The dispersal and survivorship of pateke (*Anas chlorotis*) in relation to experimental release techniques; supplementary feeding and wing-clipping.

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Abstract

The pateke, or brown teal (*Anas chlorotis*), is a cryptic species and this is reflected in the dearth of knowledge regarding their basic ecology and demography. The difficulty in establishing secure self-sustaining breeding populations at historic locations by introducing captive-bred birds is likely a reflection of a lack of knowledge about some aspects of their ecology, and therefore the necessary knowledge for their management.

Two major factors appear to inhibit pateke reintroductions, these are dispersal out of predator controlled release areas and the associated mortality before viable breeding populations establish. This study aims to reduce these factors by increasing understanding of the causes, and refining release techniques.

Secondary releases of captive-bred pateke to Tawharanui Regional Park and Cape Kidnappers and Ocean Beach Wildlife Preserve (CKOBWP) provided the opportunity to investigate whether populations could establish in the target areas under prescribed management regimes involving supplementary feeding and wing-clipping.

Pateke at each site were fitted with radio transmitters to monitor dispersal, and PIT tags to monitor feeder use over 24hrs remotely. Supplementary feeding appeared to increase the time pateke spent at the release site, and in particular decrease the dispersal of male pateke post-release. Supplementary feeding may also influence survivorship by reducing cases of starvation in newly-reintroduced pateke. Wing-clipping reduced dispersal and there were no apparent negative effects in terms of increased mortality or dependence on supplementary

feed. It is hypothesised that wing-clipped birds may even increase residency of fully-flighted birds at release sites by acting as conspecific attractants.

In addition to providing baseline data on these populations, the trialing of PIT tag technology on pateke in this study is likely to be significant because it provides an accurate low-labour method of data collection and thus has potential to improve both future studies of the species and the conservation management of pateke.

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Quack.x.

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Chapter 1

Introduction

Biodiversity in New Zealand is under increasing pressure from human induced changes, predation by introduced pest species, exotic diseases and habitat loss (Ji & Clout, 2006). Increasingly populations of many New Zealand native species are being translocated to islands free of introduced predators, either offshore islands such as Little Barrier, Tiritiri Matangi, and Motuora, or within mainland islands such as Waitakere's 'Ark in the Park' and Tawharanui Regional Park. New Zealand's avifauna are generally non-migratory, weak fliers, and produce offspring which do not tend to travel far to establish new territories. These traits restrict their movement and reduces the chance and rate of colonising new areas and establishing new populations (Heather & Robertson, 2005; Jamieson, Wallis, & Briskie, 2006; Parsons & Galbraith, 2006). Translocation is therefore often used as a tool for conservation management to alleviate those traits, to enhance the survival of critically small populations, to increase genetic diversity, and to minimise the risk of local extirpation whilst enlarging overall distribution (Stoinski, Beck, Bloomsmith, & Maple, 2003; S. S. Taylor, Jamieson, & Armstrong, 2005).

In New Zealand over 90% of former wetlands have been drained or filled and many remaining wetlands are at risk of pollution from farming and industrial run-off. Healthy wetlands support high biodiversity, are places of cultural significance, and perform vital ecosystem services such as improving water quality, acting as carbon sinks, and reducing the effects of flooding (NWTNZ, 2008; Peters & Clarkson, 2010). Many wetland species are classified as threatened or endangered (NWTNZ, 2008). As a relatively visible and attractive wetland species with an active recovery group and successful established captive breeding programme the pateke, or brown teal (*Anas chlorotis*), was chosen as a flagship species for wetlands in New Zealand, with the long-term goal of the species becoming a national icon for healthy wetland and forest ecosystems and sustainable farming practices (O'Connor, Maloney, & Pierce, 2007). Before 2000, many reintroductions of pateke failed to establish self-sustaining populations (Innes, Jansen, & Baucke, 2000). The recovery group currently continues to reintroduce pateke to their former range with a focus on utilising predator-free sites (O'Connor, et al., 2007). These reintroductions provide numerous opportunities to investigate factors which may improve pateke translocations. This study investigates the use of supplementary feeding stations and wing-clipping as methods to decrease dispersal from release sites, to increase the chances of self-sustaining populations of pateke forming at chosen release areas.

1.1 Study species; Pateke, *Anas chlorotis,* an endemic dabbling duck

1.1.1 Taxonomic classification

Class: Aves

Order: Anseriformes

Family: Anatidae

Sub-family: Anatinae

Species: *Anas chlorotis*

Vernacular names: pateke (Maori), brown teal (English)

1.1.2 Morphological characteristics and behavioural ecology

The pateke, or brown teal, is a small species of endemic dabbling duck which prefers wetlands and swamp forests. Pateke are sexually dimorphic, this being particularly obvious when in breeding plumage. Both sexes are a deep chocolate brown with paler brown mottling, and both have a distinctive white eye ring. In breeding plumage the male's chest deepens to a rich chestnut, the white neck ring and wing bars form, and a green-blue iridescence develops on the head and nape. Female pateke weigh 500-600g, and males up to 800g (Heather & Robertson, 2005). As in most dabbling duck species, only the female quacks (a deep rasping quack). The male makes numerous whistles, peeps and wheezing vocalizations.

Pateke are cryptic and prefer habitat with dense ground and overhead cover. The ecological niche of the pateke is described as *"almost unique amongst the world's waterfowl"* (Williams & Dumbell, 1996) due to its evolution in the absence of land mammals and therefore adoption of characteristics similar to that of wetland rodents found in other parts of the world (Williams & Dumbell, 1996). Pateke tend to spend their day resting on or close to waterways, dabbling and socialising, moving off the water to feed at night. Although competent fliers, pateke often prefer either to run or freeze when faced with danger, flying mainly when dispersing and searching for new habitat, or to travel to a feeding or flock site (Evans, 2010; Heather & Robertson, 2005). These evolutionary traits result from the lack of ground predators and the prevalence of avian predators in New Zealand's past (Ji & Clout, 2006).

1.1.3 Diet

The pateke diet is primarily insectivorous, with some plant material taken. As a nocturnal-crepuscular species the majority of feeding takes place after dark. Pateke feed in ponds, lakes and streams, in long grass, and in grazed paddocks. In coastal areas they also feed at night on beaches, taking insects from amongst the tide-wrack (Heather & Robertson, 2005; Moore, Battley, Henderson, & Webb, 2006). On Great Barrier Island pateke have been observed opening and consuming cockles (Moore, et al., 2006).

1.1.4 Breeding

Pateke are productive breeders. Clutches typically contain 6-8 eggs, and it is not uncommon for pateke to double clutch in a season, or re-nest if a nest is lost (Dumbell, 1987; O'Connor, et al., 2007). Some pateke breed year round, particularly those in captivity where conditions are most favourable in terms of a safe nesting site and a continuous and reliable food source (Evans, 2008). The typical breeding season is from June-October, depending on local weather conditions. Unlike many *Anas* species the male plays an active role in rearing the young, primarily by defending the nest and food sources for the female and young (Evans, 2010; O'Connor, et al., 2007). In the wild in unmanaged areas breeding success is limited by predation of nests, incubating females, and of ducklings and juveniles (O'Connor, et al., 2007).

After breeding pateke tend to return to a flock site where pair bonds are strengthened, or new pair bonds are formed. Pair bonds are usually monogamous, but some instances are polygyny have been reported (Evans, 2008). Juveniles which have not formed pair bonds will often remain at flock sites year round (Dumbell, 1987; O'Connor, et al., 2007).

Captive-bred pateke are often released in February and May each year when juveniles from first and second clutches reach an age suitable for release. In the wild, pateke flock together between January and March to create or strengthen pair bonds before moving to a breeding territory around April or May, with breeding typically from June to October (O'Connor, et al., 2007).

1.2 What is a 'successful' translocation and what affects 'success'?

The definition of a 'successful' translocation, what defines success and how to achieve it, is much debated. A major problem with defining the success of a translocation is that the definition of success is always temporally limited (Sarrazin & Barbault, 1996; Seddon, 1999; Seddon & Maloney, 2003). The word 'success' implies an end point, after which management and monitoring may be withdrawn, possibly to the detriment of the translocated species' continued survival (Seddon, 1999). Therefore the term should be used with caution.

Seddon and Maloney (2003) identified indicators of success in relation to three objectives; survival of the founder group, breeding by the founder group and their offspring, and persistence over time. The parameters of these objectives vary between species with different life history traits and individual translocation programme specifics (Seddon, 1999).

Various studies and reviews of translocations have indicated that the behavioural ecology of a species can render it more or less suited to reintroduction and/or translocation. There are several reported factors which may enhance the success of reintroductions and translocations. Obviously, eliminating the major factors which extirpated the species in the first place rates highly (Fischer & Lindenmayer, 2000; Griffith, Scott, Carpenter, & Reed, 1989; Lovegrove, 1996; Smith & Clark, 1994; Wolf, Griffith, Reed, & Temple, 1996). For pateke this means predator control or eradication, and restoring quality wetland habitats. Indeed it is thought by some that if a budget allows for only one thing to be done for pateke, it should be to provide effective predator control (Hogarth, 2010).

Any programme of releases should be planned to include releasing individuals into prime habitat within their former range (Smith & Clark, 1994; Wolf, et al., 1996), to include multiple releases at a variety of sites (Smith & Clark, 1994), and to release over 100 individuals over a ten year time-frame (Green, 1997). It is logical that a species would do better being released into its former range than to be forced to adapt to a new ecosystem. Pateke were historically found throughout New Zealand (O'Connor, et al., 2007), however today choosing suitable release sites is difficult due to the extreme modification of their former habitat, through drainage and degradation of wetland ecosystems, and the presence of introduced predatory mammals. For this reason release sites are currently being chosen based upon a combination of whether there is adequate protection from predation and whether there is adequate quality habitat to support a target population of 50 or more breeding pairs (Maloney, Caldwell, Gummer, & O'Conner, 2006; Pierce, Maloney, & O'Conner, 2002). Re-introductions of pateke currently follow a minimum three year release structure, with 25-30 individuals on the first release to test predator control, followed by at least two more releases of 40-60 birds.

Taxonomic class and life history traits have also been found to have an effect on the success of translocated species. In general translocated mammals have a higher survival and success rate than birds (Wolf, et al., 1996). Young or sub-adult individuals, and those species with high reproductive rates (Lovegrove, 1996) may also have better success post-release. Pateke have been likened to a species which fills the niche of wetland rodents found in other countries (Williams & Dumbell, 1996), and thus may have more of the mammalian behavioural qualities that aid in a successful translocation. Pateke also have a high reproductive rate when their breeding efforts are not thwarted by mammalian predators. Since captive-bred pateke are used in all releases at present, it is possible to choose sub-adult birds for these releases.

