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Review

A Review of the World's Active Seabird Restoration Projects

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ABSTRACT Within the past several decades, seabird populations have been actively restored in locales where they were reduced or extirpated. Chick translocation, acoustic vocalization playbacks, and decoys are now used widely to lure breeding seabirds to restoration sites. In this first worldwide review of seabird restoration projects we evaluate the factors affecting project success or failure and recommend future directions for management. We identified 128 active restoration projects that were implemented to protect 47 seabird species in 100 locales spanning 14 countries since active restoration methods were pioneered in 1973. Active seabird restoration can achieve conservation goals for threatened and endangered species, and for species affected by anthropogenic impacts (e.g., oil spills, invasive species, fisheries). It also can be used to relocate populations from undesired breeding locales to more favorable locations, and to establish multiple breeding locations to reduce risks posed by catastrophic events. Active restoration can help to restore ecological processes, as large seabird colonies function to cycle marine nutrients to terrestrial ecosystems and create habitats for commensal species. Active restoration is especially appropriate where the original causes of decline are no longer working to suppress colony establishment and growth. Successful restoration efforts require careful planning and long-term commitments. We introduce the different forms of active seabird restoration techniques, review their utility for different seabird species, and use case studies to suggest how to optimize this technique to restore seabird species globally. Wildlife managers can use this review to guide their seabird restoration projects in the planning, implementation, and monitoring stages; tailor their restoration to seabird-specific life histories; and identify areas for further research to improve restoration utility in the future.

KEY WORDS coloniality, philopatry, seabird reintroduction, seabird restoration, social attraction, social facilitation.

Nearly one-third of seabird species are threatened with extinction due to entanglement with fishing gear, reduction in marine food supplies, environmental contaminants, oil spills, overharvest (mostly of eggs and chicks), and introduction of invasive species that prey on seabirds or destroy their nesting habitat (International Union for Conservation of Nature [IUCN] 2009). Even species with large populations are at risk, especially where few colonies exist and ranges have contracted due to the effects of global climate change and ocean acidification (Croxall et al. 2002, Frederiksen et al. 2004). Active seabird restoration (hereafter, seabird restoration) programs expand existing colonies, restore historical populations, and help protect seabirds from further threats. Seabird restoration denotes efforts to actively restore seabirds through direct management interventions rather than allowing seabirds to passively recover following the removal of disturbance factors such as invasive mammals (Jones et al. 2011).

Seabird restoration efforts began in the 1970s with efforts to reestablish populations of Atlantic puffins (*Fratercula arctica*) that were eliminated from islands in the Gulf of Maine (Kress 1998). Since then, new restoration techniques have been implemented worldwide to encourage recolonization of seabird nesting colonies to their historical ranges, and to augment or translocate current breeding populations. Seabird restoration methods typically supplement the more conventional methods of eliminating invasive predators and managing habitat, because these activities alone may prove inadequate to reestablish colonies. Seabird restoration was primarily developed to restore populations where they were lost due to human exploitation or invasive species predation (Kress 1998). Restoration has since been applied to relocate seabird colonies when populations conflict with fisheries (Roby et al. 2002), or when they are vulnerable to effects of climate change (J. Madeiros, Bermuda Department of Conservation Services, personal communication), environmental dangers such as volcanism (Hasegawa and Watkinson 1982) and marine pollution (Parker et al. 2007). In this review, we consider 2 methods of restoration: chick translocation and social attraction.

Chick translocation refers to active movement of chicks to a new location, and is preferred for species that exhibit high natal site philopatry, do not exhibit post colony-departure care, or for those restoration projects without a nearby source colony. Most seabirds exhibit some degree of natal philopatry (Greenwood and Harvey 1982, Warham 1990), which

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makes them excellent candidates for translocation (Kress 1998). Although it is not fully understood when and how birds acquire their homing information, it is likely that seabird chicks imprint on their natal colony before becoming fledglings (Fisher 1971, Serventy et al. 1989). Therefore, most chick translocation projects translocate downy chicks to release sites and hand-rear them to fledging age. Hand-rearing methods are now well established for many seabird species, especially burrow nesters, leading to 100% fledging success in many cases (Miskelly et al. 2009). The translocated chicks return as adults to breed and often lure immigrant conspecifics to the restoration site, thereby increasing colony numbers (Kress 1978, Miskelly et al. 2009).

Chick translocation is labor intensive, expensive because of the need for either resident chick tending stewards or frequent visits to the translocated chicks, and is successful only for species with particular life history traits. Because adults are not moved with chicks (adults would readily abandon the restoration site), chicks must be fed with dietary supplements until they fledge. Therefore, chick translocation is limited to species that feed their chicks whole fish or those that depend on regurgitated meals (e.g., albatross and petrels). Species that feed their young after colony departure (e.g., terns, murres, razorbills, and precocial murrelets) are poor candidates for chick translocations.

Accordingly, a second method, social attraction, is often employed for species that are poor candidates for chick translocation. Social attraction aims to lure adult birds to restoration sites with the goal of establishing breeding colonies. More than 95% of seabirds are colonial, meaning they are attracted to breeding sites by the presence of conspecifics and other seabirds (Rolland et al. 1998). Coloniality makes seabirds excellent candidates for restoration because they can be lured using decoys (models of adults, chicks, and eggs), sound recordings, mirrors, scent, and artificial burrows, all of which replicate features of an established colony. These attractants are placed in suitable habitat usually within a few miles of an existing source colony. Social attraction can be used with chick translocations to increase the likelihood of success. Typically, acoustic playback of non-aggressive vocalizations, decoys, and other enticements that simulate the colony from a distance lure prospecting seabirds to new nesting habitat (Parker et al. 2007). Acoustic attraction can be used for both diurnal and nocturnal species, but decoys have been used only for diurnal species. Decoys sometimes are supplemented with mirrors to give the appearance of a larger colony and movement in the colony (Parker et al. 2007). As such, prospecting birds become living decoys that help to attract conspecifics. Acoustic playback has been used alone, or in combination with decoys and chick translocation to attract new breeders.

Despite the widespread implementation of seabird restoration techniques, the circumstances under which they are or are not successful have not been identified. We therefore conducted a search of the literature on seabird restoration to assess the success of projects with differing methodologies. Our goal was to collate information on seabird restoration projects globally, provide guiding principles for future seabird restoration projects, and identify case studies useful to demonstrate the advantages, challenges, and potential utility for seabird restoration.

APPROACH

We compiled data from peer-reviewed and unpublished literature about seabird restoration projects. We also searched Web of Science with the concatenated string of the following words: seabird AND social attraction AND facilitation AND decoy AND chick translocation AND restoration AND new colony. We then searched the cited literature in each of the manuscripts located for further applicable manuscripts. We relied on the authors' interpretations to judge whether or not a project was successful. If no author opinion was available, we considered a project successful if it attracted breeding seabirds and maintained or added to the number of breeding seabirds for at least 2 years.

To date, at least 128 seabird restoration projects have been implemented to protect 47 seabird species in 100 locales in 14 countries (Fig. 1; Supporting Information Appendix). Thirty-four percent (16 of 47) of the seabird species that have been targeted for restoration are near threatened if not critically endangered (Supporting Information Appendix). Of the projects where methodology was clearly described, 10 used only chick translocation, 8 used only decoys, and 14 used only acoustic playback to attract breeding seabirds. Nine projects used a combination of chick translocation and acoustic playback, 59 used a combination of decoys and acoustic playback, and 3 used a combination of chick translocation and decoys. Many projects were begun too recently to ascertain success or had incomplete information. We thus have incomplete success or failure data for 40 of the restoration projects.

Of the 88 projects where measures of success were available, 55 were deemed successful by the authors or by our criteria. Success rates varied among methodologies, with projects using only acoustic attraction, chick translocation, or decoys having 50% ($n = 7$ of 14), 100% ($n = 5$ of 5), and 29% ($n = 2$ of 7) success rates, respectively. Projects using some combination of all 3 methods had a 70% success rate (Fig. 2; $n = 41$ of 59). Although our results appear to show that adding decoys to translocation projects reduces success rate (Fig. 2), we believe that is an artifact of small sample size in the translocation-decoy category ($n = 3$), rather than a reflection of reality. Seabird families had differing success rates, with the highest success seen for procellarids (83% of projects successful), terns (67% of projects successful), and alcids (60% of projects successful) and the lowest success rate for Phalacrocoracidae (29% of projects successful; Table 1; Fig. 3). We chose some of the most consequential studies to demonstrate key considerations for designing effective seabird restoration programs.

