Canna seabird recovery project: 10 years on

R. Luxmoore[1], R. Swann[2] and E. Bell[3]

[1]National Trust for Scotland, Hermiston Quay, 5 Cultins Road, Edinburgh, EH11 4DF, Scotland. <rluxmoore@nts.org.uk>. [2]Highland Ringing Group, 14 St Vincent Road, Tain, Ross-shire, IV19 9JR, Scotland. [3]Wildlife Management International Ltd, P.O. Box 607, Blenheim, Marlborough 7240, New Zealand.

Abstract Rats were eradicated in 2005–2006 from the islands of Canna and Sanday, Scotland (total area 1,320 ha). Poison bait was laid from December 2005 onwards and the last rat was killed in February 2006. An intensive period of monitoring over the next two years confirmed that no rats remained on the islands. Seabirds have been monitored on Canna for nearly 50 years and some species have shown good evidence of recovery since the eradication. Other species have not recovered and this may have been due to mortality caused by food shortages or storm events which have been impacting seabirds in the region. These regional changes in pressures affecting the seabird populations make the interpretation of the impacts of the rat eradication programme much more difficult. Atlantic puffins, formerly confined to offshore stacks, have recolonised sites on the mainland of Canna and a count of over 2,000 was recorded in 2016. Manx shearwaters, which had ceased nesting in the monitored colony have made a slow recovery to one or two pairs in 2016. Productivity has also increased from a low of 0.2 chicks per nest in the 1990s to 0.74 in 2017. European shags nesting in boulder colonies were most susceptible to rat predation. One such colony has recovered from 45 nests in 2005 to 75 in 2016 and productivity increased from less than 0.7 chicks per nest to an average of 1.6 following eradication. Populations of shags nesting in cliff locations have shown no recovery or have declined. Mew gulls, which nest along the shoreline, have increased from five to over 30 pairs. Other seabirds, such as common guillemots and black-legged kittiwakes, have shown no clear trends and are probably affected by other factors. Rabbit populations have increased on both islands, reaching an estimated 15,500 animals in 2013 that were causing considerable damage through grazing, erosion, and disturbance of archaeological remains. It is unclear whether the increase in rabbit numbers can be attributed to rat eradication. An intensive control programme has brought the rabbit population under control. While some seabirds have responded positively to the rat eradication, the response of some has been slow and others have not responded, probably as a result of regional pressures on their survival. It is important that monitoring of both seabirds and rabbits continues to track the success of this important seabird colony.

Keywords: contingency plans, invasive species, monitoring, quarantine, rabbits, rat eradication

INTRODUCTION

The islands of Canna and Sanday, which are connected at low tide (total area 1,320 ha) are in the Inner Hebrides, off western Scotland. They are owned and managed by the National Trust for Scotland and are designated as a Special Protection Area because of their internationally important seabird colony. Seabird populations and breeding success have been monitored on the islands since 1969 by the Highland Ringing Group, making this one of the best monitored sites in Scotland. The main species present are common guillemot (*Uria aalge*), razorbill (*Alca torda*), black-legged kittiwake (*Rissa tridactyla*), northern fulmar (*Fulmaris glacialis*), European shag (*Phalacrocorax aristotelis*) and Atlantic puffin (*Fratercula arctica*). Manx shearwater (*Puffinus puffinus*) used to be present in large numbers (1,500 apparently occupied burrows) but suffered very poor breeding success and, by 2000, had been virtually wiped out (Swann, 2002) Other seabirds were also recorded as declining. Predation by a large population of brown rats (*Rattus norvegicus*) was identified as the likely cause of this decline, from three types of evidence: 1. Direct observation of increasing numbers of rats foraging in the seabird colonies and of stashes of predated egg shells and carcases; 2. Declining numbers and decreasing breeding success of vulnerable species; and 3. Changing nesting behaviour of breeding seabirds moving to less accessible sites. After favourable feasibility studies (Bell & Bell, 2004), it was decided to eradicate the rats using poison bait, and funding was obtained from the EU LIFE fund, Scottish Natural Heritage and the National Trust for Scotland. The programme objective was to halt declines in breeding seabird populations on Canna and Sanday and to facilitate their recovery and long-term protection. It was carried out under contract by Wildlife Management International, starting in late 2005. By February 2006 the last rat sign was detected and, after a two-year period of intensive monitoring, the island was declared rat-free in 2008 (see Bell, et al., 2011).

