Biol Invasions
DOI 10.1007/s10530-010-9776-x

ORIGINAL PAPER

Bird demographic responses to predator removal programs

Jennifer L. Lavers · Chris Wilcox · C. Josh Donlan

Received: 3 July 2009 / Accepted: 14 May 2010

Abstract Invasive predators pose a significant risk to bird populations worldwide. Humans have a long history of removing predators from ecosystems; current island restoration actions typically focus on the removal of invasive predators, such as non-native rodents, from seabird breeding islands. While not overly abundant, the results of predator removal studies provide valuable information on the demographic response of birds, and can assist conservation practitioners with prioritizing invasive predator removal projects. We review such studies focusing on observed demographic responses of bird populations to predator removal campaigns and whether ecological factors are useful in predicting those responses. From the 800+ predator removal programs indentified, a small fraction ($n = 112$) reported demographic responses of bird populations. Change in productivity was the most commonly reported response, which on average increased by 25.3% (2.5 SE) with predator removal. The best supported model for predicting the change in productivity from predator removal incorporated bird body mass, egg mass, predator type, nest type and an interaction term for body mass and nest type (AIC_c weight $= 0.457$). The predicted percent increase in productivity resulting from hypothetical predator removal ranged from 16.9 to 63.0% (mean = 45.0, 5.6 SE), and was lowest for large, surface nesting birds such as albatrosses. The predicted increase in productivity resulting from predator removal alone was insufficient to reverse the predicted population decline for 30–67% of bird species considered, suggesting that in many cases, removal of predators must be performed in combination with other conservation actions in order to ensure a stable or increasing population.

Keywords Eradication benefits · Island restoration · Invasive predator · Population recovery · Predator control

J. L. Lavers (✉)
University of Tasmania, Hobart, TAS 7001, Australia
e-mail: jllavers@utas.edu.au

C. Wilcox
Wealth from Oceans National Flagship, CSIRO Marine Research, GPO Box 1538, Hobart, TAS 7001, Australia

C. Josh Donlan
Advanced Conservation Strategies, P.O. Box 1201, Midway, UT 84049, USA

C. Josh Donlan
Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY 14853, USA

Introduction

The threats leading to population declines in birds are many and varied, including bycatch in fisheries, habitat destruction, and pollution (Birdlife International 2008). Non-native predators pose a significant risk to

Published online: 05 June 2010

many bird populations, and are currently ranked as the third most significant threat to birds according to the International Union for the Conservation of Nature (Birdlife International 2008). Rats (*Rattus* spp.), feral cats (*Felis catus*), and mustelids are cosmopolitan predators of bird populations, particularly on islands (Atkinson 1989; Jones et al. 2008; Nogales et al. 2004). There is a long history of humans controlling both native and non-native predators to protect birds or simply to increase their numbers for human benefit (e.g., coyote (*Canis latrans*) control programs to increase Bobwhite Quail (*Colinus virginianus*) populations for recreational hunting) (Guthery and Beasom 1977). Studies that follow bird responses to such predator control programs can provide valuable information and guidance with prioritization and planning, since many bird conservation programs today involve the eradication or control of non-native predators at breeding colonies (Aguirre-Muñoz et al. 2008; Harding et al. 2001; Howald et al. 2009).

Conservation prioritization efforts typically target species that are most endangered or areas where restoration efforts appear most effective or feasible (Brooke et al. 2007; Martins et al. 2006). More recently, the return on investment approach has been advocated as a tool to maximize conservation benefits, such as habitat protection or increases in the number of breeding seabirds (Donlan and Heneman 2007; Murdoch et al. 2007; Naidoo et al. 2006). This approach requires the ability to predict both the cost and benefit of conservation interventions. However, while bird responses to non-native predator removal have been studied, the demonstrated benefits of those removal campaigns have not been systematically reviewed (but see Beauchamp et al. 1996; Côté and Sutherland 1997 for a limited review of terrestrial birds). Controlling non-native predators has not lead to population recovery for some bird populations (Beauchamp et al. 1996; Carter et al. 1992), while other populations have dramatically increased in numbers following predator removal (Donlan et al. 2007; Keitt and Tershy 2003; Rayner et al. 2007). Thus, identifying life-history characteristics or other factors that can be used to help predict benefits to bird populations from invasive predator control would provide value to conservation planners and practitioners.

Here we present a literature review on the demographic responses of birds resulting from predator removal programs. We focus on invasive predator removal programs, but also include native predator control programs because of the overall dearth of published studies. The objectives of our analysis were to (1) provide an overall estimate of the known changes in bird productivity as a result of predator removal programs, (2) determine what factors (bird body mass, egg mass, nest type, or predator type) can be used to predict predator removal benefits, (3) assess the demographic contribution of past predator removals to bird population recovery, and (4) explore how much invasive predator removal campaigns are likely to contribute to population recovery for some bird species currently at risk.

Materials and methods

Predator removal and bird productivity

We collated studies reporting on bird demographic responses resulting from the control or removal of predators from the published and grey literature. All studies were included in the overall summary of the benefits of the removal of predators. For statistical analyses, however, we used a subset that included those studies reporting the results of removing a single predator or in a few cases a single predator-type (i.e., two species of invasive rat). We chose to exclude studies involving the removal of more than one predator from statistical analysis since the bird's demographic response could not be attributed to a particular predator. In a few multiple-predator studies, authors identified one predator as being responsible for most or all of the bird mortality, and thus those studies were included in the analysis. Lastly, studies reporting demographic benefits for groups of birds only (e.g., ducks) were excluded since bird body mass (an explanatory variable in our model; details below) could not be determined.

Factors influencing predator removal benefits for birds

Bird productivity estimates pre- and post-predator removal were compared, with the difference between the two values assumed to be the result of predator removal. We used generalized linear models to explore whether bird nest type (i.e., surface, not surface), bird body mass, egg mass, or predator type (rodent, non-rodent) were important factors in determining the observed effect of predation on birds. Due to the small sample size on non-rodent removal studies and the severity of invasive rodent predation, we chose to group predators as rodent or non-rodent (Atkinson 1985; Jones et al. 2008). Because the response variable, productivity, is a proportion, values were logit-transformed (Crawley 2007). Since only four explanatory variables were considered, all possible model combinations were run. The best performing model were selected based on Akaike's Information Criterion (AIC; Burnham and Anderson 2002). We conducted analyses in the statistical program R and SPSS and adopted a α-level of 0.05 (R version 2.7.0, R Foundation for Statistical Computing; SPSS 16 for Mac, SPSS Inc., Chicago).

Predator removals and bird population recovery

Demographic population models were developed for two distinct data sets. The first data set included species with complete demographic data (i.e., breeding success, juvenile survival, and adult survival) and empirical data on the demographic response of removing predators. We estimate the change in the population growth rate (λ) following predator removal. The second data set included bird species with complete demographic data and known predator impacts, but no predator removal program had been initiated. Here, we predict the change in population growth rate from a hypothetical predator removal. In cases where multiple studies yielded contrasting demographic parameter estimates, we used information from the longest-term or most recent studies rather than averaging data across all studies.

For both datasets, we developed a stochastic, stage-structured, population-projection matrix for each bird population. We chose a 20-year time interval because it is most relevant from a management perspective and allowed us to overlook density-dependent processes associated with long-term projections for most species (Morris and Doak 2002). The model consisted of two stage-classes (juveniles and adults), and only females were included (i.e., productivity was multiplied by 0.5 assuming a 1:1 sex ratio). The model was written in Matlab (version 7.5.0, MathWorks Inc.).

We evaluated the effect of predator removal on bird population dynamics in two phases. First, using the stage-based matrix and published population parameters, we obtained a baseline or pre-removal population growth rate. Second, we incorporated the change in productivity as a result of predator removal (in the case of the first data set; see "Appendix 1"). In cases where a predator removal program had not yet been initiated, we estimated the demographic response as a result of predator removal using the general linear model described above. The predicted response in productivity as a result of a hypothetical removal was adjusted for bird body mass, egg mass, nest type, and predator type. The new demographic model then generated a post-removal population growth rate. We then scored the estimated demographic benefits from predator removal with respect to its contribution to reversing population decline ($\lambda \geq 1.00$).

Results

Predator removal and bird productivity

A review of the literature yielded 112 studies that examined the change in productivity of 87 bird species as a result of the control or removal of predators ("Appendix 1"). Average study duration was 6.0 years, with 4.8 years of data prior to control/removal efforts and 3.8 following (total range of study years: 1–38). Eleven studies examined the effects of predators on adult or juvenile survival ("Appendix 1") and one study reported on the removal of a domesticated herbivore, *Ovis aries* (Norman 1970). These studies were excluded from statistical analysis due to small sample size. The mean change in productivity for all studies following predator removal was +25.3% (2.5 SE). All but 12 studies reported a positive response in productivity. Overall, predator type (rodent or non-rodent) did not have a significant effect on changes in bird productivity following predator removal ($P = 0.085$; Table 1). However, when predator types were treated on an individual basis, the observed change in bird productivity as a result of predator removal was significantly less following the removal of avian predators compared to rats (Fig. 1; $P = 0.011$) and stoats ($P = 0.019$). Percent change in productivity ranged from −82 to 6,150%; four studies reported zero productivity prior to and increased productivity following predator removal (range 0.455–0.625; "Appendix 1").