CASE STUDIES

Pioneering Projects

The pioneering seabird restoration project began in 1973 and brought 954 Atlantic puffins over 12 years from

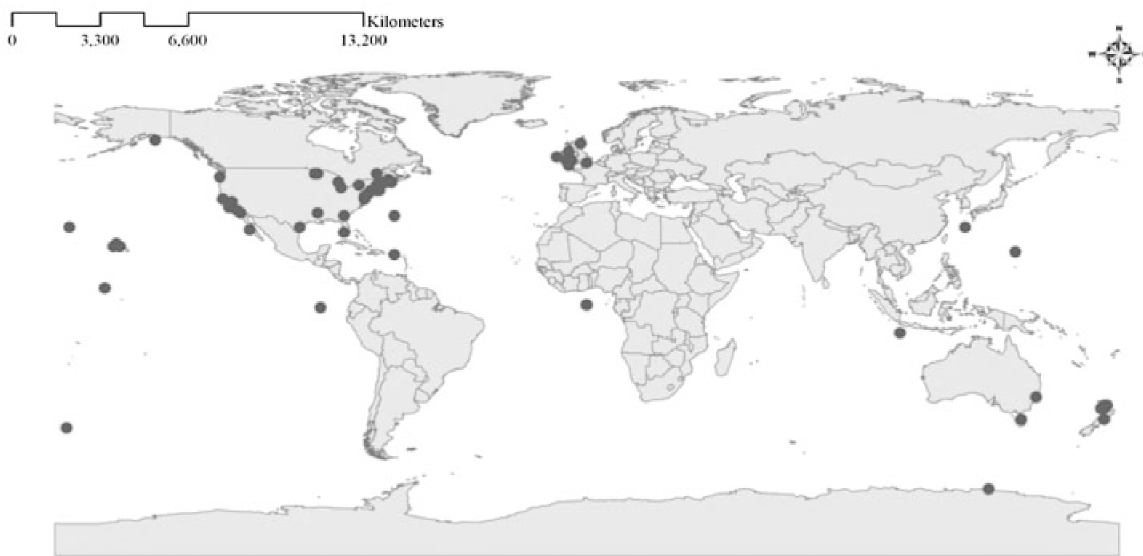

Figure 1. Worldwide locations (circles) of seabird restoration projects. Adapted from Jones et al. (2011).

Newfoundland to their historical nesting site on Eastern Egg Rock Island in Maine (Kress 1997). This project was the first to use decoys for attracting seabirds back to a historical nesting site. Nine hundred forty puffin chicks fledged and adult puffins began nesting on Eastern Egg Rock 8 years after translocation began. In 1981, 5 pairs nested, the first puffins to breed at Eastern Egg Rock in nearly 100 years (Kress and Nettleship 1988). The Eastern Egg Rock puffin colony has now reached 123 nesting pairs (Kress et al. 2009).

This project demonstrates the need for a program that includes 5 or more years of translocation cohorts and spans at least a decade to monitor the results. This project took 4 years for the first translocated puffin to return, 8 years for the first nesting attempt, and 35 years for the colony to reach 100 pairs. Returns from the transplant cohorts prior to 1977 were too small to form a colony. Consequently, if translocations had ended prior to the 1977 transplant cohort (in which 52 puffins returned and many eventually nested), it is unlikely

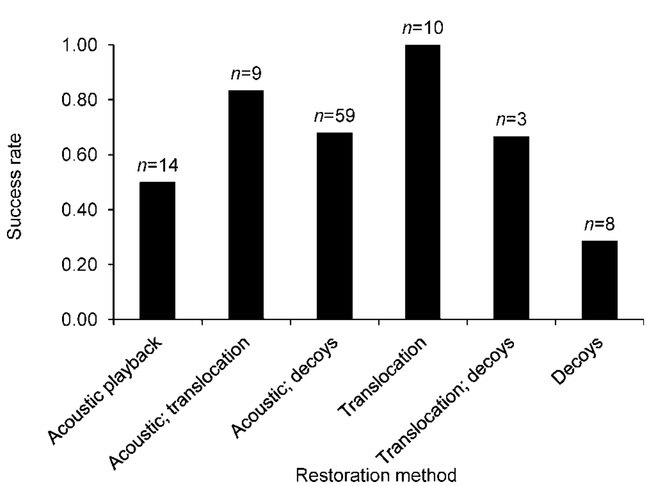

Figure 2. Success rate of seabird restoration projects as a function of methodology. Numbers above bars indicate the total number of projects used to calculate success rates.

that the project would have proved a success, as these colonists no doubt helped to attract additional breeders in subsequent years. Return rates varied widely among puffin cohorts (Fig. 4). Some of this variability may have resulted from advances in chick-rearing methodology during the project (e.g., designing burrows with suitable drainage), but it also may reflect variation in environmental factors affecting puffin survival. Both advances in chick rearing methods and variability in marine conditions during the project argue for multiple years of translocations to increase odds for success.

Puffins were not the only species that was lost from the Gulf of Maine in the 20th century. Tern (*Sterna* spp.) colonies used to be abundant around Maine, but hunting and gull predation drove terns to near extirpation by 1914 (Kress 1997). Terns have life histories that precluded the use of chick translocation so new restoration techniques had to be developed to restore them in the Gulf of Maine. In contrast to puffins, adult terns are not highly philopatric, feed their chicks at sea after fledging, and typically accompany their chicks to their wintering area. Therefore, the focal life stage for tern restoration is adults instead of chicks. To restore terns, their predators (nesting gulls [*Larus argentatus and L. marinus*]) were eliminated from Eastern Egg Rock in 1980 (Kress 1983). Managers then played acoustic non-aggressive tern vocalizations and deployed tern decoys to encourage adults to colonize and breed in high-quality habitat. Both arctic (*S. paradisaea*) and common (*S. hirundo*) terns were immediately observed landing in and around the decoys (Kress 1998). Common and arctic terns nested in 1980 and roseate terns (*S. dougallii*) joined the colony in 1981. By 2010, there were 714 pairs of common terns, 83 pairs of arctic terns, and 82 pairs of roseate terns breeding on the island (Kress et al. 2009). Twelve similar projects throughout the Gulf of Maine have restored nesting colonies with consistently high reproductive success (Kress et al. 2009; Supporting Information Appendix). All of these

Table 1. The number of seabird restoration projects characterized by both seabird family and method. Success rates for each combination are in parentheses. NA indicates insufficient data to calculate success rates.

	Acoustic	Acoustic and chick translocation	Acoustic and decoy	Chick translocation	Chick translocation and decoy	Decoy
Alcidae	2 (50)		4 (75)		3 (67)	2 (0)
Diomedeidae	2 (NA)	1 (NA)	1 (100)			
Hydrobatidae	7 (43)					
Laridae			1 (100)			
Pelecanoididae		2 (100)				
Phalacrocoracidae			7 (29)			
Procellariidae	3 (67)	6 (75)	2 (NA)	9 (100)		
Spheniscidae			1 (NA)			1 (100)
Sternidae	1 (100)		36 (76)			3 (33)
Sulidae			3 (NA)	1 (NA)	1 (NA)	1 (NA)

projects require ongoing management of tern predators and competitors and vegetation to ensure the terns' continued nesting success.

Other Seabird Restoration Projects

Many of the world's island ecosystems are dominated by seabirds. On such islands, large nesting colonies of seabirds provide an allochthonous nutrient subsidy through input of marine resource-based guano that enhances primary and secondary production in island food webs (Bancroft et al. 2005, Croll et al. 2005, Fukami et al. 2006, Jones 2010). Island managers now recognize the importance of seabird restoration not only for species preservation but also for restoring ecosystem functions (Miskelly 1999).

Mana Island, New Zealand, provides a case study where managers restored seabird populations specifically to promote ecosystem recovery through seabird-derived nutrients. Invasive species and agriculture led to the demise of seabird colonies on this island. Beginning in 1993, managers played common diving petrel (*Pelecanoides urinatrix*) calls continuously on Mana and transferred 239 chicks from a nearby source colony from between 1997 and 1999 (Miskelly and Taylor 2004). By 2004, 20 of these translocated petrel chicks had returned to Mana as well as 57 new immigrants. In 2008, at least 10 pairs were known to be nesting, and as many as 18 pairs have nested in recent years (Miskelly et al. 2009).

