Control of house mice preying on adult albatrosses at Midway Atoll National Wildlife Refuge

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Abstract Sand Island, Midway Atoll National Wildlife Refuge (MANWR), is home to 21% of all nesting black-footed albatross (*Phoebastria nigripes*) and 47% of all nesting Laysan albatross (*P. immutabilis*) worldwide. During the 2015–2016 nesting season predation and disturbance by non-native house mice (*Mus musculus*), here documented for the first time, resulted in 70 abandoned nests, 42 adult birds killed and 480 wounded. In the following nesting season the affected area increased, resulting in 242 dead adults, 1,218 injured birds and 994 abandoned nests. Mouse predation activities triggered a mouse control response to reduce mouse densities in the affected areas using multi-catch live traps, kill traps, and limited use of anticoagulant rodenticides in bait stations. In 2016–2017 we applied a pelleted cholecalciferol rodenticide, $AGRID_3$ (Bell Laboratories, Madison, WI), at a rate of 20 kg/ha in all affected areas. The purpose of this study was to evaluate the efficacy of using $AGRID_3$ to reduce mouse density and rate of mouse attacks on nesting albatrosses on Sand Island. Mouse attacks decreased and mouse abundance was reduced following rodenticide applications in the plots treated in December but changes in attack rates in the plots treated in January were not detectable and mouse abundance increased subsequent to treatment. The plots in the December treatments were much larger than those used in January and rainfall rate increased after December. A minimum size of treatment area may be necessary to achieve a reduction in injury rates in albatrosses. No deleterious effects were observed in non-target organisms. The casualties resulting from mouse predation (mostly Laysan albatross) represent a small proportion of the 360,000 pairs nesting on Sand Island. However, the risk to adult breeding albatrosses representing such a large fraction of the global population prompted the United States Fish & Wildlife Service to prioritise mouse control efforts.

Keywords: cholecalciferol, non-target species, Pacific, rodent, seabirds, tropical

INTRODUCTION

Midway Atoll National Wildlife Refuge (MANWR) is home to over three million birds representing 29 species including species of conservation concern and the largest albatross breeding colony in the world. MANWR supports 36% of the earth's black-footed albatross (*Phoebastria nigripes*) and 73% of all Laysan albatross (*P. immutabilis*). Of the three islands that make up the refuge, Sand Island is the largest and provides habitat to approximately 360,000 breeding pairs of Laysan albatross, making it a globally significant colony. House mice (*Mus musculus*) were introduced to Sand Island more than 75 years ago and persisted after black rats (*Rattus rattus*) were eradicated in 1996. Until recently, these non-native mammals appeared to co-exist with the refuge's large seabird populations without harm.

This changed in December 2015 when, shortly after the initiation of the albatross breeding season, severe wounds were discovered on the dorsa of several incubating albatrosses on Sand Island and images from motion-sensing cameras revealed that the source of the wounds were mice (Fig. 1). This was the first time house mice had been observed attacking adult albatrosses and the first documentation of mice preying on albatross in the Northern hemisphere. House mice had not been considered a threat to seabird populations until 2001 when they were found preying on albatross chicks as well as other seabird species at two sites in the Southern hemisphere (Cuthbert & Hilton, 2004; Angel, et al., 2009; Jones & Ryan, 2009).

The discovery of attacks by mice on Sand Island caused immediate concern for wildlife managers at the refuge. Adult mortality has the strongest effect on population growth rates in species such as albatrosses with low fecundity, longevity, high age at first breeding, and prolonged parental care. The loss of the breeding adult is compounded by the loss of its egg or chick, and also reduces the fecundity of its surviving mate, as it often takes more than a year for a widowed bird to find a new mate. In response to the attacks first discovered in December 2015, emergency control efforts were immediately initiated at a 5 m grid resolution over attack areas using a combination of available methods; live traps, kill traps, and difethialone rodenticide applied in bait stations near structures.

