Atolll Restoration in the Phoenix Islands, Kiribati: Survey Results

November–December 2009

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7

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Atoll Restoration in the Phoenix Islands, Kiribati: Survey Results in November–December 2009

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CRITICAL ECOSYSTEM PARTNERSHIP FUND

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This document is part of a technical report series on conservation projects funded by the Critical Ecosystem Partnership Fund (CEPF) and the Conservation International Pacific Islands Program (CI-Pacific). The main purpose of this series is to disseminate project findings and successes to a broader audience of conservation professionals in the Pacific, along with interested members of the public and students. The reports are being prepared on an ad-hoc basis as projects are completed and written up.

In most cases the reports are composed of two parts, the first part is a detailed technical report on the project which gives details on the methodology used, the results and any recommendations. The second part is a brief project completion report written for the donor and focused on conservation impacts and lessons learned.

The CEPF fund in the Polynesia-Micronesia region was launched in September 2008 and will be active until 2013. It is being managed as a partnership between CI Pacific and CEPF. The purpose of the fund is to engage and build the capacity of non-governmental organizations to achieve terrestrial conservation. The total grant envelope is approximately US$6 million, and focuses on three main elements: the prevention, control and eradication of invasive species in key biodiversity areas (KBAs); strengthening the conservation status and management of a prioritized set of 60 KBAs and building the awareness and participation of local leaders and community members in the implementation of threatened species recovery plans.

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CRITICAL ECOSYSTEM PARTNERSHIP FUND

CONSERVATION INTERNATIONAL Pacific Islands

Location of the project in the Polynesia-Micronesia Biodiversity Hotspot

Contents

Abbreviations and Acronyms

Birnie	Birnie Island
CEPF	Critical Ecosystem Partnership Fund
CG	Clea Gardner
CI	Conservation International
Enderbury	Enderbury Island
GC	Glen Coulston
GoK	Government Of Kiribati
GPS	Global Positioning System
GW	Dr Graham Wragg, Pacific Expeditions
Kanton	Kanton Island or Abariringa
KT	Katareti Taabu, WCU, Kiritimati
LS	Dr Louise Shilton
McKean	McKean Island
MHWS	Mean High Water Spring Tide
NA	Nautonga Anterea, Agriculture, Kiritimati
NZAID	New Zealand Aid
NZDOC	New Zealand Department of Conservation
Orona	A PIPA island previously known as Hull Island
PIPA	Phoenix Islands Protected Area
RP	Dr Ray Pierce
SVSC	Sailing Vessel Southern Cross
WCU	Wildlife Conservation Unit, Kiritimati

Executive Summary

A survey of selected atolls of the Phoenix Islands Group, Kiribati, was undertaken during 22 November to 13 December 2009. The primary aims were to check on the success of rabbit and rat eradication operations of the previous year and to help plan for the restoration of additional priority islands in the Group. The work was funded by the Critical Ecosystems Partnership Fund (CEPF administered by Conservation International) and New Zealand Aid (NZAID), the latter facilitated by NZ Department of Conservation. Government of Kiribati staff from Agriculture and Environment sections participated along with ecological specialists from Australia and New Zealand.

The survey determined that the pest eradication work of May–June 2008 was successful with no sign of Asian rats on McKean Island or European rabbits on Rawaki. These pests had been causing catastrophic damage to vegetation and animals on the two islands, but now 18 months after the eradications, the biota of both islands are showing signs of recovery. The vegetation response is particularly striking with the islands now supporting more luxuriant and diverse plant growth despite conditions having been fairly dry. Several species of birds are also responding positively with increased breeding success on McKean and more extensive nesting areas on Rawaki due to the improved vegetation cover on these islands.

Targeted surveys wre undertaken on Enderbury, Orona and Kanton in order to help in restoration planning for those islands, while Birnie had been surveyed in 2006 and 2008. Enderbury and Birnie are infested with only Pacific rats, but Orona and Kanton both support cats, Pacific rats, with Kanton also supporting a large *Rattus* species (species to be determined genetically). From these surveys, a draft operational plan is being prepared for the restoration of Enderbury, Birnie and Kanton. Further feasibility work in relation to crabs and cats is required for Orona (and Manra and Nikumaroro) and we recommend that restoration of those islands takes place at a later date.

This survey provided capacity building support to Government of Kiribati (GoK) staff and focused on pest surveillance, improved biosecurity, restoration planning and biota monitoring. There are several opportunities for GoK staff to undertake important additional restoration work in the Phoenix Islands Protected Area (PIPA). These include the eradication of Pacific rats from 4 ha Channel Island at Kanton on which seabirds are currently being devastated by the rats, and applying specific improved quarantine measures at Kanton to enhance biosecurity of the PIPA generally.

1 Background

The terrestrial habitats of the Phoenix Islands and their globally important bird populations are being restored as part of the Government of Kiribati's management plan for the PIPA (Government of Kiribati in prep). These restoration initiatives are supported by a number of international agencies including Conservation International, EcoOceania Pty Ltd, NZAID, NZ Department of Conservation (NZDOC), Pacific Expeditions and Pacific Invasives Initiative. The current work is funded by the Critical Ecosystem Partnership Fund (CEPF) and NZAID.

This survey (November–December 2009) had three principal aims:

- Evaluate success of the 2008 pest eradication operations – Asian rats on McKean Island and European rabbits on Rawaki.
- Collect data to help plan pest eradications on Orona (cats and possibly rats present), Enderbury and Birnie (rats present) and if possible other islands including Manra and Kanton (pest suites to be determined).
- Work with GoK staff to set up associated tasks including improved biosecurity, pest surveillance and biota monitoring, including assessment of short-term biota responses to pest eradication.

2 Timetable

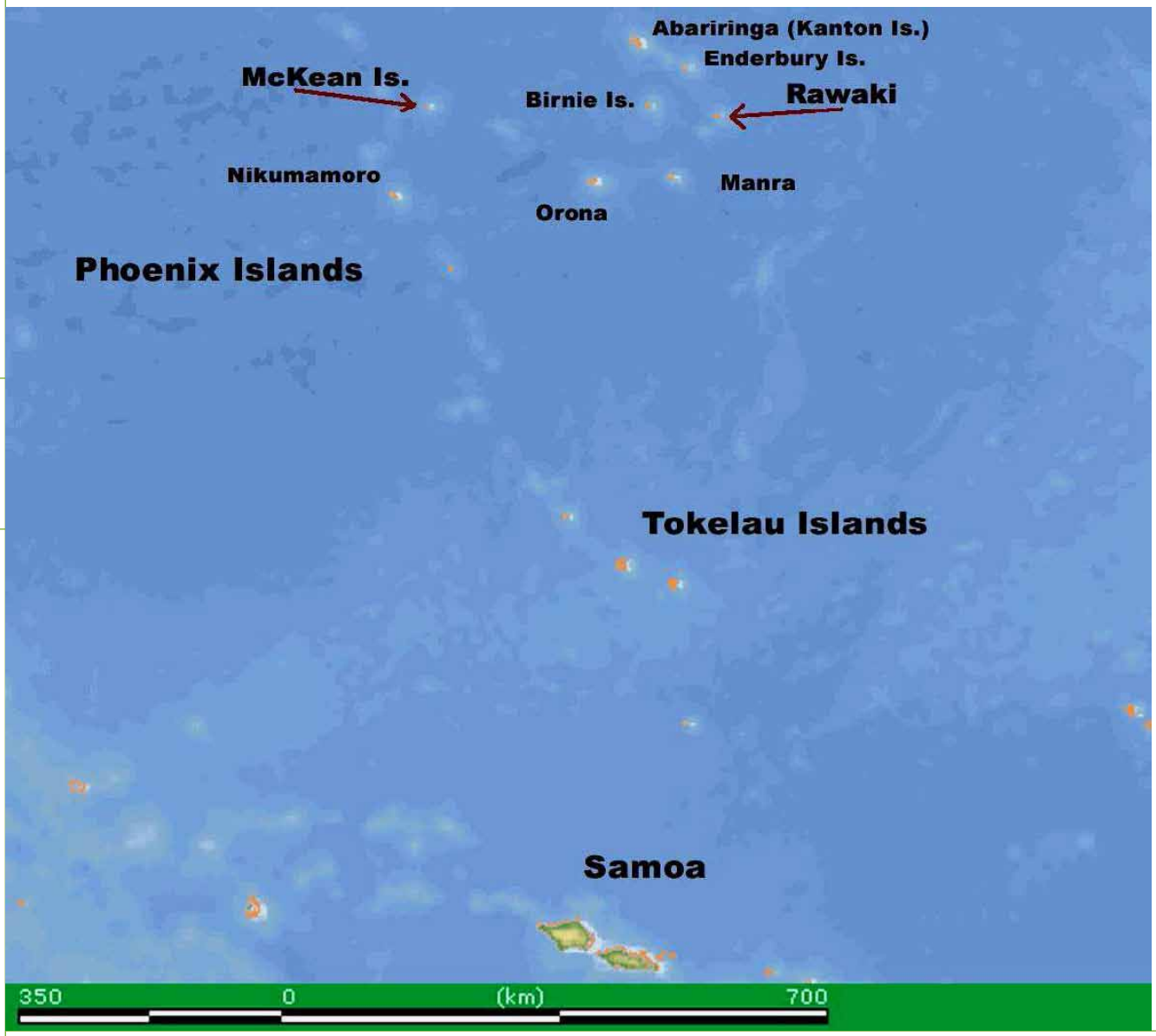
The expedition embarked from Apia, Samoa via the SV Southern Cross on 22 November 2009 (Kiribati time) and returned to Apia on 13 December 2009. Kiribati team members joined the expedition at Kanton on 3 December 2009. A team of two people (GC and CG) remained on Orona for 13 days. The timetable of island visits is provided in Table 2.1 (see Figure 2.1 for map of the PIPA). The original plan was to spend longer at the PIPA (Rawaki and Manra) but a medical condition and unsafe sea-swells during landings precluded this.

TABLE 2.1 – Summary of locations and activities.

Date	SV Southern Cross	Orona team
22–25/11	Apia–Orona; seabird transects	As for SV Southern Cross
26/11	Orona – skiff survey distant motu	As for SVSC set rodent traps at village.
27/11	Orona – distant survey; departed pm	As for SVCC; set up camp. Evening Fly-on.
28/11	At sea bound for McKean	Establish rodent traps. Establish Crab exclusions cat boxes/techniques.
29/11	McKean – biota and rat searches	Check traplines. Establish rodent traps at east end main motu . Search main motu ocean coast line for cat sign and perimeter GPS. Evening fly-on.
30/11	McKean – bait stations, rat etc searches	Check trap lines and cat boxes. Village cleanup. Day Search lagoon coastline for cat sign and GPS lagoon edge.
1/12	Depart McKean for Kanton	Check trap and boxes lines, Clean up hospital supplies and officials building
2/12	At sea, SE Peninsula Kanton	Check and removed eastern trap lines. Village cleanup and disposal of old waste,
3/12	Kanton – survey SE Peninsula	Day Searched Western Motu and tern colonies. GPS motu perimeters
4/12	Kanton – meet GoK team, community meeting; sail to Enderbury	Check trap and box lines. Village clean up. Evening Fly-on.
5/12	Enderbury GPS, biota survey	Check trap and box lines. Village cleanup. Evening Fly-on

6/12	Depart Enderbury for Rawaki	Check trap and box lines. Village Cleanup. Spotlight Night
7/12	Rawaki – pests, biota, depart evening	Check trap and box lines. Village clean up. Evening Fly-on. Spotlight night
8/12	Kanton – depart for Orona am; evening flyon at Birnie	Check trap and box lines. Village clean up. Spotlight Night
9/12	Orona – arrive am, depart for Apia pm	Show NA, RP and KT around; collect rat traps and cat trial boxes, depart pm
10–12/12	At sea; seabird transects	–
13/12	Arrive Apia	–
14–15/12	Meetings with CI and others, members depart	–

FIGURE 2.1 – Location of the islands targeted for pest eradication in 2008 and other islands in the PIPA.



