Control and eradication of Black Rats (*Rattus rattus*) on Penguin Island, Western Australia, December 2012 – July 2013

Karen Bettink, Department of Parks and Wildlife, Western Australia

INTRODUCTION

Background

Many Australian coastal islands have high recreation and conservation value, supporting a range of endemic and iconic species. Penguin Island, part of the Shoal water Island Marine Park off the coast of Rockingham, is no exception. For eight months of the year the 12.4 hectare Island is a hugely popular international tourist and recreation destination. It is also home to the largest and most northern breeding colony of little penguins (*Eudyptula minor*) in Western Australia, resident large colonies of breeding pelicans, a range of migatory tern species, and Australian sea lions (*Neophoca cinerea*). As one of the few other mammals present on the island the invasive pest House mice (*Mus musculus*) have been known to occur on there for many years. However in early 2011 secondary signs of black rats (*Rattus rattus*) were observed, followed by confirmation of their presence on remote cameras in May 2012. The rat incursion was most likely a result of one or more stowaway animals in construction materials, by boat or alternatively by animals moving across shallow water on the sandbar at low tide. An attempt to eradicate the black rat population was considered vital for the protection of the island's seabird colonies.

Unlike house mice, black rats are considered a significant threat to nesting seabirds on Penguin Island, in particular the little penguin colony. Black rats are one of the most widespread and destructive invasive animals in the world. The impacts on native fauna, flora and ecosystems particularly coastal islands, is well documented. Black rats pose a significant threat to wildlife directly through predation, competition and ecosystem transformation. They are perhaps the most problematic and destructive invasive rat species because of their high dispersal and reproductive rate, generalist habitat requirements and omnivorous diet, consuming anything from seeds, fruits, refuse, reptiles, vegetation, invertebrates to birds and small mammals. They are implicated in decline and extinction of small native mammals and seabirds on island environments, directly preying on bird eggs, chicks and adults. This was recognized in 2006 with predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha) being listed as a key threatening process under Commonwealth EPBC ACT. They are also a major vector of diseases that affect humans and wildlife, including Salmonella, plague, *Listeria*, *Leptospira* and Toxoplasma.

Impacts on Penguin Island biodiversity

While some impacts of black rats on the Islands biodiversity was not quantified, several impacts were clear. In 2012, changes in food availability led to a marked decline in little penguin breeding, undoubtedly black rats predating on eggs, chicks and fledglings played a key role. Dead penguin chicks were retrieved from nests with severe injuries consistent with black rat predation. Up until March 2013 adult birds were found with deep lacerations caused by rat incisors (Figure 1), one so badly it required veterinary care. Over the breeding period of migratory bridled terns, normally 2000 fledglings are reared on the Island, however in 2012/13 only eight were recorded. Several bridled terns needed to be euthenased due bite injuries. Other observations of injuries, scarring and tail

damage to King's skinks (*Egernia kingii),* large viviparous scincid lizards, was common. Rats were also observed consuming fruit, seeds and ringbarking vegetation, possibly with the aim of gaining water where none was available.

Figure 1: Top left clockwise, bridled tern with typical rat injuries (photograph: Erin Biggs), adult little penguin with incisor lacerations on rear hind leg/body (photograph: Karen Bettink) and headless little penguin chicks (photograph Erin Biggs).

Initial baiting program

An initial baiting program was set up around the main infrastructure on the Island in May 2012, where all the rat sightings were occurring. This was carried out by DPAW (formerly DEC) Swan Coastal District Regional Services staff in conjunction with the Island's PVS staff. Based upon advice from DEC Science Division, the toxin X-Verminator (active constituent brodifacoum 0.05g/kg) was used. Unlike most Australian rodent baits, it does not contain the bitter wax coating designed to deter people and pets, which can provide a sub-lethal dose and subsequent bait aversion, however it is registered in Australia only for use within two m of buildings. X-verminator has been used successfully on Kimberley Islands and in bait stations designed to exclude non-target species.

Initially 10 bait stations, comprised of 10 litre plastic buckets with two raised access holes (50 mm diameter on opposite sides, 150 mm above the ground) on opposite sides, with lids were baited with 5 X-Verminator rodent bait blocks (~25 g each) threaded onto a metal pin. The height of the hole is

designed to exclude banded rails (*Gallirallus philippensis*) and King's skinks, the most likely non-target species on Penguin Island at risk of being attracted to the bait. Two remote cameras were installed to monitor rat activity. There was rapid uptake of bait. Deployment of 12 remote cameras spread throughout the Island soon showed that black rats were widespread. After this point and with increasing reports of rat predation and decline in seabird recruitment an intensive rat eradication program was implemented.

METHODS

Planning (including obtaining necessary permits and ethics) for the eradication program commenced in July 12, chiefly led by DPAW Swan Coastal District Regional Services staff with Russell Palmer (DPAW Science Division), liaising with Island PVS staff members. August and September was deemed the ideal opportunity to implement the program when the island is closed to visitors, however this was delayed until approvals were received. Commonwealth approval was sought to use X-Verminator (active constituent brodifacoum 0.05g/kg) off-label. The application included an Environmental Risk Assessment outlining the risk to non-target species. Conditions on the permit granted (Permit Number PER13612) included a strict timeframe for checking and removal of rodent carcasses, considered important for minimising secondary poisoning by foraging birds of prey and reptiles. AEC approval was required to undertake monitoring of fauna on the island. Once this was gained, a detailed schedule for baiting and monitoring was developed (see Appendix 2).

Baiting was scheduled to commence on 14th January 2013, following the timeline set out in permit conditions. Although this was among the hottest period, it was a break between most seabird nesting and when food resources for the rats on the island were at the lowest. Care needed to be taken to minimise disturbance to vegetation and seabirds nesting at the time.

Bait station design

Bait stations were used to greatly reduces the amount of toxin required and exclude non-target species, as well as protecting baits from the weather. Prior to deploying bait stations across the island, bait station designs with non-toxic baits were trialled across 32 days (3000 trap nights) in order to maximise rat access but exclude King's skinks, particularly after reports of several King's skinks accessing bait stations placed near the infrastructure in 2012. These had been raised several centimetres above the ground but were still not excluding the skinks. Ten remote cameras were used to monitor activity on various stations designs with, including those with and without handles, hole heights of 18cm to 22cm and hole diameters of 40 mm to 50 mm. It was thought the skinks had been using the handles to access the stations, however while they showed a strong preference to use the handles to aid entry, adults were readily able to access entry holes without them. The skinks showed to be incredibly agile, capable of climbing vertical steel pickets, launching into holes from objects within a 20cm radius, ensuring that when setting up stations they needed to be in clear areas. Five baits per bait station will be threaded on a pin wedged in the bottom of the bucket and sand in the bottom of the bucket will be used to weigh it down. Rats were observed to be able to remove the entire metal pins with threaded toxic baits from bait stations deployed in May 2012, thus pin length and thickness was tailored to bucket dimensions while still allowing bait blocks to be threaded.