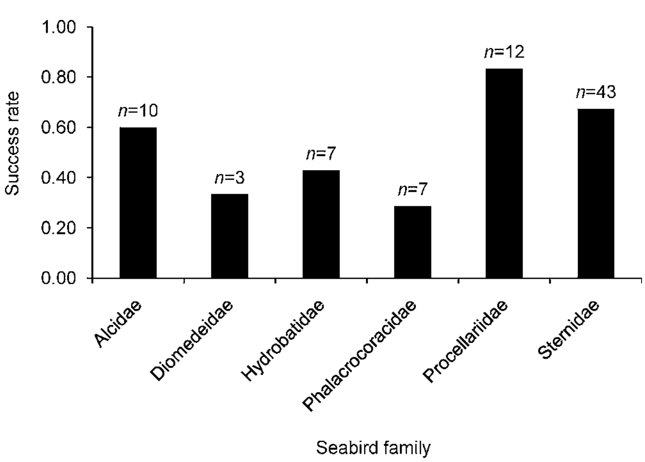

Figure 3. Success rate of seabird restoration projects as a function of seabird family. Numbers above bars indicate the total number of projects used to calculate success rates.

Similar chick translocations were undertaken to establish fairy prions (*Pachyptila turtur*) and fluttering shearwaters (*Puffinus gavia*) from 2002 to 2008. Both species have returned and bred in small numbers (C. Miskelly, Museum of New Zealand Te Papa Tongarewa, personal communication), and many more shearwater returns are expected as it takes from 5 to 10 years for individuals to reach reproductive maturity (Bell et al. 2005).

Many social attraction projects (usually combining acoustic playback with display of decoys) have added to the pioneering projects described above (Supporting Information Appendix). One of the biggest successes was the relocation of an entire colony of about 9,000 breeding pairs of Caspian terns (*Hydroprogne caspia*) to East Sand Island in the Columbia River estuary. Previously, there were around 4 smaller colonies along the Washington coast. However, in 1997, biologists discovered that over 7,000 pairs of Caspian terns had abandoned their previous nesting sites to nest on Rice Island, where terns were first noted nesting in 1986. This presented 2 problems: 1) A catastrophic event could wipe out two-thirds of the North American west coast population of Caspian terns; and 2) the terns were feeding on threatened or endangered populations of salmon and steelhead smolts as well as large numbers of hatchery-reared smolts (Collis et al. 2002, Roby et al. 2002).

Federal resource managers began a program in 1999 to prepare an alternative historical nesting site 21 km west of Rice Island on East Sand Island. It was hoped the terns could

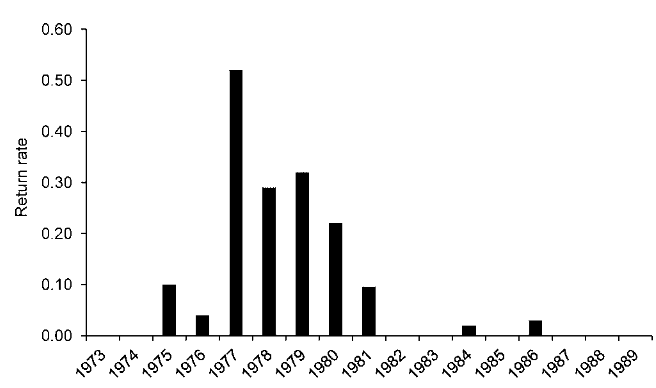

Figure 4. Return rate versus cohort year for Atlantic puffins translocated to Eastern Egg Rock, Maine from 1973 to 1985.

find a greater variety of prey species, and specialize less on fish species of conservation concern on East Sand Island. To encourage colonization, managers removed vegetation to expose underlying sand (bare sand is the preferred nesting habitat for Caspian terns) and then installed an acoustic sound system surrounded by 380 Caspian tern decoys. Within 2 years, the entire colony moved to East Sand Island, where their diets were composed of only 33% salmon and steelhead versus 74–90% in previous years when the colony was on Rice Island (Roby et al. 2002, D. Roby, Oregon State University, personal communication). Because this still left the single large colony vulnerable to a catastrophic event, the Army Corps of Engineers built artificial islands for the terns to nest on throughout Washington, which ultimately increased the number of Caspian tern breeding colonies (D. Roby, personal communication).

Managers often conduct pilot studies to address particular issues with the focal seabird species. For example, a study on the feeding frequency, meal size, and chick growth of Pycroft's petrel (*Pterodroma pycrofti*) ensured petrel chicks were fed an adequate diet upon translocation (Gangloff and Wilson 2004). Likewise, a study of prospecting Laysan albatross (*Phoebastria immutabilus*) at Kilauea Point, Hawaii tested the effects of decoys in different postures and dimensions with and without acoustic playback of vocalizations on prospecting bird behavior. The study showed that decoys and vocalizations used together were most effective at attracting prospecting birds and that 3-dimensional decoys in sky-pointing postures were the most effective decoys (Podolsky 1990). Pilot studies such as these illustrate an important first step to any seabird restoration project because they ensure restoration efforts are tailored to the focal species and restoration location.

DISCUSSION

Many seabird species are threatened with extinction (IUCN 2009). Life histories of delayed age to maturity, low reproductive rates, Allee effects, high natal philopatry, and high colony fidelity make establishing new seabird colonies challenging. Despite these odds, many successful projects demonstrate that it is possible to restore seabird populations using chick translocation and social attraction. Given the need to expand ranges and establish multiple breeding sites for threatened seabirds, these restoration techniques offer an encouraging future for rare species whose populations have declined, whose ranges have contracted, or who have lost important nesting sites. It is especially encouraging that 2 of the 4 most threatened seabird families (alcids and procellarids, based on number of species threatened per family, IUCN 2009) show the highest seabird restoration success rates.

Unfortunately, much of the information on seabird restorations remains unpublished or difficult to access (only 13 papers cited out of 29 in the Supporting Information Appendix were in peer-reviewed journals or books). This resulted in substantial data gaps in some cases (Supporting Information Appendix). Despite this general lack of data, several factors affecting the success or failure of seabird restoration projects can be identified. Kress (1997, 1998) reviewed many of these, but the most important issues seem to be: 1) the original cause of decline or extirpation is abated, 2) funding is guaranteed for many years, 3) adequate life history research is conducted to understand the habitat requirements and breeding ecology of focal species, and 4) pilot studies are conducted to determine which restoration methods are most effective for the focal species. In particular, chick translocation can only be used for species that are highly philopatric, have diets that are easy to replicate, and do not feed their young after leaving the nesting colony (e.g., many procellarids, some alcids, and albatross). Social attraction decoys can only be used for diurnal species that use visual cues for breeding (e.g., terns, albatross, and boobies) whereas acoustic attraction can be effective for both diurnal and nocturnal species.

Failures are often more instructive than successes for developing restoration techniques, yet very few examples of failures are published in the literature. For example, attempts to start colonies of Australasian gannet (*Morus serrator*) in New Zealand (Mana Island) and northern gannet (*Morus bassanus*) in Maine, Nova Scotia, and Quebec failed, but a restoration project using decoys and sound playback for Australasian gannets at Young Nick's Head, New Zealand achieved colonization (S. Sawyer, Ecoworks New Zealand, personal communication). In this case, the proximity of a nearby large, expanding colony apparently provided enough potential colonists. In contrast, the failed gannet restoration projects for both northern and Australasian gannet attempted to start colonies far from source colonies, underscoring the importance of distance to source colonies in restoration projects.

Some seabird taxa (Sulidae, Pelecanidae, Phaethontidae, Fregatidae) are either rarely targeted or have not yet been targeted for seabird restoration. This is likely an artifact of there being relatively few species in these families ($n = 11, 7, 3, 5$ species, respectively) compared to more commonly targeted families (e.g., Alcidae, Procellariidae, Sternidae; $n = 24, 82, 45$ species, respectively) rather than seabird restoration being ineffective or more difficult for these species. In contrast, some other taxa are well represented in seabird restoration efforts. Terns in particular are often actively restored for several reasons. First, they show relatively little natal philopatry and often feed their young after they leave the colony. This makes social attraction the only option for restoring them. Social attraction is less expensive than translocations, and may result in signs of success more quickly because it focuses on adults rather than waiting years for chicks to reach breeding age. Second, terns are very responsive to decoys and playbacks so tern restoration projects nearly always lead quickly to success, a delight to managers and funders. Third, the same agencies conduct many tern projects, and local success encourages other agencies to carry out similar projects. Lastly, terns are umbrella species, which means that when they are restored, other species often follow, in part because tern restoration typically means setting up resident camps that can deter avian and mammalian predators, and other seabird species benefit from this protection.