Canna and Sanday are inhabited by a population of 15–20 people and are farmed with a mixture of sheep and cattle. They are served by a ferry service five days a week. The harbour and all houses are in the eastern portion of the islands, where there are a number of fenced pastures and some planted woodlands. There are high cliffs around much of the coast, particularly to the north and west, and the higher ground is mostly covered in wet heath. There is a population of distinctive, large (presumed introduced) field mice (*Apodemus sylvaticus*) that were not removed by the rat poisoning programme and a substantial (introduced) population of rabbits (*Oryctolagus cuniculus*). There is a small number of (introduced) hedgehogs (*Erinaceus europaeus*), and regular sightings of European otters (*Lutra lutra*), but no other ground predators. Two pairs of white-tailed eagles (*Haliaeetus albicilla*), one pair of golden eagles (*Aquila chrysaetos*), up to two pairs of peregrine falcons (*Falco peregrinus*), about 15 pairs of common buzzards (*Buteo buteo*) and ravens (*Corvus corax*) regularly breed on the island and there are small numbers of great skuas (*Catharacta skua*) and great black-backed gulls (*Larus marinus*). Predation by eagles, and possibly locally by otters, may impact populations of northern fulmar, while ravens may impact shags, particularly on the cliff-nesting colonies (Swann, 2008; Swann, et al., in press), but none of these predators exerts substantial pressure on other seabird populations.

Following the eradication programme, biosecurity measures were put in place, consisting of continuous monitoring (wax blocks and kill traps), quarantine and contingency plans. No incursions of rats have been detected.

The main post-eradication monitoring has been a continuation of the long-running seabird programme which can be used to detect any changes following the eradication of rats. A rapid expansion in the rabbit population was

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. 576–579. Occasional Paper SSC no. 62. Gland, Switzerland: IUCN.

noted in 2011–2013 which caused locally severe grazing and considerable erosion through collapsed burrows. This necessitated the introduction of control measures consisting of a rapid reduction cull in January–March 2014, followed by continuous lower level culling thereafter. There have been surveys of vegetation condition (SNH, 2014), grassland fungi (Murfitt & Macdonald, 2012), invertebrates (Rotheray & Lyszkowski, 2012) and lichens (Acton, 2011). Any changes in the vegetation are thought to be due to rabbit grazing or livestock management, rather than directly related to the removal of rats.

This paper reviews the changes in seabird population size and breeding success reported in Swann, et al. (in press) and discusses fluctuations in rabbit populations and the control measures employed.

MATERIAL AND METHODS

All seabird population and productivity estimates follow the methodology of Walsh, et al. (1995) and are described in Swann, et al. (in press). Seabird population estimates for the years 1995 to 2017, derived from Swann (2008) and Swann, et al. (in press), were analysed. For northern fulmar, European shag, black-legged kittiwake, mew gull, herring gull, lesser black-backed gull and greater black-backed gull, the population figures represent the number of apparently occupied territories or apparently occupied nest sites throughout the two islands. For common guillemots and razorbills, they are the number of nest sites at a small number of accessible monitoring plots. Nest sites were recognised by the presence of an egg, chick or, in the case of razorbill, a shell or dense mass of droppings. The data were divided into the 11 years prior to the eradication (1995–2005) and the 12 years following (2006–2017). Population trends were determined by fitting an exponential line to each set of data. The exponents shown on the graphs represent r in the equation $N = e^{rt}$, where N is the population size (pairs) and t is the time in years.