Comparison of raised and unraised buckets to vary the hole height showed King's skinks were readily able to access unraised buckets despite holes being drilled at maximum bucket height. Buckets raised 40-50mm above the ground excluded all King's skinks but also black rats. Buckets raised 20-30mm excluded the majority of King's skinks except for large adults, but allowed access by all black rats seen on camera. To exclude the largest adult King's skinks, 70 mm long PVC sleeves were then added to the holes. At this raised height, skinks were not able to balance on their tail and enter via the sleeves (Figure 2). It was found a height of 22cm off the ground would exclude almost all King's skinks while still allowing rats to access the stations. This design of raised buckets using sandbags was then deployed across the entire island.

Figure 2: King's skink attempting to enter bait station with PVC sleeves installed.

Several King's skinks that were able to access the bait stations were treated on a course of Vitamen K and later released on the island.

A decision was made on the 7th February to remove PVC sleeves all stations after remote camera evidence that remaining sub-adult and juevenile rats, along with several over-sized obese adults were having difficulty accessing the holes with sleeves, versus those without (see figure 16 Appendix 3). This also led to adult King's skinks gaining greater access.

Baiting

The method of baiting on a grid across the entire Island with 20m intervals followed similar rat control programs on islands in the eastern Australian states. From spatial assessment initially it was thought 270 stations would be adequate, however owing to the hilly diverse terrain 350 stations were required to effectively cover the Island (see Figure3, with detailed map in Appendix 1). All stations and monitoring points were recorded by Differential GPS.

Figure 3: Map of entire Island showing locations and labels of bait stations.

Where there were low rugged inaccessable limestone cliffs and scree areas that were deemed unsafe and unsuitable to deploy bait stations normally, buckets were lowered by rope, place into position by boat or hand broadcasting of X-verminator pellet bait at nominal rates of 12kg/ha and 8kg/ha (two applications 10-12 days apart) was undertaken during periods of clear weather

Baiting commenced on the 14th January 2013, taking two full days to bait all stations. A random sub-section of bait stations were sampled every three days with percentage classes of bait remaining recorded. After five days poisoned black rats and carcasses were observed. All stations were rebaited after 10 days, which allowed sufficient time for dominant rats to consume lethal doses of bait. Several stations, sleeves and bait storage containers needed replacing after being chewed through by black rats. In some locations where it seemed there was bait station avoidance (particularly in the north east cave area) 3 individual toxic and non toxic bait blocks were wired together and hung from cave edges and Nitraria thickets off the ground to allow rats to consume baits but limit skinks' access. This proved very effective.

It was originally thought 2-3 baitings of the entire island would be sufficient, however in the end, five full baitings were required. The last full baiting of island was 28th March 2013. Baits were removed from most stations 15th April, excluding key stations. A rebait of infrastructure stations was carried out on 1st May then rebait of shed area (where a rat was detected on 20th May 2013). A rebait of radius of stations around in the south of Island was carried out on 30th July after rat detection. Specific areas have been rebaited immediately (ie within 12 hours) as a rat detected.

Monitoring

A carcass tethering trial with remote cameras was conducted to observe what, if any, native species are attracted to and predate the rodent carcasses, and therefore assess what impacts there may be from secondary poisoning once the baiting commenced. 8 black rats and four mice carcasses were tethered at various sites throughout the Island for a period of 5 days.

Three permanent trapping transects consisting of 2 nights with 30 Sheffield cage traps and 30 small Elliot traps were established across the island (see Appendix 2). Traps were set and opened at dusk to try and exclude reptile captures. The transects provide baseline monitoring of black rat levels, to assess the program's success and as an indicator of future black rat incursions. Fur samples were taken from rats and mice trapped in January to be sent for stable isotope analysis, to gain insight into the diet components. Trapping was undertaken in January, then every 3 months (April, July). Fur samples were taken from rats and mice trapped in January were for sent for stable isotope analysis, to gain insight into each of their diet components. 24 Inked cards within Trakka tunnels designed to record tracks were deployed in April and July in an east-west and north-south transect throughout the Island.

13 remote cameras (Reconyx HC500/600) were initially deployed to monitor bait stations and lures (see Appenix 2). PVC lures with non-toxic bait were eaten through by black rats and quickly replaced with wire mesh cylinders with three suspended non-toxic bait blocks, secured in place by wire or heavy tent pegs (see image for an example). Nine cylinders were placed throughout the Island, including in northern and southern caves. Cameras were set to record a series of 3 images with a 15 second quiet period, on medium/high sensitivity. Lures were refreshed monthly and camera images downloaded and reviewed fortnightly for rat activity. Camera images are being entered into the database Camerabase.

RESULTS

Carcass tethering trial

Results from the carcass tethering trial indicated that several species displayed interest in the carcasses (including banded-rails) but only Australian Ravens took entire mice, while King's skinks and other rats predated rat carcasses (Table 1). Silver gulls were interested in tails but did not consume any part of the body. Rats accounted for 82% of predation on rat carcasses (Table 2). While King's skink show significant interest (29%) in rat carcasses they accounted for only 8.8% of predation. Example images from remote cameras are given below (Figure x).

Table 1: Number of different event types on tethered black rat and mouse carcasses, where N= no interest, I= interest but no predation and P= predation on carcass.

Species	Tethered Mus musculus (n=5)				Tethered Rattus rattus (n=7)			
	N	I	P	Comment	N	I	P	Comment
Australian raven	0	2	2	Entire removal	0	2	0	
King's skink	0	0	0		6	16	3	fighting, entire removal of one carcass
Silver gull	0	0	0		23	7	2	2 pulling, no consumption
Buff-banded rail	0	0	0		8	0	1	1 pecking
Bridled tern	0	0	0		3	0	0	
Black rat	0	0	0		10	31	28	consumption
House mouse	0	0	0		0	0	0	
TOTAL		2	2	0	50	56	34	

Table 2: Frequency of different event types on tethered black rat and mouse carcasses as a percentage of total events, where N= no interest, I= interest but no predation and P= predation on carcass.

