Chick translocation as a method of establishing new surface-nesting seabird colonies: a review

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ABSTRACT

The establishment of new seabird colonies, for conservation purposes, has been successfully achieved with a range of burrow-nesting and surface-nesting species. This report reviews international examples of techniques to attract birds to new sites including habitat creation or modification, and artificial visual and acoustic social stimulation. It also discusses the translocation of burrow-nesting seabird chicks at various stages of growth, which has been successfully accomplished, with birds returning to release sites as breeding adults. In New Zealand, chick translocation of burrow-nesting species has developed into a major management tool for increasing the distribution of threatened species, and restoring ecological values to islands recently cleared of predators. Long-term conservation benefit to several threatened, surface-nesting seabird taxa would result from the establishment of additional colonies. Chick translocation would be appropriate, if other social attraction methods proved ineffective, but success may be more difficult to achieve since the age at which chicks (of surface-nesting species) imprint on natal locality is unknown. The report concludes with an investigation to determine the most appropriate New Zealand species to use in trials to establish methods for surface-nesting seabird chick translocation.

Keywords: Surface-nesting seabirds, colony establishment, chick translocation.

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1. Introduction

1.1 THE USE OF COLONY ESTABLISHMENT IN SEABIRD CONSERVATION

Techniques are being continually developed to attract both surface-nesting and burrow-nesting seabirds to new colony sites with various conservation aims. Information sourced from references discussed in this report shows that restoration projects have been initiated at historical colony sites where local extinction (extirpation) has occurred through habitat destruction, predation or human disturbance, or at new safe sites where the existing conservation values of the site are not compromised. Restoring or creating additional breeding colonies serves to safeguard a species that is vulnerable to threats at one or more of its breeding locations. Small, existing colonies can be augmented by increasing the colonisation rate using artificial techniques. Entire existing colonies of some species can be moved to a new, safer location, sometimes in order to benefit other wildlife and/or ecosystems. Seabirds provide major nutrient input for associated ecosystems, so projects to restore colonies to traditional sites that have been modified are considered to contribute to the overall ecological restoration of such areas.

Colony establishment techniques include habitat creation or modification, a range of social attraction methods, and also translocation of chicks at various stages of growth (G. Taylor, Department of Conservation, pers. comm.)

Habitat creation or modification for surface-nesting species relates to the provision of a substrate suitable to nest on, and often the clearance of encroaching vegetation (e.g. for terns) or even native re-vegetation of areas (e.g. for forest-nesting penguins). Nesting shelters to protect birds from avian predators are also sometimes installed. For burrow-nesters, habitat creation/ modification tends to be the provision of artificial nesting chambers, and sometimes the preparation of access tracks to nest sites. For both surface- and burrow-nesters, management of potential pest and predator threats may be required using fencing and/or control methods.

Social attractants can be visual (decoys, mirrors) or acoustic (sound playback systems). Visual attractants are required for diurnal species to give the impression of a currently active site. Realistic models in a range of breeding behaviour postures tend to be positioned in a formation appropriate to the species; more rather than fewer decoys are usually recommended. Decoy nests, eggs and chicks, and even simulated guano have also been used. Acoustic attraction is employed for both diurnal and nocturnal species; it is a particularly important method for attracting nocturnal species and tends to be used in conjunction with provision of nest-sites in the near proximity of the sound source. The vocalisation call that established pairs of a species use exclusively underground is suggested as the most effective for attracting prospecting conspecifics, as opposed to aerial calls (Kress 1997).

Chick translocations are now an established method for seeding new burrow-nesting seabird colony sites. The major prerequisites required when translocating highly philopatric seabirds are: to ensure habitat quality at the release site is suitable for breeding birds, and to ensure that translocated birds imprint upon the locality at the release site (Numata 1996).

Burrow-nesting seabird chicks are thought to gain cues from their surroundings following emergence from the burrow shortly prior to fledging. 'Locality-imprinting' is considered to develop during this period (Serventy et al. 1989). Transferred chicks making their first emergence at the release site are tricked into regarding the new colony as their natal site, and will potentially return to that site as adults. The use of social attraction stimuli to accompany chick translocations is thought to hold the attention of returning birds until a critical mass of adults (for breeding) is assembled at the site (Kress 1987).

Natural colony formation within a strongly philopatric seabird species is usually initiated by a few unusual individuals who take the risk of starting colonies in places where there is no recent history of breeding success (S. Kress, National Audubon Society USA, pers. comm.). For such species, new colony establishment is considered to be a rare event, even under ideal conditions.

Pioneers of new colonies tend to be first-time breeders who have not established themselves at other breeding sites (Podolsky 1990). Many seabirds spend their pre-breeding years visiting potential breeding sites before reaching sexual maturity (Podolsky 1990). Podolsky (1990) suggests that sustained artificial stimulation of a prospected site for several years could result in the establishment of a breeding colony. However, many suitable sites, some with a history of occupation, are not visited by non-breeding members of a population. The chances of rare individuals settling down at sites determined by biologists are relatively remote, even with the best lure techniques (S. Kress pers. comm.). For endangered species, the odds of 'rare pioneers' discovering restoration sites are even less likely due to a small pool of survivors. Whether a population of a species is expanding or contracting also influences its distribution; species' in a balanced state or contracting phase are less likely to seek out alternative breeding sites (Taylor 2000b).

The Action Plan for Seabird Conservation in New Zealand (Taylor 2000a,b) states that colony establishment is expected to contribute long-term conservation benefits to threatened seabird taxa. It recommends colony establishment projects are initiated within the next 20 years for the following surface-nesting species: Pacific (northern) Buller's albatross (*Thalassarche platei* nov. sp.), Chatham albatross (*Thalassarche eremita*), northern royal albatross (*Diomedea sanfordi*), masked booby (*Sula dactylatra fullagari*), Kermadec petrel (*Pterodroma neglecta neglecta*) and northern giant petrel (*Macronectes halli*). Hitchmough (2002) lists the following threat classifications (and qualifiers) for five of these species as: Pacific Buller's albatross—range restricted (stable population); Chatham albatross—serious decline (single population); northern royal albatross—nationally vulnerable (recruitment failure); masked booby—nationally critical (threatened overseas); Kermadec petrel—nationally endangered (secure overseas). None are expanding in population size and as a consequence are less likely to prospect in new localities. All, except the masked booby, have been identified as species that would benefit from the translocation of chicks to assist with breeding colony establishment.

Since chick translocations of long-lived, slow-reproducing species require extreme long-term commitment (C. Robertson pers. comm), and would be costly in terms of location, logistics and labour, translocations are recommended only if other social attraction methods prove unsuccessful. Even then, the growth of such artificially established colonies might be expected to be extremely slow. The Chatham albatross feeds at the most northern limit of the feeding range for the species complex and the availability of food may limit population expansion. This is a probable explanation for the lack of overflow from the existing colony on The Pyramid, Chatham Islands (M. Imber, DOC, pers. comm.). Imber also suggests that the low survival rates of black petrels (*Procellaria parkinsoni*) during the pre-breeding migration, attributed in part to the species being caught as by-catch in fishing nets in migratory waters, limited the expansion of the Little Barrier colony where chicks had been transplanted.

Artificial fostering of albatross chicks has already been achieved. Two northern royal albatross chicks at the Taiaroa Heads colony have been solely hand-reared following parental abandonment (L. Perriman, DOC, pers. comm.). Both chicks were left at the nest site for rearing. One of these hand-reared birds is known to have returned as a breeding adult. With artificial rearing techniques producing surviving adults, it remains to determine the time at which natal locality imprinting occurs, and thus the optimum age for successful transfer, for such species.

Burrow-nesting species appear to gain cues following emergence from the burrow during a relatively narrow visual sensitive period (Serventy et al. 1989). Chicks of surface-nesting seabirds are likely to have a much broader period during which to imprint on natal locality. Experimental translocations are recommended, since trials require a sufficient sample size to be tested statistically and this is not feasible for an endangered species.

Key factors that would contribute to the success of a translocation trial include: a large, stable number of chicks available for repeated translocations; suitable techniques for transfer and artificial feeding; suitable habitat quality at release sites; and preferably the immigration of birds from other colonies into the release site (Numata 1996). In addition, the monitoring of both donor and recipient colony sites would be important to assess outcome.

1.2 RESEARCH AIMS

Building on the development of successful techniques for translocating burrow-nesting seabird chicks, the Wellington Conservancy, Department of Conservation (DOC) with assistance from the DOC Science, Technical and Information Centre, is interested in initiating a trial to establish techniques for the more challenging surface-nesting species. Objective 6 of the work plan for the recovery of albatrosses in the Chatham Islands (administered by Wellington Conservancy) recommends the investigation of techniques for establishing additional albatross colonies within the archipelago, a preferred long-term option necessary to protect species that are vulnerable to the current degradation of habitat (Aikman et al. 2000).

This report is aimed at answering questions posed by the Conservancy to assist with the proposal and preparation of a trial. The questions are as follows:

- What work has been done internationally on developing techniques to establish surface nesting seabirds at new sites? (Section 2).
- Has chick translocation of surface nesting birds been attempted, and if so, which species, and what was the outcome? (Section 3).
- What are the most appropriate New Zealand seabird species to work with? (Section 4).
- Are these species known to have strong natal philopatry (i.e a tendency to recruit to breeding populations at their natal home) and do they need parental support after fledging? (Section 4).

Methods used to obtain information were as follows: literature research: web search, personal contacts, interviews with key persons, and personal experience.

2. Internationally developed techniques for establishing surface-nesting seabirds at new sites

Success has been achieved in many projects at an international level with the restoration of burrow-nesting seabird colonies. Since techniques proposed for surface-nesting seabird colony restoration (especially chick translocation) will be based on those used with burrow-nesting species, work undertaken (with project updates) with burrow-nesting puffins, shearwaters, petrels and storm-petrels is reviewed. This is followed by a discussion of projects involving surface-nesting albatrosses, penguins, gannets, cormorants/shags, terns and skimmers. A project outlining the chick translocation of a predominantly burrowing penguin species has been included in Section 3, as this species is occasionally found to nest on the surface under cover.

2.1 BURROW-NESTING SEABIRD COLONY RESTORATION PROJECTS

2.1.1 Puffins

The success of the Atlantic puffin (*Fratercula arctica*) colony creation project in the USA established a baseline for seabird translocation techniques. The National Audubon Society Research Department initiated Project Puffin in 1973 in an attempt to restore the species to Eastern Egg Rock in the Gulf of Maine (Kress 1978). Puffins had been extirpated here due to over-hunting for food and feathers by the end of the 19th century. Puffin nestlings were transplanted at a mean of 17 days (fledging age is c. 50 days) from Great Island, Newfoundland, to artificial burrows on Eastern Egg Rock where they were confined during an acclimatisation period. Chicks were then fed twice daily until fledging. Wooden puffin decoys were positioned in conspicuous places in 1977 to hold the attention of any returning birds, and gull control was implemented (Kress & Nettleship 1988).