3 Mckean Island Rat Eradication Assessment

3.1 Searches for rodent sign

Methods

Two methods were used to determine rat presence/absence on McKean:

- Surveying for direct observations during the late afternoon and at night – Asian rats had been active from late afternoon daily and they were also easily observed at night in 2006 and 2008. We spent 2 days and nights on the island and undertook a total of c.14 person-hours of late afternoon observations and after-dark spotlight surveys.
- Surveying for sign of rat predation on egg shell and plants – Asian rats had preyed on virtually all eggs of sensitive species (terns, noddies and shearwaters) found in 2006 and 2008. Hence during this survey we spent several hours observing the contents of nests of terns and noddies for a total of c.364 nests observed. Note that some conventional methods used elsewhere (e.g. trapping and using gnaw sticks) are not applicable here because of bird and crab interference.

Results and conclusions

No sign of rats was found using either method. There were no sightings of rats or possible rats during the 14 person-hours of observation (Table 3.1). Many additional hours spent doing other tasks on the island would also have exposed rats to being detected.

TABLE 3.1 – Rat survey results on McKean Island

Date	Approx time start (& hrs)	Observer	Location	Rat sightings
28/11	1700 (1.5 h)	LS	Outer GPS circuit	Nil
28/11	1700 (1.5)	RP	Landing	Nil
28/11	2000 (2.5)	RP	Circuit and lagoon edge	Nil
28/11	2000 (2.0)	GW	Island wide	Nil
29/11	0430 (1.0)	RP	Island wide	Nil
29/11	1900 (3.0)	RP	Island wide	Nil

29/11	2030 0.5)	LS	Landing site	Nil
29/11	2000 (1.0)	GW	W side	Nil
30/11	0300 (1.0)	RP	Island wide	Nil
Total	14 hours	All	Island wide	Nil

There were no instances of suspected rat sign on eggs (Table 3.2). We conclude that rats were successfully eradicated during May–June 2008.

TABLE 3.2 – Observations of nests of sensitive species at seven representative McKean Island seabird colonies. GRBT = grey-backed tern, BNNO = brown noddy, BKNO = black noddy.

Species	Estimate No. pairs	Nests checked	1 e	1 downy	1 pul	Juvs present	Suspected rodent predation
GRBT	500	c.110	100+	3	5	150+	Nil1
GRBT	100	22	20	0	2	20+	Nil
GRBT	10	3	3	0	0	0	Nil
GRBT	20	8	6	0	2	0	Nil
BNNO	150	63+	30+	15	18	100+	Nil
BNNO	150	55	23	11	21	30+	Nil
BKNO	5	3	2	1	0	0	Nil
Total	c.935	364	184	30	48	300+	Nil

Note 1: Some crab predation on eggs in this colony.

3.2 Biota responses to Asian rat removal

Seabird productivity

In November 2009 there was a spectacular increase in the productivity of seabirds compared with 2006 and 2008 when rats were present. In both previous years there was no evidence of breeding success of the tern and noddy species, despite our being there at peak breeding time in May–June (Pierce et al 2006, 2008). In November 2009, the sensitive species identified in Table 3.2 above were all breeding successfully. A contrast to this seasonal observation is on rat-infested Enderbury where the failure rates were high in both seasons – May–June 2006 and December 2009. In addition to this observation, McKean supported large non-breeding roosts of brown noddies which contained hundreds of juveniles, and there were hundreds of juvenile lesser frigatebirds at the colony site indicating that the recent breeding season has been successful.

FIGURE 3.2 –McKean Island Lagoon, November 2009, with a roost of masked boobies in the foreground and some of the many roosts of brown noddies in the background.

FIGURE 3.3 – Grey-backed tern chick; terns were nesting successfully at McKean Island in 2009 compared with virtually total failure there in 2006 and 2008 due to rat predation.

Seabird species and numbers

Overall seabird species and abundance was similar to that observed in 2006 and 2008, with the exception that numbers of red-footed boobies, brown noddies and black noddies had increased in numbers (Table 3.3). The booby response may reflect a seasonal difference, but the numbers of both species of noddies may be a result of their now successful breeding at the island. The fly-on and spotlighting data indicate that blue noddies and storm-petrels are both still very rare at the island and recovery of their populations will take some time.

TABLE 3.3 – Estimated number of seabird pairs at McKean in 2006–09.

Species	Methods 2009	28 Apr – 1 May 06	5 – 13 Jun 08	29 – 30 Nov 09
Audubon's shearwater	Night counts	60	50	50
Christmas shearwater	Night counts	0	0	0
Wedge–tailed shearwater	Night counts	2 i	0	4i
Phoenix petrel	Night counts, wws	0	0	0
Bulwer's petrel	Flyons	0	0	0
White-throated storm petrel	Night count; flyons	10+	0	2i
Red-tailed tropicbird	Day transects	34	85	P
Masked booby	Day transects	c.400	318	354
Masked booby cont.	Night counts	–	c.1000 i	1200+i
Brown booby	Day transects	75	18	8
Red-footed booby	Day transects	60	23	c.50
Great frigatebird	Day counts	400	200	P
Lesser frigatebird	Day counts	1500	1200	P
Lesser frigatebird cont.	Night counts	–	–	c.3000 i
Sooty tern	Day estimates	500 i	c.1000 i	c.100 i
Grey-backed tern	Day estimate	800 i	500+ i	800
Black noddy	Day counts	6	10+	50
Brown noddy	Day estimate	1630	1000+ i	3000+
Blue noddy	Night est, flyons	1 i	1 i	1 i
White tern	Day estimate	100 i	40+ i	100+ i
Approx total pairs	–	5000	3300	5300
Total species	–	15	13	15

Note: P = present. All counts are of pairs unless i is indicated in which case count = individuals.

Vegetation responses

The removal of rats from the island has been accompanied by a spectacular vegetation response including:

- The same plant species were present as recorded in 2006–08, but far greater extent of vegetation – formerly bare coral rubble is increasingly vegetated
- Height of vegetation – *Boerhavia* and *Portulaca* have attained greater heights including growing over 130 year old coral walls (refer www.phoenixislands.org)
- Increased flowering and seeding.
- Some examples are provided below of photopoints taken when rats were present in 2008 and from the same points in November 2009. A full set of photopoints has been provided to the PIPA office.

3.3 Miscellaneous

Bait stations

Some 83 bait of the 100 stations deployed in 2008 were relocated as follows:

- Intact, bait present 6
- Intact bait gone 25
- Broken lid, bait present 5
- Broken lid, bait gone 47

These bait stations were incinerated in a deep pit on the island and the pit was subsequently re-filled with sand.

Island area

A smaller than expected land area (21 ha) had been calculated in the 2008 eradication trip to McKean Island (Pierce et al 2008). On the 2009 trip two Garmin 60CSx GPS units were used to calculate total area and lagoon area and hence land area. Later, LS used Google Earth Pro to compare total island areas (resolution was not adequate to measure lagoon area). There was however a very close agreement between both the 2009 GPS units and Google Earth Pro for total island area (Table 3.3), hence the revised land area for McKean is c.27 ha. Therefore, the bait application rates were about 30% lower than calculated in Pierce et al (2008).

TABLE 3.3 – McKean areas calculated in 2009

Method	GPS CSx No. 1	GPS CSx No. 2	Google Earth Pro
Total area	47.5 ha	47.5 ha	47.8
Lagoon area	20.7 ha	20.7 ha	–
Total land area	26.8 ha	26.8 ha	–

Lessons learned

For small islands don't rely on a single GPS for calculating small areas.

4 Rawaki
Rabbit Eradication Assessment

4.1 Searches for European rabbit sign

Methods

Two methods were used to determine rabbit presence/absence on Rawaki:

- Direct observations during the day and evening – rabbits had previously been active during the day and especially in the evening and night. We spent one day ashore, departing after sunset and undertook a total of 16 person hours of observations focused in the late afternoon and evening. Six people took part in the evening observations. Four used binoculars from fixed scanning points and two walked around the entire island. (We had also intending staying overnight but due to unforeseen circumstances we needed to abort this plan).
- Sign of rabbit browse on plants and damage to egg-shells – rabbits had been severe on *Boerhavia* and *Portulaca* during our 2006 and 2008 visits, with browse on Portulaca being particularly conspicuous. Seabird eggs were also being crushed. We searched for sign of browse and egg damage throughout our stay,

Results and conclusions

No sign of rabbits was found using either method. There were no sightings of rabbits or possible rabbits during the 16 person hours of observation. Many additional hours spent doing other tasks on the island (e.g. photo-points) also produced no rabbit sightings.

We found no sign of anything resembling rabbit browse on plants. Some sign of predation by birds and crabs on seabird eggs was found (Table 4.1).

TABLE 4.1 – Observations of nests of sensitive seabird species at Rawaki and suspected predation. GRBT = grey-backed tern, SOTE = sooty tern, BNNO = brown noddy, BLNO = blue noddy, BTCU = bristle-thighed curlew.

Species	Estimate No. pairs	Nests checked	1 egg	1 downy	1 pul	Juvs present	Suspected egg predation
GRBT	1000+	c.200	170+	20+	20+	Many	30+ – BTCU, crabs
SOTE	300000+	c. 200	c.200	0	0	Many	10+ – BTCU, crabs
BNNO	10000+	100+	100+	3	4	Many	7 – BTCU
BLNO	5000+	35	32	3	0	0	Nil
Total	316000+	364	184	30	48	300+	47+

Rabbits are highly fecund (gestation 1 month, year round breeding) and the island offered abundant "rabbit-food" by June 2008 (Pierce et al 2008). If any rabbits had survived the eradication campaign they would have undergone a rapid recovery in numbers and been conspicuous during this visit 18 months later. We conclude that rabbits were successfully eradicated during May–June 2008.

4.2 Biota responses to European rabbit removal

Vegetation

Although our limited time ashore precluded a complete vegetation assessment, it was clear that the removal of rabbits had resulted in a spectacular positive response from the vegetation as a whole and from some individual species. Key observations in December 2009, 18 months after rabbit removal were:

- A continuation in the recovery of the bare "desert" observed to be "greening" at the end of rabbit operations in June 2008. Eighteen months later this area contained extensive *Portulaca* and especially *Boerhavia*, many of which appeared to have recovered from grazed root stock.
- The presence of hundreds of kaura (*Sida fallax*) of which only 2–3 seedlings had been previously detected in 2006 and 2008 (M Thorsen pers. obs.; Pierce et al 2006). In December 2009 there was a large concentration of kaura at the north end of the lagoon where many were already being utilized for nest sites by frigatebirds (see frontispiece). Many other kaura plants were seen around the atoll.
- A greater mosaic of vegetation in some areas, e.g. in an area where the grass *Lepturus* had died off in June 2008 the grass was being replaced by *Boerhavia, Portulaca, Sesuvium* and regenerating *Lepturus* in December 2009.

Some examples of photopoints are provided below and a complete set has been given to the PIPA office.

Overall, the vegetation on Rawaki was more prostrate and less dense than that at McKean. Two factors may have caused this: the 2006–08 vegetation at Rawaki had been more extensively depleted by rabbits than had been the case at McKean where rats were the only invasive, and there was evidence of a lower rainfall at Rawaki than at McKean.

FIGURE 4.2 – Photopoint 4.2 N Point Survey Plaque looking S June 2008 (left) and December 2009 (right).

Birds

Seabird species, numbers and distribution

Overall seabird species diversity and abundance was similar to that observed in 2006 and 2008, with 17 species being recorded. A summary of bird numbers observed in 2009 compared with 2006 and 2008 is provided in Table 4.2. Limited time ashore in 2009 precluded an assessment of bird numbers of many species.