Species	Tethered Mus musculus (n=5)				Tethered Rattus rattus (n=7)			
	N%	I%	P%	Comment	N%	I%	P%	Comment
Australian raven	0	100	100	Entire removal	0	3.5	0	
King's skink					12	29	8.8	fighting, entire removal of one carcass
Silver gull					46	13	5.9	2 pulling, no consumption
Buff-banded rail					16	0	2.9	1 pecking
Bridled tern					6	0	0	
Black rat					20	55	82	consumption
House mouse					0	0	0	
TOTAL		100	100		100	100	100	

Figure 3: Images from remote cameras during carcass tethering trials, showing (top) a black rat predating the tethered rat carcass, (middle) a King's skink attempting and silver gull (bottom) pulling at a tethered rat's tail.

Carcass checks

123 black rat carcasses were collected and disposed of in deep landfill off the island. It is difficult to estimate the number of rats on the island prior to baiting however it is likely to have been between 2000 and 5000 or 1 rat per 25 to 60 m^2. The majority of rats are presumed to have died below ground, under vegetation or be in inaccessible areas. Eight adult King's skink carcasses were retrieved; the majority in late February/March after sleeves were removed. Most were in late decomposition, however one was sent to Murdoch Veterinary Pathology for a necropsy and testing levels of brodifacoum. The preliminary necropsy confirms death by haemorrhaging, likely a result of poisoning. Two feral pigeon carcasses were also retrieved, with cause of death unknown.

Figure 4: Adult King's skink found dead on 13/4/13 (left), with obvious bleeding from cloacca (right).

Trapping transects

Results of trapping over 2 nights on each of three occasions between 8th January and 30th July 2013 are shown in Table 3, below. Initial (pre-baiting) trapping saw 13 rats of various ages captured along with a small number of house mice (4) and a larger number of King's skinks (19) . Subsequent trapping in April saw one adult female rat trapped, with several house mice and little penguins. The most recent trapping in July saw no rats, but increased levels of house mice (17) and silver gulls (5).

Table 3: Total numbers of captures per species for 2 nights on each trapping session from 8th January to 30th July 2013.

	Date		
Species	8/1/2013	30/4/13	30/7/13
Black rat (*Rattus rattus*)	13	1	0
House mice (*Mus musculus*)	4	2	15
King's skink (*Egernia kingii*)	19	1	0
Little penguin (*Eudyptula minor*)	1	1	0
Buff-banded rail (G*allirallus philippensis*)	0	1	0
Bridled tern (*Onychoprion anaethetus*)	1	0	0
Silver gull (*Chroicocephalus novaehollandiae*)	0	0	4

Inked trakka cards

Mice and King's skink activity was only recorded on inked cards during both deployment times at the later stages of baiting, with an example of an inked card in Figure 5.

Figure 5: Inked trakka cards showing King's skink and house mice prints.

Stable isotope analysis

Results of stable isotope analysis of sampled fur from black rats and house mice showed they were consuming seabird tissue as well as items from the terrestrial food chain (Figure 6). Black Rats were particularly focused on 'seabird' resources. Results were inserted into the isoscape of Point Peron and Penguin Island as a reference.

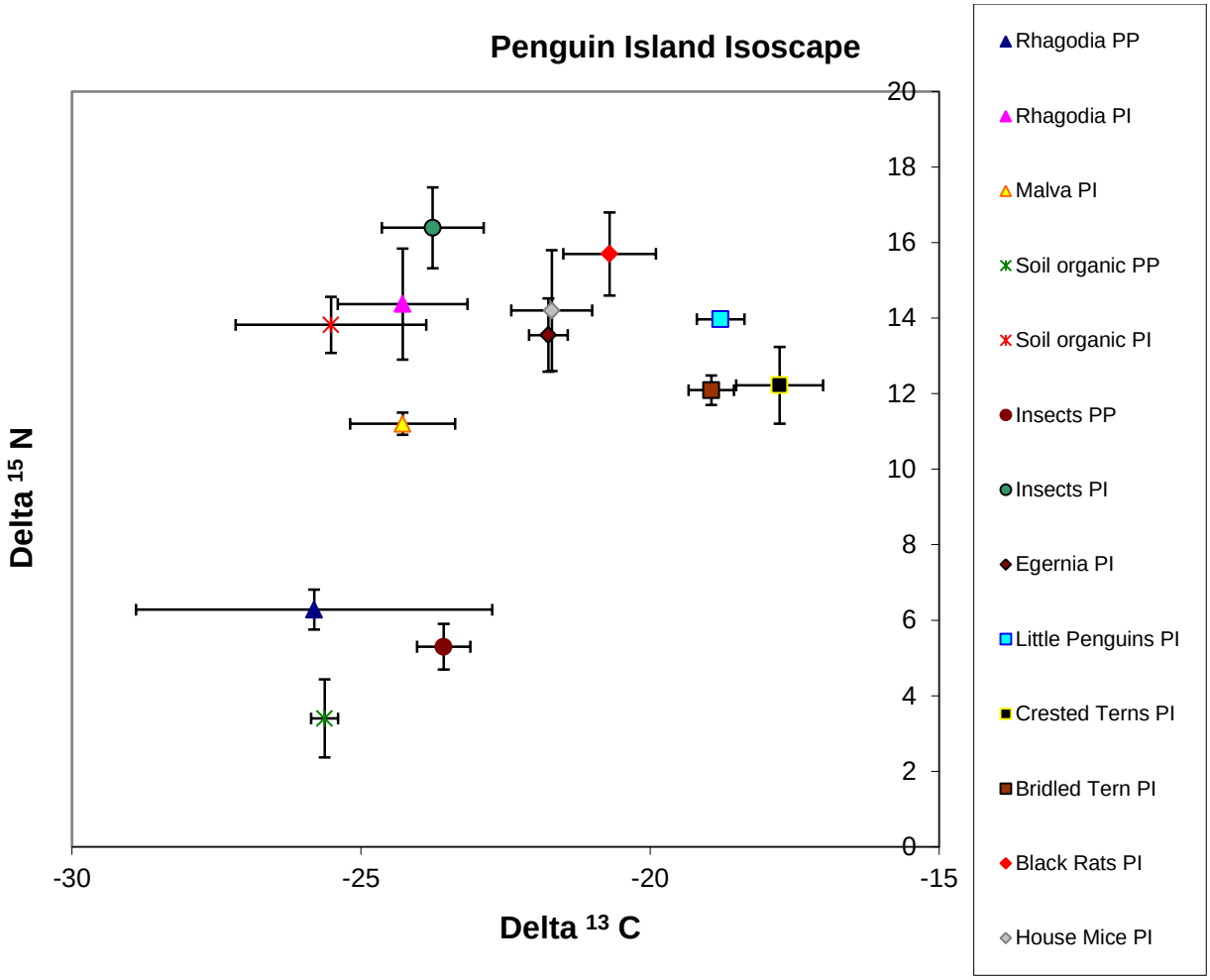

Figure 6: Results of stable isotope analysis from Penguin Island for a house mice and black rats and a range of native species.