Productivity estimates represent large young/chicks per occupied nest within all the monitoring plots for northern fulmar and black-legged kittiwake. For great black-backed gulls and herring gulls, they represent large chicks per apparently occupied territory. For European shags, the breeding success (chicks per occupied nest) is separated into plots within the boulder colonies and plots on cliff sites. Productivity of Manx shearwaters was calculated as the number of large chicks produced per occupied burrow located.

In June 2013 and 2014 (the latter following a rabbit reduction programme in January–March 2014) rabbit populations were estimated by walking over the entire island using the Modified McLean scale, an 8-point scale based on the observation of rabbits and pellets (NPCA, 2012). Densities were estimated within different topographic or vegetation units and the area of each unit was calculated using GIS. The approximate population of rabbits was then calculated by multiplying the area of each unit by the densities corresponding with the McLean scale. Rabbit culls were recorded by the trappers on a weekly basis in different zones.

RESULTS

Seabird population size

Seabird population trends are shown in Fig. 1. Numbers of breeding pairs of almost all species, except the black-legged kittiwake were declining prior to 2005 but after 2006, three gull species were stable or slowly increasing and populations of all other species, except the northern fulmar, showed a reduced rate of decline. It should be noted that the correlation coefficients (R^2) were low, showing significant declines for most species prior to eradication but significant increases only for mew gull and lesser black-backed gull after eradication.

In the case of Manx shearwater, the population had already fallen to very low levels prior to 1995 from a high