TABLE 4.2 – Estimated seabird numbers at Rawaki in 2009 compared with earlier years.

Species	Methods 2009	19–21 Apr 2006	16–18 Jun 2008	7 Dec 2009
Audubon's shearwater	Fly-on	800	530+	P
Christmas shearwater	Fly-on	500	435+	P
Wedge-tailed shearwater	Burrows, fly-on	250	20+	200+
Phoenix petrel	Nests, fly-on	11+	31+	30+
Bulwer's petrel	Fly-on	1i	5+	10+
White-throated storm petrel	Fly-on	20+	50–100	P
Red-tailed tropicbird	Day estimate	70	126	<30
Masked booby	Day estimate	700	686	300+
Brown booby	Day estimate	24	28	10+
Red-footed booby	Day estimate	3	8	P
Great frigatebird	Day counts	5	100	20
Lesser frigatebird	Day counts	4300	18000 i	P
Sooty tern	Day estimate	10000	250000	300000
Grey-backed tern	Day estimate	1000+	6500	1000
Black noddy	Day counts	<10	0	0
Brown noddy	Day estimate	4000	3000	5000
Blue noddy	Day estimate	2500	5000i	3000
White tern	Day estimate	20	20+	P
Approx total pairs		24500	280000	310000
Total species	–	18	17	17

Note: P = present. All counts are of pairs unless indicated as "i" which represents individuals

Seabird distribution was strikingly different for one species – the blue noddy. In 2006 and 2008 breeding by blue noddies was almost entirely confined to the SE section of the island where the last surviving stands of Portulaca provided good nesting cover. Elsewhere, some cover was provided by coral ledges but these were heavily utilized by other larger seabirds and of course rabbits. In December 2009 blue noddies were common throughout the island. The driving force for this change appeared to be the increased availability of shade vegetation in the form of Portulaca and Boerhavia (Figure 4.3, 4.4). Lower levels of disturbance are also likely to be the case now.

Although we were unable to collect quantitative data for species other than blue noddies during this visit, the following additional species are likely to be benefiting already from increased plant cover – Phoenix petrel, Audubon's shearwater, Christmas shearwater, wedge-tailed shearwater, white-throated storm-petrel, red-tailed tropicbird, great frigatebird and lesser frigatebird. The petrels, small shearwaters, storm-petrels and tropicbirds all nest beneath dense vegetation, while wedge-tailed shearwaters will benefit from more stabilized soil for burrowing. As shrubs and trees recover on Rawaki, additional species to benefit could include the tree-nesting red-footed booby, frigatebirds and black noddy. All these species and others will benefit from increased productivity due to safer nest sites and no longer having their eggs exposed to rabbit trampling.

FIGURE 4.3 – Example of blue noddy nest site (left) in the former desert area (right – KT pointing to location of blue noddy nest site).

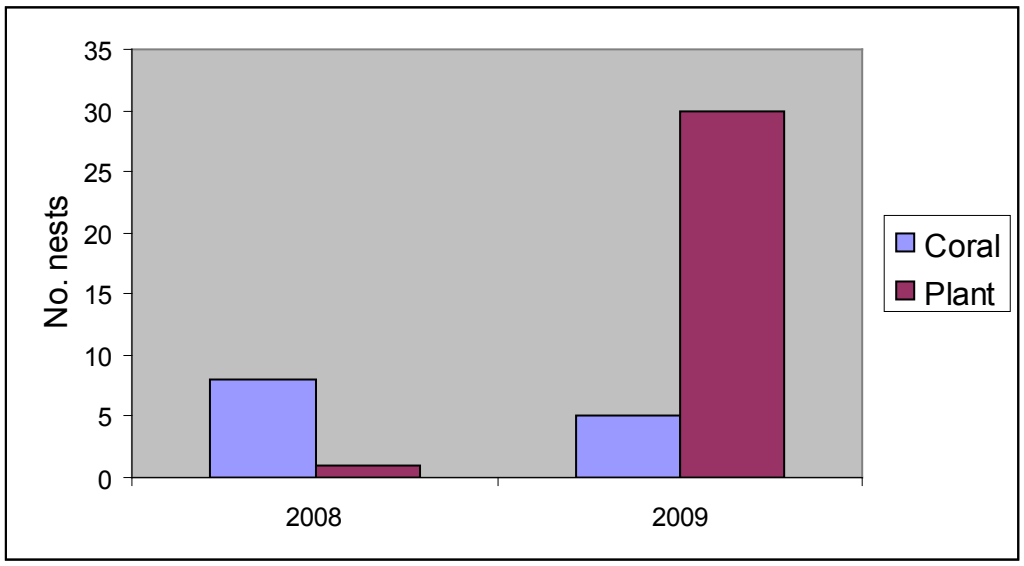


FIGURE 4.4 – Changes in nest site selection of blue noddies that nested in the Rawaki "Desert" area before (June 2008) and after (December 2009) rabbit removal.

5 Enderbury and Birnie Restoration Planning

Supplementary data were collected on several aspects of Enderbury and it's biota to help with operational planning for rat eradication.

5.1 Atoll area

The area of Enderbury was calculated by two methods – firstly by walking a GPS around the island perimeter at MHWS and also the main lagoon area, and secondly using GPS PRO to calculate land area. These resulted in the following:

TABLE 5.1 – Enderbury areas calculated in 2009

Method	GPS CSx No. 1	Google Earth Pro
Total area	586.6 ha	586.7 ha
Lagoon area incl islets	41.8 ha	42.6 ha
Total land area	544.8 ha	544.1 ha

5.2 Lagoon characteristics

There is one main lagoon in the centre of the island and several very small ephemeral lagoons, the latter of which were dry during our visit. The main lagoon has permanent water but unlike Rawaki and McKean the water on Enderbury covers only a small proportion of the island (3–5 % the total area).

The main lagoon is very convoluted (refer Appendix 7) and includes c.30 islets, most of which are bare soil and typically 50–500 m^2, but several up to 2 ha in size are covered in dense Sesuvium. These were unable to be accessed. Thus the total area of lagoon water is likely to be in the order of 10–20 ha.

Many of the unvegetated islets had small colonies of brown noddies that were nesting successfully indicating little or no rat access at that time. However the larger islets did have rats so it needs to be assumed that all islets support rats.

Due to the convoluted nature of the lagoon, peninsulas and islets, it would be very difficult to aerially bait the islets without landing much bait in the water. However the water is supersaline and there was no sign of animal life in the water or in the submerged mud when several samples were examined. There are several options for baiting including i) aerial baiting (and acknowledge some wastage), ii) using land operators to catapult bait to islets (would need to mud-wade for accessing some islets), or iii) using "petrel-shoes" to access all the islands on foot and distribute bait by hand, or using combinations of the above. The water is too shallow for the islets to be accessed using a canoe or kayak.

5.3 Vegetation

The island's vegetation is more diverse than that of McKean and is dominated by prostrate plants – Boerhavia, Portulaca, Tribulus, Ipomoea, Cassytha and Sesuvium – with scattered stands of trees. The trees comprise the following:

- Cocos – 14 coconut trees all located along the west coast with a cluster of 8 near the north end, and isolated trees scattered down to the south end. They are all less than 7 m in height.
- Pisonia and Cordia – there are three dense stands of trees, the largest located in the SE corner of the island and covering a few hectares. Tree height is typically less than 7 m except for one emergent of c.10 m in the middle of the SE cluster.
- Scaevola – scattered plants up to 1.5 m in height and clusters occur throughout the island.
- Tournefortia – a group of dense trees located on the W side of the island covering less than 0.5 ha with heights less than 3 m.
- Pluchea – only a single plant with height of less than 1 m plant near the Tournefortia.

The prostrate plants occur in clear bands along the length of the island comprising:

- Portulaca, Boerhavia, Tribulus – along the western edge and east a few hundred metres
- Sesuvium – along the edge of the lagoon and other low-lying areas – thus the central axis of the island and the SE corner is dominated by Sesuvium.
- Ipomoea – a band of this Convovulacea vine occurs between Sesuvium and the Portulaca complex to the west.

Overall vegetation patterns are mapped in Appendix 7.

FIGURE 5.2 – Part of Enderbury lagoon.

FIGURE 5.3 – Part of eastern sector of Enderbury Island – Ipomoea in foreground.

5.4 Pest status and abundance

Day observations and night spotlighting revealed only one pest species to be present – Pacific rat – as had previously been recorded by Mike Thorsen and others in 2006. We quantified rat and crab abundance by undertaking nocturnal transects through different habitats between 2000 and 2200 h on the night of 5 December 2009. This involved two teams each of two people undertaking c.10 m wide spotlight walks along a continuous series of 25 m transects. Both teams identified consistent inter-habitat patterns and these are pooled and summarized in Figure 5.3.

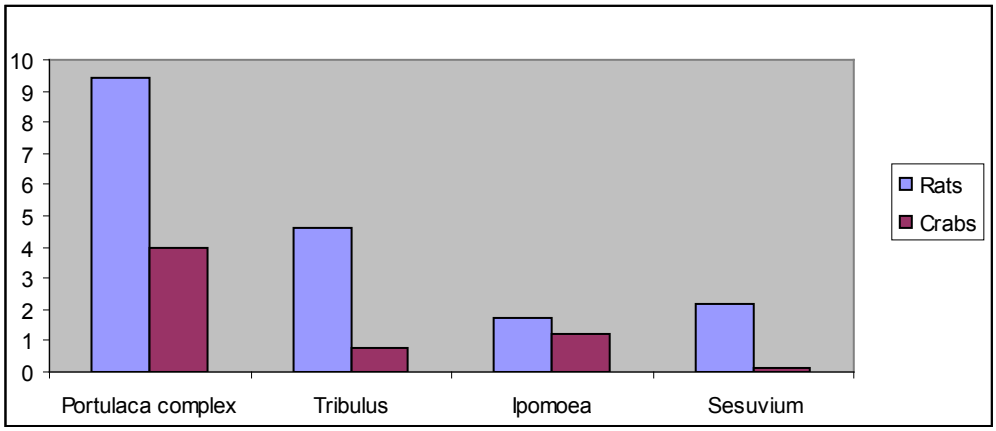


FIGURE 5.3 – Mean counts of rats and crabs along 10 m x 25 m transects in four habitats at Enderbury on 5 December 2009.

No more than broad interhabitat patterns should be inferred from these data because the number of rats and especially crabs observed during our transects would be significantly less than the numbers actually present. Broadly, the results are similar to that obtained by Mike Thorsen in May 2006 (Pierce et al 2006), e.g. relatively high densities in Portulaca and low densities in Sesuvium on both occasions. One difference between 2006 and 2009 was that Mike recorded much higher densities in Ipomoea than we did. This probably reflects a seasonal difference and associated

flowering and/or seeding as we saw only one instance of Ipomoea flowering and no seeding in December 2009. The average of 9.5 rats per 250 m2 in Portulaca equates to 380/ha which is particularly high for any rodent species.

Rat eradications in the PIPA are constrained to the period May–August when most waders are absent therefore the distribution of rats and crabs should be confirmed or determined immediately prior to the operation.

5.5 Non-target species

Seabirds, like frigatebirds, boobies and terns are clearly a potential non-target issue and safety issue for aerial operations because they nest in large, dense colonies. Patterns were broadly similar between May 2006 and December 2009 and nesting status is summarized in Table 5.3 below.

TABLE 5.3 – Breeding status of key seabirds in December 2009. All figures represent pairs.

