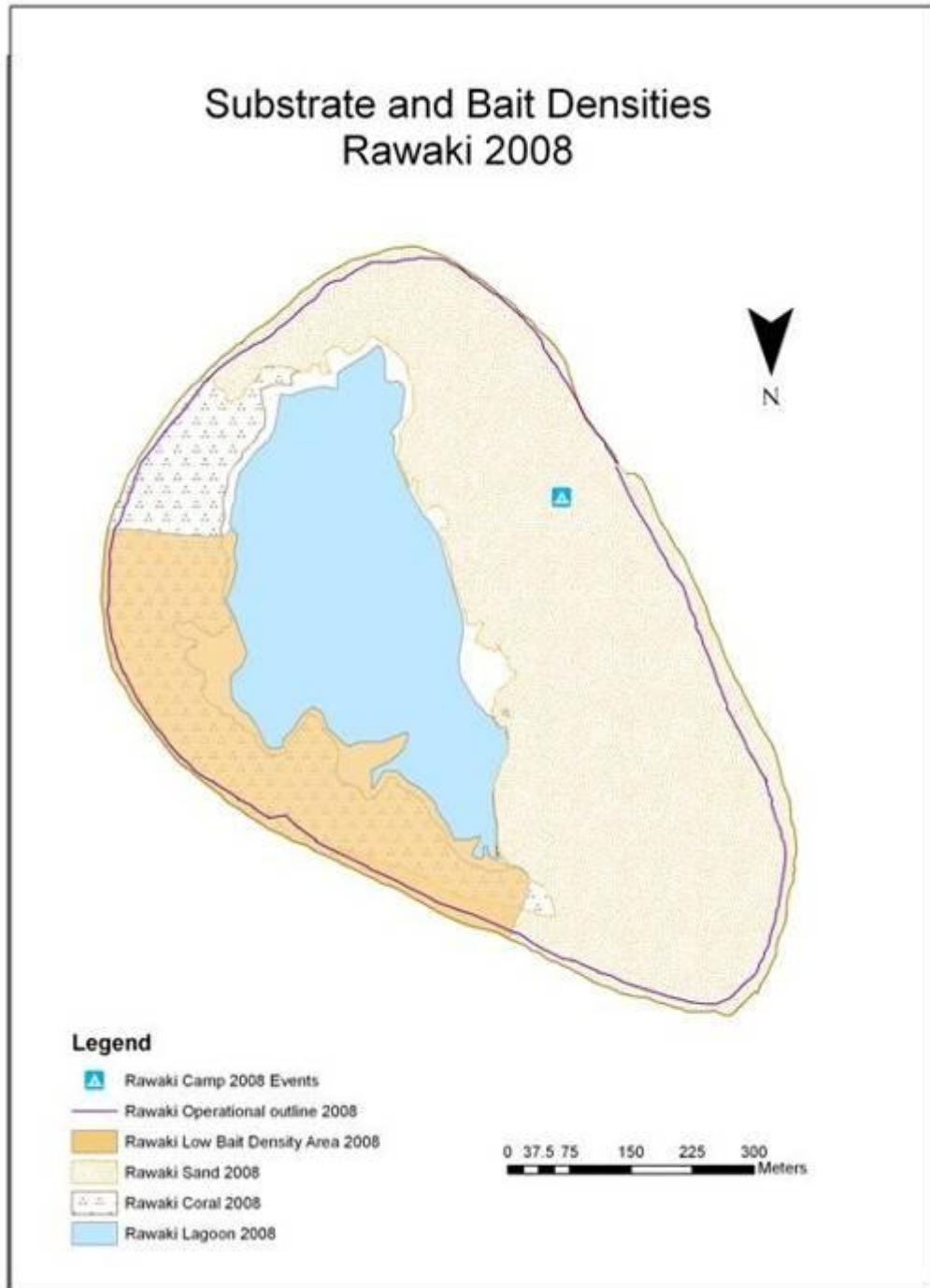


Figure 3.1 – Map of substrates or Rawaki and the low bait density area (dark shaded). The high bait density area corresponds with the island area within the operational outline and exclusive of the low bait density area.

### 3.2 Rabbit population densities and behaviour

Population densities were measured using the same methodology as in 2006 (Pierce et al. 2006) and using the same observer (Mike Thorsen).

#### Population density

The overall population density estimate of rabbits on Rawaki was lower than that estimated in 2006 (Appendix 2) and overall there was a 28.1% reduction in total population size. This could be attributed to a recent long drought reported from the region. A change from 2006 was that more individuals were recorded in coral-based succulent shrubland habitats in 2008. The peak density of 85 individuals ha<sup>-1</sup> was lower than the 114 individuals ha<sup>-1</sup> recorded in 2006.

#### Demography

The demography of the population of rabbits on Rawaki in 2008 consisted of smaller animals with lower body weight than recorded in 2006 (Refer Appendix). Pelt condition of rabbits in 2008 was in worse condition, with most animals having areas of matted fur. Some individuals also had a mange-like condition on the ears. 67% of the individuals captured in 2008 were female, similar to the 70% recorded in 2006. As in 2006, no females were found that had evidence of recent breeding activity.

#### Behaviour

Behaviour (such as approachability) of rabbits in 2008 was similar to that in 2006. Mating was recorded several times in 2008, 3-5 days after initial bait deployment. No mating was observed in 2006, and it is possible that the recent additional food source provided by the bait, possibly in conjunction with the recent breaking of a drought, may have stimulated breeding in the population.

Rabbits were frequently observed feeding on dead *Boerhavia* twigs picked up from the ground. Some feeding was observed on *Portulaca* flowers. Feeding sign on *Portulaca* stems and stems of seedling *Boerhavia* was common. It was apparent that some individuals would travel considerable distances between shaded daytime retreats and their feeding areas.

Sunbathing, in which animals stretch out along the ground with legs extended, was observed on some mornings and following rain in a few animals. Social behaviour was most intense at dusk at which time individuals frequently interacted, sometimes moving more than 50 m to do so.

### 3.3 Baiting grid layout

The aim was to spread bait over the entire island using a pre-established 25 m x 25 m grid. To achieve this, a central reference line was established along the main axis of the island using 1 m tall sections of flexible 25 mm white PVC pipe. From this central line grid lines were established at 25 m intervals along set compass lines perpendicular to the central reference line. Points were marked using four different colours of flagging tape attached to 30 cm wire pegs - a single colour of tape was used on each line, this being different to the adjacent

lines in order to avoid confusion and to avoid accidental ‘crossover’ when travelling each line. A total of 57 parallel lines 25 m apart were established across the high target bait density area of the island. A total of 478 points were marked. The longest line had 17 stations at 25 m intervals, the shortest just two. It took most of one day for 5-7 people to establish the bait grid. At the same time as the grid was being laid out several people established strategic ‘dumps’ of bait. These were situated at 50 m spacing along the central reference line and with a further dump situated in the low target bait density part of the island. Approximately 5-6 hours were required for the bait to be spread in each application, using a team of 4-7 people.

The grid was not extended into the densely-packed frigate bird colony where disturbance was deliberately kept to a minimum. Rabbits did not appear to reside within the most densely occupied portions of these colonies, so approximately 120 kg (first application) and 80 kg (second application) of bait was distributed ‘by eye’ around the periphery of the frigate bird sub-colonies, the largest of which was estimated to measure 60 m x 15 m. These six sub-colonies included discrete nesting (mainly incubating) and displaying concentrations (of lesser frigate bird) and a single more diffuse concentration of nesting great frigatebirds (mainly adults and large chicks).

The grid was also not established in the low target bait density area. Here, for approximately 300 m, it was so narrow between the internal lagoon and exterior coast that grid points were not required, and effective treatment could be obtained by several people walking line-abreast at approximate 20 m intervals, and spreading bait at 25 m intervals set by a lead baiter.

Extra bait was applied at approximate 25 m intervals around the edge of the lagoon and around the northwest to south coasts where rabbit numbers appeared highest and cover in the form of coral boulder rubble was most common.

### 3.4 Bait coverage, bait take and bait longevity

Because of a discrepancy between calculated area and actual area of the island, surplus bait that had been landed on the island was spread in high risk areas such as dense rabbit populations, areas of abundant cover, and peripheries of operational areas. Bait coverage and bait take was monitored using 25 m x 2 m transects, placed randomly on each occasion to avoid disturbance to resident rabbits. On Rawaki the remeasurement was taken at a new randomly selected site, but on McKean a mixed approach was used - the above approach plus remeasuring at the same transect. Bait density was measured using the number of 10 kg bags of bait used in each area for both islands.

#### Effort involved

Approximately 5-6 hours were required for the bait to be spread in each application, using a team of 4-6 bait spreaders supplied by 2-3 people (when available) transporting bait from the temporary bait dumps.

#### Bait coverage

Bait coverage, as measured by number of baits recorded in randomly-located 25 x 2 m transects, in the first application varied between 0 (10.1% of 99 transects in high bait density target area, 22% of 41 transects in low target bait density area) and 211 (in high target bait density area) or 121 (in low target bait density area) (Figure 3.41). No significant gaps in bait coverage were detected within the operational area.

#### Bait density

Target bait densities for Rawaki as detailed in the Operational Plan, were 50 kg ha<sup>-1</sup> over the high target bait density area and 25 kg ha<sup>-1</sup> in the low target bait density area for the first application, and 20 kg ha<sup>-1</sup> over the high target bait density area and 12 kg ha<sup>-1</sup> in the low target bait density area for the second application (Table 3.2). Overall bait quantities used on Rawaki in the first application on 29 May were 130 kg in the low target bait density area (= 12.7 kg ha<sup>-1</sup>) and 1810 kg in the high target bait density area (= 56.9 kg ha<sup>-1</sup>).

Table 3.2 - Bait densities used at Rawaki

|                         |          | 1 <sup>st</sup><br>Application<br>(kg ha <sup>-1</sup> ) | 2 <sup>nd</sup><br>application<br>(kg ha <sup>-1</sup> ) | Total<br>overall<br>(kg ha <sup>-1</sup> ) |
|-------------------------|----------|--|--|--|
| High<br>density<br>area | Planned  | 50   | 20   | 70   |
|                         | Actual   | 56.9   | 34   | 90.9                                       |
|                         | Measured | 33.5   | 24.1   |  |
| Low<br>density<br>area  | Planned  | 25   | 12   | 37   |
|                         | Actual   | 12.7   | 11.8   | 24.5                                       |
|                         | Measured | 27.6   | 0.7  | 28.3                                       |

Bait quantity used in the second application on 1 June was 1080 kg in the high target bait density area (= 34 kg ha<sup>-1</sup>). Bait quantity used in the second application in the low target bait density area on 1 June was 120 kg (= 11.8 kg ha<sup>-1</sup>). Combined bait density over the two applications was 90.9 kg ha<sup>-1</sup> in the high target bait density area and 24.5 kg ha<sup>-1</sup> in the low target bait density area. Bait density, as measured in randomly-located 25 x 2 m transects, varied between 0 and 145.2 kg ha<sup>-1</sup> and averaged 33.5 ±10.6 kg ha for the first application and 24.1 ±4.5 kg ha<sup>-1</sup> for the second application in the target high bait density area, and 27.6 ±10.2 kg ha<sup>-1</sup> for the first application and 0.7 kg ha<sup>-1</sup> ±2.0 in the low bait density target area (refer Figure 3.1). The transects showed lower densities of bait than was actually applied (even when confidence levels are applied). This is hard to explain, but may have resulted from combinations of some bait being eaten or falling into crevices, burrows, etc; bait being deliberately placed in specific sites; or insufficient sampling.

#### Bait condition and longevity

Bait condition during this operation was similar to that observed on McKean Island, but baits were not subjected to the same quantity of rain and so remained much more intact than baits on McKean Island. Seabird movement had a much greater effect on baits than on McKean Island, and a low proportion of baits (c.

10% at time of departure from the island) had become partially buried as a result of seabird trampling.

Bait take

Bait loss, which includes the quantity of bait consumed by target and non-target species, is given in Figure 3.2. Bait loss was minimal, and undetectable by the monitoring method used, over the five nights of monitoring in both the high and low target bait density areas.

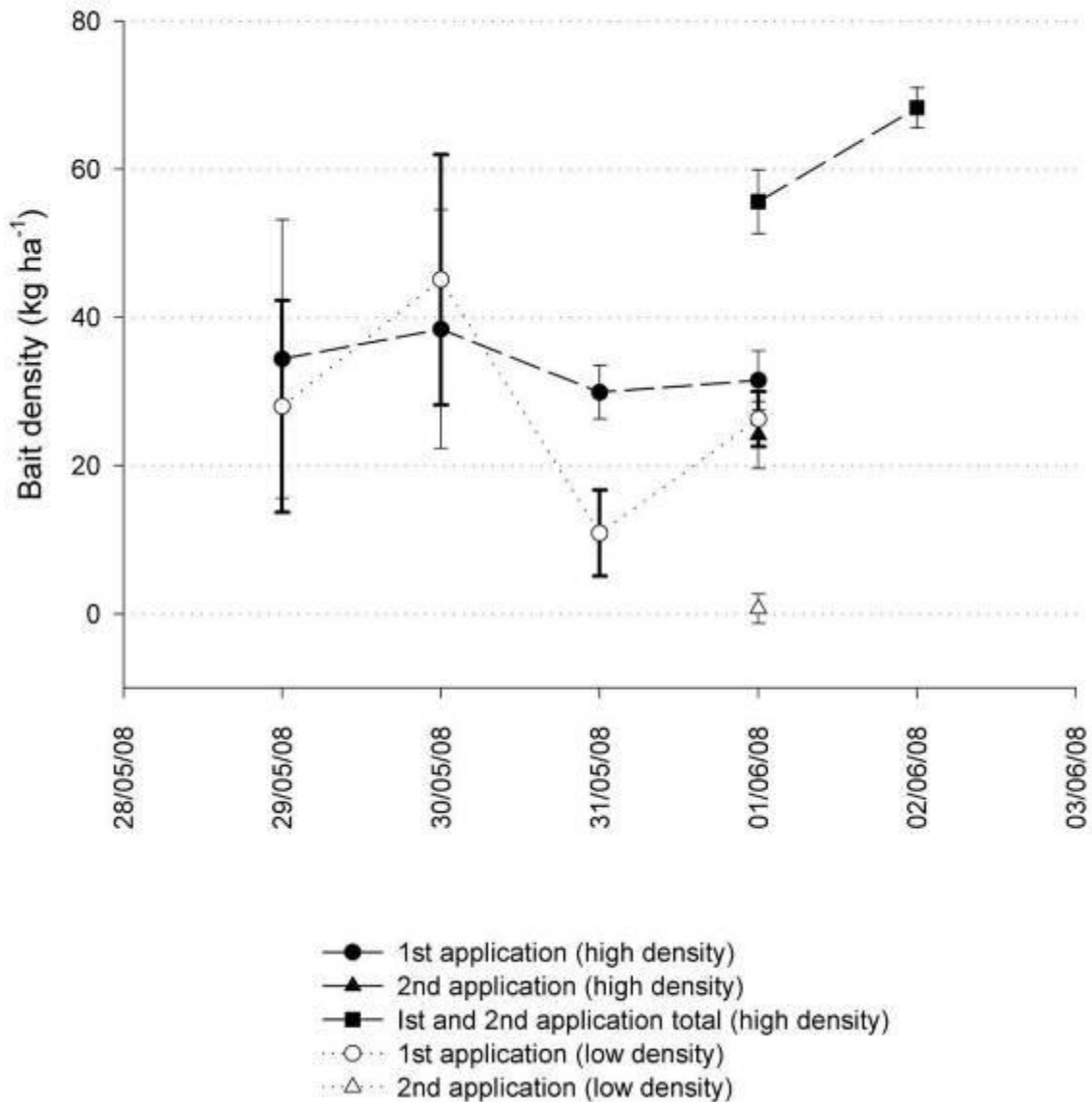


Figure 3.2 - Bait density and changes in bait density for first and second applications of bait in high density (high density) and low density (low density) rabbit areas estimated from 50 m<sup>2</sup> transects on Rawaki. Error bars are ± 95% Confidence Interval

*Bait take by rabbits:*

The quantity of bait consumed by rabbits is unknown, but clearly more bait was used than was necessary. Some individual rabbits investigated baits on the evening of Night 1, but it was not until the evening of Night 2 that some rabbits were seen consuming baits. By the evening of Night 4 most observed rabbits were consuming some bait. Rabbits were observed consuming baits during the evening and at night from this point on. Rabbits fed on bait in a distinctive fashion – the head is held low and the bait maneuvered by the mouth until in position. Only a small amount was consumed from each bait (1-2 bites), before moving on to another bait. In some instances many baits (c. 20) were fed on by an individual in one session. The total amount of bait consumed however, was negligible in comparison with the total amount of bait deployed.

One rabbit shot on the morning of Night 3 had bait in the stomach and 15 rabbits shot on the morning of Night 6 all had some sign of bait in their stomachs, but in two of these this was reduced to white flecks in the gut. One of these rabbits also showed clinical sign of brodifacoum poisoning with haemorrhaging around the kidney. The first rabbits that had died as a result of poisoning were found four days after initial baiting. Freshly dead rabbits were encountered regularly the next day. On returning to the island on 9<sup>th</sup> of June many dead rabbits were found, most of which had died within 1-2 m of a retreat site. It is estimated that approximately 98% of the rabbits were killed by the poison operation (Fig 3.3).

*Bait take by non-target species*

Bait was observed being consumed by several non-target species on Rawaki – bristle-thighed curlew, Pacific golden plover, ruddy turnstone, , cockroaches, ants, and the crabs *Geograspus* sp., *Coenobita perlatus* (hermit crabs) and a single *Birgus latra* (coconut crab) which was also present (refer Section 5). None of these species was thought, or observed, to consume significant quantities of bait in relation to total bait.

Baits partially consumed by non-target species had a relatively fresh appearance, compared with some other baits not eaten, which may have increased their attractiveness to target species.

Table 3.3 - Area in hectares (rounded to 1 decimal place) of cover types on McKean and Rawaki as calculated in ArcMap from hand-held GPS points. Cover types are not exclusive.

| Cover type                           | Rawaki (ha) | McKean |
|--------------------------------------|-------------|--------|
| Land                                 | 45.7        | 28.6   |
| Lagoon                               | 13.8        | 18.7   |
| Sand substrate                       | 31.9        | 16.5   |
| Coral substrate                      | 10.7        | 9.4    |
| Operational Area                     | 42.0        | 28.6   |
| Low target bait density area         | 10.2        | 8.7    |
| High target bait density area        | 31.8        | 19.9   |
| Sand-based <i>Boerhavia</i> sandflat | 13.1        | 0      |

|   |                                     |      |
|---|-------------------------------------|------|
| Sand-based <i>Portulaca/Boerhavia</i> shrubland | 16.6 (incl. 8.3 of dense shrubland) | 10.2 |
| Coral-based <i>Portulaca</i> shrubland          | 8.7                                 | 9.4  |
| <i>Sesuvium</i> herbfield                       | 3.2                                 | 4.5  |
| <i>Lepturus</i> grassland                       | 4.1                                 | 0    |
| <i>Tribulus</i> shrubland                       | 0                                   | 4.0  |
| <i>Sida</i> shrubland                           | 0                                   | 0.4  |
| <i>Pisonia</i> grove                            | 0                                   | 0.1  |

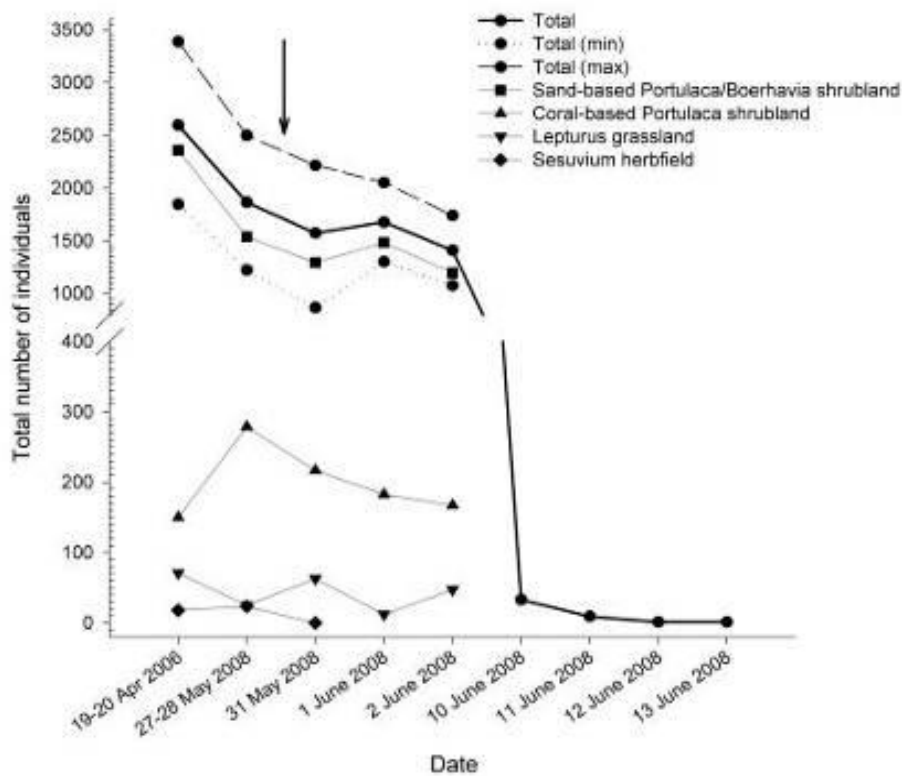


Figure 3.3 - Change in total population (thick line,  $\pm$  95% confidence level, broken lines) and mean total population in different habitat types (grey lines) of rabbits on Rawaki 2006 to 2008. Notes: arrow indicates first bait application date (29 July 2008), y-axis (date) not to scale, x-axis crosses below 0 and is broken between 400 and 800, inner tick marks represent 10 individuals (below break) or 50 individuals (above break).

