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Translocation of fluttering shearwater (*Puffinus gavia*) chicks to create a new colony

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Abstract A trial translocation to establish a new fluttering shearwater (*Puffinus gavia*) colony is reported. From 1991 to 1996, 334 fluttering shearwater chicks were transferred from Long Island to Maud Island, Marlborough Sounds, New Zealand. Chicks were artificially housed and hand-fed until fledging. Overall fledging success was 82%, 32 of the 273 chicks that fledged returned to Maud Island, and 30 have bred. Mean age of first breeding was 6.8 years (range 5-10 years). Returning chicks were heavier at fledging and spent longer on Maud Island than chicks that did not return. Transferred chicks showed typical post-fledging behaviour by dispersing to southeast Australian waters. The new colony has gradually increased, and 15 pairs bred in 2003/04. Methods developed have application to endangered species management.

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Keywords Fluttering shearwater; *Puffinus gavia*; translocation; chick transfer; hand-rearing; colony establishment.

INTRODUCTION

Seabirds are particularly vulnerable to reduction in population size and local extinctions caused by introduced predators (Moors & Atkinson 1984). In New Zealand, 49% of seabird taxa are ranked as vulnerable, threatened or endangered (Taylor 2000). Restoring such seabirds to historical breeding sites is required to achieve conservation objectives (Taylor 2000).

Although widely used in terrestrial bird conservation (Fischer & Lindenmayer 2000), there are few examples of translocation of burrow-nesting Procellariidae (petrels, shearwaters and their allies). Generally, petrels are highly philopatric, returning to breed near their natal nest, and breeding adults are extremely site faithful (Warham 1990). Serventy *et al*. (1989) moved short-tailed shearwater (*Puffinus tenuirostris*) chicks during the desertion phase prior to fledging, but most birds returned to their natal colony. The proximity of the natal colony and the belief that its location was already imprinted on the chicks were considered the reasons for failure (Serventy *et al.* 1989). The provision of artificial burrows and broadcasting of calls has been used successfully to concentrate breeding of the dark-rumped petrel (*Pterodroma phaeopygia*) (Podolsky & Kress 1992), and a Leach's storm-petrel (*Oceanodroma leucorhoa*) colony developed at a new site following acoustic attraction (Podolsky & Kress 1989). Some translocated Gould's petrel (*Pterodroma leucoptera leucoptera*) chicks returned to their adopted nest sites in a trial where chicks were shifted to new sites on Cabbage Tree Island, New South Wales (Priddel & Carlile 2001), and a combination of acoustic attraction and chick transfers led to the establishment of a common diving petrel (*Pelecanoides urinatrix*) colony on Mana Island, New Zealand (Miskelly & Taylor 2004).

The need to develop translocation techniques for the use in conservation management of endangered seabirds led members of the Ornithological Society of New Zealand to trial a translocation method using a common species, the fluttering shearwater (*Puffinus gavia*). It was hoped that the techniques learnt could then be applied to other species. Here we report on the success of chick translocations between 1991 and1996, and colony development following first breeding in 1996.

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METHODS

Fluttering shearwater biology

The fluttering shearwater is a medium-sized shearwater (mean 300g, range 230-415g), which feeds predominantly on fish, typically within the inshore zone. It is endemic to New Zealand, and breeds on islands from Three Kings Islands south to within the Marlborough Sounds (Marchant & Higgins 1990; Heather & Robertson 1996). Within Marlborough Sounds, laying has occurred in mid-September to early October, mean fledging weight was 400 g (range 315-520 g, n = 31), and mean fledging date was 31 January (P. Hodum unpubl. data). The length of the desertion period is not known, but for Manx Shearwater (*Puffinus puffinus*) is 8.5 days (range 1-23 days) during which chicks

come to the surface more or less nightly (Brooke 1990). Observation of transferred chicks suggests a similar emergence pattern for fluttering shearwater. Young disperse to south-east Australian waters after fledging (Marchant & Higgins 1990). The total fluttering shearwater population is estimated at 100,000 to 1,000,000 breeding pairs (Robertson & Bell 1984). Based on data from the closely allied Manx shearwater we expected chicks to return to the colony in two to three years, and to breed when five to six years-old (Brooke 1990).

Study sites

Maud Island (276 ha) is a scientific reserve situated in Pelorus Sound, Marlborough Sounds. The entire island, apart from a small 20 ha block of coastal broadleaf forest, was farmed for over 100 years until reservation in 1973 after which much of the island has been allowed to regenerate. The site chosen for the establishment of the colony was at the end of Harter Peninsula (30 m a.s.l.) facing the entrance of Pelorus Sound. The soil at the site was deep clay loam, and was predominantly covered in exotic grass with some isolated native tauhinu (*Ozothamnus leptophylla*) shrubs.