Alcids, procellarids, and terns have relatively high restoration success rates whereas projects targeting gannets, storm-petrels, and cormorants are less often successful. Such failures may in part be related to local factors such as long distances to source populations and the small number of projects. Some successful projects with these latter groups suggest that local conditions and methodology are especially important (Table 1; Fig. 3). New methods may help to increase success rates. For example, luring storm-petrels (and other tube-nosed seabirds) with scent could increase colonization since they use olfactory senses to forage, navigate, and locate their nests (Minguez 1997, Nevitt 2000). More research on this attraction method would be valuable for future attempts to restore storm-petrels and other Procellariiformes populations.

The Importance of Habitat Suitable for Nesting

Habitat has been shown to be a key factor in establishing new seabird colonies (Kildaw et al. 2005). Different seabird species have different nesting habitats including burrows, crevices, ground-surface, vegetation, and trees. So, depending on the focal seabird species, artificial or enhanced habitat may be needed to establish a colony. Some ground-nesting species, such as terns, require active intervention to produce their preferred low-growing vegetation for nesting (Dunlop et al. 1991, Kress et al. 2008).

Artificial burrows are some of the most common modifications to nesting habitat and are typically used in chick translocations. Usually, artificial burrows are hand excavated into soil or consist of artificial wooden or plastic burrows placed in suitable habitat. Such burrows typically have a door on their top so that researchers can readily check the burrow for productivity and growth studies.

Predator and Competitor Control

Islands are generally devoid of land-based predators in their natural states, and most seabirds have therefore evolved in the absence of land-based predators and lack the defense mechanisms required to avoid predation (Igual et al. 2007). Predator-naivety makes seabirds particularly vulnerable to predation so seabird restoration projects should ensure restoration sites are free from invasive predators. If predators cannot be removed, predator-proof nesting structures or areas may be required to protect breeding seabirds (e.g., Chatham petrels [*Pterodroma axillaris*] in New Zealand; Miskelly et al. 2009).

Although over 300 predator eradications have been conducted, often costing millions of dollars (Nogales et al. 2004, Donlan and Wilcox 2007, Howald et al. 2007), relatively few of these projects have been followed with seabird restoration (Jones et al. 2011). Seabirds fail to return to breed on many islands because of natal philopatry or a continued perceived predation risk (Gaze 2000). In the absence of these nutrient vectors, managers may not be meeting their goal of island restoration to pre-invasion states (Mulder et al. 2009, Jones 2010). Seabird restoration can thus be a catalyst for recovery of entire ecosystems because seabirds play integral roles in maintaining trophic interactions and nutrient cycling on breeding islands (Croll et al. 2005, Fukami et al. 2006, Kurle et al. 2008). Seabird restoration could be efficiently implemented in conjunction with predator eradications because both require similar infrastructure, logistics, and staff coordination. Moreover, if the goal of eradicating predators is ecosystem recovery, restoring seabirds will be a critical step to reaching that goal and could be considered as part of eradication project budgets. This would be an important step forward for both eradication and seabird restoration projects and could bring new funding sources to both efforts.

Native avian predators such as gulls and owls may also need to be actively removed or relocated far from the capture site if they aggressively hunt restoration species (Kress et al. 2008). For example, even a single great horned owl (*Bubo virgianianus*) or black-crowned night-heron (*Nycticorax nycticorax*) can cause common and roseate tern colonies to abandon their eggs and chicks at night, exposing them to extreme climates and increased risk of predation (Shealer and Kress 1991). Newly restored colonies are especially vulnerable to predators as they are typically small, such that even minimal predation can prevent colonies from being established.

Gull populations have been steadily increasing due to anthropogenic food sources (Weiser and Powell 2010) and their expansion often hinders restoration of other seabird species (Jones et al. 2011). Gulls compete for nesting habitat and also prey on some seabird species' eggs, chicks, and adults, and are thus a principal threat to colony establishment where they are abundant (Kress 1983, Anderson and Devlin 1999). For these reasons, where large gulls are abundant, gull control is usually the first step to seabird restoration (Blokpoel et al. 1997, Kress 1998). Even after successful restoration projects, ongoing gull control may be necessary to maintain restored populations (Blokpoel et al. 1997). Gull control may be the only action necessary to reestablish populations that have been eliminated by gull predation or competition (Anderson and Devlin 1999). Management to reduce the effects of growth of invasive vegetation, levels of chronic human disturbance, and effects of climate change such as ocean level rise may be required in other cases.

Defining Success

Definitions of seabird restoration success vary between specific projects, stages of projects, and methodology. For example, chick translocations may be considered successful if most chicks fledge at the restoration site. However, the program would only be successful if translocated birds returned to breed. For social attraction with decoys and acoustics, projects may be considered successful at early stages when adults begin prospecting among decoys, eggs are laid, and chicks fledge successfully. Early indicators of success (especially during the prospecting stage) are difficult to measure without resident observers. Success indicators are especially difficult to measure for nocturnal species, but they are important early predictors of the outcome of a program.

Realistic timelines should be used to calculate budgets and predict the time needed for employing personnel. Projects are often time and staff-intensive in the beginning (e.g., when translocating and feeding chicks, setting up decoys, and setting up speakers), and require less time and effort later on (e.g., the time between when chicks fledge and return to breed for chick translocation projects or non-breeding time for social facilitation projects). In this review, we used nesting for at least 2 years as a minimum criterion for a successful restoration project, but emphasize the need to have ongoing measurements of success that ideally should span decades rather than years.

We suggest that the ultimate measure of success for any seabird restoration program is when a restored population reaches a self-sustaining population. Only a demographic study can evaluate whether success has been achieved, and the data for such studies are often lacking. The Mana Island diving petrel population is a successfully growing colony (Miskelly et al. 2009) and many of the projects we reviewed (Supporting Information Appendix) continue to grow without further intervention. For other projects, ongoing habitat and predator management may be necessary to manage invasive vegetation, human disturbance or human-subsidized predator populations. These programs should be considered successful in terms of consistent nesting success. Many projects we reviewed meet this criterion and can be considered successful, although some are in such early stages that it is too soon to tell. The projects that have had the longest to unfold, such as those in the Gulf of Maine, are good examples of restoration success with ongoing management.

Although self-sustaining populations are the ultimate goals for most seabird restoration projects, some projects have additional or different goals and thus have different criteria for success. Our definition of success may be too narrow for such projects, which should develop criteria for evaluating success that are appropriate to the intricacies of their seabird species and project goals. For example, the goals of the Caspian tern case study mentioned above were to move the terns to reduce predation on threatened salmonid populations and to establish multiple breeding sites to reduce vulnerability of the population to catastrophic events impacting any individual site, with a tangential goal of a self-sustaining population. Therefore, the project was considered successful when the terns reduced predation pressure on salmonids and when they established multiple breeding locales. Although success definitions may vary according to the project, the key common themes for defining success are identifying specific, attainable, and measurable goals so that success or lack thereof is immediately obvious.

The opportunities for future research in seabird restoration are tremendous. As the number of projects increases, more quantitative meta-analyses will be possible. Such analyses could investigate the roles played by distance to source colony, funding amount and duration, location and deployment duration of vocalization playbacks and decoys, the number of chicks translocated, and many of the other factors listed above in influencing restoration success. Research on the potential role of scent in attracting Procellariiformes seabirds would be useful as would research on methods for families underrepresented in this review (Spheniscidae, Phaethontidae, Fregatidae, Sulidae, Pelecanidae).

Financing Seabird Restoration

Financing seabird restoration projects is typically the greatest obstacle to success. Seabirds are long-lived and have deferred breeding, which often requires restoration plans to span a decade or more. For example, the Eastern Egg Rock Project took 35 years to establish 100 pairs of Atlantic puffins (Kress et al. 2009). Species that respond to social attraction (e.g., decoys and recorded sound) may respond more quickly to colony restoration than species that do not, but ongoing stewardship may still be necessary to sustain the restored colonies.

Long-term projects are difficult to sustain financially, especially in the early years when there are few signs of success. Annual budgets for programs such as these should allocate money to maintain the necessary fundraising efforts. Although the costs to restore seabirds will vary from country to country, they are substantial and ongoing. For example, maintenance of the 7 islands maintained by National Audubon Society's Seabird Restoration Program in the Gulf of Maine costs about $800,000 annually. Where ongoing management is necessary, public education can help build community support and interest in sustained protection, but this component can add another $100,000 annually. Projects are most likely to succeed where partnerships exist between government agencies and non-profit organizations.