Table 1 Top five models examining the effects of removing single predators on bird productivity ($n = 33$)

Model	AIC_c	ΔAIC_c	W
$\beta_o + \beta_{nest} + \beta_{mass} + \beta_{predator} + \beta_{egg}$ (main effects)[a,b]	42.649	0.000	0.457
$\beta_o + \beta_{nest} + \beta_{mass} + \beta_{predator} + \beta_{egg} + \beta_{mass} \times \beta_{nest}$	43.943	1.294	0.239
$\beta_o + \beta_{nest} + \beta_{mass} + \beta_{egg} + \beta_{mass} \times \beta_{nest}$	46.423	3.774	0.069
$\beta_o + \beta_{nest}$	47.619	4.970	0.038
β_o (null model)	47.947	5.298	0.032

Bird body mass, egg mass, nest type (surface and not surface), and an interaction between body mass and nest type made up the best performing model. ΔAIC is the difference between AIC values for each model and the lowest AIC value. A lower AIC value indicates a better fitting model; *W* is the model's Akaike weight, the relative probability that the model is the best fit to the data tested. β_{nest} = bird nest type (surface or not surface), β_{mass} = bird body mass, $\beta_{predator}$ = predator type (mammal or bird), β_{egg} = fresh egg mass

[a] Model coefficients: intercept = 1.6106, nest type = 0.9222, body mass = −0.0010, egg mass = 0.0100, predator type = −0.9264

[b] *P*-value: nest type = 0.024, body mass = 0.031, egg mass = 0.050, predator type = 0.085

Factors influencing predator removal benefits for birds

Twenty-six studies included the removal of a single predator and estimates of changes in bird productivity (some studies provided data for multiple bird species, total $n = 33$). The best performing model (main effects) based on AIC_c values included bird body mass, egg mass, nest type, and predator type (Table 1). The second model (which includes an interaction term for bird body mass and nest type) performed nearly as well ($\Delta AIC_c < 2.0$; Burnham and Anderson 2002) therefore model averaging was applied. The averaged model was used to estimate the effects of hypothetical predator removal.

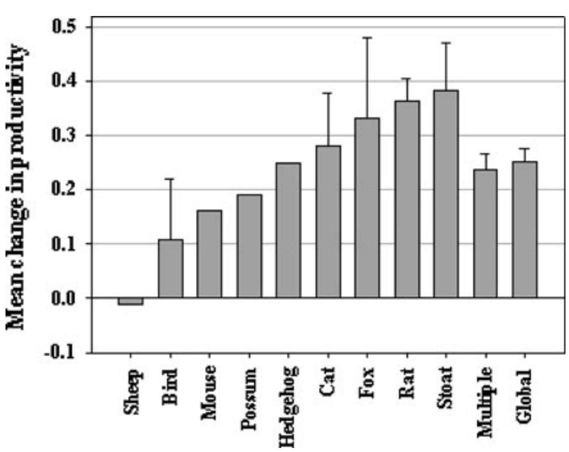

Fig. 1 Mean change (±SE) in bird productivity following the removal or eradication of predators ($n = 111$). Sample sizes differ: sheep *Ovis aries* (1), birds *Cassidix mexicanus prosopidicola*, *Corvus brachyrhynchos*, *C. corone*, *C. corax*, *Larus canus*, *L. n. scopulinus*, *L. argentatus* (5), deer mouse *Peromyscus maniculatus* (1), brushtail possum *Trichosurus vulpecula* (1), hedgehog *Erinaceus europaeus* (1), cat *Felis catus* (6), fox *Alopex lagopus*, *Vulpes fulva* (2), rat *Rattus rattus*, *R. norvergicus*, *R. exulans* (18), stoat *Mustela erminea* (3), and multiple predators (73). Multiple predator removal studies included native and non-native predators. Global value includes all studies

Predator removals and bird population recovery

Complete demographic data were available for 24 bird species, including data on productivity before and after predator removal. Percent change in lambda before and after predator removal ranged from −12.3 to +36.7%, with an overall mean of 11.3% (2.3 SE; Table 2). Of the 24 species assessed, three had a positive population growth rate prior to predator removal, while 17 had positive population growth rates following ($\lambda \geq 1$, Table 2).

Complete demographic data were available for an additional 12 bird species that currently suffer from predation by introduced predators, but currently lack a control/eradication campaign (Table 3). Prior to adjusting the demographic parameters to account for hypothetical predator removal, nine of the 12 species were predicted to be in decline (baseline $\lambda < 1.00$, Table 3). The predicted increase in productivity resulting from hypothetical predator removal ranged from 16.9 to 63.0% (mean = 45.0%, 5.6 SE) and was lowest for large, surface nesting birds (Table 3). Hypothetical predator removal resulted in a positive population growth rate for three of the nine species in

Table 2 Projected population growth rates (λ) for birds pre- and post-predator removal based on the empirically estimated demographic rates provided in "Appendix 1"

Species	Predator	λ-pre	λ-post	% Change	Source(s)
Cory's Shearwater *Calonectris diomedea*	Black rat *Rattus rattus*	0.898 (0.003)	0.954 (0.003)	5.8	Amengual and Aguilar (1998) and Jenouvrier et al. (2008)
Sooty Shearwater *Puffinus griseus*	Weka *Gallirallus australis* & black rat	0.954 (0.003)	1.053 (0.013)	9.9	Clucas et al. (2008), Harper (2007) and Jones (2002)
Red-tailed Tropicbird *Phaethon rubricauda*	Polynesian rat *Rattus exulans*	0.882 (0.009)	0.896 (0.010)	1.5	Fleet (1972) and Schreiber et al. (2001)
Black Brandt *Branta bernicla*	Arctic fox *Alopex lagopus*	0.916 (0.016)	0.935 (0.010)	2.0	Anthony et al. (1991), Ward et al. (1997) and Ward et al. (2004)
Mallard *Anas platyrhynchos*	Many, primarily red fox *Vulpes vulpes*	0.954 (0.003)	1.083 (0.004)	26.0	Drilling et al. (2002) and LaGrange et al. (1995)
Blue-winged Teal *Anas discors*	Many, primarily striped skunk *Mephitis mephitis*	0.863 (0.011)	1.092 (0.015)	20.9	LaGrange et al. (1995) and Rohwer et al. (2002)
Blue Duck *Hymenolaimus malacorhynchos*	Stoat *Mustela erminea*	0.821 (0.004)	1.188[a] (0.004)	36.7	Whitehead et al. (2008)
American Coot *Fulica americana*	Many, primarily red fox	0.937 (0.003)	1.019 (0.003)	7.8	Brisbin and Mowbray (2002) and Garretson et al. (1996)
Ring-necked Pheasant *Phasianus colchicus*	Many, primarily striped skunk	0.894 (0.012)	1.013 (0.0150	11.7	Chessness et al. (1968) and Leif (1994)
Ruffed Grouse *Bonasa umbellus*	Many, primarily Great Horned Owl *Bubo virginianus*	1.069 (0.003)	1.191 (0.004)	16.2	Bump et al. (1947) and Small et al. (1991)
Southern Dunlin *Calidris alpina schinzii*	Many, primarily red fox	0.986 (0.003)	1.030 (0.003)	4.4	Pauliny et al. (2008)
Snowy Plover *Charadrius alexandrinus*	Red fox and feral cat *Felis catus*	0.977 (0.022)	1.088 (0.016)	10.2	Neuman et al. (2004) and Paton (1994)
Piping Plover *C. melodus*	Many, primarily red fox	0.832 (0.012)	0.967 (0.013)	19.8	Larson et al. (2002) and Melvin et al. (1992)
Golden Plover *Pluvialis apricaria*	Carrion Crow *Corvus corone* and Common Gull *Larus canus*	0.987 (0.014)	0.864 (0.020)	−14.2	Parr (1993) and Piersma et al. (2005)
Lapwing *Vanellus vanellus*	Red fox and Carrion Crow	0.998 (0.003)	1.036 (0.003)	2.3	Bolton et al. (2007) and Peach et al. (1994)
Greater Sandhill Crane *Grus canadensis tabida*	Many, primarily coyote *Canis latrans*	0.811 (0.008)	1.036 (0.003)	3.7	Ellis et al. (2000), Littlefield (2003) and Tacha et al. (1992)
Bridled Tern *Onychoprion anaethetus*	Black rat	0.811 (0.008)	1.008 (0.013)	19.5	Haney et al. (1999) and Lorvelec and Pascal (2005)
Least Tern *Sternula antillarum*	Many, primarily red fox	0.943 (0.003)	1.135 (0.002)	19.2	Massey et al. (1992) and Minsky (1980)
Western × Glaucous-winged Gull *Larus occidentalis × glaucescens*	Many, primarily gulls	0.845 (0.003)	0.914 (0.003)	6.9	Good (2002) and Spear et al. (1987)

Table 2 continued

Species	Predator	λ-pre	λ-post	% Change	Source(s)
Chatham Island Pigeon *Hemiphaga novaeseelandiae*	Many, including Harrier *Circus approximans*	1.119 (0.013)	1.104 (0.015)	−1.4	Flux et al. (2001)
New Zealand Wattlebird *Callaeas cinerea*	Many, including black rat	0.982 (0.004)	1.228[a] (0.003)	24.5	Basse et al. (2003)
Stitchbird *Notiomystis cincta*	Polynesian and Norway rat *R. norvegicus*	0.853 (0.004)	0.905[a] (0.005)	5.2	Empson and Miskelly (1999)
Rarotonga Monarch *Pomarea dimidiata*	Many, primarily black rat	0.971 (0.009)	1.110 (0.012)	12.5	Robertson et al. (1994) and Robertson and Saul (2007)
Yellow-headed Blackbird *Xanthocephalus xanthocephalu*	Many, primarily red fox	0.990 (0.004)	0.998 (0.004)	0.8	Garretson et al. (1996) and Twedt and Crawford (1995)

[a] Best case scenario using juvenile and adult survival rates from intensively managed sites

decline. The mean increase in population growth rate was 3.6% (0.9 SE, range: 0.2–9.8%).

Discussion

The results of our literature review highlight that for the majority of bird species studied, the removal of predators has resulted in increased productivity and survival. In only a few instances was bird productivity or survival lower following predator removal (Empson and Miskelly 1999; Flux et al. 2001; Norman 1970; Powlesland et al. 1999). Due to the paucity of studies involving the removal of a single native predator ($n = 2$), it was not possible to determine whether native or non-native predators have a greater impact on bird demography. However, the increases in bird productivity following the removal of a native mouse and fox were some of the lowest reported, 16.2 and 18.3%, respectively (Fig. 1; Anthony et al. 1991; Millus et al. 2007).