When albatrosses returned to Sand Island in the autumn of 2016, surveys were initiated to look for signs of mouse attack and it quickly became clear that mice were attacking the albatross again. Moreover, the rate at which birds were being killed or injured suggested that the 2016–2017 outbreak might be much greater than during the previous year. This time, however, United States Fish & Wildlife Service (USFWS) staff had a plan and were prepared to address the situation. Research had suggested that $AGRID_3$

Fig. 1 Introduced house mouse attacking adult Laysan albatross as it incubates. As captured by a Reconyx trail camera.

In: C.R. Veitch, M.N. Clout, A.R. Martin, J.C. Russell and C.J. West (eds.) (2019). Island invasives: scaling up to meet the challenge, pp. 21–25. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

(Bell Laboratories, Madison, WI), a cholecalciferol rodenticide, might provide an effective tool for reducing the number of mice in areas where they were attacking albatross, thereby reducing the impacts to the nesting birds. A plan was developed for applying the rodenticide in affected areas and also for measuring the effects of the treatments on both mice and nesting albatross.

In this paper we describe the mouse predation on albatross that occurred on Sand Island during the 2016–2017 breeding season and the actions taken to abate the threat they imposed on the albatross population there: specifically, a broadcast application of $AGRID_3$ in the areas in which we observed mouse predation on albatrosses. We also describe the monitoring that was undertaken to measure both the direct effects of the rodenticide on the mouse population and the indirect effects that this treatment had on reducing albatross death, injury, and nest abandonment.

MATERIALS AND METHODS

Study area

MANWR is located at the north-west end of the Hawaiian Islands archipelago, 1,930 km from Honolulu, Hawaii at 28.208° N; -177.379° W. One of the oldest atoll formations in the world, MANWR consists of three islands within an 8 km diameter fringing reef. MANWR is classified as a tropical wet/dry savannah with an average annual rainfall of 1,104 mm (43.5 in). MANWR has had a relatively continuous human presence since 1904 when a station was built to support the construction of a trans-Pacific telegraph cable. From 1941 until 1997, Midway Atoll was used by the United States Military during which time both black rats and house mice were introduced. As a consequence, the atoll's ecosystems are highly altered. In 2015 there were 190 species of plants observed, 24 (13%) native and 166 (87%) non-native (Starr & Starr, 2015). The largest, and only, mouse infested island is Sand at 460 ha. MANWR currently supports a resident human community of 50 people along with an operational runway, Henderson Airfield. In 1988 the natural habitats of Midway Atoll began to be managed as part of the National Wildlife Refuge system. Its conservation importance is reflected in its designation as a UNESCO World Heritage Site and its inclusion within the Papahānaumokuākea Marine National Monument.

Baiting methods

During 2016–2017, $AGRID_3$ (Bell Laboratories, Madison, WI), a cholecalciferol rodenticide, was hand-broadcast in all affected areas to reduce mouse populations more effectively and with less disturbance to other wildlife species compared to trapping. $AGRID_3$ pellets contain 0.075% cholecalciferol (non-anticoagulant), which acts by disrupting calcium (Ca) homeostasis through increasing Ca absorption from the small intestine, mobilisation of Ca from the bones into the blood stream, and decreasing Ca excretion by the kidneys (Marshall, 1984). Cholecalciferol has been proven to be toxic and effective at controlling rodents, yet relatively safe to non-target species when used according to label specifications. Due to cholecalciferol's unique mode of action, target specificity, no taste aversion, and delayed toxic effect, it has been successfully used in commensal and agriculture field rodent control situations (Hix, et al., 2012). These attributes make it ideal for use as an interim control measure in the event that eradication is subsequently preferred and approved. The registered use of $AGRID_3$ in the United States has only been for agriculture purposes in the past. The USFWS collaborated with Bell Laboratories, Inc. to develop a supplemental label to be attached to $AGRID_3$ Pelleted Bait (EPA REG. NO. 12455-117-3240). This supplemental label specifically for use by USFWS to control house mice on MANWR was approved by the Environmental Protection Agency for use in a wildland setting.