MANAGEMENT IMPLICATIONS

Before initiating a seabird restoration project, we recommend managers consider a few key factors. First, there must be a thorough site selection process that assesses both biological constraints to breeding success (e.g., risks from predators, food limitation, and human disturbance) and logistic constraints (e.g., costs and practicality of establishing a field camp for managers and a business plan for long-term stewardship). Second, seabird restoration should only commence when the principal cause(s) for extirpation or depletion are known and corrective actions are in place to reduce threats. Third, a long-term plan for funding, monitoring, and management should be in place and specific measurable goals should be defined. If managers follow these general rules, they can improve survival prospects for threatened seabirds by encouraging colonization at locations where seabirds are safe from biological and environmental stressors.

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Supplemental Material

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Jones, H. P., and S. W. Kress. 2012. A review of the world's active seabird restoration projects. Journal of Wildlife Management 76.

Appendix A. Details of reviewed seabird restoration projects. Blank spots indicate unknown data fields.

Bird scientific name	**Bird common name**	**Family**	**IUCN[a] status**	**Restoration technique**	**Successful?**	**Measure of success**	**Chick fledge data**	**Most recent numbers of breeders attracted**	**Ongoing?**	**Years of project**	**Island or location**	**Country**	**State**	**Agency[b]**	**Citation**
Bulweria bulwerii	Bulwer's Petrel	Procellariidae	Least concern	Acoustic playback	Yes	Eggs laid in artificial burrows	None	5 birds frequenting burrows	Yes	2003-2010	Midway Island	USA	Hawaii	NAS	J. Klavitter, U.S. Fish and Wildlife Service, personal communication
Chlidonias niger	Black Tern	Laridae	Least concern								Montezuma NWR	USA	New York	ODNR; USFWS	Kress and Borzik 2003
Daption capense	Cape Petrel	Procellariidae	Least concern	Acoustic playback; Decoys							Adelie Island	Antarctica		FAT	Gummer 2003

Fratercula arctica	Atlantic Puffin	Alcidae	Least concern	Chick translocation; Decoys	Yes	0-56% chicks of different cohorts returned to release site	940 of 954 fledged	107 pairs in 2009	Yes	1973-2009	Eastern Egg Rock	USA	Maine	SRP; MDIFW; CWS	Kress et al. 2010
Fratercula arctica	Atlantic Puffin	Alcidae	Least concern	Chick translocation; Decoys	Yes	0-47% chicks of different cohorts returned to release site	892 of 950 fledged	425 pairs in 2009	Yes	1984-2009	Seal Island NWR	USA	Maine	SRP; USFWS; CWS	Kress et al. 2010
Fratercula arctica	Atlantic Puffin	Alcidae	Least concern	Chick translocation; Decoys	No	Chicks translocated near fledging age and two nested in Scotland	150 of 200 fledged	None	No	1979	Ile Bono; Sept-I'lles	France			M.P. Harris, Hill of Brathens, personal communication; Duncombe and Reille 1980
Fratercula arctica	Atlantic Puffin	Alcidae	Least concern	Decoys	Too early to know	150 decoys placed and puffins seen in adjacent water	Too early to know	Too recent for returns	Yes	2009	Ramsey Island	Wales		RSPB	G. Morgan, University of Plymouth personal communication
Fratercula arctica	Atlantic Puffin	Alcidae	Least concern	Decoys	No						Wooden Ball Island	USA	Maine	SRP	Kress and Borzik

															2003
Hydroprogne caspia	Caspian Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	9,500 successfully relocated		7,000 breeding pairs	Yes	1999-2009	East Sand Island	USA	Washington	OSU; USGS; CRITFC; RTR; BPA; SRP	Roby et al 2002; D. Roby, Oregon State University, peronal communication
Hydroprogne caspia	Caspian Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	388 pairs initiated nests and laid clutches; barge removed before hatching		~776	No	2001	Commencement Bay barge	USA	Washington	OSU; USGS; CRITFC; RTR; USACE; SRP	Kress and Borzik 2003, 2004; D. Roby, personal communication
Hydroprogne caspia	Caspian Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	Terns seen on island but no nesting attempts		0	Yes	2008-present	Fern Ridge tern island	USA	Oregon	OSU; USGS; RTR; USACE; SRP	Kress and Borzik 2003, 2004; D. Roby, personal communication
Hydroprogne caspia	Caspian Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	700 pairs attracted to island in 2009	Low fledging success in 2009	~ 1,400	Yes	2008-present	Crump Lake tern island	USA	Oregon	OSU; USGS; CRITFC; RTR; BPA; SRP	Kress and Borzik 2003, 2004; D. Roby, personal

															communication
Hydroprogne caspia	Caspian Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	7 pairs attracted to island in 2009	6 young fledged	14	Yes	2009-present	East Link Impoundment, Summer Lake Wildlife Area	USA	Oregon	OSU; USGS; CRITFC; RTR; BPA; SRP	Kress and Borzik 2003, 2004; D. Roby, personal communication
Hydroprogne caspia	Caspian Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	8 pairs attracted to island in 2009	5 young fledged	16	Yes	2009-present	Dutchy Lake, Summer Lake Wildlife Area	USA	Oregon	OSU; USGS; CRITFC; RTR; BPA; SRP	Kress and Borzik 2003, 2004; D. Roby, personal communication
Larus heermanni	Heermann's gull	Laridae	Near threatened	Acoustic playback; Decoys	Yes	Nesting		23 pairs in 2008 and 25 pairs in 2010	Yes	2008	San Roque Island	Mexico		IC; SRP	Kress and Borzik 2003; Kress et al. 2008, 2010
Megadyptes antipodes	Yellow-eyed penguin	Spheniscidae	Endangered	Decoys	Yes	Nesting		10 pairs		2001	Mainland	New Zealand		DOC	Gummer 2003
Morus bassana	Northern Gannet	Sulidae	Least concern	Decoys	No	Project abandoned after 6			No		Perroquet Island, Mingan	Canada	Quebec	SRP; QLF; MICS	Gummer 2003

						field seasons					Islands				
Morus bassana	Northern Gannet	Sulidae	Least concern	Acoustic playback; Decoys							Gannet Rock	Canada	Nova Scotia	TDE	Kress and Borzik 2003
Morus serrator	Australasian Gannet	Sulidae	Least concern	Acoustic playback; Decoys	Too early to know	Incubating adults	Too early to know	12	Yes	2009-2010	Nick's Head	New Zealand		EW	Ecoworks New Zealand 2010
Morus serrator	Australasian Gannet	Sulidae	Least concern	Acoustic playback; Decoys					No		Cat Island	Australia		TDLPW	Gummer 2003
Morus serrator	Australasian Gannet	Sulidae	Least concern	Decoys	No	No breeding occurred					Mana Island	New Zealand		DOC; WC; FOMI; NZFBS	Kress and Borzik 2003
Oceanodroma leucorhoa	Leach's Storm-Petrel	Hydrobatidae	Least concern	Acoustic playback	No				No	1996-2003	Asuncion Island	Mexico		IC; SRP	B. Keitt, Island Conservation, personal communication
Oceanodroma leucorhoa	Leach's Storm-Petrel	Hydrobatidae	Least concern	Acoustic playback	Yes	Breeders attracted		9 burrows colonized	No	1980	Old Hump Ledge	USA	Maine	SRP; MDIFW	Podolsky and Kress 1989
Oceanodroma leucorhoa	Leach's Storm-Petrel	Hydrobatidae	Least concern	Acoustic playback	Yes	Burrows occupied	None	14 burrows colonized	No	1980	Ross Island	USA	Maine	SRP	Podolsky and Kress 1989