Rodents, especially rats (*Rattus* spp.), are notorious bird predators (Atkinson 1985; Jones et al. 2003). Even the small Polynesian rat (*R. exulans*) and house mouse (*Mus musculus*) are known to cause significant mortality of albatrosses and petrels more than 50× their size (Cuthbert and Hilton 2004; Wanless et al. 2007; Woodward 1972). Jones et al. (2008) reported significant impacts of rats, especially the black rat *Rattus rattus*, on small burrowing seabirds. While the results of our analysis showed that rats and stoats are more effective bird-predators than other bird species, overall, the removal of predators (rodent vs. non-rodent) was not well supported by our model ($P = 0.085$; Table 1). The inability to detect an effect in this analysis is likely due to the inclusion of a vast array of predators ($n = 61$). In the case of the non-rodent group, predators varied greatly in size and ability from small crabs *Coenobita* spp. to coyote (Littlefield 2003; Schaffner 1991). In addition, a number of studies reported predation by small mammals or birds which could not be excluded with fences or otherwise removed from the treatment area (Lokemoen et al. 1987; Mayer and Ryan 1991; Parr 1993). Thus, the change in bird productivity included in our model may not have resulted from the removal of the target predator species.

The type and location of a bird's nest has been shown to influence predation rates (Burger and

Table 3 Model results for a hypothetical predator eradication for species/locations where little or no predator control currently exists

Species	Bodymass (g)[a]	Egg mass (g)[a]	Nest type	Predator type	Parameters			% increase in F_a^b	λ		Source
					P_a	S_j	S_a		Baseline	Post-eradication	
Tristan Albatross *Diomedea dabbenena*	7,050	449	S	R	0.33	0.81[c]	0.91	21.4	0.948 (0.003)	0.955 (0.003)	Wanless et al. (2009)
Northern Royal Albatross *Diomedea e. sandfordi*	6,577	416	S	NR	0.19	0.93	0.95	24.2	0.973 (0.002)	0.980 (0.002)	Robertson (1998) and Taylor (2000)
Laysan Albatross *Diomedea immutabilis*	3,310	218	S	R	0.56	0.92	0.93	35.4	1.017 (0.003)	1.048 (0.003)	Fisher (1975) and Ludwig et al. (1998)
Sooty Albatross *Phoebetria fusca*	3,250	207	S	R	0.58	0.88	0.90	33.5	0.952 (0.001)	0.976 (0.001)	Weimerskirch and Jouventin (1998)
Westland Petrel *Procellaria westlandica*	1,294	138	NS	NR	0.62	0.64[d]	0.96	62.7	1.041 (0.001)	1.081 (0.001)	Waugh et al. (2006)
Manx Shearwater *Puffinus puffinus*	487	57	NS	R	0.56	0.44[d]	0.85	63.0	0.966 (0.005)	1.034 (0.005)	Appleton et al. (2006) and Mavor et al. (2006)
European Storm-petrel *Hydrobates pelagicus*	28	7	NS	R	0.65	0.82	0.83	62.2	0.935 (0.002)	1.007 (0.002)	Mínguez and Oro (2003) and Oro et al. (2005)
Brown Pelican *Pelecanus o. californicus*	4,000	110	S	NR	1.09	0.30[d]	0.88[e]	16.9	1.001 (0.005)	1.012 (0.005)	Anderson et al. (1996) and Shields (2002)
Yellow-eyed Penguin *Megadyptes antipodes*	5,140	242	S	NR	1.36	0.59	0.90	19.3	0.959 (0.002)	0.964 (0.002)	Marchant and Higgins (1990), Ratz et al. (2004) and Richdale (1957)
African Penguin *Spheniscus demersus*	2,836	106	S	R	0.47	0.32[d]	0.91	39.1	0.976 (0.001)	0.988 (0.002)	Crawford et al. (1999) and Mclean (1985)
Akepa *Loxops coccineus*	12	1.5	NS	NR	0.48	0.31	0.77	61.3	0.843 (0.002)	0.889 (0.001)	Freed et al. (2008)
Hawaii Creeper *Oreomystis mana*	14	1.4	NS	R	1.70	0.31[d]	0.78	61.2	0.939 (0.004)	1.038 (0.004)	Lepson and Woodworth (2002)

P_a productivity (mean number of fledged chicks per pair per year), S_j annual juvenile survival, S_a annual adult survival, λ population growth rate (SE), *S* surface, *NS* not surface, *R* rodent, *NR* not rodent

[a] From Brooke (2004), del Hoyo et al. (1992), Marchant and Higgins (1990) and Schönwetter (1967)

[b] Predicted demographic benefit based on the coefficients from the best-supported eradication effects model (see Table 1)

[c] Juvenile survival estimated from Wandering Albatross *Diomedea exulans* (Wanless et al. 2009)

[d] First year survival only

[e] Estimate based on small sample size and survival for 180 days post-release, extrapolated to annual rate (Anderson et al. 1996)

Gochfield 1991; Igual et al. 2007; Moors and Atkinson 1984). Typically, birds nesting on or near the ground or in burrows are especially vulnerable to predation due to ease of access to nests (Atkinson 1985). Thus seabirds and other surface nesting birds would presumably experience the largest increase in productivity following predator removal compared to tree dwelling species which can avoid some predators (e.g., foxes). Our results provide further support for this idea with nest type (surface vs. not surface) a significant factor in our model ($P = 0.024$; Table 1).

Bird body mass and egg mass are also known to influence predation rates with smaller birds and smaller, thin-shelled eggs typically suffering increased predation (DeGraaf and Maier 1996; Haskell 1995; Imber 1975; Jones et al. 2008; Roper 1992). However, Blight et al. (1999) and Jones et al. (2008) found that egg mass, eggshell thickness, and predator gape did not differentially affect predation by rodents. Our results suggest bird body mass ($P = 0.030$) is a reliable predictor of predator removal benefits (Table 1) and provides limited support for egg mass ($P = 0.058$; Table 1).

The ability of the model to predict the benefits of predator removal prior to an eradication event varied across species. In the case of the California Brown Pelican *Pelecanus occidentalis californicus*, the predicted 16.9% increase in productivity following hypothetical predator removal is above the range of values reported for feral cat predation (Anderson et al. 1989; Table 3) However, for Tristan Albatross (*Diomedea dabbenena*), the predicted increase in productivity resulting from predator removal is 21.4%, which is comparable to the reported mortality by Cuthbert and Hilton (2004) who suggest that 15–39% of chicks die as a result of mouse predation each year. Like any set of models, discrepancies do and will exist for a suite of reasons. First, biases in reporting may influence the dataset since studies reporting a null effect can be difficult to publish (Csada et al. 1996). Only 15 of the 112 studies presented report no significant increase (or decrease) in fecundity following predator removal ("Appendix 1"; Bolton et al. 2007; Clark et al. 1995; Dion et al. 1999; Flux et al. 2001; Garretson et al. 1996; Harper 2007; Kauhala 2004; Powlesland et al. 2003; Rohwer et al. 1997). Second, there may be unusual or idiosyncratic circumstances that are not anticipated by the model. For example, on Gough Island, the mice predating Tristan Albatross have developed large body size compared to populations elsewhere (mean 27.2 g compared to 9–25 g; Jones et al. 2003) and on the Falkland Islands, the tiny Thin-billed Prion (*Pachyptila belcheri*; 145 g) manages to coexist with mice, cats, and black rats (Quillfeldt et al. 2008). Finally, our ability to accurately predict the outcome of conservation actions, and thus prioritize management, is limited by the availability and quality of published data. Despite more than 800 successful invasive mammal eradications worldwide (Donlan and Wilcox 2008), less than 20% of studies directly quantified the benefits to birds. Inclusion of additional quantitative studies examining the demographic response of birds (especially those >1,500 g) following predator removal would increase the ability to predict conservation benefits *a priori*.

From the data available, removing invasive predators often reverses a negative population growth rate. Seventeen of the 24 bird species predicted to be in decline in Table 2 had estimated lambdas greater than one following invasive predator removal. Further, three of the nine declining species in Table 3 showed a positive population growth rate following hypothetical invasive predator eradication. For those bird species that predator eradication does not reverse population decline, predator removal is likely to result in cost-effective increases in lambda relative to other conservation actions (Wilcox and Donlan 2007, 2009). Like any threatened species program, multiple conservation strategies will often be necessary to ensure recovery of threatened populations.

Acknowledgments This work was conducted as a part of the 'Exploring compensatory mitigation and markets as mechanisms for resolving fisheries bycatch and biodiversity conservation conflicts' Working Group supported by the National Center for Ecological Analysis and Synthesis, a Center funded by NSF (Grant #DEB-0553768), the University of California, Santa Barbara, and the State of California. We would like to thank A. Bond and P. Dunstan for their insightful comments and guidance on earlier versions of this manuscript. Financial support for this project was provided by the Commonwealth Environment Research Facilities Programme and an Endeavour Research Fellowship from the Government of Australia. Funding for CJD was provided by the Alcoa Foundation, the Switzer Foundation, Resources for the Future, and Cornell University.

Appendix 1

See Table 4.