### 3.5 Hunting

Hunting of rabbits began 11 days after the first bait application and involved a two person self-supported team. Rabbits were observed to be naive to hunters: they could in almost all situations be approached to within 20-30 m without

undue reaction, especially if the approach was oblique (i.e. not directly towards them but at an angle to bring the hunter closer whilst not seemingly presenting a threat to the rabbit). While avoiding close proximity to humans, rabbits showed little wariness. The intensive 'benign' human activity associated with bait spread and biota monitoring may have helped to accustom the rabbits to human presence prior to commencement of hunting. Cover was extremely limited, and hunter's visual coverage was excellent – rabbits were extremely conspicuous when out of their daytime cover. Rabbits were active at all stages of the day but noticeably less so during the heat of midday.

Three distinct hunting periods were targeted during each day – the first two hours of daylight, the last two hours, and throughout the night using spotlights. Coverage of the island could be achieved by one hunter within a couple of hours. Effort was staggered with both hunters doing afternoon hunts, but operating sequentially with spotlights at night, with the person doing the early night shift also doing the early morning hunt.

All rabbits were shot using .22 calibre rifles with sound modifiers. Both hunters used a shooting stick as a support when firing to ensure accuracy. A total of 43 rabbits were shot within four days, and there was subsequently no sign of any further rabbits remaining. Most rabbits were shot during late afternoon (25), with 13 shot at night, and 5 in the morning hours. However, this bias towards late afternoon success reflects firstly that the majority of the rabbits were shot in the first four hours of hunting (in the afternoon of the 9<sup>th</sup>) and secondly the relative effort.

Importantly, all rabbits shot at were killed. There were no instances of rabbits being shot at and missed or in any other way surviving a bad encounter with humans that might have educated them or made them more wary. On several occasions rabbits ran into one of the very limited areas of deep cover (rock jumbles) before any shot was attempted. However, return visits to each of these locations accounted for the rabbit concerned. Rabbits were often individually identifiable by their colour and pattern, and the last two rabbits shot were known from sightings in the same areas over the previous days.

There was no obvious pattern to the areas of the island in which the rabbits were shot, or where the last few animals were encountered - it appeared to be chance, or a simple reflection of former densities. Most animals shot were in areas of previously high density, principally on the western portion of the island. No obvious difference in survival rates on coral or sand-based substrate was detected. Only two of the 43 animals were shot in the low density baiting areas (the coral rubble on the eastern side of the island).

The last two rabbits shot were at the extreme north end of the island, and at the NW corner of the lagoon. These areas had been searched repeatedly, and both rabbits had been seen on previous days, but the relatively good cover (in the form of large coral blocks and rubble) in those areas assisted in their temporary evasion of hunters.

Rabbits shot were an approximately even mix of adult males and females although precise details were not kept. Approximately one-third had clinical signs (internal haemorrhaging) of brodifacoum poisoning and/or some bait in their gut. Most appeared no longer to be feeding on the bait, and in all likelihood would have survived the baiting operation.

The trained rabbit-locating dog Sako was used daily during the last six days on the island with at least two sweeps of the island being made per day. Sako located freshly dead rabbits, but encountered or discovered no live rabbits. It was reassuring to have her present at this time (when no rabbits were sighted) in order to test for changed rabbit behaviour, hiding rabbits, etc. The other hunting/trapping options (e.g. live-capture and leg-hold traps, Magtoxin fumigant, .223 rifle, shotguns) were similarly not required. Fresh water placed in bowls did not seem to attract any rabbits. Several rabbits were seen licking their fur after the brief but regular rain showers, and it appears this is how they obtained their limited requirements for water intake.

While the monitoring after the last rabbit was shot was limited in time, we are very confident of successful eradication. Both hunters had had considerable opportunity to study the rabbit behaviour and the use of habitats before and during the baiting operation and in the early stages of the hunting phase, and this was very useful in developing hunting and surveillance strategies. Particular search emphasis was placed on the previously heavily-used hiding places of coral slabs at the north end of the island and rubble and *Sesuvium* at the north end of the lagoon. Overall, we feel the comprehensive searching possible in such a small and very open island more than compensated for the time constraints.

### 3.5 Lessons learnt

A considerable amount was learnt during the eradication for future campaigns against rabbits (and rats, refer Section 4) in a tropical setting. Key lessons were as follows:

- The 200-litre black barrels were a good way to transport the bait to the Phoenix Islands. They alleviated a concern about biosecurity (particularly crazy ants) in storage at Apia. However, unless empty, they were too heavy to man-handle on and off the inflatable to get ashore at the islands, so repeated handling of each bag of bait was necessary. The barrels did prove handy (once cleaned) as temporary waterproof storage on the island prior to and between bait applications. The use of 50 litre dry bags for landing bags of bait and also for transporting them around the island worked very well. Smaller barrels could also be useful for this type of work, but they would reduce the ratio of bait to total space available in containers, etc.
- Placement of loose bait in barrels should be avoided as far as practical in future. Loose bait proved to be hazardous and extra work as it was difficult to remove from the barrels without considerable spillage and dust contamination, and was also more difficult to transport around the islands than the intact bags of bait. Also, as amount of loose bait in each

barrel apparently varied, it made precise calculations of bait unloaded and/or spread difficult to achieve, though discrepancies would have been relatively small.

- Desiccant was trialed within the bait barrels and proved unnecessary in this instance. No appreciable difference could be detected in general quality of bait in barrels without desiccant to that in barrels with various quantities of desiccant. The only observed effect of desiccant was negative: where the bags of desiccant had contact with the loose bait in a barrel it appears that the desiccant concentrated any moisture in the barrel, and this then 'wicked' onto the loose bait touching the desiccant bag. The result was a few wet baits surrounding many of the bags and if left much longer they would probably have promulgated development of mould.
- Monitoring of bait densities should use two methods 1) quantity of bait spread over a known area, and 2) repeated measures of randomly located transects as used on McKean. The use of completely randomized transects (used on Rawaki) should only be used where there is concern that repeated visits to a site may result in behavioural changes to animals at that site.
- The care taken in hunting rabbits to make each encounter lethal and thereby eliminate the opportunity for survivors to learn to avoid hunters was considered an important factor on the success of this eradication. Hunting of rabbits began earlier (11 days after first bait broadcast) than ideal, as information from previous operations e.g. Enderby (Torr 2002), St Paul (Micol & Jouventin 2002) and Cabbage Tree Islands (Priddel et al 2000) suggests some rabbits take 14 days or more to succumb. However, timetable constraints compelled us to begin hunting at this stage.
- The short planning period (refer Section 3) had flow on effects to the operational aspects of the project in the field, including lines of responsibility and communications, and longer planning periods are needed. Ideally the Eradication Leader should visit the target islands beforehand (was not possible in this case) which would help in decision-making on the appropriateness of various techniques, e.g. usefulness of Magtoxin and other contingencies in combating aversion behaviours if they occur.
- Far more bait was used than was necessary as large quantities remained uneaten at the end of the operation. However it was appropriate to take and use the planned amount in this instance as the effect of non-target species (especially *Coenobita* crabs) was less than expected and rabbit densities were lower than in 2006, both of which may have had a bearing on amount of uneaten bait. Future operations could potentially be more cost-effective and time-effective if lower quantities of bait were transported and used, but planners would also need to factor in fluctuations in rainfall (if known) and potential effects of this on crab and rabbit densities.

## 4.0 MCKEAN ISLAND RAT ERADICATION

### 4.1 Summary of operational activities and timetable

- Target pest: *Rattus tanezumi*
- Refer island map Fig 4.1
- Rat densities estimated by transect
- Pest-Off 20R bait hand-spread in two pulses 5 days apart
- The hand-spreads were at 25 m intervals on pre-established 50 m grid
- First hand-spread baiting density was 30.7 kg/ha in high rabbit density areas and 18.4 kg/ha in low rabbit density areas, after which all operators left the island for 5 days
- Second hand-spread baiting density was 16.6 kg/ha in high rabbit density area and 14.9 kg/ha in low density areas (but this was later repeated due to wet weather)
- Supplementary bait spreads were undertaken around the perimeter of the island and the edge of the lagoon
- 100 bait stations were established on a 50 m grid and loaded with 250 g of bait and rebaited 5 days later
- A follow-up check of rat status should occur in late 2009.

June 5<sup>th</sup> – arrived at McKean Island c.0700 h, most equipment and stores ashore and camp established by midday. 25 m x 50 m bait grid established in pm.

June 6<sup>th</sup> – first bait application, using c. 770 kg over the entire treatment area and wreck of MV Chance. 100 stations with 250 g bait installed at 50 m intervals over entire island, including shipwreck. Rat seen consuming bait.

June 7<sup>th</sup> – Team departed for Rawaki.

June 8<sup>th</sup> – In transit to Rawaki

June 9<sup>th</sup> – Rabbit team dropped on Rawaki

June 10<sup>th</sup> – Rat team visit Birnie then depart for McKean Island.

June 11<sup>th</sup> – Rat team arrive McKean Island and do second bait application (530 kg) in high target bait density area. Stations rebaited with a further 250 g of bait each.

June 12<sup>th</sup> – Bait re-applied on McKean Island high target bait density at 20 kg ha<sup>-1</sup> (385 kg) after heavy rain (c. 10-15 mm) at night

June 13<sup>th</sup> – Rain during night (c. 7-8 mm) and in morning. Second bait application in low target bait density area (130 kg) + 20 kg spread around ruins + 30 kg around lagoon edge + 40 kg in northern target high density area on McKean Island. Rat team boards Bounty Bay but stay at McKean Island in order to monitor weather conditions.

June 14<sup>th</sup> – Rat team depart McKean Island for Abariringa and Rawaki

### 4.2 Asian rat population densities and behaviour

Population densities of Asian rats on McKean were measured using the same methodology as in 2006 (Pierce et al. 2006) and using the same observer.

### Population density

The population of Asian ship rats on McKean were at a lower over-island average density and within-habitat density (with the exception of coral-based succulent shrubland habitat) than that recorded in 2006 (Appendix 2). Overall there was a 59.4% reduction in total population size from 2006 to 2008. This is could be attributed to two factors: a recent long drought recorded from the region and the population is also probably in a post-irruptive stage following their invasion of the island (assumed to be in c.2001-02). However, the peak density recorded of 135 animals ha<sup>-1</sup> was slightly higher than the 110 animals ha<sup>-1</sup> recorded in 2006. Changes in total population of Asian ship rats between 2006 and 2008 is given in Figure 4.2.

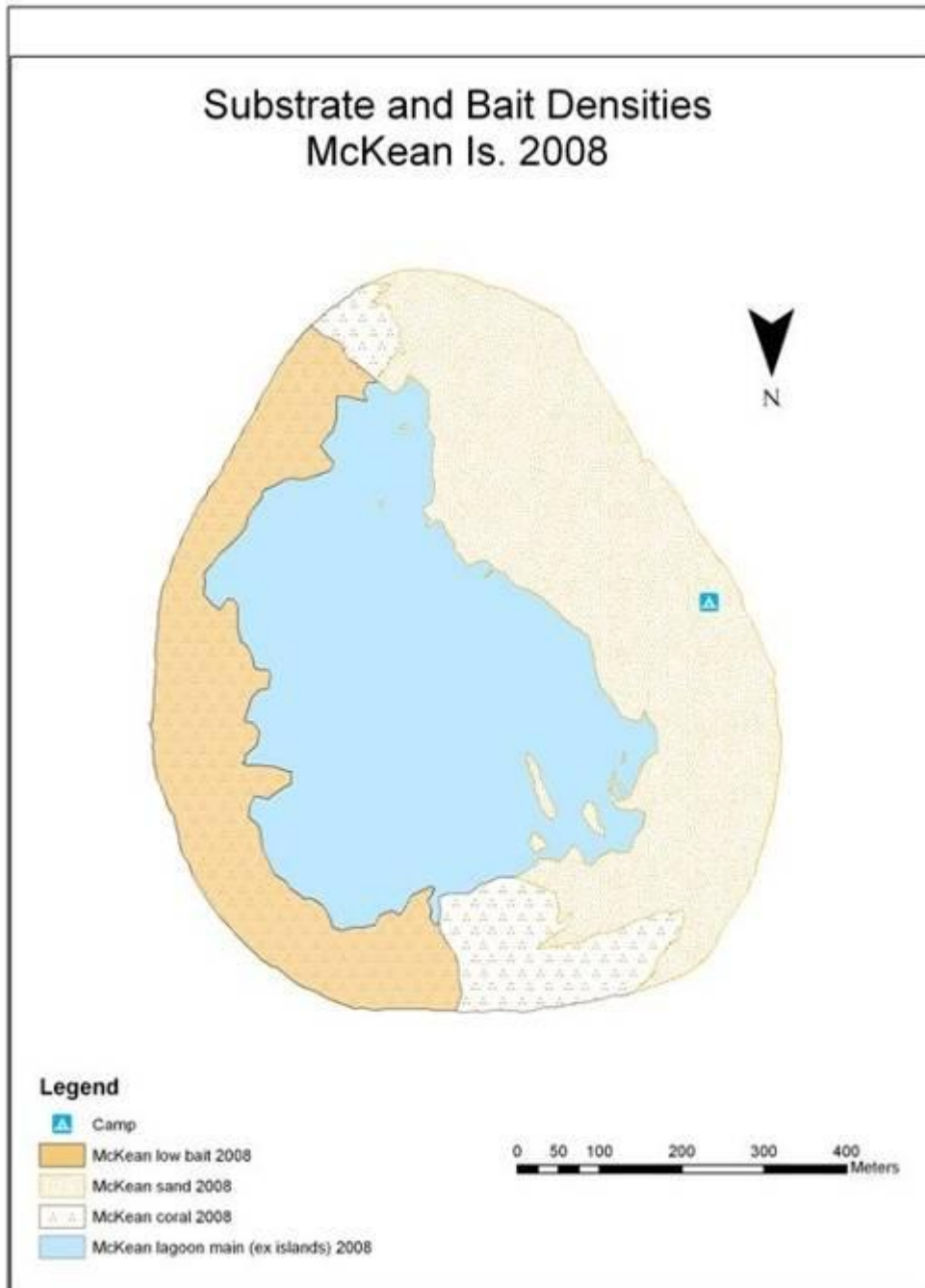


Figure 4.1. Map of the substrates of McKean Island and low bait density area (dark shaded). The high bait density area (not shown) is the rest of the land area excluding the low bait density area.

Demography

Very few animals were captured. The few captured indicate that breeding was occurring at the time of the visit, but this is likely (as it was in 2006) to have been from a small proportion of the population. Some smaller rats than in 2006 were recorded (Appendix 2) and it is possible that average body size of the population in 2008 was smaller than in 2006. Body condition appeared similar to 2006.

Behaviour

Unlike in 2006, no individuals were seen during daylight hours.

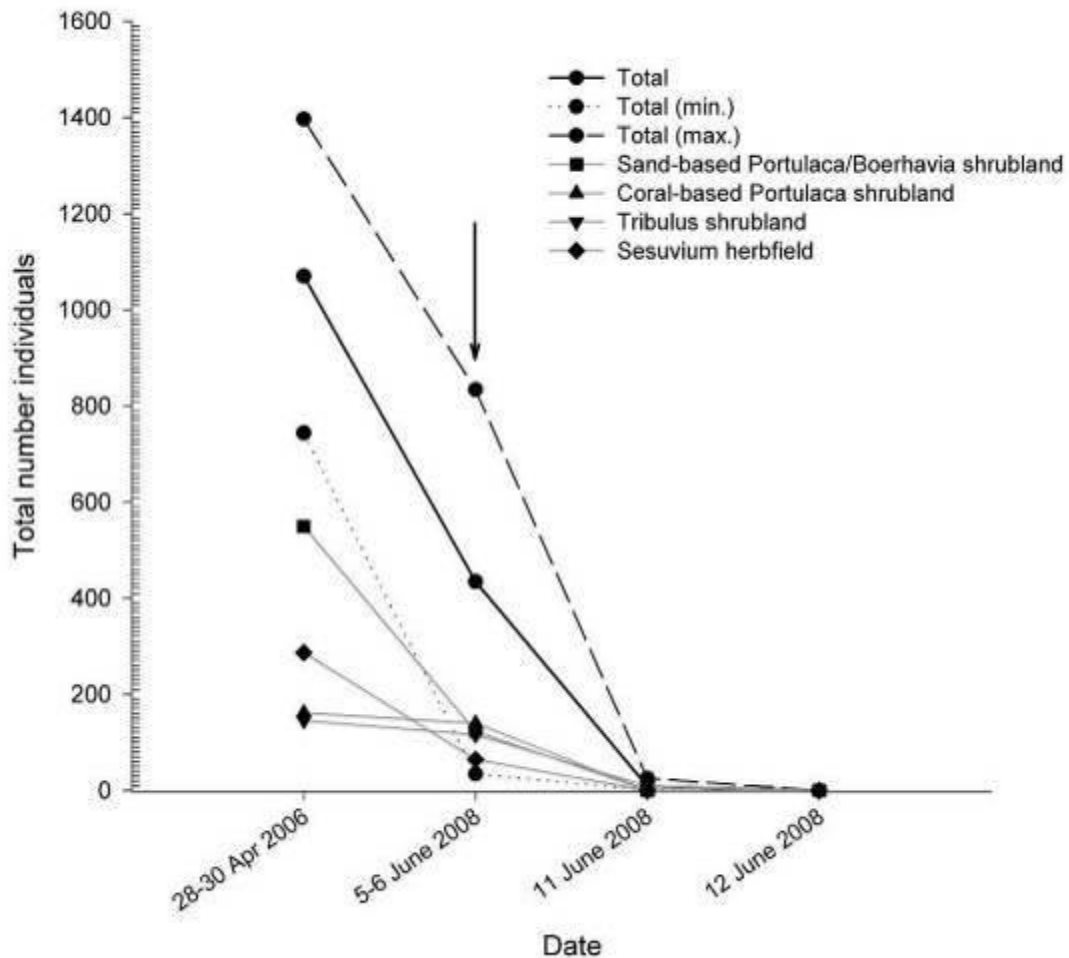


Figure 4.2. Change in total population (thick line, ± 95% confidence level, broken lines) and mean total population in different habitat types (grey lines) of Asian ship rats on McKean 2006 to 2008. Notes: arrow indicates first bait application date (6 June 2008), y-axis (date) not to scale, x-axis crosses below 0, inner tick marks represent 10 individuals.

## 4.3 Bait grid layout

### Hand-spread grid

The bait grid was established in the high target bait density area using parallel lines 50 m apart, with flagged points at 25 m intervals along each line. To achieve this, a central reference line was established along the main axis of the island using 1 m tall sections of flexible 25 mm white PVC pipe. From this central line grid lines were established at 50 m intervals along set compass lines perpendicular to the central reference line. Points were marked using two different colours of flagging tape attached to 30 cm wire pegs (each line consisted of points of a single colour of tape, and adjacent lines were of the alternate colour, to ensure the baiter could identify their own line by colour of the flags, avoiding accidental crossover onto an adjacent line). A spacing of 50 m was used between grid lines instead of the planned 25 m to speed establishment time. A total of 159 points was established on the grid. Bait was spread on a 25 m x 25 m grid by a person walking between the established lines and maintaining a 25 m spacing using 'eye' judgment. At the same time as the grid was being laid out several people established strategic 'dumps' of bait. These were situated at 50 m spacing along the central reference line and with a further dump situated in the low target bait density part of the island. Approximately 3-4 hours were required for the bait to be spread in each application, using 5-7 people.

In the low target bait density area bait spread was by 3-4 people walking line-abreast parallel to the lagoon edge and coast. Some 42 stops were made at 25 m intervals.

### Bait stations

The bait stations used were 15 litre 230 mm x 230 mm square x 340 mm high plastic pails with a secure lid (Fig 4.3). In one wall of this a 150 mm wide x 100 mm high entrance hole was cut. A trial to determine accessibility by hermit crabs (*Coenobita perlatus*) was conducted of the bait stations with the entrance hole 160 mm above ground level and 200 mm above ground level. No crabs could gain access at either height so bait stations were constructed using the 160 mm entrance hole height as this was thought to be less of a deterrent to rat access.