Nearly 1000 puffin chicks had been transferred to Eastern Egg Rock by 1986, and a similar number to Seal Island National Wildlife Refuge between 1984 and 1989. Fledging success of the transferred chicks was high, with 940 fledging from Eastern Egg Rock and 892 fledging from Seal Island (Kress & Borzik 2002). A total of 19% of these birds have been re-sighted as adults in the Gulf of Maine. In 1992, transplanted birds constituted 71% of nesters at the two colony sites. By 2002, transplants constituted just 9% of nesting puffins on Egg Rock, and 4% of the breeders on Seal Island. Rapid expansion of the colonies was attributed to recruitment from other larger colonies in the Gulf of Maine (Kress & Borzik 2002).

Efforts to restore burrow-nesting species in the United Kingdom have primarily focussed on the removal of rats from existing or historical colony sites (N. Ratcliffe, Royal Society for the Protection of Birds UK, pers. comm.). Seabird numbers naturally increased on Ailsa Craig, Scotland, as soon as rats were exterminated, and rats are currently being removed from Lundy, England, with the aim of protecting a few pairs of Atlantic puffins and the small population (c.160 pairs) of Manx shearwaters (*Puffinus puffinus*) (N. Ratcliffe & H. Booker, Royal Society for the Protection of Birds UK, pers. comm.). Atlantic puffins have recently naturally recolonised Aisla Craig. Decoys were tried in an attempt to lure back the puffins but because they do not interact, the birds showed only a passing interest (B. Zonfrillo, Glasgow University UK, pers. comm.). It was considered that the colonisation of the lower slopes by other species such as shags and razorbills eventually enticed the puffins ashore. The island of Handa (near Cape Wrath, NW Scotland) was subject to a major predator clearance operation in 1997. It has shown a superb response with puffins increasing, and terns and other shorebirds nesting on the beaches where before, they were absent.

2.1.2 Shearwaters

Chick translocation experiments have been undertaken in Australia, to determine the stage a young seabird forms an attachment to the area to which it later returns as an adult (Serventy et al. 1989). These experiments were not designed to initiate new colonies as control chicks at the recipient colony had to be monitored as part of the study. Building on failed translocations of fledglings immediately prior to their migration in 1954, and in the knowledge that chicks (from transferred eggs) hatching under foster parents returned as adults to the hatching site, Serventy furthered his studies on philopatry. Between 1960 and 1971, 157 short-tailed shearwater (*Puffinus tenuirostris*) fledglings were transferred to neighbouring Fisher Island in Bass Strait, Tasmania, shortly after the perceived desertion period and coinciding with chick emergence behaviour. Only 3% of these birds returned to Fisher Island.

Complete analysis of 20 years of recovery data indicated that the short-tailed shearwater chicks were likely to have developed an attachment to their natal island before transfer (Serventy et al. 1989).

In Hawaii during the late 1970s, 65 Newell's shearwater (*Puffinus newelli*) eggs were transferred from the mountains on Kauai to the coastal Kilauea Point Wildlife Administrative Site, and 25 eggs were taken to nearby Mokuaeae Island State Seabird Sanctuary (Byrd 1984). The eggs were cross-fostered to the similar sized wedge-tailed shearwaters (*Puffinus pacificus*). With good overall hatching success and 94% of chicks fledging, it was recommended that both sites be monitored for birds returning to breed. By 2003, a couple of nests of Newell's shearwaters were found at Kilauea Point and it is believed they may have come from those original translocated birds. (B. Flint, US Fish and Wildlife Service & V. Byrd, Alaska Maritime National Wildlife Refuge, pers. comm.).

In the United Kingdom, a project to establish a Manx shearwater colony on Cardigan Island in Wales using chick translocations was ultimately declared unsuccessful. A total of 250 chicks were moved from Skomer Island to Cardigan Island between 1980 and 1984 (Brooke 1990). Chicks were taken soon after parents had deserted them and placed in artificial burrows at the release site. Evidence that birds had returned was found in 1984. By 1988, there was still evidence of activity at two or three burrows, however an increasing gull population on the island is thought to have deterred the shearwaters from settling. The installation of a sound attraction system may have assisted in attracting more of these birds to the site although amplifiers were not placed on the island until 1989. A single bird transferred in 1980 was found dead at its natal colony on Skomer Island 7 years later (P. Davis unpubl. data).

Plans are currently underway to eradicate rats from Canna, Scotland where Manx shearwaters were finally extirpated by rats in 2001 (I. Mitchell, Joint Nature Conservation Council UK, pers. comm.).

In New Zealand, translocations of several hundred non-threatened fluttering shearwater (*Puffinus gavia*) chicks in the 1990s from Long Island to Maud Island, resulted in the establishment of a small colony. Breeding was reported on Maud Island in the 1996/97 season, and six pairs were established by 1998 (B. Paton, pers. comm., cited in Taylor 2000b). Two beach-wrecks were also found on the east Australian coast, where juveniles are thought to travel to following fledging (Bell 1995).

2.1.3 Storm-petrels

Podolsky & Kress (1989) have successfully attracted breeding Leach's storm-petrels (*Oceanodroma leucorhoa*) to two islands—Old Hump Ledge (a former colony site) and Ross Island (a new colony site)—in the Gulf of Maine by playing recordings of vocalisations, and providing artificial burrow sites at varying distances from the sound source. These islands were known to be visited frequently by storm-petrels. This study demonstrated that, once established, birds continued to breed at the site without artificial sound attraction (Kress 1997).

A colony attraction project is currently underway for Tristram's storm-petrel (*Oceanodroma tristami*) at Midway, Hawaii, assisted by the National Audubon Society (B. Flint pers. comm.).

One of the only active schemes in terms of habitat creation for burrow-nesters in the United Kingdom has been initiated on the island of Auskerry in the Orkneys where increased sheep grazing since the 1990s has lead to a large proportion of European storm-petrel (*Hydrobates pelagicus*) burrows collapsing (I. Mitchell pers. comm.). The colony has apparently declined substantially since 1995 due to erosion of nesting habitat. A proposal by a landowner to create artificial burrows for the storm-petrels is under review (H. Riley, Scottish Natural Heritage, pers. comm.).

2.1.4 Petrels

Attempts to concentrate dark-rumped petrels (*Pterodroma phaeopygia*) in an extinct volcano cone (where rat predation levels were relatively low) in the highlands of Santa-Cruz Island, Galapogos, proved that sound playback was effective in attracting birds to a site (Kress 1990; Podolsky & Kress 1992). Over 1988 and 1989, 160 artificial burrows were constructed in the crater, and recordings of a large petrel colony played at night. Five days into the project, birds began to prospect. Evidence of breeding was found in 1990. An attraction site for dark-rumped petrels on predator-free Pinta Island was subsequently created (Kress 1990).

The Phoenix petrel (*Pterodroma alba*) attraction project at Jarvis Island National Wildlife Refuge, Hawaii, is small-scale and low-key (B. Flint pers. comm.). In 2001, a solar-powered machine playing recordings of Phoenix petrel calls gathered on Christmas Island, was set up. A year later the machine was still working when staff briefly visited the site but there was no sign of any petrel activity. There is no strong evidence that the petrels are not visiting the site and the staff monitoring visit may have been at the wrong time of year. Birds nest under vegetation as opposed to doing a lot of digging, so signs of activity may not be obvious. Staff did not visit the island during the 2003 season.

A colony attraction project is currently underway for Bulwer's petrel (*Bulweria bulwerii*) at Midway, Hawaii, assited by the National Audubon Society (B. Flint pers. comm.).

Biologists of the French Antarctic Team are monitoring the recolonisation of burrow nesting petrels following eradication of predators (mainly rats) from St. Paul and Kerguelen Islands (H. Weimerskirch, French Antarctic Team, pers. comm.).

In Australia, a trial translocation of 30 Gould's petrel (*Pterodroma leucoptera leucoptera*) chicks was made within the sole breeding grounds on Cabbage Tree Island (Priddel & Carlile 2001). Chicks were selected on plumage characteristics, and were fed every third day in artificial boxes. By 2001, three birds had returned to the release gully close to where they had fledged in 1995. Following on from the success of the trial translocation, a plan was initiated to re-establish Gould's petrels on nearby Boondelbah Island to augment a tiny, recently discovered population (Priddel & Carlile 1997). In 1999, 100 nestlings were moved from Cabbage Tree Island to Boondelbah Island in the first large-scale transfer (Priddel & Carlile 1999). Chicks were transferred 10–21 days before fledging. They were housed in artificial burrows and fed fresh squid and whitebait each day. Data has yet to be published on return of birds to the adopted colony site since October 2002.

In New Zealand, the depleted colony of the vulnerable black petrel on Little Barrier Island was augmented by transferring 249 chicks from Great Barrier Island, 30 km away, between 1986 and 1990 (McHalick 1999), following the removal of cats. Chicks were removed at their peak body weight close to fledging time (M. Imber pers. comm.). Imber reports mixed success for this project; the average recovery rate (4.8%) of translocated birds was similar to that of controls at both donor and recipient sites. Two birds were breeding at the release site by 1997. The limited number of birds returning to the release site is likely to be due to their low survival during the pre-breeding migration.

An experiment to lure northern diving petrels (*Pelecanoides urinatrix urinatrix*) and other species to Mana Island using tape playback and artificial burrows was set up in 1993 and had attracted three non-breeding females by 1998 (Taylor 2000b). A chick translocation project was initiated in 1997. A total of 239 chicks were moved from North Brothers Island and Sugarloaf Islands over three years, and hand-fed for periods between 1 and 44 days. About 120 chicks are thought to have fledged, with a 15% return rate by 2001 (C. Miskelly, DOC, pers. comm.). The first locally reared chick fledged in 1999, with six fledging in 2001. While many colonists and returning chicks, and one of two white-faced storm petrels (*Pelagodroma marina*), have been recovered near the loud speakers, Miskelly reports that most breeding burrows are 20–200 m away from the loud speakers.

In two transfers of a 3-year translocation project, 140 fairy prion (*Pachyptila turtur*) chicks have so far been transferred to burrows at the diving petrel colony site on Mana Island. All chicks transferred from Stephens Island in 2003 fledged successfully 5 to 21 days after transfer (Miskelly & Gummer 2003). Fairy prion vocalisations also feature on the diving petrel tape playback, so species other than those released at the site can also be attracted.