Five full baitings were required, finishing on 28th March 2013. Baits were removed from most stations 15th April. Infrastructure stations were rebaited on 1st May followed by a rebait of a radius of the shed where a rat was detected on 20th May and 18th July 2013. Several baits were handwired in vegetation 1m off the ground to encourage rat bait uptake but minimise non-target species access. A rebait in the south of Island was carried out on 30th July 2013 within 12 hours of after single rat detection.

Camera images during the first several weeks showed extremely high rat activity, measured as events separated by 1 minute, with the highest activity recorded as 153 events on the 22nd December 2012. Adult rats dominated bait stations often with daytime activity recorded. Nights of lower rat activity saw increased activity of native species, including penguins and bridled terns. Activity dropped from high levels (figure below) at the start of January to less than event per night averaged over a week at the start of March 2013. This stayed at zero until single events were recorded until late July 2013. First records of other species occurred in mid to late March, including a small skink (*Morethia* spp.), marbled gecko (*Christinus marmoratus)* and willy wagtail (*Rhipidura leucophrys)*.

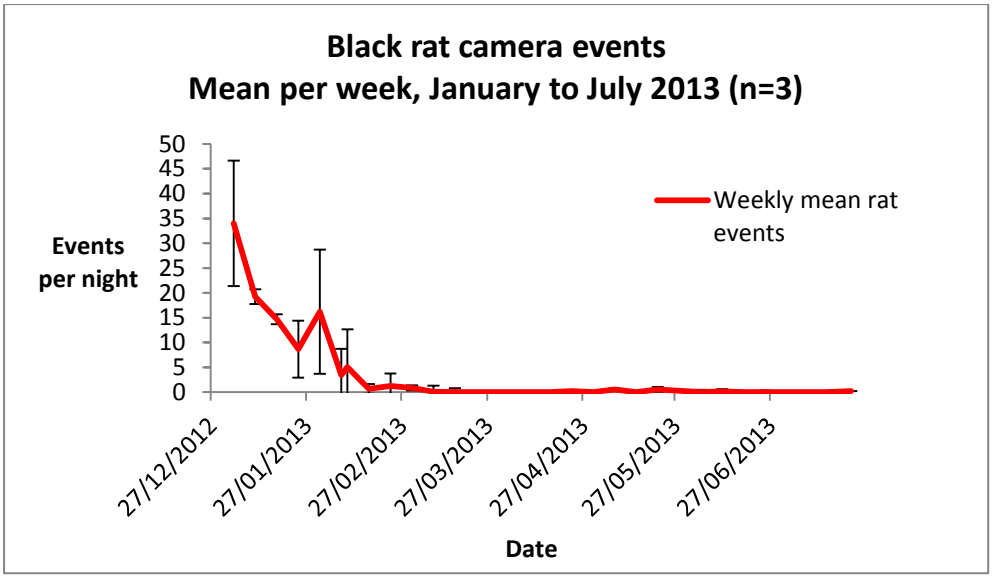

Figure 7: Rat activity recorded as mean number of events per night on remote camera over one week intervals from January to July 2013. Seperate events were defined on intervals of 1 minute.

Resources

A significant number of staff and volunteer hours were needed to complete the program, along with over $6,000 of materials, summarised in table . In excess of 750 staff hours and over 200 volunteer hours were committed. With carcass check time included, well over 1000 hours of time was devoted between January and May 2013. Cost of original bait and bait stations were largely incurred by Science Division. A full rebait of the Island took between 2-3 full days.

Table 4: Resources (time/cost) expended on the program between January and May 2013.

Resource	Time/cost
Staff (hours)	757*
Volunteer (hours)	195*
Bait	$1,370
Plant and equipment	$750
Signage	$417
Bait stations	TBA
Other rates (disposal)	$232
Remote cameras	$1,820
Food	$444
Vehicle	$800
Materials/stationary	$56
TOTAL (excluding wages, salaries)	$5,889

* excludes carcass check hours

DISCUSSION

The rat project has been a success in dramatically reducing rat numbers from several thousand to only occasional sightings of single rats, which have been targeted immediately with rebaiting. It is not surprising that these small numbers (only one since 25th May 2013) remain given the original numbers and the complexity of the habitat (including limestone caves, crevices, areas of thick vegetation particularly Nitraria) and the amount of food resources available on the island.

Results of stable isotope analysis is consistent with the injuries observed on sea birds (particularly bridled terns and penguins) and damage to vegetation.

Initial high number of black rats captures in the monitoring transects have given way to increased captures of house mice, which is an expected result after steep declines in rat abundance. House mice are considered to have a lesser impact to native wildlife on the island. King's skink captures were highest in January then declined in April until no captures were recorded in July, partly due to altering setting traps as close as possible to sunset, after which time the skinks became inactive, and partly due to slowing of skink activity with the onset of cooler weather. While King's skink deaths from brodifacoum poisoning were recorded it is unlikely this was the main driver in changes in trapping rates.

Remote cameras were integral to developing bait stations that were effective in excluding most King's skinks but allowing rats ready access. Camera images during the first several weeks of baiting showed that large adult rats dominated bait stations. By the start of February it became apparent there were numerous smaller adult and sub-adult rats remaining, many of which could not access raised bait stations with sleeves. Removing these allowed all rats, as well as increased number of King's skinks to consume baits. One collected dead King's skink submitted for necropsy, will provide greater insight into lethal doses of brodifacoum for a native reptile species.

Camera images for different stations over the weeks when rat activity (ie number of events) started to dramatically decline show that as rat activity decreased, activity of native species, including little penguins, bridled terns, buff-banded rails increased. The first record of *Morethia* sp., willy wagtail, brown honeyeater and marbled gecko occurred after rat activity decreased significantly.