We hand-broadcast $AGRID_3$ pelleted bait along a 5 m grid (one application within each 25 m^2 square grid cell) over every mouse attack area on Sand Island, as well as a 10 m buffer zone on the periphery of the area, on December 17–18, 2016. Previous experimental bait uptake trials using the protocol described in Pott, et al., (2015), in which we applied placebo bait at 40 kg/ha, marked pellets, and measured pellets taken over a four-day period, led to the selection of 20 kg/ha as an effective application rate under average conditions and 35 kg/ha when mouse density was very high. Following bait application, we surveyed treatment areas to document any sick or injured non-target species or instances of non-target species foraging on bait pellets. We repeated the application at the same rate of 20 kg/ha on 20 January 2017. Over the course of the season from 17 December 2016 to 20 January 2017 we applied 721 kg of $AGRID_3$ to the treatment areas. Areas receiving only a single application included the control plot and impact areas identified after the December application such as Plots 4 and 5. Each application took approximately 440 person-hours to complete.

Non-targets

In order to reduce house mouse predation on incubating albatrosses while minimising the effects (mortality and disturbance) to non-target species, including Laysan ducks and migratory shorebirds, managers treated albatross attack areas where dead adults or abandoned nests were found on Sand Island, MANWR, with $AGRID_3$. $AGRID_3$ was chosen specifically because of its minimal potential effects on non-target species, specifically endangered Laysan ducks (*Anas laysanensis*; listed under the United States Endangered Species Act of 1973) and shorebirds which are protected under the Migratory Bird Treaty Act, particularly bristle-thighed curlews (*Numenius tahitiensis*), Pacific golden plovers (*Pluvialis fulva*), and ruddy turnstones (*Arenaria interpres*). These species were present in large numbers on Sand Island, MANWR, during the mouse attacks and are known to have ingested rodenticide pellets or insects that have consumed bait at other sites where rodent eradication has been implemented. Eason, et al. (2000) documented that mallard ducks fed cholecalciferol at a rate of 2,000 milligrams/kilogram were not affected and concluded that ducks would have to consume 2,000 g (4.4 lbs) of bait with this concentration to receive a lethal dose. Smaller Laysan ducks may consume some bait; however, it is unlikely the ducks would consume enough to cause injury and would need to ingest more than twice their body weight in pellets to experience lethal effects.

Study design and monitoring methods

Starting in December 2016, when most albatrosses had laid their eggs, observers trained to detect mouse-injured albatrosses again searched for, documented, and mapped birds showing signs of mouse attack as well as areas that had an unusually high occurrence of abandoned eggs in nest cups across Sand Island. To avoid double counting, they marked dead adult albatrosses. Nests belonging to injured birds (typically bite wounds, sometimes resulting in severe infection) and abandoned eggs were also marked every three days in the intensive monitoring area (Plot 1). Once the majority of mouse attack areas had been identified, three baiting plots (Plots 1 [16,493 m^2], 2 [15,119 m^2], and 3 [11,740 m^2]) and a control [6,031 m^2] that was not treated with rodenticide were established and monitored for changes in mouse abundance in all plots prior to rodenticide applications on 17 December 2016 and for two weeks afterwards. Two additional baiting plots (Plots 4 [1,900 m^2] and 5 [4,725 m^2]) were added later and monitored for dead adults and abandoned eggs one day before and once at six days and once at 10 days after a second bait application that began on 18 January 2017. The plots were all of different sizes because we chose entire discrete areas in which dead albatrosses and abandoned nests were found to label as attack areas. The control area was smaller than the treatment plots because our priority was to implement a management action as quickly as possible in as much of the colony as possible. General surveillance for signs of mouse attacks continued after hatching in early February and throughout the rest of the chick rearing period.