Species	April 2006	December 2009
Lesser frigatebird	Two colonies total 4000	One colony, two roosts, total 2000+
Red-tailed tropicbird	Scattered nests 500+	Relatively low numbers <100
Masked/brown booby	600+ scattered nests	c.2000 scattered nests
Red-footed booby	100+ in trees	500+ nests, roosts in SE and W tree areas
Sooty tern	One colony 3000	Two colonies 200,000+
Brown noddy	1000+ lagoon nests	2000 lagoon nests
Black noddy	100+ tree nests, roosts	5,000 nesting and roosting SE trees

Key locations and observed patterns of movement of seabirds are as follows:

- SE trees and NW trees which should contain thousands of roosting and nesting birds (red-footed boobies and black noddies) at all times of the year. In December 2009 there was an increasing stream of birds coming to these stands of trees from late afternoon – starting at least two hours before sunset and peaking between sunset and dark. Boobies and noddies typically approach from downwind (if prevailing easterly is blowing this involves many birds flying across the island at heights up to 50 m or more). In the morning peak departure is early and rapid and is largely over within an hour after sunrise with birds flying into the wind. Note that if frigatebirds are also present here, their pattern could include patterns described for E trees/shrubs below.
- E trees/shrubs which will contain thousands of nesting and/or roosting frigatebirds at all times of the year. There are hundreds or thousands of birds present all day, but after c.4 pm there is a noticeable increase in bird numbers in fairly diffuse plumes above the colony and gradually descending to the colony. These plumes of birds can involve birds at up to 500 m altitude and they can drift across the island or along the long axis of the island. Morning departure is comparatively rapid and involves birds flying into the wind.
- Central flats could support nesting or roosting frigatebirds in their thousands as in April 2006 and the patterns of movement would be like that described for E trees/shrubs above. Both the late afternoon return and early morning departure could pose problems for flying aircraft at those times.

- Other flats could support sooty tern colonies in their 10s or 100s of thousands. Birds return at relatively low altitudes in the late afternoon and evening and depart early in the morning, but not surprisingly there is intense activity around these colonies throughout the day simply because of the large numbers.
- Lagoon islets support colonies of brown noddies and grey-backed terns. There patterns are not known but are likely to be similar to that for sooty tern.

Note however that the behaviour of these birds around aircraft is relatively unknown.

Other non-target issues are identical to those addressed in the 2008 PIPA operational plan and include disturbance to nesting frigatebirds, boobies etc, and potential poisoning of migrant waders (bristle-thighed curlew, pacific golden plover, ruddy turnstone and wandering tattler).

No fish or invertebrate species were detected in the lagoon waters, but the lagoon edges are a favoured feeding area for golden plover and turnstones which were observed preying on terrestrial flies in December 2009. The absence of hermit crabs from the lagoon means that their feeding occurs elsewhere and observations suggested that they were widely distributed along the western side of the island and in all areas with trees and shrubs.

5.6 Safe boat landing and flying areas

Potential ship and helicopter landing areas at Enderbury and Birnie atolls

During normal weather conditions the best vessel anchorage is along the lee side of the islands (i.e. along the west coasts of these atolls). The surrounding reef system is relatively narrow, so anchorage options are often limited and require constant vigilance (in case a change in wind direction swings the boat into shallow water). The PIPA does not permit large vessels to anchor.

As the bait will be air lifted ashore (to a place that the bait bucket can be easily loaded) it would be best to investigate open areas of land away from trees and other tall objects, but as close as practical to the anchorage place of the support vessel. It would be prudent to keep away from sandy and dusty areas to reduce the risk of damaging the engine and rotor blades etc of the helicopter. Areas of high seabird concentrations (e.g. nesting colonies) will need to be avoided to limit disturbance to the local avifauna, and also to limit damage to the helicopter if a collision was to occur. As helicopters are relatively slow moving and noisy, it is doubtful that bird collisions will be a major hazard but this aspect is being further researched. Each bird species may behave differently to the presence of helicopters and constant vigilance will be required to minimize potential risks involved. This aspect of the operations will provide valuable lessons for later tropical island helicopter operations in areas of high bird populations.

Aerial obstructions at Enderbury and Birnie atolls

Enderbury:

Apart from the trees, the only other tall features that could be a hazard to aircraft at Enderbury are all artificial:

- One 8 m tall lighthouse located on the SW coast
- Two 10 m tall towers (poles) located at the SW and SE corners of the island approximately 150 m inland of the coast
- A cluster of building ruins up to 2 m in height within 200m and SE of the lighthouse
- A c.8 m tall mound of guano beside the beach in the NW of the island
- Scattered (isolated) groups of trees (c.5 m – 8 m tall).

Birnie:

The tallest object on Birnie is a 3 m high stone cairn on the NE coast. There are no trees on Birnie and it is doubtful that there will be a large number of birds resident based on our previous observation in May 2006, June 2008 and December 2009.

6 Orona Restoration Planning

Supplementary data were collected on several aspects of Orona and it's biota to help with operational planning for pest eradication.

6.1 Atoll area

The land area of Orona (using Google PRO – Graham, Louise). Outline map of island Appendix 7

6.2 Invasive species

Objectives

The 2006 Phoenix Islands expedition survey detected no rats on Orona Island and cats were in low numbers of approx 10–15 on the village motu only. The 2006 report concluded however that it was not confident in these results due to the limited time spent searching the northern motu and a suspicious sighting of rodent like movement at the village camp site by a boat crew member when the rat surveyors were not present. The key purpose of this Orona visit was to eliminate the doubts that existed about rat and cat populations and better understand the pest dynamics on the island by carrying out a more intensive survey of the various motu and further observation of the pests. A further objective was to undertake testing for non target exclusion and target attractiveness of various cat trap sets to determine techniques suitable for an eradication effort.

Methods

Rodent and cat search techniques

We spent 14 days and 13 nights on the island.

The following methods were used to determine rat and cat presence/absence and distribution on Orona:

- Direct observations during the day and night. A total of 165 person hours of daylight observations and 16 person hours of after-dark spotlight surveys were undertaken.
- Sign of rat and cat predation on egg shell, dead chicks and adults in tern colonies and tracking in damp sand.
- Raised set Victor Snap trapping for rats. Traps set in isolated favorable habitat sites or 25m apart in continuous favorable habitat.
- Many additional hours were spent doing other tasks on the island and potentially exposing rats and cats to being detected, but none were seen during these activities.

Results and conclusions

Cats and Pacific rats were confirmed throughout the various motu of Orona atoll and were found in high numbers overall.

Rats

Rats were observed to be active all day with heightened activity from late afternoon through the evening. Forty-two daylight hours were spent searching on the northern and western motu where rats were conspicuous and abundant. No spotlighting was undertaken on these motu due to lack of boat accessibility. Some 123 daylight hours were spent searching the village motu with only one rat sighting. No rats were seen during 16 h spotlighting although two were seen at night in the village camp.

Trap results produced a similar marked difference between the village motu and the northern motu. On the village motu 204 trap nights produced 3 rats. (0.014 rats per trap night), versus the northern motu with 40 trap nights producing 21 rats (0.525 rats per trap night).

FIGURE 6.2 – Pacific rats caught running around during the day on sooty tern occupied motu

FIGURE 6.3 – Rat prints on sooty tern occupied motu

All rats were field identified as *Rattus exulans*. Morphometrics data and grid references are included in Appendix 6 and samples of many were collected for DNA analysis.

Pacific rats were found to be evenly distributed and in very high densities on the northern motu and islets that supported tern colonies. They were present on all other motu as well. The higher localized densities appeared to be directly related to the presence of tall tree species such as *Tournefortia*.

On the village motu, rats were at extremely low density. The immediate adjoining smaller motu at the west and east end of the village motu also had a very low rat density. This might be a reflection of cats having decimated the tern colonies and then having switched to preying on the rodents and hence are keeping them at a low density.

Cats

Three cats were seen during the day (.018 cats per search hour) and four cats were seen spotlighting (0.25 cats per search hour). These were all ascertained as being different individuals by their colour and they were all within 500 m of the village. Cat tracking was found consistently every 200-300 m along the shoreline of the village motu wherever there was an association with the coconut plantations. There were no cat sightings or sign away from coconut palms on the Village motu. On the northern motu and smaller western and eastern motu, cat sign was only found in proximity of the tern colonies. No cats were actually seen on the northern and smaller motu but predation and tracks were evident. Based on the tracking and timing of cat sightings, cat visitation to the beach areas appeared to coincide with the lower half of the outgoing tide. Cats were definitely nocturnal in behaviour given the ratio of search effort by day versus night and the respective sighting ratios. During May 2006 one cat was seen sleeping in a hammock during the day (R Pierce pers. obs).

FIGURE 6.4 – Adult cat (bottom right) and kitten (top left) tracking on village motu

FIGURE 6.5 – Cat predation on sooty tern chick

It is presumed the cats require the shade and habitat of the taller tree species and coconut palms to survive the hot, dry conditions, finding the dry scrub areas inhospitable. One particular part of the village motu appeared to be cat-free, being the extensive dry scrub area between the two coconut plantations in the south eastern quarter of the motu.

On the western, northern and eastern motu cat sign was confined to the close proximity of tern colonies. This suggests the cats that have swum to these motu are focused on the birds as their prey. It is not clear whether the high rat densities on these islands attract cats or are left in favour of the seabirds as a food source, the latter if terns are the drawcard.

The only area cats were not confirmed present was at the north eastern end of the northern motu, where beach inspections showed no tracking and colonies of masked, brown and red-footed boobies, noddies and terns showed no sign of predation. It is speculated that the cats that are "following" the tern colonies have simply not had to venture this far north-east up the atoll while the colonies further south continue to provide enough food. Based on the fact the cats have displaced Colony 1 from the west end of the village motu between 2006 and 2009, another two – three years could see cats impacting on this untouched colony at the north eastern end by 2012.

Comment on pest population behaviour

A maximum estimate of the cats currently on Orona Island would be in the vicinity of 50–100 individuals. They are evenly distributed on the village motu and motu without tern colonies, and, clustered distribution in/around tern colonies on the motu with colonies.

An estimate on rat densities would be in the vicinity of 1-3 per ha on the village motu and those motu not occupied by tern colonies, and, 100-200 per ha on the motu with tern colonies.

Cats and rats have eradicated all breeding populations of sooty tern from the village motu. It appears that cats on the village motu have a different feeding and territorial behaviour to the cats

on the motu where terns are present. Colony 1 as shown below has shifted onto the small southern group of the western motu. Colony 2 has also dispersed onto the northern parts of the western motu. Colony 3 and 4 were not visited and a 6th colony was found to exist half way between Colony 4 and 5. Colony 5 has also stretched further south – not due to increasing population, as population was noted by RP as having declined since 2006, but potentially due to the disturbance going on at the site and the birds naively looking to move away from the cats.

On the Western, Northern and Eastern motu the cats are impacting heavily on the tern colonies, but appear not to be impacting on the rodents which remain at high density. It is suspected the cats are getting all the food they need from eggs and chicks and with only a small window during the year when no eggs or chicks are present, any prey switch by cats during such time to rodents is having negligible effect on the rodent population.