From a behavioural ecology viewpoint it has been found that species with low dispersal rates, those which exhibit flocking behaviour, hold small territories, and have broad habitat requirements experience higher translocation success rates (Lovegrove, 1996). Pateke exhibit some of these traits, for example seasonal flocking, although this can be variable between individuals, and some birds never appear to flock (Fraser & Beauchamp, 2009); territories are relatively small, and they have quite broad habitat requirements (Worthy, 2002). However dispersal can be variable. It is possible that captive-bred birds disperse more and further than wild-born pateke, and appear to do so when they are juveniles or sub-adults (Browne, 2010; Fraser & Beauchamp, 2009).

Other methods which have been shown to increase the success of translocations include selecting wild-sourced releasees as opposed to captive-bred individuals (Fischer & Lindenmayer, 2000; Smith & Clark, 1994), post-release training of releasees, and using anchoring techniques (Armstrong, 1995a, 1995b; Molles, et al., 2008; Monnie, 1966). For pateke at present the wild populations are too small and fragile to allow harvesting of birds for translocation. Thus there is currently no option but to utilise captive-breeding facilities to produce the numbers of birds needed to give any chance of successful re-introductions at numerous sites. Some post-release conditioning is provided, particularly by providing supplementary food from feeders which have the dual purpose of providing a visual and practical anchor to release sites (Pierce, et al., 2002).

It has been proposed that the factors affecting success can be divided into two categories; those affecting the founder group during establishment, and those affecting population dynamics over the long-term (D. Armstrong, I. Castro, J. C. Alley, B. Feenstra, & J. K. Perrott, 1999). Establishment factors tend to be management related, such as the method and timing of the translocation, training or conditioning of captive-bred or animals held in captivity, and post-release provisioning. Long-term factors are more nature-based, such as habitat suitability and competitors (D. Armstrong, et al., 1999).

When a population reaches a point of self-sustainability, it is not always guaranteed that long term persistence will be achieved without further management. One study found that only 11% of reintroductions resulted in a viable population being formed (Beck, Rapaport, Stanley-Price, & Wilson, 1994). Another found that just 5% of translocations deemed successful were, five years later, in decline (Seddon, 1999). The reasons for decline after initial success may be due to the arrival of new threats. A prominent example is the Arabian Oryx (*Oryx leucoryx*). Once deemed a success-story for re-introduction biology (May, 1991; Stanley-Price, 1989), until a previously absent threat, poaching, rendered the population unviable 20 years after its initial releases began (Seddon, 1999).

Overall the reasons for failures of many translocations are poorly investigated, understood and/or documented (Beck, et al., 1994; Sarrazin & Barbault, 1996; Wolf, et al., 1996). Many translocations were poorly monitored. Wolf et al (1996) reported that of 100 out of 336 translocation programmes they reviewed, in 90-100% of these the reason for the loss of animals was unknown. Between the late 1960s and 2000 over 1800 captive-bred pateke were reintroduced to the wild. However no viable populations resulted (Moore, 2003; Moore & Battley, 2003) (Table 1). Before 2000 a lack of monitoring meant that the main causes of failure in pateke translocations were not identified (Innes, et al., 2000; Pierce, et al., 2002).

Several concerns surround the use of translocations as a conservation tool. These include: the welfare of released animals in terms of availability of adequate resources at the new site, particularly food and shelter; the possibility of causing harm to the existing ecosystem by increasing predation or competition and introduction of disease; the possibility that captive animals may be behaviourally and physiologically handicapped in comparison to their wild conspecifics; and genetic consequences. The failure of any translocation in terms of financial cost and the cost to the species is also of concern (Meek, Burmanb, Nowakowskic, Sparksa, & Burmanb, 2003).

1.3 Conservation status, threats, and causes of decline

Pateke are currently classified by the International Union for Conservation of Nature (IUCN) as endangered (IUCN, 2008), and by the Department of Conservation (DOC) as 'at risk but recovering' with the qualifiers conservation dependent (likely to move to a higher threat category if current management ceases) and range restricted (taxa confined to specific substrates, habitats or geographic areas of less than 1000 km^2) (Townsend, et al., 2008). The threat classification of pateke was changed to 'at risk' in 2008 from 'nationally endangered', with the qualifiers human induced (present distribution is a result of direct or indirect human activity), and conservation dependent (Hitchmough, Bull, & Cromarty, 2007; Molloy, et al., 2002; O'Connor, et al., 2007), reflecting the effort and successes achieved in pateke recovery since 2000.

The IUCN status of 'Endangered' is given to species classified as having a 20% probability of becoming extinct within twenty years, which have a mature adult population numbering less than 2500 individuals, and which occur in an overall area amounting to less than 5000km^2, or occupancy of a fragmented area of less than 500km^2 (Sutherland, 2004). The DOC classification system uses criteria similar to that of the IUCN to measure population features, however numerical limits and timeframes are tailored for New Zealand's unique island ecosystem circumstances (Molloy, et al., 2002; Townsend, et al., 2008).

Studies of fossils have shown that pateke where once the most numerous anatid in all regions of New Zealand, present throughout the North and South Islands, Stewart Island and Campbell Island. At that time they also inhabited a much wider range of habitat types, including coastal dunes, lagoons, and swamps, and inland forests from wet to seasonally dry, to montane and dry mountain beech up to 800m in altitude (Worthy, 2002).

By the 1960's pateke had declined in numbers and distribution and became locally extinct in all areas but Great Barrier Island, areas of eastern Northland and eastern Coromandel, and pockets of Fiordland (Heather & Robertson, 2005; O'Connor, et al., 2007). Before a series of reintroductions that began in 2000, aiming to establish self-sustaining breeding populations of pateke at several protected sites around the country (Pierce, et al., 2002), the wild pateke population was estimated at 1000-1500 birds (O'Connor, et al., 2007) (Fig 1).

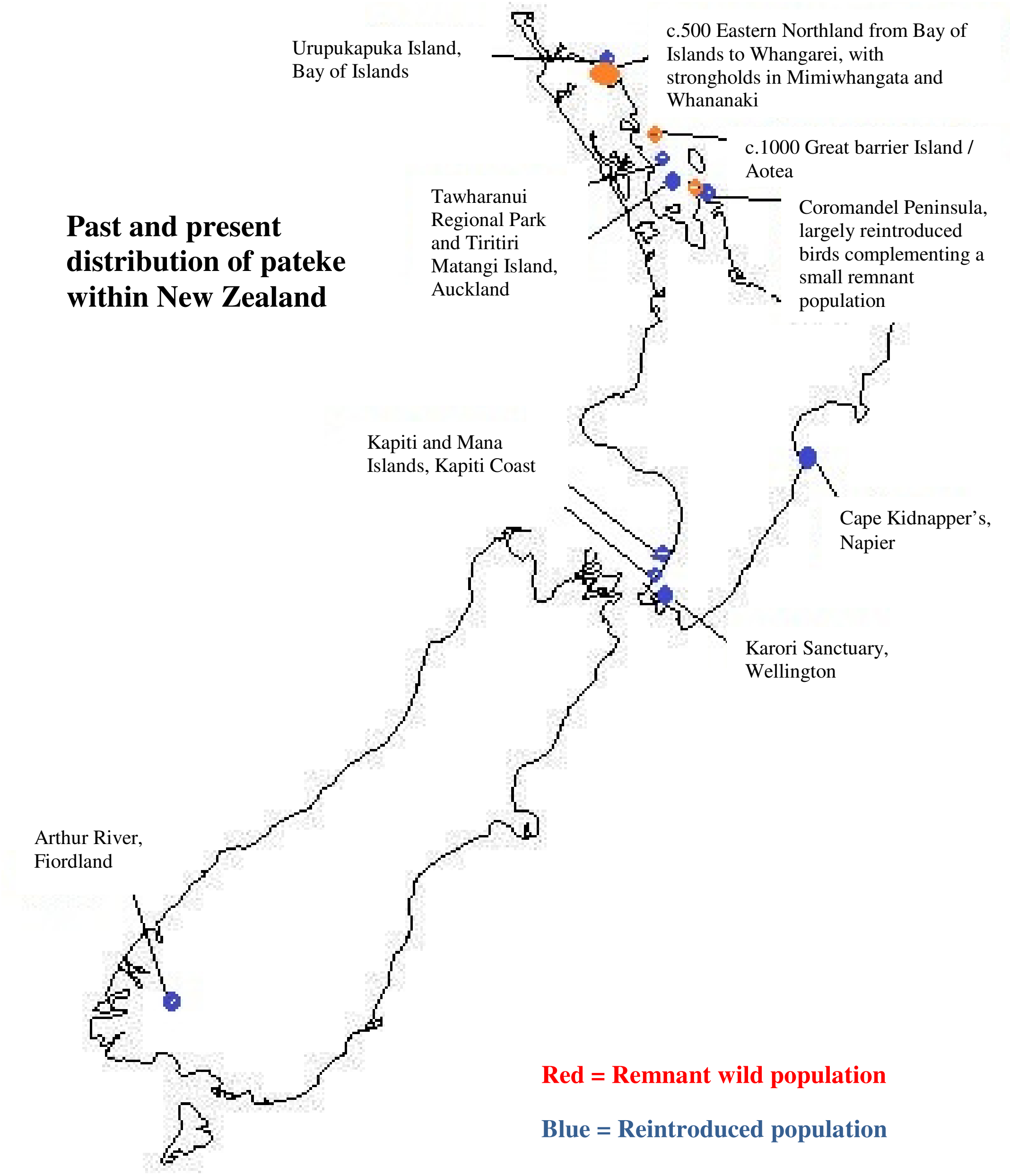

Fig 1. Map showing the distribution of remnant wild populations of pateke (red) and reintroduced populations of pateke (blue) within New Zealand.

Like many of NZ's native wildlife taxa, pateke also are threatened by introduced mammalian predators. Cats (*Felis catus*), dogs (*Canius lupis familiaris*) and mustelids (*Mustela spp.*) threaten adult birds, while rats (*Rattus spp.*) are suspected of taking eggs and ducklings. Natural predators include harriers, or kahu (*Circus approximans*) which take both adult and juvenile pateke (Browne, 2010; O'Connor, et al., 2007; Pierce, et al., 2002), and pukeko (*Porphyrio porphyrio melanotus*) and eels (*Anguilla spp.*) which take young ducklings (Browne, 2010; Hogarth, 2010; O'Connor, et al., 2007; Sim, 2008). Loss of habitat and resulting fragmentation of populations has also had a huge impact on pateke (O'Connor, et al., 2007). Over 90% of NZ's wetlands have been drained and/or degraded, primarily for farming, dramatically reducing available habitat for this once widespread species (NWTNZ, 2008; Peters & Clarkson, 2010).

