The Eradication of Invasive Rats from Adele Island – Environmental Risk Assessment

Aerial view of Adele Island.

Report prepared for the Department of Parks and Wildlife Animal Ethics Committee – March 2013

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Acknowledgments

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Summary/Background

This environmental risk assessment is based on the Department of Parks and Wildlife's application (# 13966) to the Australian Pesticides and Veterinary Medicines Authority (APVMA) for a minor-use permit to use an unregistered cereal-based bait (Pestoff 20R Rodent Bait) containing the approved active constituent brodifacoum (0.02g/kg) on Adele Island (15°31'30"S, 123°09'30"E), to eradicate the introduced Pacific Rat (*Rattus exulans*). The primary method of bait delivery will be dispersal from a spreader bucket slung beneath a helicopter. Hand dispersal of bait will occur on several small islets in a tidal inlet on the eastern side of Adele Island to ensure accurate delivery of bait.

Our application (#13966) was lodge on the 22 December 2012 and remains with the Department of Sustainability, Environment, Water, Population and Communities (DSEWP&C), who is conducting the technical risk assessment for the proposed use of brodifacoum baits at Adele Island. It is anticipated a permit will be granted in the coming weeks and this will be forwarded to the DPaW Animal Ethics Committee.

Adele Island is a Class A Nature Reserve for the conservation of flora and fauna. It is regarded as one of three internationally significant seabird breeding islands situated within the Browse Basin. Eighty-two species of bird have been recorded on Adele Island. Twenty species of seabird, eight of the ten coastal waterbirds, and twenty-seven of the twenty-nine shorebird species recorded there are represented on the Japan-Australia Migratory Birds Agreement (JAMBA), China-Australia Migratory Birds Agreement (CAMBA) and/or Republic of Korea Migratory Birds Agreement (ROKAMBA) and/or listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as marine and/or migratory. Adele Island has no known land based native mammals or reptiles, although Saltwater Crocodiles (*Crocodylus porosus*) and the threatened Green Turtle (*Chelonia mydas*) and Flatback Turtle (*Natator depressus*) are present in the surrounding waters.

The Pacific Rat was first recorded on Adele Island in 1891 and it was probably introduced by traditional Indonesian fishers. Although not quantified, it is likely that the Pacific Rats have a negative impact on the biodiversity values of Adele Island, especially the smaller nesting seabirds. The impact of Pacific Rats on insular seabirds is well documented elsewhere (Jones, et al. 2008) and predation by exotic rats on Australian offshore islands of less than 1000 km² (100,000 ha) is listed as a key threatening process under the EPBC Act 1999.

APVMA has already assessed the use of Pestoff 20R in aerial application, and has issued numerous minor-use permits to bait rodents on islands in New South Wales, namely Montague Island, the Broughton group of islands and Solitary group of islands (permit numbers 8423, 10788, 12498 and 13536, respectively), as well as islands in the Montebellos group in Western Australia and on the World Heritage listed, Macquarie Island in Tasmania (PER10895).

Brodifacoum is toxic to mammals, birds, and fish. Brodifacoum acts by inhibiting the synthesis of vitamin-K-dependent clotting factors synthesised in the liver, thereby disrupting normal blood-clotting processes. Brodifacoum bio-accumulates in the

tissues of mammals and birds following sub-lethal exposures and has the potential to accumulate in fish. Invertebrates bio-accumulate the poison, but in the absence of repeat feeding on brodifacoum, rapidly excrete the compound. Accordingly, risks of primary and secondary poisoning are the chief concerns in evaluation of the environmental hazard possible from the proposed distribution of brodifacoum baits on Adele Island. The risk to non-target species during an eradication program will be a function of their behaviour, susceptibility of those species present to the poison, composition and delivery method of the bait and the probability of exposure to the poison either directly or indirectly.

Bird information was collated from 22 surveys, spanning 1891 to 2012. Although sparse, these bird survey data was considered adequate to allow the level of risk of primary and/or secondary poisoning to these non-target species to be estimated as well as the development of strategies to minimise non-target mortalities (Tables 1 to 5). Whilst it is expected that some non-target deaths of a small number of species may occur because of the proposed eradication program, these are not expected to have a significant long-term effect on the non-target populations.

Baiting is timed to occur after the larger and more abundant seabirds have finished nesting and their young have fledged (late October-early November) to reduce the risk of bird strike on the helicopter. Pacific Rats are expected to face food shortages at this time (late in the dry season), increasing their propensity to eating the bait.

1 Adele Island

Adele Island is situated ~90 km north east of Cape Leveque, Dampier Peninsula, Western Australia at 15°31'30"S 123°09’30"E. The island is a Class A Nature Reserve for the conservation of flora and fauna. It is regarded as one of three internationally significant seabird breeding islands situated within the Browse Basin and supports large numbers of breeding species including Lesser and Greater Frigatebird, Brown, Masked and Red-footed Booby, Common Noddy, and Bridled, Crested and Lesser Crested Terns. Despite the island’s relative proximity to the Australian mainland and its recognition as a nature reserve, data on the breeding seabirds and visiting shorebirds is generally sparse and, with the exception of complete surveys in April and November 2012 (Clarke et al. 2012a&b), has to date been collected in an ad hoc manner.