All nests in Plot 1 were monitored to determine reproductive success, defined as number of nests with an incubating adult present at the beginning of February divided by the total number of nests with eggs present at the start of the study. The reproductive success in Plot 1 was compared to data from plots unaffected by mouse predation that were part of a long-term albatross demography project being conducted at MANWR for the same time interval.

We measured mouse relative abundance in all five plots and the control area two days before rodenticide treatment, one day a week later and one day two weeks after application. We used six multi-catch mouse traps (Trapper 24/7 Bell Laboratories) per treatment area, baited with peanut butter, and summed the number of mice captured over one night for each plot. The traps were centred within the plot ca.10 m from each other. To detect any change in number of mice at each plot, we conducted a one-tailed, paired t-test comparing the mean number of captures prior to bait application with the number of captures two weeks post-treatment ($\alpha = 0.05$). In addition, for Plots 1, 2, 3 and the control area we walked a 150 m transect and counted all mice seen within 2.5 m of the path on either side between 7:30 and 10:00 p.m. the night immediately before the bait application and then one night one week after broadcast and one night two weeks after the broadcast.

We used weather data measured daily at Henderson Airfield weather station located on Sand Island and available from the U.S. National Climate Data Center, <(https://www7.ncdc.noaa.gov/CDO/cdopoemain.cmd?datasetabbv=DS3505&countryabbv=&georegionabbv=&resolution=40>) to evaluate fluctuations in mouse relative abundance over time in the context of rainfall and aid in our interpretation of results.

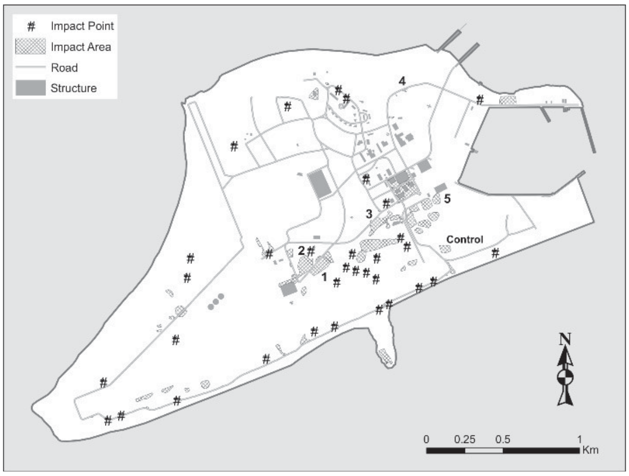

Fig. 2 Areas in which mouse attacks (dead adults, wounded adults, abandoned eggs) were detected in the 2016–2017 albatross breeding season.

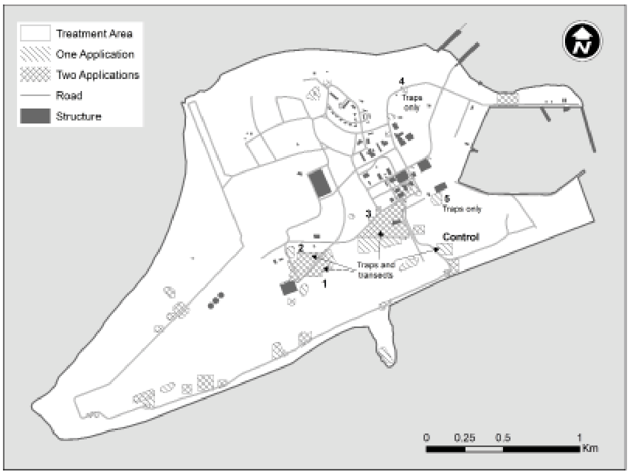

Fig. 3 Areas treated with AGRID$_3$ at a rate of 20 kg/ha December 2016 through January 2017.