1.4 Taxonomy and genetics

In the 1950s and 60s the New Zealand endemic teals were believed to be sub-species of the Australian chestnut teal, *Anas castanea* (Kennedy & Spencer, 2000). From 1975 to 1990 the taxonomy of the sub-family Anatinae classified *Anas chlorotis, A.nesiotis* and *A.aucklandica* as conspecifics, ie. belonging to the same species (Hay, 2002). Kennedy and Spencer (2000) sequenced mitochondrial DNA to measure divergence amongst the three New Zealand teal taxa enabling their phylogenetic relationship to be determined. From this DNA assessment Kennedy and Spencer (2000) found that the spectrum and decay index showed *"the level of support for grouping the brown teal and Campbell Island teal is relatively low… Branch lengths... indicate that the New Zealand teals are as divergent from one another as the grey and chestnut teals"* (Kennedy & Spencer, 2000). This work supports the classification of pateke as separate species. At present all three taxa are recognized as full species (Hay, 2002). South Island and North Island pateke have been proposed as sub-species, based on the

South Island form having smaller wing measurements. Upon DNA testing it was found that hybridisation between South Island pateke and grey (*Anas superciliosa*) and mallard ducks (*Anas platyrhychos*) has occurred, causing a divergence in genetics (Kennedy & Spencer, 2000).

The vast majority of pateke in the captive breeding programme were sourced from Great Barrier Island (GBI) (Bowker-Wright, 2008; Evans, 2010). In 2008 a study was undertaken to determine the current levels of genetic variation in the remnant, captive and reintroduced pateke populations. It was found that GBI pateke have just two haplotypes, one of which is in high abundance, and all samples from pateke at re-introduction sites also share this same GBI haplotype. In contrast pateke from Mimiwhangata Coastal Farm-park (a DOC parkland managed specifically for pateke conservation in Northland) were found to have eleven different haplotypes, including the GBI haplotypes (Bowker-Wright, 2008). This reduced genetic diversity of the captive breeding population and the re-introduced populations has prompted a series of translocations of eggs from wild Northland birds with a variety of haplotypes to the captive breeding programme to increase the genetic diversity of pateke being produced and distributed to re-introduction sites (Booth, 2010; Browne, 2010).

1.5 Translocation and pateke recovery

In 2000 an Audit of the Brown Teal Recovery Plan stated that *"Brown teal are a critically endangered species and are likely to become extinct within the next 10 years without management intervention… (they are) rarer than any kiwi..."* (Innes, et al., 2000). This statement highlighted the increased urgency towards pateke recovery at the time, and drove the current focus for pateke, which is based on improving the security of current populations, whilst developing new populations at appropriate sites in order to move the species into a recovery phase (O'Connor, et al., 2007). The 2000 audit defined three main directions to be made in an attempt to recover the species (Innes, et al., 2000) (Fig.2).

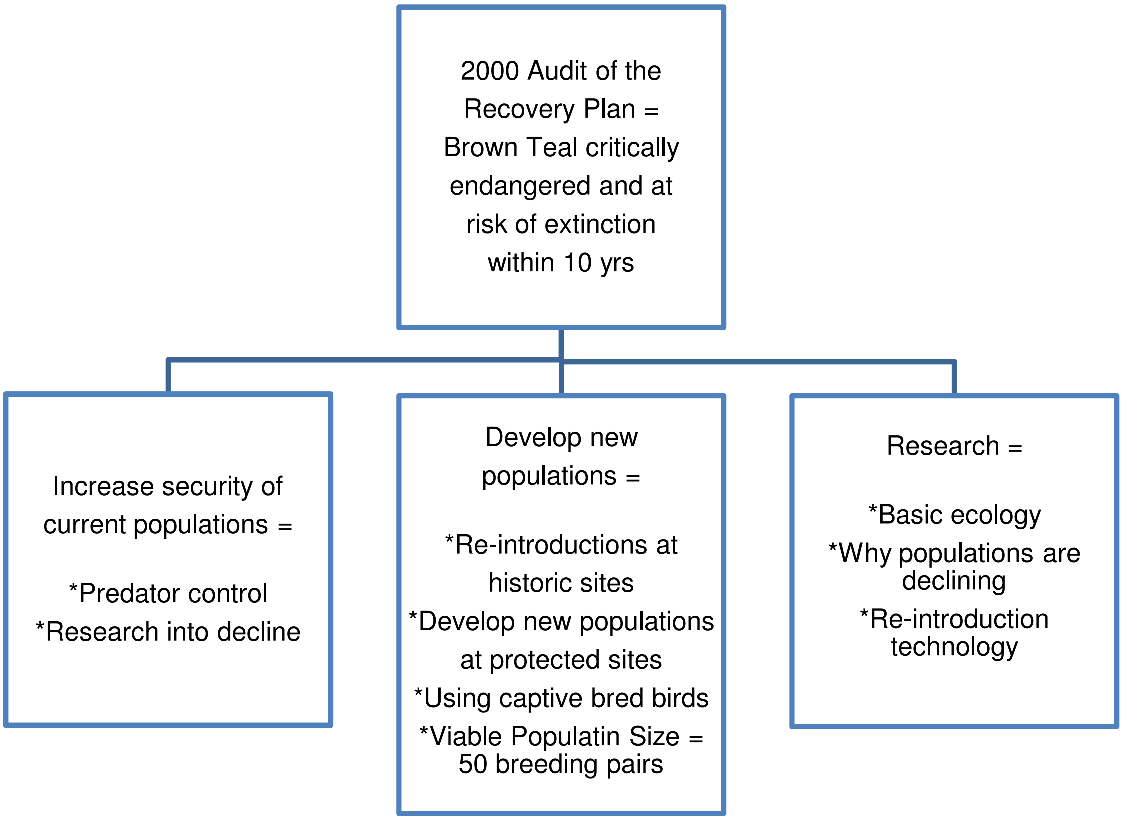

Fig 2. Diagrammatic representation of the outcomes of the 2000 audit of the brown teal recovery plan

As a result of the audit of the recovery plan a programme of re-introductions of captive-bred pateke to protected sites around the country has occurred over the past ten years (Table 1). The majority of releasees are radio-tagged to monitor dispersal and causes of mortality (Pierce, Maloney, Neill, & O'Conner, 2006; Pierce, et al., 2002).

As emphasised in the current recovery plan, the future security of pateke is widely believed to be reliant on reintroductions of captive-bred birds to suitable and well managed sites (Innes, et al., 2000; Moore, 2003; O'Connor, et al., 2007; Pierce, et al., 2002). Historically, attempts to reintroduce pateke largely failed "*due to inadequate planning and site management, and a general lack of monitoring*" (Innes, et al., 2000; Pierce, et al., 2002).

The knowledge gaps in pateke recovery primarily relate to our lack of knowledge of diet, dispersal and home-range, and detailed habitat preferences (N. Miller, 2006, 2010). In addition to these basic ecological factors we need further information on the best methods of recovery, particularly in relation to reintroduction biology. As pointed out by Sarrazin and Barbault (1996), although endangered species such as pateke may become the centre of interest in regards to translocations, it is often endangered species that are the least understood by scientists.

Pateke currently occur in the wild in two remnant strongholds, c.1000 birds on Aotea/Great Barrier Island in the Hauraki Gulf, and c.500 in Eastern Northland (Fig 1) (O'Connor, et al., 2007). As previously discussed, due to the low number of wild birds and the unstable nature of their population recovery (Innes, et al., 2000) harvesting birds for translocation from these remnant population is inadvisable. Therefore all birds for release currently come from the captive population, a programme initiated in the 1960's by Ducks Unlimited, and now headed by Kevin Evans (captive breeding co-ordinator) in conjunction with the DOC's Pateke Recovery Group. Captive breeding facilities are a mix of private breeders and establishments which hold pateke for display, such as Auckland Zoo, Orana Park, Otorohonga Bird Park, Queenstown Kiwi Birdlife Park, Palmerston North Esplanade Park and Mt Bruce. There are currently approximately eighteen active pateke breeding facilities in New Zealand (Evans, 2010). At present the captive breeding population of pateke is over 300% more efficient at producing viable young than the wild population (Evans, 2010). Almost all birds in the captive breeding programme are genetically sourced from Great Barrier Island, with a few from Mimiwhangata, Northland (1.4, pg13) (Bowker-Wright, 2008).

Several studies suggest that there may be severe limitations to using captive-bred animals for translocations, and in general, translocations of wild-caught founders have been more successful than those of captive-bred individuals (Berry, 1998; Brightsmith, et al., 2005; Brittas, Marcstrom, Kenward, & Karlbom, 1992; Fischer & Lindenmayer, 2000). Brittas et al's (1992) study compared captive-bred and wild pheasants (*Phasianus spp.*) and showed captive-bred birds to suffer a high rate of mortality soon after release, lower annual survival, and fewer young produced. Similarly studies of golden lion tamarins (*Leontopithecus rosalia*) found captive-bred reintroduced tamarins had less efficient foraging skills and locomotive skills than their wild counterparts, behaviours which increased their mortality (Stoinski, et al., 2003). Reintroductions of red wolves (*Canis lupus rufus*), Arabian oryx (*Oryx leucoryx*) (Stoinski, et al., 2003), Ethiopian wolves (*Canis Simensis*) (Sillero-Zubiri & Macdonald, 1997), grey wolves (*Canis lupus*) and African wild dogs (*Lycaon pictus*) (Fitts, Paul, & Mech, 1985; Sillero-Zubiri & Macdonald, 1997) have also found higher survivorship rates when translocating wild rather than captive-bred individuals. In contrast Meek et al. (2003) found no significant difference in survival, mortality, dispersal or breeding success between wild and captive-reared barn owls (*Tyto alba*) in a twenty-one year study. However as discussed previously, for some endangered species, such as pateke, there is little alternative but to use captive-bred stock.

Captive stock may be less successful in translocations due to a variety of reasons, such as a lowered ability to recognise predators or lowered ability to defend them-selves. Captive-bred animals may be less able to cope with environmental changes such as the weather, variable food sources, and seasonal differences in both the physical environment and the availability of food. These factors may render them nutritionally handicapped. They may also lack immunity to some diseases. Some captive-bred animals may not retain, or have had the chance to learn, culturally transmitted behaviours. All of these factors, when combined with the inherent stress of the translocation process itself (Adams, Farnworth, Rickett, Parker, & Cockrem, 2008; Teixeira, De Azevedo, Mendl, Cipreste, & Young, 2007), may result in lowered ability to survive (Brittas, et al., 1992), lowered reproductive success and lack of establishment of a population at the release site (Fitts, et al., 1985; Sillero-Zubiri & Macdonald, 1997; Teixeira, et al., 2007).

In light of this information and the fact that for pateke there is no option at present but to use captive stock for reintroductions, research into release techniques, the response of individuals to reintroduction, and adaptive management is required to learn how reintroductions, and subsequent survivorship, reproductive success, and stability of populations, can be improved to progress the conservation status of pateke.