The project faced a number of challenges. These included working in difficult and unstable limestone rocky terrain, inaccessible (except by boat) cliff edges, extreme heat during January, February and March, working around public visitation levels, and minimising disturbance to vegetation and roosting and breeding seabirds (including large pelican roosts at southern and northern ends of the Island). Coordinating the range of groups assisting including DPaW staff (PI rangers, marine rangers, AWU, nature conservation staff, PVS, Science Division), Naragebup volunteers, PI (Penguin Centre) volunteers, other volunteers particularly researchers and university students, friends and partners was a significant task.

Adaptive management and team work have been central to overcoming challenges and achieving the goals of the program. Off-target species effects have been kept to an absolute minimum and within animal ethics approval parameters. Elimination of the majority of rats has allowed seabirds (at present penguins) to commence breeding while eggs and chicks protected, with the hope populations will recover. Control has been achieved but eradication is still the overall aim, however this cannot confidently be declared until 2 years after last sign of rat activity. To achieve this, the following set of recommendations have been made.

RECOMMENDATIONS

Monitoring and surveillance

Monitoring and surveillance for the rapid detection of rat outbreaks and/or new incursions is critical for rapid response. The following monitoring measures are recommended:

- Carcass checks to occur for 100 days from 10 days after final baiting (8th March to 21st June 2013), completion of data sheets - WEEKLY
- Checks for secondary signs of rodent activity including tracks, scats, teeth marks (beaches, caves, stations) - WEEKLY
- Commencing 21st March - replace non-toxic baits (lures) in each of 3 cages with cameras – MONTHLY
- Replace/replensih the non-toxic lures in wire cages with the monitoring cameras - MONTHLY.
- Purchase 5 additional remote cameras to be deployed with lures at strategic locations
- 21st March - deploy trakka tunnels, collect after 2 nights (Saturday 23rd March). Redeploy after 4 weeks (23rd April)- MONTHLY for 2 months
- Monitoring trapping transects (3) to be revisited Monday 29th April for 2 nights - then BIANNUALLY
- Camera monitoring - replace SD cards and batteries in cameras and review any rat activity on camera. Notify Alice Reaveley and Karen Bettink by email - FORTNIGHTLY

Response to outbreaks

Responses to detections should be initiated immediately, and involve rebaiting stations in a radius of 100m. Monitoring effort (through trakka tunnels and remote cameras) may need to be increased in the area. Carcass collections will need to occur daily, to weekly up until 100 days post-baiting.

Biosecurity

Despite a clear strategic objective within the 2007-2017 Management Plan (DEC 2006) maintain and enhance the key ecological values of Islands within the Marine Park, there was

no information provided on biosecurity and in particular, invasions by introduced rodents. A biosecurity plan for ensuring no invasive rats are able to be transported to the Island should be developed as soon as possible. This should include quarantine of materials (particularly for construction) and changes to public mooring policies.

Use of lower toxicity bait (Pestoff® 20R)

To date only X-Verminator (0.05 g/kg Brodifacom as the active constituent) has been used on Penguin Island. While this has proved to be highly effective in significantly reducing the black rat numbers, it has so far failed to eradicate them from the island. As of May 2013, baiting was scaled back to localised application of bait in bait stations in the vicinity of recent rat detections on remote camera traps, due to concerns regarding the poisoning of King's skinks.

Changing to an alternative less potent rodent pellet bait (Pestoff® 20R) is recommended. This bait have been extensively used and it has proven efficacy in numerous island eradications globally. It is a cereal-based pellet, dyed emerald green to reduce its attractiveness to birds. The cereal seed used as the base in the bait is ground to flour, screened to 1.5 mm (smaller than cereal seed) and heated. This 'denatures' the proteins required for germination so there is no risk of the cereal becoming a weed problem. Typically, 10 mm diameter bait pellets weighing approximately two grams are used for eradications targeting rats. The amount of brodifacoum proposed to be in each bait is 0.02 g/kg rather than 0.05 g/kg as in X-Verminator.

The use of Pestoff® 20R requires approval from the Australian Pesticides and Veterinary Medicines Authority (APVMA) as this product is not currently registered for use in this country. The APVMA has previously been granted permits to use Pestoff 20R® on several islands in NSW, Western Australia and Tasmania. Approval will be sought from the APVMA to provide a variation on the previously issued permit (PER13612) to include the use of the less potent Pestoff® 20R rodent bait on Penguin Island. DPaW has recently been granted an import permit and minor use permit (PER13966) to use this bait on Adele Island to eradicate the invasive Pacific Rat. An amendment to the DEC AEC for use of this alternative bait will be submitted.

REFERENCES AND FURTHER READING

Banks PB & NK Hughes (2012) A review of the evidence for potential impacts of black rats (*Rattus rattus*) on wildlife and humans in Australia, *Wildlife Research*.

Baudat-Franceshi, J., Cromarty, P., Golding, C., Cranwell, S., Le Breton, J., and Boudjelas, S. (2011). Rodent eradication to protect seabirds in New Caledonia: the importance of baseline biological surveys, feasibility studies and community support. In: Veitch, C. R.; Clout, M. N.

and Towns, D. R. (eds.). *Island invasives: eradication and management.* Pp 26-31 IUCN, Gland, Switzerland.

Department of Environment (2006) EPBC ACT, Key Threatening Processes, *Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha)* Available at http://www.environment.gov.au/biodiversity/threatened/ktp/island-rats.html, Australian Government.

Department of Environment and Conservation (2006) *Shoalwater Islands Marine Park Management Plan 2007-2017*, Management Plan no. 58, Department of Environment and Conservation, Western Australia.

Conservation Council of Western Australia (2008?) *The Recovery of Rat Island following the eradication of introduced predators,* PDF Available at http://islandarks.com.au/files/2013/06/Rat-Island-MP-final.pdf.

Priddel, D., Carlile, N., Wilkinson, I. and Wheeler, R. (2011). Eradication of exotic mammals from offshore islands in new South Wales, Australia. In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). *Island invasives: eradication and management*. pp. 337–344. IUCN, Gland, Switzerland.

Varnham, K. (2010) *Invasive rats on tropical islands: their history, ecology, impacts and eradication*, The Royal Society for the Protection of Birds,The Lodge, Sandy, Bedfordshire SG19 2DL, UK.

ACKNOWLEDGEMENTS

I wish to thank the following people for their advice, support and particular efforts: Russell Palmer, Nic Dunlop, Aurelie Labbe, Grazyna Packowska, Julia Cullity, Robyn Prior, Nicole Godfrey and Erin Biggs, Jane, Mike Lohr.