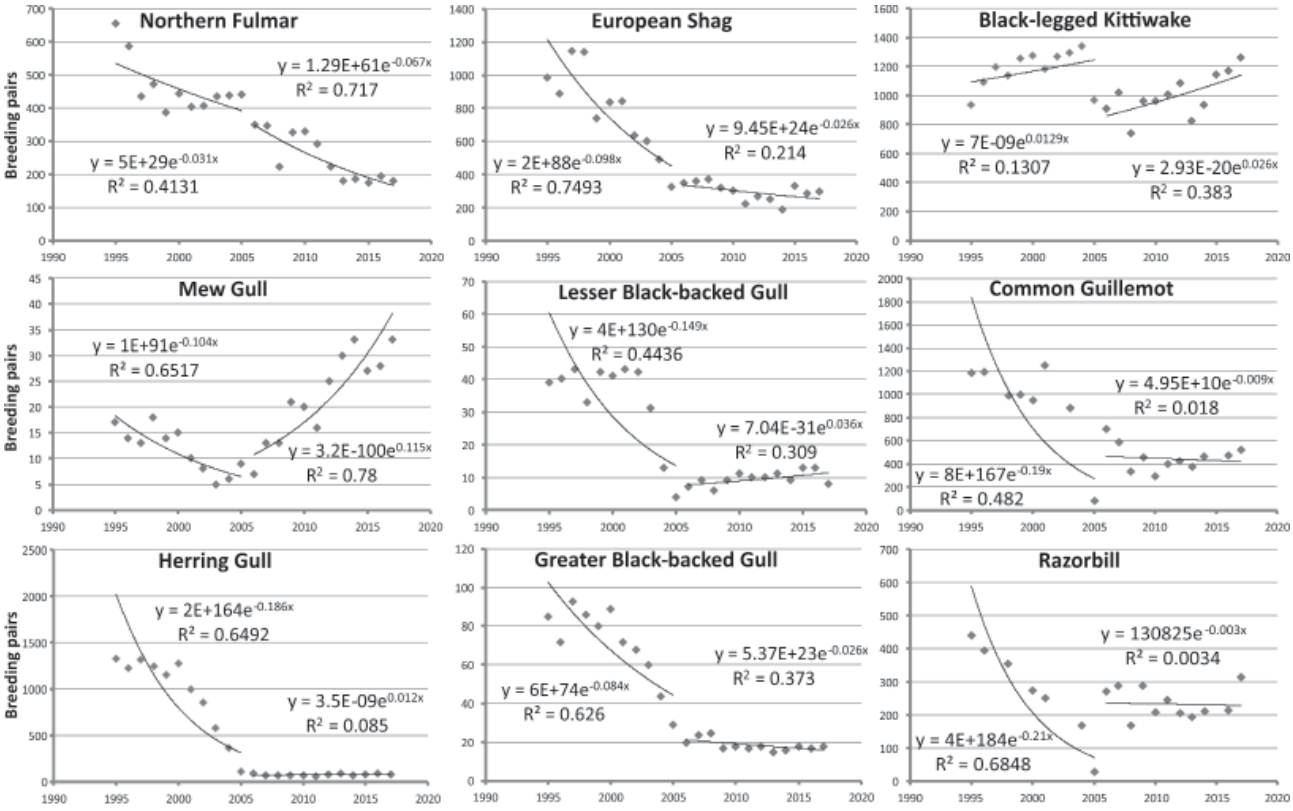

Fig. 1 Population trends in the numbers of breeding pairs of nine species of seabird on Canna during the period 1995–2017. Data were split into pre-eradication (1995–2005) and post-eradication (2006–2017) and exponential graphs fitted to each.

of 1,500 pairs in the mid-1970s. By 2000, no nests could be located in the main colony, along Tarbert Road (see Fig. 2). Following the rat eradication in 2006 the first nesting shearwater was detected again in the Tarbert Road colony, but by 2017 this had grown to only two nests. A further four nests were located at accessible locations in the west of the island and all of these nests were monitored for breeding success. Based on calling behaviour at night, it was estimated that there were more nests, possibly 10–20 pairs, in inaccessible locations (M. Carty, pers. comm.)

Mew gulls (*Larus canus*) nest along the shore on Canna. Numbers have increased from nine pairs at the time of the eradication to around 30 pairs in recent years. Other large gulls, especially herring gulls (*Larus argentatus*), declined rapidly in the 1990s and early 2000s similar to colonies elsewhere in Scotland. Since 2006, populations on Canna have remained low.

The overall number of breeding European shags had dropped to about 300 nests by 2005. Different sub-colonies have performed differently, with those nesting under boulders declining most rapidly (Swann, 2005). One boulder colony, Lamasgor, has subsequently shown an increase from 45 nests in 2005 to 75 in 2016. Other sub-colonies, particularly those on cliffs, however, have remained stable, or declined, so that overall the population has not increased. Nevertheless, the overall rate of decline of all of the nests on the island has slowed (Fig. 1).

Atlantic puffin breeding populations are difficult to monitor, especially because, prior to 2005, they were virtually confined to two inaccessible stacks. After 2006 they began to spread to sites along the north coast of Canna at Guegasgor (see Fig. 2). Where more accurate census methods are not practical, Walsh, et al. (1995) recommend counting puffins rafting on the sea near the colony. A count of rafting puffins in 1995 gave 1190 individuals while, in 2016, 2050 were counted. Though not conclusive, this is consistent with an increase in breeding numbers as well as the recorded expansion of the puffin colony to colonise previously unoccupied sites on the mainland of Canna.

Seabird breeding success

Between 1999 and 2004, breeding success of European shags in monitored nests in boulder colonies had dropped to <0.7 young per nest. Since the eradication breeding success has averaged 1.6 young per nest. In contrast, breeding success at colonies nesting on cliff ledges averaged 0.97 per nest over the years 2006–2017 (Table 1).

Manx shearwater breeding productivity has greatly improved. In the 1980s it averaged 0.6 young/nest, dropping to <0.2 young/nest in the mid-1990s. Since 2009. out of a total of 19 burrows that were known to contain an egg, 14 successfully produced a chick, an average of 0.74 young/nest.