Translocations of captive-bred pateke back into the wild began in 1968 when the NZ Wildlife Service released ten pairs onto Kapiti Island (Evans, 2010). Although the definition of what a successful translocation is, can be debated (Seddon, 1999; Seddon & Maloney, 2003), up until the early 2000's there were very few pateke translocations which could be deemed successful. Of 97 releases at 30 different locations only 19 releases (19.6%) at 7 different sites are either currently deemed successful, or have the potential to become successful (Moore, 2003) (Table 1).

Table 1; Comparison of pateke releases 1968 – 2006.

Re-introduction site	Years re-introduced	# of releases	Total # of birds released	Current status
Kapiti Island	1968-2000	3	23	Still present in small numbers (Site has limited carrying capacity)
Karori Sanctuary	2000	1	8	Still present in small numbers (Urban location, limited carrying capacity, advocacy only?)
Mana Island	2000	1	10	Still present in small numbers (Site has limited carrying capacity)
Moturoa Island	1985-1994	3	22	Still present (Site has limited carrying capacity)
Tiritiri Matangi Isl	1987-1990	4	12	Still present in low numbers (3-4 breeding pairs) (Site has limited carrying capacity, advocacy only?)
Urupukapuka Island	1988-1994	4	25	Present in small numbers but probably in decline (Site has limited carrying capacity, but potential to increase post-pest eradication with ongoing management)
Moehau Sanctuary	2004-2007	4	226	Now present in large numbers, apparently stable breeding population

(Caldwell, 2005, 2006, 2007; Moore, 2003).

Of these releases, five sites are islands with limited carrying capacity due to their size and habitat types, and the remaining two sites are within mainland sanctuaries, one of which (Karori) is protected by a predator proof fence; Karori Sanctuary is also of limited carrying capacity due to its size and central city location. It is not intended or envisaged that this population will expand to form a naturally self-sustaining population, however they have a role in conservation advocacy for the species and they are also a possible source for the captive breeding scheme (Empson, 2001, 2004; Evans, 2008). Thus of the 7 release sites where populations have not declined and disappeared, at only two sites, Moehau and Urupukapuka Island is there potential to develop self-sustaining populations, but even here success is dependent upon ongoing management including intensive control or eradication of remaining predators.

Of the remaining 78 (80.4%) releases at a further 23 sites, the birds were recorded to have declined or disappeared by 2003 (Moore, 2003). One of these failed releases was at Tawharanui in 1995, before a predator proof fence was built. Only eight birds were released, and of these five were found dead and a further two presumed dead in the first three weeks post-release. The seventh bird persisted for seven weeks after release. It is thought that all of the birds that died were predated on by mammalian predators, and recommendations were made to increase predator control along with using radio-telemetry to monitor movements and survival (Greene, 1996).

Many of the reasons for failure of translocations go unrecorded or are not fully understood. Reasons include a lack of predator control at the release site, dispersal and birds losing contact with each other and thus failing to breed, or predation when they have moved outside the managed releases site. Another reason has been too few founding birds released coupled with no subsequent follow up releases or management (Gillies, et al., 2003; Greene, 1996; Innes, et al., 2000; N. Miller, 2006; Moore, 2003; O'Connor, et al., 2007; Pierce, et al., 2002; Williams, 2001). The dispersal of founder birds post-release, or subsequently of juveniles, can also undermine a reintroduction by creating a source-sink effect, as translocated individuals and/or juveniles leave the managed area.

1.6 Translocation protocol and guidelines

In response to the increasing number of re-introductions and translocations both world-wide and within NZ, the IUCN re-introduction specialist group (RSG) and DOC have produced guidelines for implementing translocations (IUCN, 1998; Pierce, et al., 2006; Pierce, et al., 2002). These guidelines aim to ensure that translocations achieve their intended conservation gains, and do not cause adverse side-effects, whilst allowing for progressive improvements to be made, so that the wider conservation community learns from each initiative, whether successful or not (IUCN, 1998; Pierce, et al., 2006; Pierce, et al., 2002).

This study accords with the IUCN/RSG and DOC translocation guidelines in that it investigates dispersal and habitat choice, and collects data on survivorship, rate of residency and cause of death, in the translocated population. The IUCN/RSG guidelines recognise post-release monitoring, as a *"most vital aspect"* (IUCN, 1998) of translocations. Close monitoring enables the reasons for successes and failures to be identified and also enables one to intervene where necessary, and revise programmes where needed.

In response to the 2000 audit of the pateke recovery programme the "National Pateke Release Strategy" was produced in 2002 to provide strategic direction and guidance for pateke translocations through to 2006 (the life of the current recovery plan at that time) (Pierce, et al., 2002). In particular the release strategy identified suitable release sites and identified the best release techniques.

Following the 2002 release strategy, the DOC produced another species-specific plan for pateke in 2006, the "National Guidelines for Monitoring Pateke" (Pierce, et al., 2006). This was in response to the identified need for further information on, and monitoring of, both existing wild populations, additions of captive-bred birds to existing populations, and newly-created translocated populations. The plan states that *"Monitoring is an important component of many of the objectives of the recovery plan"* (Pierce, et al., 2006). The guidelines identify the objectives of post-release monitoring of pateke, and the relevant parameters to monitor so that the response of populations to management can be measured (Pierce, et al., 2006). Two of these parameters, adult survival and dispersal, are particularly important and are integral to this study. The DOC guidelines identify adult survival as a key parameter, and *"currently the pivotal demographic parameter to measure"* (Pierce, et al., 2006). The close monitoring of adults (eg by radio telemetry) helps to determine population size, aids in finding nests and broods, and allows nesting success and juvenile survival to be measured.

Close study of dispersal and habitat use enables managers to determine how far the pateke can move, their seasonal movements, and, perhaps critically, to which specific sites. It also allows the size of the management area, both spatially and temporally, to be determined (Pierce, et al., 2006). Monitoring by radio-telemetry is the most effective way of investigating causes of mortality, because without mortality signals provided by telemetry it is unlikely carcasses would ever be found, or found soon enough to be able to establish cause of death (Pierce, et al., 2006). Radio telemetry has been deemed negative in some studies, due to the effects of carrying the transmitter to the animal's well-being and natural behaviours (Curry, 2008; Godfrey, Bryant, & Williams, 2003; Guyn & Clark, 1999), whilst others have found no negative consequences (Curry, 2008; Nunes, Benford, & Balda, 2006). No detailed study has been undertaken specifically into the effects of transmitters on pateke (Hogarth, 2010). It is generally recommended that transmitters for flying birds should not exceed 5% of the total lean body mass (Caccamise & Hedin, 1985). Pateke are fitted with long-life mortality transmitters less than 15g in weight, which are approx 3% of a lean female's body-weight (Pierce, et al., 2006) (2.3.3, pg36).

1.7 Impacts of post-release dispersal

Short-term post-release survival and the first breeding season are crucial parameters for the success of a project long-term (Tavecchia, et al., 2009) .

Dispersal is a behavioural process which may involve an animal sampling various sites, selecting one or more particular sites due to perceived habitat quality, or moving to another site due to a disturbance or stress response (Molles, et al., 2008; Reed, 1999). Dispersal as a response to stress is a typical response of many species (Wingfield, et al., 1997), and translocations are known to be a significant cause of stress (Jamieson & Wilson, 2003; Kitaysky, Wingfield, & Piatt, 1999; Teixeira, et al., 2007), which may explain the high incidence of post-release dispersal seen in many translocations (Armstrong, 1995a; D. Armstrong, et al., 1999; M. F. Clarke & Schedvin, 1997; Smith & Clark, 1994). For social species post-release dispersal may be a social activity; a translocated bird will not know where conspecifics, potential mates, or territorial boundaries are in its new environment, thus dispersing is a way to investigate these important factors (Molles, et al., 2008).

The dispersal of released individuals is an important aspect in reintroductions as it can create a source-sink effect, which results in negative population growth at the release site. Flocking behaviour can act in reverse (Reed, 1999). Discouraging dispersal and encouraging aggregation of conspecifics can increase the chances of a population persisting in a chosen area. Another negative effect of dispersal is that it can make monitoring difficult or impossible, so that gauging success is more difficult because fate of released individuals may not be known (Molles, et al., 2008).

As previously discussed, success depends on numerous factors. For pateke in particular threats to successful establishment are predation, dietary change from captive to wild, and dispersal causing source-sink dynamics. As with many other introductions (Griffith, et al., 1989; Tavecchia, et al., 2009), pateke losses are high soon after release, through both mortality and dispersal into areas where the birds are at risk of predation (Pierce, et al., 2006; Pierce, et al., 2002).

Tavecchia et al. (2009) suggest that immediately after re-introduction there is a 'cost of release' where a high number of individuals are lost due to mortality or dispersal. Conversely it was also found that survival of crested coots (*Fulica cristata*) increased with time elapsed since release. Whether this was due to natural selection, acquired experience, or a lower propensity to disperse was unclear in this case (Tavecchia, et al., 2009).

Several methods of increasing site fidelity and decreasing dispersal of translocated animals have been used in the past with success. Temporary penning of translocated gopher tortoises (*Gopherus polyphemus*) has been used to effectively increase site fidelity by limiting their movement, thus helping a stable breeding population to form at the target release site. It was found that long term penning (9-12 months) was more effective than short term penning (less than one month) (Tuberville, Clark, Buhlmann, & Gibbons, 2005). Sound-anchoring and con-specific presence has been shown to reduce dispersal of kokako (*Callaeas cinerea*) (Molles, et al., 2008).

Other techniques to reduce dispersal include the use of decoys, which have helped to secure birds to new colonies by imitating the bird, its gestures, and even simply suggesting at their presence by white paint mimicking guano (Molles, et al., 2008; R. Podolsky & Kress, 1992; Sarrazin, Bagnolini, Pinna, & Danchin, 1996). Supplementary feeding and wing-clipping as methods to reduce dispersal are further discussed below.

1.8 Supplementary feeding to increase survivorship and limit dispersal

Supplementary feeding post-release is a commonly used management method and may be used to ease the stress of release via supplementing natural food, aiding the adjustment from captive to wild diet and foraging for food, and to anchor the population to a specific location, or to draw individuals to a specific place for observation. Armstrong et al. (1999) investigated whether supplementary feeding lowered mortality or changed foraging behaviour of hihi, *Notiomystis cincta*. Brightsmith et al. (2005) investigated whether supplementary feeding increased survival of scarlet macaws, *Ara macao*, and Berry (1998) investigated how supplementary feeding of re-introduced kaka (*Nestor Meridionalis*) influenced their transition to the wild in terms of post-release behaviour and foraging abilities. In the case of pateke, supplementary feeding has been used for, or recommended for, several of the aforementioned reasons, however no specific study has been undertaken to investigate the success of doing so (Caldwell, 2005, 2006, 2007; Empson, 2001; Evans, 2008; Maitland, 2008b; N. Miller, 2006; Moore, 2003; Moore & Battley, 2006; O'Connor, et al., 2007; Pierce, et al., 2002).