Table 4 Summary of published studies reporting the demographic response of birds to the control or eradication of predators (including multi-predator studies)

Family	Species	Body mass (g)[a]	Egg mass (g)[b]	Nest type	Predator(s)	Par	Eradication Pre	Eradication Post	S_j	S_a	Source(s)
Procellaridae	Blue Petrel *Halobaena caerulea*	197	42	NS	Feral cat *Felis catus*	P_a	0.24	0.64			Cooper et al. (1995)
	White-chinned Petrel *Procellaria aequinoctialis*	1,335	134	NS	Feral cat	P_a	0.55	0.86			van Rensburg and Bester (1988)
					Feral cat	P_a	0.36	0.22			Cooper et al. (1995)
					Norway rat *Rattus norvegicus*, black rat *R. rattus*	P_a	0.48	0.69			Jouventin et al. (2003)
	Cory's Shearwater *Calonectris diomedea*	840	99	NS	Black rat	P_a	0.43	0.86	0.88	0.92	Mougin et al. (2000) and Towns et al. (2006)
					Black rat	P_a	0.47	0.85			Lorvelec and Pascal (2005)
					Black rat	P_a	0.48	0.89			Igual et al. (2006)
					House mouse *Mus musculus*, rabbit *Oryctolagus cuniculus*	P_a	0.41	0.55			Zino et al. (2008)
					Black rat	P_a	0.33	0.49			Thibault (1995)
					Black rat	P_a	0.18	0.67			Amengual and Aguilar (1998)
	Sooty Shearwater *Puffinus griseus*	803	95	NS	Weka *Gallirallus australis*, black rat	P_a	0.83	0.77	0.85	0.95	Clucas et al. (2008), Harper (2007) and Jones (2002)
	Short-tailed Shearwater *Puffinus tenuirostris*	619	89	NS	Sheep *Ovis aries*	P_a	0.51	0.50			Norman (1970)
	Black-vented Shearwater *Puffinus opisthomelas*	405	52	NS	Feral cat	A_m	0.16	0.01			Keitt and Tershy (2003) and Keitt et al. (2002)
	Audubon's Shearwater *Puffinus l'herminieri*	163	29	NS	Black rat	P_a	0.45	0.86			Pascal et al. (2008)
					Black rat	P_a	0.00	0.75			Pascal et al. (2004)
	Little Shearwater *Puffinus assimilis*	156	32	NS	Polynesian rat *Rattus exulans*	P_a	0.24	0.62			Pierce (2002)
	Galapagos Petrel *Pterodroma phaeopygia*	408	56	NS	Black rat	P_a	0.30	0.72			Cruz and Cruz (1987)
	Zino's Petrel *Pterodroma madeira*	204	37	NS	Black rat, feral cat	P_a	0.08	0.51			Zino et al. (2001)

Table 4 continued

Family	Species	Body mass (g)[a]	Egg mass (g)[b]	Nest type	Predator(s)	Par	Eradication Pre	Eradication Post	S_j	S_a	Source(s)
	Great-winged Petrel *Pterodroma macroptera*	587	81	NS	Feral cat	P_a	0.16	0.64			Cooper et al. (1995)
					Feral cat	P_a	0.08	0.54			van Rensburg and Bester (1988)
	Grey-faced Petrel *Pterodroma m. gouldi*	668	80	NS	Norway rat[c]	P_a	0.13	0.37			Imber et al. (2000)
	Pycroft's Petrel *Pterodroma pycrofti*	146	32	NS	Polynesian rat	P_a	0.33	0.60			Pierce (2002)
	Cook's Petrel *Pterodroma cookii*	179	41	NS	Polynesian rat, feral cat[d]	P_a	0.49	0.75			Imber et al. (2003)
	Bonin Petrel *Pterodroma hypoleuca*	176	39	NS	Black rat, house mouse[e]	P_a	0.47	0.82			Seto and Conant (1996)
	Salvin's Prion *Pachyptila vittata salvini*	162	35	NS	Feral cat	P_a	0.47	0.66			van Rensburg and Bester (1988)
Phaethontidae	Red-tailed Tropicbird *Phaethon rubricauda*	624	77	S	Polynesian rat	P_a	0.20	0.26	0.47	0.85	Fleet (1972), Schreiber and Schreiber (1993) and Schreiber et al. (2001)
	White-tailed Tropicbird *Phaethon lepturus*	334	43	S	Many, primarily black rat	P_a	0.30	0.42			Schaffner (1991)
Anatidae	Black Brant *Branta b. nigricans*	1,230	100	S	Arctic fox *Alopex lagopus*	P_a	0.64	0.82	0.23	0.84	Anthony et al. (1991) and Ward et al. (1997, 2004)
	Mallard *Anas platyrhynchos*	1,029	52	S	Many, primarily red fox *Vulpes vulpes*	P_a	0.36	0.57	0.61	0.55	Drilling et al. (2002) and Pearse and Ratti (2004)
					Many, primarily red fox	P_a	0.63	0.93			Duebbert and Lokemoen (1980)
					Many, primarily striped skunk *Mephitis mephitis*	P_a	0.14	0.39			LaGrange et al. (1995)
	Blue-winged Teal *Anas discors*	387	28	S	Many, primarily striped skunk	P_a	0.14	0.30	0.38[f]	0.55	Rohwer et al. (2002) and LaGrange et al. (1995)
	Northern Shoveller *Anas clypeata*	613	38	S	Many, primarily red fox	P_a	0.23	0.63			Sargeant et al. (1974)
	Blue Duck *Hymenolaimus malacorhynchos*	775	62	S	Many, primarily stoat *Mustela erminea*	P_a	0.10	0.54			Whitehead et al. (2008)
						S_j	0.00	0.49			

Table 4 continued

Family	Species	Body mass (g)[a]	Egg mass (g)[b]	Nest type	Predator(s)	Par	Eradication Pre	Eradication Post	S_j	S_a	Source(s)
						S_j	0.81	0.69			
	Ducks[g]				Many, primarily striped skunk	P_a	0.24	0.68			Balser et al. (1968)
	Ducks[g]				Striped skunk, Franklin's ground squirrel *Spermophilus franklinii*	P_a	0.03	0.15			Greenwood (1986)
	Ducks[g]				Many, primarily red fox	P_a	0.17	0.54			Lokemoen and Woodward (1993)
	Ducks[g]				Many, primarily striped skunk	P_a	0.06	0.14			Sargeant et al. (1995)
	Ducks[g]				Many, primarily red fox	P_a	0.60	0.89			Duebbert and Kantrund (1974)
	Ducks[g]				Many, primarily feral cat	P_a	0.25	0.07			Meckstroth and Miles (2005)
	Ducks[g]				Many, primarily feral cat	P_a	0.06	0.81			Greenwood et al. (1990)
	Ducks[g]				Many, primarily striped skunk	P_a	0.30	0.58			Lokemoen et al. (1982)
	Ducks[g]				Many, primarily red fox	P_a	0.08	0.60			Lokemoen et al. (1987)
	Ducks[g]				Many, primarily raccoon dog *Nyctereutes procyonoides*	P_a	0.62	0.61			Kauhala (2004)
	Ducks[g]				Many, primarily striped skunk	P_a	0.10	0.33			Doty and Rondeau (1987)
	Ducks[g]				Many, primarily raccoon *Procyon lotor*	P_a	0.20	0.54			Rohwer et al. (1997)
	Ducks[g]				Many, primarily red fox	P_a	0.26	0.55			Garretson et al. (1996)
	Ducks[g]				Many, primarily striped skunk	P_a	0.29	0.53			Chodachek and Chamberlain (2006)
	Ducks[g]				American Crow *Corvus brachyrhynchos*	P_a	0.07	0.12			Clark et al. (1995)
	Ducks[g] and Sharp-tailed Grouse *Pedioecetes phasianellus*				Many, primarily red fox	P_a	0.20	0.50			Sargeant et al. (1974)

Table 4 continued

Family	Species	Body mass (g)[a]	Egg mass (g)[b]	Nest type	Predator(s)	Par	Eradication Pre	Eradication Post	S_j	S_a	Source(s)
Rallidae	American Coot *Fulica americana*	638	29	S	Many, primarily raccoon	P_a	0.67	0.86	0.44	0.49	Garretson et al. (1996) and Brisbin and Mowbray (2002)
	Purple Swamphen *Porphyrio porphyrio*	950	32.3	S	Rabbit, Australasian Harrier *Circus approximans*	P_a	0.76	0.19			Haselmayer and Jamieson (2002)
Phasianidae	Malleefowl *Leipoa ocellata*	2,000	168	S	Red fox	S_j	0.12	0.40			Priddel and Wheeler (1997)
	Ring-necked Pheasant *Phasianus colchicus*	1,109	33	S	Many, primarily striped skunk	P_a	0.22	0.32	0.61	0.51	Chessness et al. (1968) and Leif (1994)
	Ruffed Grouse *Bonasa umbellus*	572	20	S	Many, primarily Great Horned Owl *Bubo virginianus*	P_a	0.38	0.68	0.14	0.34	Edminster (1939) and Rusch et al. (2000)
						S_a	0.82	0.79			Edminster (1939)
					Many, primarily red fox	P_a	0.27	0.51			Bump et al. (1947)
						S_a	0.71	0.71			Bump et al. (1947)
	Weka *Gallirallus australis greyi*	760	34	S	Many, primarily feral cat	P_a	0.06	0.38			Bramley (1996)
	Gray Partridge *Perdix perdix*	390	18	S	Red fox *Vulpes vulpes*	P_a	0.33	0.40			Tapper et al. (1996)
	Tetraonids[g]				Many, primarily red fox	P_a	0.59	0.77			Marcstrom et al. (1988)
Recurvirostridae	Black Stilt *Himantopus novaezelandiae*	223	40	S	Many, primarily feral cat	P_a	0.19	0.33			Keedwell et al. (2002)
					Many, primarily ferret	P_a	0.01	0.11			Pierce (1986)
					Many, primarily feral cat	P_a	0.29	0.53			Reed (1998)
Charadriidae	Killdeer *Charadrius vociferus*	97	17	S	Many, including deer mice *Peromyscus maniculatus*	P_a	0.33	0.14			Mabee and Estelle (2000)
					Many, primarily gulls (*Larus* spp.)	P_a	0.26	0.62			Nol and Brooks (1982)
	Snowy Plover *Charadrius alexandrinus*	42	8	S	Red fox, feral cat	P_a	0.43	0.68	0.38	0.73	Neuman et al. (2004) and Paton (1994)
					Many, including deer mice	P_a	0.54	0.57			Mabee and Estelle (2000)
					Many, primarily coyote *Canis latrans*	P_a	0.76	0.90			Koenen et al. (1996)
	Piping Plover *Charadrius melodus*	55	10	S	Many, primarily red fox	P_a	0.17	0.90	0.48	0.74	Larson et al. (2002) and Melvin et al. (1992)