Rabbit population

The rabbit population on Canna has routinely fluctuated in response to disease and weather conditions, but numbers had not been formally monitored. By 2013, rabbit numbers were causing serious damage to agricultural interests and were damaging archaeological remains. A rapid assessment of rabbit population density gave an overall population estimate of 15,500 (Fig. 2). As a consequence, a rabbit population reduction exercise was carried out in January–March 2014, with a total of 8,200 rabbits removed. This brought the population down to an estimated 7,000 by July 2014. Continuous culling of around 5,000 rabbits a year has maintained it at a level where agricultural damage is acceptable.

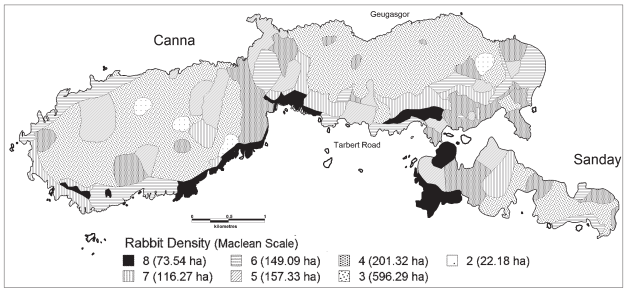

Fig. 2 Estimated rabbit density on Canna in July 2013. Densities relate to the Modified McLean Scale (NPCA, 2012).

DISCUSSION

The response of Canna seabirds to the successful rat eradication in winter 2005/06 was species specific. For some populations, such as the Atlantic puffin, the mew gull and the boulder-nesting colonies of European shag, there have been apparent increases in numbers of breeding pairs. The colony of European shags on Canna is of international importance and formerly numbered 1,800 pairs. Many of them nest under boulders in relatively accessible locations and these birds were found to be particularly susceptible to rat predation, declining most rapidly. Simultaneously, there was a shift whereby a greater proportion of shags started nesting on more exposed cliff locations where they were less susceptible to rat predation but more exposed to avian predation (Swann, 2005). Following the eradication of rats, some boulder colonies have expanded rapidly but the cliff-nesting birds have continued to decline. The net effect has been a continuing decline in the overall shag population but at a reduced rate.

Similarly, although populations of common guillemots and razorbills have continued to decline there has been a slowing in the rate of decline. These two species of auk nest in similar locations to the European shags and were also affected by rat predation. Guillemots were badly affected by a severe period of stormy weather in western Scotland in late summer 2004 (Swann, 2004) which caused heavy mortality of both adults and chicks. Ringing studies showed that adult survival dropped from a long term average of 0.9 to 0.6 between 2004 and 2005. Breeding numbers of guillemots on Canna were very low in 2005 and breeding success remained low until 2008 probably as a result of subsequent food shortages. Breeding success improved in 2009 and the population has started to increase.

Numbers of breeding razorbills showed a sharp jump in 2006, and this was almost certainly due to a reduction

Table 1 Breeding productivity of Manx shearwaters at Tarbert Road colony and European shags in the boulder and cliff colonies on Canna, 2001–2017. "-" = Productivity not monitored.

Year	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Manx shearwater	-	-	-	-	-	-	-	-	0	1	1	0.25	0.5	0.2	0.5	1	0.5
Shag – boulder colonies	0.1	0.26	0.16	0.01	0.7	1.2	1.4	1.5	1.8	-	1.4	-	1	1.5	1.8	2.2	1.3
Shag – cliff colonies	-	-	-	1.4	0.7	0.7	1.0	0.3	0.7	1.5	0.8	1.6	1.0	0.7	1.2	1.0	1.2

in predation by rats, eggs appearing in areas that had been clear of nesting for several years (Swann, 2008). However, the number of occupied breeding sites then remained roughly stable at this level until 2016, and the breeding success remained low, probably as a result of food shortage (Swann, et al., in press). Since occupied breeding sites in this species are identified by the presence of an egg or chick, failure to breed does not necessarily indicate the absence of adults attempting to breed – they may have laid an egg and then left again following predation of the egg. The population increase observed in 2006 may therefore indicate higher early survival of eggs rather than a greater number of adults attending the colony.