APPENDICES

1. Map of station layout
2. Location of monitoring trapping transects, lures and cameras
3. Additional images
4. Program timeline (spreadsheet)
5. DEC AEC application approval

Appendix 1. Map of station layout

Appendix 2. Location of monitoring trapping transects, lures and cameras.

Appendix 3. Additional images.

Figure 8: (above) A little penguin (*Eudyptula minor)* being assessed and treated for injuries sustained in a rat attack. It was taken to vets and required stitches for deep lacerations. This pattern of injuries was commonly seen particularly in penguins and (below) rat injuries (possibly pre or post-mortem on a dead penguin (photo Erin Biggs).

Figure 9: The distinctive Buff-banded rail (*Gallirallus philippensis*) occurs on the Island and will most likely have been affected by rat incursion. Few chicks were observed by Island staff late in 2012.

Figure 10: (left) threading X-Verminator baits onto metal pins and (right) signs placed at strategic points around the Island to advise the public of the baiting program and risks of interfering with bait stations.

Figure 11: black rat recorded during daylight on a caged lure containing non-toxic baits.

Figure 12: (above) freshly dead adult black rat collected on a north-west beach in February after the program had been underway for 4 weeks.

Figure 13: (right) bridled tern guarding one of less than 10 fledgling chicks observed during the entire breeding season on the Island.

Figure 14: (below, top) adult bridled tern euthanised due to severe bite injuries to its wing, neck and dorsal area, January 2013 and (below, base) bridled tern stripped by black rat during March 2013, with entire carcass removed by a black rat the same night.

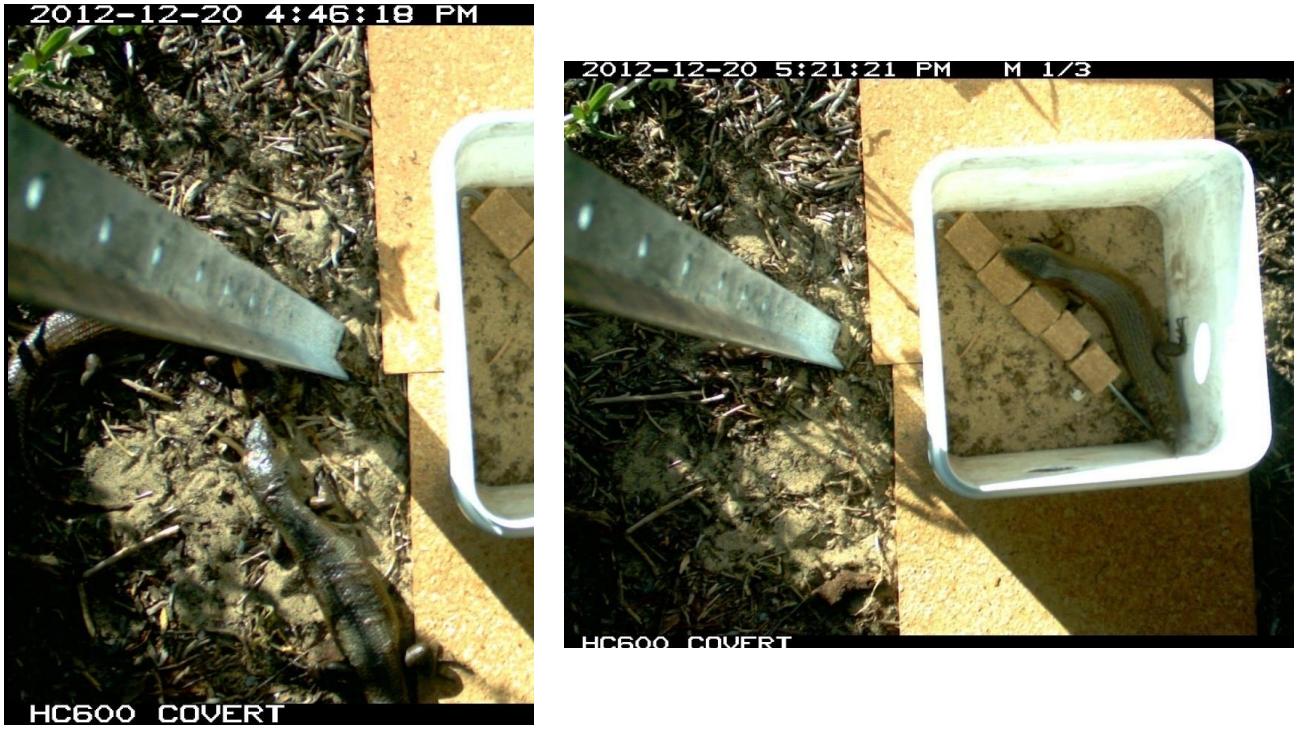

Figure 15: (top left) remote camera image of King's skink taken during December 2012, showing scarring across its dorsum, possibly due to rat attack injuries and (top right) King's skink showing typical tail damage.

Figure 16: chewed through bait station entry hole observed later in the program when oversized/obese rats remained, who could not access baits through normal means.

Appendix 4. Program timeline January – May 2013.