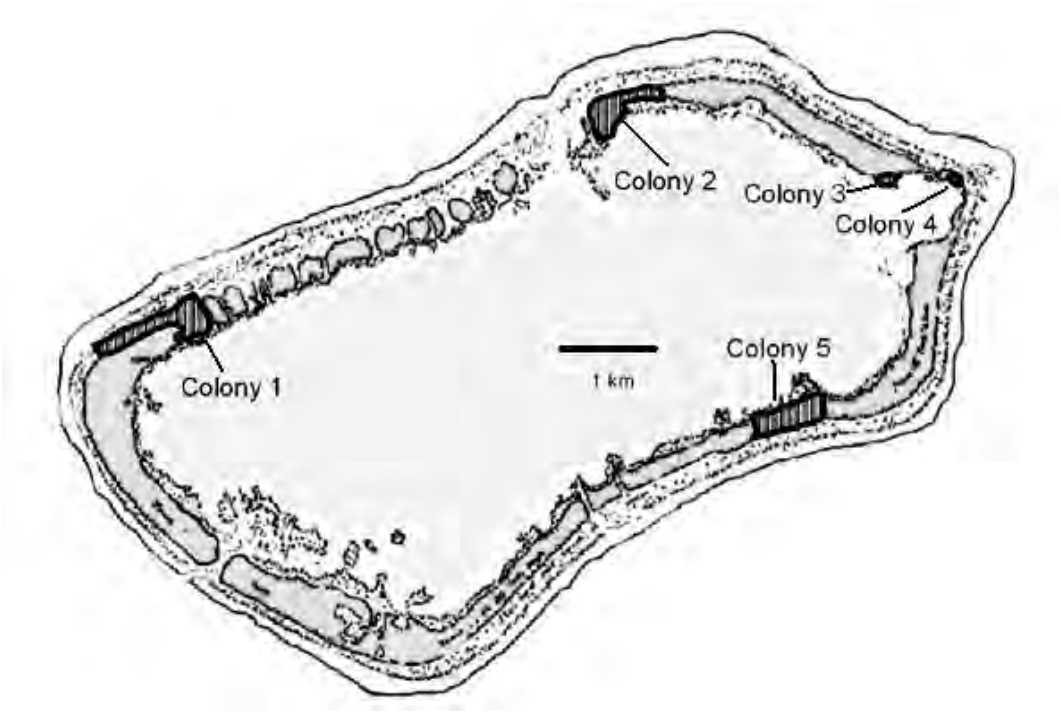


FIGURE 6.6 – Orona tern colonies from May 2006 expedition.

Eradication methods trialed

Rats

Rats were found to be extremely trap-shy on the village motu, but were very naïve on all other motu. On the village motu, a rat was observed in the village camp every night and it took 51 trap nights to catch one individual. The night following this capture another rat was seen and despite a further 63 trap nights we failed to catch this particular rat. (Potentially having eluded us for 114 trap nights!) (Note only 26 of these 114 trap nights are counted in the results total of 204 rat trap nights as trap placement was more intensive than for the rest of the island work in an effort to catch the known animal). This apparent aversion to traps cannot be a reflection of the trapping and poisoning effort Kiribati residents had undertaken in 2001–2004, as Pacific rats could not possibly live for 6 years. With no ongoing exposure to traps since, there has been no opportunity for learnt behaviour to pass to their young. If the rats were simply neophobic or difficult to trap one would expect that behaviour to be consistent across all the island motu, which it was not, so the previous occupation may still have something to do with trap shyness on the village motu. However, the

density of rats in the two different site situations could be the most likely factor with the rats at low density sites having more food availability thus becoming fussy) compared with the high density sites where there is a lot of competition for food. In terms of future poison eradication options, whilst it is reported the residents had conducted poisoning operations with brodifacoum at least six years earlier, an aversion is unlikely to still be present, given brodifacoum's mode of action and the time lapsed.

Cats appeared to be neophobic to the trap sets including the traditional techniques employed with New Zealand feral cats. All tunnels were set where cat sign and sightings had been made and where clear areas of sand could track the presence of a visiting cat. Each box was set with a pair of 'Black Trekker' ink tracking pads inside to show if the cat or any other animal actually entered the trap. None of the trap sets were set with traps in order to avoid the potential of making animals trap shy by a failed catch. The ink pads surprisingly showed no rodent tracking with insect and skink prints the only marks recorded on the ink pads. The ink pads required replacing every two days due to the ink drying. The Jump in PVC Pipe was set with log jump ins and was the only trap set that succeeded at enticing a cat into take the bait over the 11 day period that it was set. A cat visited it on day two, revisited it day four and took the bait, then revisited on day six and then vanished. The Jump in PVC pipe was highly effective at keeping hermit crabs out.

FIGURE 6.7 – PVC Jump In pipe

PVC Chimney Tunnel

A cat visited this on day four but did not climb into it or re-visit it. It was highly effective at keeping crabs out with the crabs only being able to climb the mesh at each end and then sliding off the smooth surface. Its slipperiness may have also been detracting to the cats. A modification with a flat timber platform on the top of the tunnel section could improve attractiveness. Likewise seating a PVC pipe on the top of a traditional wooden tunnel may create a more natural platform.

FIGURE 6.8 – PVC Chimney Tunnel

Traditional Wooden Chimney Box – Initial thoughts were that it would need to be a raised set on steel poles above the ground to exclude crabs. Surprisingly it was highly effective at keeping crabs out when set on the ground with the crabs only able to climb the external timber right angle joins as they found the internal right angle of the chimney impossible to navigate their way down. This box was shifted three times around the village camp site with no visitation for the first six nights at the first two locations. At the last site a cat visited but did not enter after being in situ for two days. The Chimney Box was removed after only four days in situ due to us leaving the island.

FIGURE 6.9 – Chimney box and ramp showing crab exclusion.

Traditional Diagonal Ramp – At first it was thought the hermit crabs would find this very easy to access so we did not trial it to start with. After finding a 200 x 25 cm plank of rough sawn coconut timber we discovered crabs in fact could not climb the flat surface but could get up the right angled edge similar to the wooden box. We found that the crabs had difficulty once it was set over 45 degrees and 60 degrees was near impossible except for the odd cunning crab. An aluminium collar installed at the bottom of the ramp stopped all crab access. Unfortunately, apart from one being set in the village camp it did not get trialed for cat access until the last two days of the trip when we discovered that crabs couldn't climb it. This trap set made of high grade smooth plywood would be very effective for crab exclusion and create another option for cat trapping with the likes of SA cat traps or ramp set leg hold traps.

Note: cage traps were not trialed, but could be effective as long as they are raised to avoid crabs and screening established to avoid crabs transferring from surrounding vegetation onto the cage. However, the level of caution exhibited by the cats to other trap sets appeared surprisingly high and could impact on cats also entering a raised cage trap set. Future eradication supplies should include some cage traps.

Cats seen were fairly lethargic in movement, even when disturbed. No cats were seen climbing, even when they were disturbed. It is quite possible cats will only climb objects as a last resort (possibly due to reluctance to expend the amount of effort/energy required to do so). All cats were in very good condition showing no sign of malnutrition. Dogs should be very effective at catching cats on this island due to their slow movement and preference to stay on the ground.

All the trap sets trialed are worth using in an eradication attempt. The 11 day period may not have been long enough time for the cats to adjust to something new in their environment. A further contributing factor to their reluctance to enter the trap may have been due to the bait decomposing very quickly and not being of interest to an already well fed cat. Eradication attempts will need to use a combination of fresh bait checked regularly plus long-life bait. The two day rebaiting regime may have been compounding the cautiousness of the cats with fresh human scent always present, however cats will usually adjust to human scent as long as the situation remains consistent. The use of traps with long life bait may help lure cats that do avert to fresh human scent.

Non-targets

Elevated rat traps set on vertical branches/trunks had minimal hermit crab interference.

Hermit crabs were attracted to both the peanut butter and the coconut used in the traps and were extremely good climbers managing to figure out convoluted climbing routes to gain access to the bait. Traps needed to be set on wide, smooth, +45 degree tree trunks to prevent the crabs from climbing up or down the branches and gaining access.

FIGURE 6.10 – Example of hermit crabs ability to pinpoint food sources and climb abstract routes including external right angles to get the fish hanging at top left.

No geckos were caught in the 204 'Victor snap trap' nights, but an 'Intruder – Better Rattrap' with a treadle plate that was set in the village camp caught two gecko and was not used thereafter.

Mania (Tupa) crabs were at no risk from raised rat traps or from any of the cat techniques with none trying to access the trap sets. They do not have much climbing ability. The manai/tupa appear to be vegetative feeders and may therefore eat pollard bait.

Ants and black beetles also fed vigorously on any bait including peanut butter, coconut, fish, jelly meat and ham. They were found to largely devour all bait within 1–2 nights meaning rebaiting regularly is an unavoidable necessity with any fresh bait. Bait went putrid within 1–2 days. The use of salted meat, or long life artificial baits, may be the only option to get around the insects and temperature effects on fresh bait. The frequent re-visitation for baiting may have been a contributing factor to the shyness of cats to enter the traps.

The bristle-thighed curlew was found around the various motu with an estimate of 50 individuals on the island. The barren landscape between the two coconut plantations on the village motu had good numbers with a flock of 20 observed there on one day. It was evident this area holds channels of brackish saltwater from the lagoon on spring tides and could be both a favorable roosting and feeding site. Curlew are unlikely to get caught in traps but are known to feed on cereal pollard baits used for rodent eradications (Pierce et al 2008).

Recommendations

Eradication of rats and cats is feasible but will require aerial toxin applications and extensive trapping, shooting and dogging for residual cats. The latter exercise will be time-consuming and the whole operation expensive, but the ecological values of Orona warrant this. The scale of the island c.500–600 ha and the density of the vegetation combined with climatic conditions renders a ground-based poison operation impractical. Recommended at this stage would be a double application of brodifacoum at medium/high rates to counter the hermit and manai/tupa crab bait interference.

Many cats are likely to die from secondary poisoning although rat densities are currently low on the village motu. Success rates with the cat secondary poisoning may also be confounded on the motu where seabird colonies still exist due to the rat/seabird/cat dynamics and that cats may simply not eat dead rats due to having an abundance of fresh food. On motu with no seabird colonies, the opposite situation may confound secondary poisoning by having too low rat densities to act as a toxin vector.

Other work completed

Evening seabird fly-ons

Refer Appendix 2.

Village cleanup

Numerous hours were spent picking up, burning and/or burying village rubbish strewn around the village site. Broken glass and rusty metal products were significant hazards along with hospital medical products, syringes, needles, drugs etc. With a high risk of infections on the islands, future visitors should be made aware of these hazards. Most of these hazards were cleaned up within an area of 50 m from the camp site.

Infrastructure maintenance

Waters supplies were resurrected with the limited materials that were available and both water tanks were made operable again. The Administration building and Copra shed were made secure and sealable with Louvre windows freed and doors fastened. The two concrete buildings, meeting house and nearest dwelling plus the two sole remaining weather proof dwellings all had vegetation cleared away from them to prevent further damage and to improve airflow.

Bokikokiko habitat

Suitable habitat and nesting material for Pacific Island warbler was assessed. A large population of the vine Cassytha (used as nest material) was found covering 400 square meters at the south eastern end of the village. There were large areas of the island interior that were not searched. No terrestrial birds, other than waders, were observed during the visit, but some unidentified ducks were seen. The reintroduction of Bokikokiko warbler may be feasible when pests are eradicated.

GPS high water mark

The entire village motu, the first nine western motu and the first eastern motu were mapped on GPS round the high water mark. The large eastern motu, the top of the western motu group, and, the northern motu were partially mapped by GPS where boat landings occurred. This information is stored in track logs for future use if required. It could be useful for accurately calculating the actual area of the island and producing scaled and navigable maps of the island which are currently unavailable.

Biosecurity

A constant vigilance was kept up for unwanted organisms. A number of ant species were collected for identification.

Lessons learned

Logistical aspects

Equipment

Not having a lagoon boat was a severe handicap. The pest dynamics at the northern end could have revealed more information had we been able to spotlight at night on the northern motu. The cat activity in particular was not satisfactorily explored neither the abundance of rats at night compared with the village motu. Wading to the north end is very arduous under hot climatic conditions and is risky with the channel crossings being tidal dependent and shark infested. Any future eradication attempt will require a boat on the island to transport crew and equipment.

Satellite phone coverage was intermittent due to the unit not holding satellites long enough for a phone call. It appeared that most outgoing texts were received but texts sent to Orona were sometimes received in an unreadable format.