RESULTS

Over the course of the 2015–2016 breeding season, mice killed at least 42 adult albatross, wounded an additional 480 birds, and resulted in 70 abandoned nests in three distinct areas, totalling 1.65 ha of Sand Island. During the breeding season of 2016–17 mouse predation was first observed on 4 December, 2016. Numbers of injured and dead adult albatross and abandoned nests increased dramatically in comparison with the previous breeding season. The number of affected areas in the colony increased from three to 50 and the total affected area increased from 1.65 ha to 11 ha (Fig. 2). Albatrosses nest on all of the 460 ha of Sand Island except where they are excluded by active runway paving or structures, so the area affected is still a relatively small proportion of all the albatrosses at Midway. All areas where albatross mortality was detected in 2015–2016 also had mouse predation in 2016–2017. By mid-February there were 242 dead adults, 1218 injured birds, and 994 abandoned nests. This represented a 7-fold increase in mortality, more than double the rate of injury and a more than 10-fold rate of nest abandonment compared to the previous year. The majority of birds found injured and dead were Laysan albatrosses; few black-footed albatrosses were affected. Six carcasses recovered fresh from the area were sent to the USGS Wildlife Health Laboratory in Honolulu in January 2016. Analysis of the specimens revealed that the birds were in excellent body condition with no cause of death evident other than the large wounds on their necks, backs or flanks. Study of the wound sites confirmed the rodent bites occurred before death.

There were no confirmed instances of mouse predation after February 6, 2017, about the time that most eggs started hatching. Most identified mouse attack areas were baited twice before predation stopped in February (Fig. 3). There were no observations of any non-target organism such as shorebirds or Laysan ducks interacting with bait pellets in the field or being found sick or dead in the baited areas.

The number of newly deceased adults and abandoned nests diminished after both bait applications in Plot 1 (Fig. 4) where we were able to conduct more intensive mortality and nest abandonment monitoring every three days. In contrast, during December, the number of abandoned eggs more than doubled in the control area from 10 to 23 but no dead adults were recorded in that area. In January, Plot 4 showed a decrease in the number of abandoned nests after the AGRID$_3$ application but Plot 5 continued to have relatively steady counts of newly dead adults and abandoned nests (Fig. 5). Reproductive success (number of eggs in early February / number of eggs in mid-December)

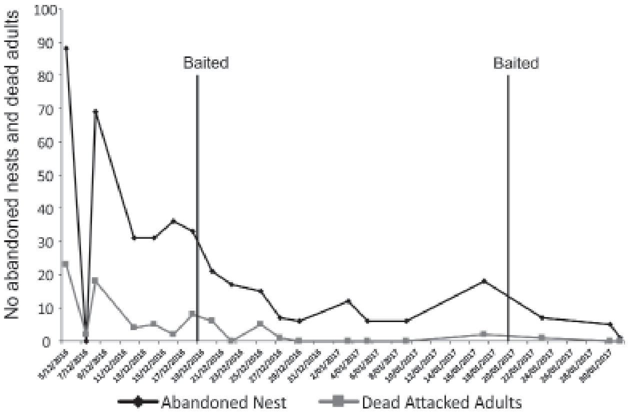

Fig. 4 Absolute counts of new detections of abandoned eggs and dead adults surveyed approximately every three days in Plot 1 throughout the incubation period of breeding Laysan albatrosses at Midway.

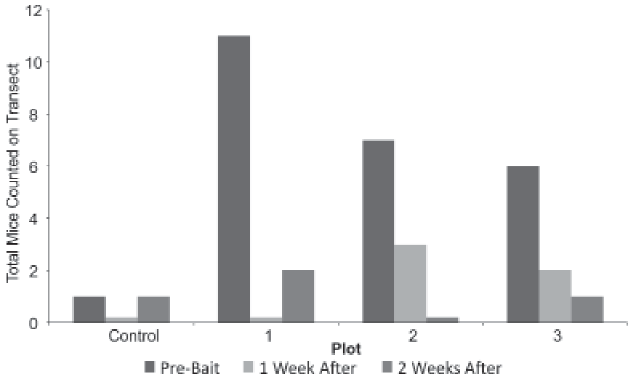

Fig. 7 Total mice counted at night on a 150 m transect (2.5 m to each side) prior to and one and two weeks after application of cholecalciferol bait in Plots 1–3 and a control site on Sand Island during December 2016.