1.1 Physical characteristics

Adele Island is ~ 3 km by 1.6 km in size, with a wide base to the south. On the eastern shore, an inlet opens to a tidal lagoon that occupies one quarter of the interior. It is a low-lying sand island that rises no more than 4 m above the high water mark. The island has a dense cover of coastal grasses, herbs and, to a lesser extent, shrubs. Adele Island is surrounded by extensive sand flats and fringing reefs that extend up to 25 km out to sea at low tide (Coates 1997). These flats are broken by numerous tidal channels and, at their outer edge, are fringed by intertidal reef flats. In the north-west (and to a lesser extent, the south), several large sand bars provide roosting areas for shorebirds and other bird species during neap tide series (Boyle *et al.* 2004). Most sand bars are devoid of vegetation and largely inundated on spring tides, however the largest sandbar, several kilometres to the north of Adele Island has now been colonized by several plant species.

Dense Beach Spinifex *(Spinifex longifolius)* is the dominant vegetative cover on Adele Island. There are also areas of Saltwater Couch Grass (*Sporobolus virginicus)* adjacent to the lagoon and thickets of Indian Lantern Flower *(Abutilon indicum)* within the southern interior. These latter shrubs have established on narrow dune ridges. Around the fringes of the island Prickly Saltwort (*Salsola kali*) bushes can be found, especially on the western side where they form a hedge-like structure adjacent to the beach (Boyle *et al.* 2004).

1.2 Previous bird surveys

The ornithological history of Adele Island was reviewed by Coates (1997). In addition to this review, other bird survey information was obtained through literature/archive searches and discussions with ornithologists. Data was compiled from 22 bird surveys on Adele Island (Bibliography provided in Appendix 1).

Briefly, the first birds were recorded by James, J. Walker of the HMS Penguin in May 1891 (Walker 1892). Serventy (1952) followed with brief information based on a visit to Adele Island in the 1949. Since 1989, naturalist Kevin Coate has participated in several dry season expeditions to the island and published summaries of Adele

Island's seabirds (Coate et al. 1994, Coate 1995 & 1997). Coate provided descriptions of the island's seabirds and the locations of their breeding colonies. During a visit in 1990, Coate (1994) documented the first breeding records for both Red-footed Booby and Greater Frigatebird in Western Australia. Several other species of seabirds were recorded breeding during the months of May-July, including Australian Pelican, Masked and Brown Boobies, Pied Cormorant, Lesser Frigatebird and Caspian Tern. As Kevin Coate typically visited the island as a tour guide with tourists in tow, most visits were for a single day only and the opportunity to systematically count all seabirds and shorebirds that were present was not available. In 2000 and 2002 George Swann visited as a tour guide under similar circumstances. During these visits, the presence of large numbers of migratory shorebirds were noted (Swann 2002).

The first complete count of shorebirds at Adele Island was subsequently conducted in November 2004 (Boyle *et al.* 2004). More than 24,000 shorebirds were recorded, representing 24 migratory and three resident species. Nine of these species were recorded in numbers that exceeded the criteria for occurring in internationally significant numbers. Consequently, Boyle *et al.* (2004) recommended the island be recognized as an important shorebird site under the Ramsar Convention. Although efforts were also made to count the breeding seabirds during the same expedition, logistical constraints meant these counts were not complete (Boyle *et al.* 2004). In 2012, a formal monitoring protocol for seabirds and shorebirds was employed on Adele Island for the first time during the peak survey times for both groups of birds, seabirds in April and shorebirds in November (Clarke et al. 2012a & b). They found more than 28,500 seabirds and 5,500 shorebirds during the April survey, and 33,800 seabirds and 17,000 shorebirds in November.

These formal baseline counts, and further counts planned for 2013 will underpin plans to assess the recovery of birds on Adele Island following the eradication of the rats.

1.2.1 Other vertebrate fauna

The invasive Pacific rat was first recorded on Adele Island by J. J. Walker in May 1891. He lodged voucher specimens with the British Museum of Natural History. Molecular sequencing of five individuals collected from Adele Island in 2012 by Melanie Hingston at the University of Auckland, linked these rats closely with the Lesser Sunda Islands. It seems probable that their introduction was facilitated by traditional Indonesian fishers. Trapping using a 10m square grid on Adele Island in April 2012 revealed extraordinary densities of Pacific rats, estimated at 1 rat per 12 m^2 (based on 97 captures in 190 traps set).

The only other non-avian land vertebrate recorded on Adele Island is the introduced Asian house gecko (*Hemidactylus frenatus*). Saltwater Crocodiles (*Crocodylus porosus*) are present at Adele Island, reports range from 1 to 3 individuals seen. The threatened Green Turtle (*Chelonia mydas*) and Flatback Turtle (*Natator depressus*) are present in the surrounding waters. Nesting by turtles on Adele Island is apparently rare, with Boyle et al. (2004) reporting eight Green Turtle nests.

2 Assessment of environmental hazards

Brodifacoum is toxic to mammals and birds. Accordingly, risks of primary and secondary poisoning are the chief concerns in evaluation of the environmental hazard possible from the proposed distribution of brodifacoum baits on Adele Island. The risk to non-target species during an eradication program will be a function of the species present on Adele Island and their behaviour, susceptibility of those species present to the poison, composition and delivery method of the bait and the probability of exposure to the poison either directly or indirectly.