Table 4 continued

Family	Species	Body mass (g)[a]	Egg mass (g)[b]	Nest type	Predator(s)	Par	Eradication Pre	Eradication Post	S_j	S_a	Source(s)
					Many, including deer mice	P_a	0.75	0.60			Mabee and Estelle (2000)
					Many, primarily red fox	P_a	0.25	0.92			Rimmer and Deblinger (1990)
					Many, primarily mink *Mustela vison*	P_a	0.33	0.51			Mayer and Ryan (1991)
					Many, primarily mink	P_a	0.34	0.62			Kruse et al. (2001)
					Many, primarily coyote	P_a	0.28	0.93			Smith et al. (1993)
					Many, primarily coyote	P_a	0.45	0.91			Murphy et al. (2003)
					Many, primarily red fox	P_a	0.25	0.42			Larson et al. (2002)
	Golden Plover *Pluvialis apricaria*	215	27	S	Carrion Crow *Corvus corone*, Common Gull *Larus canus*	P_a	0.47	0.09[h]	0.71	0.82	Parr (1993) and Piersma et al. (2005)
	Lapwing *Vanellus vanellus*	234	23	S	Red fox and Carrion Crow	P_a	0.26	0.34	0.60	0.75	Bolton et al. (2007) and Peach et al. (1994)
					Many, primarily red fox	P_a	0.66	0.39			Isaksson et al. (2007)
	Redshank *Tringa totanus*	159	20	S	Many, primarily red fox	P_a	0.38	0.92			Isaksson et al. (2007)
	New Zealand Dotterel *Charadrius obscurus*	153	23	S	Many, primarily feral cat	P_a	0.47	0.80			Dowding (1997)
					Many, primarily feral cat	S_a	0.83	0.82			Dowding (1997)
	Banded Dotterel *Charadrius bicinctus*	60	9	S	Many, primarily feral cat	P_a	0.51	0.78			Norbury and Barlow (1998)
					Many, primarily feral cat	P_a	0.78	0.46			Norbury and Heyward (2008)
	Chatham Island Oystercatcher *Haematopus chathamensis*	600	46	S	Many, primarily feral cat	P_a	0.35	0.64	0.81	0.94	Moore (2009)
					Many, primarily feral cat	S_a	0.94	0.98			Moore (2009)
	Shorebirds[g]				Hedgehog *Erinaceus europaeus*	P_a	0.68	0.93			Jackson (2001)
	Southern Dunlin *Calidris alpina schinzii*	55	9.4	S	Many, primarily red fox		0.40	0.65	0.33[f]	0.77	Pauliny et al. (2008) and Warnock and Gill (1996)
Gruidae	Greater Sandhill Crane *Grus canadensis tabida*	5,571	161	S	Many, primarily coyote	P_a	0.42	0.55	0.80	0.87	Ellis et al. (2000), Littlefield (2003) and Tacha et al. (1992)

Table 4 continued

Family	Species	Body mass (g)[a]	Egg mass (g)[b]	Nest type	Predator(s)	Par	Eradication Pre	Eradication Post	S_j	S_a	Source(s)
Sternidae	Bridled Tern *Onychoprion anaethetus*	100	20	S	Black rat	P_a	0.00[i]	0.53	0.78	0.83	Haney et al. (1999) and Lorvelec and Pascal (2005)
	Sooty Tern *Onychoprion fuscatus*	180	35	S	Black rat, feral cat	A_m	0.23	0.02			Rodríguez et al. (2006)
	Brown Noddy *Anous stolidus*	200	37	S	Black rat	P_a	0.05	0.77			Pascal et al. (2004)
	Least Tern *Sternula antillarum*	42	7	S	Many, primarily red fox	P_a	0.35	0.99	0.54	0.88	Massey et al. (1992) and Rimmer and Deblinger (1992)
					Red fox, occasionally Great Horned Owl	P_a	0.19	0.67			Minsky (1980)
					Many, primarily coyote	P_a	0.56	0.81			Koenen et al. (1996)
	Common Tern *Sterna hirundo*	125	21.0	S	Ring-billed *Larus n. scopulinus* and Herring Gull *L. argentatus*	P_a	0.45	0.62	0.54	0.87	Burness and Morris (1992) and Nisbet and Cam (2002)
	Western x Glaucous-winged Gull *L. occidentalis* × *glaucescens*	951	94.6	S	Many, primarily gulls	P_a	0.01	0.11	0.55[f]	0.84	Good (2002) and Spear et al. (1987)
Alcidae	Xantus's Murrelet *Synthliboramphus hypoleucus*	168	37	NS	Black rat	P_a	0.48	0.93			Whitworth et al. (2005)
					Deer mouse	P_a	0.63	0.80			Millus et al. (2007)
Columbidae	Chatham Island Pigeon *Hemiphaga n. chathamensis*	800	40	NS	Many, including Harrier *Circus approximans*	P_a	0.66	0.58	0.85[f]	0.96	Flux et al. (2001)
	New Zealand Wood Pigeon *Hemiphaga novaeseelandiae*	600	30	NS	Black rat, brushtail possum *Trichosurus vulpecula*	P_a	0.00	0.52			Innes et al. (2004)
					Brushtail possum	P_a	0.25	0.75			Powlesland et al. (2003)
					Many, primarily black rat	P_a	0.00	0.46			Clout et al. (1995)
	White-winged Dove *Zenaida asiatica*	153	8	NS	Many, primarily Great-tailed Grackle *Cassidix mexicanus prosopidicola*	P_a	0.38	0.50			Blankinship (1966)

Table 4 continued

Family	Species	Body mass (g)[a]	Egg mass (g)[b]	Nest type	Predator(s)	Par	Eradication Pre	Eradication Post	S_j	S_a	Source(s)
Psittacidae	New Zealand Kaka *Nestor meridionalis*	429	21	NS	Brushtail possum, black rat	P_a	0.33	0.50			Powlesland et al. (2003)
						S_j^{j}	0.60	0.50			Powlesland et al. (2003)
						A_m	0.12	0.06			Powlesland et al. (2003)
					Stoat, brushtail possum	P_a	0.19	0.84			Moorehouse et al. (2003)
	Glossy Black-cockatoo *Calyptorhynchus lathami*	430	26	NS	Brushtail possum	P_a	0.23	0.42			Garnett et al. (1999)
Icteridae	Yellow-headed Blackbird *Xanthocephalus xanthocephalus*	65	5	NS	Many, primarily raccoon	P_a	0.61	0.63	0.43[f]	0.67	Garnett et al. (1999) and Twedt and Crawford (1995)
	Red-winged Blackbird *Agelaius phoeniceus*	53	4	NS	Many, primarily raccoon	P_a	0.62	0.64			Garnett et al. (1999)
Emberizidae	Songbirds[g]				Many, primarily raccoon	P_a	0.15	0.25			Dion et al. (1999)
Cotingidae	Bellbird *Anthornis melanura*	36	3	NS	Stoat	P_a	0.16	0.66			Kelly et al. (2005)
Petroicidae	New Zealand Robin *Petroica australis longipes*	35	3	NS	Brushtail possum, black rat	A_m^{k}	0.10	0.02			Powlesland et al. (1999)
						P_a	0.21	0.70			Powlesland et al. (1999)
					Polynesian and Norway rats	P_a	0.42	0.57			Empson and Miskelly (1999)
						S_a^{l}	0.88	0.54			Empson and Miskelly (1999)
	Yellowhead *Mohoua ochrocephala*	28	2	NS	Stoat	P_a	0.65	0.86			O'Donnell et al. (1996)
Callaeidae	New Zealand Wattlebird *Callaeas cinerea wilsoni*	230	19	NS	Many, including brushtail possum and black rat	P_a	0.13	0.42	0.79	0.85	Innes et al. (1999)
					Brushtail possum, black rat	P_a	0.05	0.62			Basse et al. (2003)
	Stitchbird *Notiomystis cincta*	35	3	NS	Polynesian and Norway rats	P_a	0.77	0.87			Empson and Miskelly (1999)
						S_j^{l}	0.87	0.88			
						S_a^{l}	0.79	0.91			
Monarchidae	Rarotonga Monarch *Pomarea dimidiata*	22	2	NS	Many, primarily black rat	P_a	0.26	0.62	0.79	0.84	Robertson et al. (1994) and Robertson and Saul (2007)
Mean ± SE (all studies)							0.33 ± 0.02	0.59 ± 0.02			

Table 4 continued

Family	Species	Body mass (g)[a]	Egg mass (g)[b]	Nest type	Predator(s)	Par	Eradication		S_j	S_a	Source(s)
							Pre	Post			
Mean ± SE (single predator studies only)							0.33 ± 0.04	0.64 ± 0.04			

Results of models examining the effect of predator control or eradication on bird population trajectories are presented. *S* Surface, *NS* not surface, *Par* demographic parameter affected by predator removal, P_a productivity (mean number of fledged chicks per pair per year), S_j annual juvenile survival, S_a annual adult survival, A_m adult mortality (proportion of population predated)

[a] Mean mass of males and females combined (Dunnin 1993)

[b] From Marchant and Higgins (1990), Schönwetter (1967), and Thomson et al. (1998)

[c] Rabbits also present on the island, however, only affected petrel breeding in 1 year (Imber et al. 2000)

[d] *Pterodroma cookii* productivity most affected by rats predating eggs and chicks: deteriorated seriously after extermination of feral cats from Hauturu, but improved significantly after eradication of rats from Whenua Hou (Imber et al. 2003)

[e] Control program initiated for rats only. Mice were found in traps, but no mouse predation was recorded (Seto and Conant 1996)

[f] First year survival only

[g] Individual species not identified in this study

[h] Removal of gulls and crows likely lead to increased predation by foxes which were not controlled (Parr 1993)

[i] Only 1 year of monitoring data available prior to the eradication

[j] Proportion of fledglings alive after 2 months of leaving the nest

[k] 1996 data excluded because the use of fine particle bait lead to 43% incidental mortality of North Island Robins

[l] Survival from September to December only (Empson and Miskelly 1999)

References

Aguirre-Muñoz A, Croll DA, Donlan CJ et al (2008) High-impact conservation: invasive mammal eradications from the islands of western Mexico. Ambio 37:101–107

Amengual JF, Aguilar JS (1998) Ecologie des oiseaux marins et gestion intégrée du littoral en Méditerranée. In: Walmsley JG, Goutner V, El Hili A, Sultana J (eds) 4th Medmaravis seabird symposium, Les Amis des Oiseaux (Tunisia) and Medmaravis, Hammamet, pp 94–121

Anderson DW, Gress F, Fry DM (1996) Survival and dispersal of oiled Brown Pelicans after rehabilitation and release. Mar Pollut Bull 31:711–718