Oceanodroma leucorhoa	Leach's Storm-Petrel	Hydrobatidae	Least concern	Acoustic playback	Yes	Burrows occupied	None	4 burrows colonized	No	1980	Wreck Island	USA	Maine	SRP	Podolsky and Kress 1989
Oceanodroma melania	Black storm-petrel	Hydrobatidae	Least concern	Acoustic playback	No	Little monitoring	None	None	No	1996-2003	Asuncion Island	Mexico		IC; SRP	B. Keitt, personal communication
Oceanodroma melania	Black Storm-Petrel	Hydrobatidae	Least concern	Acoustic playback	No				No	1996-2003	San Roque Island	Mexico		IC; SRP	B. Keitt, personal communication
Oceanodroma tristrami	Tristram's Storm-Petrel	Hydrobatidae	Near threatened	Acoustic playback	No	Burrows visited	None	None	Yes		Midway Island	USA	Hawaii	NAS	J. Klavitter, personal communication
Pachyptila turtur	Fairy Prion	Procellariidae	Least concern	Chick translocation	Yes	100% of chicks fledged; chicks returned to nest	100% Fledged	19 had returned by 2009	No, still sound system	2002-2004	Mana Island	New Zealand		DOC; WC; FOMI; NZFBS	Miskelly and Gummer 2004
Pagodroma nivea	Snow Petrel	Procellariidae	Least concern	Acoustic playback; Decoys							Adelie Island	Antarctica		FAT	Gummer 2003
Pelecanoides urinatrix urinatrix	New Zealand Diving petrel	Pelecanoididae	Least concern	Acoustic playback; Chick translocation	Yes	Annual nesting	50% Fledged	20 returned to breed; 57 additional immigrants attracte	No	1993	Mana Island	New Zealand		DOC; WC; FOMI; NZFBS	Miskelly and Taylor 2004

								d; 8 locally bred chicks							
Pelecanoides urinatrix urinatrix	New Zealand Diving petrel	Pelecanoididae	Least concern	Acoustic playback; Chick translocation	Yes	High fledging success; waiting for returns	86 of 91 fledged	Too recent for returns		2007-2008	Motoura Island	New Zealand			Miskelly et al. 2009
Phaethon lepturus	White-tailed Tropic bird	Phaethontidae	Least concern								Castle Harbor	Bermuda		BDC	Kress and Borzik 2003
Phalacrocorax auritus	Double-crested Cormorant	Phalacrocoracidae	Least concern	Acoustic playback; Decoys	No	None seen at site		0	No	2005	Trestle Bay rock island	USA	Oregon	OSU; USGS; RTR; BPA; USACE; SRP	Y. Suzuki, Oregon State University, personal communication
Phalacrocorax auritus	Double-crested Cormorant	Phalacrocoracidae	Least concern	Acoustic playback; Decoys	Yes	Nested in areas not previously used for nesting	High nesting success	~ 200 pairs	No	2004-2007	East Sand Island	USA	Oregon	OSU; USGS; RTR; USACE; SRP	Y. Suzuki, personal communication
Phalacrocorax auritus	Double-crested Cormorant	Phalacrocoracidae	Least concern	Acoustic playback; Decoys	No (nesting occurred	30-40 pairs attracted to nest at site not	High nesting success	30-40 nesting pairs	No	2006	Rice Island	USA	Oregon	OSU; USGS; RTR; USACE; SRP	Y. Suzuki, personal communication

					only in one year)	used in 3 years									
Phalacrocorax auritus	Double-crested Cormorant	Phalacrocoracidae	Least concern	Acoustic playback; Decoys	Yes	Breeders attracted to nest at site where no previous successful nesting had occurred	High nesting success	~ 90 breeding pairs	No	2004-2007	Miller Sands Spit	USA	Oregon	OSU; USGS; RTR; USACE; SRP	Y. Suzuki, personal communication
Phalacrocorax auritus	Double-crested Cormorant	Phalacrocoracidae	Least concern	Acoustic playback; Decoys	No	No adults observed at site		0	No	2007-2009	Fern Ridge Wildlife Area	USA	Oregon	OSU; USGS; RTR; USACE; SRP	Y. Suzuki, personal communication
Phalacrocorax auritus	Double-crested Cormorant	Phalacrocoracidae	Least concern	Acoustic playback; Decoys	No	Only one adult observed at site		0	No	2007-2009	Foundation Island	USA	Washington	OSU; USGS; RTR; USACE; SRP	Y. Suzuki, personal communication
Phalacrocorax penicillatus	Brandt's Cormorant	Phalacrocoracidae	Least concern	Acoustic playback; Decoys	No				No	2003-2004	San Pedro Rock	USA	California	USFWS; HSU; SRP	McChesney et al. 2005
Phoebastria albatrus	Short-tailed Albatross	Diomedeidae	Vulnerable	Acoustic playback; Decoys	Yes	1 pair nested near decoys in 1995, 4 pairs in 2005, 15 in 2006, and 45		45 pairs		1992	Torishima Island	Japan		YIO; JWS	Kress and Borzik 2003; Kress et al. 2010

						pairs produced chicks in 2010									
Phoebastria albatrus	Short-tailed Albatross	Diomedeidae	Vulnerable	Acoustic playback; Chick translocation	Too early to know	100% of chicks fledged; waiting for returns	10 of 10 fledged in 2008 and 15 of 15 fledged in 2009 and 2010	One pair prospecting in 2009; translocated chicks too recent for returns	Yes	2008-2010	Mukojima Island	Japan		YIO; JWS	Kress et al. 2010
Phoebastria immutabilus	Laysan Albatross	Diomedeidae	Vulnerable		No	"Deemed unsuccessful"			No		Kaohikaipu Islet	USA	Hawaii	SRP; USFWS; HDFW; HAS	Gummer 2003
Phoebastria albatrus	Short-tailed Albatross	Diomedeidae	Vulnerable	Acoustic playback; Decoys	No	A pair has formed for three years, nest built, first egg in 2010		One pair	Yes		Midway Atoll NWR	USA		USFWS	J. Klavitter, personal communication

Procellaria parkinsoni	Black Petrel	Procellariidae	Vulnerable	Chick translocation	Yes	4.8% recovery rate of 249 chicks	Only those translocated in 1990 fledged			1986-1990	Little Barrier Island	New Zealand		DOC	Gummer 2003; Kress et al. 2002
Pterodroma alba	Phoenix Petrel	Procellariidae	Endangered	Acoustic playback	No	No signs					Christmas Island	USA	Hawaii		Gummer 2003
Pterodroma axillaris	Chatham Island Petrel	Procellariidae	Endangered	Acoustic playback; Chick translocation	Too early to know	100% fledging success	47 of 47 fledged	Too recent for returns		2008	Sweetwater CC in Chatham Islands	New Zealand		DOC	Miskelly et al. 2009
Pterodroma axillaris	Chatham Island Petrel	Procellariidae	Endangered	Chick translocation		6 birds returned, too early for all returns	198 of 200 fledged				Pitt Island, Chatham Islands	New Zealand		DOC	Miskelly et al. 2009
Pterodroma cahow	Cahow	Procellariidae	Endangered	Acoustic playback; Chick translocation					Yes	2004	Castle Harbor	Bermuda		BDC	Kress and Borzik 2003
Pterodroma cahow	Cahow	Procellariidae	Endangered	Acoustic playback; Chick translocation	Yes	One pair of translocated birds bred in 2009 and produced a fledgling; seven pairs occupying	102 of 105 fledged	Three new pairs attracted to artificial burrows near playback; 4 translocated	Yes	2004	Nonsuch Island	Bermuda		BDC	Madreios pers. comm; Kress et al. 2010

						burrows in 2010		chicks returne d to prospe ct							
Pterodro ma leucopter a	Gould' s Petrel	Procellarii dae	Vulnera ble	Chick translocati on	Yes	24 eggs produced 14 fledgling s after 5 years	196 of 200 fledged	41 translo cated and 27 non-translo cated birds	Yes	1999-2000	Boondel bah Island	Austr alia		NSWN PWS	Priddel and Carlile 1999; Kress and Borzik 2003; Priddel et al. 2006
Pterodro ma macropte ra	Grey-faced Petrel	Procellarii dae	Least concern								Ihumoan a Island	New Zeala nd		DOC	Kress and Borzik 2003
Pterodro ma macropte ra	Grey-faced Petrel	Procellarii dae	Least concern								Tiritiri-Matangi Island	New Zeala nd		DOC	Kress and Borzik 2003
Pterodro ma macropte ra	Grey-faced Petrel	Procellarii dae	Least concern	Chick translocati on			114 of 174 fledged			2004-2008	Matakoh e Island	New Zeala nd		DOC	Miskelly et al. 2009
Pterodro ma magenta e	Chatha m Island Taiko	Procellarii dae	Criticall y endange red			100% fledging success	22 of 22 fledged	Too recent for returns		2006-2008	Sweetwa ter CC in Chatham Islands	New Zeala nd		DOC	Kress and Borzik 2003