The nearest fluttering shearwater colony is 10 km away (Chetwodes Islands) and the nearest major colony 20 km (Trio Islands). Chicks were sourced from Long Island, Queen Charlotte Sound, which is separated from Maud Island by a sea distance of over 50 km, and hills rising to 1 200 m a.s.l. (Bell 1994).

Translocation of chicks

In October 1990, 103 artificial burrows were constructed on Maud Island. Each consisted of a 25 cm^3 nest chamber with a 60-75 cm connecting tunnel to the surface. Tunnels were made from 112 mm diameter PVC drainage pipe that had a 90° bend to prevent birds seeing directly out of burrows, and to reduce light entering the nest chamber. The nest chamber and tunnel were sloped slightly downhill to ensure that any seepage flowed out during rain events. The nest chamber was fitted with an overlapping wooden lid covered with heavy-duty plastic sheeting, soil and turf, to act as an inspection hatch (Bell 1994). Regular opening of chambers to remove birds for feeding caused some disturbance of the soil covers and regular burrow maintenance was required. Each burrow was individually marked with a numbered stake. Between March 1998 and March 2000, the number of burrows was reduced to 59, and burrows were improved by fitting partial wooden sides to chambers, and double lids; this reduced burrow collapses during opening of inspection hatches.

Teams of 4-6 people collected chicks during a day trip to Long Island each year from 1992 to 1996, but took two days in 1991. In 1991, a mixed-age sample was taken, but this was refined to selecting chicks in full down with primaries half grown in 1992-96. Birds further advanced than this were considered unsuitable as they had possibly been outside their burrows and, therefore, may have begun their orientation to Long Island. Chicks were placed in cardboard pet-transport boxes (two per box, with a dividing wall) for the journey to Maud Island. This involved two one-hour boat journeys and a one-hour transfer by road. Upon arrival at Maud Island the birds were fed, but left in the boxes overnight in a well-ventilated shed. The following morning they were carried out to the colony, where each was banded and fed before being placed in an artificial burrow.

Chicks were fed twice daily until fledging on a diet of blended whole salmon smolt (65 %), water (25 %), golden syrup (3 %), muttonbird oil (3 %), vegetable oil (3 %) and vitamin B1 (Bell 1994). Adult salmon flesh was used in 1993. The mixture was heated to body temperature prior to feeding. The birds were fed using 6 mm Nelaton™ catheter tubes attached to 60 ml Monoject™ syringes to avoid food being accidentally pushed into the lungs. Extreme care had to be taken to ensure that neither the bird's bill nor oesophagus was damaged. After a few days the birds become familiar with the process and tended to swallow the tube themselves. Birds were initially fed 30 ml., but this was increased to 50 ml. per feed over the first three days. Chicks were weighed each day before their morning feed; plumage (down) condition and departure dates were recorded.

Acoustic system

From January 1994, an automatic solar-powered sound system has operated at the colony site. Initially, an audio cassette tape playing fluttering shearwater calls was used, but this was later upgraded to a compact disc system. Calls were broadcast though two 80-watt weatherproof loudspeakers facing out towards the mouth of Pelorus Sound. The system ran annually from September to February, switching on at dusk and off at dawn, matching the normal colony attendance pattern of the shearwaters. The system has operated continuously from this time except during brief periods for servicing or during mal-function.

Checking for returning birds

From 1995 onwards, the Maud Island colony site was searched twice each season for returning birds. The majority of these searches were during incubation and chick rearing. As a result, the age of first breeding is well known, but not the age at which birds first returned to the colony. Checks were made at night to search for adults coming ashore, and during the day to check band numbers of incubating or brooding adults. In addition to

Table 1. Numbers of fluttering shearwater chicks transferred to Maud Island, fledging success, mean number of nights on Maud Island before fledging, mean weight at fledging numbers returning to Maud Island to breed.

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	Total
Number birds moved	101	46	102	41	27	17	334
Number died	2	3	39	2	1	0	47
Number missing	4	1	5	2	1	1	14
Number fledged	95	42	58	37	25	16	273
Mean number of nights on Maud	12	10	13	14	20	22	14
Range	0-34	0-28	0-36	0-29	0-34	0-34	0-36
Mean weight (g) at fledging	332	387	374	385	393	404	364
Range (g)	205-405	250-495	270-425	335-470	335-495	365-450	205-495
Number of cohort recruited	4	5	6	8	8	1	32

these searches, Department of Conservation staff checked burrows at other times during the breeding season. We also undertook two short trips to Long Island to search for returning birds in September 1997 and 2003.