Fig 4.3 – McKean bait station.

One hundred bait stations were established at 50 m intervals and were placed with the entrance hole facing west, sheltered from the prevailing easterly trade winds. These were baited on the same day as they were installed, using approximately 250 g of bait per station and were rebaited with a further 250 g of bait 5 days later.

#### 4.4 Bait coverage, bait take and bait longevity

Because of the discrepancy between calculated area and actual area of island, surplus bait that had been landed on the island was spread in high risk areas such as dense rat populations, areas of abundant cover, and peripheries of operational areas. Bait coverage and bait take was monitored using 25 m x 2 m transects in a mix of randomly placed and permanent transects. Bait density was measured using the number of 10 kg bags of bait used in each area for both islands.

##### Effort involved

Approximately 3-4 hours were required for the bait to be spread in each application, using a team of 4-6 bait spreaders supplied by 2-3 people (when available) transporting bait from the temporary bait dumps.

##### Bait coverage

Bait coverage, as measured by the number of baits in permanent and randomly-located 25 x 2 m transects, varied between 0 (3.8% of instances in high bait density target area, 40% of instances in low target bait density area) and 41 (in high target bait density area) or 22 (in low target bait density area) (Figure 4.4). No significant gaps in bait coverage were detected within the operational area.

##### Bait density

Target bait densities for McKean Island as detailed in the Operational Plan were, for both the first and second applications, 25 kg ha<sup>-1</sup> over the high target bait density area and 12 kg ha<sup>-1</sup> in the low target bait density area (Table 4.1).

Table 4.1 - Bait densities used at McKean Island

|                         |          | 1 <sup>st</sup><br>Application<br>(kg ha <sup>-1</sup> ) | 2 <sup>nd</sup><br>application<br>(kg ha <sup>-1</sup> ) | Total<br>overall<br>(kg ha <sup>-1</sup> ) |
|-------------------------|----------|--|--|--|
| High<br>density<br>area | Planned  | 25   | 25   | 50   |
|                         | Actual   | 30.7   | 16.6+19.3  | 80.4                                       |
|                         | Measured | 12   | 14.6+8.8   | 33.4                                       |
| Low<br>density<br>area  | Planned  | 12   | 12   | 24   |
|                         | Actual   | 18.4   | 14.9   | 35.1                                       |
|                         | Measured | 4.9  | -  | -  |

Overall bait quantity used on McKean Island in the first application on 6 June were c. 770 kg, 160 kg in the low target bait density area (= 18.4 kg ha<sup>-1</sup>) and 610 kg in the high target bait density area (= 30.7 kg ha<sup>-1</sup>).

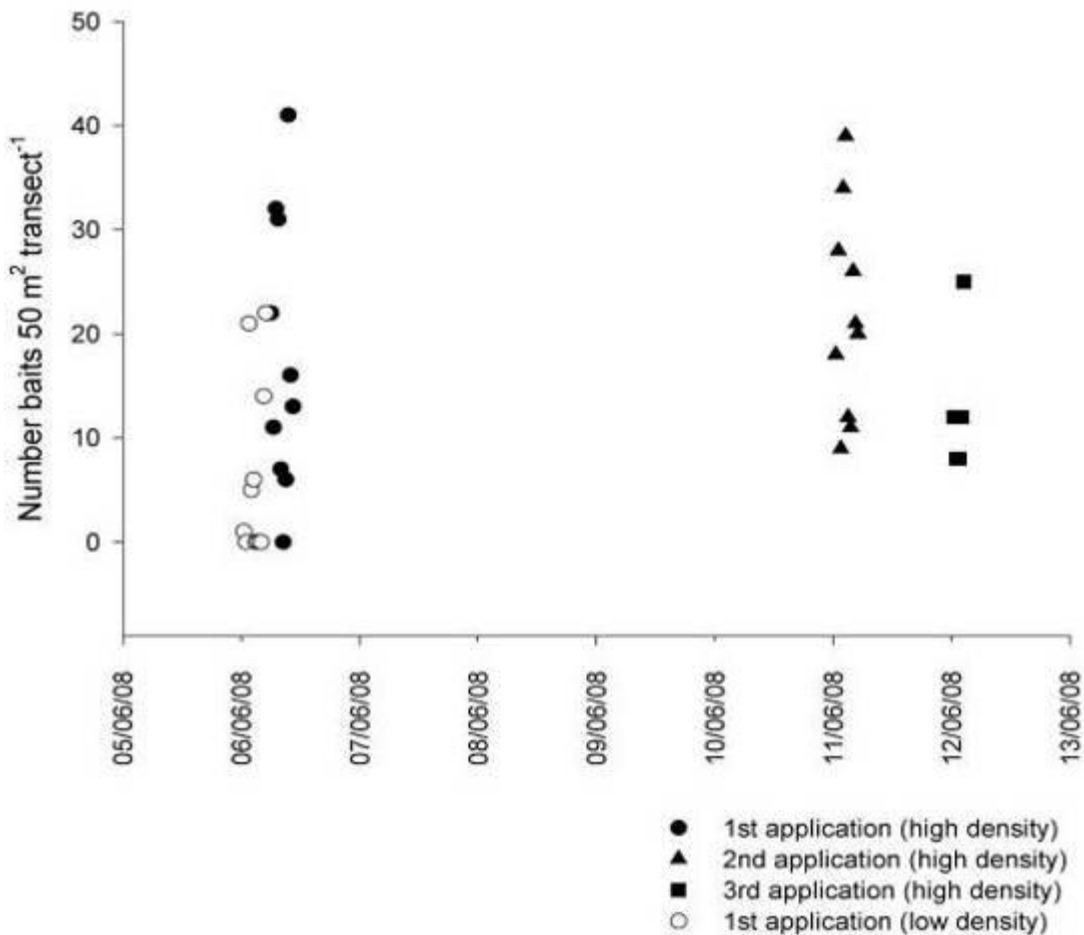


Figure 4.4 - Number of Pestoff 20R baits recorded in permanent and randomly-located 25 x 2 m transects in high and low target bait density areas for bait applications one, two and three on McKean Island.

Bait quantity used in the second application on 11 June was 530 kg in the high target bait density area (= 16.6 kg ha<sup>-1</sup>). Following c. 10-15 mm of rain on the night of the 11<sup>th</sup> a third application was done in the high target bait density area using 385 kg (= 19.3 kg ha<sup>-1</sup>) on 12 June. Bait quantity used in the second application in the low target bait density area on 12 June was 130 kg (= 14.9 kg ha<sup>-1</sup>). Also, on the 12<sup>th</sup> June further bait was spread along the lagoon edge (30 kg), around ruins (20 kg) and in the high target bait density area (40 kg). In total, an average of 49.7 kg ha<sup>-1</sup> was spread in the high target bait density area and 16.7 kg ha<sup>-1</sup> in the low target bait density area during the second visit to McKean Island.

Combined bait density over the two applications was 80.4 kg ha<sup>-1</sup> in the high target bait density area and 35.1 kg ha<sup>-1</sup> in the low target bait density area.

Bait density, as measured in permanent and randomly-located 25 x 2 m transects, varied between 0 and 30.3 kg ha<sup>-1</sup> and averaged 12.0 ± 4.4 kg ha for the first application, 14.6 ± 4.1 kg ha<sup>-1</sup> for the second application, and 8.8 ± 4.1 kg ha<sup>-1</sup> for

the third application in the target high bait density area, and  $4.9 \pm 5.0 \text{ kg ha}^{-1}$  for the first application in the low bait density target area (Figure 4.5).

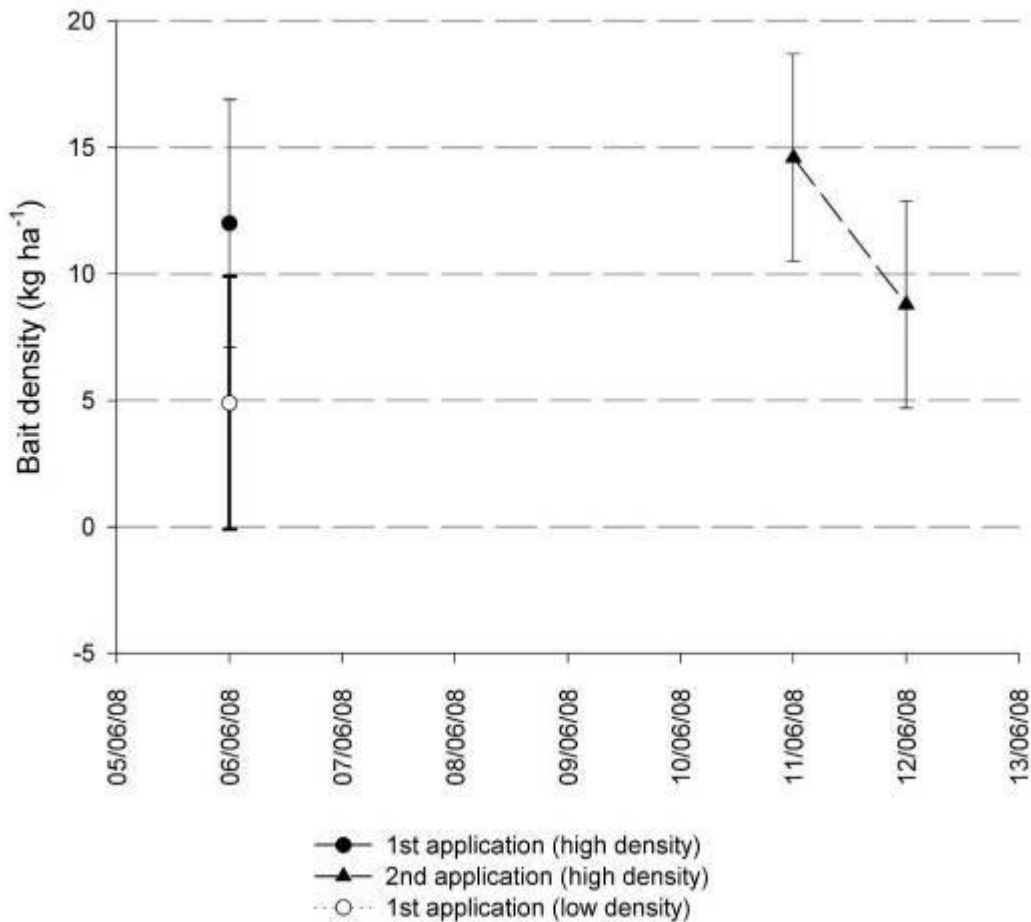


Figure 4.5 - Bait density for first and second applications of bait in high density (high density) and low density (low density) rat areas estimated from 50 m<sup>2</sup> transects on McKean Island. Error bars are  $\pm$  95% Confidence Interval

#### *Bait condition and longevity*

There was no detectable deterioration in bait condition (bait size, hardness, mould contamination) prior to use. Following deployment baits quickly lost colour at sites exposed to full sun. Short showers caused the baits to slightly swell and for the surface to become roughened. On drying the baits would shrink back to approximately normal size, but the surface would remain rough. Repeated short showers had little additional impact on baits. Heavy rain caused the baits to swell and increase weight by c. 56.8%, to begin to lose shape, and also lightly covered baits in some areas with sand.

Seabird activities appeared to have little impact on the baits on McKean Island, but some rain-softened bait was trampled into the sand, especially at the edge of the lagoon. Bait condition within bait stations remained excellent during the trip, with only some slight loss of colour. Rain did not affect the baits in bait stations due to their weather-proof design.

#### Bait take – from hand spread bait

Bait loss, which includes the quantity of bait consumed by target and non-target species, is given in Figure 14. Bait loss averaged 94.6%  $\pm$ 9.6 of weight over five nights in the high target bait density area. Bait loss per night was not linear. 51.4%  $\pm$ 6.4, or approximately half, of bait weight was lost in the first night in the high target bait density area and 29.6%  $\pm$ 42 in the low target bait density area. Loss of bait was primarily through whole bait removal with 90.4%  $\pm$ 12.2 of baits removed over the five nights. Partial bait consumption accounted for the remaining bait loss, with remaining baits losing 65%  $\pm$ 39.6 of weight over the five nights. Some transport of bait by *Coenobita* into the monitoring transects is thought to have occurred, which could explain the increase in average bait weight in the first night at the low target bait density area (Figure 4.6).

#### By Asian ship rat

The quantity of bait consumed by Asian ship rats is unknown. From Night 1 individual rats were observed carrying baits in their mouth and several bait caches were found under debris. Only one non-poisoned rat was captured, on Night 1, and this animal was carrying bait. On returning to the island five days following initial bait application 17 dead or dying rats were seen, including 5 adult ♂, 4 adult ♀, 2 juveniles, 6 of unknown sex or age. All dead rats showed clinical signs of brodifacoum poisoning (haemorrhaging in the body cavity or stomach wall).

#### By non-target species

Bait was observed being consumed by several non-target species and groups – waders, *Geograpsus* sp., cockroaches, ants, and *Coenobita* on McKean Island. Of these species, only *Coenobita* was thought, and observed, to consume significant quantity of bait. *Coenobita* were observed to have an almost feverish response to the first bait application on McKean Island with individuals beginning to feed on baits within 1 hour and groups concentrated around baits. Individuals frequently carried bait some distance (c. 2+ m), sometimes climbing rocks and vegetation, probably to remove the food source from conspecifics. This feverish response was not observed to the same degree after subsequent bait applications. This decrease in crab response to baits probably, in part at least, explains the decreased bait removal rate following Night 1. Why crabs responded to baits less strongly following initial exposure is unknown. Possible explanations are satiation after digestive system is full or after tissue energy levels are increased. No obvious change in crab numbers was observed or measured over this time period. Crab densities varied greatly around the island and in different habitats. Average densities from transects measuring 2 x 25 m<sup>2</sup> were 13.9 per 50 m<sup>2</sup> (0-61, n = 51, refer Appendix 4). Baits partially consumed by crabs and other non-target species had a fresh appearance, which may have increased their attractiveness to target species.

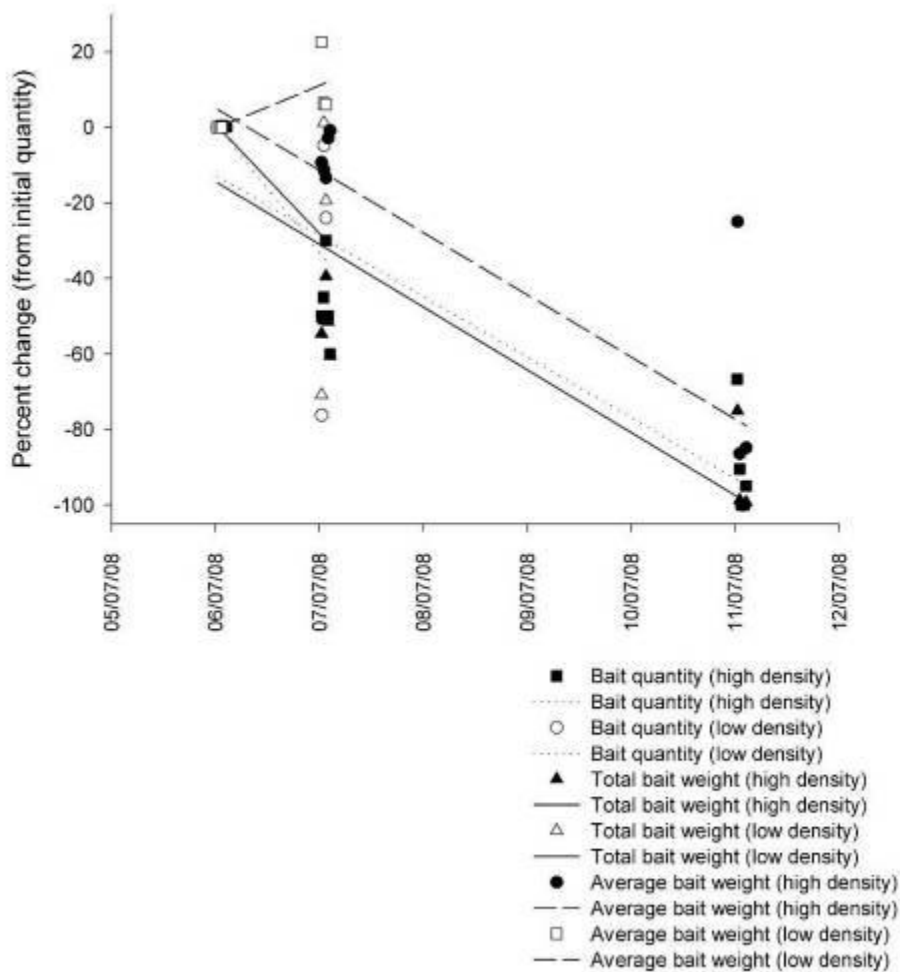


Figure 4.6 - Percentage change following first bait application in bait quantity, total weight of bait, and average bait weight recorded from three (in low target bait density area) and six (in high target bait density area) permanent 25 m x 2 m transects on McKean Island. Bait figures corrected for environmental changes.

*Bait take – from bait stations*

Bait take from bait stations was negligible. Approximately 1% of bait stations contained indications that bait had been consumed. These indications were consistent with bait take by crabs, probably *Coenobita* utilizing surrounding vegetation to access the bait station. No evidence of rats taking bait from the stations was found during our presence on the island.

## 4.5 Lessons Learned

A high incidental bait take was thought to be a certainty based on advice from other projects in arid, sparsely vegetated islands. In reality this issue, though significant, was not as bad as had been considered. Using the results of this eradication, future operations should consider the following:

- Two baiting applications of 12 kg ha<sup>-1</sup> should be sufficient against rat species on crab-infested islands of a similar nature, including coconut palm-dominated coral atolls (refer also Griffiths et al 2008).
- The use of a 25 m x 50 m marked grid as the basis for bait broadcast on McKean proved effective and time saving. However it is a technique best suited to open islands where visibility between baiters is good. Use of such a technique on densely vegetated islands may be more prone to error.
- The use of bait stations is justified when dealing with more complex situations, such as eradications against novel rodent species, but risks to non-targets were unable to be assessed (see Section 5.2 for non-target issues).
- Our evidence is that rodents may not use bait stations in situations where there is an abundance of bait in the environment. As rodents may take time to begin to use bait stations (sometimes requiring over 30 days to do so, M. Thorsen, unpub.), this should not preclude the use of bait stations in eradication campaigns.
- Islands need to have size accurately calculated in order to determine precise bait quantity requirements.

## 5.0 ENVIRONMENTAL EFFECTS, BIOSECURITY AND SAFETY

### 5.1 Key issues

In the AEE for the operation (Pierce et al. 2008), we assessed environmental risks to fauna, flora, ecosystem, soil and water as well as to operators and cultural and historic values. Key concerns were:

- Bristle-thighed curlews dying from secondary poisoning after eating hermit crabs that have consumed bait.
- Pacific golden plovers and turnstones after eating invertebrates that have consumed bait or dead rats or rabbits.
- Frigatebirds that might scavenge on dead or dying rats or rabbits.
- Damage to birds' nests including isolated endangered Phoenix petrel nests.
- Disturbance to birds generally including potential desertion of lesser frigatebird colonies.
- Persistence of brodifacoum.
- Biosecurity risk of alien biota being inadvertently introduced.
- Personnel risks if accidents occurred in such an isolated area.

The AEE considered that if appropriate precautions were taken, all of these factors would be mitigated or at sufficiently low levels to be acceptable. It considered that there could be some secondary kills of birds and other impacts such as nest losses. However, any mortality would be more than compensated through the long term benefits to the island ecosystems, such as increased diversity and abundance of seabird populations (including Phoenix petrels, storm petrels, shearwaters and terns) and flow-on ecosystem benefits to others (e.g. frigatebirds and shorebirds) outweighs any minor impact that might occur as a result of the operation. Recent operations such as the eradication of rats from Motuopao, Red Mercury and other New Zealand islands have resulted in spectacular responses in seabird populations (Towns et al. 2006)

### 5.2 Precautions taken and outcomes observed

Precautions taken to minimize potential environmental effects follow those of the AEE and only a summary is provided here along with details of observed outcomes.

#### Bristle-thighed curlew, golden plover and turnstones

The AEE recommended confining the poisoning to the period when most bristle-thighed curlew, Pacific golden plover and turnstones had returned to their Arctic breeding grounds – the main curlew exodus northwards occurs about late April, returning from mid August onwards (L Tibbitts, USGS, Hawaii, pers comm., Pierce et al. 2006). Poison baits will have broken down and crabs eliminated most of the toxin by the time the main population returns. During the

intervening period the only curlew that will be at risk are sub-adults that remain on the tropical Pacific islands until they mature. Other options, such as scaring them off the island or using vitamin K1 antidote, were discounted for practical reasons.