Boutin (1990) reviewed a total of 138 cases in papers investigating food supplementation experiments on terrestrial vertebrates (70 mammals, 58 birds, and 10 herpetofauna cases). He found that supplemental food often resulted in smaller home range size (82.6% of cases), higher body mass (70% of cases), and extended or advanced breeding seasons (84.6%). He also recorded that density of supplemented populations increases two-three fold. However, as with numerous other experiments where food was manipulated, assessing of actual food availability or limitation can hamper the accuracy of results (Boutin, 1990).

Home range is largely believed to reflect resource availability and requirements of the individual. Therefore it is expected that food supplementation should result in a decrease in home range size (Boutin, 1990). Swans kept wing-clipped and supplementary fed were later found to spend much time re-visiting the soft release site post-breeding (Monnie, 1966). This supports the hypothesis that supplementary feed can be used to anchor species to their release sites.

There is some concern that feeder stations can expose users to predators (Szymanski, 2004). However research on common American garden birds (house sparrows (*Passer domesticus*), goldfinch (*Spinus tristis*), European starling (*Sturnus vulgaris*), house-finch (*Carpodacus mexicanus*), blue-jay (*Cyanocitta cristata*), mourning dove (*Zenaida macroura*) and rock dove (*Columba livia*)) by Dunn and Tessaglia (1994) suggests that feeders may provide safer feeding opportunities due to a greater number of individuals on hand to watch and raise the alarm if a predator approaches. Shorter foraging times also result in less time exposed to predators. Feeder placement itself may alter exposure to predators, and may be an important variable in such experiments.

Another concern is that providing supplementary food could alter the foraging behaviour of individuals. Indeed this was seen in translocated hihi (*Notiomystis cincta*) which spent more time foraging for invertebrates when given sugar-water feed (D. Armstrong, et al., 1999). All pateke in the current release programmes are captive-bred and thus have been raised mainly on a pellet-based diet. It is assumed that these captive-raised birds may take time to develop natural foraging behaviours, rather than their behaviour being negatively altered.

A fact to consider when releasing captive birds into the wild is the ability of their digestive morphology to handle a change in food source. It has been observed in several species (mallard ducks (*Anas platyrhynchos*), pateke (*Anas chlorotis*), pintails (*Anas acuta*), and grouse (*Lagopus lagopus*)) that differing amounts of dietary fibre alter the morphological structure of the digestive tract. It is hypothesised that this is an evolutionary trait to deal with seasonal changes in diet and dietary changes due to migration (Battley & Piersma, 2005; Charalambidou, Santamaria, Jansen, & Nolet, 2005).

Although digestive plasticity is high in many species (Battley & Piersma, 2005), a period of 5-10 days, or even up to six weeks, may be required for gut morphology and flora to adjust (Battley & Piersma, 2005; Charalambidou, et al., 2005; Moore, 2003; Moore & Battley, 2006). In a highly stressful situation such as translocation, this has been shown to result in starvation in brown teal (Moore & Battley, 2006). Supplementary feeding provides a way to mitigate this problem.

Captive-bred pateke have been provided with supplementary food at release sites at Moehau, Coromandel (Caldwell, 2005, 2006, 2007). However there has been no detailed investigation of whether the feeder stations have had an effect on site fidelity or survivorship. From a management perspective, food supplementation can be labour intensive and costly. It is therefore important to be assured that supplementary feeding is worthwhile and effective.

1.9 Wing-clipping; a suitable and safe method of limiting dispersal?

There is a dearth of published information on experimental wing-clipping. Presumably it is deemed too basic a standard practice to warrant investigation. Wing-clipping has been traditionally used to keep birds within a desired area, for example on a pond or lake.

One study which specifically used wing-clipping to prevent dispersal and promote attachment to a specific area was that of Monnie (1966), who wing-clipped trumpeter swans (*Cygnus* *buccinator*) when reintroducing them to their former range. Monnie found that wing-clipping the trumpeter swans was instrumental in successfully establishing a breeding population at that site. A second study by Rosvall (2009) experimentally wing-clipped male songbirds to investigate the effects of lowered male provisioning during breeding. The result was higher nestling mortality.

A third study of houbara bustards (*Chlamydotis undulate*) investigated predation and successful introduction of three groups; sub-adults, wing-clipped sub-adults, and chicks. The wing-clipped group had the highest losses to predators (80%) and subsequently the lowest rate of successful introduction (17%) (Combreau & Smith, 1998). This study highlights the importance of ensuring experimental release techniques which carry an obvious risk, such as releasing wing-clipped birds into the wild, have measures in place to eliminate or minimise those risks. When used to hold an endangered species inside a managed area it is critical to ensure that negative effects on survivorship and reproduction are minimised. Wing-clipping can only work if the birds can still evade predators. The possible negative effects of wing-clipping were not seen as too significant for pateke as the releases were being made into predator-managed areas.

1.10 Study Aims

Releases of captive-bred pateke to Tawharanui Regional Park and Cape Kidnappers Wildlife Preserve provided an opportunity investigate whether populations established in the target areas under prescribed management regimes (O'Connor, et al., 2007; Pierce, et al., 2006).

The aims of the study were;

1. To determine whether supplementary feeders limit dispersal and increase residency in target release areas, whilst testing the use of PIT tags as a monitoring tool for pateke:

It is hypothesised that a greater use of supplementary feeders will result in lower dispersal and increased residency at release sites. It is expected that PIT tags will provide an effective way of monitoring supplementary feeder use by pateke remotely 24 hours a day with minimal disturbance.

2. To ascertain if wing-clipping increases residency in the target release areas:

It is hypothesised that wing-clipped birds will have shorter dispersal distances compared with fully-feathered birds and therefore a higher rate of residency at release sites than fully-feathered birds.

3. To assess whether supplementary feeding or wing-clipping causes an increases survivorship and/or improves the physical condition of released pateke:

It is hypothesised that a greater use of supplementary feeders will result in higher survivorship and/or improved physical condition of released pateke, and that wing-clipped pateke will experience higher mortality and a lower physical condition compared with fully-feathered pateke.

4. To investigate post reintroduction dispersal of pateke at multiple locations and to develop management techniques for translocations from this information:

Monitoring was undertaken to determine survival rates of released birds, cause of death, rate of residency, breeding attempts, dispersal patterns, habitat choice, and whether populations established in the target areas under the prescribed management regimes.

Chapter 2

The effects of supplementary feeder use on dispersal, survivorship and condition of pateke at Tawharanui Regional Park.

2.1 Introduction

Supplementary feeding post re-introduction is recommended for all pateke releases (Pierce, et al., 2002). Primarily this is to ease the stress of release on captive-bred birds and to aid the process of adjusting to foraging for wild food as pateke are highly susceptible to starvation in the first month post-release (Moore & Battley, 2006).

Predation by introduced mammals is a major cause of decline of pateke (O'Connor, et al., 2007). For this reason it is important to attempt to anchor pateke to chosen release sites where predators are being managed so that they remain in a safe area long enough to establish a self-sustaining breeding population (Maloney, et al., 2006; O'Connor, et al., 2007; Pierce, et al., 2002). The post release dispersal of pateke can undermine recovery efforts when newly-reintroduced individuals disperse from the managed area to sink habitats where mammalian predators are not controlled. Therefore research into post-release dispersal and the effect of supplementary feed on dispersal will help to evaluate whether this technique can be used to minimise dispersal into unmanaged sink habitats.

A review of 138 studies of food supplementation experiments (including 58 cases of birds) found that 82.6% of cases resulted in a smaller home range size, and 70% of cases experienced higher body mass (Boutin, 1990). A study of possums (*Trichosurus vulpecula*) found supplementary fed animals had a significantly increased body weight than their un-fed counterparts (Isaac, Johnson, Grabau, & Krockenberger, 2004).

As outlined in the current recovery plan (O'Connor, et al., 2007), the future security of pateke is widely believed to rely on reintroductions of captive-bred birds to suitable, well managed-sites (Innes, et al., 2000; Moore, 2003; O'Connor, et al., 2007; Pierce, et al., 2002). Ensuring pateke remain at these sites once released is therefore critical in the implementation of the current recovery plan.

See chapter 1 sections 1.7 and 1.8 for further detailed review of the impacts of post-release dispersal and the use of supplementary feeding to increase survivorship and decrease dispersal.

2.2 Aims and objectives

The aims of this part of the study were to:

1. Determine whether supplementary feeders limit dispersal and increase residency in a target release area, whilst testing the use of PIT tags as a monitoring tool for pateke:
It is hypothesised that a greater use of supplementary feeders will result in lower dispersal and increased residency at the release site. It is expected that PIT tags will provide an effective way of monitoring supplementary feeder use by pateke remotely 24 hours a day with minimal disturbance.

2. Determine whether supplementary feeding increases survivorship and/or improves the physical condition of pateke after release:

It is hypothesised that a greater use of supplementary feeders will result in higher survivorship and/or improved physical condition of pateke after release.

2.3 Methods

2.3.1. Study site: Tawharanui Regional Park, Auckland

Tawharanui Regional Park (588ha) is located at the eastern end of the Takatu Peninsula, 90 km north of Auckland in the Rodney district. The open sanctuary within Tawharanui Regional Park comprises of 550ha, of which c.150ha is farmed. The remaining land includes retired pasture, regenerating coastal forest and scrublands, wetlands, salt-marshes and dune-lands (Fig 3).

Tawharanui has been predator-fenced since 2004, and is free of most introduced predatory mammals. Mice, rabbits and hedgehogs remain. There are occasional rat incursions (including a serious incursion in the summer of 07/08). Cats occasionally enter the open sanctuary along the beach by walking around the Northern end of the pest-proof fence which stops on the foreshore above the high water mark (Plate 5). Minor possum incursions occurred in the summers of 08/09 and 09/10. Pest surveillance is carried out via a network of monitoring tunnels and bait stations, along with trap lines in the buffer zone outside the fence and in high risk areas within the park (TOSSI, 2006).

Tawharanui was extensively milled for kauri (*Agathis australis*) in the late 1800s then manuka (*Leptospermum scoparium*) and kanuka (*Kunzeaericiodes*) was removed for firewood. Besides the grazed pastures Tawharanui has extensive areas of manuka and kanuka scrublands and remnants of coastal forest in some valleys. These forests feature kauri and rimu (*Dacrydium cupressinum*) on the ridgelines, and puriri (*Vitex lucens*), taraire (*Beilschmiedia tarairi*), tawaroa (*Beilschmiedia tawaroa*) and nikau (*Rhopalostylis sapida*) in the valleys. The steep southern coastal areas have pohutukawa (*Metrosideros excelsa*), flax (*Phormium tenax*), and cabbage trees (*Cordyline australis*)(Auckland Regional Council, 2003). Around the dam areas raupo (*Typha orientalis*) and cabbage trees (*Cordyline australis*) grow, along with freshwater species in the wetlands including red water fern (*Azolla filiculoides*) , starwort (*Cardamine debilis*), water purslane (*Ludwigia palustis*), watercress (*Nasturtium spp.*) and duckweed (*Lemansa minor*) (Auckland Regional Council, 2003). Salt-marshes and shallow estuarine areas are vegetated with sedges (*Cyperus spp., & Carex spp.*), rushes (*Juncus spp.*) and mangroves (*Avicennia marina australasica*). Typical dune vegetation is found in the Ocean Beach dunes, including spinifex (*Spinifex spp.*), marram grass (*Ammophila arenaria*), lupin (*Lupinus spp.*), pingao (*Desmoschoenus spiralis*) and pioneer sedges (Auckland Regional Council, 2003).