	Date	Task	Personnel required	Staff	Volunteers
JANUARY	7th	1. 9am Briefing for the baiting program at Naragebup Environment Centre, Rockingham	All personnel involved in the baiting program	Erin Biggs & RP/KB to conduct the briefing (all 20 hours)	All involved
	7th (ctd)	2. Transport equipment and materials to island 3. late pm. lay out and bait cages & elliotts in a transect line for baseline monitoring. 4. Grid and lyout bait stations (unbaited). 5. Install signage		Karen Bettink (9) Nicole Godfrey (9) Tracy Sonneman (9) Erin Biggs (4) Russell Palmer (8)	Aurelie Labbe (9) Robyn Prior (2) Voln (2)
	8th	1. Check, clear and close traps for the day. 2. Tether 10 rat and 10 mouse carcasses with cameras 3. 1 or 2 teams continue installing stations (unbaited) in correct positions along gridlines. 4. 1 team to install buckets in sensitive sites - pelican and tern roosts/rookeries and island perimeter including limestone caves. 5. Reopen and rebait traps		Karen Bettink (10) Nicole Godfrey Tracy Sonneman (8) Zoe Scarlett (5)	Aurelie Labbe (8)
	9th	1.Check traps. Process rats & mice and tether additional carcasses if required. Remove traps. 2.Continue installing bait stations in correct positions along gridlines & put non-toxic bait in the buckets. 3. 1 team to install buckets in sensitive sites - pelican and tern roosts/rookeries and island perimeter, including limestone caves	2 ppl for trapping.2-3 teams of 2 people for the bait station set-up.	Karen Bettink (9) Nicole Godfrey (9) Geoff Barrett (7)	Aurelie Labbe (8)
	10th	1. Check camera traps on carcasses. 2. Finish installing bait stations in correct positions along gridlines & put non-toxic bait in the buckets. 3. 1 team to finish installing buckets in sensitive sites 4. Re-check all installed bait stations for king skink access.	3 teams of 3 + 3 extra pple to re-check all installed bait stations for king skink access	Karen Bettink (10) Nicole Godfrey (9) Geoff Barrett (7) Alice Reaveley (8)	
	11th	1.Check cameras, Complete any set up, Re-check all installed bait stations for king skink access. Remove cameras and tethered carcasses		Karen Bettink (9)	Aurelie Labbe (8)
	12th				
	13th				
	14th	Implement 1st baiting in program. Replace the non-toxic baits with X-verminator in all bait stations. Hand broadcast baits on the limestone scree slopes. Baits in trays in building ceilings. Remove remainder of tethered carcasses	3 teams of 2/3	Karen Bettink (9) Erin Biggs (8) Julia Cullity (9) Nicole Godfrey (8) Grazyna Paczkowska (8) 2 x AWU Russell Palmer (8) Robert Jordan (3)	Aurelie Labbe (9) Robyn Prior (8) Voln (8)

	15th	Baiting continued. Continue GPSing station locations	2 to 3 teams of 2	Karen Bettink (10) Julia Cullity (8) Grazyna Packowska (8) Erin Biggs (4) Robert Jordan (3)	Aurelie Labbe (9)
	16th	Check all bait stations for non-target species ie king skinks. Modify stations if necesssary.	2 to 3 teams of 2	Karen Bettink (4)	Aurelie Labbe (4)
	17th	Start looking for carcasses. Carcasses individually bagged, labelled & put in freezer.	2 to 3 teams of 2	Karen Bettink (10)	Aurelie Labbe (8) Peng vols (2)
	18th	Look for carcasses.	2/3 teams of 2		
	19th	Look for carcasses.	2/3 teams of 2		
	20th	Look for carcasses.	2/3 teams of 2		
	21st	Subsampling bait stations, Look for carcasses	2/3 teams of 2	Karen Bettink (10)	Aurelie Labbe (8)
	22nd	Look for carcasses.	2/3 teams of 2	Karen Bettink (10)	Aurelie Labbe (8)
	23rd	Rebait (2nd baiting) all bait stations with X-verminator. Hand broadcast the limestone scree slopes. Look for carcasses.	3 teams of 3	Karen Bettink (10) Erin Biggs (8) Alice Reaveley (9) Russell Palmer (8) Shaun Emmett (5) Steve Dutton (5) 4 x AWU	Mike Lohr (8) Aurelie Labbe (8)
	24th	Second handbroadcasting in south. Place out additional stations in shortfall areas/areas of high activity Look for carcasses.	2-4 ppl	Karen Bettink (9)	
	25th	Look for carcasses.	2-4 ppl		
	26th	Look for carcasses.	2-4 ppl		
	27th	Look for carcasses. Check bait stations for non-target access. Subsampling stations	3 teams of 3		Aurelie Labbe (5) Voln (5)
	28th	Look for carcasses.	2-4 ppl		
	29th	Look for carcasses.	2-4 ppl		
	30th	Look for carcasses. Subsampling bait sations. Cave entrance/openings assessment	2-4 ppl	Karen Bettink (8)	Aurelie Labbe (8)
	31st	Look for carcasses	2-4 ppl		
FEBRUARY	1st	Commence rebait (3rd baiting) all bait stations with X-verminator. Handbroadcast on southern cliffs Look for carcasses.	2-4 ppl	Karen Bettink (10.5) Steve Dutton (3) Robert Jordan (3)	Aurelie Labbe (4)
	2nd	Look for carcasses.	2-4 ppl		
	3rd	Look for carcasses.	2-4 ppl		
	4th	Complete rebait (3rd baiting) all bait stations with X-verminator. Look for carcasses. Check stations and cards near buildings for rat activity and access with sleeves on raised stations	2-4 ppl	Karen Bettink (10.5) Nicole Godfrey (9)	4 x AWU
	5th	Look for carcasses.			

	6th	Look for carcasses.			
	7th	Remove sleeves (south and central). Replace camera cards and batteries. Set up cameras on 3 trial stations without sleeves. Look for carcasses.		Karen Bettink (9.5) Alice Reaveley (9.5) Tracy Sonneman (9)	
	8th	Look for carcasses.			
	9th	Look for carcasses.			
	10th	Look for carcasses.			
	11th	Look for carcasses.			
	12th	Look for carcasses.			
	13th	Subsampling bait stations, remove sleeves, opportunistic rebaiting of empty stations		Alice Reavely (9) Aurelie Labbe (9)	
	14th	Look for carcasses.			
	15th				
	16th				
	17th				
	18th	Once weekly patrol looking for carcasses, rodent signs and checking sub-samples of bait stations for bait take			
	19th				
	20th				
	21st	Commence rebait (4th baiting) all bait stations with X-verminator. Look for carcasses. Checked and replace cards, 2 cameras removed from Island		Alice Reaveley (9) Julia Culltu (9) Tracy Sonneman (9)	4 x AWU (30)
	22nd	Look for carcasses			
	23rd	Look for carcasses			
	24th	Look for carcasses			
	25th	Look for carcasses			
	26th	Completion of rebait (4th baiting) remaining stations with X-verminator.		Robert Jordan (8)	4 x AWU (30)
	27th	Look for carcasses			
	28th	Look for carcasses			
MARCH	1st	Look for carcasses			
	2nd	Look for carcasses			
	3rd	Look for carcasses			
	4th	Look for carcasses			
	5th	Look for carcasses			
	6th	Look for carcasses			
	7th	Look for carcasses			
	8th	Look for carcasses			
	9th				
	10th				
	11th				
	12th				
	13th				
	14th	Once weekly patrol looking for carcasses, rodent signs and checking sub-samples of bait stations for bait take (to take place for 100 days)			
	15th				
	16th				
	17th				
	18th				
	19th				