An assessment of the vertebrate species recorded on Adele Island has allowed the level of risk of primary and/or secondary poisoning to these non-target species to be estimated as well as the development of strategies to minimise non-target mortalities (Tables 1-5). The key fauna component of Adele Island is the bird life. To date, 82 species of bird have been recorded, none of which are listed as threatened under the Western Australian Wildlife Conservation Act 1950 (WC Act) and/or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Most of the seabirds, shorebirds and coastal waterbirds found there are listed under the EBPC and WC Acts as Marine and/or Migratory species (Table 1-4). Most of the land birds are vagrants.

2.1 Seabirds

Twenty species of seabird are known from Adele Island. Due to their diet few of the seabird species are likely to be harmed by the eradication project (Table 1). However, the larger species, including Booby and Frigatebirds, breed in their 1000s on the island during the Austral winter, and pose a significant collision risk to the helicopter. Based on this risk, the baiting is timed to occur after their breeding season in late October- early November, when fewer adults of the large seabird species will be present. Large numbers of Noddys will be present, but they are expected to breed after the baiting in late November. Baiting runs in the helicopter will be timed to avoid the main activity periods of the large seabirds. Where possible, flights will also coincide with lower tides, so that Noddys and other abundant species can loaf on sand bars away from the vegetated (baited) part of the island. Some deaths of Silver Gulls may occur via secondary poisoning following the scavenging of dead rats. Gull-billed Terns may be at risk of secondary poisoning by feeding on contaminated invertebrates, but at Adele Island it is more likely they forage at sea rather than over land.

2.2 Shorebirds

Twenty-nine species of shorebird are known from Adele Island (Table 2). The Pied Oystercatcher, Black-winged Stilt and Red-capped Plover are resident Australian species. The remaining 26 are migratory species that breed in the northern hemisphere during the Austral winter, departing Australia between March and May. It is not possible to take advantage of this migratory period because the seabirds breed at the same time on Adele Island. Eleven species of shorebirds probably visit

Adele Island as vagrants or infrequently, and when they do, their numbers are low (<10 individuals) (Table 2). These species were at no risk of being harmed by the eradication program. The 18 species of shorebird, more commonly reported, were at some risk of secondary poisoning by eating bait contaminated invertebrates along beaches and the intertidal zones (Table 2). Two species of shorebird, Common Greenshank (*Tringa nebularia*) Ruddy Turnstone (*Arenaria interpres*), may eat dead or dying rodents if they encountered then on the beach.

Dotterels (*Charadrius obscurus*) in New Zealand have succumbed to secondary poisoning following rodent eradication using brodifacoum (Dowding et al. 2006). The poisoning was probably the result of the dotterels eating crustaceans, mostly sandhoppers (*Talorchestia* ssp.), that had been feeding on the poison baits that they had cached. These crustaceans congregated under beachcast seaweed, where they were found by the dotterels. As such, it is possible that shorebirds on Adele Island with similar foraging strategies are also potentially at risk of secondary poisoning if they eat crustaceans, such as sandhoppers, that have fed heavily on pellets. To mitigate the threat posed to shorebirds, we plan to use the unregistered (Pestoff 20R Rodent Pellet Bait) that contains 0.02g/kg of brodifacoum rather than rodent pellet baits that are registered in Australia, which all contain 0.05g/kg of brodifacoum. We will also collect bait that lands on beaches to prevent beach invertebrates from feeding on the pellets. Baiting will mostly be conducted during low tide (7-9m tide at Adele Island) providing personnel the chance to remove bait. A quad bike will be used to enable personnel to travel rapidly around the island to inspect the beach. The high tide mark on the beach will be checked the day after each baiting session for any washed-up bait (ie bait that may fall in the water). Bait will be hand broadcast on small islets within the tidal inlet to ensure accurate dispersal of bait. Due to these mitigation measures, the proposed eradication program should not result in significant harm to the shorebirds present on Adele Island.

Pacific rats use the beaches at Adele Island, so they could potentially die there after the baiting and then be eaten or feed on by Common Greenshank or Ruddy Turnstone. Due to the high cost of mooring a vessel with a helipad off Adele Island (~ $10K per day), we are currently not planning to remain on site after each baiting session. Therefore, removing dead rats (ie die four days after baiting) from the beach is not feasible. Common Greenshanks were generally not abundant at Adele Island with a maximum count of 323 individuals in 19th-21st November 2012 (Clarke et al. 2012b). Ruddy Turnstones were more abundant with counts of 1250 in November 2004 (Boyle et al. 2004) and 1807 in November 2012 (Clarke et al. 2012b).