A 3-year translocation project to establish the threatened Pycroft's petrel (*Pterodroma pycrofti*) on Cuvier Island completed its last season of transfers in 2003 (G. Taylor pers. comm.). Over 230 Pycroft's petrel chicks, sourced from Red Mercury Island, were artificially fed as required at the recipient location, and high fledging success is reported. Techniques established for this small Pterodroma are now successfully being applied to the nationally threatened Chatham petrel (*Pterodroma axillaris*). Two transfers of 90 Chatham petrel chicks, sourced from the single known breeding colony on South East Island, have shown high fledging success rates (H. Gummer pers. obs). Feeding regimes have been refined to meet individual chick demands.

2.2 SURFACE-NESTING SEABIRD COLONY RESTORATION PROJECTS

Surface-nesting seabird colony establishment projects are occurring in both Pacific and Atlantic regions, and in both Northern and Southern hemispheres. Species that have been translocated to alternative locations following oil-spills have not been included in the following review since such projects aimed to move affected birds as far away from the disaster site as practically possible. Locations are chosen at appropriate distances from the oil-slick zone to allow birds' time to feed and rest away from the contaminated site prior to their anticipated return to natal and/or breeding sites (Hull et al. 1998). Birds have not been encouraged to nest at such release locations. Recent natural colonisations of a few species have been included because these are considered significant events and have triggered additional colony restoration management.

2.2.1 Albatrosses

Albatrosses are legendary for breeding at the same nest site year after year (Fisher 1971), as demonstrated in a range of species. The Laysan albatross (*Diomedea immutabilis*) has been the subject of long and detailed studies in Hawaii which indicate that individuals of this species are firmly attached to the island and colony of origin, the vicinity of the natal nest site, and the nest previously used (Fisher 1971). First-time breeders show a tendency to breed near the site of their natal nests. Fisher conducted experiments in the early 1960s involving the translocation of individuals of this species to determine the age at which Laysan albatrosses first acquire information cues that allow them to return to the island of origin, the colony, and the natal nest at a later date. His work, discussed in Section 3.1, was also aimed at trialling methods for augmenting existing smaller colonies of breeding Laysan albatrosses as an additional measure to safeguard the species given that the Midway Atoll population was potentially under threat from military operations and runway developments.

Colonial seabirds also select breeding sites based on a variety of other factors which include the sight and sound of conspecifics (Podolsky 1990). The presence of conspecifics indicates that the site is worth visiting (Podolsky 1990). Podolsky states that pre-breeders will recognise the locality as safe relative to unoccupied localities, and as a productive site if those conspecifics are seen to be breeding. New colonists tend to be first-time breeders who have not established themselves at other breeding sites. Building on this knowledge, seabird conservationists have primarily focussed on methods of artificial social stimuli in attracting albatross species to new sites.

Hawaii

There have been two Laysan albatross attraction projects, conducted in the 1980s and 1990s, in Hawaii. At Kilauea Point National Wildlife Refuge on the island of Kauai, prospecting Laysan albatrosses were successfully attracted to a previously unoccupied site using both models and sound recordings of a full range of vocalisations. Landing behaviour, and distribution and behaviour of birds on the ground, clearly indicated that the albatrosses were responding to the presence of both visual and auditory stimulation (Podolsky 1990). During his study, Podolsky also reports that the albatrosses appeared to be sensitive to the social grouping and behavioural state of the models, with birds attracted significantly closer to pairs of models over single models, 3-D models over 2-D models, and to models showing sky-pointing behaviour.

On the island of Kaohikaipu, to the east of Oahu, a similar colony attraction project was set up in 1993. Over 40 polyethylene life-size models, six decoy chicks, and decoy eggs, along with two CD sound systems were placed in a cluster at a site previously favoured by albatrosses. The aim was to encourage birds to nest at the state wildlife sanctuary rather than on airport runways. Albatrosses were observed on or near the island on 27% of observation days in 1994–95, and on 19% of observation days in 1995–96 (Borzik et al. 1995, 1996). They were irregularly visiting the island by 1999 (Kress et al. 1999). The project has been deemed unsuccessful by those involved; the difference (between this and Podolsky's Kauai project) may have been the initial density of birds in the area (B. Flint pers. comm.). Laysan albatrosses already had a presence on Kauai, with two relatively recent colonies existing in the presence of a range of threats. Kaohikaipu, however, was not exposed to the same level of visitation by this species. Flint suggests that it is also possible that the site chosen for the new colony on Kaohikaipu was uncongenial to albatrosses for some wind or aspect reason. The National Audubon Society Ornithological Research Unit, co-supervising this project, indicate that they have had less success with the Laysan albatross, compared with other species managed, in terms of successfully establishing a new colony (S. Kress pers. comm.). Kress considers the project on Kaohikaipu suffered because there were too few prospectors in the area to experience the artificial decoys.

A natural colonisation of the Laysan albatross has occurred within the last decade in a new location: Kaena Point on the island of Oahu (B. Flint pers. comm.). Although the environment is harsh with strong winds, salt spray and hot sun, the habitat was regarded as conducive to nesting seabirds prior to the introduction of mammalian predators even though there were no reported nesting records before 1992 (Sugimura et al. unpubl. data). The colony was founded by a single successful breeding pair in 1992 and has grown recently due to a management programme implemented by the United States Fish and Wildlife Service involving predator control and increased protection from human disturbance (Sugimura et al. unpubl. data). Lack of monitoring at Kaena Point prior to this first discovery of evidence that the Laysan albatross was nesting means that there is uncertainty as to when and how the pair started nesting in this location. There is speculation that one or both members of the pair were driven away from the airport because their presence may have posed a hazard to aircraft. Two years later, following the initiation of a predator control regime, the burrow-nesting wedge-tailed shearwater was reported as breeding successfully for the first time at Kaena Point (Sugimura et al. unpubl. data).

At Midway Atoll, Hawaii, 400 000 nesting Laysan albatrosses and black-footed albatrosses (*Diomedea nigripes*) have attracted a few of the larger, endangered short-tailed albatrosses (*Diomedea albatrus*) (Kress et al. 2001). Approximately

1000 short-tailed albatrosses survive on two remote islands to the south of Japan (Torishima and Minami-kojima). In winter 2000, decoys of this species were placed near sound playback equipment in ideal habitat on Eastern Island, Midway, among the other two nesting species, in an effort to encourage this species to stay (Kress et al. 2001).

Japan

Hiroshi Hasegawa placed very realistic decoys and excellent sound recordings in a non-volcanic part of Torishima Island, Japan, and had one pair of short-tailed albatross select his site immediately. These birds were immature when they first nested. This was initially very encouraging, but there has been no further colonisation (S. Kress pers. comm.).

New Zealand

A notable new natural colonisation event appears to have been initiated in 2003 on the Chatham Islands by an albatross species that has never been recorded breeding in this location (Miskelly 2003). The Antipodean albatross (*Diomedea antipodensis*) is a relatively small, dark form of wandering albatross otherwise known to nest on the Antipodes Islands and Campbell Island. Large albatrosses, formerly suspected as being northern royal albatrosses, have been frequently sighted on and over farmland on the southwest coast of main Chatham in recent years. In April 2003, a female Antipodean albatross was reported to be incubating an egg which was subsequently lost to an unknown cause. The sightings of birds in flight are now considered to refer to the Antipodean albatross, a species for which there is no confirmed evidence of any breeding on the Chatham Islands, even before human settlement (Miskelly 2003).

Features which might make the site attractive to nesting birds include a plateau 150 m above sea-level, vegetation similar to that found on the Antipodes Island plateau, and farm-bike tracks through the rough pasture which may be used for take-off purposes. At least two female and two male Antipodean albatrosses are known to be visiting the vicinity of the nest, based on birds seen on the ground and in flight on a single day (Miskelly 2003); it is very likely that there will be further breeding attempts on southwest Chatham Island. Whilst failure to breed in an inexperienced pairs' first breeding year is not uncommon, management of any future breeding attempts would be required to secure the survival of chicks against predators. This could be facilitated if nests occurred near to each other, rather than scattered over the 2 km of farmland where birds have been recording landing. A proposal to use albatross decoys to focus the attention of flying birds to the near vicinity of the current nest site has been put forward (Miskelly 2003).

2.2.2 Penguins

Antarctica

Biologists of the French Antarctic Team have been involved in a seabird restoration programme in Adélie land creating new nesting sites for Adélie penguins (*Pygoscelis adeliae*), Cape petrels (*Daption capense*) and snow petrels (*Pagodroma nivea*) following the destruction of traditional sites for the construction of an airstrip (H. Weimerskirch pers. comm.). Prior to the destruction of the nesting sites, nesting birds were banded and removed to neighbouring islands. The subsequent fate of these birds and their breeding success has been followed each year, and the proportion of birds returning to the islands determined. The distance that birds are recovered from the destroyed site for each species has also been recorded. After the destruction, new sites were built up for the Cape and snow petrels; these species can be regarded as surface-nesters although crevices would be favoured sites. Decoys and sound recordings were also used, although the details of these and the nature of the habitat creation were not obtained for this report. There is no pubished information regarding these projects.

South Africa

There was a relatively recent natural colonisation of a mainland site at Stony Point, Betty's Bay, in South Africa in 1982 by the Jackass penguin (*Spheniscus demersus*), but there is no clear explanation for this event (Whittington et al. 1996). Results of flipper-banding indicated that some of these young birds had originated 60 km away at Dyer Island. Whittington et al. suggested that there may have been decreased food availability near Dyer Island, or that birds may have moved from a neighbouring colony on Geyser Island where predation by seals was increasing. Forty nests were recorded at Stony Point in 1986. Once the colony was fenced in 1987, the site became attractive to other marine birds (see Section 2.2.4).

New Zealand

The destruction of suitable nesting habitat has become a major threat to New Zealand mainland colonies of yellow-eyed penguins (*Megadyptes antipodes*). The Otago Conservancy (DOC) has used 2-D, painted plywood cutouts as decoys to attract yellow-eyed penguins to re-vegetated sites with some success (D. Houston, DOC, pers. comm.). The decoys were first used at Katiki Point, Moeraki, in 1989 to try to entice the penguins to suitable nesting sites in a re-vegetated area (D. Houston & K. Pearce, DOC, pers. comm.). There had been a number of rehabilitated yellow-eyed penguins released into this area but none had nested. Two to three decoys were placed in prominent places clear of vegetation in the sorts of places that the birds like to roost. Almost immediately, the decoys were visited by the penguins. It is unclear whether this actually induced penguins to prospect for nest sites, but there are now 10 breeding pairs at this site. The second site where decoys were used was at Bobby's Head near Palmerston in 2000, with the aim of encouraging the penguins to use a particular landing site that would provide access to re-vegetated habitat. Two decoys were placed above the landing site and were visited by penguins, however none have yet been induced to stay and breed (D. Houston pers. comm.).