Travel times for future reference were noted as follows:

Walking

- Village camp to Lagoon Hut – 15 min return – track cut and marked with flagging tape
- Lagoon Hut to north east end along lagoon shoreline – 2 hrs one way (50% easy/50% wading or bush bashing)
- Village camp to northeast end along coast – 2.15hrs one way (easy)
- Village camp to end of first coconut plantation – 1hr one way (easy on coast side/wading on lagoon side)
- Village camp to west end along coast – 30 min one way (easy)
- Lagoon hut to west end along lagoon – 30 min one way (extensive wading/bush bashing).

Boating

- 20 min to west end of North motu
- 30min to east end of North motu

HSE

The following need inclusion in future operation plans and safety briefings.

- Presence of scorpions, blister beetles, centipedes and large spiders (only the large centipede is poisonous).
- Human refuse around the settlement area.
- Sturdy foot wear should be worn at all times when wading in salt water.
- Carry a stick for stonefish, cone shell, shark attacks, etc.
- Safety helmets should be worn when working underneath dense coconuts where it is not always possible to pick safer routes around the fall zones.
- Minor building facility maintenance for future expeditions to Orona.
- 4 sets of stainless steel door hinges.
- Silicon sealant for water tank
- Stainless steel gate valve taps for water tanks and plumbing fittings for the 50 mm outlet. Preferably stainless, then Hansen polyethylene or PVC.
- More extensive building maintenance – full guttering system replacement for the concrete buildings. Louvre window mechanisms and frames are corroded but the glass is still OK. Probably not worth maintaining/replacing unless plastic or fully stainless is available, but may be worth removing to avoid more broken glass.

6 Kanton Restoration Planning

Background information was collected on Kanton during 1–4 December 2009.

7.1 Atoll area

Mainland area = 1089.2 ha from Google Earth Pro (refer map Appendix 7)

"Channel Island" = 4.0 ha (GPS) and 4.1 ha by Google Earth Pro

Spam Islands = < 1 ha.

7.2 Pests

Pest mammals

Observations were completed on the SE Peninsula (from offshore and landing from lagoon), on Channel and Spam Islands, together with the village and port areas. Twelve traps were operated for one night each at the port and at the SE Peninsula (abandoned village on the opposite side of the channel to the port). Mammalian pests identified were:

- House cat – these were focused in the village and port area where they are semi-domesticated; none were seen on SE Peninsula, but feral individuals are likely to visit there, although the locals indicated tthat they didn't see cats away from the village and seaport vicinity.
- Pacific rat *Rattus exulans* – observed on SE Peninsula and reported from village and port; abundant on Channel Island
- *Rattus* sp. – collected at port and SE Peninsula on 2–3 December 2009, none observed on Channel Island.
- The *Rattus* sp. is probably *Rattus rattus*. Individuals are large, long-eared, long-tailed rat with rufous pelage. Tail samples were delivered to Lisa Matisoo-Smith at University of Otago to undertake DNA identification.

TABLE 7.1 – Details of *Rattus* sp. specimens collected on Kanton 2–3 December 2009

Location	Sex	Head and body	Tail	Hind foot	Weight g
Port	F	148	177	36	80
Port	F	162	188	33	81
SE Peninsula	F	162	185	33	117
SE Peninsula	F	108	137	27	36

Five Pacific rats were caught on Channel Island and they weighed 32–74 g (mean 58 g). It is likely that Rattus sp. is replacing R exulans at Kanton as the only place that *R exulans* was observed to be abundant was on Channel Island which Rattus sp. has not yet colonized.

Other pests

Many weed species, e.g. *lantana* and *Pluchea* sp., are present at the village and port area and others are likely to occur at abandoned villages and dwellings elsewhere. A thorough inventory is needed. Ant collections were made at the port and at the abandoned village on the SE Peninsula and identifications are pending.

7.3 Birds

Observations were made around the island by using the SV Southern Cross to undertake bird fly-ons from outside the island and a 3.5 m inflatable boat on the lagoon from which we landed at intervals to survey bird colonies. We also used the inflatable to access Channel Island and spotlight the Spam Islands at night.

Key findings were:

- Phoenix petrel – at least 4 birds were prospecting in the extreme S end of the island on 1–4 December
- Brown booby – up to 110 birds and some masked boobies were roosting at Channel Island during bad weather on 4 and 8 December
- Red-footed booby – c.1000 roosting in Scaevola and other vegetation on SE Peninsula 2 December
- Grey-backed tern – c.3000 nesting on Channel Island where Pacific rats were consuming most eggs and causing apparently total nesting failure
- Brown noddy – 5000+ nesting successfully and roosting on the pest-free Spam Islands.

These all represent significant populations. Other notable birds were waders with estimated total numbers for the island as follows: bristle-thighed curlew 100–200, Pacific golden plover c.200, ruddy turnstone c.200, wandering tattler c.200, bar-tailed godwit c.10, whimbrel 2, sanderling c.10.

7.4 Comments on potential ecological restoration

Despite the current settlement and history of military operations, Kanton has a high level of naturalness and provides significant opportunities for conservation management in the terrestrial environment. If the cats and rats are eradicated from Kanton in the very near future, the Phoenix petrel colony would be secured and potentially provide a viable second colony to the one present on Rawaki. Likewise, the tern and noddy colonies on Channel and Spam Islands should expand to include mainland sites when these islands and the mainland are pest-free. If only Channel Island is restored via rat removal in the interim, it will still provide important seabird gains locally as well as boost local ecotourism (refer Section 9 for potential GoK approach to rat removal).

Coincidental to our visit to the PIPA the GoK announced plans for opening the airport at Kanton which will enable ecotourism and targeted management to go ahead at Kanton and elsewhere in the PIPA. Kanton is particularly attractive for eco-tourism given high marine values in the channel (G. Wragg pers. obs) as well as historical interest and bird and turtle values.

Other features relevant to pest eradication planning include:

- People live in dwellings at the port and in the village
- No domesticated animals are present apart from a few semi-domesticated cats
- There are many above ground and underground structures stemming from World War II to the 1970s that may be used by rats and cats
- There is a functional airfield that could be used for emergency purposes
- There is a roughly formed atoll perimeter road linking the seaport, village and airfield and which extends further east from the airfield. Currently quad bikes can access c.50% or more of the atoll circumference via this road.

FIGURE 8 - Discussions during Kanton meeting December 2009.

8 Biosecurity

Protocols followed

This expedition attempted to follow existing protocols identified by the PIPA and GoK as well as identifying deficiencies in existing approaches and better approaches for the future. The latter will be included in the Biosecurity Guidelines being developed for the PIPA.

Existing protocols followed included the following:

At source (Apia)

- searching and repacking all material being loaded on to the SV Southern Cross
- spraying all suspect material
- spraying mooring lines of our vessel and neighbouring ant infestations at the Apia marina

En route

- collecting biosecurity breaches (2 species of ant, spider and cockroaches)
- searching for pest sign particularly rodents in the galley stores
- Pre-landing and pre-return to boat
- all gear searched for invertebrates
- all gear placed in dry-bags or plastic barrels and sprayed liberally with Mortein

Deficiencies identified and improvements needed

At source (Cook Islands and Apia)

- vessel should have been fumigated (methyl bromide or similar)
- vessel should not have carried bulk fruit and vegetable items immediately prior to the expedition
- vessel should have been moored in farthest berth from shore (thereby minimizing risk of rodent and invertebrate access)
- biosecurity measures needed to be put in place immediately on boats arrival at Apia
- quarantine staff at Apia need to be made aware of the ant and rodent risks at the marina and set up simple control measures (letter written to Port Authority copied to CI).

En route

- vessel should carry adequate pesticide including Ripcord
- vessel should have suitable sealable containers for all gear going ashore.
- Island landings and pick-ups
- implement searches for all potential pests especially rodents, invertebrates, seeds.

Defending the pest-free islands

Now that McKean and Rawaki are free of mammalian pests (and it is planned to restore other islands), all steps should be taken to ensure that no invasive species access these islands. Strict measures need to be followed including those identified in 8.1–8.2 above and others included in the pending Biosecurity Guidelines. However, even these strict approaches could expose the islands to a level of risk which is unacceptable. All members of our expedition and the PIPA Management Committee agreed that the simplest approach to providing maximum protection for the islands is to prohibit landing except when approved personnel are undertaking essential conservation work approved by the PIPA. The latter would also need to have GoK Biosecurity staff present for their operations.

Kanton procedures

Existing situation

Kanton is currently a weak link in the biosecurity of the PIPA. Key problems include the following:

- The Port area being infested with pests including *Rattus* sp, *Rattus exulans*, cats, weeds and possibly invasive ants (data to come)
- Many freighters tying up directly at the wharf and unload goods and/or load goods that could be pest-infested
- There have been no adequate procedures to deal with pest movement on boats
- Other visiting boats can tie up directly to wharf (similar risks).

Needs

Biosecurity was discussed at a community meeting at Kanton on 4 December and further discussed with GoK staff during the expedition and at Tarawa. The following aspects were agreed and are being detailed in the Biosecurity Guidelines:

- Urgently increase the use of rodent bait stations on freighters that Agriculture in Kiritimati have recently initiated – needs extending to all 6 or so freighters that use Kanton (Quarantine at Kiritimati and Tarawa to implement)
- Urgently control rats at Kanton, particularly 1–2 weeks prior to scheduled freighter arrival (GoK to decide interim responsibility e.g. quarantine delegates to Kanton Police and potentially also one or two of the locals e.g. Owen and his wife Piteta, who is a teacher)
- Implement rodent control at Kiritimati and Tarawa departure/arrival points (Agriculture)
- Appoint permanent Quarantine staff at Kanton to deal with anticipated increased boat and aircraft visitors to Kanton and associated quarantine risks – mammals, invertebrates, seeds, etc. Ideally rotated position, potentially involving Agriculture and WCU staff (GoK)
- Survey pest plants at Kanton and develop a management plan to deal with eradications and other management (GoK).

9 Capacity Building

9.1 General

Two key GoK staff participated in the expedition – Nautonga Anterea (Agriculture) and Katareti Taabu (Wildlife Conservation Unit, WCU), both of Kiritimati. Nautonga and Katareti joined the expedition at Kanton and undertook work on Enderbury and Rawaki and also visited Birnie and Orona before the entire expedition returned to Apia, Samoa. Tasks that they were involved in were:

- Community consultation Kanton including helping to clarify points otherwise lost
- Ant and rat surveillance at Kanton
- Rat and crab survey work on Enderbury – night transects in different habitats.
- Plant lists on Enderbury and Rawaki
- Bird nesting counts Enderbury and Rawaki
- Bird fly-ons Enderbury and Birnie from boat
- Rabbit surveillance Rawaki
- Photopoints Rawaki
- Inspect Orona pest work undertaken by GC and CG
- Biosecurity – throughout

These tasks built on previous work with both NA and KT at Kiritimati, and also NA in the PIPA. It was particularly useful for Nautonga to see the results of all the hard work he did on Rawaki last year – setting up bait lines, carrying and distributing bait, searching for rabbits etc. Katareti noted that he was seeing similar positive vegetation and bird responses on some of the restored Kiritimati islets where rats had been targeted in June 2009 to that occurring on Rawaki.

Some suggestions for moving forward at the PIPA

Some important jobs in the PIPA could be undertaken entirely by the GoK staff at Kiritimati and involve relatively modest resources. These both involve work at Kanton: planning for and eradicating rats on Channel Island (WCU lead) and setting up biosecurity at Kanton Port (Quarantine lead). These are described below.