2.3 Coastal Waterbirds

Ten species of coastal waterbirds have been detected on Adele Island (Table 3). The Australia Pied Cormorants, Australian Pelicans and Eastern Reef Egrets are residents that breed on the island. They feed on fish at sea or on the reefs, facing no threat from the bait itself, but they do pose a collision risk to the helicopter. The large breeding colony of Australian Pied Cormorants will have completed their nesting by October. Where possible, baiting will be conducted during lower tides to allow these larger species to roost/feed on sand bars and reefs away for the planned baiting

zone on Adele Island. Buff-banded Rails and Nankeen Night Herons are potentially residents of Adele Island, while the other coastal waterbirds are visitors or vagrants (Table 3). The Buff-banded Rail is at risk of local extinction as field trials on Lord Howe Island show they will eat non-toxic cereal baits (pers. comm. Ian Wilkinson). Regurgitated pellets from Nankeen Night Heron on Adele Island contained Pacific Rats, putting them at risk of secondary poisoning. Both these species are proficient island colonisers and they are expected to recover rapidly via reinvasion. Some individual Great Egrets, Little Egrets and White-faced Herons may be at risk of secondary poisoning, but their numbers are generally low, suggesting overall risk to them is negligible.

2.4 Land birds

Twenty-three land birds have been sighted on Adele Island (Table 4). All are vagrants apart from the Tawny Grassbird and the Brown Quail. Tawny Grassbirds forage on insects in the dense vegetation, they are not likely to eat any invertebrates contaminated by brodifacoum. Brown Quails are granivorous, so they may eat the cereal bait. Brown Quails are proficient island colonisers, so their population on Adele Island is expected gain in the long-term from the eradication of Pacific Rats.

2.5 Herpetofauna

The large species of herpetofauna, Saltwater Crocodiles and Marine Turtles, are not at risk from the proposed rodent eradication project (Table 5).

3 Conclusion

While the above-mentioned potential losses are unfortunate, these deaths are deemed an acceptable cost in eradicating Pacific Rats from such a significant seabird nesting island. The avian species at risk of primary and/or secondary poisoning (no mitigation strategies available to reduce risks) are nationally common and any losses are likely to be offset by immigration or increased reproductive output following the removal of rats.

Impacts of the baiting program on the avifauna of Adele Island will be monitored by an independent sea/shore bird expert, Dr. Rohan Clarke of Monash University. The DEC plans to engage Clarke and his team to undertake complete counts of the avifauna of Adele Island in mid to late November 2013 (~3 weeks after second baiting) and April 2014. These counts will be consistent with the previous November 2012 and April 2012 surveys, and a planned count for April 2013. He will investigate the non-target impacts (if any) of the aerial baiting program. Longer-term funding will be sought for this team to continue this survey program to determine what effects the eradication of rats has on the avifauna of Adele Island.

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Table 1. Risk assessment for the known seabirds of Adele Island to the proposed Pacific Rat eradication program in October/November 2013.

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Gull-billed Tern (*Gelochelidon nilotica*)	Visitor	Recorded during 10 of the 22 surveys, counts usually low <50 birds. Max. count 438 in November 2012, loafing on northern end of island. It has a broad diet and does not depend on fish. Gull-billed terns feed on insects, small crabs, and other prey snatched from the ground, air, or even bushes.	Yes. Secondary poisoning by feeding on contaminated invertebrates.	May not forage over land on Adele Island and therefore unlikely to be threatened by the proposed baiting.	Marine
Silver Gull (*Larus novaehollandiae*)	Resident	Recorded during all surveys, estimates up to 300 birds. Silver gulls may peck at any novel food material. Likely to scavenge dead or dying rats.	Yes (deaths likely) secondary poisoning.	Some individuals may die no mitigation measures possible. Green coloured baits ignored by many birds. Vegetation is very dense on the island so most dead rats are not likely to be visible to the birds. Ornithologists have expressed concerns about the predatory impacts of Silver Gulls on seabird eggs and young chicks at Adele Island.	Marine
Bridled Tern (*Onychoprion anaethetus*)	Irregular visitor	Seven records from summer/spring surveys. Usually low numbers, except for Oct 2002, 3000 counted and Nov 2012, 3500 counted + nesting. Marine forager.	No. Risk of collision with the helicopter or spreader bucket.	Ground nester but not in colonies (likely to benefit greatly from rat eradication). Likely to flush well in advance of the Helicopter.	Marine, Migratory
Brown Booby (*Sula leucogaster*)	Resident	Forages on fish by diving into the water. Breeding from March through May, with fledging by September. Max. count 3451 nests April 2012. 4329 Adults Nov 2012.	No. Risk of collision with the helicopter or spreader bucket.	Likely to flush well in advance of the helicopter. Baiting will occur after fledging. No baiting in late afternoon when adults are returning from feeding.	Marine, Migratory
Common Noddy (*Anous stolidus*)	Regular visitor	Recorded during 16 of the 22 surveys, counts usually in 100s in winter. Max. count 26930 in November 1994. Breeding Nov 1999, 2004 & 2012. They surface-skim the sea for fish and small crustaceans.	No. Risk of collision with the helicopter or spreader bucket.	Very large numbers likely to be present. Focus baiting during lower tides to allow birds to loaf on sand bars.	Marine, Migratory
Crested Tern (*Thalasseus bergii*)	Regular visitor (Resident ?)	Frequently recorded, several winter breeding colonies reported. Max. count 2000 birds in May 2011. They feed mostly at sea by plunge diving for fish.	No. Risk of collision with the helicopter or spreader bucket.	Lower numbers Oct/Nov, not nesting. Visible on the shoreline at the northern-most tips of the island.	Marine, Migratory