2.2.3 Gannets

North America

A northern gannet (*Sula bassana*) colony restoration project has been attempted on an island in the Mingan archipelago, off the coast of Québec on the north shore of the Gulf of St. Lawrence. The project involves a collaboration between the National Audubon Society, Québec-Labrador Foundation, Mingan Islands Cetacean Study, Parks Canada, Canadian Wildlife Service, and the local community. Ile-aux-Perroquets was home to a once-thriving gannet colony that suffered through decades of over-exploitation (fish-bait) and disturbance (Blanchard 2000). The colony abandoned the site during the 19th century following construction of a lighthouse (Kress et al. 2001).

On Seal Island in the Gulf of Maine, 23 life-sized decoys had been installed on an east-facing cliff-top (Borzik et al. 1995). The models were set on seaweed nests, and the sounds of an active colony broadcast day and night. However, with gannets showing little interest in the artificial colony on Seal Island, the equipment was relocated to Ile-aux-Perroquets in 1997, to attract gannets dispersing from the nearby colonies (Kress & Borzik 1997). A total of 47 life-sized decoys were installed on Perroquet Island. In the first year of the project, several hundred gannets were sighted near the island, and some landings were recorded.

In 1999, 43 decoys were placed on seaweed nests, each on top of a weed barrier mat (Kress et al. 1999). Paint, resembling guano, was applied around the nests. For three consecutive seasons, one adult resided among the decoys. As many as 1900 gannets were sighted in a single day flying, feeding and sitting on the water around the island, yet the decoys remained mostly unvisited. In the fourth field season of 2000, two adults landed among the decoys. Gannet activity around the island was at its lowest since the project began (Kress et al. 2000). In 2001, one bird visited for several days only. The gannet project was abandoned after six field seasons, partly because few gannets were prospecting among the decoys despite there being thousands of birds within site of the restoration location (S. Kress pers. comm.).

In 1994, Ted D'Eon (local pharmacist) took six carved cedar decoys to Gannet Rock, 20 km off the shore of Nova Scotia in the Bay of Fundy (Jaimet 1998), hoping to re-establish the gannetry which had been exterminated by the end of the 19th century. Gannet Rock lies on the flight path of thousands of gannets in the spring. Jaimet reports that by 1998 there were 46 foam and fibre-glass decoys taken to the island each spring to act as attractants to the passing gannets.

Australia

The Tasmanian National Parks and Wildlife Service initiated a project to restore a gannet colony on Cat Island in Bass Strait in the mid 1980s. The, now virtually extinct, gannetry was reportedly the largest of its kind in Australian waters, with at least 2000 pairs of Australasian gannets (*Morus serrator*) estimated as breeding there at around the start of the 20th century (Phillipps 1993). Lack of official protection for the birds through the early part of the 1900s lead to virtual extinction of the colony through human predation and vandalism. By 1984 the remaining colony consisted of seven breeding pairs which suffered as a result of fire on the island. Subsequently, no more than three chicks were reared each season at the site until 1990, when only a single gannet fledged.

Following the 1984 fire, 60 spray-moulded plastic foam model gannets were painted, and placed at the colony site in an attempt to lure in the prospecting birds seen flying around and over the site. The models were accepted by the few residents at the colony. However, a pair of sea-eagles (*Haliaeetus leucogaster*) from neighbouring Babel Island destroyed the models, and began to attack the live gannets settling to breed. The models were considered to have potential to attract more gannets to the site, but efforts were thwarted by the harassment from the sea-eagles. Plastic models were later replaced with more robust concrete versions. In the same 1993–94 season, a single pair was attracted to the new decoys and nested, but failed to breed (Johnson 1994). Plans to advance the Cat Island Gannetry Attempted Resurrection project (CIGAR) in subsequent years included construction of more decoys, creating artificial nest mounds, simulation of guano, and setting up an audio system to play recordings of gannet calls.

Unfortunately, CIGAR ran out of resources and political support to sustain the programme, in part because the gannet is not considered to be threatened as a species and breeds elsewhere in Bass Strait (H. Phillipps, Royal Australasian Ornithological Union, pers. comm.). Local resentment over the use of resources may also have contributed to its downfall. Volunteer wardens from the Royal Australasian Ornithological Union have not been involved in manning the island in recent years.

New Zealand

In partnership with the Friends of Mana Island Society Inc., DOC are attempting to attract Australasian gannets to Mana Island using over 100 concrete, painted decoys installed in 1997. A sound attraction unit, installed in 1999, plays the sounds of an active gannetry throughout the day (J. Christensen, DOC, pers. comm.). Whilst up to two gannets at a time have landed at the site, sightings are infrequent (C. Miskelly pers. comm.).

Australasian gannet numbers are increasing in New Zealand, yet there are only two gannet colonies in the Cook Strait region. There are reports of a small site at the south end of Mana Island over a century ago, although the breeding status of those birds remains unknown (J. Christensen pers. comm.). Further justification for establishing this species here is outlined in the Mana Island Restoration Plan (Miskelly 1999) which states that reintroduction can occur for species known to be present in the southern North Island but are unlikely to independently establish self-sustaining populations in pest-free sites. Such re-introductions should not compromise the conservation values on the island. A gannetry would also fulfil the role of restoring some of the ecological processes representative of the exposed Wellington west coast, i.e. nutrient input from seabird guano.

2.2.4 Cormorants and shags

The National Audubon Society Ornithological Research Unit, USA, are planning to commence a Brandt's cormorant (*Phalacrocorax penicillatus*) colony creation project in California (S. Kress pers. comm.). It is hoped that establishment of a Brandt's cormorant breeding site will benefit the surface-nesting common murre (*Uria aalge*), since murre colonies tend to form within the Brandt's cormorant nesting areas.

In South Africa, a fencing project to protect a developing colony of Jackass penguins (see Section 2.2.2) had beneficial spin-offs for other seabird species

(University of Cape Town Avian Demographic Unit web page, http://web.uct.ac.za/depts/stats/adu/index.html, viewed April 2003). Once the fence was erected in 1987 at Stony Point, Betty's Bay, four local species of marine cormorants took up residence inside the predator-free area. White-breasted cormorants (black shags) (*Phalacrocorax carbo*), bank cormorants (*Phalacrocorax neglectus*), and crowned cormorants (*Phalacrocorax coronatus*) were observed regularly breeding at the site, and Cape cormorants (*Phalacrocorax capensis*) regularly visited but did not breed every year.

In New Zealand, pied shags (*Phalacrocorax varius*) have been successfully 'transplanted' from Nelson to an alternative nesting area about 300 m away in the South Island (P. Gaze, DOC, pers. comm.). The shags were nesting on the waterfront and became a nuisance to a public area. They were attracted to nearby Haulashore Island using plywood cutouts as decoys and by making the area appear already occupied by simulating guano using white paint. Birds were discouraged from returning to the original nesting site by modification of the habitat making it unsuitable for nesting. The Norfolk Island pine trees where the shags had nested were trimmed to half their original height, destroying the nests. The birds eventually moved to Haulashore Island but nested as far from the cutout decoys as possible. The Norfolk Island Pines at the original site have since re-grown, but the shags are reported as doing well on the island.

2.2.5 Terns and skimmers

North America

The National Audubon Society Ornithological Research Unit report the greatest success with terns in terms of establishing new colonies when compared to similar work with other species. The tendency of terns to move from one ephemeral habitat to the next in response to storms and predators predisposes them to be responsive to management (S. Kress pers. comm.). A combination of predator control (particularly gulls), vegetation management and social attraction (decoys and sound recordings) have been used to initiate new tern colonies in the USA. In some cases, no living terns with a memory of previous nesting at the artificial sites were available for recolonisation (Kress 1997). These programmes have been spectacularly successful. Recently, 10 000 pairs of Caspian terns (*Sterna caspia*) were encouraged to relocate to a historic nesting site—East Sand Island—at the mouth of the Columbia River, Oregon to reduce the impact of the terns on the salmon smolt. Before terns were relocated, 91% of their diet was young salmon; after the move salmon comprised 44% of the terns' diet (Kress et al. 2000).

For social attraction, typically a large number of decoys are used as a lure, e.g. 100 life-sized decoys to attract common terns (*Sterna hirundo*) back to Outer Green Island (Kress & Borzik 2002); or up to 100 decoys to attract Arctic terns (*Sterna paradisaea*) to Eastern Egg Rock, Maine (Kress 1983). Taped recordings for broadcast over the decoys were of non-aggressive sounds (courtship calls) of a tern colony. Kress (1983) observed that the Arctic terns responded positively to the presence of decoys with visitation to Eastern Egg Rock improving from 59% to 96% of observation days with tern sightings. The terns often interacted with the models, with pecking or aggressive displays, and even courtship displays (feeding and mounting). When nesting commenced, birds formed a single group around the decoys, with some nests very close to models. Kress (1983) suggests that social attractants may initiate courtship behaviour through social stimulation (or facilitation), influencing nearby birds and even passive pairs to display similar behaviour.

Several colonies of endangered roseate terns (*Sterna dougallii*) have also been started, and common and Arctic terns have now become state listed since the establishment of additional colonies on islands in the Gulf of Maine (S. Kress pers. comm.). In 2001, 71% of Maine's nesting terns were using National Audubon Society-managed sites (Kress & Borzik 2002). By 2002, productive tern colonies have been restored to a total of 12 islands by the Gulf of Maine Tern Working Group (now the Gulf of Maine Seabird Working Group), a partnership of US/Canadian conservation organisations and agencies.

Podolsky (1990) states that the black skimmer (*Rynchops niger*) has been subject to colony attraction techniques in the form of models and/or vocalisation playbacks in the USA. Literature to expand on this project has not been sourced for this report; details of whether models and sound were used in conjunction with predator control and/or substrate modification are, therefore, not available. Kress (1983) considers that decoys, and the provision of a prepared surface of crushed oyster shell, could have been useful in the re-establishment of an abandoned black skimmer colony on a parking lot in Freeport, Texas.