The large gulls, especially the lesser black-backed gull and the herring gull, suffered a particularly sharp decline in the period 2000–2005 and have since shown a slight increase. Foster, et al. (2017) have analysed this trend and shown that it is closely correlated with the commercial landings of fish in the nearby port of Mallaig, with the gulls feeding extensively on discards from the fishing industry. Since 2006, numbers have stabilised at a much lower level. It is unclear whether the subsequent slow increase of lesser black-backed gulls had anything to do with the reduction in rat predation.

The number of breeding pairs of other species, such as the northern fulmar, have continued to decline and there has been no reduction in the rate of decline. The fulmars nest largely in cliff locations and would have been less affected by rat predation, although it is possible that predation by eagles may be significant (Swann, 2008).

The black-legged kittiwake population has stayed roughly stable over the whole period, although it too suffered poor breeding success in the period 2005–2008, probably as a result of the food shortage experienced by other seabirds in the region. This species typically nests on near-vertical cliffs and is therefore probably the least susceptible to ground predators such as rats. The causes of any changes in population size or breeding success must therefore be sought elsewhere.

One species that was expected to benefit strongly from the removal of rats was the burrow-nesting Manx shearwater. Although there has been a tiny increase in breeding numbers and a clear improvement in breeding productivity, there are still thought to be fewer than 20 pairs nesting on the island. Shearwaters are long-lived and slow-maturing species, possibly not breeding until eight years of age and so endogenous growth of the surviving, relict population would be expected to be slow (Brooke, et al., 2018). However, Canna lies next to the larger Manx shearwater colony on Rum (estimated to be around 60,000 pairs) and is regularly visited by (presumably non-breeding) birds at night. It is apparent that these have not colonised the former colony on Canna to any great extent. The shearwater colony on Rum is subject to predation by a large population of brown rats. The impact of this predation is unclear and it is not known whether the colony is stable or declining (Lambert, et al., 2015). If predation is high, the pressure for emigration from Rum would be lower than from a colony that was limited by shortage of nest sites. An attempt was made to attract breeding birds to re-colonise Canna by playing recordings of shearwater calls at night in 2006 and 2007. This was discontinued because of a lack of obvious success.

It is possible that the growth in the rabbit population is attributable to the removal of rats as young rabbits would be likely to have suffered predation by rats. However, large fluctuations are a characteristic of rabbit populations and high numbers have been reported in previous years. Thus, while 15,500 may seem a high population for Canna, and it undoubtedly caused damage to agricultural interests, it may not be unprecedented. It has been necessary to control rabbits on Canna for many years prior to the eradication of rats although historically the rabbit populations used to cycle due to outbreaks of myxomatosis. Surprisingly, there has been no evidence of myxomatosis in recent years. Total eradication of rabbits has been deemed unfeasible (Bell, 2012) and so it is inevitable that control of rabbit populations will be necessary for the foreseeable future to prevent the build-up of excessive numbers. Although vacated rabbit burrows can provide nest sites for Manx shearwaters, at high densities there is likely to be competition for burrows and this will reduce sites available for shearwaters. The burrows have also caused severe erosion, including large landslips, in some of the former shearwater colonies (Bell, 2012).

Overall, the removal of rats from Canna has had some very beneficial impacts on some species of seabirds but this effect was masked for other species by some very difficult local conditions in the period 2004–2008, firstly by storm-related mortality and subsequently by regional food shortages. The gulls were also impacted by a lack of fisheries discards following a drop in commercial fisheries. Because these external factors occurred at approximately the same time as the rat eradication programme it may take many years for the full benefits to play out. It is clear that continued detailed monitoring of seabird populations and breeding success is vital in unravelling the complex interactions between local conditions on the breeding colony and regional changes in the marine ecosystem.