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Great Frigatebird (*Fregata minor*)	Resident (colonised in 1989?)	First confirmed record 1989. Up to ~300 breeding pairs present through winter, numbers vary usually much lower outside breeding season. Juveniles present in Nov. They steal food from other seabirds and forage for fish by dipping into the water.	No. Risk of collision with the helicopter or spreader bucket.	Generally low numbers present in Oct/Nov. Soar on high on thermals once the day heats-up. Avoid baiting early in the morning, and late in the day when foraging seabirds return. Frigatebirds rob other seabirds of their catch, by harassing their victims until they regurgitate their stomach contents.	Marine, Migratory
Lesser Frigatebird (*Fregata ariel*)	Resident	Recorded during all 22 surveys. Max. count of 5200 nests present through winter. They steal food from other seabirds and forage for fish by dipping into the water.	No. Risk of collision with the helicopter or spreader bucket.	Baiting to be conducted Oct/Nov following the breeding season, far fewer birds present (ie 71 adults and 1470 Juveniles in November 2012). Adults soar on high on thermals once the day heats-up. Avoid baiting early in the morning, and late in the day when foraging seabirds return. Frigatebirds rob other seabirds of their catch, by harassing their victims until they regurgitate their stomach contents.	Marine, Migratory
Masked Booby (*Sula dactylatra*)	Resident	Forages on fish by diving into the water. Breeding from April, with fledging by September. Max. count 694 in November 2004.	No. Risk of collision with the helicopter or spreader bucket.	Likely to flush well in advance of the helicopter. Baiting will occur after the breeding season when fewer adults will be present. No baiting in late afternoon when birds are returning from feeding.	Marine, Migratory
Red-footed Booby (*Sula sula*)	Resident (colonised in 1990?)	Recorded most surveys following June 1990. Max. count is 14 nests. Fish eating species.	No. Risk of collision with the helicopter or spreader bucket.	Low numbers present, likely to be fewer than 15. As for other Boobies.	Marine, Migratory
Black Noddy (*Anous minutus*)	Irregular visitor?	Recorded during six surveys since 1999. Max. count 2459 Nov 2012 (+ 8 nests) Forage at sea.	No	First breeding event recorded 19-21 Nov 2012, likely to nest after planned baiting if they return again.	Marine
Caspian Tern (*Hydroprogne caspia*)	Resident	Recorded during every survey. Autumn-Winter breeding on the island with up to 140 nesting pairs seen. Mostly a marine forager of fish.	No	Low numbers in Oct/Nov, not nesting.	Marine, Migratory
Common Tern (*Sterna hirundo*)	Irregular visitor	Marine forager often seen in waters around Adele Island. Birds loaf on beaches on island, recorded during 7 surveys. Max. count of 313 birds in November 2004.	No		Marine, Migratory

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Lesser Crested Tern (*Sterna bengalensis*)	Regular visitor (Resident ?)	Frequently recorded, usually in low numbers, occasional nesting record. Max. count 32 birds. They feed at sea by plunge diving for small pelagic fish.	No		Marine, Migratory
Lesser Noddy (*Anous tenuirostris*)	Vagrant ?	Recorded for the first time in Nov 2012, with 33 adults and 3 nests found.	No		Marine, See *
Little Tern (*Sternula albifrons*)	Irregular visitor	Seven records, Max. count 2134 November 2012. They feed mainly on fish (but also crustaceans, insects and molluscs) collected by diving into the sea or gleaning from its surface, make it unlikely that this species will be affected by the baiting.	No		Marine, Migratory
Roseate Tern (*Sterna dougallii*)	Visitor	Some records (8 of 22 surveys), Max. count of 414 birds Nov 2012, usually fewer birds (<40 counted). Marine forager	No		Marine, Migratory
Sooty Tern (*Onychoprion fuscata*)	Infrequent visitor	Occasional (4) record of a few individuals of this marine forager.	No		Marine
Whiskered Tern (*Chlidonias hybrida*)	Infrequent visitor	Marine forager, a few birds recorded on three surveys.	No		Marine
White-winged Black Tern (*Chlidonias leucopterus*)	Infrequent visitor	Marine forager, occasional record (5), usually <130 birds. Max. count 552 Nov 2012.	No		Marine, Migratory

*May potentially be *Anous tenuirostris melanops* Australian Lesser Noddy, listed as threatened EPBC Act

Table 2. Risk assessment for the known shorebirds of Adele Island to the proposed Pacific Rat eradication program in October/November 2013.