Despite confining the poisoning to the prescribed period, significant numbers of curlews and golden plover were present, especially on Rawaki, c.f. turnstones and tattler which were scarce. Some individuals of three species – bristle-thighed curlew, golden plover and turnstone – were seen consuming the baits directly. Curlews were first seen eating baits on Rawaki on 2 June, four days after the first baiting of the island. At this time the baits were baked fairly solid on the outside but had soft interiors. On this day five birds were seen foraging at the edge of the lagoon and all consumed parts of baits or entire baits. Whole baits were typically consumed after 3-5 mandibulations and 2-3 swallows per bait, often taking only a few seconds to consume individual baits. Some bait-stealing was observed between birds. On 3 June several curlew (probably some of the same individuals) were again seen consuming baits prior to our departure from the island. It is possible that some social facilitation was involved with curlew feeding on baits, i.e. most birds learning of the bait palatability from watching a neighbour rather than learning by itself. Golden plover and turnstone, in comparison to curlew, pecked at baits, taking only just a small proportion of individual baits.

Two dead curlew and five dead golden plover were found on Rawaki 13 days after the first bait spread, with carcasses found on 11th June (plover), 12th (curlew), 14th (plover), 15th (plover), 16<sup>th</sup> (2 plover), 17<sup>th</sup> (decomposed curlew). It is likely that some other individuals would have died after we left, or some carcasses not found. It is not certain that the few apparently sick birds were necessarily affected by poison, as a sick (apparently heat-stressed) golden plover was seen on Rawaki during the 2006 expedition.

Table 5.1 – Numbers of curlew and other waders on Rawaki and McKean Island in 2006 and 2008. Note that on Rawaki in 2008, 27 curlews were observed up until 1 June when 12 flew northward from the island.

| Island                        | Rawaki      |                |             | McKean       |           |             |
|-------------------------------|-------------|----------------|-------------|--------------|-----------|-------------|
|                               | 2006        | 2008A          | 2008B       | 2006         | 2008A     | 2008B       |
| Year                          | 2006        | 2008A          | 2008B       | 2006         | 2008A     | 2008B       |
| Date                          | 19-21 April | 27 May-3 June  | 9-18 June   | 28 Apr-1 May | 5-7 June  | 11-13 June  |
| Bristle-thighed curlew (live) | <b>c.60</b> | <b>27 (15)</b> | <b>8</b>    | <b>6</b>     | <b>7</b>  | <b>4</b>    |
| Bristle-thighed curlew (dead) | 0           | 0              | 2           | 0            | 0         | 0           |
| Bristle-thighed curlew (sick) | 0           | 0              | 1           | 0            | 0         | 1           |
| Pacific golden plover (live)  | <b>100+</b> | <b>142</b>     | <b>c.65</b> | <b>30</b>    | <b>72</b> | <b>c.60</b> |
| Pacific golden plover (dead)  | 0           | 0              | 5           | 0            | 0         | 0           |

|                              |      |    |    |    |      |   |
|------------------------------|------|----|----|----|------|---|
| Pacific golden plover (sick) | 1    | 0  | 1+ | 0  | 0    | 0 |
| Turnstone                    | 120+ | 20 | 2  | 60 | c.15 | 5 |
| Sharp-tailed sandpiper       | 1    | 0  | 0  | 0  | 0    | 0 |
| Wandering tattler            | 2    | 1  | 1  | 30 | 3    | 2 |
| Grey-tailed tattler          | 0    | 0  | 0  | 0  | 1    | 0 |
| Bar-tailed godwit            | 0    | 1  | 0  | 0  | 0    | 0 |

#### Frigatebirds scavenging on dead or dying rats or rabbits

No evidence of frigatebirds gaining brodifacoum was observed. Two injured birds were observed on Rawaki – both with broken wings – but this is considered normal for such a large population (c.30000).

#### Damage to nests of Phoenix petrels and other threatened species

The AEE suggested that this may be an issue if rabbits needed to be hunted excessively and recommended finding and marking nest sites. This was carried out early during the first visit to Rawaki with the main colony and one outlying concentration being searched and nests flagged with pink tape. Several additional nests were found on our second visit to Rawaki. No nests or eggs of this endangered species were known to be destroyed during the operation, but the precaution was considered justified.

#### Loss of or desertion of other seabird nests

The AEE considered that there was significant risk to nesting frigatebirds and care would need to be taken at their colonies. Both islands support large colonies of lesser frigatebird, each containing thousands of nests mainly at the egg and early chick stages during our visit. On Rawaki we left baiting of the large colony to last and took care not to enter parts where there were dense concentrations of nests. We used 4-6 people to simultaneously throw bait into the colonies, this task lasting only a few minutes. Many frigatebirds at the edges of the colonies reacted by temporarily flying from their nests at this time, but no sign of permanent nest desertion or kleptoparasitism was detected.

Some eggs of common species (especially sooty terns) were crushed, but given that there were hundreds of thousands of tern nests on Rawaki, this was considered both inevitable and negligible. Possibly the biggest effect of this operation was the desertion on Rawaki of two of c.18 nests of brown booby. These nests were located close to the landing site and area of high human activity.

## Biosecurity

We were conscious of the need to ensure that no alien biota were introduced to the target islands. This was addressed at several levels, including training, general awareness, checking equipment and stores at their source in Apia, and final pre-landing checks aboard the RV Bounty Bay. The transport of bait in sealed barrels greatly alleviated the risk of transporting ants and other IAS biota.

### *Training and awareness*

At Kiritimati, our training emphasized the need to minimize the chances of transporting rodents and invertebrates, particularly ants. This training used practical examples with boats at the local port (London), ant monitoring and discussed via PowerPoint presentations the consequences if rodents and ants get to these islands. Expedition members were provided an emailed outline of the biosecurity risks of invertebrates and the basic precautions needed.

### *Checking and/or spraying equipment and stores at Apia*

Yellow crazy ants were present in one of two chalets used at Vaila Beach, Apia. The contaminated chalet was treated with Claw (30 g/l (10%) bifenthrin) and Ripcord (Cypermethrin) insecticide, on different sides of the accommodation. Both appeared to kill and/or deter all ants because the following day the only live ants that were seen were in another part of the chalet that had been overlooked in the spraying.

Risky items were totally avoided (e.g. palm-frond baskets, bamboo) or minimized and checked (e.g. cartons) at the purchase site in Apia and before going on board the RV Bounty Bay. Yellow crazy ants, spiders, beetles and weevils were detected and removed during this process. The RV Bounty Bay was moored at the outer end of the Marina at Apia c.100 m from shore, which would have reduced potential invasives from boarding. Local security personnel had seen rats on the adjacent shore at night, but had never seen them on the mooring boardwalks or swimming in the area.

### *Aboard the RV Bounty Bay*

All biosecurity breaches detected were collected and preserved. These were:

- a spider (Lycosidae) – found in galley
- a weevil (Curculionidae, Dryophthorinae formerly Rhynchophorinae) – found in boat's galley; normally associated with palms
- ants (*Monomorium* sp.) – detected in two locations, firstly near stored sweet foods and the other on disinfected traps
- cockroaches (Blattaria) – present in the galley throughout the voyage.

Areas in which ants were found were sprayed with Ripcord or Claw and later laced with ICON (300 g/kg lambda – cyhalothrin) which is considered by the ICON Company in Apia to have a knockdown and residual control effect on ants. Attempts to eradicate the cockroaches on the RV Bounty Bay failed. During inspections of equipment and stores going ashore, no alien species were detected.

### *Ashore*

Rawaki and McKean had both been surveyed for ants in 2006, with several species of indigenous and tramp ant species being detected on each island (Pierce

et al 2006). During the current work, 5 pairs of the same lure types used in 2006 (paired protein and sugar baits) were operated within the Rawaki and McKean camp sites that contained stores and the cooking and dining area. No ants were detected at camp.

#### Brodifacoum residue

The pattern of brodifacoum breakdown in this type of dry sandy environment is not completely known (Fisher and Fairweather 2006, Pierce et al. 2008) and we could offer no further useful insights. Carcasses of rabbits did, however, decay or were scavenged relatively quickly (c. 1-2 weeks).

#### Operator health and public access

Prior to the eradication a comprehensive Health and Safety Plan was prepared. This document was distributed among eradication team members. Team members were asked to provide details of any medical conditions and a contact person in case of emergency.

Safety briefings were undertaken throughout the expedition, on board the RV Bounty Bay and prior to high risk activities such as shore landings (the highest risk activity). Health and safety equipment was carried aboard the RV Bounty Bay (life-raft, fire extinguishers etc) and on shore (sat phone, radio, first aid kit, desalinator etc). The personal protective equipment required for brodifacoum use was also provided (dust masks, work shirts etc).

The AEE described the need to ensure operators have appropriate safety gear, including mask and gloves. This proved to be a critical need during the unloading of barrels, all of which had some loose bait and associated dust. There was less risk of skin absorption or inhalation during the spreading of bait, but we wore masks and usually also gloves as a precaution.

For the general public, signage written in iKiribati was erected at the islands' landing sites. The contingency measure of shifting bait from Kanton to Kiritimati was accompanied by a briefing of family elders at Abariringa and the barrels being secured with a tarpaulin and signage erected.

The expedition reported no serious incidents. There were a few minor incidents noted:

1. An infected foot wound (exasperated ironically by safety boots), cleared by a course of antibiotics,
2. Infected tooth, also cleared by an antibiotics course.
3. Aggravation of an old back injury after carrying large loads of bait, and this was treated by another team member trained in massage therapy.

These cases were rectified by early detection and treatment.

The highest risk activity, as cited in the Health and Safety Plan, was boat landings. Fortunately three of the eradication team members had vast experience in this activity and the most experienced (Grant Oakes) operated the landing boat throughout without mishap. The methodology of landing on islands of this nature in marginal conditions was further developed during this trip with the addition of a shore-based wave-spotter who would indicate to the inflatable operator when there were safer gaps between larger sets of waves.

### 5.3 Lessons Learned

Non-target issues included some that were more serious than anticipated:

- The current work showed that some bristle-thighed curlews will eat poison baits directly, so risks are not confined simply to secondary poisoning. The limiting of bait-spreading operations to the austral winter (refer AEE) to avoid killing breeding adults of this threatened species is therefore vindicated. Late May and June should be the main target period for future poisoning, allowing time for poison baits to break down before the return of migrants.
- As to the non-breeding curlews present at this time, observations at Rawaki support the AEE suggestion that it may be practical to scare curlews away from the target islands at the start of a bait-spread operation. This should be attempted in future operations. It is not clear whether this would be needed for bait station operations as we were not able to stay sufficiently long on McKean Island in order to test this.
- This operation shows that other waders, notably Pacific golden plover and turnstone, are also at risk from primary poisoning at least. This is probably not surprising given that plovers, turnstones and curlews readily take handouts (bread etc) from people at Johnston Atoll, north of the Phoenix Islands (Johnson et al. 2004). The later departure of many golden plover including those wintering in Samoa (Johnson et al 2008) suggests that operations carried out in late June or July would be of lesser impact to this species. However, the fact that waders readily move between islands perhaps in response to local food availability, means that large numbers of non-breeders could still be present on these islands, e.g. Enderbury Island, in any month.
- Other concerns raised in the AEE however proved to be less of a problem, notably disturbing of nesting frigatebirds. This operation demonstrated that with reasonable care it is possible to dispense bait in large colonies of lesser and greater frigatebirds without causing mass desertions.

Health and safety improvements include:

- Simplify the health and safety plan and refer to it throughout the trip
- Emphasize the hazards associated with brodifacoum to all team members
- Provide hand-washing facilities other than the ocean
- Loose bait in barrels presents an unnecessary hazard to operators and should be avoided in future.
- Update the first aid kits kept on the vessel and in island kits.

## 6.0 CAPACITY BUILDING

Building technical capacity in GoK staff was a key objective of the PIPA work. This project focused on the following key needs:

- Awareness of the threats of IAS
- Awareness of eradication and biosecurity needs
- Planning eradications and biosecurity
- Ability to carry out pest eradication work and support work
- Ability to carry out outcome monitoring
- Ability to manage and interpret data.

These needs were addressed in the following two ways.

### Kiritimati workshop

A one-week workshop was held with staff of WCU, Agriculture, Police, Customs and Linnix Ministry staff on Kiritimati. This workshop focused on all of the needs above, and combined classroom presentations and practical exercises (refer Brown and Pierce 2008).

### Participation in the eradications

Two GoK staff participated in the eradication work – Nautonga Anterea of the Agriculture Division, Kiritimati, and Uriam Anterea of the Wildlife Conservation Unit, Kiritimati.

At the Phoenix Islands Nautonga and Uriam were an integral part of the eradication and monitoring teams, taking equal roles in the following:

- Preparing for eradications, e.g. signage and other safety precautions
- Preparing bait and equipment for landing
- Bait transport on the islands
- Preparing 25 m grids on the islands
- Carefully spreading bait across the islands
- Baiting precautions and contingencies around sensitive non-target biota, e.g. frigatebird colonies
- Pest monitoring, particularly rabbit surveillance
- Observing non-target biota and their behaviour, e.g. bristle-thighed curlew
- Establishing vegetation photopoints
- Monitoring seabirds, particularly by fly-ons and colony counts
- Recording data.

Their expedition reports, if available, will be appended to this report.

### Lessons learned

The GoK staff were keen to participate in all aspects of this work, including at the Kiritimati workshop which was well-attended. The challenge is to maintain impetus and interest in this pest eradication and biosecurity work and a number of relevant points are noted in Brown and Pierce (2008).

Throughout the workshop and pest eradication work, we noted a number of aspects that worked well, e.g.

- Keeping examples and field work practical, meaningful and where possible, fun
- Developing personal relationships –leading to better trust and improved self-confidence, etc
- Allocating responsibilities for individual tasks
- Providing a mechanism for ongoing feedback before and after the field events, i.e. maintaining the technical support (buddy) system when they return to their normal work place

Some aspects that need further or reinforced support include:

- Technical aspects of some other biodiversity projects that GoK are involved with, e.g. planning for other pest eradication, plus biosecurity and awareness work at Kiritimati and in support of PIPA
- Help or advice on collecting data on biota generally, its storage and analysis.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

From initial results, the team is confident that rabbit eradication was achieved on Rawaki. Operational work for the eradication of Asian rats on McKean Island proceeded as planned with a clear knock-down of the rat population being evident during our second visit to the island. However, because animals at very low densities can be very difficult to detect, confirmation of success will not be possible until after the islands are re-visited and surveyed for rats in one or two years time. Having this delay (of two years in New Zealand) before confirmation of success is standard practice for rodent eradication programmes.

No attempt was made to eradicate rats on Birnie Island due to dangerous landing conditions. It may be safest to attempt the eradication of rats on Birnie Island as an annex to a future aerial bait spreading operation targeting rats on larger islands in the Group, e.g. Enderbury Island. If aerial baiting of other Phoenix Islands does not occur (and there are a number of logistic and safety considerations to be made in regard to aerial operations), then a carefully planned sea-landing operation would be needed at Birnie Island. The unused bait intended for Birnie Island will be used by GoK at Kiritimati for local pest eradication on small motu and for improved biosecurity for the Phoenix and Line Islands.

A number of techniques were developed or refined to help with this work, including the use of 200 litre barrels for transporting bait, a simple bait station design to help combat crab interference, and some simple biota monitoring techniques. The expedition was however faced with a number of logistical challenges in a narrow timeframe, mainly stemming from the contract being settled at a very late stage, a situation to be avoided in the future.

If the Rawaki and McKean Island operations were successful, the priorities for restoration and biosecurity work in the Phoenix Islands are now as follows:

- Implementing more effective biosecurity and awareness programmes in order to minimize the chances of new pests arriving at the restored islands and the Group as a whole
- Restoration of Enderbury and Birnie by removing Pacific rats
- Restoration of Orona by removing cats (no rats detected in partial island surveys in 2006 and 2008)
- Check on the status of pests on Rawaki and McKean Island in late 2009 and if rat-free, remove the bait stations from McKean Island and repeat biota monitoring
- Survey Manra (landing was not possible during the 2006 survey)

There are some clear linkages and synergies possible between restoration plans for the Phoenix Islands and the Line Islands, including the role of the GoK departments (WCU, Agriculture and others) on Kiritimati and Tarawa, the community on Abariringa, and the support of international agencies, tourist ventures, etc. A strong approach would be one that involves the collaboration of GoK, funders and international agencies, for example:

1. Five year CEPF budget (bids soon to be announced) that could provide:
  - Funds for PIPA management plan implementation
  - Funding support GoK to eradicate cats on Orona, potentially in 2009 or 2010
  - Funding support GoK to eradicate rats on Enderbury and Birnie Islands, potentially in 2010 or 2011.
2. Continued capacity building support for GoK staff particularly at Kiritimati (e.g. via NZAID) that advances the following;
  - Improved local ability to eradicate island pests
  - Improved biosecurity for the Line and Phoenix Islands, Kiritimati and Tarawa being major departure ports for the Phoenix Islands
  - Improved biota surveys and monitoring, the ensuing knowledge of which enables more informed responses to local issues, e.g. black rat concerns, possible Bokikokiko translocations, etc.
  - Assist in educational and awareness programmes for Kiritimati and the Line and Phoenix islands generally.
3. Major focus on biosecurity for the PIPA in particular, via assistance with compliance patrols, remote surveillance, education, etc, potentially funded via Australian aid agencies.

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## APPENDICES

### Appendix 1 - Expedition Log

|             |   |   |
|-------------|---|---|
| May         | Activities, observations  |   |
| 15<br>NZST  | Nautonga and Uriam leave CXI for Fiji   |   |
| 16          | Derek, Grant, Hannah, Mike, Ray leave AKL for Apia  |   |
| 16<br>Samoa | Tour of markets etc with Sue from CI, meet with CI and SPREP re Kiritimati, RV BB arrives, check freight in Apia, clarify firearms process with Police, Graham arrives from AKL, Nautonga and Uriam arrive  |   |
| 17-18       | Prepare lists of gear and supplies, equipment, pack gear, test ant sprays, dinner with CI and SPREP 18 <sup>th</sup>  |   |
| 19          | Shop for groceries, equipment; immigration/passports; container to port – load bait barrels using boom truck; collect Fran and Lance from airport; Sako collected by Customs/Ag and brought to Bounty Bay. Meeting to discuss load limit and contingencies.   |   |
| 20          | Boat fuelling; customs/immigration; discussions with yacht owner for taking passengers to PIPA, and alternative discussions with MV Tokelau   |   |
| 21          | Graham and Sue meet with MV Tokelau regarding freighting 3 tonnes of bait to Tokelau – agreed and one of Bounty Bay crew to accompany, offloaded 3 tonnes, poison signs printed by CI and attached to barrels; bank and emails; firearms received 8 pm, Customs 8 pm, safety briefing 9.30 pm; departed Apia during the night.  |   |
| 22          | Departed 0200 bearing 30-40 degrees due to NW of previous few days, wind and waves easing; hot and sunny; seabird transects; bristle-thighed curlew flying north; couple of sea-sick passengers, Sako fine.   |   |
| 23          | Bearing 20 degrees initially, to 355 by early afternoon; hot and sunny; seabird transects; gear prepared – pegs, tapes  |   |
| 24          | Bearing 355 degrees, overcast, rainy day, moderate sea, heavy seabird migration, especially sooty shearwaters   |   |
| 25          | Bearing 355; warm, sunny; seabird transects; meeting re teams on the islands, procedures for getting bait ashore, dealing with loose bait, etc  |   |
| 26          | Bearing 355 degrees, hot sunny day, seabird transects, preparation of safety etc gear for shore camps; weather forecast for showers over the next several days (to 2 <sup>nd</sup> June); approached a very noisy and smelly Rawaki at dusk and anchored in the lee of the island   |   |
| 27          | Landed at Rawaki beginning 0930 – Grant expertly operating skiff, supported on boat by Derek, Asaeli, Graham, Nautonga and Uriam, and onshore by Fran, Hannah, Lance, Mike, Ray and Soko; bait brought ashore last; broke for lunch on the boat and finished landing by early afternoon; established tent camp; evening fly-ons; night searches for rabbits, Phoenix petrels; few showers |   |
| 28          | Bait gridding (3 teams) and bait humping to caches around the island the later helped by Bounty Bay crew; refreshing showers of rain; news of delay of MV Tokelau, nocturnal crab and rabbit surveys by Ray and Mike  |   |
| 29          | Baiting day – principal baiting team of Derek, Hannah, Lance and Uriam with Mike checking spread and Asaeli, Fran, Grant, Nautonga, Ray and Soko humping bait to strategic points; occasional   | News of MV Tokelau repaired so RV Bounty Bay departed to Tokelau Islands in afternoon |