The wetlands at Tawharanui once covered the entire Takatu flats area, but were drained and altered extensively by farming practices (Auckland Regional Council, 2003). Within Rodney District it is believed only around 0.1% of the original wetland area remains, the rest having been drained for farming, and existing wetlands often suffer from pollution, particularly from farm run-off (Ritchie, 2002).

Tawharanui's wetlands can be classified on the whole as estuarine salt-marsh wetlands as they are affected by salinity from a tidal lagoon, however significant parts of the wetlands are freshwater and fed by groundwater and streams. The saline lagoon at Jones Bay was formed by mining for shingle in the late 1950's and early 1960's. The wetlands around the campground and in the Mangatawhiri valley were drained for pasture in the past, and the water level is now controlled with weirs and bunds (Boffa Miskell, 2001). In the Anchor Bay stream a variety of freshwater fish and invertebrates are found, including eels (*Anguillida spp*.), giant kokopu (*Galaxias argenteus*), banded kokopu (*Galaxias fasciatus*), red finned bully (*Gobiomorphus huttoni*), freshwater crayfish (*Paranephrops planifrons*), shrimps

(*Paratya curvirostris*), damselflies (*Zygoptera*) and freshwater mussels (*Hyridella menziesi*). On the beaches sand-hoppers (*Talorchestia quoyana*) are found above the high tide mark, snails, limpets and crabs on the gravel beaches, seaweeds and barnacles in and around rock-pools, pipi (*Paphies australis*) and green lip mussels (*Perna canaliculus*) in the lagoons and tidal flats, and paua (*Haliotis sp*.) and scallop beds in offshore bays (Auckland Regional Council, 2003). Some of these species are food sources for pateke.

In 2007 a $30,000 grant was given to Tawharanui Open Sanctuary Society Inc (TOSSI) by Banrock Station Wines through the NZ Wetland Trust (Maitland, 2008a). The majority of these funds were used to reconstruct Tawharanui's wetlands in preparation for the re-introduction of pateke along with other native wetland species. The earthworks were completed in 2007 and planting, which began in winter 2007, is ongoing. Boardwalks and track work within the wetlands with interpretational signage is partly completed. Wetlands at Tawharanui, including existing and regenerating areas, now cover approximately 100 hectares (Maitland, 2008a). However this is not inclusive of the numerous other areas usable to pateke, such as areas of damp forest, wet grazed paddocks, drains and culverts. The first re-introduction of pateke took place on World Wetlands Day, 2nd February 2008, at Ecology Stream, in the centre of the park (Fig 3). This area features an artificial dam in the stream, which itself is approximately 240m long and c.20m wide at its widest point. The banks are densely forested providing plenty of cover for pateke. A popular walking trail and service vehicle access track run along one side and an intermittently noisy pump-house at one end of the dam pumps water to the farm troughs.

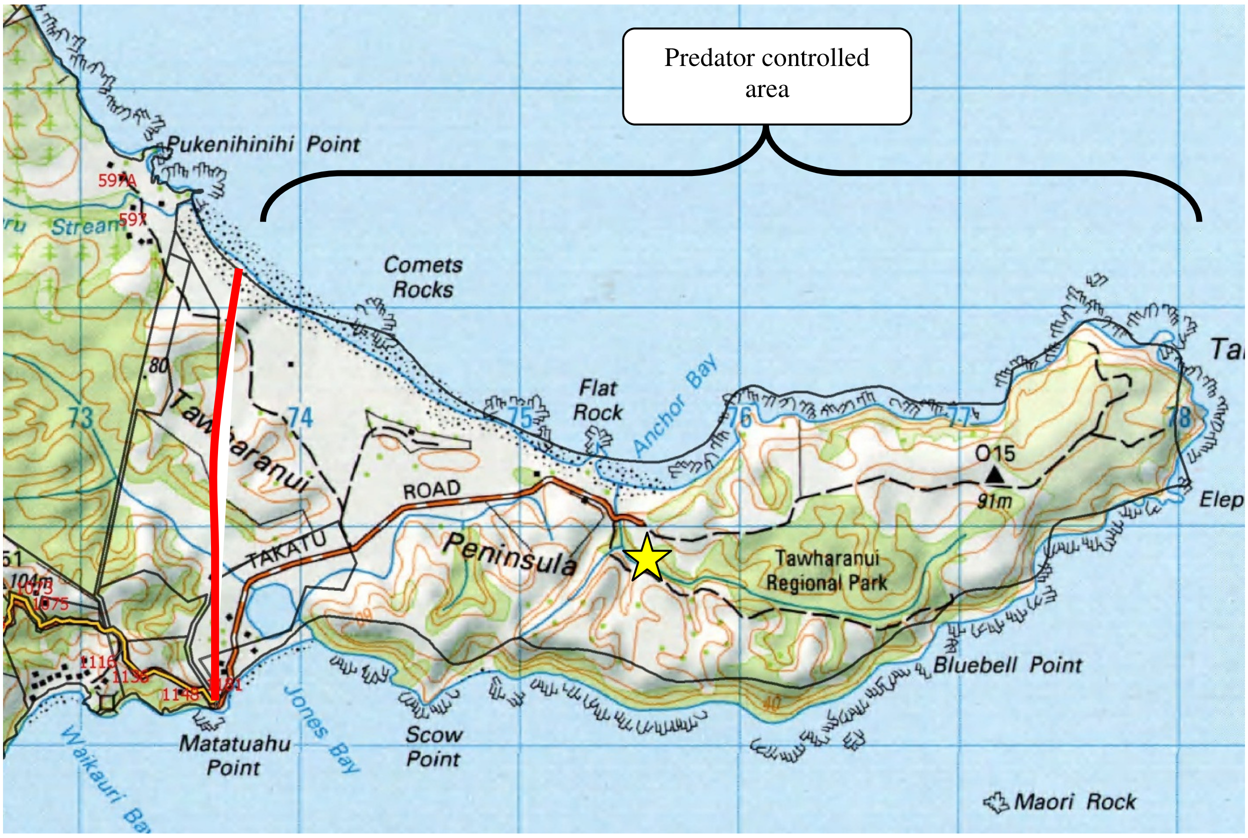

Fig 3. Map of Tawharanui Regional Park showing the release site (yellow star), predator managed area, and predator fence (red line).

My study of dispersal in response to supplementary feeding took place using three translocations of pateke to Tawharanui (Table 2). I collected data from the first release in February 2008 as part of a previous study (Rickett, 2008) and was able to utilise that information for inclusion in this study. Information on dispersal of the February 2009 and May 2009 releases was collected as part of the fieldwork undertaken for this study. Some of the information from all three releases was collected by volunteers, of whom key people are gratefully acknowledged (pg ***iii***). All pateke released in February 2008 and 2009 carried radio-transmitters. In May 2009 10 birds carried radio-transmitters and PIT tags, however the PIT tag failed in one of these birds, therefore the nine remaining birds carrying both a PIT tag and radio-transmitter were used for this study.

Table 2. Summary of releases of pateke at Tawharanui Regional Park

Tawharanui Regional Park	Total # of birds released	# of females	# of males	Received supplementary food
Release group Feb 2008	24	15	9	No
Release group Feb 2009	39	25	14	No
Release group May 2009	20 (of which 9 were used in this study*)	9 (Of which 5 were used in this study*)	11 (Of which 4 were used in this study*)	Yes

*Although a total of twenty birds were released in May 2009, ten did not carry transmitters and a further bird's PIT tag failed. Information from those 11 birds could therefore not be collected for this study.

Although feeders were present during the first two releases in Feb 2008 and Feb 2009 they failed to provide food to the birds due to mechanical faults in the dispenser and the design of the cage intended to keep species other than pateke away from the food source (Maitland, 2008a). I therefore used the data from these two releases without supplementary food to compare to a release in May 2009 when birds were offered supplementary food for a period following their release.

At Tawharanui the May 2009 release of pateke had supplementary food freely available for the first 46 days after release (phase 1). From days 47-73 a weaning process was implemented where two of the five feeders were emptied and in the remaining three the food was allowed to run out (phase 2). Between days 74-91 no supplementary food was available (phase 3). For the purposes of comparison these same phase periods are also applied to the birds which did not receive supplementary food (Feb 08 and Feb 09).

2.3.2 Pre-release training

All released pateke are captive-bred juveniles or sub-adults. All birds in this study were transferred to Peacock Springs in Christchurch for a six week disease screening and hardening-off period before release. This included being mixed with the other pateke they were to be released with, and being introduced to more wild type foods along with the supplementary feeder stations they would be provided with upon release. This was done to encourage natural foraging and to decrease the negative effects of the digestive morphology change, which can lead to starvation during early release (Moore, 2003; Moore & Battley, 2006).

2.3.3 Monitoring dispersal distances of pateke using radio-telemetry

The recommended transmitter for pateke monitoring is a long-life mortality transmitter of less than 15g in weight (Pierce, et al., 2006). I used Sirtrack ‘12 month two-way’ transmitters attached by a backpack harness with built-in linen thread weak-link (Plate 1). The weak-link theoretically allows the transmitter to break loose if the bird becomes entangled or trapped by its transmitter harness. It should also rot and release the transmitter after a period of time if the bird cannot be re-caught and have the transmitter removed. The transmitters were set at 40 pulses per minute, with a mortality mode of 80 pulses per minute. A ‘time since death’ mortality function emits 80 pulses per minute if the bird has not moved in 24 hours. A code is also emitted which can be used to calculate time since death.

At Tawharanui telemetry monitoring was undertaken daily or approximately every other day for 91 days post-release. Telemetry monitoring attempted to pinpoint and record each individual’s daytime roost. If a bird was not found at a roost near the release site or its last known site, a wider search was made to locate its new position. Locations of roosts were recorded by GPS (See 2.3.6 page 40 for details of calculation of dispersal distances).

Plate 1. Attaching radio-transmitters (Photo: J.Rickett)

2.3.4 Monitoring feeder use of pateke using PIT tags

The PIT tags I used were Allflex branded, 11mm x 2mm, inserted subcutaneously into the fatty tissue in the base of the neck (Plate 2) as per the Department of Conservation's Standard Operating Procedure for PIT insertion (G. Taylor, 2008). Animal ethics permit number 09/42 (Appendix 1) was granted by the Massey University animal ethics committee (MUAEC) for insertion of PIT tags under DOC permit AK-23882-FAU for Tawharanui (Appendix 2).