Channel Island rat eradication

This should be planned and implemented by the WCU with outside advice as required. Key planning considerations include the following:

- Project leader – ideally one of WCU staff
- Other important stakeholders, e.g. Quarantine, Kanton community, Health, etc
- Island features – size 4.0 ha, distance across channel to SE Peninsula c.160 m, distance across channel to mainland at port c.200 m
- Target species – Pacific rats – they are at high densities over most of the island where there is vegetation but lower densities on the rubble peninsula sticking out to the east
- Human health issues – there are some crabs – Manai/*Coenobita* and marine crabs – how to prevent human consumption – meetings, signage etc
- Timing and non-target issues – many waders roosted here at night in December 2009 (including 24 bristle thighed curlews one evening), but few waders would be present in May–August each year
- Bait – talon containing brodifacoum – calculate amount of bait for 4 ha – best to do 2 bait pulses about a week apart, each of 12.5 kg/ha.
- Bait logistics – Availability of bait and means of getting more bait from NZ if needed
- Equipment and safety gear – what's needed and how to get it
- Travel arrangements to Kanton, access to island
- Follow-up monitoring, biosecurity, etc.
- Collecting additional data for operational planning for pest removal from all of Kanton atoll.
- Kanton Port Biosecurity

Suggestions for improving biosecurity were developed during the expedition including at the Kanton meeting (refer section 8.4). These will be further developed in Biosecurity Guidelines for the PIPA. These could then be acted on by Agriculture staff based at Kiritimati, potentially working in with the rat eradication work of WCU described above.

10 Conclusions and Recommendations

Rawaki and McKean Island are now free of pest mammals, with both already demonstrating positive responses from vegetation and birds only 18 months after the pest eradications. Key responses have been the recovery of kaura (*Sida*) bushes on Rawaki, more extensive growth of *Boerhavia* and *Portulaca* on both islands, greater nest site availability for several bird species, and higher nesting success of several seabird species. However, it will be some time before populations of several of the more sensitive species such as storm-petrels, shearwaters and blue noddies recover at McKean Island. In the meantime Rawaki remains crucially the single most important PIPA atoll – the only one with viable populations of Phoenix petrel, white-throated storm petrel, Bulwer's petrel, Christmas shearwater and blue noddy.

It is vital that no further invasive species get ashore at Rawaki and McKean Island – this includes not only mammals, but also invasive invertebrates (e.g. ants) and invasive plants. There is zero chance of rabbits being reintroduced but there remains a significant threat from accidental introduction of rats and other invasives via shipwrecks and illegal landings. Meanwhile, biosecurity of the entire PIPA is being improved by on board surveillance by Fisheries observers and the Police patrol boat. These can be enhanced and complemented by other methods, e.g. requiring all vessels entering the PIPA to be pest-free and prohibiting all landings at Rawaki and McKean Island except for those that are essential to PIPA conservation.

All other PIPA atolls offer opportunities for restoration. Of these Enderbury (and Birnie) are important because of their existing high values (Pacific rats are the only invasive species present) and their close proximity to Rawaki from where they receive visits from several sensitive species. For example during both the 2006 and 2009 surveys of Enderbury we observed single Phoenix petrels prospecting, two species of shearwaters attempting to breed and up to 20 blue noddies were observed roosting there at night and apparently attempting to breed in the lagoon area. A draft operational plan is currently being prepared.

Kanton is also an important candidate for restoration because of the presence of a remnant colony of Phoenix petrels on SE Peninsula and important concentrations of boobies, terns and noddies. It also offers significant tourism opportunities via the sea-port and airport where biosecurity issues can be managed by local community and GoK staff if the appropriate protocols are followed and resources provided. Although cats and two rat species are present at Kanton, eradication of these is considered feasible (refer Appendix 7). In the interim, eradication of Pacific rats from the Channel Island could be undertaken by GoK staff (refer Section 9.2).

The southern and higher rainfall islands of Orona, Manra and Nikumaroro all offer important opportunities for restoration. Orona is infested by cats and Pacific rats, Nikumaroro by Pacific rats, and Manra was last recorded in 2000 as having cats and one

or more unidentified rat species and requires an updated survey. The biosecurity issues of these three islands are currently significant given they support coconut plantations (and other food opportunities) and the western two provide safe landing sites. With respect to pest eradications there are significant crab issues on these islands and it is hoped that similar issues elsewhere (e.g. Palmyra) will be resolved in the near future.

Key recommendations are as follows:

Biosecurity

- Cease landings on Rawaki and McKean except for priority conservation tasks
- Implement other effective biosecurity measures for the PIPA generally following provisions of imminent Biosecurity Act and biosecurity guidelines, including maintaining pest-free inter-island freighters focusing initially on rodents and other pest vertebrates; step up biosecurity measures at Kanton including controlling rats at Kanton Port and other source ports; train Fisheries observers in biosecurity protocols.

Restoration planning

- Complete restoration plan for Enderbury and Birnie (draft in train) and seek funding for removing Pacific rats (underway)
- Complete restoration plan for Kanton and seek funding to eradicate rats and cats. There would be significant cost savings if the Kanton operation was merged with that of Enderbury-Birnie (underway)
- Plan for the removal of Pacific rats from Channel Island at Kanton (potentially WCU)
- Study subfossil fauna of representative PIPA islands (e.g. Enderbury, Orona) to determine past landbird and seabird assemblages (potential MSc research topic).
- Complete feasibility studies (beginning with Orona this report) and planning for restoring the three southern islands at a later date.

Capacity building

- Maintain technical support to GoK initiatives spanning biosecurity, pest surveillance and management, and biota monitoring at PIPA and Kiritimati and associated support
- Provide support to GoK on rat eradication projects as required at e.g. Channel Island at Kanton (Section 9.2) and at Kiritimati (links well with recommendations of Pierce and Brown 2009)
- Provide advice to GoK on further monitoring and research, e.g. biota responses at restored islands, studies of past fauna (advice on funding and technical approach).
- It is important to maintain the impetus of the current work in order to address the above recommendations. The existing projects funded by CEPF and NZAID will help to facilitate much of the biosecurity and restoration planning as well as strengthen capacity for GoK staff.

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APPENDICES

Appendix 1

Plant and bird names mentioned in the text

A – Plant names

Kiribati name	Species	English name	Family
Teutente ni mane	*Lepturus sp.*	Male weed (a grass)	Graminae
Te nii	*Cocos nucifera*	Coconut palm	Palmae
	Boerhavia albiflora		Nyctaginaceae
	Pisonia grandis		Nyctaginaceae
Uteuten toari	*Sesuvium portulacustrum*		Alzoaceae
	Portulaca aff. Lutea		Portulaceae
Ten tanini	*Cassytha filiformis*	Orange vine	Lauraceae
	Tribulus cistoides		Zygophyllaceae
Te aroua	*Suriana maritime*		Surianaceae
Te koura	*Sida fallax*		Malvaceae
	Ipomoea macrantha		Convulvulacea
Te kanawa	*Cordia subcordata*		Boraginaceae
Te ren	*Tournefortia argentea*	Areotrope	Boraginaceae
	Lantana camara		Verbenaceae
Te mao	*Scaevola sericea*	Saltbush	Goodeniaceae
	Pluchea sp.		Asteraceae

B – Bird names

Kiribati name	Species	English name	Family
Te ruru	*Pterodroma alba*	Phoenix petrel	Procellaridae
Te tangiuoua	*Puffinus pacificus*	Wedge-tailed shearwater	Procellaridae
Te tinebu	*Puffinus nativitatis*	Christmas shearwater	Procellaridae
Te nna	*Puffinus lherminieri*	Audubon's shearwater	Procellaridae
	Bulweria bulwerii	Bulwer's petrel	Procellaridae
Te bwebwe ni marawa	*Nesofregetta fuliginosa*	White-throated storm-petrel	Hydrobatidae
Te take	*Phaethon rubricauda*	Red-tailed tropicbird	Phaethontidae
Te gnutu	*Phaethon lepturus*	White-tailed tropicbird	Phaethontidae
Te mouakena	*Sula dactylatra*	Masked booby	Sulidae
Te kibwi	*Sula leucogaster*	Brown booby	Sulidae
Te koota	*Sula sula*	Red-footed booby	Sulidae
Te eitei are e bubura	*Fregata minor*	Great frigatebird	Fregatidae
Te eitei are e aki rangi ni bubura	*Fregata ariel*	Lesser frigatebird	Fregatidae
Te karakara	*Sterna bergii*	Great crested tern	Sternidae
Te tarangongo	*Sterna lunata*	Grey-backed tern	Sternidae
Te keeu	*Sterna fuscata*	Sooty tern	Sternidae
Te io	*Anous stolidus*	Brown noddy	Sternidae
Te mangikiri	*Anous minutus*	Black noddy	Sternidae
Te raurau	*Procelsterna cerulea*	Blue-grey noddy	Sternidae
Te matawa	*Gygis alba*	White tern	Sternidae
Te kun	*Pluvialis fulva*	Pacific golden plover	Charadridae
Te kirikiri	*Heteroscelus incanus*	Wandering tattler	Scolopacidae
Te kewe	*Numenius tahitiensis*	Bristle-thighed curlew	Scolopacidae
Te kitibwa	*Arenaria interpres*	Ruddy turnstone	Scolopacidae

Appendix 2

Seabird Fly-on data November–December 2009

Island	McKean	McKean	Kanton SE Pen	Enderbury	Rawaki	Birnie
Date	28/11	29/11	4/12	5/12	7/12	8/12
Observers	RP	RP	KT, RP	KT, RP	RP, KT	KT, RP, LS
Viewed from	Shore	Shore	Boat	Shore	Shore/boat	Boat
Wind	Mod E	Lt ESE	Lt SE	Mod NE	Mod E	Mod E
Species						
Phoenix petrel	0	0	4	0	3+	0
Wedge t shearwater	0	0	0	1	4+	0
Christmas shearwater	0	0	0	0	20+	0
Audubon's shearwater	13	7	0	18	60+	0
Bulwer's petrel	0	0	0	0	8+	0
WT storm-petrel	0	0	0	0	10+	0
Red-tailed tropicbird	0	0	0	P	P	0
Masked booby	210	166	P	36	100+	59
Brown booby	26	7	P	18	9+	8
Red-footed booby	35	23	P	7	4+	10
Lesser frigatebird	P	P	P	P	P	P
Great frigatebird	P	P	0	P	P	0
Brown noddy	P	P	P	P	P	P
Black noddy	P	P	0	P	0	0
Blue noddy	0	1	0	12	150+	0
Sooty tern	P	P	P	P	P	P
Grey-backed tern	P	P	P	P	P	0
Great crested tern	0	0	P	1	0	0
White tern	P	P	P	P	P	P

Island	Orona	Orona	Orona	Orona	Orona
Date	27/11	29/11	4/12	5/12	7/12
Observers	GC, CG	GC, CG	GC	GC, CG	GC, CG
Viewed from	Shore	Shore	Shore	Shore	Shore
Wind	E	SE	Calm	N	S
Species					
Phoenix petrel	0	0	0	0	0
Wedge t shearwater	0	0	0	0	0
Christmas shearwater	0	0	0	0	0
Audubon's shearwater	0	0	0	0	0
Bulwer's petrel	0	0	0	0	0
WT storm-petrel	0	0	0	0	0
Red-tailed tropicbird	0	0	0	0	0
Masked booby	0	0	1	0	0
Brown booby	01	0	2	0	0
Red-footed booby	10	2	3	2	5
Frigatebird sp	0	10	0	0	P
Lesser frigatebird	0	0	0	P	0
Great frigatebird	0	0	P	P	0
Brown noddy	P	P	P	P	P
Black noddy	P	P	P	P	P
Blue noddy	0	0	0	0	0
Sooty tern	P	P	P	P	P
Grey-backed tern	0	0	0	0	0
Great crested tern	0	0	0	0	0
White tern	P	P	P	P	P

Note: all observations were 1700 – 1845 h (dark), except for Kanton S Peninsula (1615–1715 h) and Rawaki 1710–1800 h (from shore) and1830–1850 (from boat).

Appendix 3

Pelagic Seabird Data Samoa to Phoenix Islands Return Nov–Dec 2009.

Daily totals. Observations were of birds up to c.300 m from one side of boat, all by RP.