|         |   |   |
|---------|---|---|
|         | showers   |   |
| 30      | Baited frigatebird colony moving to c.20 m of the birds and throwing bait into colony sectors; pm booby and frigatebird counts and observations of curlews, evening fly-ons (Ray, Nautonga and Uriam) and rabbits (Mike); showers                             | RV Bounty Bay in transit to Tokelau   |
| 31      | Weather forecast from Ulamila – fine for 7 next days; checks of bait spread and rabbit behaviour (Mike, Derek and co); counts of terns, turtle nests and curlew observations, evening fly-ons Ray and Uriam; fine weather                                     | RV Bounty Bay in transit to Tokelau, arriving at Atafu at 3pm   |
| 1 June  | 2 <sup>nd</sup> bait spread today – all working on this and finished by 1130 h; curlew observations pm – 12 fly north from the island; evening fly-ons Ray and Uriam; night GPSing of petrel burrows  | RV Bounty Bay loads bait, fuel and water from MV Tokelau, plus fruit and veges from Apia. Departs at midday for Rawaki  |
| 2 June  | Curlews feeding on baits early morning (Nautonga, Ray, Uriam); Vegetation photopoints Ray and Uriam; Mike GPSed island area and assessing bait spread; rabbits dying today  | RV Bounty Bay in transit to Rawaki predicts arrival 1500 tomorrow   |
| 3 June  | Mike assessing bait spread; break camp in anticipation of Bounty Bay returning; left water barrels and some gear on the island  | RV Bounty bay arrives 1545 h, load boat and leave for McKean 1900 h after seabird flyons  |
| 4 June  | At sea, bearing 280 to McKean; seabird transects; prep for landing  |   |
| 5 June  | Arrived McKean 0600 h; established camp; set out 50 m bait grid; checked out MV Chance wreck; evening fly-ons from boat (crew) and ashore; rat and crab assessments at night  |   |
| 6 June  | More bait landed for second deployment later in month; bait laid out on grids, lagoon edge and outer windward side of island; prepared bait stations for follow-up, all baited and in position; GPSed area – 31.9 ha including 20.7 ha land. Evening fly-ons. |   |
| 7 June  | Assessed bait spread; curlew observations; bait deployed in barrels round the island; evening fly-ons; left for Rawaki 1100 h   |   |
| 8 June  | In transit McKean-Rawaki; seabird transects   |   |
| 9 June  | Landed Derek, Lance and Sako on Rawaki and departed for Birnie; in transit; arrived Birnie 1600 h; Grant and Mike checked in vain for safe landing; evening fly-ons   | Derek and Lance shot 31 rabbits on Rawaki during 3 hunting bouts, some rabbits haemorrhaging; plenty of bait still on ground; night spotlight shooting shifts   |
| 10 June | Checked landing at high tide – unsafe; most of party swam ashore; Mike collected female kiore; lagoon full of super saline water; few birds; one Pisonia tree; initially considered checking later, but consensus that still would be too dangerous           | Spotlight shooting shifts at night and morning and evening; shot 3 rabbits in morning; Sako pointing freshly dead rabbits well; sick golden plover seen. Additional 6 rabbits shot pm/night mainly by spotlighting. |

|         |   |   |
|---------|---|---|
| 11 June | Encountered “Sea Encounter” purse seining between Birnie and McKean at 3 ° 30’ S and 173 ° 45’ W at 0800 h; arrived McKean pm   | Spotlight and dusk/dawn shooting shifts; shot 1 rabbit; estimated two still alive   |
| 12 June | Second bait spread over most of island (except E rubble); rained overnight 0130-0400 h  | Spotlight and dusk/dawn shooting shifts; shot 2 rabbits   |
| 13 June | Baits of yesterday soggy, so rebaited at lower application rate, baited rubble area late in day; also showers today so decided to spend night of 13th on Bounty Bay just offshore – no further rain, 1-2 showers  | Spotlighting and dusk/dawn shooting shifts; no live rabbits seen; one dead curlew seen  |
| 14 June | Departed McKean for Kanton 0900 h; seabird transects; rain showers  | Spotlight and dusk/dawn shifts; no live rabbits seen  |
| 15 June | In transit to Kanton; seabird transects; showers cease; arrived Kanton 1500 h; meet with Policeman (Customs/ Immigration); offloaded excess poison (21 barrels) and empty barrels (12) to shed for later freighting to Kiritimati and 7 empty barrels to Kanton families; met family leaders at village and discussed poison storage, safety, biosecurity, long-term restoration options for Kanton – all keen for pest removal (cats, kimoa and black rat) ; cats at village and beyond; no dogs; only transport motorbikes, bikes and wheel barrows; no usable outboard motors on island, so limited fishing options for local population. Left for Rawaki 2200 h | Spotlight and dusk/dawn shifts; no live rabbits seen  |
| 16 June | Passed in lee of Enderbury 0800 h; arrived Rawaki early afternoon   | Evening observations and random and structured night spotlight searches by several additional observers; no live rabbits seen |
| 17 June | Rawaki evening observations and random and structured spotlighting searches by several observers; no live rabbits seen; bait counts; observations of curlews, etc; tropicbird counts; evening fly-ons; night GPSing of Phoenix petrel burrows and shearwater counts   |   |
| 18 June | Broke camp at Rawaki; loaded Bounty Bay and departed southward c.1300 h   |   |
| 19 June | In transit south; seabird transects   |   |
| 20 June | In transit south; seabird transects; confirmed flights  |   |
| 21 June | Landed on Nukunono, Tokelau Islands, in morning and met with Casimilo Perez, Chair of the Nukunono Island Council and discussed restoration options for Tokelau; late morning; in transit south; seabird transects  |   |
| 22 June | In transit south; seabird transects   |   |
| 23 June | Arrived Apia 1500 h; evening dinner and debrief; meet with Francois Martel CI 25th; members depart 24th (Derek, Lance and Sako), 25 th (Grant and Hannah), 26 <sup>th</sup> (Fran, Mike, Graham, Ray), 28 <sup>th</sup> (Nautonga and Uriam)  |   |

## Appendix 2 – Supplementary pest data

Table - Population densities of rabbits on Rawaki for the first two nights of measurement (2008) and overall measurements (2006).

| Habitat   | 2006 individuals ha <sup>-1</sup><br>(mean, <i>n</i> transects, 95% confidence interval) | 2008 individuals ha <sup>-1</sup><br>(mean, <i>n</i> transects, 95% confidence interval) |
|---|--|--|
| Coral-based <i>Portulaca</i> shrubland          | 17.2, 9, ±7.5  | 31.9, 9, ±11.4   |
| Sand-based <i>Portulaca/Boerhavia</i> shrubland | 79.4, 14, ±20.1  | 51.8, 14, ±16.6  |
| <i>Sesuvium</i> herbfield                       | 5.7, 4, ±6.5   | 7.5, 4, ±4.4   |
| <i>Lepturus</i> grassland                       | 17.4, 7, ±26.5   | 6.2, 5, ±6   |
| <b>Estimated total population size</b>          | 1846-2596-3387   | 1223-1866-2498   |

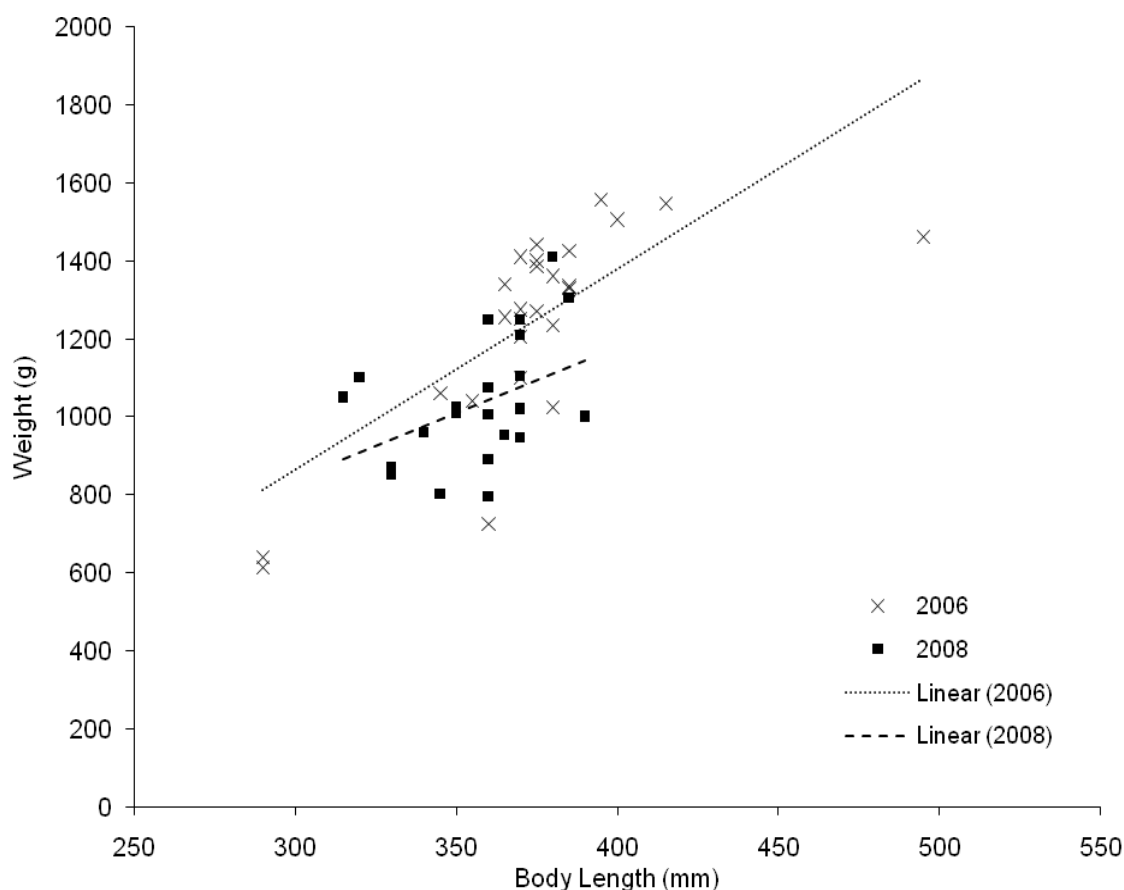


Figure - Body length versus weight of rabbits in 2006 and 2008 on Rawaki. Least-squares regression lines plotted for each year to show relationship

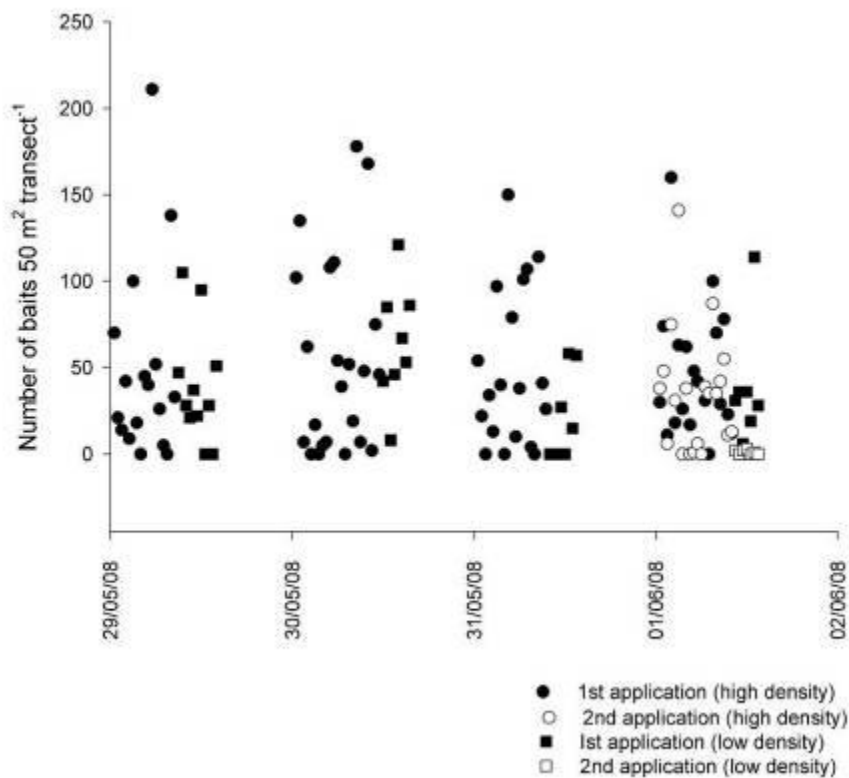


Figure - Number of Pestoff 20R baits recorded in randomly-located 25 m x 2 m transects in high and low target bait density areas for bait applications one and two on Rawaki

Table - Population densities of Asian ship rats on McKean for first two nights of measurement (2008) and overall measurements (2006).

| Habitat   | 2006 individuals ha <sup>-1</sup><br>(mean, n transects, 95% confidence interval) | 2008 individuals ha <sup>-1</sup><br>(mean, n transects, 95% confidence interval) |
|---|---|---|
| Coral-based <i>Portulaca</i> shrubland          | 17.1, 21, ±10.1   | 14.8, 12, ±11.8   |
| Sand-based <i>Portulaca/Boerhavia</i> shrubland | 53.7, 24, ±12.2   | 12, 5, ±11.8  |
| <i>Sesuvium</i> herbfield                       | 63.9, 13, ±13.6   | 14.4, 9, ±15.7  |
| Sand-based <i>Tribulus</i> shrubland            | 36.7, 18, ±13.8   | 29.3, 9, ±27.8  |
| Sand-based substrates                           | 49.5, 49, ±8.7  | 23.1, 14, ±18.5   |
| Coral rubble-based substrates                   | 26.5, 27, ±11.2   | 14.8, 12, ±11.8   |
| <b>Estimated total pop size</b>                 | 744-1070-1396   | 34-434-834743   |

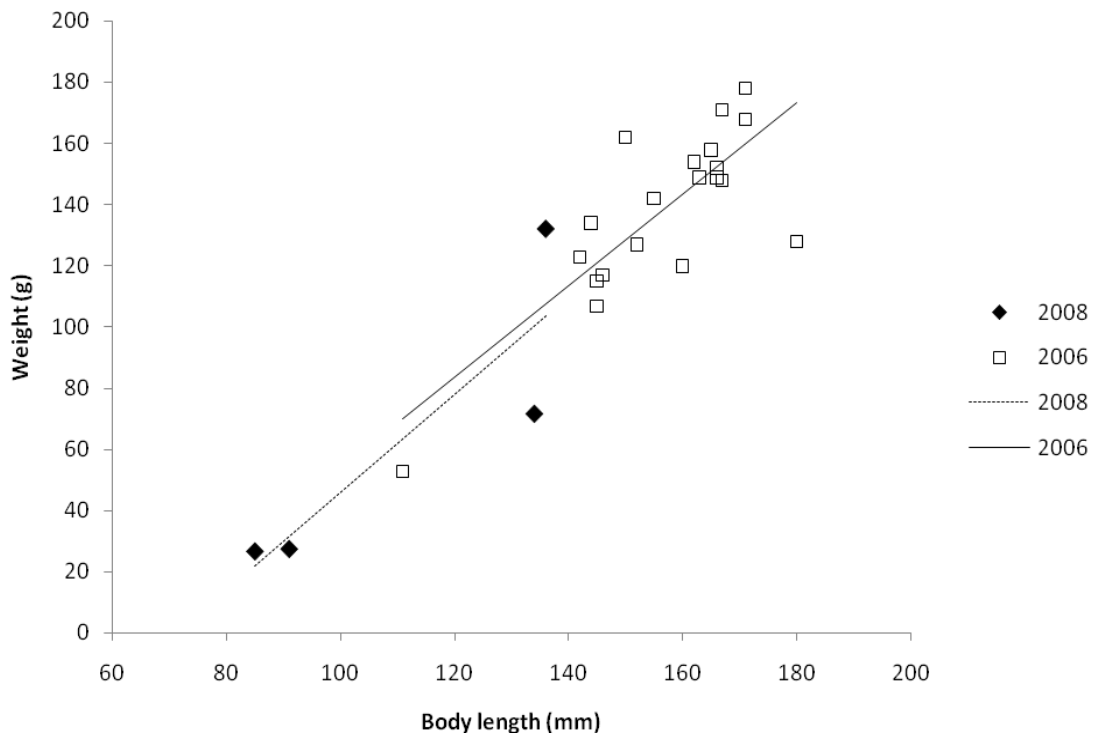


Figure - Body length versus weight of Asian ship rats in 2006 and 2008 on McKean. Least-squares regression lines plotted for each year to show relationship

Table - Morphometrics of Asian ship rats on McKean 2006 and 2008

| Year | Age   | Sex    | ID code | body length (mm) | weight (g) | breeding status    | kidney fat | Parasites | head length | head width | head depth | Ear  | Ear to eye | eye to nose tip | Hind foot (to pad) | Hind foot (incl. nail) | tail to pelvis | tail to fur | front foot (to pad) |  |
|------|-------|--------|---------|------------------|------------|--------------------|------------|-----------|-------------|------------|------------|------|------------|-----------------|--------------------|------------------------|----------------|-------------|---------------------|--|
| 2006 | Adult | female |         |                  |            | none               | none       |           |             |            |            |      |            |                 |                    |                        |                |             |                     |  |
| 2006 | Adult | female |         | 171              | 168        | none               | none       |           | c. 50       |            |            | 20.8 |            |                 | 30.6               | 32.8                   | 194            | 165         | 15.8                |  |
| 2006 | Adult | female |         | 165              | 158        | very small embryos | none       |           | 46.8        |            |            | 20.2 |            |                 | 31.7               |                        | 197            | 184         |                     |  |
| 2006 | Adult | female |         | 160              | 120        |                    |            |           |             |            |            |      |            |                 |                    |                        |                |             |                     |  |
| 2006 | Adult | female |         | 167              | 171        | none               | none       | none      | 48.8        | 26.6       |            | 20.9 | 16.9       | 21.4            | 32.1               |                        |                |             |                     |  |
| 2006 | Adult | female | A       | 166              | 149        | none               | none       | none      | 49          | 23.2       |            | 20.2 | 15.9       | 22.1            | 31.9               |                        |                |             |                     |  |
| 2006 | Adult | female | B       | 162              | 154        | none               | none       | none      | 53.4        | 28.4       |            | 18   | 14.9       | 20.6            | 31.6               |                        | 185            | 175         |                     |  |
| 2006 | Adult | female | C       | 171              | 178        | none               | none       | none      | 54          | 24.4       |            | 21.6 | 15.2       | 23.5            | 33.5               |                        | 207            | 193         |                     |  |
| 2006 | Adult | female | D       | 155              | 142        | none               | none       | none      |             |            |            |      |            |                 |                    |                        |                |             |                     |  |
| 2006 | Adult | female | G       | 152              | 127        | none               | none       | none      | 48.3        | 23.8       | 20.8       | 18.8 | 16.1       | 20.5            | 29.2               |                        | 191            | 175         |                     |  |
| 2006 | Adult | female | J       | 180              | 128        | none               | none       |           | 51.4        | 22         | 20.7       | 18.3 | 15.5       | 24              | 31                 |                        | 211            | 191         |                     |  |
| 2006 | Adult | female |         | 145              | 115        | none               | none       | none      | 47.6        | 21.1       | 20.5       | 18.7 | 10.7       | 21              | 29.5               |                        | 183            | 166         | 13.5                |  |
| 2006 | Adult | male   |         | 163              | 149        |                    |            |           |             |            |            |      |            |                 |                    |                        |                |             |                     |  |
| 2006 | Adult | male   |         |                  | 144        |                    |            |           |             |            |            |      |            |                 |                    |                        |                |             |                     |  |
| 2006 | Adult | male   |         | 144              | 134        |                    |            |           | 50.4        | 23.4       |            | 20   |            |                 | 32.2               |                        | 207            | 183         |                     |  |
| 2006 | Adult | male   | E       | 142              | 123        |                    |            |           | 51.3        |            |            |      |            |                 | 30.9               |                        |                |             |                     |  |

| Year | Age      | Sex    | ID code | body length (mm) | weight (g) | breeding status                    | kidney fat | Parasites | head length | head width | head depth | Ear  | Ear to eye | eye to nose tip | Hind foot (to pad) | Hind foot (incl. nail) | tail to pelvis | tail to fur | front foot (to pad) |
|------|----------|--------|---------|------------------|------------|------------------------------------|------------|-----------|-------------|------------|------------|------|------------|-----------------|--------------------|------------------------|----------------|-------------|---------------------|
| 2006 | Adult    | male   | H       | 166              | 152        |                                    |            |           | 48.4        | 23.2       | 19.2       | 21.1 | 14.1       | 20.6            | 34.1               |                        | 201            | 191         |                     |
| 2006 | Adult    | male   | I       | 167              | 148        |                                    |            | none      | 50.2        | 20.3       | 18.4       | 17.2 | 14.5       | 21.8            | 30.6               |                        | 200            | 180         |                     |
| 2006 | Adult    | male   |         | 150              | 162        |                                    |            |           | 48.9        | 23.9       | 20.6       | 21   | 14.8       | 21.1            | 31.4               |                        | 192            | 174         | 15.1                |
| 2006 | Juvenile | female |         | 145              | 107        | none                               | none       | none      | 43.1        | 20.5       | 19         | 19.1 | 15.3       | 19.1            | 27.8               |                        | 168            | 154         |                     |
| 2006 | Juvenile | female |         | 111              | 53         |                                    |            |           | 39.5        | 18.8       | 16.1       | 18.9 | 11.4       | 16              | 27.9               |                        | 125            | 110         | 14.8                |
| 2006 | Juvenile | male   | F       | 146              | 117        |                                    |            | ticks     |             |            |            |      |            |                 |                    |                        |                |             |                     |
| 2008 | Adult    | Female |         | 136              | 132        | Pregnant (4 late-mid term embryos) | 0          | 0         | 43.3        | 19.1       | 17         | 18.6 | 13.7       | 19.3            | 30.8               |                        | 169            |             | 19.9                |
| 2008 | Juvenile | Male   |         | 85               | 26.5       |                                    |            |           | 32.6        | 19.1       | 15.7       | 14.5 | 10.6       | 12.3            | 23.1               |                        | 99             |             | 14.9                |
| 2008 | Juvenile |        |         | 91               | 27.3       |                                    |            |           | 33.9        | 16.1       | 14.6       | 15.8 | 11.3       | 13.3            | 15.7               |                        | 107            |             | 10.8                |
| 2008 | Adult    | Female |         | 134              | 71.5       |                                    |            |           | 39.2        | 19.1       | 17.2       | 15.6 | 11.9       | 16.5            | 28.8               |                        | 144            |             | 13.4                |
| 2008 | Adult    | Male   |         | 164              |            |                                    |            |           | 49.2        | 23.7       | 19.6       | 19.1 | 16         | 19              | 29.5               |                        | 196            |             | 16.2                |