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Bar-Tailed Godwit (*Limosa lapponica*)	Regular visitor	Migrating shorebird, numbers peak in summer (max. count 4819). Recorded from 16 surveys. Godwits feed on crustaceans, molluscs, worms, insects and plant material.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Common Greenshank (*Tringa nebularia*)	Regular visitor	Migratory shorebird, generally present in low numbers (10s during 16 of 22 surveys). Max. count of 323 birds in November 2012. Their diet includes crustaceans, molluscs, insects, fish and frogs. They have been recorded eating rodents.	Yes. Secondary poisoning by eating contaminated invertebrates. May eat dying rodents.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Curlew Sandpiper (*Calidris ferruginea*)	Visitor	Generally present during spring/summer surveys. Only one record of 2 birds present in winter. Max. count of 493 birds in November 2004. Forages on tidal flats, its diet in made up of worms, molluscs, crustaceans, insects, small fish and seeds.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Eastern Curlew (*Numenius madagascariensis*)	Visitor	Migratory shorebird, usually in low numbers (<10 birds), recorded on 10 of the 22 surveys. Max. count of 57 birds in November 2004. Eastern Curlew is carnivorous, mainly eating crustaceans (including crabs, shrimps and prawns), small molluscs, as well as some insects.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Great Knot (*Calidris tenuirostris*)	Visitor	Recorded between spring and autumn during 7 surveys, usually in low numbers. Not recorded in winter. Max. count 2945 in November 2004. Forages within sheltered, coastal habitats containing large, intertidal mudflats or sandflats.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Greater Sand Plover (*Charadrius leschenaultii*)	Visitor	Long distance migrant, only recorded between spring and autumn, 9 records. Max. count 2358 Nov 2012. Feeds from the surface of wet sand or mud on open intertidal flats of sheltered areas.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Grey Plover (*Pluvialis squatarola*)	Visitor	Long distance migrant, usually recorded in warmer months (10 records). Max. count 564 November 2004. Non-breeding birds sometimes present in winter. They forage for food on beaches and tidal flats. The food	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
		consists of small molluscs, polychaete worms, crustaceans, and insects.			
Grey-tailed Tattler (*Heteroscelus brevipes*)	Visitor	Common visitor during warmer months, occasionally a few individuals present in winter (2 records). Max. count 5489 November 2004. Tattlers feed on crustaceans and other invertebrates on mudflats.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Lesser Sand Plover (*Charadrius mongolus*)	Irregular visitor	Five records, October to April sightings, low numbers. Max. count of 671 in November 2004. They eat invertebrates, such as molluscs (especially bivalves), worms, crustaceans (especially crabs) and insects.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Pacific Golden Plover (*Pulvialis fulva*)	Visitor	Recorded mainly during surveys in the warmer months (9 of 22 surveys). Max. count 198 November 2012. They feed on insects, molluscs, crustaceans and some plant material.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Pied Oystercatcher (*Haematopus longirostris*)	Regular Visitor	Usually recorded (16 of 22 surveys). Max. count 52 November 2012. Pied Oystercatchers forage on exposed reefs, beaches and muddy estuaries for small fish, limpets, worms, crabs and mussels.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	
Red Knot (*Calidris canutus*)	Irregular visitor	Four records, low numbers, max. count of 60 in April 2012. Forage in soft substrate near the edge of water on intertidal mudflats or sandflats exposed by low tide.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Red-capped Plover (*Charadrius ruficappillus*)	Visitor	Eleven records, usually 5 or fewer birds. Max. count 15 in November 2012. They forage for molluscs, small crustaceans and some vegetation, on mudflats, sandy beaches and salt-marsh.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Red-necked Stint (*Calidris ruficollis*)	Visitor	Some records (8 of 22 surveys), Max. count 4107 in November 2004. Migratory wader that arrives in September and leave from early March. Red-necked Stints are omnivorous, taking seeds, insects, small vertebrates, plants in saltmarshes, molluscs, gastopods and crustaceans.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Ruddy Turnstone (*Arenaria interpres*)	Regular visitor	Migratory shorebird recorded on 16 of 22 Surveys (usually from Sept-May), max. count of 2000 birds in May 1993. Ruddy turnstones primarily eat marine invertebrates, including worms, small fish, bivalves and crustaceans, but they will also eat carrion.	Yes. Secondary poisoning by eating contaminated invertebrates. May eat dead rodents.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Sanderling (*Calidris alba*)	Irregular visitor	Seven records between September and April. Max. count 544 in November 2012. Sanderlings are omnivorous, foraging on plants, seeds, worms, crustaceans, spiders, insects, and occasionally on medusae.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Terek Sandpiper (*Tringa (Xenus) cinereus*)	Visitor	Some records (8 of 22 surveys), max. count 780 birds reported November 2012. Terek Sandpipers feed on crustaceans and insects found on the surface of the water or by probing in shallow water, on soft wet intertidal mudflats.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Whimbrel (*Numenius phaeopus*)	Visitor	Migrant sometimes found low numbers (max 92 November 2012) in the warmer months. Some individuals may over-winter. Diet is mostly limited to worms, molluscs, crustaceans, insects, reptiles, tern chicks and seeds.	Yes. Secondary poisoning by eating contaminated invertebrates.	Bait that lands on the beach or inlet will be collected, limiting opportunities for invertebrates to feed on the pellets.	Marine, Migratory
Black-tailed Godwit (*Limosa limosa*)	Infrequent visitor	Three records of only a few individuals.	No		Marine, Migratory
Black-winged Stilt (*Cladorhynchus leucocephalus*)	Irregular visitor	Only 6 records of 1 to 2 individuals.	No		Marine
Broad-billed Sandpiper (*Limicola falcinellus*)	Vagrant	Only 3 records of relatively small numbers. Max. count 21 birds.	No		Marine, Migratory
Common Redshank (*Tringa totanus*)	Vagrant	Lone birds seen in 2004 & 2012.	No		Marine, Migratory