RESULTS

Fledging of transferred chicks

Between the 1990/91 and 1995/96 breeding seasons, 334 fluttering shearwater chicks were transferred from Long Island to Maud Island, of which 273 (81.7%) fledged. Fledging success varied from 56% to 94% between years, but was usually over 90% (Table 1). In 1992/93, 39 chicks died at the colony, from food poisoning; this was the only year in which adult salmon flesh was used rather than whole smolt, and it is probable that this resulted in the introduction of a toxin.

There was high variation in the mean annual fledging weight of chicks, with a gradual increase in mean fledging weight during the project (Table 1). Average weight at fledging was 364 g (range 205 - 495 g, n = 273), and 70 % of chicks weighed 321 - 400g (Fig. 1). Chicks gradually put on weight until reaching a peak weight seven days before fledging, and then losing a little (2%) during the last four days (Fig. 2).

A few chicks spent less than three nights on Maud Island and are classified as "missing" (Table 1); these chicks were covered in down and so were too young to fledge. Missing chicks were searched for, but none was ever found and it is likely that they wandered away from the colony and died. Overall, chicks stayed on Maud Island for an average of 14 nights (range 0 – 36 nights, n = 273) before fledging (Fig. 3).

Recoveries of transferred chicks away from Maud Island

Four transferred shearwaters were recovered dead in South Australia and Victoria 12, 19, 22 and 89 days after fledging, One chick transferred in 1991 was recorded back on Long Island in September 1997; it had been on Maud Island for only three nights before fledging.

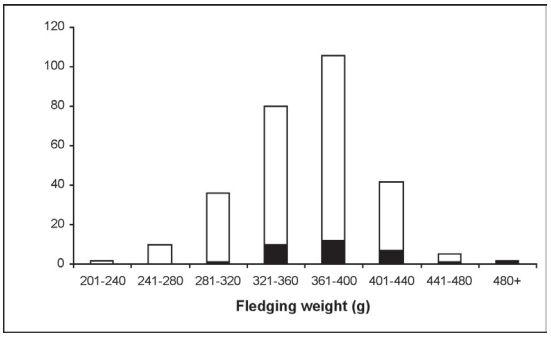

Figure 1 Distribution of fledging weights of translocated fluttering shearwater chicks (white - the 241 chicks that did not return; black - the 32 chicks that returned).

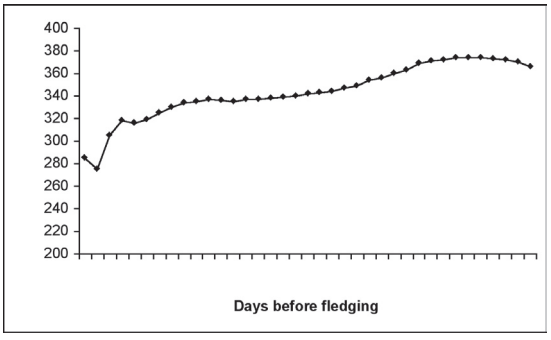

Figure 2 Weight changes of hand-fed fluttering shearwater chicks in relation to number of days before fledging.

Recruitment of transferred chicks

The first birds returned and bred on Maud Island in 1996. A total of 32 transferred chicks have since returned, of which 30 have attempted to breed. The other two birds were recorded only once, as prospecting six- and seven-year-olds. Eight unbanded birds have also been caught at the colony (Table 2); seven of these immigrants have bred on the island, all with returned transferred chicks. The breeding population has increased from two pairs in 1996/97 to 15 pairs in 2003/04 (Table 3).

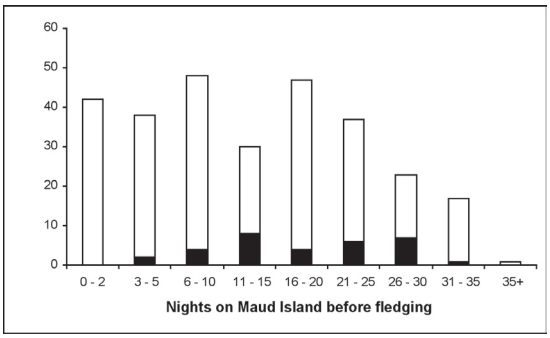

Figure 3 Distribution of the numbers of nights that translocated fluttering shearwater chicks stayed on Maud Island (white - the 241 chicks that did not return; black - the 32 chicks that returned).

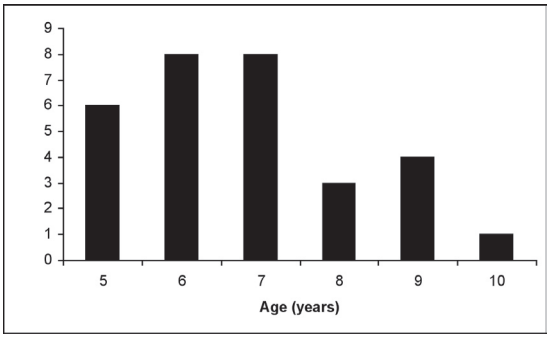

Figure 4 Ages at which translocated fluttering shearwaters first bred on Maud Island.