Table - Morphometrics of rabbits on Rawaki 2006 and 2008

|      |          |        |     |      |                |  |
|------|----------|--------|-----|------|----------------|--|
| 2006 | Adult    | female | 385 | 1425 | none           |  |
| 2006 | Adult    | female | 385 | 1330 | none           |  |
| 2006 | Adult    | female | 380 | 1235 | none           |  |
| 2006 | Adult    | female | 415 | 1545 | post-lactating | moderate   |
| 2006 | Adult    | female | 375 | 1440 | none           |  |
| 2006 | Adult    | female | 375 | 1385 | none           |  |
| 2006 | Adult    | female | 495 | 1460 | none           | some   |
| 2006 | Adult    | female | 375 | 1270 | none           | none   |
| 2006 | Adult    | female | 370 | 1275 | none           | some   |
| 2006 | Adult    | female | 345 | 1060 | none           | very little  |
| 2006 | Adult    | female | 370 | 1205 | none           | very little  |
| 2006 | Adult    | female | 370 | 1250 | none           | none   |
| 2006 | Adult    | female | 365 | 1255 | never bred?    | very little  |
| 2006 | Adult    | female | 375 | 1400 | none           | some   |
| 2006 | Adult    | female | 395 | 1555 | none           | moderate   |
| 2006 | Adult    | female | 365 | 1340 | none           | moderate   |
| 2006 | Adult    | female | 385 | 1335 | none           | moderate   |
| 2006 | Adult    | male   | 400 | 1505 |                |  |
| 2006 | Adult    | male   | 370 | 1100 |                |  |
| 2006 | Adult    | male   | 380 | 1360 |                |  |
| 2006 | Adult    | male   | 370 | 1410 |                |  |
| 2006 | Adult    | male   | 365 | 1340 |                |  |
| 2006 | Adult    | male   | 355 | 1040 |                |  |
| 2006 | Adult    | male   | 380 | 1025 |                |  |
| 2006 | Adult    | male   | 360 | 725  | none           | starved to death? Bladder greatly extended. Faecal pellets present, some food in stomach and intestines. Liver reduced. Lungs to about 1/4 thoracic cavity with 3rd lung developed attached to midline. No granulations etc. |
| 2006 | juvenile | female | 290 | 615  | none           |  |
| 2006 | juvenile | female | 290 | 640  | none           |  |
| 2008 | Adult    | female | 370 | 1105 | none           |  |
| 2008 | Adult    | female | 360 | 795  |                |  |
| 2008 | Adult    | female | 365 | 953  |                |  |
| 2008 | Adult    | female | 370 | 1210 |                |  |
| 2008 | Adult    | female | 360 | 1250 |                |  |
| 2008 | Adult    | female | 370 | 1250 |                |  |
| 2008 | Adult    | female | 380 | 1410 |                |  |
| 2008 | Adult    | female | 360 | 1005 |                |  |

|      |          |        |     |      |      |      |
|------|----------|--------|-----|------|------|------|
| 2008 | Adult    | female | 370 | 1020 |      |      |
| 2008 | Adult    | female | 320 | 1100 |      |      |
| 2008 | Adult    | female | 340 | 960  |      |      |
| 2008 | Adult    | male   | 385 | 1305 |      |      |
| 2008 | Adult    | male   | 350 | 1015 |      |      |
| 2008 | Adult    | male   | 315 | 1050 |      |      |
| 2008 | Adult    | male   | 360 | 890  |      |      |
| 2008 | Adult    | male   | 350 | 1025 |      |      |
| 2008 | juvenile | male   | 330 | 870  |      |      |
| 2008 | Subadult | female | 360 | 890  | none | Tick |
| 2008 | Subadult | female | 370 | 945  | none |      |
| 2008 | Subadult | female | 345 | 800  |      |      |
| 2008 | Subadult | female | 330 | 850  |      |      |
| 2008 | Subadult | female | 390 | 1000 |      |      |
| 2008 | Subadult | male   | 350 | 1010 |      |      |
| 2008 | Subadult | male   | 360 | 1075 |      |      |

Appendix 3 – Summary of wader feeding observations on Rawaki and McKean May-June 2008

| Island        | Date  | Mins | Details  |
|---------------|-------|------|--|
| Curlews       |       |      |  |
| Rawaki        | 28    | 90   | 3 NW lagoon edge and Sesuvium, feeding on hermit crabs, grasshoppers, spiders  |
| Rawaki        | 29-30 | 220  | Up to 22 at LT coral reef foraging taking marine crabs and hermit crabs<br>Night – many single birds foraging in open sandy, grassy areas, taking hermit crabs, worms, spiders and smaller prey  |
| Rawaki        | 31    | 90   | HT - Up to 25 roosting N Point occ. Feeding on marine and hermit crabs; 3 at N end lagoon feeding on grasshoppers, spiders, moths  |
| Rawaki        | 2     | 100  | HT – 5-9 birds feeding intermittently on baits at edge of lagoon, also feeding by variety of methods (peck, prod, probe) on natural foods (worms, spiders, grasshoppers, slaters) in mudflat and adjacent Sesuvium, dead Lepturus grass, rubble and dry ground. Some aggression observed between birds, forcing feeder to drop bait and aggressor consumed same bait |
| Rawaki        | 3     | 105  | Flood tide and HT – 2 birds feeding on baits at edge of lagoon   |
| McKean        | 5-7   | 160  | HT – singles and groups of up to 4 foraging at edge of lagoon and adjacent Sesuvium, taking crabs (2 spp.), spiders, moths, grasshoppers and small prey (possibly aquatic flies) from water surface. Walked past baits several times - no bait seen consumed.  |
| McKean        | 12-13 | 80   | Various tides – up to 4 birds foraging together at edge of lagoon feeding as above; one sick bird also with lame left leg  |
| Rawaki        | 16-18 | 60   | Various tides – up to 8 birds foraging at lagoon edge, taking natural foods. One sick and one lame bird (right leg).   |
| Golden plover |       |      |  |
| Rawaki        | 29-30 | 30   | HT - up to 142 foraging on lagoon flats at HT, dropping to c.30 LT. Scattered groups and singles throughout island   |

|                                    |       |     |  |
|------------------------------------|-------|-----|--|
|                                    |       |     | terrestrial habitats LT and HT feeding on small invertebrates, including spiders; LT many also foraging in intertidal reef areas.  |
| McKean                             | 12-13 | 35  | Various tides – small flocks foraging around lagoon, lagoon edge, rubble, sandy and vegetated areas. Prey unknown, but also pecking at whole baits at lagoon edge and consuming small pieces |
| Turnstone                          |       |     |  |
| Rawaki                             | 29-30 | 10  | LT - 3 foraging on reefs; HT foraging lagoon edge.   |
| Rawaki                             | 16-18 | 15  | 2 foraging in sandy areas, prey unknown, but also pecking at whole baits and consuming small pieces.   |
| Bar-tailed godwit, tattler species |       |     |  |
| Rawaki                             | 28-3  | 20+ | All foraging along intertidal reefs or lagoon  |

## Appendix 4 - Biota Baseline Monitoring

### Objectives

The objectives were to establish baseline monitoring to enable GoK and visitors to measure responses of biota over time to pest removal. Key components were:

- To measure responses of seabird populations to pest eradication
- To establish a simple method of determining atoll health by identifying and counting seabird indicator species during evening fly-ons
- To measure and better understand the response of vegetation and other biota to pest removal.

### Methods

Monitoring methods include the following:

- Seabird colonies – counts, transects, night searches
  - Phoenix petrels – nocturnal searches and war-whooping to locate and mark burrows, GPS and map sites, count nests occupied – best completed in June every 3-5 years, but opportunistic visits in any month will also be useful
  - Storm-petrels – map distribution of nesting concentrations – difficult to get an accurate count – see fly-ons below
  - Tropic-birds – transects 3-5 people walking at c.10-20 m intervals, checking beneath shelters, e.g. coral slabs and driftwood
  - Boobies – transects 2-3 people walking at 30-50 m intervals and counting all birds and their nesting stages
  - Terns – head counts of small colonies or density of nests and mapping perimeter and area with GPS.
- Seabird fly-ons - determine the health of atoll by simple index counts of sensitive indicator birds,  
Pierce et al (2006) demonstrated a close correlation between the number of species detected during fly-ons and the number of species actually present on the islands. In 2008 it was possible to compare the inter-night variability of fly-on counts at Rawaki (5 counts) and McKean Island (4 counts) in order to determine the use of fly-ons for comparing populations on different islands. We also compared shore-based and boat-based observations.  
Methods comprised:
  - From boat 150-200 m offshore and perpendicular to wind direction of the evening (most birds come in directly upwind)
  - Alternatively count from beach also perpendicular to wind direction
  - Count along 200 m corridor
  - Begin counting at 1700 h and cease at dark

- Count only the following – all Procellariiforms (Phoenix petrel, shearwaters, storm-petrels, Bulwer’s petrel), all boobies, blue-grey noddies
- Don’t count frigatebirds, tropicbirds, terns, other noddies, but keep list of species observed
- Pelagic birds - determine distribution and abundance of species at sea
  - Observe from a boat once out of sight of islands
  - Observe one sector of ocean, e.g. one 90 degree sector using best light conditions
- Count all birds out to c.300 m (approximate identifiable range).Vegetation – vegetation and species Responses to pest removal
  - GPS maps of plant communities
  - Species lists (refer 2006 report)
- Other biota
  - Species lists
  - Crab distribution and abundance by transects of 2 x 25 m and repeated mark-resight counts in 6 5 m x 5 m plots

## Results

### Seabird colonies

If the pest eradications are successful at Rawaki and McKean, many of the small birds (storm-petrels, petrels, shearwaters, noddies and terns) are expected to increase in numbers, while others, e.g. frigatebirds, respond positively to the greater biomass of birds. To test these assumptions, baseline monitoring was established in 2006 and 2008 and is summarised in the table below.

Appendix Table 4.1– Summary of seabird species diversity and overall numbers of seabirds present on Rawaki and McKean April 2006 and June 2008 surveys

| Common name                 | Methods             | Rawaki         |                | McKean              |               |
|-----------------------------|---------------------|----------------|----------------|---------------------|---------------|
|                             |                     | 19-21 Apr 2006 | 16-18 Jun 2008 | 28 Apr – 1 May 2006 | 5-13 Jun 2008 |
| Audubon’s shearwater        | Night counts        | 800+ pr        | 530+ pr        | 60 pr               | 50 pr         |
| Christmas shearwater        | Night counts        | 500+           | 435+ pr        | 0                   | 0             |
| Wedge-tailed shearwater     | Night counts        | 250+           | 20+ pr         | 2 i                 | 0             |
| Phoenix petrel              | Night counts, wws   | 11+ pr         | 31+ pr         | 0                   | 0             |
| Bulwer’s petrel             | Fly-ons             | 1 i            | 5+ pr          | 0                   | 0             |
| White-throated storm petrel | Night count; flyons | 20+ pr         | 50-100 pr      | 10+pr               | 0             |
| Red-tailed tropicbird       | Day transects       | 70 pr          | 126 pr         | 34 pr               | 85 pr         |
| Masked booby                | Day transects       | c.700 pr       | 686 pr         | c.400 pr            | 318 pr        |
| Masked booby cont.          | Night counts        | -              | -              | -                   | c.1000 i      |
| Brown booby                 | Day transects       | 24             | 28 pr          | 75 pr               | 18 pr         |
| Red-footed booby            | Day transects       | 3 pr           | 8 pr           | 60 pr               | 23 pr         |
| Great frigatebird           | Day counts          | 5 pr           | c.100 pr       | 400 pr              | 200 pr        |

|                          |                    |           |             |          |          |
|--------------------------|--------------------|-----------|-------------|----------|----------|
| Lesser frigatebird       | Day counts         | 4300 pr   | 18000 i     | 1500 pr  | 1200 pr  |
| Lesser frigatebird cont. | Night counts       | -         | c.30000 i   | -        | -        |
| Sooty tern               | Day estimates      | 10000 pr  | c.250000 pr | 500 i    | c.1000 i |
| Grey-backed tern         | Day estimate       | 1000+ pr  | c.6500 pr   | 800 i    | 500+ i   |
| Black noddy              | Day counts         | <10 pr    | 0           | 6 pr     | 10+ pr   |
| Brown noddy              | Day estimate       | 4000 pr   | c.3000 pr   | 1630 pr  | 1000+ i  |
| Blue noddy               | Night est, fly-ons | c.7000 i  | c.5000 i    | 1 i      | 1 i      |
| White tern               | Day estimate       | 20+       | 20 + pr     | 100 i    | 40+ i    |
|                          |                    |           |             |          |          |
| Approx total pairs       | -                  | 24,500+pr | 280,000 pr  | 5,000 pr | 3300 pr  |
| Total species            | -                  | 18        | 17          | 15       | 13       |

Note: pr = pairs; i = individuals

The two years of baseline estimates were carried out in different months (April and June) and offer useful interpretation of seasonal changes in the presence of pests. In general there was little change on each island between the two baselines surveys, i.e. species diversity was similar, e.g. 18 and 17 species were recorded on Rawaki where black noddies (a tree nester) were rare in 2006 and not recorded in 2008. On McKean the species recorded dropped from 15 to 13 with wedge-tailed shearwaters and white-throated storm-petrels not being recorded in 2008. The absence of wedge-tailed shearwaters is probably partly seasonally related (a decline also occurred on Rawaki – refer Appendix Table 4.1 above). The lack of records of storm-petrels on McKean Island is of concern given that they begin nesting in May-June and numbers detected on Rawaki had increased between the two surveys. This species is very susceptible to rats and has unsurprisingly declined to critically low levels on McKean Island.

Other changes between the two years included a spectacular increase in sooty terns on Rawaki, reflecting the onset of breeding in May-June 2008, with colonies suddenly forming during our time spent on the island. Apart from this however, numbers of most species were remarkably consistent between the two surveys, notably for shearwaters and boobies, although numbers of red-footed and brown boobies had declined on McKean Island.

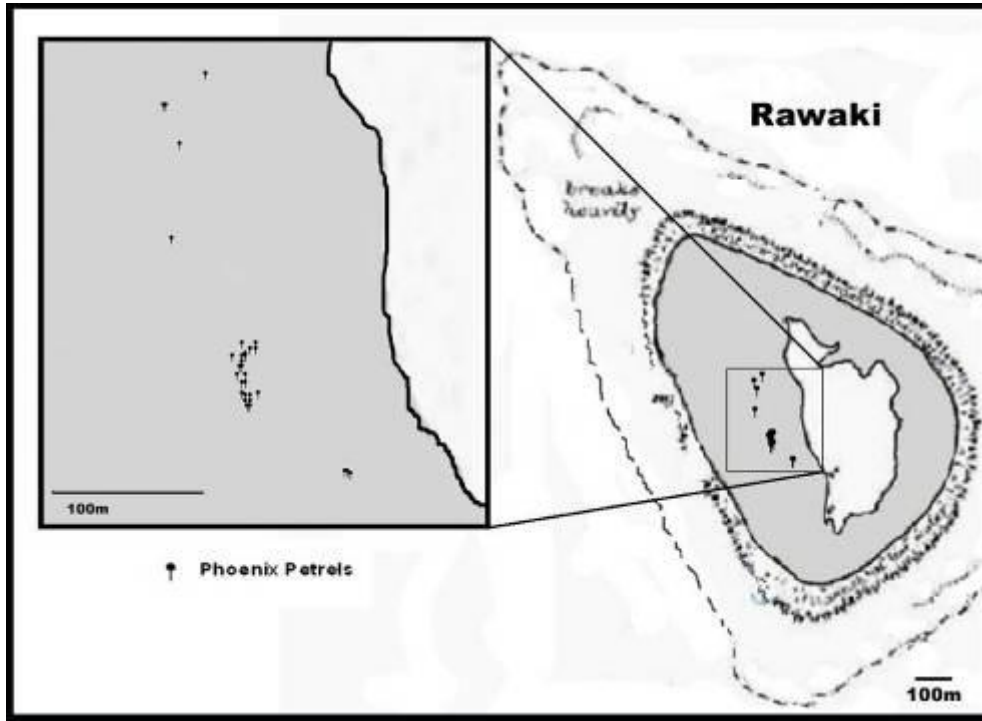
#### Key threatened and indicator species

Comments on the threatened and near threatened species are provided below:

- Phoenix petrel

At least 31 active nests were found in 2008, compared with only 11 in 2006. This difference reflects the later timing of the 2008 work, coinciding with the main laying period. The same spatial pattern was evident however, with one main colony and several outliers mainly in *Lepturus* (two exceptions, both in burrows in open areas where there had been extensive *Boerhavia* growing in the recent past) (refer Appendix Fig 4.1 for map of burrows). Two instances of nest failure were noted in 2008, when eggs were smashed apparently by rabbits. After the poison operation dead rabbits were found in at least three Phoenix petrel burrows beneath *Lepturus*, further indication of the disruption that rabbits had been placing on this endangered

seabird species and other species over the years. Because of this disruption from rabbits, future surveys timed in May-July, are likely to find more incubating petrel pairs than the 10 that we found in May-June 2008.