REFERENCES

Acton, A. (2011). *Canna and Sanday Lichen Survey*. Unpublished report to the National Trust for Scotland, Edinburgh, Scotland.

Bell, E.A. and Bell, B. (2004). *An Assessment of the Proposal to Eradicate Brown Rats from the Isle of Canna, Scottish Hebrides*. Unpublished report to the National Trust for Scotland, Edinburgh, Scotland.

Bell, E., Boyle, D., Floyd, K., Garner-Richards, P., Swann, B., Luxmoore, R., Patterson, A., and Thomas, R. (2011). 'The ground-based eradication of Norway rats (*Rattus norvegicus*) from the Isle of Canna, Inner Hebrides, Scotland'. In: C.R. Veitch, M.N. Clout and D.R. Towns (eds.) *Island invasives: eradication and management*, pp. 269–274. Occassional Paper SSC no. 42. Gland, Switzerland: IUCN and Auckland, New Zealand: CBB.

Bell, E. (2012). *Rabbits on Canna: Assessment and Advice on the Rabbit Situation on Isle of Canna, Inner Hebrides, Scotland*. Unpublished report to the National Trust for Scotland, Edinburgh, Scotland.

Brooke, M.de L., Bonnaud, E., Dilley, B.J., Flint, E.N., Holmes, N.D., Jones, H.P., Provost, P., Rocamora, G., Ryan, P.G., Surman, C., and Buxton, R.T. (2018). 'Seabird population changes following mammal eradications on islands'. *Animal Conservation* 21(1): 3–12.

Foster, S., Swann, R.L. and Furness, R.W. (2017). 'Can changes in fishery landings explain long-term population trends in gulls?' *Bird Study* 64: 90–97.

Lambert, M., Carlisle, S. and Cain I. (2015). *The Role of Brown Rat (Rattus norvegicus) Predation in Determining Breeding Success of Manx Shearwaters (Puffinus puffinus) on Rum*. Scottish Natural Heritage Commissioned Report No. 697, Inverness, Scotland.

Murfitt, A. and Macdonald, A. (2012). *Grassland Fungi Survey; Isle of Canna*. Unpublished report to the National Trust for Scotland, Edinburgh, Scotland.

NPCA (2012). "Modified Maclean Scale". <http://www.npca.org.nz/index.php/news/84-general/226-rabbit-control-training.html>.

Rotheray, G.E. and Lyszkowski, R. (2012). *The Entomological Significance of Coastal Grassland on Canna and Sanday*. Unpublished report to the National Trust for Scotland, Edinburgh, Scotland.

SNH (2014). *Site Condition Monitoring Note, Canna and Sanday, Cycle 3*. Unpublished report. Inverness, Scotland: Scottish Natural Heritage.

Swann, R.L. (2002). *Canna Seabird Studies 2001*. Joint Nature Conservation Committee Report 327, Peterborough, UK.

Swann, B. (2004). 'Seabird Wreck, North West Scotland late summer 2004'. Seabird Group Newsletter 98: 12–14.

Swann, R.L. (2005) *Canna Seabird Studies 2005*. Joint Nature Conservation Committee Report, No. 474b, Peterborough, UK.

Swann, R.L. (2008). *Canna Seabird Studies 2008*. Joint Nature Conservation Committee Report No. 474e, Peterborough, UK.

Swann, R.L., Aiton, D.G., Call, A., Foster, S., Graham, A., Graham, K. and Young, A. (in press). *Canna Seabird Studies 2017*. Joint Nature Conservation Committee Report. Peterborough, UK.

Walsh, P.M., Halley, D.J., Harris, M.P., del Nevo, A., Sim, I.M.W. and Tasker, M.L. (1995). *Seabird Monitoring Handbook for Britain and Ireland: A Compilation of Methods for Survey and Monitoring of Breeding Seabirds*. Peterborough: JNCC, RSPB, ITE, Seabird Group.