Plate 2. Insertion of PIT tag (Photo: J.Rickett)

Feeder stations consisted of a bucket with ‘nos-lock’ dispenser supported by a ‘warratah’ steel standard driven into the ground. The feeder was enclosed to prevent access by other species by a rectangular cage with access holes at the front and sides. Upon entering the cage the pateke then had to pass through a circular antenna of approx 30cm diameter to reach the ‘nos-lock’ dispenser (Plates 3 & 4). When a bird passed through the antenna the data-logger recorded the PIT tag number of the bird, along with time and date. If the bird remained in the feeder for longer than one minute, the data-logger would record that bird’s PIT tag number again. If multiple pateke accessed the feeder within the same minute the reader would record each of those birds once for that same minute.

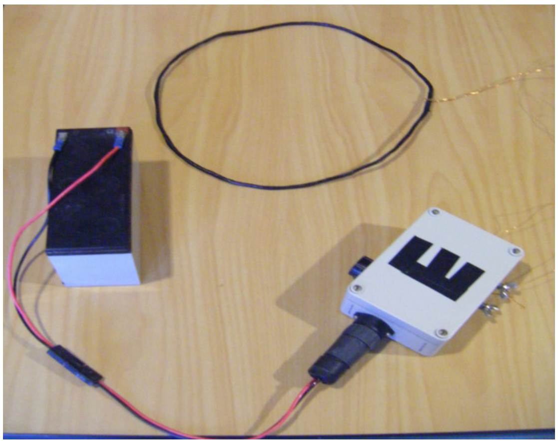

Plate 3. Data-logger, antenna and battery set-up (Photo: J.Rickett)

Plate 4. Feeder station set-up with data logger and antenna (Photo: J.Rickett)

Data-loggers were set up on feeder stations prior to the birds being released. After the release the feeders were checked to ensure the food was free-flowing every second day when the battery for the data-logger was changed. Each data-logger was powered by a 12V 7Ah battery. The information recorded was downloaded approximately once a month. (see Appendix 3 for more information on data-logger set-up). This study was the first in which PIT tag technology was used on pateke.

2.3.5 Monitoring weight as an indicator of condition

Six to nine weeks after release I attempted to recapture as many of the released pateke as possible at both sites to weigh them. I placed captured birds in cotton bags and weighed them using a 1kg spring-balance. I then calculated the percentage weight change from each individual's weight taken at Peacock Springs by DOC before release, and their re-capture weight. Weight changes could then be compared with records of each bird's use of the supplementary feeders. Other measurements of body condition such as presence or absence of parasites, body fat indexing or for example wing or tarsus measurements, were not used as no pre-release data other than weight had been recorded in which to compare to. I re-captured some birds at night, when they were at their most active, by spot-lighting and hand-netting. Other birds were re-captured during the day using clap-traps baited with feed pellets.

2.3.6 Calculation of daily dispersal distances, feeder usage and survivorship

2.3.6.1 Daily dispersal distance

Dispersal distance was calculated by measuring the distance from the feeder at the individuals release site to that individual's day-time roost, as determined by radio-telemetry fixes. All measurements within a phase (Phase 1; days 1-46 after release, phase 2; days 47-73 after release, and phase 3; days 74-91 after release) for each individual were then added together and the total divided by the number of days within that phase that the bird was located (or, if it died, the number of days it was located up until it died). This gave a mean daily dispersal distance that the individual had moved from the feeder within that phase (See Appendix 4 for an example of this calculation). Therefore for each bird there were three average daily dispersal distances, one for each of the three time phases.

2.3.6.2 Daily feeder usage

Daily feeder use was calculated by dividing the total number of feeder visits within a phase by the number of days within that phase (Phase 1, 46 days; phase 2, 27 days; phase 3, 18 days; or, if the bird died, the number of days in the phase up until it died). This gave a figure of mean daily feeder usage for each phase for each individual bird (See Appendix 5 for an example of this calculation).

2.3.6.3 Survivorship

Survivorship was calculated following Robertson and Westbrooke (2005). The Mayfield method (Mayfield, 1975) was used to calculate mortality rate, survival rate and to calculate an estimated annual survival rate, the Kaplan-Meiner procedure (Pollock, Winterstein, Bunck, & Curtis, 1989; Pollock, Winterstein, & Conroy, 1989) was used to correct survivorship for the assumption of constant survival, and the Mantel-Haenszel statistic (Robertson & Westbrooke, 2005) was used to compare between treatment groups.

2.3.7 Statistical methodology

All statistical tests were conducted using SPSS version 17.0 (SPSS, 2009). Data was assessed for normality to establish whether parametric or non-parametric tests were appropriate. Hypotheses were tested at a 5% level of significance.

Data was logged for graphs in order to avoid large outliers skewing the appearance of the graphs.

2.3.7.1 Relationship between feeder use and dispersal post-release

Friedman tests were run first of all to look for any differences in daily feeder visits between the three monitoring phases, and for differences in the daily dispersal distances travelled between the three monitoring phases. Spearman's rank tests were then run to look for correlations between daily feeder visits and daily dispersal distances. To look more in-depth at the patterns that were emerging Wilcoxon signed ranks tests were run to look for differences between the phases; between phase 1 and phase 2, and phase 2 and phase 3. This was done for both daily feeder visits and daily dispersal distances.

2.3.7.2 Comparison of dispersal distances of the Tawharanui un-fed groups Feb 08 and Feb 09, with the May 09 fed group

Mean daily dispersal distances for each of the three monitoring phases were graphed to compare between the three Tawharanui groups. Wilcoxon signed rank tests were run to look at dispersal distances in each phase when compared between the fed (May 09) and each of the un-fed (Feb 08 and Feb 09) Tawharanui groups. Another Wilcoxon signed rank test was run to look for differences in rates of dispersal distance in-between phases; between phase 1 and phase 2, and phase 2 and phase 3. This analysis allowed the effects of supplementary feeding on post-release dispersal distances to be compared.

2.3.7.3 Comparison of distances dispersed and feeder use between males and females

Mann Whitney U-tests were performed to compare differences in average daily dispersal distances and average daily feeder use between sexes in the un-fed groups (Feb 2008 and 2009) and the supplementary fed group (May 09).

2.3.7.4 Survivorship and condition of supplementary fed pateke

The Mayfield method (Mayfield, 1975) was used to calculate mortality rate, survival rate and to calculate an estimated annual survival rate. The Kaplan-Meiner (Pollock, Winterstein, Bunck, et al., 1989; Pollock, Winterstein, & Conroy, 1989) procedure was used to create a visual comparison of the survivorship data from all three release groups with each other for the first six months post-release. The Mantel-Haenszel (Robertson & Westbrooke, 2005) statistic was then run to compare survivorship between the three groups at three and six months post-release.

Since the sample size of data collected for condition as measured by weight change was small no statistical tests were run on this data set.

2.3.8 Experimental design

This study was undertaken as part of an existing series of translocations of captive-bred birds to Tawharanui Regional Park. As such some of the experimental design was already determined. Most significantly, there were no control groups in May 09 available for direct comparisons. The main reason for the lack of a control group was that it was not practical to prevent all birds from using the feeders, and that for the welfare of the reintroduced pateke it was deemed necessary to allow all birds the opportunity to have access to supplementary feed.

At Tawharanui the supplementary fed birds were weaned off food between days 47-73 post-release, and had food removed at day 74 post-release. Moreover, the data for the un-fed groups at Tawharanui was not collected with the aims of this study specifically in mind, and nor was there the opportunity to gain feeder visitation data from these groups. The

Tawharanui birds receiving supplementary feed were translocated in May, in contrast to the two previous translocations to Tawharanui, which were undertaken in February. The number of birds released fitted with radio transmitters in May 09 was also less than previous translocations, 10 birds as opposed to the previous 24 (Feb 08) and 39 (Feb 09). This was due to the May 09 release being an unplanned top-up release of surplus captive-bred birds. The later release of the supplementary fed group (May 09) compared with the un-fed groups (Feb 08 & 09) may have had an effect on their dispersal patterns due to seasonality. Pateke generally flock together from Jan – March/April, then pair up with mates and move off to territories around May/June ready to breed from June – Oct. Unpaired or juvenile birds may stay on and around the flock sites for longer. Wild food availability may also have been different in May than February.

It is suspected that two or more pairs of previously-released pateke hold breeding territories close to the Tawharanui release site. These birds may have been aggressive to newly introduced groups, forcing them out of the area sooner than they would otherwise have chosen to disperse.

At Cape Kidnappers (Chapter 3) supplementary food was provided all year round ad-lib, and birds were not weaned off or had supplementary food removed at any point. This means that Cape Kidnappers and Tawharanui cannot be directly compared. It is therefore recommended that to provide valid comparisons in any repeats of this experiment release times and feeding regimes need to be standardised and a control group added.

The sample sizes in this study were also small (supplementary feeder use data from a total 9 birds at Tawharanui), with endangered species this often cannot be helped, however better planning to ensure appropriate numbers of birds are included in any future experimental releases is advisable to increase the power of statistical tests and also to allow for slippage in sample sizes due to deaths, missing birds, or failure of equipment (radio transmitters and/or PIT tags).

2.4 Results

2.4.1 Relationship between feeder use and dispersal post-release

At Tawharanui the supplementary fed group (May 09) experienced a significant decline in daily feeder visits between the three monitoring phases (Friedman's tests; χ^2=14.6, p<0.001). This group also showed a significant increase in the daily dispersal distances travelled between the three phases (Friedman's tests; χ^2=8.5, p<0.05).

A strong negative correlation between changes in average daily feeder visits and time (measured in phases) (Spearman's rank tests; r = -.820, p = <0.005), and the frequency of feeding events (r = -.722, p = <0.005) was demonstrated. A strong positive correlation was seen between average daily dispersal distances travelled and time (r = 0.717, p = <0.005). This indicates that as feeder use declined, due to change in availability, distance from the feeder stations increased (Fig 4 & 5, Table 3 shows actual average dispersal distances (m) and average daily feeder visits (fpd)).