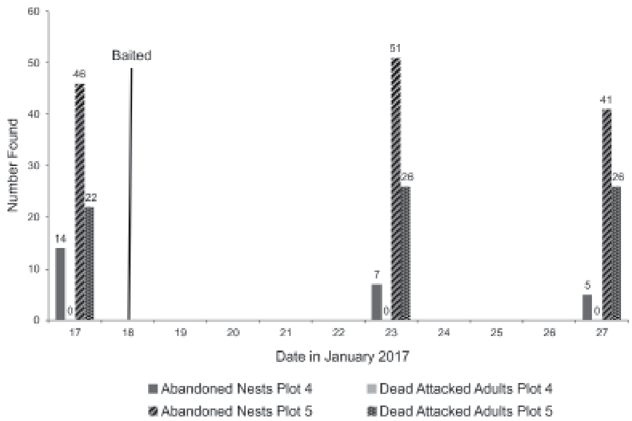

Fig. 5 Count of new detections of abandoned eggs and dead adults in Plots 4 and 5 immediately before and one week and two weeks after baiting.

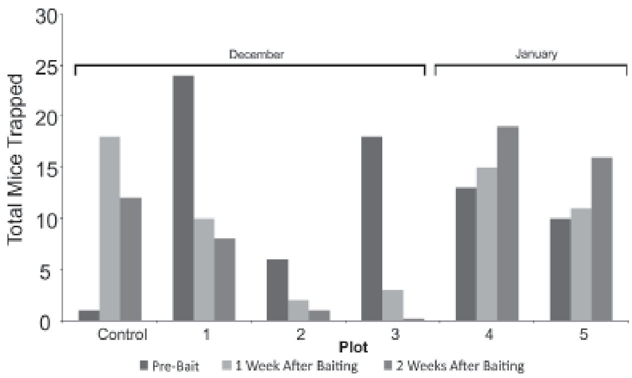

Fig. 6 Number of mice trapped in 6 multi-catch traps per plot, one day before and one and two weeks subsequent to applications of cholecalciferol rodent bait in Plots 1–5, and a control site at Sand Island during December 2016 and January 2017. Only 1 application was done in areas 4 and 5.

in Plot 1 was six percent lower than in the unaffected long-term demography plots.

After the December rodenticide application, the number of mice trapped in Plots 1, 2, and 3 dropped (Fig. 6) (Plot 1 $t(5) = 2.46$ $P = 0.03$; Plot 2 $t(5) = 0.8$ $P = 0.23$; Plot 3 $t(5) = 2.18$ $P = 0.04$). Over the same time period the control site showed an increase in mice trapped ($t(5) = -2.63$ $P = 0.02$). Trapping in Plots 4 and 5, done a month later in January, showed a different pattern with mouse numbers increasing after treatment (Plot 4 $t(5) = -0.99$ $P = 0.18$; Plot 5 $t(5) = -1.66$ $P = 0.08$). Mouse detections on the 150 m transect in Plots 1, 2, and 3 showed a decline after the application of $AGRID_3$ while detections remained much the same in the control plot (Fig. 7).

DISCUSSION

The exposure of a non-negligible proportion of the world's Laysan and black-footed albatrosses to a threat of adult mortality stimulated the management team at MANWR to seek short-term and long-term solutions. The application of a pelleted cholecalciferol rodenticide, $AGRID_3$, in a wildland setting at MANWR, where many non-target species are present, shows promise as a management tool to limit house mouse predation on breeding seabirds without causing harm to the non-target shorebird and duck species that inhabit Sand Island. $AGRID_3$ measurably reduced mouse predation on nesting albatross in the areas where injured and dead albatrosses and abandoned nests were being detected.