Appendix Figure 4.1 – map (above) and data (below) for Phoenix petrel burrow locations on Rawaki during 1-17 June 2008

Locations of Phoenix petrel active burrows 1 -17 June 2008

| S         | W          | S         | W          |
|-----------|------------|-----------|------------|
| 03 43.357 | 170 42.775 | 03 43.293 | 170 42.805 |
| 03 43.355 | 170 42.775 | 03 43.348 | 170 42.778 |
| 03 43.355 | 170 42.777 | 03 43.357 | 170 42.776 |
| 03 43.353 | 170 42.777 | 03 43.348 | 170 42.777 |
| 03 43.352 | 170 42.778 | 03 43.342 | 170 42.778 |
| 03 43.345 | 170 42.780 | 03 43.342 | 170 42.779 |
| 03 43.345 | 170 42.777 | 03 43.338 | 170 42.778 |
| 03 43.340 | 170 42.778 | 03 43.335 | 170 42.775 |
| 03 43.338 | 170 42.782 | 03 43.333 | 170 42.773 |
| 03 43.337 | 170 42.777 | 03 43.230 | 170 42.792 |
| 03 43.333 | 170 42.778 | 03 43.338 | 170 42.777 |
| 03 43.335 | 170.42.773 | 03 43.353 | 170 42.775 |
| 93 43.242 | 170 42.808 | 03 43.382 | 170 42.738 |
| 03 43.242 | 170.42.807 | 03 43.382 | 170 42.739 |
| 03 43.257 | 170 42.802 | 03 43.383 | 170 42.737 |
| 03 43.352 | 170.42.772 |           |            |

- White-throated storm-petrel

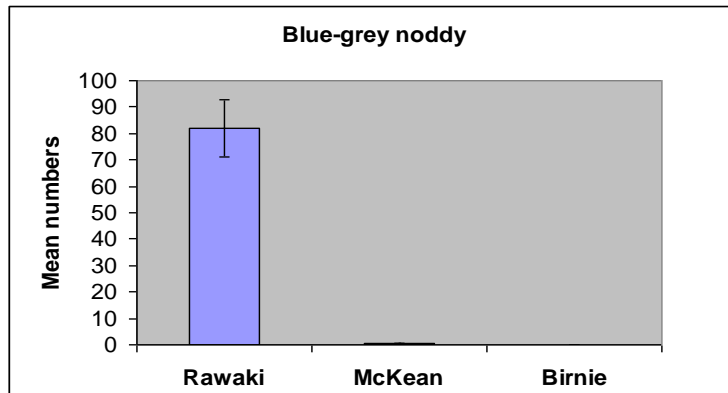
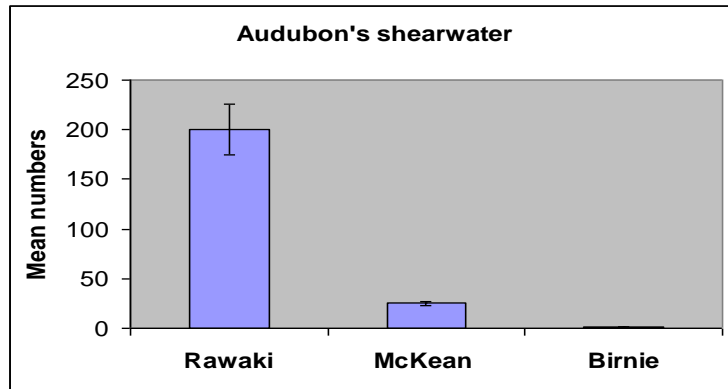
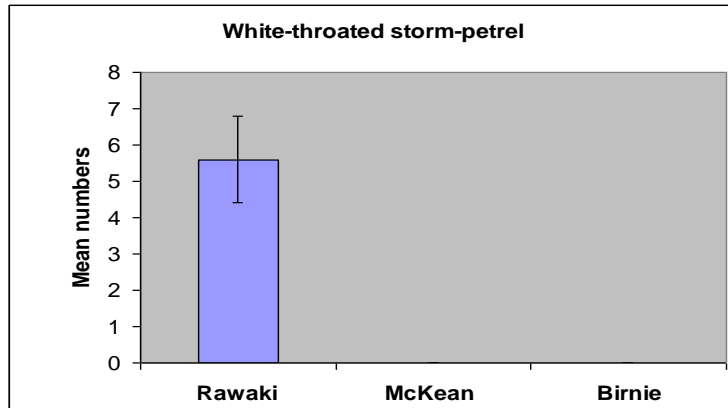
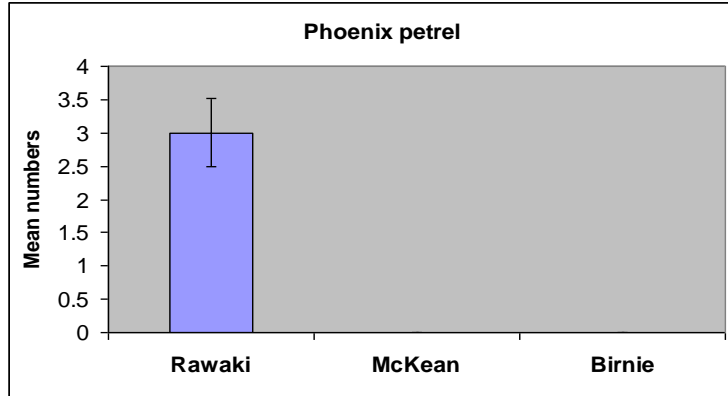
The storm-petrel nesting season was well underway in May-June 2008. Nesting was taking place in areas of dead *Lepturus* immediately W of the lagoon edge and areas of coral slabs (mainly in the upper beach on the W side of the island). One exception was a nest that was in a depression completely lacking cover – a bird was incubating the egg on the night of 2 June 2008, but had abandoned the nest by 1000 h the following day. This site had previously had *Boerhavia* cover and presumably had been a regular nest site for this pair. It can be expected that in the future, storm-petrels will be found nesting throughout much of the island beneath *Boerhavia* and *Portulacca* as well as the current (2008) nests sites. McKean offers more potential cover (vegetation and coral slabs) for storm-petrel nests than currently is the case on Rawaki. Ultimately both islands will support hundreds of pairs of storm-petrels and assist in securing this species in the central Pacific.

- Blue noddy

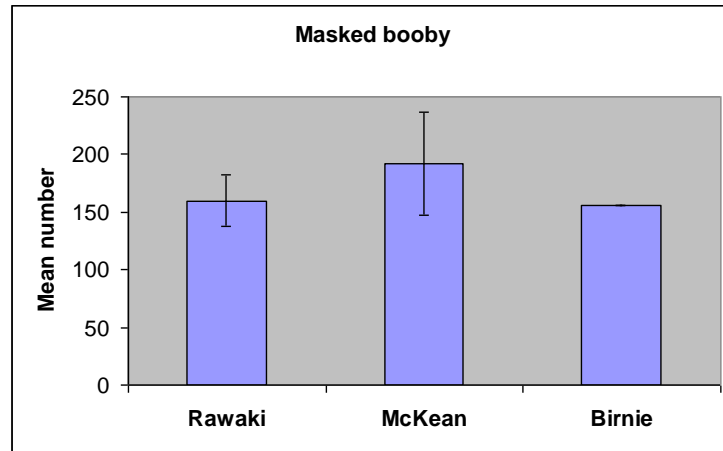
As in 2006, only Rawaki supported thousands of blue noddies, with nesting well underway in May-June 2008. Nests were confined to areas of healthy *Portulacca* and in the semi-shelter of coral slabs. Large areas of Rawaki, particularly the desert area, were not being used for nesting in 2008, but these areas will become heavily utilised in the future as *Boerhavia* and other plants recover there, and eventually the island is likely to support over 10000 birds. Given these birds regularly visit other islands in the Group (Pierce et al. 2006), McKean Island and other islands will be rapidly recolonised as they become pest-free.

#### Fly-ons for indexing populations

Results from seabird fly-ons showed low variability between nights for numbers of Phoenix petrels, storm-petrels, shearwaters, blue noddies and boobies flying ashore at each of Rawaki and McKean Island. The difference in counts between islands was striking however, with the sensitive species have been greatly depleted or eliminated from the rat-infested McKean and Birnie Islands (refer Appendix Fig 4.2). In contrast, species like masked booby, that are less susceptible to rats and rabbits showed no significant difference between fly-on counts at the three islands (refer Appendix Fig 4.3). Thus the index provides a useful indication of responses and health of populations of sensitive birds of an island without necessarily going ashore.



Appendix Figure 4.2 – Mean and standard error of fly-on counts for four sensitive species on three islands at Phoenix Islands May-June 2008.



Appendix Figure 4.3 – Mean and standard error of fly-on counts for masked boobies on three islands at Phoenix Islands May-June 2008.

Appendix Table 4.2 - Relationship between fly-on indices and numbers present on islands for different seabird species

| Species                     | Island | Mean fly-on | Island estimate | Estimated % seen on fly-ons |
|-----------------------------|--------|-------------|-----------------|-----------------------------|
| Phoenix petrel              | Rawaki | 3.0         | 80+             | 4-5                         |
| White-throated storm petrel | Rawaki | 5.5         | 120+            | 5                           |
| White-throated storm petrel | McKean | 0           | 0-10            | 0?                          |
| Audubon's shearwater        | Rawaki | 200         | 1500            | 13                          |
| Audubon's shearwater        | McKean | 25          | 100+            | <25                         |
| Christmas shearwater        | Rawaki | 47          | 1000            | 5                           |
| Bulwer's petrel             | Rawaki | 2.3         | 10+             | <20                         |
| Masked booby                | Rawaki | 153         | 2000            | 15                          |
| Masked booby                | McKean | 255         | 1000            | 25                          |
| Brown booby                 | Rawaki | 14.4        | 60              | 25                          |
| Brown booby                 | McKean | 10.5        | 50              | 20                          |
| Red-footed booby            | Rawaki | 0.8         | 20              | 4                           |
| Red-footed booby            | McKean | 29          | 60              | 50                          |

The fly-on counts are most sensitive for species in which individuals return mainly during the last two hours of darkness, e.g. blue noddy, Audubon's shearwater and

least sensitive for species in which individuals return over a longer period, e.g. Phoenix petrels (2 pm till after dark) and wedge-tailed shearwater (return after dark).

Appendix Table 4.3 - Seabird Fly-on data Phoenix Islands May-June 2008

A. Rawaki

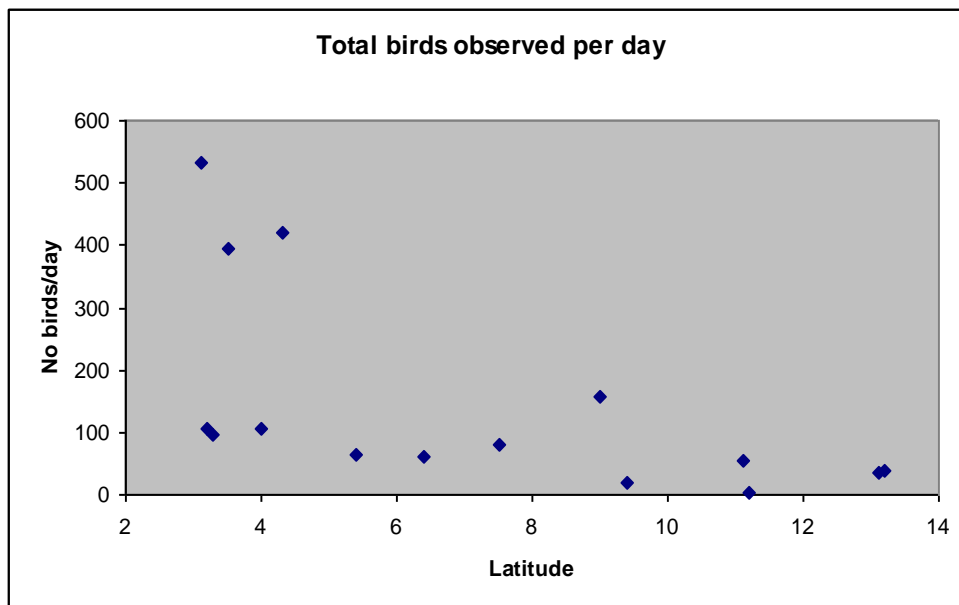
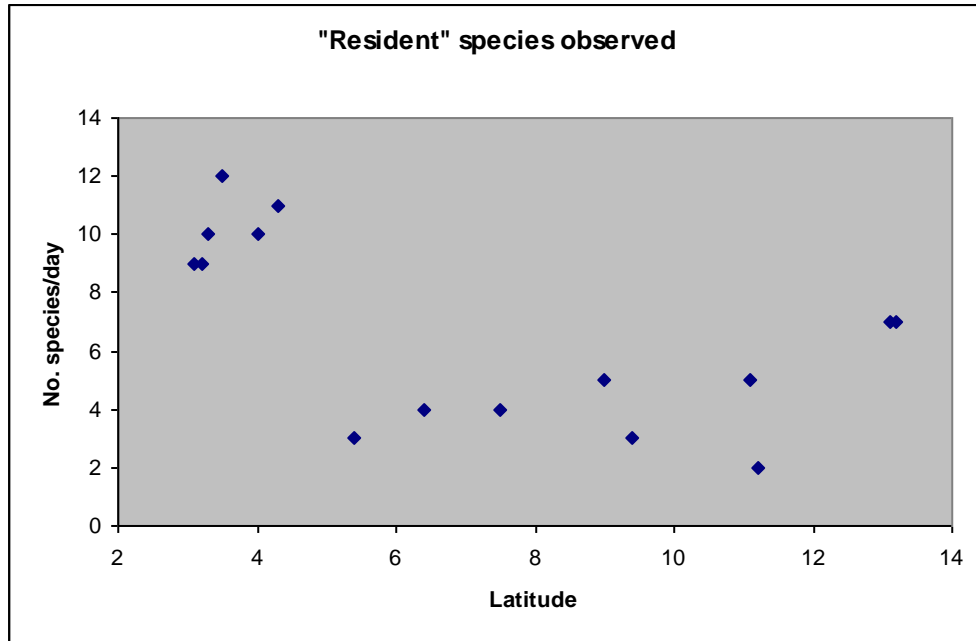
| Date                  | 27/5  | 27/5  | 29/5  | 30/5     | 31/5    | 1/6    | 3/6      | 17/6    |
|-----------------------|-------|-------|-------|----------|---------|--------|----------|---------|
| Observers             | RP    | GW    | RP UA | RP UA    | RP UA   | RP UA  | RP       | RP NA   |
| Viewed from           | Shore | Boat  | Shore | Shore    | Shore   | Shore  | Boat     | Shore   |
| Wind                  | Mod E | Mod E | Mod E | Strong E | Light E | Lt ESE | Light SE | Light E |
| Species               |       |       |       |          |         |        |          |         |
| Phoenix petrel        | 5     | 10    | 2     | 2        | 2       | 4      | 2        | 3       |
| WT shearwater         | 0     | 2     | 0     | 0        | 1       | 0      | 0        | 2       |
| Christmas shearwater  | 30+   | 7     | 20    | 50       | 55      | 12     | 25       | 116     |
| Audubon's shearwater  | 150+  | 22    | 156   | 211      | 257     | 140    | 63       | 287     |
| Bulwer's petrel       | 3     | 0     | 4     | 1        | 4       | 2      | 0        | 0       |
| WT storm-petrel       | 7     | 7     | 3     | 9        | 2       | 4      | 4        | 8       |
| Red-tailed tropicbird | P     | 2     | P     | P        | P       | P      | 4        | 6       |
| Masked booby          | P     | P     | 60    | 228      | 162     | 118    | 260      | 95      |
| Brown booby           | P     | P     | 20    | 21       | 13      | 8      | 3        | 10      |
| Red-footed booby      | P     | P     | 1     | 1        | 0       | 1      | 1        | 2       |
| Lesser frigatebird    | P     | P     | P     | P        | P       | P      | P        | P       |
| Great frigatebird     | P     | P     | P     | 0        | P       | 0      | 1        | 1       |
| Brown noddy           | P     | P     | P     | P        | P       | P      | P        | P       |
| Black noddy           | P     | P     | P     | P        | P       | P      | P        | P       |
| Blue noddy            | 67    | 66    | 95    | 89       | 56      | 59     | 189      | 126     |
| Sooty tern            | P     | P     | P     | P        | P       | P      | P        | P       |
| Grey-backed tern      | P     | P     | P     | P        | P       | P      | P        | P       |
| White tern            | P     | P     | P     | P        | P       | P      | P        | P       |

B. McKean and Birnie

| Island                | McKean | McKean | McKean | McKean | McKean  | McKean  | McKean | Birnie |
|-----------------------|--------|--------|--------|--------|---------|---------|--------|--------|
| Date                  | 5/6    | 5/6    | 6/6    | 6/6    | 11/6    | 12/6    | 13/6   | 9/6    |
| Observers             | RP     | GW UA  | RP     | GW     | RP UA   | RP NA   | RP NA  | RP     |
| Viewed from           | Shore  | Boat   | Shore  | Boat   | Shore   | Shore   | Shore  | Boat   |
| Wind                  | Mod E  | Mod E  | Mod E  | Mod E  | Mod ENE | Mod ENE | Mod E  | Mod E  |
| Species               |        |        |        |        |         |         |        |        |
| Phoenix petrel        | 0      | 0      | 0      | 0      | 0       | 0       | 0      | 0      |
| WT shearwater         | 0      | 0      | 0      | 0      | 0       | 0       | 0      | 0      |
| Christmas shearwater  | 0      | 0      | 0      | 0      | 0       | 0       | 0      | 0      |
| Audubon's shearwater  | 19     | 14     | 22     | 10     | 34      | 26      | 24     | 1      |
| Bulwer's petrel       | 0      | 0      | 0      | 0      | 0       | 0       | 0      | 0      |
| WT storm-petrel       | 0      | 0      | 0      | 0      | 0       | 0       | 0      | 0      |
| Red-tailed tropicbird | 1      | 0      | 3      | 1      | 3       | 2       | 1      | 5      |
| Masked booby          | 192    | 117    | 185    | 95     | 379     | 265     | 285    | 156    |
| Brown booby           | 14     | 14     | 15     | 7      | 17      | 6       | 12     | 15     |
| Red-footed booby      | 32     | 19     | 32     | 20     | 26      | 25      | 12     | 5      |
| Lesser frigatebird    | P      | P      | P      | P      | P       | P       | P      | P      |
| Great frigatebird     | P      | P      | P      | P      | P       | P       | P      | 0      |
| Brown noddy           | P      | P      | P      | P      | P       | P       | P      | P      |
| Black noddy           | 2      | 0      | P      | P      | 0       | 0       | 0      | P      |
| Blue noddy            | 0      | 0      | 2      | 0      | 0       | 0       | 0      | 0      |
| Sooty tern            | P      | P      | P      | P      | P       | P       | P      | P      |
| Grey-backed tern      | P      | P      | P      | P      | P       | P       | P      | P      |
| White tern            | P      | P      | P      | P      | P       | P       | P      | P      |

Pelagic seabirds

Observations of pelagic seabirds indicate a high use of the PIPA by resident birds and also by a wide range of migratory seabirds from breeding grounds at higher latitudes, particularly in Australasia (refer Appendix Figures 4.4 and Tables 4.4 and 4.5 below).



Appendix Figure 4.4 – Total seabird species and individuals observed per day between Samoa (14<sup>0</sup> S) and Phoenix Islands (3-4<sup>0</sup> S) May-June 2008

Appendix Table 4.4 - Pelagic seabird observations Samoa-Phoenix Islands return  
May-June 2008

| Transect leg                | Samoa | Swains | Tokelau | N<br>Tokelau | S<br>Phoenix | C<br>Phoenix | C<br>Phoenix |
|-----------------------------|-------|--------|---------|--------------|--------------|--------------|--------------|
| Date                        | 22May | 23May  | 24-May  | 25-May       | 26-May       | 04-Jun       | 14-Jun       |
| Tahiti petrel               |       | 2      | 2       |              |              |              |              |
| Phoenix petrel              |       |        |         |              |              |              | 1            |
| Mottled petrel              |       | 1      | 3       | 2            |              | 1            |              |
| Kermadec petrel             |       |        |         |              |              |              |              |
| White-necked petrel         | 1     | 1      |         |              |              |              | 1            |
| Juan Fernandez petrel       |       | 3      |         |              |              |              |              |
| Black-winged petrel         | 1     |        |         |              |              |              |              |
| Cook's petrel               |       |        |         |              |              | 1            | 1            |
| Pycroft's petrel            |       |        |         |              |              |              |              |
| Gould's petrel              |       |        | 1       |              |              |              |              |
| Collared petrel             |       |        |         |              |              |              | 1            |
| Unidentified petrel         | 2     | 1      |         |              |              |              | 1            |
| Buller's shearwater         |       | 2      | 2       | 4            | 2            | 1            | 1            |
| Streaked shearwater         |       |        |         |              | 1            |              |              |
| Flesh-footed shearwater     | 1     | 2      |         |              |              | 1            |              |
| Wedge-tailed shearwater     | 4     | 4      | 5       | 1            | 2            | 2            |              |
| Sooty shearwater            | 5     | 21     | 75      | 19           | 4            | 3            |              |
| Short-tailed shearwater     | 1     | 12     | 5       | 3            |              |              |              |
| Christmas shearwater        |       |        |         |              | 4            |              |              |
| Audubon's shearwater        | 1     |        |         |              |              |              |              |
| Unidentified shearwater     |       |        | 5       | 2            | 2            | 1            |              |
| White-throated storm-petrel |       |        |         |              |              |              |              |
| Wilson's storm-petrel       |       |        |         |              |              |              |              |
| Unidentified storm-petrel   |       |        | 1       |              |              |              |              |
| Red-tailed tropicbird       |       |        |         |              | 1            | 1            |              |
| White-tailed tropicbird     |       | 1      | 4       |              |              |              |              |
| Masked booby                |       |        |         |              | 17           | 12           | 4            |
| Red-footed booby            | 1     |        |         |              |              | 15           | 5            |
| Brown booby                 | 1     |        |         |              |              | 1            | 2            |
| Great frigatebird           | 1     |        |         |              | 3            | 1            |              |
| Lesser frigatebird          |       |        |         |              | 11           | 9            | 10           |
| Pomarine skua               |       |        |         |              | 1            |              |              |
| Grey-backed tern            |       |        |         |              | 21           | 23           | 3            |
| Sooty tern                  | 13    | 5      | 39      | 26           | 299          | 303          | 62           |
| Black-naped tern            |       |        |         |              |              |              |              |
| Brown noddy                 |       |        | 8       | 1            | 11           | 2            | 2            |
| Blue noddy                  |       |        |         |              | 13           | 4            |              |
| White tern                  | 1     | 1      | 7       | 3            | 27           | 13           | 1            |
| Bristle-thighed curlew      | 1     |        |         |              |              |              |              |
| Total                       | 34    | 56     | 157     | 61           | 419          | 394          | 95           |
| Total species               | 13    | 14     | 13      | 8            | 15           | 17           | 14           |
| Resident species            | 7     | 5      | 5       | 4            | 11           | 12           | 10           |