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Common Sandpiper (*Tringa (Actitis) cinereus*)	Irregular visitor	Seen in low numbers on 7 trips from 2002. Max. count 4.	No		Marine, Migratory
Little Stint (*Calidris minuta*)	Vagrant	Ten birds seen in 1949.	No		Marine
Marsh Sandpiper (*Tringa stagnatilis*)	Vagrant/ Visitor	Only 3 records, in November of 1999, 2004 and 2012. Max. count of 4 birds.	No		Marine, Migratory
Pectoral Sandpiper (*Calidris melanotos*)	Vagrant	One individual seen on a survey in November 2004	No		Marine, Migratory
Sharp-tailed Sandpiper (*Calidris acuminata*)	Vagrant	Three records, 1982, 1993 and 10 birds seen in November 2012.	No		Marine, Migratory
Sooty Oystercatcher (*Haematopus fuliginosus*)	Vagrant	Three records, 1891, 2011 and two birds seen in November 2012.	No		
Streaked Shearwater (*Calonectris leucomelas*)	Vagrant	Lone individual seen 2004	No		Marine, Migratory

Table 3. Risk assessment for the known coastal waterbirds of Adele Island to the proposed Pacific Rat eradication program in October/November 2013.

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Buff-banded Rail (*Gallirallus philippensis*)	Visitor, maybe resident since ~2000	Present during four most recent surveys (2004, 2011 and twice in 2012), other record 1982 and WAM voucher from 2000. Field trials on Lord Howe Island show this species eats non-toxic cereal pellet baits distributed on the ground by hand.	Yes. Local extinction is possible.	No mitigation procedures are proposed for this species. Green coloured bait may limit intake. Buff-banded Rails are proficient island colonisers; any reduction in current Adele Island population will be made good by the reproductive output of the survivors and/or immigration.	Marine
Great Egret (*Ardea alba*)	Regular visitor	Regularly (14 of 22 surveys) seen in low numbers, counts of between 12 and 41 birds.	Yes, Secondary poisoning by eating contaminated invertebrates and they may prey on dying rats.	A small number of individuals are at risk of secondary poisoning, the eradication programme is not a threat to this species at the population level.	Marine, Migratory
Little Egret (*Egretta garzetta*)	Vagrant	Between 1 and 5 individuals recorded on 7 of 22 surveys.	Yes. Secondary poisoning by feeding on contaminated invertebrates.	Rarely seen and numbers usually low. Bait that lands on the beach or inlet will be collected to prevent invertebrates from feeding on the pellets. Small islets in the inlet bait by hand. Negligible risk.	Marine
Nankeen Night Heron (*Nycticorax caledonicus*)	Resident ?	Sporadically recorded (10 of 22 surveys), potentially a resident that is missed due to cryptic nature. They feed on fish, invertebrates and a range of small terrestrial vertebrates, including mice and rats. Generally seen on Adele Island on the exposed sand banks feeding as tide rises, max. count 75.	Yes. Secondary poisoning through the scavenging of dead or dying rodents. Local extinction is possible.	No mitigation procedures are proposed for this species. Nankeen night herons are proficient island colonisers; any reduction in current Adele Island population will be made good by the reproductive output of the survivors and/or immigration.	Marine
White-faced Heron (*Ardea novaehollandiae*)	Irregular visitor	A few individuals sporadically recorded (6 surveys). They are known to eat house mice, so could consume young dead or dying Pacific rats.	Yes. Secondary poisoning by feeding on dead or dying young rats.	Possible a few individuals (if present) may be harmed. No mitigation procedures are proposed for this species.	
Australian Pelican (*Pelecanus conspicillatus*)	Resident	Breeding colony/ies present on the island in winter. Max count 160 birds. Marine forager. Recorded on all surveys.	No. Risk of collision with the helicopter or spreader bucket.	Bait when tides are lower, providing opportunities for Pelicans to roost on exposed sand bars and reef.	Marine

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Australian Pied Cormorant (*Phalacrocorax varius*)	Resident	Large compact breeding colony present in winter, up to 400 nests. Max count 1000 birds. Marine forager of fish. Recorded every survey.	No. Risk of collision with the helicopter or spreader bucket.	Bait when tides are lower, providing opportunities for birds to roost on exposed sand bars and reef.	
Beach Stone-curlew (*Esacus neglectus*)	Vagrant	Two records (1891 & 1982) of lone birds	No		Marine
Eastern Reef Egret (*Egretta sacra*)	Resident	Recorded on almost every survey, max. count 400. Feeds on fish on reefs.	No		Marine, Migratory
Intermediate Egret (*Ardea intermedia*)	Vagrant	Single record of one individual seen on a survey in July 1990	No		Marine

Table 4. Risk assessment for the known land birds of Adele Island to the proposed Pacific Rat eradication program in October/November 2013