	20th				
	21st	Change camera cards, deploy Trakka tunnels, swap old lures with fresh, remove all except 5 cameras. Collect rat and any non-target spp carcasses. Review camera data.		Alice Reaveley (8) Karen Bettink (8) Karen Taylor (8)	Mike Lohr (8) Monique (8)
	22nd				
	23rd				
	24th				
	25th	Collect Trakka tunnels and cards.		Ranger (3)	
	26th				
	27th				
	28th	Rebait entire island (5th baiting) using fresh X-Verminator. Patrol looking for carcasses, rodent signs and checking sub-samples of bait stations for bait take. Reviewed trakka cards.		Alice Reaveley (8) Robert Jordan (8) Rangers 3 x AWU (23) Paul Tholen (8)	Mike Lohr (8)
	29th				
	30th				
	31st				
APRIL	1st	Carcass check		Rangers & volunteers	
	2nd	Carcass check		Rangers & volunteers	
	3rd	Exchange and check cards in cameras. Sub-sample bait stations for activity. Check sandpad sites particularly north east caves. Assess whether baits need to be removed. Carcass check		Alice Reaveley Karen Bettink	
	4th	Carcass check. Remove remainder of baits????		Rangers & volunteers	
	5th	Carcass check		Rangers & volunteers	
	6th	Carcass check		Rangers & volunteers	
	7th	Carcass check		Rangers & volunteers	
	8th				
	9th				
	10th	Checked camera cards, Survey island edges for secondary signs, sand pad surveys for rat prints. Weekly patrol looking for carcasses, rodent signs and checking sub-samples of bait stations for bait take		Karen Bettink (8) Erin Biggs (4)	
	11th		Rangers, volunteers		
	12th	Commence removal of baits from majority of stations, excluding jetty, north and south pelican rookeries and 2 stations near infrastructure. Replace baits on ferrys.			
	13th				
	14th				

	15th	Commence removal of baits from majority of stations, excluding jetty, north and south tips (near Pelican rookeries, and PenGentre 6			
	16th				
	17th				
	18th	Once weekly patrol looking for carcasses, rodent signs		Rangers	
	19th				
	20th				
	21st				
	22nd				
	23rd				
	24th				
	25th	Swap and check camera cards, Check sand pad surveys for rat prints. Weekly patrol looking for carcasses, rodent signs		Rangers	
	26th				
	27th				
	28th				
	29th	Monitoring trapping transects (3), Deploy trakka tunnels (24)	4 to 6	Karen Bettink (6) Nicole Godfrey (6) Zoe Scarlett (2)	Student (6) Aurelie Labbe (6)
	30th	Check and clear traps from 3 transects	4	Karen Bettink (10) Nicole Godfrey (5) Alice Reaveley (4)	Aurelie Labbe (5) Student (5)
MAY	1st	Complete trapping transects (3), collect trakka tunnels (24). Carcass checks. Refresh non-toxic bait in lures in cages, Change SD cards and check batteries. Collect trakka tunnels to due to inclement rain.	4 to 6	Karen Bettink (8) Alice Reaveley (8) Paul Tholen (4)	
	2nd				
	3rd				
	4th				
	5th				
	6th			All	
	7th				
	8th	Carcass checks			
	9th				
	10th				
	11th				
	12th				
	13th				
	14th				
	15th	Check camera cards, download data. Report on any rat activity. Carcass checks		Ranger/s	
	16th				
	17th				
	18th				
	19th				
	20th				

	21st				
	22nd	Carcass checks		Ranger/s	
	23rd				
	24th				
	25th				
	26th				
	27th				
	28th				
	29th	Carcass checks. Check camera cards, download data. Report on any rat activity. Replace non-toxic lures in cages.		Ranger/s	
	30th				
	31st				
JUNE	1st				
	2nd				
	3rd	Continue as per previous fortnight			
	4th				
	5th	Review status of black rats and house mice on Penguin Island and non-target impacts. Pending outcome, remove all bait stations and other materials from the island (3 teams of 3 people – 1 day)			

Appendix 5. DEC AEC Approval.

DEC AEC Project Application — Form last updated: 25/9/2012

Office Use Only:

Date Received: 30/11/2012	*1. Signatures received:*	☑ Yes ☐ No ☐ Incomplete
AEC Meeting Date: 14/12/2012	*2. Competencies received:*	☐ Yes ☐ No ☑ Incomplete
Agenda Item No.: 4.1	*3. Reg 17 licence current:*	☑ Yes ☐ No ☐ Pending
	4. Poisons Permit obtained:	☒ Yes ☐ No ☐ Pending ☐ N/A

Department of Environment and Conservation
Animal Ethics Committee

APPLICATION FORM COVER SHEET

To fill out this form you must refer to the DEC Standard Operating Procedures and the Disease Risk Management Guidelines. Answer all sections, indicating when there is no information available. Incomplete forms will result in delays in assessment or rejection of the nomination.

1. Project Title:

Eradication of introduced rodents from Penguin Island

2. Chief Investigator (CI):

CI's name:	Russell Palmer/Karen Bettink	Telephone:	9405 5128/9303 7724
Agency/Company:	DEC	Mobile:	
Current Position:	Research Scientist/Conservation Officer	Fax:	9306 1641
Contact Address:	Dept of Environment and Conservation Woodvale Wildlife Research Centre PO Box 51, Wanneroo, W.A.	Email:	Russell.Palmer@dec.wa.gov.au/Karen.Bettink@dec.wa.gov.au

3. Expected date of commencement and duration of project (project to be renewed every 3 years):

Commencement date must be on or after the date of the AEC meeting at which the project is assessed.

Commencement date (dd/mm/yyyy): 17th Dec 2012 Completion date (dd/mm/yyyy): 31st Dec 2014

4. Projects involving the collection of voucher specimens or targeting areas poorly surveyed are to be discussed with WA museum staff prior to commencement:

No ☐ Yes ☐ N/A ☒

***COMMITTEE USE ONLY:* Approval Slip**

The DEC AEC has considered this proposal and approves for the period 14/12/2012 to 14/12/2015 subject to, (i) the following conditions and (ii) submission and AEC approval of annual reports.

1. Annual Report required by 15/11/2013
2. Condition of approval/other comments:
   CI to provide details of personnel administering 1080 baits
   CI to note that carcasses must be picked up every two days
   CI to clarify Murdoch Uni has agreed to accept ext. injured birds
3. Chief Investigator to inform AEC Executive Officer immediately of any staff changes to this project.

AEC APPROVAL NUMBER: DEC AEC: 2012/70

CHAIR / EXECUTIVE OFFICER: [signature] DATE: 14/12/2012