Anthony RM, Flint PL, Sedinger JS (1991) Arctic fox removal improves nest success of Black Brant. Wildl Soc Bull 19:176–184

Appleton D, Booker H, Bullock DJ et al (2006) The seabird recovery project: Lundy Island. Atl Seab 8:51–60

Atkinson IAF (1985) The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. International Council for Bird Preservation, Cambridge

Atkinson IAE (1989) Conservation for the twenty-first century. Oxford University Press, New York

Balser DS, Dill HH, Nelson HK (1968) Effect of predator reduction on waterfowl nesting success. J Wildl Manag 32:669–682

Basse B, Flux I, Innes J (2003) Recovery and maintenance of North Island Kokako (*Callaeas cinerea wilsoni*) populations through pulsed pest control. Biol Conserv 109:259–270

Beauchamp WD, Nudds TD, Clark RG (1996) Duck nest success declines with and without predator management. J Wildl Manag 60:258–264

Birdlife International (2008) State of the world's birds: indicators for our changing world. Cambridge, UK

Blankinship DR (1966) The relationship of White-winged Dove production to control of Great-tailed Grackles in the lower Rio Grande Valley of Texas. In: Trefethen JB (ed) Transactions of the thirty-first North American wildlife and natural resource conference, Wildlife Management Institute, Pittsburgh, pp 45–58

Blight LK, Ryder JL, Bertram DF (1999) Predation on Rhinoceros Auklets by a native population of *Peromyscus*. Condor 101:871–876

Bolton M, Tyler G, Smith K et al (2007) The impact of predator control on lapwing *Vanellus vanellus* breeding success on wet grassland nature reserves. J Appl Ecol 44:534–544

Bramley GN (1996) A small predator removal experiment to protect North Island Weka (*Gallirallus australia greyi*) and the case for single-subject approaches in determining agents of decline. N Z J Ecol 20:37–43

Brisbin IL Jr, Mowbray TB (2002) American Coot (*Fulica americana*). In: Poole A (ed) The birds of North America online. Cornell Lab of Ornithology, Ithaca

Brooke M (2004) Albatross and petrels of the world. Oxford University Press, New York

Brooke ML, Hilton GM, Martins TLF (2007) Prioritizing the world's islands for vertebrate-eradication programmes. Anim Conserv 10:380–390

Bump G, Darrow RW, Edminster FC et al (1947) The Ruffed Grouse: life history, propagation, and management. New York State Legislature, New York

Burger J, Gochfield M (1991) Predation and effects of humans on island-nesting birds. BirdLife International, Cambridge

Burness GP, Morris RD (1992) Shelters decrease gull predation on chicks at a Common Tern colony. J Field Ornithol 63:186–189

Burnham KP, Anderson DR (2002) Model selection and multi-model inference. Springer, New York

Carter HR, McChesney GJ, Jaques DL et al (1992) Breeding populations of birds in California 1989–1991. U.S. Fish and Wildlife Service, Dixon

Chessness RA, Nelson MM, Longley WH (1968) The effect of predator removal on pheasant reproductive success. J Wildl Manag 32:683–697

Chodachek KD, Chamberlain MJ (2006) Effects of predator removal on upland nesting ducks in North Dakota grassland fragments. Prairie Nat 38:25–37

Clark RG, Meger DE, Ignatiuk JB (1995) Removing American crows and duck nesting success. Can J Zool 73:518–522

Clout MN, Denyer K, James RE et al (1995) Breeding success of New Zealand Pigeons (*Hemiphaga novaeseelandiae*) in relation to control of introduced mammals. N Z J Ecol 19:209–212

Clucas RJ, Fletcher DJ, Moller H (2008) Estimates of adult survival rate for three colonies of Sooty Shearwater (*Puffinus griseus*) in New Zealand. Emu 108:237–250

Cooper J, Marais AVN, Bloomer JP et al (1995) A success story: breeding of burrowing petrels (Procellariidae) before and after the eradication of feral cats *Felis catus* at Subantarctic Marion Island. Mar Ornithol 23:33–37

Côté IM, Sutherland WJ (1997) The effectiveness of removing predators to protect bird populations. Conserv Biol 11:395–405

Crawford RJM, Shannon LJ, Whittington PA (1999) Population dynamics of the African Penguin *Spheniscus demersus* at Robben Island, South Africa. Mar Ornithol 27:139–147

Crawley MJ (2007) The R Book. Wiley, England

Cruz F, Cruz JB (1987) Control of black rats (*Rattus rattus*) and its effects on nesting Dark-rumped Petrels in the Galapagos Islands. Vida Silv Neotrop 1:3–13

Csada RD, James PC, Espie RHM (1996) The "file drawer problem" of non-significant results: does it apply to biological research? Oikos 76:591–593

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

DeGraaf RM, Maier TJ (1996) Effect of egg size on predation by white-footed mice. Wilson Bull 108:535–539

del Hoyo J, Elliott A, Sargatal J (1992) Handbook of the birds of the world. Lynx Edicions, Barcelona

Dion N, Hobson KA, Lariviere S (1999) Effects of removing duck-nest predators on nesting success of grassland songbirds. Can J Zool 77:1801–1806

Donlan CJ, Heneman B (2007) Maximizing return on investments for island restoration with a focus on seabird conservation. Commonwealth Ocean Policy Program Report. Advanced Conservation Strategies, California

Donlan CJ, Wilcox C (2008) A path to a return on investment framework for island restoration with a focus on seabirds. Commonwealth Ocean Policy Program. Advanced Conservation Strategies, Victor

Donlan CJ, Campbell K, Cabrera W et al (2007) Recovery of the Galápagos rail (*Laterallus spilonotus*) following the removal of invasive mammals. Biol Conserv 138:520–524

Doty HA, Rondeau AJ (1987) Predator management to increase duck nest success. In: Great plains wildlife damage control workshop proceedings, University of Nebraska, Lincoln

Dowding J (1997) Protecting New Zealand Dotterels from predators. In: Sim J, Saunders A (eds) Proceedings of the predator workshop. Department of Conservation, Wellington, pp 65–67

Drilling N, Titman R, Mckinney F (2002) Mallard (*Anas platyrhynchos*). In: Poole A (ed) The birds of North America online. Cornell Lab of Ornithology, Ithaca

Duebbert HF, Kantrund HA (1974) Upland duck nesting related to land use and predator reduction. J Wildl Manag 38:257–265

Duebbert HF, Lokemoen JT (1980) High duck nesting success in a predator-reduced environment. J Wildl Manag 44:428–437

Dunnin JB Jr (1993) Handbook of avian body masses. CRC Press, Boca Raton

Edminster FC (1939) The effect of predator control on Ruffed Grouse populations in New York. J Wildl Manag 3:345–352

Ellis DH, Gee GF, Hereford SG et al (2000) Post-release survival of hand-reared and parent-reared Mississippi Sandhill Cranes. Condor 102:104–112

Empson RA, Miskelly CM (1999) The risks, costs, and benefits of using brodifacoum to eraticate rats from Kapiti Island, New Zealand. N Z J Ecol 23:241–254

Fisher HI (1975) Mortality and survival in the Laysan Albatross, *Diomedea immutabilis*. Pac Sci 29:279–300

Fleet RR (1972) Nesting success of the Red-Tailed Tropicbird on Kure Atoll. Auk 89:651–659

Flux IA, Powlesland RG, Dilks PJ et al (2001) Breeding, survival, and recruitment of Chatham Island Pigeon (*Hemiphaga chathamensis*). Notornis 48:177–206

Freed LA, Cann RL, Bodner GR (2008) Incipient extinction of a major population of the Hawaii Akepa owing to introduced species. Evol Ecol Res 10:931–965

Garnett ST, Pedler LP, Crowley GM (1999) The breeding biology of the Glossy Black-Cockatoo *Calyptorhynchus lathami* on Kangaroo Island, South Australia. Emu 99:262–279

Garretson PR, Rohwer FC, Zimmer JM et al (1996) Effects of mammalian predator removal on waterfowl and non-game birds in North Dakota. In: Wadsworth KG, McCabe RE (eds) Transactions of the 61st North American wildlife and natural resource conference, Tulsa, Oklahoma

Good TP (2002) Breeding success in the Western Gull × Glaucous-winged Gull complex: the influence of habitat and nest-site characteristics. Condor 104:353–365

Greenwood RJ (1986) Influence of striped skunk removal on upland duck nest success in North Dakota. Wildl Soc Bull 14:6–11

Greenwood RJ, Arnold PM, McGuire BG (1990) Protecting duck nests from mammalian predators with fences, traps, and a toxicant. Wildl Soc Bull 18:75–82

Guthery FS, Beasom SL (1977) Responses of game and nongame wildlife to predator control in South Texas. J Range Manag 30:404–409

Haney JC, Lee DS, Morris RD (1999) Bridled Tern (*Sterna anaethetus*). In: Poole A (ed) The birds of North America online. Cornell Lab of Ornithology, Ithaca

Harding EK, Doak DF, Albertson JD (2001) Evaluating the effectiveness of predator control: the non-native red fox as a case study. Conserv Biol 15:1114–1122

Harper GA (2007) Detecting predation of a burrow-nesting seabird by two introduced predators, using stable isotopes, dietary analysis and experimental removals. Wildl Res 34:443–453

Haselmayer J, Jamieson IG (2002) Increased predation on pukeko eggs after the application of rabbit control measures. N Z J Ecol 25:89–93

Haskell DG (1995) Forest fragmentation and nest predation: are experiments with Japanese quail eggs misleading? Auk 112:767–770

Howald G, Donlan CJ, Faulkner K et al (2009) Eradication of black rats from Anacapa Island. Oryx 44:30–40

Igual JM, Forero MG, Gomez T et al (2006) Rat control and breeding performance in Cory's Shearwater (*Calonectris diomedea*): effects of poisoning effort and habitat features. Anim Conserv 9:59–65

Igual JM, Forero MG, Gomez T et al (2007) Can an introduced predator trigger an evolutionary trap in a colonial seabird? Biol Conserv 137:189–196