Pterodroma phaeopygia	Dark-rumped Petrel	Procellariidae	Critically endangered	Acoustic playback	Yes	Breeders attracted		Signs of breeding 5 days into the project		1988	Santa Cruz Island	Ecuador	Galapagos	CDRC; GNP; SRP	Gummer 2003
Pterodroma pycrofti	Pycroft's Petrel	Procellariidae	Vulnerable	Chick translocation		19 birds returned	227 of 232 fledged			2001-2003	Cuvier Island	New Zealand		DOC	Gummer 2003
Ptychoramphus aleuticus	Cassin's Auklet	Alcidae	Least concern	Acoustic playback	Yes	First evidence of Cassin's auklets on Asuncion in 20 years		Yes	No	1996 - 2004	Asuncion Island	Mexico		IC; SRP	B. Keitt, personal communication
Ptychoramphus aleuticus	Cassin's Auklet	Alcidae	Least concern	Acoustic playback	No				No	1996-2003	San Roque Island	Mexico		IC; SRP	Kress and Borzik 2003
Puffinus gavia	Fluttering Shearwater	Procellariidae	Least concern	Acoustic playback; Chick translocation	Yes		211 of 225 fledged	Some prospectors	No, still sound system	2006-2008	Mana Island	New Zealand		DOC; WC; FOMI; NZFBS	Miskelly et al. 2009
Puffinus gavia	Fluttering Shearwater	Procellariidae	Least concern	Acoustic playback; Chick translocation	Yes	Annual nesting	273 of 334 fledged	34	No, still sound system	1991-1996	Maud Island	New Zealand		DOC; OSNZ	Bell et al. 2005; Miskelly et al. 2009
Puffinus huttoni	Hutton's Shear	Procellariidae	Endangered	Chick translocation	Yes		270 of 291 fledged	First pair on egg in		2005-2008	Kaikoura Peninsula	New Zealand			Miskelly et al. 2009;

	water							2010							Kress et al. 2010
Puffinus newelli	Newell's Shearwater	Procellariidae	Endangered	Chick translocation	Yes	94% fledging success and a few nests of translocated birds	94% fledged		No	1970's	Mokuaeae Island	USA	Hawaii		Gummer 2003
Puffinus puffinus	Manx Shearwater	Procellariidae	Least concern	Acoustic playback; Chick translocation	No	"Deemed unsuccessful" due to gull colonization		2-3 burrows active after 4 years		1980-1984	Cardigan Island	UK			Gummer 2003
Puffinus tenuirostris	Short-tailed Shearwater	Procellariidae	Least concern	Chick translocation		Five returned to the translocation site	157 fledged			1960-1971	Fisher Island				Serventy et al. 1989
Pygoscelis adeliae	Adelie Penguin	Spheniscidae	Least concern	Acoustic playback; Decoys							Adelie Island	Antarctica		FAT	Gummer 2003
Rynchops niger	Black Skimmer	Rhynchopidae	Least concern								Bird Island	USA	Georgia	GDNR	Kress and Borzik 2003
Rynchops niger	Black Skimmer	Rhynchopidae	Least concern								Rockport	USA	Texas	AT; USFWS	Kress and Borzik 2003
Rynchops niger	Black Skimmer	Rhynchopidae	Least concern								Sanibel Island	USA	Florida	USFWS	Kress and Borzik 2003

Sterna albifrons	Little Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	Unsuccessful after 1 season					Chesil Beach	UK			Gummer 2003
Sterna albifrons	Little Tern	Sternidae	Least concern								Inch Geck	Scotland		SNH	Kress and Borzik 2003
Sterna antillaru m	Least Tern	Sternidae	Least concern								Arroyo Grande	USA	Califor nia	DOD; CSD; USFWS; CDPR; VAFB; TNC; NAWS	Kress and Borzik 2003
Sterna antillaru m	Least Tern	Sternidae	Least concern								Assateague Island National Seashore	USA	Virgini a	CNWR	Kress and Borzik 2003
Sterna antillaru m	Least Tern	Sternidae	Least concern	Decoys	No	No breeding occurred				1983	Island Beach	USA	New Jersey	NJFG	Kress and Borzik 2003; Kotliar and Burger 1986
Sterna antillaru m	Least Tern	Sternidae	Least concern								Carlsbad	USA	Califor nia	DOD; CSD; USFWS; CDPR; VAFB; TNC; NAWS	Kress and Borzik 2003
Sterna antillaru	Least Tern	Sternidae	Least concern								Gardner Point	USA	Conne cticut	CNC	Kress and

m															Borzik 2003
Sterna antillarum	Least Tern	Sternidae	Least concern								Lompoc	USA	California	DOD; CSD; USFWS; CDPR; VAFB; TNC; NAWS	Kress and Borzik 2003
Sterna antillarum	Least Tern	Sternidae	Least concern								Long Beach	USA	California	DOD; CSD; USFWS; CDPR; VAFB; TNC; NAWS	Kress and Borzik 2003
Sterna antillarum	Least Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	Birds landed and courted			No	1992-1993	Los Angeles-Dockweiler Beach	USA	California	DOD; CSD; USFWS; CDPR; VAFB; TNC; NAWS	Baird 1993
Sterna antillarum	Least Tern	Sternidae	Least concern	Decoys	Yes	16 fledglings produced	16 fledglings from 42 nests. Low rate due to predation	21 pairs		1983	Mike's Island	USA	New Jersey	NJFG	Kress and Borzik 2003; Kotliar and Burger 1986

Sterna antillarum	Least Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting	20 chicks; fledgling unknown	12 pairs	Yes	2009	Mississippi Delta	USA	Mississippi	MCA	Kress and Borzik 2003
Sterna antillarum	Least Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting	0.7 chicks/nest in 2009	59 breeding pairs in 2008	Yes	2002-2010	Stratton Island	USA	Maine	SRP; USFWS; CWS	Kress and Borzik 2003
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		21 breeding pairs in 2006		2006	Dry Tortugas National Park	USA	Florida	NPS; FFWCC	Kress and Borzik 2003, 2005
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		101 breeding pairs in 2009	No but ongoing predator and competitor control	1978-1982	Eastern Egg Rock	USA	Maine	SRP; MDIFW; CWS	Kress and Borzik 2003, 2005
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		43 pairs in 2009	Ongoing predator and competitor control	1998-2009	Pinekese Island	USA	Maine	SRP; MDIFW; CWS	Kress and Borzik 2003: Kress et al. 2008

Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Nesting		2 breeding pairs in 2008	No but ongoing predator and competitor control		Jenny Island	USA	Maine	SRP	Kress and Borzik 2003, 2005
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	No nesting or sightings	None	None	No; ended for lack of funding	2003	Machias Seal Island	Canada	New Brunswick	CWS	Kress and Borzik 2003
Sterna dougallii	Roseate Tern	Sternidae	Least concern								Cartwright Point	USA	New York	GGIP	Kress and Borzik 2003
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	Nesting in most years			No	2000-2007	Muskeget Island	USA	Massachusetts	TNC; CUNY	Kress and Borzik 2003
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Nesting		1 to 12 pairs between 2003-2006	Yes	1996-2009	Pond Island NWR	USA	Maine	SRP; USFWS	Gummer 2003; Kress and Borzik 2003, 2005
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Breeders attracted		500 pairs in 2009	Yes	1990-2009	Ram Island	USA	Massachusetts	MDFW	Kress and Borzik 2003

Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Breeders attracted	1.24 chicks/nest in 2009	37 pairs in 2009	No but ongoing predator and competitor control	1997-2009	Seavy Island	USA	New Hampshire	NHAS; NHDFG	Kress and Borzik 2003
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Breeders attracted	1.31 chicks/nest in 2009	As many as 127 pairs	Yes	1989-1991	Stratton Island	USA	Maine	SRP; PNAS	Kress and Borzik 2003, 2005
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	Unsuccessful	None	None	No	1988-1989	Dalkey Island	Ireland		BI	Gummer 2003
Sterna dougallii	Roseate Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	Unsuccessful	None	None	No	1988-1989	Keeragh Islands	Ireland		BI; IWC	Kress and Borzik 2003
Sterna dougallii	Roseate Tern	Sternidae	Least concern		No	Temporarily abandoned			Yes		Mew Island	Ireland		CBO	Gummer 2003
Sterna dougallii	Roseate Tern	Sternidae	Least concern		No	Unsuccessful			No		Tern Island	Ireland			Kress and Borzik 2003
Sterna elegans	Elegant tern	Sternidae	Near threatened	Acoustic playback; Decoys	Too early to know	Terns landed on the island			Yes	2008 - present	Asuncion Island	Mexico		CI	M. Felix, Conservacion de Islas, personal communication