While this study was limited in scope and sample size due to the prioritisation of rodent management for the purposes of protecting nesting albatrosses, the larger plots studied during the December application of rodenticide showed decreases in the attacks by mice on albatross as well as some reduction in mouse abundance. The results from the January trial were less promising, showing an increase in mouse density and ambiguous effects on albatross mortality and nest abandonment counts.

There were two differences between the December and January trials that might explain the contrasting outcomes. First, the plots baited in December were much larger in area than the plots baited in January. In a food-limited environment, mice may have been attracted by the bait into the smaller plots elevating the mouse density thus offsetting mortality and mouse population reduction. In an experimental application of cholecalciferol over a much larger area of 100 ha in New Zealand Hix, et al. (2012) observed a 100% reduction of mouse numbers. Second, rainfall increased dramatically over the two months of the study. The increase in rain between December and January might have increased the amount of natural rodent foods within the study area while also leading to higher rates of pellet degradation due to the moister conditions, thus reducing bait availability. There was no control plot established in the January trials so changes in mouse behaviour or abundance cannot be evaluated but Plot 1 continued to show a decrease in mouse attacks throughout the January trial period leading to the possible conclusion that the results in Plots 4 and 5 were due to the smaller plot size. During future efforts to control rodent populations in targeted areas using a broadcast of rodenticide, control areas of at least 1.2 ha should be considered to ensure sufficient coverage to compensate for edge effects.

The decision to apply $AGRID_3$ prior to the albatross breeding season in any particular year may be informed by the likelihood that conditions will trigger mouse predation. Hypotheses about the conditions on Sand Island that may have triggered the emergence of house mouse attacks include population fluctuations of mice and a shift in mouse behaviour due to habitat changes and food availability. Golden crownbeard, *Verbesina encelioides,* an introduced sunflower-relative, was once dominant across the island with coverage now reduced to less than one percent due to control measures ongoing since 2011. We have no evidence that *Verbesina* is consumed by mice, and it is considered a poisonous plant to ungulates (Keeler, et al., 1992) and is allelopathic, thus inhibiting all other vegetation (Inderjit, et al., 2000). *Verbesina* distribution and density was much reduced several years before mice were documented killing albatrosses at Midway. Changes in seasonality of rainfall patterns observed during the 2015–16 and 2016–17 El Niño event may have shifted the timing of normal population fluctuations in the mouse population of Sand Island, in which drying conditions reduce forage and subsequently cause mass-starvation. In 2015–16 and 2016–17 this crash occurred just as albatrosses began the vulnerable incubation period when the adult birds are reluctant to leave their eggs. Rodent populations are well known to fluctuate with rainfall (Jaksic, et al., 1997) and climate change may increase the frequency of El Niño–Southern Oscillation events (Timmermann, et al., 1999), exacerbating the risk to albatrosses in the future. The question of whether there was cultural transmission of albatross predation behaviour in the mice at Sand Island remains open. During 2016–17 the behaviour arose almost simultaneously over much of the island so it seems unlikely.

Preparations for a proposed mouse eradication attempt at Sand Island, MANWR, are underway and the proposed toxicant is brodifacoum. $AGRID_3$, being a cholecalciferol-based rodenticide may be advantageous for control operations prior to a possible eradication to reduce the chance of mice developing aversion or resistance to the type of bait products and toxicants that might be used in an actual eradication operation.