Imber MJ (1975) Petrels and predators. Bull Int Counc Bird Preserv 12:260–263

Imber M, Harrison M, Harrison J (2000) Interactions between petrels, rats and rabbits on Whale Island, and effects of rat and rabbit eradication. N Z J Ecol 24:153–160

Imber M, West JA, Cooper WJ (2003) Cook's Petrel (*Pterodroma cookii*) historic distribution, breeding biology and effects of predators. Notornis 50:221–230

Innes J, Hay R, Flux I et al (1999) Successful recovery of North Island Kokako *Callaeas cinerea wilsoni* populations, by adaptive management. Biol Conserv 87:201–214

Innes J, Nugent G, Prime K et al (2004) Responses of Kukupa (*Hemiphaga novaeseelandiae*) and other birds to mammal pest control at Motatau, Northland. N Z J Ecol 28:73–81

Isaksson D, Wallander J, Larsson M (2007) Managing predation on ground-nesting birds: the effectiveness of nest exclosures. Biol Conserv 136:136–142

Jackson DB (2001) Experimental removal of introduced hedgehogs improves wader nest success in the Western Isles, Scotland. J Appl Ecol 38:802–812

Jenouvrier S, Tavecchia G, Thibault J-C et al (2008) Recruitment processes in long-lived species with delayed maturity: estimating key demographic parameters. Oikos 117:620–628

Jones C (2002) A model for the conservation management of a 'secondary' prey: Sooty Shearwater (*Puffinus griseus*) colonies on mainland New Zealand as a case study. Biol Conserv 108:1–12

Jones AG, Chown SL, Gaston KJ (2003) Introduced house mice as a conservation concern on Gough Island. Biodivers Conserv 12:2107–2119

Jones HP, Tershy BR, Zavaleta ES et al (2008) Severity of the effects of invasive rats on seabirds: a global review. Conserv Biol 22:16–26

Jouventin P, Bried J, Micol T (2003) Insular bird populations can be saved from rats: a long-term experimental study of White-chinned Petrels *Procellaria aequinoctialis* on Ile de la Possession (Crozet archipelago). Polar Biol 26:371–378

Kauhala K (2004) Removal of medium-sized predators and the breeding success of ducks in Finland. Folia Zool 53:367–378

Keedwell RJ, Maloney RF, Murray DP (2002) Predator control for protecting kaki (*Himantopus novaezelandiae*)—lessons from 20 years of management. Biol Conserv 105:369–374

Keitt BS, Tershy BR (2003) Cat eradication significantly decreases shearwater mortality. Anim Conserv 6:307–308

Keitt BS, Wilcox C, Tershy BR et al (2002) The effect of feral cats on the population viability of Black-vented Shearwaters (*Puffinus opisthomelas*) on Natividad Island, Mexico. Anim Conserv 5:217–223

Kelly D, Brindle C, Ladley JJ et al (2005) Can stoat (*Mustela erminea*) trapping increase Bellbird (*Anthornis melanura*) populations and benefit mistletoe (*Peraxilla tetrapetala*) pollination? N Z J Ecol 29:69–82

Koenen MT, Utych RB, Leslie DM Jr (1996) Methods used to improve least tern and Snowy Plover nesting success on alkaline flats. J Field Ornithol 67:281–291

Kruse CD, Higgins KF, Vander Lee BA (2001) Influence of predation on Piping Plover, *Charadrills melodus*, and Least Tern, *Sterna antillarum*, productivity along the Missouri River in South Dakota. Can Field-Nat 115:480–486

LaGrange TG, Hansen JL, Andrews RD et al (1995) Electric fence predator exclosure to enhance duck nesting: a long-term case study in Iowa. Wildl Soc Bull 23:261–266

Larson MA, Ryan MR, Murphy RK (2002) Population viability of Piping Plovers: effects of predator exclusion. J Wildl Manag 66:361–371

Leif AP (1994) Survival and reproduction of wild and pen-reared Ring-Necked Pheasant hens. J Wildl Manag 58:501–506

Lepson JK, Woodworth BL (2002) Hawaii Creeper (*Oreomystis mana*). In: Poole A (ed) The birds of North America online. Cornell Lab of Ornithology, Ithaca

Littlefield CD (2003) Sandhill Crane nesting success and productivity in relation to predator removal in southeastern Oregon. Wilson Bull 115:263–269

Lokemoen JT, Woodward RO (1993) An assessment of predator barriers and predator control to enhance duck nest success on peninsulas. Wildl Soc Bull 21:275–282

Lokemoen JT, Doty HA, Sharp DE et al (1982) Electric fences to reduce mammalian predation on waterfowl nests. Wildl Soc Bull 10:318–323

Lokemoen JT, Schnaderbeck RW, Woodward RW (1987) Increasing waterfowl production on points and islands by reducing mammalian predation. In: Great plains wildlife damage control workshop proceedings, University of Nebraska, Lincoln

Lorvelec O, Pascal M (2005) French attempts to eradicate non-indigenous mammals and their consequences for native biota. Biol Invasions 7:135–140

Ludwig JP, Summer CL, Auman HJ et al (1998) The roles of organochlorine contaminants and fisheries bycatch in recent population changes of Black-footed and Laysan Albatrosses in the North Pacific Ocean. Surrey Beatty & Sons, Chipping Norton

Mabee TJ, Estelle VB (2000) Assessing the effectiveness of predator exclosures for plovers. Wilson Bull 112:14–20

Marchant S, Higgins PJ (1990) Handbook of Australian, New Zealand and Antarctic birds. Oxford University Press, Oxford

Marcstrom V, Kenward RE, Engren E (1988) The impact of predation on boreal Tetraonids during vole cycles: an experimental study. J Anim Ecol 57:859–872

Martins TLF, Brooke ML, Hilton GM et al (2006) Costing eradications of alien mammals from islands. Anim Conserv 9:439–444

Massey BW, Bradley DW, Atwood JL (1992) Demography of a California Least Tern colony including effects of the 1982–1983 El Niño. Condor 94:976–983

Mavor RA, Parsons M, Huebeck M et al (2006) Seabird numbers and breeding success in Britain and Ireland, 2005. UK Nature Conservation No. 30

Mayer PM, Ryan MR (1991) Electric fences reduce mammalian predation on Piping Plover nests and chicks. Wildl Soc Bull 19:59–63

Mclean GL (1985) Robert's birds of Southern Africa. John Voelcker Bird Book Fund, Cape Town

Meckstroth AM, Miles AK (2005) Predator removal and nesting waterbird success at San Francisco Bay, California. Waterbirds 28:250–255

Melvin SM, MacIvor LH, Griffin CR (1992) Predator exclosures: a technique to reduce predation at Piping Plover nests. Wildl Soc Bull 20:143–148

Millus SA, Stapp P, Martin P (2007) Experimental control of a native predator may improve breeding success of a threatened seabird in the California Channel Islands. Biol Conserv 138:484–492

Mínguez E, Oro D (2003) Variations in nest mortality in the European Storm Petrel *Hydrobates pelagicus*. Ardea 91:113–117

Minsky D (1980) Preventing fox predation at a least tern colony with an electric fence. J Field Ornithol 51:180–181

Moore PJ (2009) Chatham Island oystercatcher (*Haematopus chathamensis*) management techniques: guidelines for protecting nests and increasing their productivity. Department of Conservation Technical Series 35, Wellington, pp 1–50

Moorehouse R, Greene T, Dilks PJ et al (2003) Control of introduced mammalian predators improves Kaka Nestor meridionalis breeding success: reversing the decline of a threatened New Zealand parrot. Biol Conserv 110:33–44

Moors PJ, Atkinson IAE (1984) Predation on birds by introduced animals, and factors affecting its severity. Cambridge

Morris WF, Doak DF (2002) Quantitative conservation biology: theory and practice of population viability analyses. Sinauer Associates Inc, Massachusetts

Mougin J-L, Jouanin C, Roux F (2000) Demographie du puffin cendré *Calonectris diomedea* de Selvagem Grande (30°09′N, 15°52′W). Rev Écol (la Terre et la Vie) 55:275–290

Murdoch W, Polasky S, Wilson K et al (2007) Maximizing return on investment in conservation. Biol Conserv 139:375–388

Murphy RK, Greenwood RJ, Ivan JS et al (2003) Predator exclusion methods for managing endangered shorebirds: are two barriers better than one? Waterbirds 26:156–159

Naidoo R, Balmford A, Ferraro PJ et al (2006) Integrating economic costs into conservation planning. Trends Ecol Evol 21:681–687

Neuman KK, Page GW, Stensel LE et al (2004) Effect of mammalian predator management on Snowy Plover breeding success. Waterbirds 27:257–276

Nisbet IC, Cam E (2002) Test for age-specificity in survival of the Common Tern. J Appl Stat 29:65–83

Nogales M, Martín A, Tershy BR et al (2004) A review of feral cat eradication on islands. Conserv Biol 18:310–319

Nol E, Brooks RJ (1982) Effects of predator exclosures on nesting success of Killdeer. J Field Ornithol 53:263–268

Norbury G, Barlow N (1998) Effects of RHD-induced rabbit declines and predator trapping on predation of banded dotterels. Paper presented at the conference of the NZ Ecological Society and Ecological Society of Australia. Dunedin, New Zealand

Norbury G, Heyward R (2008) Predictors of clutch predation of a globally significant avifauna in New Zealand's braided river ecosystems. Anim Conserv 11:17–25

Norman FI (1970) The effects of sheep on the breeding success and habitat of the Short-tailed Shearwater, *Puffinus tenuirostris* (Temminck). Aust J Zool 18:215–229

O'Donnell CFJ, Dilks PJ, Elliott GP (1996) Control of a stoat (*Mustela erminea*) population irruption to enhance Mohua (Yellowhead) (*Mohoua ochrocephala*) breeding success in New Zealand. N Z J Zool 23:279–286

Oro D, de Leon A, Furness RW (2005) Estimating predation on breeding European Storm-petrels (*Hydrobates pelagicus*) by Yellow-legged Gulls (*Larus michahellis*). J Zool 265:535–548

Parr R (1993) Nest predation and numbers of Golden Plovers *Pluvialis apricaria* and other moorland waders. Bird Study 40:223–231