Sterna elegans	Elegant tern	Sternidae	Near threatened	Acoustic playback; Decoys	Too early to know	Terns landed on the island			Yes	2008 - present	San Roque	Mexico		CI	M. Felix, personal communication
Sterna fuscata	Sooty Tern	Sternidae	Least concern	Acoustic playback	Yes	Breeders attracted					Palmyra Atoll, Line Islands	USA		USFWS	Kress and Borzik 2003; B. Flint, US Fish and Wildlife Service, personal communication
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	Colony established; but abandoned due to crow predation			No		Sampson Island	UK			Gummer 2003
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		714 breeding pairs in 2010	No but ongoing predator and competitor control	1978-1982	Eastern Egg Rock	USA	Maine	SRP; MDIFW; CWS	Kress 1983; Kress et al. 2010
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		1788 breeding pairs in 2010	No but ongoing predator and compet	1985-2002	Seal Island NWR	USA	Maine	SRP; MDIFW; CWS	Kress et al. 2010

									itor control						
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		1151 breeding pairs in 2010	No but ongoing predator and competitor control	2002-2006	Outer Green Island	USA	Maine	SRP; MDIFW	Kress et al. 2010
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		590 breeding pairs in 2010	No but ongoing predator and competitor control	1996-2000	Pond Island NWR	USA	Maine	SRP; USFWS	Kress et al. 2010
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		857 breeding pairs in 2010	No but ongoing predator and competitor control	1989-1991	Stratton Island	USA	Maine	SRP; PNAS	Kress et al. 2010
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes			707 pairs			Country Island	Canada	Nova Scotia	CWS	GOMSWG 2010
Sterna hirundo	Common Tern	Sternidae	Least concern								Sheep Island	Canada	New Brunswick	GMBO	Kress and Borzik 2003

Sterna hirundo	Common Tern	Sternidae	Least concern								Bay City	USA	Michigan	ERS	Kress and Borzik 2003
Sterna hirundo	Common Tern	Sternidae	Least concern								Duluth-Superior Harbor	USA	Minnesota	MDNR	Kress and Borzik 2003
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	No	Annual nesting, but suffered from predation and later lack of funding	Very low productivity, around 10 chicks /year	About 200 pairs in 2000, declined to 10 pairs in 2005	No	2000-2007	Muskeget Island	USA	Massachusetts	TNC; CUNY	Kress and Borzik 2003
Sterna hirundo	Common Tern	Sternidae	Least concern								Ottawa NWR	USA	Ohio		Kress and Borzik 2003
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		1,139 pairs in 2009	Yes	1998-2009	Penekese Island	USA	Massachusetts	MDFW	Kress and Borzik 2003
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting			Yes	1990-2009	Ram Island	USA	Massachusetts	MDFW	Kress and Borzik 2003
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting	1.23 chicks/pair in 2009	1,997 pairs in 2009	Yes	1997-2009	Seavy Island	USA	New Hampshire	NHAS; NHDFG	Kress and Borzik 2003
Sterna hirundo	Common Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes						Ship Island	USA	Maine	USFWS	Kress and Borzik

															2003
Sterna hirundo	Common Tern	Sternidae	Least concern								Wasburn	USA	Wisconsin	WBER	Kress and Borzik 2003
Sterna hirundo	Common Tern	Sternidae	Least concern	Decoys	No	Increase from 1 to 149 breeding pairs in 3 years but after gull control ceased, reduced to 3 breeding pairs		149 breeding pairs in 1995 declined to 3 pairs in 1996	No	1990-1993	Ice Island	Canada	Ontario		Blokpoel et al. 1997
Sterna nilotica	Gull-billed Tern	Sternidae	Least concern								Bird Island	USA	Georgia	GDNR	Kress and Borzik 2003
Sterna paradisaea	Arctic Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		83 pairs in 2010	No but ongoing predator and competitor control	1978-1982	Eastern Egg Rock	USA	Maine	SRP; MDIFW; CWS	Kress 1998; Kress and Borzik 2003; Kress et al. 2008
Sterna paradisaea	Arctic Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		1283 breeding pairs in	No but ongoing predator and	1985-2002	Seal Island NWR	USA	Maine	SRP; USFWS; CWS	Kress and Borzik 2003; Kress et

								2010	competitor control						al. 2008
Sterna paradisaea	Arctic Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		352 pairs in 2010			Metinic Island	USA	Maine	USFWS; MCINWR	GOMSWG 2010
Sterna paradisaea	Arctic Tern	Sternidae	Least concern	Acoustic playback; Decoys	Yes	Annual nesting		13 pairs in 2010		1982-1983	Wooden Ball Island	USA	Maine	SRP	GOMSWG 2010
Sula sula	Red-footed Booby	Sulidae	Least concern	Chick translocation					No		Sea Life Park	USA	Hawaii		Gummer 2003
Uria aalge	Common Murre	Alcidae	Least concern	Acoustic playback; Decoys	Yes	Breeding was re-established in the first year of restoration efforts; 361 pairs attracted by 2006.		361 pairs attracted by 2006	No	1996-2005	Devil's Slide Rock	USA	California	USFWS; HSU; SRP	Parker et al. 2007; McChesney et al. 2007

Uria aalge	Common Murre	Alcidae	Least concern	Acoustic playback; Decoys	Yes	50 birds visited in 2000, but no nesters		118 attracted; first breeding 2009	Yes	1992-2010	Matinicus Rock	USA	Maine	SRP; USFWS	Kress et al. 2009
Uria aalge	Common Murre	Alcidae	Least concern	Acoustic playback; Decoys	Yes	Breeders attracted			Yes		Middleton Island	USA	Alaska	USFWS	S. Hatch, U.S. Geological Survey, personal communication
Uria aalge	Common Murre	Alcidae	Least concern	Acoustic playback; Decoys	No	Prospecting birds	None	None	No	1998-2004	San Pedro Rock	USA	California	USFWS; HSU; SRP	McChesney et al. 2005

[a] - International Union for Conservation of Nature

[b] - AT, Audubon Texas; BDC, Bermuda Department of Conservation; BI, Birdwatch Ireland; BPA, Bonneville Power Administration; CBO, Copeland Bird Observatory; CDPR, California Department of Parks and Recreation; CDRC, Charles Darwin Research Center; CI, Conservacion de Islas; CNC, Connecticut Nature Conservancy; CNWR, Cincoteague National Wildlife Refuge; CRITFC, Colombia River Inter-Tribal Fish Commission; CSD, City of San Diego; CUNY, College of Staten Island, City University of New York; CWS, Canadian Wildlife Service; DOC, New Zealand Department of Conservation; DOD, Department of Defense; ERS, Ecology Research Service; EW, Eco-works; FAT, French Antarctic Team; FOMI, Friends of Mana Island; GDNR, Georgia Department of Natural Resources; GGIP, Great Gull Island Project; GMBO, Grand Mariari Bird Observatory; GNP, Galapagos National Park; HAS, Hawaii Audubon Society; HDFW, Hawaii Division of Forestry and Wildlife; HSU, Humboldt State University; IC, Island Conservation; IWC, Irish Wildbird Conservancy; JWS, Japanese Wildbird Society; MCA, Mississippi Coastal Audubon; MCINWR, Maine Coastal Islands National Wildlife Refuge; MDFW, Massachusetts Division of Fisheries and Wildlife; MDIFW; Maine Department of Inland Fish and Wildlife; MDNR, Minnesota Department of Natural Resources; MICS, Mingan Island Cetacean Study; NAS, National Audubon Society; NAWS, Naval Air Weapons Station; NHAS, New Hampshire Audubon Society; NHDFG, New Hampshire Department of Fish and Game; NNFG, New Jersey Fish and Game; NPS, National Park Service; NSWNPWS, New South Wales National Parks and Wildlife Service; NZFBS, New Zealand Forest and Bird Society; ODNR, Ohio Department of Natural Resources; OSNZ, Ornithological Society of New Zealand; OSU, Oregon State University; PNAS, Prout's Neck Audubon Society; QLF, Quebec Labrador Foundation; RTR, Real Time Research; SNH, Scottish Natural Heritage; SRP, Seabird Restoration Program (Audubon); TDE, Ted D'Eon, West Pubnico, NB; TDLPW, Tasmania Department of Lands, Parks and Wildlife; TNC, The Nature Conservancy; USACE, United States Army Corps of Engineers; USFWS, United States Fish and Wildlife Service; USGS, United States Geologic Service; VAFB, Vandenberg Air Force Base; WBER, Wisconsin Bureau of Endangered Resources; WC, Wellington Conservancy; YIO, Yamashina Institute for Ornithology

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