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Brown Quail (*Coturnix ypsilophora*)	Visitor, maybe resident since ~2004	Present during 2004, 2011 and 2012 surveys, otherwise sporadic records. Mostly a granivorous species that may eat the cereal bait. Max. count 8.	Yes. Local extinction is possible.	No mitigation procedures are proposed for this species. Green coloured bait may limit intake. Brown Quail are proficient island colonisers; any reduction in current Adele Island population will be made good by the reproductive output of the survivors and/or immigration.	
Nankeen Kestrel (*Falco cenchroides*)	Vagrant	One to two individuals seen on four surveys	Yes. Local extinction is possible if they feed on poisoned rats	No mitigation procedures are proposed for this species. Nankeen Kestrel are proficient island colonisers, although they appear to be vagrants on Adele Island suggesting Pacific rats are not their main food source on the island.	Marine
Australian Pratincole (*Stiltia isabella*)	Vagrant	Only 4 records of 1 to 2 individuals	No		Marine
Barn Swallow (*Hirundo rustica*)	Vagrant	One individual seen on a survey in 2012	No		Marine, Migratory
Black-faced Cuckoo-shrike (*Coracina novaehollandiae*)	Vagrant	One individual seen on a survey in 2012	No		Marine
Black-shouldered Kite (*Elanus axillaris*)	Vagrant	One individual seen on a survey in 1999	No		
Brown Falcon (*Falco berigora*)	Vagrant	One individual seen on a survey in 1990	No		
Eastern Yellow Wagtail (*Motacilla tschutschensis*)	Vagrant	Lone or two individuals seen 2004 and April + Nov 2012	No		Marine, Migratory
Grey Wagtail (*Motacilla cinerea*)	Vagrant	Two records of one individual seen on a survey in 2004 and 2012	No		Marine, Migratory
Horsfield's-Bronze Cuckoo (*Chrysococcyx basalis*)	Vagrant	One record of four individuals seen on a survey in 2004	No		Marine
Letter-winged Kite (*Elanus scriptus*)	Vagrant	Ten individuals reported from 1952	No		

Species	Status	Comments	Individuals at risk	Mitigation measures	EPBC Listing
Magpie Lark (*Grallina cyanoleuca*)	Vagrant	Single sighting record 1990	No		Marine
Oriental Pranticole (*Glareola maldivarum*)	Vagrant	Lone individual recorded 2004	No		Marine, Migratory
Oriental Reed-warbler (*Acrocephalus orientalis*)	Vagrant	One individual seen on a survey in 2004	No		Marine
Osprey (*Pandion haliaetus*)	Vagrant	Lone individual recorded 1982	No		Marine, Migratory
Pacific Swift (*Apus pacificus*)	Vagrant	Individuals seen on survey in November 2004 and 2012	No		Marine, Migratory
Peregrine Falcon (*Falco peregrinus*)	Vagrant	One individual seen on a survey in November 2004	No		
Rainbow Bee-eater (*Merops ornatus*)	Vagrant	Single sighting record 2002	No		Marine, Migratory
Sacred Kingfisher (*Todirhamphus sanctus*)	Visitor	Occasional reports of up to 5 individuals (8 records from the 22 surveys). Kingfishers sometimes prey on house mice but it unlikely they would eat larger Pacific rats.	No		Marine
Southern Boobook Owl (*Ninox novaeseelandiae*)	Vagrant	Single sighting record 1990	No		Marine
Swamp Harrier (*Circus approximans*)	Vagrant	Lone individual seen 1992	No		Marine
Tawny Grassbird (*Megalurus timoriensis*)	Resident	Resident population, possibly over 100 individuals. They eat insects and other small arthropods, usually remaining in the dense cover of grasses.	No		
Tree Martin (*Hirundo nigricans*)	Vagrant	Two records (1999 & 2002)	No		Marine

Table 5. Risk assessment for the known herpetofauna of Adele Island to the proposed Pacific Rat eradication program in October/November 2013

Species	**Status**	**Comments**	**Individuals at risk**	**Mitigation measures**	**EPBC Listing**
Saltwater Crocodile (*Crocodylus porosus*)	Visitor	One to three individuals reported. In April 2012, one large >2m and two smaller animals seen.	No	Possible individuals may scavenge dead rats. Toxin not likely to harm large reptiles.	Marine, Migratory
Green Turtle (*Chelonia mydas*)	Resident ?	Many individuals present in sheltered waters around Adele Island, occasional records of nesting.	No	Any nests observed will be inspected to determine which species nest on the island.	Vulnerable , Marine, Migratory
Flatback Turtle (*Natator depressus*)	Vagrant ?	One report of tracks on beach by Dr. Bob Prince.	No	Any nests observed will be inspected to determine which species nest on the island.	Vulnerable , Marine, Migratory

Appendices

Supplementary Material. Adele Island Avifauna Spreadsheet

The references listed in the bibliography below were used to populate an Excel spreadsheet for the avifauna for Adele Island. For each survey, we listed the species present, and if documented; number of individual birds counted, the number of nests recorded and other relevant breeding information. The years in which bird surveys were undertaken as listed in Table A. This survey data was used to generate the information in the seabird, shorebird, coastal waterbird and land bird risk assessment Tables 1 to 4.

Table A. List of years in which avifauna data was available for Adele Island

Years	Number of visits/counts
1891	1
1949	1
1972	1
1978	1
1982	1
1989	1
1990	2
1992	1
1993	2
1995	1
1999	1
2002	2
2003	2
2004	2
2011	1
2012	2

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