Pascal M, Brithmer R, Lorvelec O et al (2004) Conséquences sur l'avifaune nicheuse de la Réserve Naturelle des Îlets de Sainte-Anne (Martinique) de la récente invasion du rat noir (*Rattus rattus*) établies à l'issue d'une tentative d'éradication. Rev Écol (la Terre et la Vie) 59:309–318

Pascal M, Lorvelec O, Bretagnolle V et al (2008) Improving the breeding success of a colonial seabird: a cost-benefit comparison of the eradication and control of its rat predator. Endanger Species Res 4:267–276

Paton PWC (1994) Survival estimates for Snowy Plovers breeding at Great Salt Lake, Utah. Condor 96:1106–1109

Pauliny A, Larsson M, Blomqvist D (2008) Nest predation management: effects on reproductive success in endangered shorebirds. J Wildl Manage 72:1579–1583

Peach WJ, Thompson PS, Coulson JE (1994) Annual and long-term variation in the survival rates of British Lapwings *Vanellus vanellus*. J Anim Ecol 63:60–70

Pearse AT, Ratti JT (2004) Effects of predator removal on Mallard duckling survival. J Wildl Manag 68:342–350

Pierce RJ (1986) Differences in susceptibility to predation during nesting between Pied and Black Stilts (*Himantopus* spp.). Auk 103:273–280

Pierce RJ (2002) Kiore (*Rattus exulans*) impact on breeding success of Pycroft's Petrels and Little Shearwaters. DOC Science Internal Series 39, Wellington

Piersma T, Rogers KG, Boyd H et al (2005) Demography of Eurasian Golden Plovers *Pluvialis apricaria* staging in The Netherlands, 1949–2000. Ardea 93:49–64

Powlesland RG, Knegtmans JW, Marshall ISJ (1999) Costs and benefits of aerial 1080 possum control operations using carrot baits to North Island Robins (*Petroica australis longipes*), Pureora Forest Park. N Z J Ecol 23:149–159

Powlesland RG, Wills DE, August ACL et al (2003) Effects of a 1080 operation on Kaka and Kereru survival and nesting success, Whirinaki Forest Park. N Z J Ecol 27:125–137

Priddel D, Wheeler R (1997) Efficacy of fox control in reducing the mortality of released captive-reared Malleefowl, *Leipoa ocellata*. Wildl Res 24:469–482

Quillfeldt P, Schenk I, McGill R et al (2008) Introduced mammals coexist with seabirds at New Island, Falkland Islands: abundance, habitat preferences, and stable isotope analysis of diet. Polar Biol 31:333–349

Ratz H, Darby JT, Edge K et al (2004) Survival and breeding of Yellow-eyed Penguins (*Megadyptes antipodes*) at two locations on Otago Peninsula, South Island, New Zealand, 1991–96. N Z J Zool 31:133–147

Rayner MJ, Hauber ME, Imber MJ et al (2007) Spatial heterogeneity of mesopredator release within an oceanic island system. Proc Natl Acad Sci 104:20862–20865

Reed C (1998) Review of Black Stilt management data (1981–1995). Conservation Advisory Science Notes No. 175, Wellington

Richdale LE (1957) A population study of Penguins. Oxford University Press, London

Rimmer DW, Deblinger RD (1990) Use of predator exclosures to protect Piping Plover nests. J Field Ornithol 61:217–223

Rimmer DW, Deblinger RD (1992) Use of fencing to limit terrestrial predator movements into Least Tern colonies. Colon Waterbirds 15:226–229

Robertson CJR (1998) Factors influencing the breeding performance of the Northern Royal Albatross. Surrey Beatty & Sons, Chipping Norton

Robertson HA, Saul EK (2007) Conservation of Kakerori (*Pomarea dimidiata*) in the Cook Islands in 2006/07. In: Clelland L (ed) DOC research & development series 296. Department of Conservation, Wellington

Robertson HA, Hay JR, Saul EK et al (1994) Recovery of the Kakerori: an endangered forest bird of the Cook Islands. Conserv Biol 8:1078–1086

Rodríguez C, Torres R, Drummond H (2006) Eradicating introduced mammals from a forested tropical island. Biol Conserv 130:98–105

Rohwer FC, Garretson PR, Mense BJ (1997) Can predator trapping improve waterfowl recruitment in the prairie pothole region? In: Eastern wildlife damage management conference, Lincoln, Newbraska, pp 12–22

Rohwer FC, Johnson WP, Loos ER (2002) Blue-winged Teal (*Anas discors*). In: Poole A (ed) The birds of North America online. Cornell Lab of Ornithology, Ithaca

Roper JJ (1992) Nest predation experiments with Quail eggs: too much to swallow? Oikos 65:528–530

Sargeant AB, Kruse AD, Afton AD (1974) Use of small fences to protect ground bird nests from mammalian predators. Prairie Nat 6:60–63

Sargeant AB, Sovada MA, Shaffer TL (1995) Seasonal predator removal relative to hatch rate of duck nests in waterfowl production areas. Wildl Soc Bull 23:507–513

Schaffner FC (1991) Nest-site selection and nesting success of White-tailed Tropicbirds (*Phaethon lepturus*) at Cayo Luís Peña, Puerto Rico. Auk 108:911–922

Schönwetter M (1967) Handbuch der Oologie. Akademie, Verlag, Berlin

Schreiber EA, Doherty PF Jr, Schenk GA (2001) Effects of a chemical weapons incineration plant on Red-Tailed Tropicbirds. J Wildl Manag 65:685–695

Seto NWH, Conant S (1996) The effects of rat (*Rattus rattus*) predation on the reproductive success of the Bonin Petrel (*Pterodroma hypoleuca*) on Midway Atoll. Colon Waterbirds 19:171–185

Shields M (2002) Brown Pelican (*Pelecanus occidentalis*). In: Poole A (ed) The birds of North America online. Cornell Lab of Ornithology, Ithaca

Small RJ, Holzwart JC, Rusch DH (1991) Predation and hunting mortality of Ruffed Grouse in central Wisconsin. J Wildl Manag 55:512–520

Smith KA, Murphy RK, Michaelson DL et al (1993) Habitat and predation management for nesting piping plovers at Lostwood National Wildlife Refuge, North Dakota. Prairie Nat 25:139–147

Spear LB, Penniman TM, Penniman JF et al (1987) Survivorship and mortality factors in a population of Western Gulls. Stud Avian Biol 10:44–56

Tacha TC, Nesbitt SA, Vohs PA (1992) Sandhill Crane (*Grus canadensis*). In: Poole A (ed) The birds of North America online. Cornell Lab of Ornithology, Ithaca

Tapper SC, Potts GR, Brockless MH (1996) The effect of an experimental reduction in predation pressure on the breeding success and population density of Grey Partridges *Perdix perdix*. J Appl Ecol 33:965–978

Taylor GA (2000) Action plan for seabird conservation in New Zealand. Wellington, New Zealand

Thibault J-C (1995) Effect of predation by the black rat *Rattus rattus* on the breeding success of Cory's Shearwater *Calonectris diomedea* in Corsica. Mar Ornithol 23:1–10

Thomson DL, Monaghan P, Furness RW (1998) The demands of incubation and avian clutch size. Biol Rev 73:293–304

Towns DR, Atkinson IAE, Daugherty CH (2006) Have the harmful effects of introduced rats on islands been exaggerated? Biol Invasions 8:863–891

Twedt DJ, Crawford RD (1995) Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*). In: Poole A (ed) The birds of North America online. Cornell Lab of Ornithology, Ithaca

van Rensburg PJJ, Bester MN (1988) The effect of cat *Felis catus* predation on three breeding Procellariidae species on Marion Island. S Afr J Zool 23:301–305

Wanless RM, Angel A, Cuthbert RJ et al (2007) Can predation by invasive mice drive seabird extinctions? Biol Lett 3:241–244

Wanless RM, Ryan PG, Altwegg A et al (2009) From both sides: dire demographic consequences of carnivorous mice and longlining for the Critically Endangered Tristan albatrosses on Gough Island. Biol Conserv 142:1710–1718

Ward DH, Rexstad EA, Sedinger JS et al (1997) Seasonal and annual survival of adult Pacific Brant. J Wildl Manag 61:773–781

Ward DH, Schmutz JA, Sedinger JS et al (2004) Temporal and geographic variation in survival of juvenile Black Brant. Condor 106:263–274

Warnock ND, Gill RE (1996) Dunlin (*Calidris alpina*). In: Poole A (ed) The birds of North America online. Cornell Lab of Ornithology, Ithaca

Waugh SM, Doherty PF Jr, Freeman SN et al (2006) Demography of Westland Petrels (*Procellaria westlandica*), 1995–2003. Emu 106:219–226

Weimerskirch H, Jouventin P (1998) Changes in population sizes and demographic parameters of six albatross species breeding on the French sub-Antarctic islands. Surrey Beatty & Sons, Chipping Norton

Whitehead AL, Edge K-A, Smart AF et al (2008) Large scale predator control improves the productivity of a rare New Zealand riverine duck. Biol Conserv 141:2784–2794

Whitworth DL, Carter HR, Young RJ et al (2005) Initial recovery of Xantus's Murrelets following rat eradication on Anacapa Island, California. Mar Ornithol 33:131–137

Wilcox C, Donlan CJ (2007) Compensatory mitigation as a solution to fisheries bycatch—biodiversity conservation conflicts. Front Ecol Environ 5:325–331

Wilcox C, Donlan CJ (2009) Need for a clear and fair evaluation of biodiversity offsets for fisheries bycatch. Conserv Biol 23:770–772

Woodward PW (1972) The natural history of Kure Atoll, Northwestern Hawaiian Islands. Atoll Res Bull 164:296–298

Zino F, Oliveira P, King S et al (2001) Conservation of Zino's Petrel *Pterodroma madeira* in the archipelago of Madeira. Oryx 35:128–136

Zino F, Hounsome MV, Buckle AP et al (2008) Was the removal of rabbits and house mice from Selvagem Grande beneficial to the breeding of Cory's shearwaters *Calonectris diomedea* borealis? Oryx 42:151–154