United Kingdom

Tern restoration projects have been conducted in the United Kingdom with mixed success (N. Ratcliffe pers. comm.). Little terns (*Sterna albifrons*) at Chesil Beach, Dorset, in recent years have concentrated on a beach near an area of high disturbance (humans) and predation (foxes). Efforts have been made to disperse them along a barren shingle ridge where colonies formerly occurred and both predation and disturbance would be less (N. Ratcliffe pers. comm.). The little tern project has attempted to use decoys and sound lures to attract terns to a fenced breeding site within 3 km from their current colony site. The beach is several kilometres long and, historically, the birds nested in several small colonies along its length. The project has two main aims: to protect the colony as far as possible at its existing site using fencing and wardening, and to attempt to relocate the colony to an area less accessible to people and foxes (using decoys) (H. Booker pers. comm.). The colony generally holds 60–80 pairs of birds but the productivity (especially hatchability) is very low, recently producing only around five fledged chicks. Kestrels (*Falco tinnunculus*) are also a problem, taking most of the chicks in some years.

The decoy site is surrounded by a 2 m-high fence, buried into the substrate, and covers an area of 100 m × 50 m. When the site was established in 1999 the area was divided into a control plot and a test plot. Each plot was 20 m^2, set 5 m in from the fence. The test plot contained two sets of decoys set 2–3 m apart, each set comprising three pairs and six individual decoys. In addition, six further single decoys were scattered within this plot. Common tern decoys were also used in this plot in a separate area. The sound system played non-aggressive little tern and common tern calls 24 h a day from spring to autumn. So far, the decoys have been unsuccessful in attracting little terns. Vandalism and storm damage at the site are problems (H. Booker pers. comm.).

Common terns on the Isles of Scilly nest on low-lying rock reefs that are prone to flooding (N. Ratcliffe pers. comm.). The presence of predators on larger islands and islets is thought to prevent this species from nesting in more favourable habitat. The island of Sampson was cleared of rats, and decoys and sound recordings were used to attract terns there. A colony began to establish on the island, but predation from crows was a problem. In 2002, the birds moved to another island that has always been rat free and where no decoys were deployed. Common terns have also been successfully attracted to floating islands covered in cockle-shells at some Royal Society for the Protection of Birds reserves (N. Ratcliffe pers. comm.).

Roseate terns are confined to a small number of colonies in the Irish Sea, so creating more colonies is desirable to reduce the risk of catastrophes at one site affecting a large proportion of the population (N. Ratcliffe pers. comm.). Decoys and tapes were used on Dalkey Island, Ireland, and Skerries, Anglesey, within existing common/Arctic tern colonies to attract roseate terns from the large colony of Rockabill. These locations are within tens of kilometres of each other. This project was not successful. An earlier project in southeastern Ireland also attempted to attract roseate terns from Tern Island, that was being eroded away by the sea, to an offshore rock several kilometres away. The terns ignored this site and settled at an islet in a coastal lagoon instead, where rat predation is periodically a problem. A plan to establish terns back onto Mew Island, Ireland, was temporarily abandoned due to gull encroachment. Although the gulls died due to a botulism outbreak, the vegetation went rank and precluded terns breeding there. Habitat is to be managed once again, this time adding a cockle-shell substrate, prior to the use of decoys and tapes to lure back roseate and common terns (B. Zonfrillo pers. comm.).

Australia

In eastern Australia, there are examples of colony establishment projects to benefit the migratory, endangered little tern. Active management involves the attraction of terns to safer nesting areas away from the threats of human disturbance, mammalian predation, the encroachment of urbanisation and industrialisation, and areas less prone to inundation from high tides (Murray 1994). The most significant management technique, resulting in a dramatically improved breeding success for the species in Gippsland, Victoria, was a habitat enhancement project. Dredge spoil from the port was used to create a safe nesting site on Rigg Island in the Gippsland Lakes, as well as to enhance existing vulnerable nesting sites by mechanically raising them. The National Parks and Wildlife Service in New South Wales has successfully attracted little terns that were displaced from the airport construction site at Botany bay, to Spit Island in the Towra Point Nature Reserve (http://www.ssec.org.au, viewed in 2003). They achieved this by clearing vegetation to create open sandy nesting areas. Sandbagging now protects the area from flooding.

2.2.6 Auks

In California, the National Audubon Society Ornithological Research Unit, United States Fish & Wildlife Service, and the National Biological Survey have restored the surface-nesting common murres to Half Moon Bay following an oil spill in 1986, and a 10-year hiatus of no breeding (S. Kress pers. comm.). In 1996, 400 decoys were placed on Devil's Slide Rock along with 12 mirror-boxes and a sound attraction system. Six pairs of birds nested the same year. The project surpassed its 10-year goal to establish 100 pairs when, by the seventh field season, there were already 123 nesting pairs of murres present (Kress & Borzik 2002).

3. Attempts to translocate chicks of surface-nesting seabirds

Work on translocation of chicks of surface-nesting seabirds has been limited. Two projects outlined below occurred in Hawaii and involved albatross and booby species. Details of two projects in New Zealand involving the translocation of seabird chicks from wild to captive (and vice versa) environments are also included. Section 3.2.3 includes a review of a chick translocation trial project focussed on a New Zealand penguin species which, although predominantly burrow-nesting, occasionally nests on the surface under cover. Aspects of this project and its long-term duration may have some relevance to surface-nesting seabird chick translocations.

3.1 HAWAII

3.1.1 Laysan albatross

Fisher (1971) designed four experiments involving the translocation of Laysan albatross chicks from Sand Island, Midway Atoll (the source colony), to other islands within the Leeward Islands of Hawaii. The aim was to determine the age at which individuals first acquire information cues that later allow them to return to the island of origin, the colony, and the natal nest.

Chicks in the first three experiments were only taken if considered close to fledging; these chicks were ready to leave the nest but not yet capable of flight, they were feathered and free of down, and c. 5.5 months of age.

In 1961, 991 fledglings were transported 4.8 km east of the source colony to Eastern Island with full visual access to cues during transit. A total of 18% of the birds estimated to have fledged from this group were recaptured as non-breeders in 1964–65 (still 3 or 4 years from breeding) at the release site (n = 47 birds) but mostly at the source colony (n = 115 birds). A total of 26% of birds estimated to have fledged from this group were recaptured at breeding age in 1968–69, with just two birds recovered at the release site, and the majority at or near their origin at the source colony (230 birds).

In a second experiment in 1961, 112 fledglings were trucked and flown to Green Island in Kure Atoll, 84 km northwest of the source colony, with no exposure to visual cues during transit. Green Island was the only release site without an existing breeding colony of Laysan albatrosses. A total of 24% of birds estimated to have fledged from this group were recaptured as non-breeders in 1964–65 (still 3 or 4 years from breeding): 1 at the release site, 1 on Eastern Island, but the majority (n = 23) at the source colony. Only 7 birds were recaptured (restricted search effort) at breeding age, all at their source colony.

In the third experiment in 1962, 2021 fledglings were taken by boat to Lisianski Island, c. 402 km southeast of the source colony, with no access to visual cues, to test the returning performance of fledglings moved a longer distance. Of an estimated 1600 birds that fledged from the release site, around 3% were found as non-breeders in 1964–65 (still 4 or 5 years from breeding) on Eastern Island (n = 40) and back at the source colony (n = 10). Lisianski was not visited to record recoveries during this year. In 1968–69, 9% of the birds estimated to have fledged from Lisianski were recaptured, all back at the source colony. Searches at the source colony were not as intensive since fledglings had been sourced from a large area.

The last of Fisher's four translocation experiments was conducted in 1965. Chicks were removed from parents at the source colony when 3–4 weeks old (an age proven suitable for acceptance by foster parents at the release site, based on previous casual exchanges). A total of 97 chicks were exchanged between nests on Eastern Island and Sand Island, with no access to visual cues during transit. The known mortality of chicks during the rearing period and predicted mortality of fledglings prior to departure on Sand Island means only 20 chicks are likely to have departed to sea. Of these, 35% were recovered at the place of release in 1968–69, and none were recorded at the place of origin.

In summary, recaptures of non-breeders (3.5 to 4.5 years of age) were predominantly at the natal colony rather than the release site; at breeding age all but two recaptures were at the natal colony. Celestial and topographical cues during transport played no role in the homing behaviour of individuals. The presence/absence of an existing breeding colony at the release site did not appear to affect the homing instincts of individuals transferred as fledglings. Chicks do not appear to acquire proper cues for homing prior to 1 month of age, but chicks of this age are restless at the foster nest. Requisite cues for homing are, therefore, likely to be established in the Laysan albatross between 1 and 5.5 months of age.

3.1.2 Red-footed booby

A booby translocation project in Hawaii resulted from the evacuation of 20 red-footed booby (*Sula sula*) chicks from an area threatened by target practice at the Marine Base on the island of Oahu (B. Flint pers. comm.). The chicks were all downy when they were taken to Sea Life Park, the locally designated seabird rehabilitator, which successfully raised 19 of them to fledging. They were released at the Park, about 16 km away from their natal colony and continued to use the release area as a roosting site. Three or four years later, the first pair from that group of chicks is reported to have laid an egg in the Park, from which at least one bird fledged subsequently. There were already adult birds in the park that were unable to fly due to long-term injuries; these served as attractants for others returning to the area. Flint suggests that adults flying to the foraging grounds may have been models or guides to the young birds when at sea. The birds that continued returning to the Park at night also received post-fledging supplementary feeding to help them through the learning period.

3.2 NEW ZEALAND

3.2.1 Australasian gannet

A captive colony of Australasian gannets was founded at Marineland, Napier in 1970 from a few juvenile gannets deserted by parents at Cape Kidnappers. These birds were bought into the man-made captive environment for a plumage study (Wodzicki et al. 1984). Young birds subsequently found stranded on beaches augmented the captive stock. Birds in the colony went on to breed but there was generally a low hatching success. Food and shelter were provided, and the free-flying birds were able to leave the enclosure at will, which usually occurred at the adult stage. The gannets had primary feathers cut if restraining them from departure was necessary (C. Robertson pers. comm).

Marineland's work with gannets currently involves the rearing of abandoned chicks (particularly those that fall off the breeding rock at the Black Reef colony), and the rehabilitation of sick and injured juveniles and adults (B. White, Marineland, pers. comm.). In recent years, many of the birds transferred to captivity have suffered health problems and these birds have not been encouraged to leave. Rehabilitating chicks and adults are held with long-term residents on display and are fed three times a day. This is likely to encourage birds to stay. Permanent residents choose to nest on a rock ledge in the corner of the pen, with limited success. The small size of the captive colony, and the lack of experienced breeding males to pair up with an old laying female are not conducive to successful breeding. Mirrors were positioned adjacent to the nesting area to give an impression of more birds, but attempts to breed did not change. Two captive-born juveniles have fledged from the colony; one of these birds departed from the enclosure (B. White pers. comm).