Table 2 Provenance of adult fluttering shearwaters caught at the Maud Island colony site.

Breeding season	Transferred Chick	Immigrant	Total
1996/97	3	1	4
1997/98	7	1	8
1998/99	0	0	0
1999/2000	10	2	12
2000/01	2	0	2
2001/02	2	1	3
2002/03	8	3	11
2003/04	0	0	0
Total	32	8	40

Most birds were first recorded when they started breeding, but four were found prospecting in the season before they started to breed. We suspect that most birds were present at least one year before breeding, but the limited searches did not enable them to be found. The average age at first breeding was 6.8 years (range 5-10, n = 30; Fig. 4).

Only 11.7 % of fledged chicks returned to the colony but, as some birds took up to 10 years to return, it is possible further birds may yet do so. The recruitment rate varied considerably between years (range 4.2 - 32%), and appeared to be correlated with mean fledging weight (Table 1). The chicks which returned had a significantly higher mean fledging weight (387 g, *s.e.* = 29.8) than those that did not (361 g, *s.e.* 44.3, t-test, $p = 0.0011$). The returning chicks also spent significantly longer on Maud Island. (18 nights, *s.e.* = 6.7) compared to those that did not return (13 nights, s.e.= 10.1, t-test, $p = 0.0025$).

BREEDING SUCCESS

Breeding success varied annually from 12.5 to 87% (Table 3). All breeding has taken place in artificial burrows; no natural burrows were found within or beyond the area of artificial burrows. The breeding failure in 1999/2000 was due to half-grown chicks starving, presumably as a result of food supply failure. As yet, no banded parent-reared chicks from the Maud Island colony have returned.

DISCUSSION

The successful establishment of a colony of fluttering shearwaters has shown that the transfer of chicks is a viable method of establishing new petrel colonies. It has demonstrated that petrel chicks moved before they become orientated to their natal site, artificially-housed and fed until fledging will return to breed at the transfer site. In addition, this transfer has shown that the recruitment rate can be affected by fledgling weight and duration of time spent at the new colony prior to fledging.

Fledglings showed typical weight gains for developing petrel chicks (Warham 1990), putting on weight to reach maximum weights of 125% of adult weight after 90% of the chick phase, but only lost 2% of this weight in the final seven days before

Table 3 Fluttering shearwater colony on Maud Island; number of breeding pairs and their breeding success.

Year	No. breeding pairs	No. eggs laid	No. chicks fledged	Breeding success (%)
1996/97	2	2	1	50
1997/98	6	6	3	50
1998/99	5	5	2	40
1999/00	8	8	1	12.5
2000/01	12	12	9	75
2001/02	12	12	7	58
2002/03	15	15	12	80
2003/04	15	15	13	87
Total	75	67	48	72

fledging. Weight of petrel chicks usually begins to decline after 60-80% of the nestling period has elapsed, when peak weights are usually 130-150% of the mean adult weight (Warham 1990). The small amount of weight lost, and the late stage at which this weight was lost was probably due to our continued feeding of chicks through to fledging, unlike the chick desertion typical for Manx shearwater in the last week or so before fledging (Brooke 1990). The recoveries in Australia show that transferred birds displayed typical post-fledging behaviour in dispersing to south-east Australian waters (Marchant & Higgins 1990).

When establishing a new colony, the best measure of success is recruitment rate, i.e. the number of young which return and breed. During this translocation overall recruitment rate was low, but increased as chicks fledged at higher weights, and those that returned, collectively, had a higher mean fledging weight than those that did not. Heavy Manx shearwater and sooty shearwater (*Puffinus griseus*) fledglings had higher post-fledging survival rates (Brooke 1990; Sagar & Horning 1998), and returning transferred diving petrel chicks had higher weights than non-returning chicks (Miskelly & Taylor 2004). Therefore, to increase recruitment rate, and ensure success of petrel transfers, managers should aim for heavier than normal fledging weight, even if this requires additional feeding.

The other pertinent observation was that the chicks which returned to Maud Island. spent an average of 18 nights on the island, approximately 25% of the chick-rearing stage; the recruitment rate was higher for chicks that spent a greater amount of time in the new colony.

Methods developed in this trial have application to management of endangered seabirds, where new, safe breeding colonies of petrels are needed to improve their conservation. Success of transfers of endangered species could be further improved by ensuring chick fledging weights are high, and that chicks are moved well before they start to emerge from their natal burrows. This increased investment in time and feeding is likely to result in greater recruitment of translocated petrels. Furthermore, methods used could be developed to provide supplementary food to endangered seabird chicks to improve survival and recruitment rates thus aiding population increase.

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