Transect leg	1	2	3	4	5	6	7	8	9	10	11	12
Date	22	23	24	25	30	1	6	8	10	11	12	13
No. hours	8	8	8	8	8	8	6	6	8	8	8	8
Phoenix petrel									1			
Tahiti/Phoenix petrel			2									1
Mottled petrel				1								
White-necked petrel	4	3									1	1
Black-winged petrel	6	2	2					1	1		2	5
Gould's petrel		1	1									1
Collared petrel												1
Bulwer's petrel			4	1							3	
Unidentified petrel			5			1		2				
Wedge-tailed shearwater	11	3	18	8	3	6	4		3		10	11
Sooty shearwater	7	1	13						1	1		
Short-tailed shearwater	14	7	1	3								
Sooty/Short-tailed SW	35	4	1								1	
Christmas shearwater			1									
Audubon's shearwater	1				1		7	1				

Transect leg	1	2	3	4	5	6	7	8	9	10	11	12
White-throated storm-petrel							1					
Leach's storm-petrel			2	13	11	2	1	4	12	5		
Red-tailed tropicbird									1			
White-tailed tropicbird	3									1		3
Masked booby					11	2	14	4		19		2
Red-footed booby	25	2		1	8	1	2	12		2	5	1
Brown booby					7		3					
Great frigatebird	2			1				1				
Lesser frigatebird					1		4					1
Pomarine skua	1		1	1								
Grey-backed tern					2	2	8					
Sooty tern	106	52	6	27	22	41	38	58	25	6	27	35
Black-noddy							4			9		
Brown noddy	20	16			1		2			5		7
Blue noddy							2					
White tern	5	34	22	2				1	8	10	1	8

Transect legs: 1 Samoa–Swains; 2 S. Tokelau; 3 N Tokelau; 4 S PIPA; 5 McKean–Kanton; 6 McKean–Kanton; 7 Enderbury–Rawaki; 8 Rawaki–Birnie; 9 S PIPA; 10 N Tokelau; 11 S Tokelau; 12 Swains–Samoa.

Appendix 4

List of marine mammal and turtle sightings November–December 2009

Species	Date	Location	No.	Behaviour
Beaked whale?	30/11	5 NM NE? of McKean	1	Solitary? 0900 h
Melon headed whale	12/12	12o 12'S 171o 42'W	1	Solitary, N of Samoa
Spinner dolphin	5/12	Beside Orona	c.50	Evening
Fraser's dolphin	25/11	Beside Orona	?	Near NW entrances 1600 h
Fraser's dolphin	25/11	9.3 nm SE of McKean	500+	Travelling E 0650 h
Fraser's dolphin	7/12	Beside Orona	c.200	Daytime
Fraser's dolphin	9/12	Beside Orona	c.10	Near NW entrances 0700 h
Green turtle	27/11	Beside Orona	1	Off landing area
Green turtle	2/12	Kanton Lagoon	5	Within 3 km of entrance

Note: a few recent turtle diggings on McKean, Rawaki and Enderbury in late November–early December.

Appendix 5

Sightings of fishing vessels and aircraft seen in the PIPA Nov–Dec 2009

Date	Vessel name	Type	Location and activity
30/11	Tunastates	Tuna (mother ship)	10 NM ENE of McKean travelling ESE
1/12	?	Purse-seiner	c.50 NM W of Kanton
1/12	Robinson R22	Helicopter	c.50 NM W of Kanton probably with Seiner

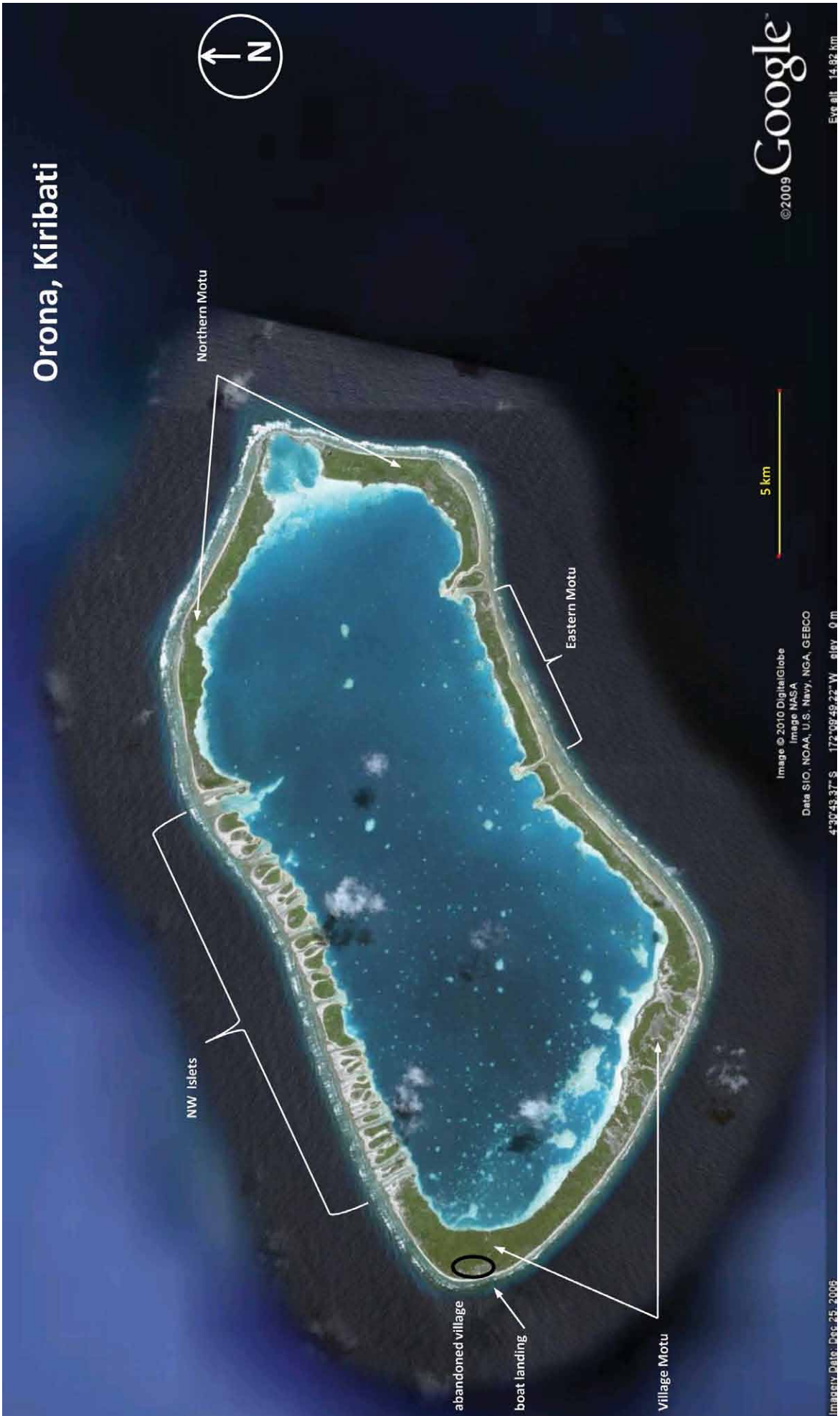
Appendix 6

Rodent data collected at Orona, December 2009, GC

Location	Date	Sex	Weight (gm)	HBL (mm)	Tail (mm)	Reproductive	Tail sample
N Motuiti	27/11/09	M	60	138	144+	N	Y
N Motuiti	27/11/09	F	57	140	151	N	Y
N Motuiti	27/11/09	F	20	106	118	N	Y
N Motuiti	27/11/09	F	33	114	118	N	Y
N Motuiti	27/11/09	F	80	150	Lost tip	N	Y
NE Motu	27/11/09	M	82	150	158	Y	–
NE Motu	27/11/09	F	72	147	155	N	–
NE Motu	27/11/09	M	69	148	138	Y	–
NE Motu	27/11/09	F	39	118	Lost tip	–	–
Eastern Motuiti	1/12/09	F	30	101	126	N	Y
Eastern Motuiti	1/12/09	M	43	125	135	Y	Y
Village Camp	2/12/09	M	64	130	145	Y	Y
East end Village Motu	2/12/09	M	40	120	134	Y	Y
West end Village Motu	2/12/09	F	56	124	130	Y	Y

Appendix 7

Appendix 7a – Map of Orona



Appendix 7b –Map of Abariringa (Kanton)

Appendix 7c – Map of Enderbury Island

Appendix 8

Mckean Photopoints 12 June 2008 and 30 November 2009

2.1 - North Wall looking N June 2008. Dominant plants Portulaca

2.1 - North Wall looking north 28 November 2009. Dominant plants Portulaca, Tribulus

2.2 - North Wall looking E. Dominants Portulaca, dead Sida, Sesuvium 2008

2.2 - North Wall looking E Nov 2009. Dominants Portulaca, dead Sida, Sesuvium

2.3 - North Wall looking S. Dominants Portulaca, dead Sida and Boerhavia

2.3 - North Wall looking S Nov 2009. Dominants Portulaca, Tribulus, Boerhavia

3.1 - Historic Outhouse looking N June 2008. Dominants Portulaca, Tribulus, Boerhavia, dead Boerhavia and Sida

3.1 - Historic Outhouse looking N Nov 2009. Dominants Tribulus, Portulaca

4.1 - SE Coral Rock looking N June 2008. Dominants Portulaca, Boerhavia

4.1 - SE Coral Rock looking N Nov 2009. Dominants Portulaca, Boerhavia

4.2 - SE Coral Rock looking E June 2008. Dominants Portulaca, Boerhavia

4.2 - SE Coral Rock looking E Nov 2009. Dominants Portulaca, Boerhavia

4.3 - SE Coral Rock looking S June 2008. Dominants Portulaca, Boerhavia

4.3 - SE Coral Rock looking S June 2008. Dominants Portulaca, Boerhavia

4.4 - SE Coral Rock looking W June 2008. Dominants Portulaca, Boerhavia

4.4 - SE Coral Rock looking W Nov 2009. Dominants Portulaca, Boerhavia

Appendix 9

Some Rawaki Photopoints June 2008 and December 2009

1.1 – South Rock looking N June 2008. Dominant plants Portulaca

1.1 - South Rock looking N Dec 2009. Dominants Boerhavia and Portulaca

1.2 - South Rock looking E June 2008. Dominants Portulaca

1.2 - South Rock looking E December 2009. Dominants Boerhavia and Portulaca

1.3 - South Rock looking S. Dominants Portulaca

1.3 - South Rock looking S June 2008. Dominants Portulaca

1.4 - South Rock looking W. Dominants Portulaca

1.4 - South Rock looking W December 2009. Dominants Boerhavia and Portulaca

2.1 - Landing historic site looking N. Dominants dead Boerhavia and Portulaca

2.1 – Landing historic site looking N Dec 2009. Dominants Portulaca, Boerhavia

2.3 - Landing historic site looking S June 2008. Dominants dead Portulaca, Boerhavia

2.3 – Landing historic site looking S Dec 2009. Dominants Portulaca, Boerhavia

2.4 - Landing historic site looking W. Dominants dead Portulaca and Boerhavia

2.4 - Landing historic site looking W Dec 2009. Dominants Portulaca, Boerhavia

3.3 – Lagoon mound looking S June 2008. Dominants Portulaca, dead Lepturus

3.3 – Lagoon mound looking S Dec 2009. Dominants Portulaca, Boerhavia, Lepturus

4.1 – N Point Survey Plaque looking E June 2008. Dominants Portulaca, dead Boerhavia

4.1 – N Point Survey Plaque looking E December 2009. Dominants Boerhavia

4.2 – N Point Survey Plaque looking S June 2008. Dominants Portulaca, dead Boerhavia

4.2 – N Point Survey Plaque looking S December 2009. Dominants Boerhavia, Portulaca

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