3.2.2 New Zealand fairy tern

Egg and chick manipulations are among various methods used in the New Zealand fairy tern (*Sterna nereis davisae*) recovery programme to maximise productivity (K. Hansen, DOC, pers. comm.). Captive rearing of this species has been undertaken following abandonment at the nest site, when suitable foster parents were not available. The release of fairy tern chicks has so far been unsuccessful with no chicks surviving following release; the problem faced is teaching juveniles how to catch fish for themselves (K. Hansen pers. comm.). Fledglings which were 'hard-released' (i.e. with no transition phase from captive to wild conditions) at Mangawhai in 1999 are thought to have perished within a short time of liberation. One fledgling was not seen after the release, and the other chick was seen at Papakanui 2 days after the release where it was fed by the warden when it appeared near his/her vehicle. The bird's body was found 25 days after release; it had probably died of starvation although no necropsy was performed. Auckland Zoo's native fauna unit reared a further chick to 101 days, encouraging the bird to catch fish in an artificial environment, but the chick died of gout (A. Nelson, Auckland Zoo, pers. comm.). Two chicks were released by Auckland Zoo in 1986 but were not banded/monitored so the release outcome is unknown.

3.2.3 White-flippered penguin

Whilst the majority of blue penguins (*Eudyptula minor*), including the white-flippered penguin (*Eudyptula minor albosignata*), nest in burrows, rock crevices, and caves etc., a few nest on the surface typically around logs or other features, or in thick vegetation (C. Challies pers. comm.). A chick translocation trial project for the endangered white-flippered penguin, conducted independently on Banks Peninsula by Challies, is reviewed here.

Challies (pers. comm.) has undertaken a series of chick transfer trials with the white-flippered penguin to develop methodologies for a proposed restoration project at Boulder Bay on the Peninsula. Over a period of 18 years he has identified methodologies and is now ready, with the help of a group or 'Trust' to get an operational programme underway subject to approval by Governmental agencies.

The translocation trial, moving birds from various colonies on the Banks Peninsula over distances of 40–70 km to a small colony at Godley head, was run in three parts during the 1980s and 1990s.

First, Challies determined the age/stage at which chicks are imprinted with the location of their natal colony. He achieved this by transferring samples of chicks from one colony to another, marking similar numbers of locally bred chicks as a control, and then monitored the relative return rates. The objective was to establish how late in the chick stage they could be transferred and yet behave as if they were locally bred. Chicks transferred as late as 55 days of age, just before fledging, showed the same return rate to the release site as controls hatched and reared at the site (Numata 1996).

Once Challies had established the maximum age for transfer, he undertook a trial transferring 30 chicks a season for 5 years, then 15 chicks per year for the next 5 years, from Banks Peninsula to Godley Head from 1985–1996. (The numbers for the planned rehabilitation project are an average of 300 chicks a season for 10 years which will give a colony of 300 pairs at the site and a further 300 pairs in adjacent bays.) The trial colony suffered a low level of predation but this issue was addressed (C. Challies pers. comm.).

Following the trial, Challies made a one-off, 'large-scale' transfer (of 46 chicks) with a helicopter to test the proposed methods for collecting, transferring, and releasing that number at one time. (His plan proposed moving the 300-chick quota each year in six helicopter loads.) The establishment of these birds is still being monitored (C. Challies pers. comm.). The proposal for establishing the new colony at Boulder Bay also includes the installation of wooden nest-boxes, a track system up the valley to aid bird access to the boxes, a predator-proof fence and a trapping regime.

Detailed studies of the penguin's demography and recruitment behaviour have been made by Challies, and the size and composition of the proposed donor colony monitored for the last 20 years. This has enabled Challies to model the development of the proposed new colony and the impact on the main donor colony.

4. New Zealand species as candidates for chick translocation trials

This section reviews the New Zealand surface-nesting seabird species and their suitability for chick translocation trials, paying particular attention to their natal philopatry, and the need for parental support after fledging. A species exhibiting low philopatry, or requiring post-fledging parental care, would be considered unsuitable for chick translocations at this stage.

4.1 ALBATROSSES

Trials to establish a methodology for transferring surface-nesting seabird chicks should be undertaken with an abundant species before application to threatened albatross species (see Section 1.1).

Methods for artificially rearing northern royal albatrosses have been established and documented by DOC at Taiaroa Heads. To improve overall productivity, abandoned or weak chicks are fostered, or given artificial supplementary food if chick manipulation is not possible (L. Perriman pers. comm). Chicks can be exchanged between nests, while very young, for feeding by a temporary foster parent, then moved back. This gives the chick fresh food and teaches it to beg properly, a behaviour it may not have been displaying at the natal nest due to weakness or pair inexperience. Once chicks reach about 4 weeks old, foster parents recognize a chick that is not their own; at this point chicks are hand-fed where necessary.

4.2 PETRELS

The northern giant petrel and the Kermadec petrel are two surface nesting-species for which new colony establishment is listed under future management actions (Taylor 2000b). Both species breed in very remote locations (Kermadec Islands, and Chatham and subantarctic islands respectively). Northern giant petrels have been little studied in New Zealand, and have low tolerance to human disturbance. The natural colonisation process of Raoul Island, recently cleared of rats and cats, by Kermadec petrels is likely to be aided initially by installing sound attraction systems (Veitch et al. in press).

4.3 PENGUINS

After the gannets (see Section 4.4), members of the penguin family are probably the next most feasible subjects for chick translocations, particularly because of their post-fledging independence, and generally low level of parental attendance following the guard stage.

Whilst the relationship between parents and offspring of many penguin species at sea remains largely unknown following their departure from the breeding colony, migratory behaviour of some species, and breeding studies of others indicate that young are independent of parents after they fledge. Little blue penguin adults and young are known to migrate to different areas after breeding in Australia (Marchant & Higgins 1990). Fully-fledged young can be driven from the natal burrow by their parents. Yellow-eyed penguins swim immediately on reaching the sea and are totally independent of their parents (Marchant & Higgins 1990).

Penguins generally have a low level of parental attendance after the guard phase, which is further reduced to guarding at night after chicks reach a few weeks of age and when a thick layer of secondary down is produced (Heather & Robertson 1996). Night visits are further decreased in duration as fledging approaches; e.g. in the post-guard phase in blue penguins, chicks are left alone except when parents come separately to feed them (Marchant & Higgins 1990).

There is a varying level of philopatry in different penguin species, and between sub-species in different areas. The blue penguins appear to exhibit a high level of philopatry; most of the blue penguins are predominantly burrow-nesting and would not be considered for the proposed surface-nesting seabirds chick transfer trial. Southern blue penguins (*Eudyptula minor minor*) exhibit a philopatry of around 98% on the Otago coast (D. Houston pers. comm.) although this may refer to general breeding area rather than actual natal site philopatry. Cook Strait blue penguins (*Eudyptula minor variabilis*) return to the same general area (R. Cossee, DOC, pers. comm.). The furthest recovery distance on Matiu/Somes Island was an estimated 800 m from the natal site. However, Challies (pers. comm.) reports that no more than 50% of the white-flippered blue sub-species reaching breeding age nest in their natal colony on Banks Peninsula, and that this behaviour is very sex-specific.

Yellow-eyed penguin philopatry is relatively low at around 50% (D. Houston pers. comm.). Richdale (1949) found a survivorship of at least 41% (of 398 fledglings entering the sea on Otago Peninsula), and that most recoveries were made in the second and third year of age. Of 6127 yellow-eyed penguin chicks banded on the South Island since 1973, a total of 522 (8.5%) have been recorded breeding (D. Houston pers. comm.). Of those, 56.3% returned to their natal site to breed while the other 43.7% bred elsewhere. About half the immature birds at a breeding area fledged from outside that area, and those that moult in an area tend to settle there to breed (Marchant & Higgins 1990). After 5 years of age, breeding site fidelity remains strong (Robertson 1985), although nesting site fidelity is lower with fewer than 30% of birds using the same nest site in successive years (Heather & Robertson 1996).

It is practicable to simulate the frequency of meals delivered to penguin chicks. Yellow-eyed penguin chicks are usually fed three times every two days (Marchant & Higgins 1990), and blue penguin chicks are fed on most nights—although adults may not return for several days. There are six species of penguins breeding in New Zealand, with data available for many on breeding biology and chick growth. For various reasons outlined below, penguins have not been proposed as the most suitable birds to use in trials.

4.3.1 Crested penguins

Three of the four penguin species breeding in the New Zealand subantarctic are crested penguins: the Snares crested penguin (*Eudyptes robustus*), erect-crested penguin (*Eudyptes sclateri*) and the native eastern rockhopper penguin (*Eudyptes chrysocome filholi*). These species are all locally common, residing in very remote locations.

The rare, endemic Fiordland crested penguin (*Eudyptes pachyrhynchus*) is a relatively accessible mainland nesting species. There are numerous colonies from Heretaniwha Point on the West Coast down into Fiordland and Stewart Island (J. Lyall, DOC, pers. comm.). The establishment of additional colonies of this species is not identified in the Seabird Action Plan (Taylor 2000a) as a future management action. Management of threats at existing sites remains the highest priority in terms of actions for recovery. Although there have been detailed studies of the breeding biology of the Fiordland crested penguin (at two geographical locations), band recoveries have yet to be analysed to determine adult and juvenile survival rates and nest-site fidelity. Fiordland crested penguins are prone to disturbance with adults temporarily fleeing from nest sites; additional disturbance over basic monitoring of the study birds is kept to a minimum (J. Lyall pers. comm.).

Crested penguins would, however, be suited for egg or chick transfers, because they all have obligate brood reduction (C. Miskelly pers. comm.), raising a maximum of one chick from two eggs laid. Fiordland crested, Snares crested and rockhopper penguins typically hatch both eggs which means that late term eggs or newly hatched chicks could be harvested with no impact on the source population. Erect-crested penguins eject the first (smaller) egg within a few days of laying the second; fresh eggs could potentially be collected without impact on the penguins

(Miskelly & Carey 1990). Miskelly suggests that Snares crested penguins could be considered as a biogeographical replacement for an extinct crested penguin on the Chatham Islands; the Snares crested penguin currently has a single population and a breeding system that allows more parental care before a potential chick 'harvest'.