| C<br>Phoenix<br>15-Jun | E<br>Phoenix<br>16-Jun | S<br>Phoenix<br>18-Jun | Manra<br>19-Jun | N<br>Tokelau<br>20-Jun | Tokelau<br>21-Jun | Swains<br>22-Jun | Samoa<br>23-Jun | Total | Bird<br>abbrev. |
|------------------------|------------------------|------------------------|-----------------|------------------------|-------------------|------------------|-----------------|-------|-----------------|
|                        |                        |                        |                 |                        |                   |                  |                 | 4     | Tape            |
|                        | 1                      |                        |                 |                        |                   |                  |                 | 2     | Phpe            |
|                        |                        |                        |                 |                        |                   |                  |                 | 7     | Mope            |
|                        |                        |                        |                 |                        | 1                 |                  |                 | 1     | Kepe            |
|                        |                        |                        |                 |                        |                   |                  |                 | 3     | WNpe            |
|                        |                        |                        |                 |                        |                   |                  |                 | 3     | JFpe            |
| 1                      | 2                      | 2                      | 4               | 5                      | 1                 | 1                |                 | 17    | BWpe            |
|                        |                        | 1                      | 2               |                        | 1                 |                  |                 | 6     | Cope            |
|                        | 1                      |                        |                 |                        |                   |                  |                 | 1     | Pype            |
|                        |                        |                        |                 |                        |                   |                  |                 | 1     | Gope            |
| 1                      |                        |                        |                 |                        |                   |                  |                 | 2     | Clpe            |
|                        |                        |                        | 1               |                        |                   | 1                |                 | 6     | Unpe            |
|                        |                        |                        |                 |                        |                   |                  |                 | 12    | Bush            |
|                        |                        |                        |                 |                        |                   |                  |                 | 1     | Stsh            |
|                        |                        |                        |                 |                        |                   |                  |                 | 4     | Ffsh            |
| 1                      |                        |                        |                 |                        |                   |                  |                 | 19    | Wtsh            |
|                        |                        |                        |                 |                        |                   |                  |                 | 127   | Sosh            |
|                        |                        |                        |                 |                        |                   |                  |                 | 21    | STsh            |
|                        |                        | 2                      |                 |                        |                   |                  |                 | 6     | Chsh            |
|                        | 1                      | 2                      |                 |                        |                   |                  | 1               | 5     | Aush            |
|                        |                        |                        |                 |                        |                   |                  |                 | 10    | Unsh            |
|                        |                        | 1                      | 1               |                        |                   |                  |                 | 2     | WTSP            |
|                        |                        | 1                      |                 |                        |                   |                  |                 | 1     | WiSP            |
|                        |                        |                        |                 |                        |                   |                  |                 | 1     | UnSP            |
|                        |                        |                        |                 |                        |                   |                  |                 | 2     | RTTB            |
|                        |                        |                        |                 |                        |                   | 1                | 3               | 9     | WTTB            |
| 3                      | 6                      | 7                      |                 |                        |                   |                  |                 | 49    | Mabo            |
| 8                      | 2                      | 1                      |                 |                        | 3                 |                  | 6               | 41    | Rfbo            |
| 1                      | 1                      |                        |                 |                        |                   | 1                | 1               | 8     | Bnbo            |
|                        |                        |                        |                 |                        |                   |                  |                 | 5     | Grfb            |
| 11                     | 8                      | 1                      | 3               | 2                      |                   |                  |                 | 55    | Lefb            |
|                        |                        |                        |                 |                        |                   |                  |                 | 1     | Posk            |
| 5                      | 3                      | 12                     |                 |                        |                   |                  |                 | 67    | Gbte            |
| 70                     | 500                    | 72                     | 52              | 54                     | 2                 |                  | 7               | 1504  | Sote            |
|                        |                        |                        |                 | 1                      |                   |                  |                 | 1     | Bnte            |
|                        |                        | 2                      |                 |                        |                   |                  | 9               | 35    | Brno            |
|                        | 8                      |                        |                 |                        |                   |                  |                 | 25    | Blno            |
| 2                      |                        | 1                      |                 | 19                     | 10                |                  | 11              | 96    | Whte            |
| 2                      |                        |                        |                 |                        |                   |                  |                 | 3     | BTCu            |
| 105                    | 533                    | 105                    | 63              | 81                     | 18                | 4                | 38              | 2163  | Total           |
| 11                     | 11                     | 13                     | 5               | 5                      | 6                 | 3                | 7               |       | Spp             |
| 9                      | 9                      | 10                     | 3               | 4                      | 3                 | 2                | 7               |       | Res sp          |

Appendix Table 4.5 – physical data associated with pelagic bird observations above

|                          |        | N      | S       | C       | C       |         |         |
|--------------------------|--------|--------|---------|---------|---------|---------|---------|
| Transect leg             | Samoa  | Swains | Tokelau | Tokelau | Phoenix | Phoenix | Phoenix |
| Date                     | 22-May | 23-May | 24-May  | 25-May  | 26-May  | 04-Jun  | 14-Jun  |
| Hours                    | 8      | 8      | 9       | 8       | 8       | 8       | 8       |
| Time start               | 800    | 700    | 700     | 630     | 635     | 640     | 700     |
| Time finish              | 1600   | 1630   | 1730    | 1700    | 1600    | 1725    | 1700    |
| Lat start                | 13210  | 11357  | 9260    | 7021    | 5004    | 3441    | 3327    |
| Lat finish               | 12458  | 10428  | 8319    | 6165    | 4032    | 3471    | 3241    |
| Long start               | 171273 | 170153 | 17018   | 170283  | 170371  | 171549  | 173597  |
| Long finish              | 171032 | 170118 | 17023   | 170322  | 170417  | 171541  | 173192  |
| Speed knots              | 5.3    | 5.7    | 5.4     | 5.4     | 6.1     | 6       | 5.5     |
| Average course (degrees) | 30     | 0      | 355     | 355     | 355     | 277     | 80      |
| Viewing conditions 1-4   | 3      | 3      | 3       | 4       | 4       | 4       | 3       |
| Sea conditions 1-4       | 2      | 2      | 2       | 2       | 1       | 2       | 1       |

|                          | C       | E       | S       | N      |         |         |        |        |
|--------------------------|---------|---------|---------|--------|---------|---------|--------|--------|
| Transect leg             | Phoenix | Phoenix | Phoenix | Manra  | Tokelau | Tokelau | Swains | Samoa  |
| Date                     | 15-Jun  | 16-Jun  | 18-Jun  | 19-Jun | 20-Jun  | 21-Jun  | 22-Jun | 23-Jun |
| Hours                    | 6       | 4       | 4       | 8      | 8       | 5       | 8      | 6      |
| Time start               | 700     | 650     | 1400    | 700    | 630     | 1300    | 700    | 700    |
| Time finish              | 1300    | 1050    | 1800    | 1500   | 1800    | 1800    | 1800   | 1300   |
| Lat start                | 3020    |         | 3530    | 5237   | 7213    | 9183    | 1054   | 1306   |
| Lat finish               | 2524    | 3.375   | 170459  | 17107  | 17130   | 17150   | 17150  | 17146  |
| Long start               | 172300  |         | 4137    | 6050   | 8210    | 9580    | 11470  | 1339   |
| Long finish              | 170505  | 170471  | 170507  | 171160 | 171410  | 17150   | 17148  | 17145  |
| Speed knots              | 5.1     | 5.1     | 5.1     | 5.3    | 5.3     | 5.7     | 5.5    | 5.5    |
| Average course (degrees) | 80      | 150     | 190     | 190    | 190     | 175     | 180    | 180    |
| Viewing conditions 1-4   | 3       | 1       | 4       | 4      | 4       | 3       | 4      | 4      |
| Sea conditions 1-4       | 1       | 2       | 2       | 2      | 2       | 2       | 1      | 1      |

## Vegetation and plants

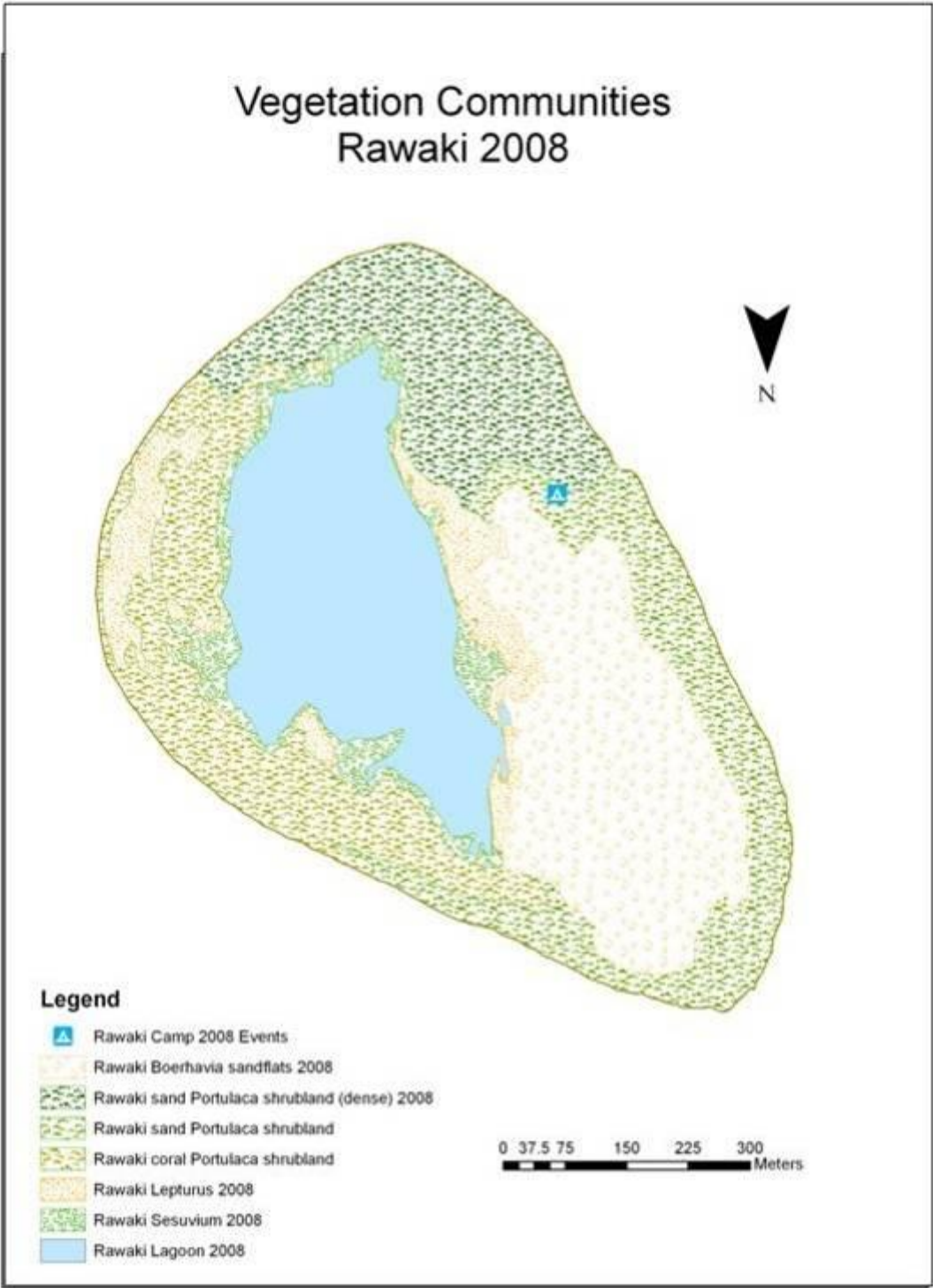
Plant lists from 2006 are listed in Pierce et al (2006). Baseline vegetation maps for Rawaki and McKean Island were completed during the eradication work and are provided in the Appendices. Vegetation photopoints were also established on the two islands (refer Appendix Table 4.6 for gridpoints) and copies of pictures will be provided on CD to GOK at PIPA office and WCU. During the last few days of the rabbit eradication on Rawaki the growth response from *Boerhavia* and *Portulacca* was noticeable and the former was also flowering (refer photographs below). It will be worth completing the Photopoints at every opportunity when visiting the islands.



Appendix Figure 4.5 – Rawaki vegetation response to browser removal and rain, 18 June 2008 (6 days after the last rabbits were shot)

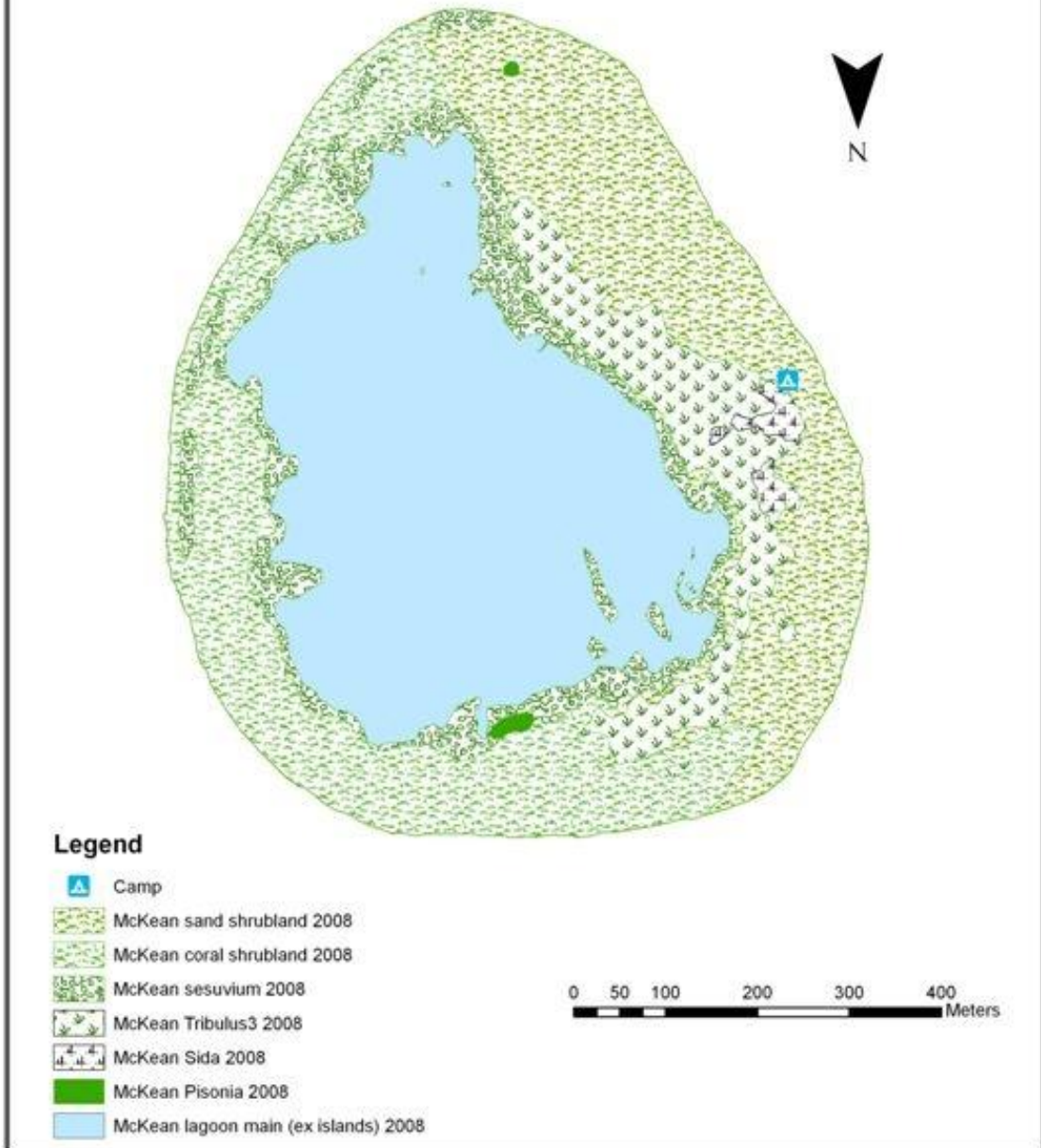
Above – *Portulacca* now providing shade for ternlet nests

Below – *Boerhavia* flowering.



Appendix Fig 4.6 – Vegetation of Rawaki in 2008

# Vegetation Communities McKean Is. 2008



Appendix Fig 4.7 – Vegetation of McKean 2008

Appendix Table 4.6 - Vegetation photopoint locations at Rawaki and McKean

### Rawaki

| No. | Site name                | Location S   | Location E    | Photo orientations (magnetic) |
|-----|--------------------------|--------------|---------------|-------------------------------|
| 1   | South Rock – from on top | 03 43' 29.2" | 170 42' 46.8" | N E S W                       |
| 2   | Landing historic site    | 03 43' 22.4" | 170 42' 51.2" | N E S W                       |
| 3   | Lagoon mound             | 03 43' 21.5" | 170 42' 44.9" | N E S W                       |
| 4   | N Point survey plaque    | 03 43' 00.1" | 170 42' 56.6" | E S SE                        |

### McKean

| No. | Site name              | Location S   | Location E    | Photo orientations (magnetic) |
|-----|------------------------|--------------|---------------|-------------------------------|
| 1   | Great Wall SE corner   | 03 35' 44.1" | 174 07' 32.0" | N E S W SE                    |
| 2   | North Wall NE corner   | 03 35' 37.2" | 174 07' 32.3" | N E S W NE                    |
| 3   | East historic outhouse | 03 35' 47.3" | 174 07' 30.1" | N E S W                       |
| 4   | Coral block            | 03 35' 53.7" | 174 07' 24.8" | N E S W                       |

### Reptiles and marine mammals

Turtle sign (assumed to be that of green turtle *Chelonia mydas*) was recorded on two areas of Rawaki in June 2008. Outlines of c.20 old nest and pit diggings were found on the vegetated sandy high point of the island immediately east of the Australian Survey plaque at North Point area. About 30 additional old diggings were located along a sandy beach on the western side of the island c.200 m north of the landing. One turtle had been ashore at the latter site on the night of 1-2 June when it visited and partially excavated 5 pits, one of which we subsequently found to contain old hatched egg-shell and rotten eggs. One green turtle was seen leaving the same area on c.10 June (D Brown pers. obs.). The previous lack of records ashore on Rawaki in April 2006 may have resulted from the ephemeral beaches having been washed away, although the higher ground at North Point had not been inundated in 2006. No turtle sign was found on McKean Island in 2006 or 2008.

The only lizards recorded in 2008 were *Lepidodactylus lugubris* which were moderately common in the coral walls of derelict buildings at McKean Island, and no lizards were recorded on Rawaki. The only marine mammals seen were 3-4 bottle-nosed dolphins that escorted the Bounty Bay south-east from the entrance to

Abariringa. There was no sign of whales despite 105 hours of pelagic seabird transects (basically involving staring at horizons) between Samoa and the Phoenix Islands.

## Crabs

Several species of crabs were present on Rawaki and McKean Island, including the common hermit crab *Coenobita perlatus*, the cryptic *Geograpsus crinipes* and *Geograpsus grayi* which occurred throughout terrestrial areas, while *Cardisoma* sp. was uncommon and *Birgus latra* apparently confined to one individual seen on Rawaki (same location as in 2006 – area of *Lepturus* in vicinity of Phoenix petrel colony). Counts were made of hermit crabs because they are attracted to and consume poison baits. These counts were undertaken on the night prior to poisoning in order to determine their preferred distribution. Transects measuring 2 x 25 m were established across each atoll, with habitat also being noted – substrate and vegetation. Overall the density of hermit crabs was noticeably lower than that recorded in April 2006, particularly on Rawaki (Appendix Table 4.7).

Appendix Table 4.7 – Mean number (and range) of crabs recorded in 50 m<sup>2</sup> random transects during pre-poison nights on Rawaki and McKean Island in May-June 2008 and compared with 2006 means.

Port/Ses/Boer = areas of Portulaca, Sesuvium and Boerhavia. P = present at low densities. To arrive at coarse estimate of crabs/ha, multiply mean count by 200.

| Species                   | Rawaki 2006 | Rawaki 2008 Port/Ses/Boer | Rawaki 2008 Lepturus/terns | McKean 2006 | McKean 2008 |
|---------------------------|-------------|---------------------------|----------------------------|-------------|-------------|
| No. transects             | 10          | 48                        | 26                         | 10          | 51          |
| <i>Coenobita perlatus</i> | 3           | 0.9 (0-8)                 | 6.8 (0-23)                 | 23          | 13.9 (0-63) |
| <i>Coenobita cavipes</i>  | 0           | 0                         | 0                          | P           | P (rare)    |
| <i>Geograpsus</i> spp.    | 2.5         | P (common)                | P (common)                 | P           | P (common)  |
| <i>Cardisoma</i> sp.      | P           | 0                         | 0                          | P           | 0           |
| <i>Birgus latra</i>       | P (rare)    | 0                         | P (rare)                   | 0           | 0           |

## Monitoring lessons learned

A previous survey of the islands in 2006 ensured that methodology used in 2008 was appropriate. Most monitoring established was simple and repeatable thereby allowing GoK staff and visitors to collect comparable data in the future. It had also been intended to band Phoenix petrels and white-throated storm petrels but this was aborted due to the allocated band size being too small for storm-petrels and unusually sharp-edges to the petrel bands. This banding should still be undertaken as a baseline over the next 3-4 years before increased recruitment begins to occur as a result of the pest eradications.