ACKNOWLEDGEMENTS

We are grateful to the managers, staff, and volunteers of Papahānaumokuākea Marine National Monument and Midway Atoll National Wildlife Refuge including Matt Brown, Robert Peyton, Dan Clark, Carmen Antaky, Nasser Hasan, Taylor Smith, Mike Marxen, Katrina Scheiner, Stephanie Kolar, Ann Humphrey, David Dow, Kristina McOmber, Wieteke Holthuijzen, Preecha Songserm, Surat, Surasak Fakkaew, Chatpong Upara, Ek Anan in Uthen, Keely Hassett, Kiah Walker, Aisha Rickli-Rahman, Eric Baker, Beth Wolff, Michelle Smith, Naira DeGarcia, and Victoria Taylor for providing support and assistance at every step. Thanks to Craig Riekena and Amy Breunig at Bell Labs for generous donation of supplies and equipment to allow us to respond on very short notice, USDA-APHIS Wildlife Services for excellent advice, The National Fish and Wildlife Foundation (NFWF) for generous support, US Environmental Protection Agency for rigorous and helpful counsel and Thierry Work of the USGS National Wildlife Health Laboratory for quick diagnoses. The careful reading and fine suggestions from two anonymous reviewers were much appreciated.

REFERENCES

Angel, A., Wanless, R.M. and Cooper, J. (2009). 'Review of impacts of the introduced house mouse on islands in the Southern Ocean: Are mice equivalent to rats?' *Biological Invasions* 11: 1743–1754.

Cuthbert, R. and Hilton, G. (2004). 'Introduced house mice *Mus musculus*: A significant predator of threatened and endemic birds on Gough Island, South Atlantic Ocean?' *Biological Conservation* 117: 483–489.

Eason, C.T., Wickstrom, M., Henderson, R., Milne, L. and Arthur, D. (2000). 'Non-target and secondary poisoning risks associated with cholecalciferol'. *New Zealand Plant Protection* 53: 299–304.

Hix, S., Aylett, P. Shapiro, L., MacMorran, D., Eason, C.T. Sam, S., Ross, J.G., Miller, A., Ogilvie, S.C. (2012). 'Low-dose cholecalciferol bait for possum and rodent control.' *New Zealand Journal of Agricultural Research* 55: 207–215.

Inderjit, Asakawa, C. and Dakshini K.M.M. (2000). 'Allelopathic potential of *Verbesina encelioides* root leachate in soil.' *Canadian Journal of Botany* 77(10): 1419–1424.

Jaksic, F.M., Silva, S.I., Meserve, P.L. and Gutierrez, J.R. (1997). 'A long-term study of vertebrate predator responses to an El Niño (ENSO) disturbance in western South America'. *Oikos* 78: 341–354.

Jones, M.G.W. and Ryan, P.G. (2009). 'Evidence of mouse attacks on albatross chicks on sub-Antarctic Marion Island'. *Antarctic Science* 22: 39–42.

Keeler, R.F., Baker, D.C., Panter, K.E. 1992. 'Concentration of galegine in *Verbesina encelioides* and *Galega oficinalis* and the toxic and pathologic effects induced by the plants.' *Journal of Environmental Pathology, Toxicology and Oncology* 11(2): 11–17

Marshall, E.F. (1984). 'Cholecalciferol: A Unique Toxicant for Rodent Control'. In: D.O. Clark (ed.) *Proceedings of the Eleventh Vertebrate Pest Conference*, pp. 95–98. Davis, CA: University of California.

Pott, M., Wegmann A.S. Griffiths, R., Samaniego-Herrera, A., Cuthbert, R., Brooke, M. de L., Pitt, W.C., Berentsen, A.R., Holmes, N.D., Howald, G.R., Ramos-Rendón, K. and Russell, J.C. (2015). 'Improving the odds: Assessing bait availability before rodent eradications to aid in selecting bait application rates.' *Biological Conservation* 185: DOI: 10.1016/j.biocon.2014.09.049.

Starr, F. and Starr, K. 2015. *Botanical Survey of Midway Atoll*. Unpublished Report. Prepared for United States Fish and Wildlife Service. Midway Atoll National Wildlife Refuge.

Timmermann, A., Oberhuber, J., Bacher, A., Esch, M., Latif, M. and Roeckner, E. (1999). 'Increased El Niño frequency in a climate model forced by future greenhouse warming.' *Nature* 398: 694–697.