4.3.2 Yellow-eyed penguins

Roughly half the breeding population of the endemic yellow-eyed penguin occurs in the remote subantarctic. The mainland breeding distribution of this species is clumped because of a shortage of suitable sites, rather than a need to form colonies (Heather & Robertson 1996). Yellow-eyed penguins are loosely colonial at breeding sites (but roost communally), with 20–100m between nests in open areas and < 20 m in dense scrub (Marchant & Higgins 1990). One or both neighbouring pairs have a tendency to fail at breeding if they are in direct visual contact. Colonies can cover large areas if habitat is not of suitable quality. Areas on the mainland have to be managed for stock and predators. After the guard phase, chicks become quite mobile seeking shade under vegetation, or cool, damp ground near streams (Marchant & Higgins 1990). The brood (up to two chicks) may wander from the nest at 4–5 weeks of age (fledging age is around 14–17 weeks); 80% of chicks at this age move to a new site, often that of the previous year's nest. They may also move seaward to greet the incoming parents.

Yellow-eyed penguins are endangered; habitat protection and enhancing the survival of adult birds are both major priorities for the species recovery (Taylor 2000a). Chick translocations would be of no conservation benefit at this stage. Edge et al. (1999) researched parental investment in single-chick and twin-chick broods by artificially reducing brood size to one chick, using chick manipulation/cross-fostering techniques. One of the aims was to determine if brood reduction had the potential to relieve the reproductive costs to an adult in the 'poor food' years that lead to high adult mortality. Parents have been shown to reduce investment in offspring to match food supply, but rarely reduce brood size. Edge et al. (1999) found no significant effects of reducing brood size on adult survival or post-fledging survival, although they speculate that there may be implications for their ability to survive post-breeding moult. It is unlikely that artificial brood reduction will be used as a management tool since prediction of food availability is difficult. If it were to be employed, the 'cropping' of chicks for translocation is not an option because artificially raising chicks in 'poor food' years would be impractical as once chicks depart, they are unlikely to survive the potential food shortage at sea.

4.3.3 Blue penguins

Blue penguins have occasional surface-nesting habits but are predominantly burrow-nesters. In rocky areas, crevices and caves are readily used and the depth of these will vary. The few that nest on the surface typically do so around logs, driftwood or other features, or in thick vegetation (C. Challies pers. comm.). Chicks are known to move outside up to 2 weeks prior to fledging. White-flippered penguin chicks start moving into the open from about 40 days (fledging age is 50–55 days) although this varies a bit depending on how well fed they are (C. Challies pers. comm.). This movement only occurs at night and appears to be in anticipation of parents returning with food. Older chicks will sometimes move to adjacent nests when the chicks there are being fed but usually return to their own nest. Challies (pers. comm.) has already developed techniques for the translocation of the white-flippered penguin sub-species.

4.4 GANNETS AND BOOBIES

Of the two members of the Sulidae in New Zealand—Australasian gannets and masked boobies—the gannet would be the more logical species to assess for potential as a trial subject, primarily because of its status and distribution. Whilst new colony establishment has been identified as a future management action for the conservation of the masked booby (Taylor 2000a), the species breeds in the remote Kermadec Islands, and has been little studied there due to the poor accessibility and fragile nature of the colony sites/islands. The masked booby could benefit from any work conducted on the closely related Australasian gannet.

Although Australasian gannets are considered one of the rarest sulids in the world, second to Abbott's booby (*Sula abbotti*), the New Zealand gannet population is increasing by 1–3% per annum (C. Robertson pers. comm). A mean annual increase rate of 2.3% was identified between the mid-1940s and early 1980s, with an estimated 46 004 pairs present in 1980–81 (Wodzicki et al. 1984).

Gannets exhibit strong philopatry, demonstrated by the reluctance of birds to establish new colonies (S. Kress pers. comm.). Nelson (1978) states that there is strong site tenacity in breeding birds. At the three Cape Kidnappers gannetries, there is a marked tendency for birds to return to the group where they were hatched, although immigration into a rapidly expanding neighbouring gannetry occurs (C. Robertson pers. comm.).

There is no parental support after fledging; juvenile gannets fly away from the colony on their departure, heading westward to warmer Australian coastal waters for the pre-breeding period (Wodzicki & Stein 1958). The minimum travelling time from New Zealand to Australia has been recorded as 8 days (Marchant & Higgins 1990). Juveniles are rarely seen in New Zealand coastal waters, whereas adults tend to remain fairly local to their breeding area. Adults leave the colonies after young have departed (Marchant & Higgins 1990).

Chicks are generally guarded until fledging (Marchant & Higgins 1990). There may be social implications for unguarded chicks at an artificial colony site, in addition to implications relating to warmth, shelter and protection from predators, but these could be addressed with careful design.

Chicks show a strong affinity to the nest site throughout the rearing period. Whilst older chicks may wander through the colony, they will return to their nest by evening, even after periods of disturbance (Warham 1958). This would make the management of chicks at an artificial site easier than with a more mobile species.

Gannet chicks receive an average of 1.9 meals per day (Waghorn unpubl. data). There may be a limitation to the amount of food immediately available to a chick because both parents are rarely absent from the nest at the same time. A single artificial feed per day (of the complete daily requirement) could prove sufficient.

Long-term breeding studies have been conducted on gannets in New Zealand at several colonies (Taylor 2000a), and methods of accurately ageing chicks developed (Wingham 1982). Suitable source and recipient sites, which are regularly monitored, are available in relatively accessible locations on or close to the mainland.

The breeding biology of gannets closely resembles that of the albatrosses (G. Taylor pers. comm.). Gannet chicks can survive unattended at the nest site once able to thermoregulate for themselves. Chicks of both groups are large and robust, with fat reserves available to carry them through lean periods of food availability and during the post-fledging period when feeding skills are acquired. This makes the successful translocation of chicks more achievable, and the transition to an artificial diet easier without compromising growth and development.

The negative aspects of using gannets in a trial include the high pre-breeding mortality (85%) of the species (C. Robertson pers. comm; Marchant & Higgins 1990), and the fact that the species has deferred maturity (Wynne-Edwards, cited in Wodzicki & Stein 1958). They commence breeding when 4–5 years old but at 6–7 years, only about half the birds are breeding (Wodzicki & Stein 1958). This would mean that only 15% of a transfer sample would return to breed, breeding might not commence for up to 6–7 years after the fledging of chicks, and not all those birds will be breeding by this age.

4.5 CORMORANTS AND SHAGS

Young shags and cormorants are attended and fed by both parents for up to several months following fledging (Marchant & Higgins 1990) until contact is lost. Parental care is likely to continue for at least several weeks after chicks leave the nest, and seems to be gradually moved away from the nest site at likely foraging sites (R. Powlesland, DOC, pers. comm.). The long association enables the fledglings to obtain regular food from their parents while they ‘learn the ropes’. This alone makes members of the cormorant and shag family unsuitable as subjects of surface-nesting chick translocation trials. Other aspects of shag and cormorant breeding biology, as indicated within the following species list, would make it difficult to raise these birds artificially.

4.5.1 Cormorants

Of the Phalacrocoracinae (cormorants, or shags in New Zealand), only one of the four species in New Zealand is truly marine: pied shags are coastal, ranging inland only to coastal lagoons and lakes (Heather & Robertson 1996), whilst black shags (*Phalacrocorax carbo*), little black shags (*Phalacrocorax sulcirostris*), and little shags (*Phalacrocorax melanoleucos*) tend to breed at, and forage in, freshwater habitat and also visit sheltered coastal waters. All of these species are common natives found throughout the New Zealand mainland.

Black shags are mostly inland breeders and are known to feed fledglings for up to 4 weeks after leaving the nest site (Marchant & Higgins 1990), or even 7–10 weeks after fledging (Heather & Robertson 1996). Prior to this, chicks also depend on parental shade throughout much of the rearing period, and receive drinks of water delivered by parents. Little black shags also nest in trees, may only be partly philopatric, and have not been subject to any detailed breeding studies (Marchant & Higgins 1990). Little shags occasionally nest on sea cliffs, but predominantly in trees by freshwater. There is no New Zealand information on growth, parental care or fledging to maturity (Marchant & Higgins 1990). These factors firmly eliminate these species as candidates for our trials.

The predominantly marine pied shag is generally sedentary, rarely venturing inland (Heather & Robertson 1996). Chicks are totally dependent throughout the nestling period; as with other shag species, chicks are vulnerable to over-heating in hot, sunny conditions and chicks of all ages are shaded at the nest by parents. In cold weather chicks are brooded until size limits this behaviour, but chicks of a brood will lie close together for warmth (Marchant & Higgins 1990). Chicks are fed up to six times per day, reducing to one to two times per day towards fledging. Food pre-digestion by the parents appears to decrease as chicks get older. Chicks are only left alone when able to ward off predators and other adults, at $\geq$ 4 weeks. Chicks then become mobile at the nest-site; older chicks move towards the incoming parent to be fed. Fledglings soliciting unsuccessfully follow parents to water. They are wholly or partially dependent on parental attendance for some time after fledging, with chicks fledging between 47–60 days but remaining dependent for at least 80 days (Marchant & Higgins 1990). Heather & Robertson (1996) report chicks being fed by parents for up to 11 weeks after fledging; Marchant & Higgins (1990) report an observation of parents feeding young from the previous season although this has not been recorded by others.

Banding studies have revealed some evidence of return by pied shags to natal breeding sites (Marchant & Higgins 1990). Pied shags may shift between nesting areas from year to year. Wooller & Dunlop (1981) noted that pied shags bred on a different area of Carnac Island in western Australia in every year in five successive seasons. However, pied shags in New Zealand typically use the same colony site and nest sites for many years until the trees die or collapse (C. Miskelly pers. comm.). Tree-nesting sites (woody perennials) can be destroyed by the combined effect of trampling and guano deposition; soft annuals replacing lost vegetation are unsuitable for nesting platforms. Frequent moves may reduce the effects of ectoparasites, common in cormorant nesting areas (Wooller & Dunlop 1981).

4.5.2 Shags

The Leucocarbinae (shags) are marine species residing in coastal waters, with some making offshore excursions. Most of the New Zealand species in this sub-family are locally common endemics occupying remote island locations: the Pitt Island shag (*Stictocarbo featherstoni*) and Chatham Island shag (*Leucocarbo onslowi*) are found at the Chatham Islands only, and the Campbell Island shag (*Leucocarbo campbelli*), Auckland Island shag (*Leucocarbo colensoi*) and Bounty Island shag (*Leucocarbo ranfurlyi*) inhabit only islands in the subantarctic. Projects involving these species would be logistically difficult and costly at this stage.

King shags (*Leucocarbo carunculatus*) are found in a geographically central location on islands within the Marlborough Sounds. Although a rare endemic that might benefit from having its range extended with the addition of new breeding sites, there are several reasons in addition to the lack of independence at fledging that make this species presently unsuitable for chick translocation trials. The species is sedentary, but breeding colony sites can shift over time (Marchant & Higgins 1990). As with other shags, the changing location of the breeding colony overrides natal-site tenacity; birds will return to the most active colony site. This timid species is reported as being extremely vulnerable to colony disturbance (Marchant & Higgins 1990). There have been no detailed breeding studies undertaken (Taylor 2000a) and, therefore, there is no information to assist with artificial management.

The Stewart Island shag (*Leucocarbo chalconotus*) breeds on the mainland as well as Stewart Island, but there is no information on incubation or fledging periods for this rare endemic. Colonies can be abandoned, to be reoccupied several years later (Heather & Robertson 1996).

Breeding information has been recorded for the locally common, endemic spotted shag (*Sticticarbus punctatus*) until the time at which fledglings congregate prior to dispersal. Marchant & Higgins (1990) report that methodologies for ageing chicks based on plumage and logistic growth models have been developed. However, there is a lack of information regarding independence from parents. Like other shags, this species is vulnerable to over-exposure to sun and heat; Fenwicke & Browne (cited in Marchant & Higgins 1990) state that birds at their study colony preferred to nest in the central area because of its shaded aspect with fewer exposure hours to the sun during the day. Chicks were left unattended by the 30th day by which age they have developed good thermoregulatory control and are protected from the sun by a thick layer of down. Chicks were still receiving several feeds per day when 24 days of age or older.

4.6 SKUAS

Skuas are generally regarded as highly philopatric, as demonstrated by the analysis of band recoveries collected between 1963 and 1990 for the great skua (*Catharacta skua*) on Foula, Shetland, United Kingdom (Klomp & Furness 1992). Immigration and emigration rates of this species were reported to be low, with an emigration rate of 1–2%. Colony fidelity appeared to be displayed by non-breeders as well as the highly site-faithful breeders. The location of breeding sites on Foula may not necessarily be directly influenced by natal area. Brown skuas (*Catharacta antarctica lonnbergi*) also show high fidelity to the natal colony (Higgins & Davies 1996).

Despite documented philopatry, skuas are not good subjects for chick translocation trials for various reasons. The young start feeding themselves around the time of first flight, but they continue to be fed by parents, and may remain in the parents' territory for several weeks after fledging (Higgins & Davies 1996). Brown skua start to fly at around 60 days, but practise take-off and landing for up to a further two weeks. The brown skua is widespread in the subantarctic with many small populations, and occurs mostly in very remote locations, including the Chatham Islands.

4.7 GULLS

Gulls are dependent on parents for food for up to 3 months after fledging (Higgins & Davies 1996). A small proportion of birds may even depend on parents for a longer period than this; extended parental care—regurgitation of food to a juvenile—of the southern black-backed gull (*Larus dominicanus*) has been observed in a bird that had to be a minimum of 17 weeks old (Powlesland 1996). Juveniles may accompany their parents for several months even after they can feed for themselves (Powlesland 1996), and are often seen begging for food at up to 6 months old (Heather & Robertson 1996). Young gull chicks are highly mobile, leaving the nest when 2–3 days old (Higgins & Davies 1996). Fifty percent of black-billed gull (*Larus bulleri*) chicks leave the nest by 5 days old (Higgins & Davies 1996), and chicks are capable of swimming from 2 weeks of age (Heather & Robertson 1996). Parents coerce gull chicks into the water to swim, probably because this is an important response to the approach of ground predators. Gull families tend to be nomadic near the nest, and chicks may form a créche, attended by one or two adults. They are also extremely vulnerable to disturbance—chicks run to shelter to hide—and to aerial predators. Torrential rain can cause 100% mortality at colonies (Higgins & Davies 1996). The feeding frequency of gull chicks is high, making rearing labour-intensive. Feeding frequency for black-backed gull chicks has been recorded as hourly when young, then once every 2 h at 3 weeks old (Higgins & Davies 1996). Management of gull chicks at an artificial colony site would prove difficult, therefore, members of the Larinae family would make unsuitable subjects of chick translocation trials.

Of the three New Zealand gull species, only two can be classified as truly marine. The black-billed gull frequents coastal and estuarine areas generally only in winter, breeding mostly at freshwater locations; there are a few breeding colonies in coastal areas. In bad weather, there is a tendency for them to move inland to feed (Heather & Robertson 1996). There is inconclusive data regarding fidelity to natal and breeding colonies (Higgins & Davies 1996).

Red-billed gulls (*Larus novaehollandiae*) and black-backed gulls are abundant native species, so there would be no conservation benefit associated with establishing new breeding locations. Red-billed gulls are particularly vulnerable to aerial predation since black-backed gulls will take small and large chicks of the smaller species. Natal site fidelity for red-billed gulls varies between areas; 42% of birds surviving to breed on Kaikoura Peninsula bred at the natal colony (Higgins & Davies 1996). For marginal colonies in South Australia, possibly > 50% of birds that breed will do so at colonies other than their natal one (Higgins & Davies 1996).

4.8 TERNS AND NODDIES

Most species of tern and noddy are dependent on their parents for food for up to 4 months after fledging (Higgins & Davies 1996). Foraging skills must be learnt with parental assistance to permit young birds to survive a lengthy period of poor success at self-feeding (Brooke & Birkhead 1991). Members of this family are, therefore, unsuitable to use as subjects for chick translocation trials using techniques other than fostering. Chicks are reported to continue to beg for months after they can fly (Heather & Robertson 1996). The frequency of feeding of tern chicks is high (A. Nelson pers. comm.), making rearing extremely labour-intensive.

Terns also have a reputation as fickle nesters. Fidelity to breeding sites is variable between species, but terns will commonly move between colonies or shift the site of the entire colony, especially as a result of breeding failure (Higgins & Davies 1996).

The young of ground-nesting terns leave the nest within one week of hatching. Cryptic chicks are mobile from an early age seeking cover in nearby shelter, or sometimes forming créches (Higgins & Davies 1996). Siblings will often separate (Parrish & Pulham unpubl. data). Managing young, mobile chicks at an artificial colony site could prove difficult, as could protecting them from the hazards of avian predation since chicks rely on parental defensive behaviour against a range of species. Higgins & Davies (1996) report that Parrish & Pulham observed New Zealand fairy tern adults chasing off gulls, waders, rock doves, and other tern species. Terns are very easily disturbed; human disturbance in the form of monitoring could lead to desertion of breeding sites.

Of the 18 species of Sterninae (terns and noddies) recorded in New Zealand waters, 10 actually breed in New Zealand. One species, the Antarctic tern (*Sterna vittata*), breeds mostly in the subantarctic, and five species breed on the Kermadecs: white tern (*Gygis alba*), sooty tern (*Sterna fuscata*), common or brown noddy (*Anous stolidus pileatus*), black (lesser) noddy (*Anous minutus minutus*) and the grey ternlet (*Procelsterna cerulea*) which sometimes also breeds in Northland. Projects involving all the above species would be logistically difficult and costly at this stage. The return of noddies to Raoul Island in the Kermadecs, recently cleared of mammalian predators, is more likely to be enhanced by the placement of decoys at suitable nesting sites (Veitch et al. in press).

Of the remaining four species breeding in the North and/or South Island, the threatened endemic black-fronted tern (*Sterna albostriata*) is not truly marine, associating with freshwater during the breeding season. This leaves three species that nest in coastal areas.

The focus of the New Zealand fairy tern programme is to maximise productivity (K. Hansen pers. comm.). With a total of c. 35 birds in the population this critically endangered species would not be suitable as a donor of chicks for trials. New Zealand fairy tern chicks would not make suitable trial subjects for translocation because the chicks are clearly recognised as not independent by the time they fledge (K. Hansen pers. comm.). They remain with their parents for up to several months after fledging and continue to be fed while they learn feeding and other survival behaviours. In addition, New Zealand fairy terns do not exhibit strong natal site philopatry, birds will return to breed at any one of the known breeding sites in Northland, although there seems to be some preference for returning to a breeding site on the same (east or west) coast. This lack of strong philopatry in fairy terns is reported in Australia (Higgins & Davies 1996). Birds banded as nestlings and mobile chicks have been recovered close to, and also far from, the natal site. In Australia, the maximum-recorded displacement between natal and breeding sites is c. 77 km, although non-breeders have been recorded hundreds of kilometres away from the natal area at a range of ages. Fairy tern chicks are known to move up to several hundred metres from the nest from 6 days old. Parrish & Pulham (cited in Higgins & Davies 1996) observed a brood of 22–23 day-old chicks move c. 2 ha in a 6-h observation period. Chicks are still receiving frequent meals at this age, with chicks of 22–23 days old fed six times in a 6-h period. Feeding events were recorded five times within a 2-h period for 14–15 day old chicks.

Caspian tern (*Sterna caspia*) chicks can remain with their parents for up to a year (K. Hansen pers. comm.). When an entire colony of this uncommon species shows breeding failure (e.g. from mass egg loss) the colony will re-nest up to several hundred metres away (Robertson 1985). Immature birds may not return to the breeding colony until of breeding age (Barlow 1991), and only some chicks return to their birthplace to breed (Horton 1973).

The abundant white-fronted tern (*Sterna striata*) appears to return to a general breeding area rather than a specific breeding site (Higgins & Davies 1996), but shows a tendency to return to the site of hatching (Robertson 1985). Breeding behaviour can be capricious, with sites abandoned for no obvious reason. Parents are recorded as feeding young for several months after fledging. During this time when hunting skills are acquired, fledglings associate with mixed-age flocks (predominantly composed of adults) until their dispersal (Robertson 1985).

5. Conclusions

The biology, status and distribution of the Australasian gannet make it a suitable and relatively abundant species for trials to develop methodologies for the translocation of surface-nesting seabirds. A proposal to use it in trials has been drafted, following this report, for Wellington Conservancy.

Mana Island Scientific Reserve in Wellington Conservancy is already the site of a gannet colony establishment project, initiated in the 1990s (see Section 2.2.3). The Mana Island artificial gannetry has failed to attract any breeding Australasian gannets, probably as a result of a general lack of prospecting gannets flying through, or feeding in this area (C. Robertson pers. comm.).

The Mana Island Restoration Plan (Miskelly 1999) does not include chick translocation as a management action for establishing the gannetry, and Taylor (2000b) has not identified this species as one requiring such management.

However, the recent rapid progress in development of techniques for translocating burrow-nesting seabird chicks suggests that surface-nesting seabird chick translocations could occur sooner than perhaps once anticipated. With attempts to attract gannets to Mana Island having failed to date, chick translocation would be the next step in attempting to establish a gannetry.

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