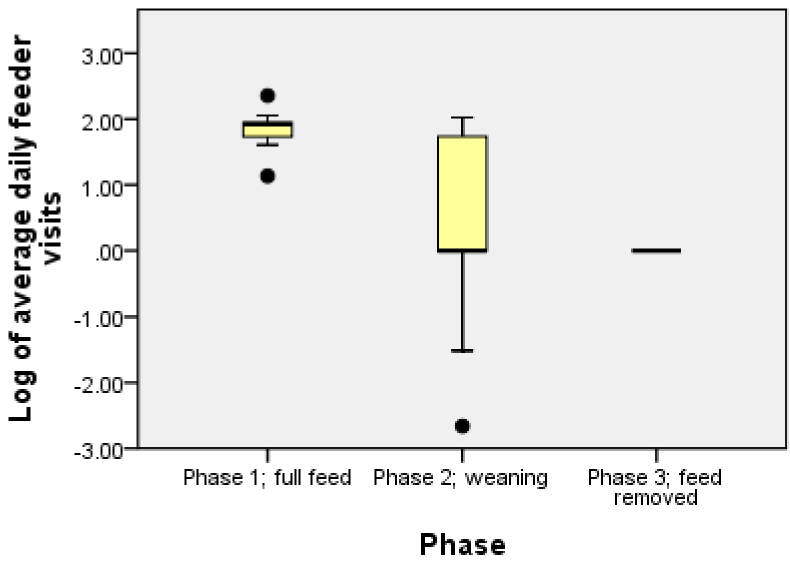

Fig 4. Log of average daily feeder visits of supplementary fed group (May 09) across the three monitoring phases at Tawharanui. No feeder visits were made in phase 3 as food was removed at this stage.

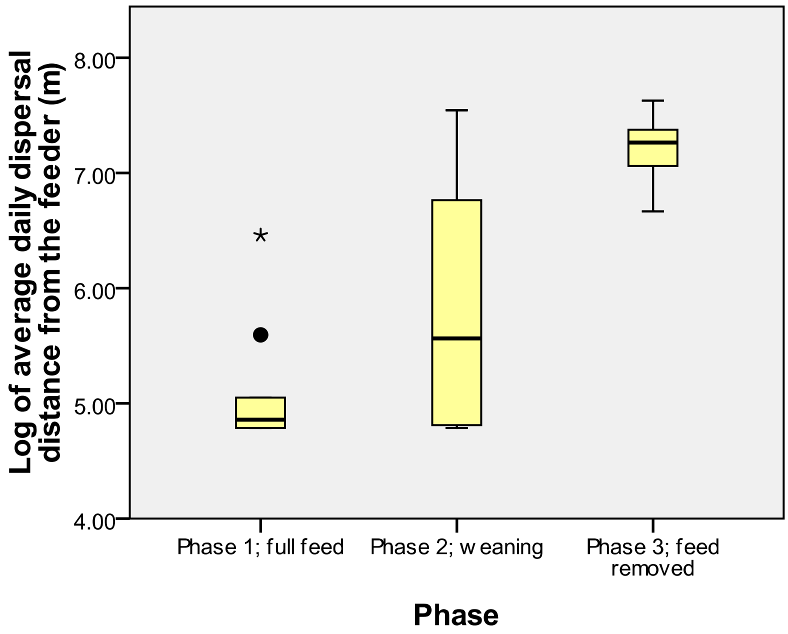

Fig 5. Log of average daily dispersal distance from the feeder (m) of supplementary fed group (May 09) across the three monitoring phases at Tawharanui.

Table 3. Comparison of average daily dispersal distance (m) and average daily feeder visits (fpd), (including range and standard deviation (SD)) across the three monitoring phases.

May 09 Fed	Phase 1	Phase 2	Phase 3
Average daily dispersal distance and range (m) Standard deviation (SD)	200.3 (120-639) SD 171.38	602.4 (120-1890) SD 652.39	1248.3 (785-2055) SD 591.51
Average daily feeder visits and range (fpd) Standard deviation (SD)	6.54 (3.11-10.54) SD 2.05	2.52 (0-7.56) SD 3.16	0

The supplementary fed group (May 09) displayed a significant difference in average daily feeder visits between phase 1 and phase 2 (Wilcoxon's test; z = -2.547, p = 0.011), and between average daily feeder visits between phase 2 and phase 3 ($z = -2.201$, $p = 0.028$). A significant difference was also seen in average daily dispersal distances between phase 1 and phase 2 ($z = -2.197$, $p = 0.028$), and between average daily dispersal distances between phase 2 and phase 3 ($z = -2.073$, $p = 0.038$). This suggests that as availability of feed was reduced average daily dispersal distances increased.

2.4.2 Comparison of dispersal distances of the Tawharanui un-fed groups Feb 08 and Feb 09, with the May 09 fed group.

Fig 6 shows a difference in dispersal distances between all three Tawharanui groups at each phase. The individuals introduced in Feb 08 had the greatest dispersal distance across each time phase, followed by those released in Feb 09. The shortest dispersal distances were recorded for the individuals in the May 09 supplementary fed group. Table 4 shows the raw data supporting Fig 6.

Wilcoxon signed ranks tests were run to look for differences is the distances dispersed between the fed and un-fed groups of birds in each phase. It was found that there was a significant difference in distances dispersed between the May 09 fed group and the Feb 08 un-fed group in phase 1 ($z = -2.666$, $p = <0.05$) but not in phases 2 or 3 ($z = -1.007$, $p = 0.314$; $z = -1.680$, $p = 0.093$). A significant difference in distances dispersed was also found between the May 09 fed group and the Feb 09 un-fed group in both phases 1 and 2 ($z = -2.192$, $p = <0.05$; $z = -2.521$, $p = <0.05$) but not in phase 3 ($z = -0.338$, $p = 0.735$).

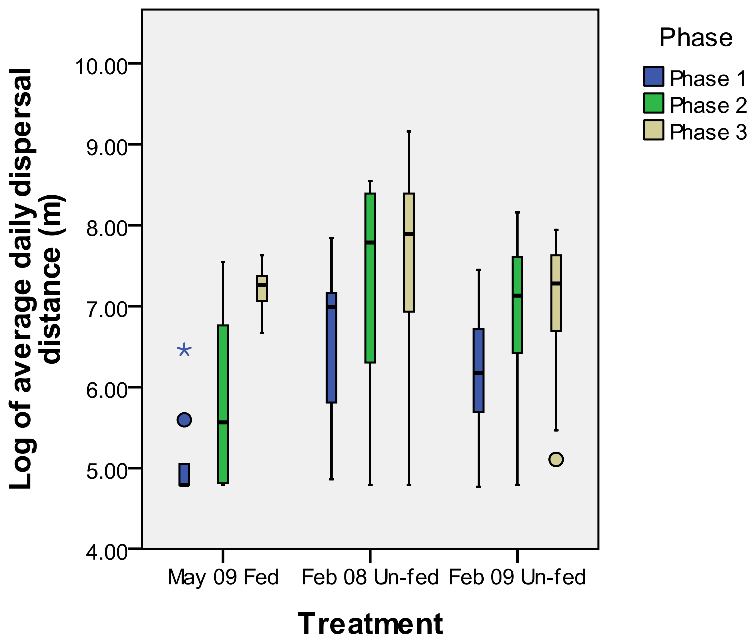

Fig 6. Box-plot showing comparisons of log of average daily dispersal distance (m) across the three monitoring phases for three Tawharanui groups; fed group May 09, un-fed group Feb 08, and un-fed group Feb 09.

Table 4. Comparison of average daily dispersal distance (m), the range of dispersal distances (m) and standard deviation (SD) across the three monitoring phases for each of the three Tawharanui release groups; May 09 fed, Feb 08 and Feb 09 un-fed.

Cohorts		Phase 1	Phase 2	Phase 3
May 09 Fed	Average daily dispersal distance and range (m)	200.3 (120-639)	602.4 (120-1890)	1248.3 (785-2055)
	Standard deviation (SD)	SD 171.38	SD 652.39	SD 591.51
Feb 08 Un-fed	Average daily dispersal distance and range (m)	960.5 (139-2548)	1716 (120-5150)	2370 (120-9500)
	Standard deviation (SD)	SD 644.5	SD 1852	SD 2428
Feb 09 Un-fed	Average daily dispersal distance and range (m)	612.6 (118-1723)	1286 (120-3494)	1358 (165-2825)
	Standard deviation (SD)	SD 368.4	SD 834.6	SD 824.2

The un-fed groups (Feb 08 and 09) differed significantly in average daily dispersal distances between phases one and two (Wilcoxon tests; Feb 08; $z = -3.103$, $p < 0.01$: Feb 09; $z = -5.016$, $p < 0.001$) compared with the fed group (May 09). Between phases two and three however no significant difference was evident between the dispersal distances of the un-fed and fed groups (Feb 08; $z = -0.848$, $p = 0.396$: Feb 09; $z = -0.552$, $p = 0.581$). This suggests that the provision of supplementary food may hold the released birds to the site for longer.

2.4.3 Comparison of dispersal distances and feeder use between males and females.

At Tawharanui males dispersed overall significantly further than females amongst the un-fed Feb 08 and Feb 09 groups (Mann Whitney tests; Feb08; $U = 29$, $z = -2.401$, $p < 0.05$: Feb09; $U = 106$, $z = -2.020$, $p < 0.05$). However in the supplementary fed group (May 09) no significant difference between the sexes for either average daily distance dispersed ($U = 9$, $z = -0.905$, $p = 0.905$) or the average number of daily feeder visits ($U = 6$, $z = -0.980$, $p = 0.413$) was found (Fig 7 & 8).

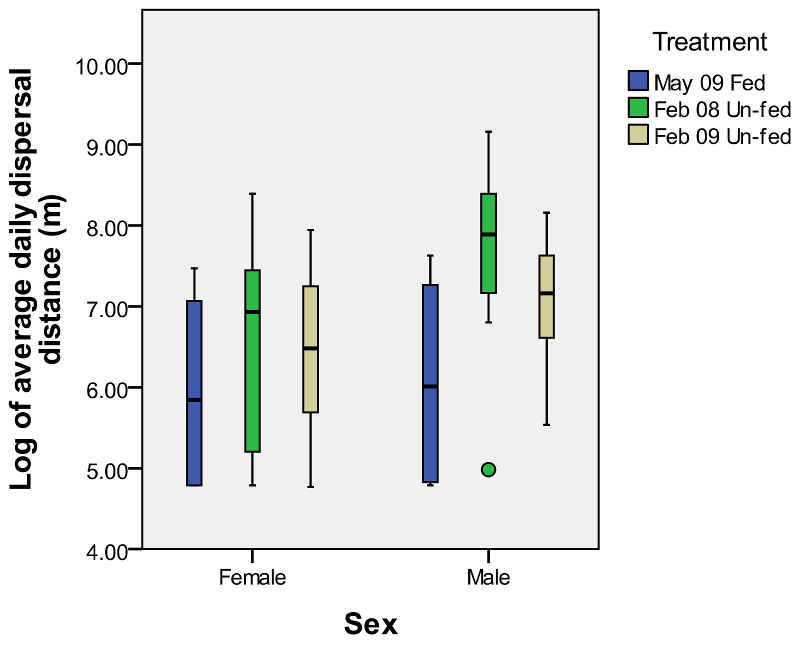

Fig 7. Comparison between sexes for log of average daily distance dispersed (m), across the three Tawharanui release groups.

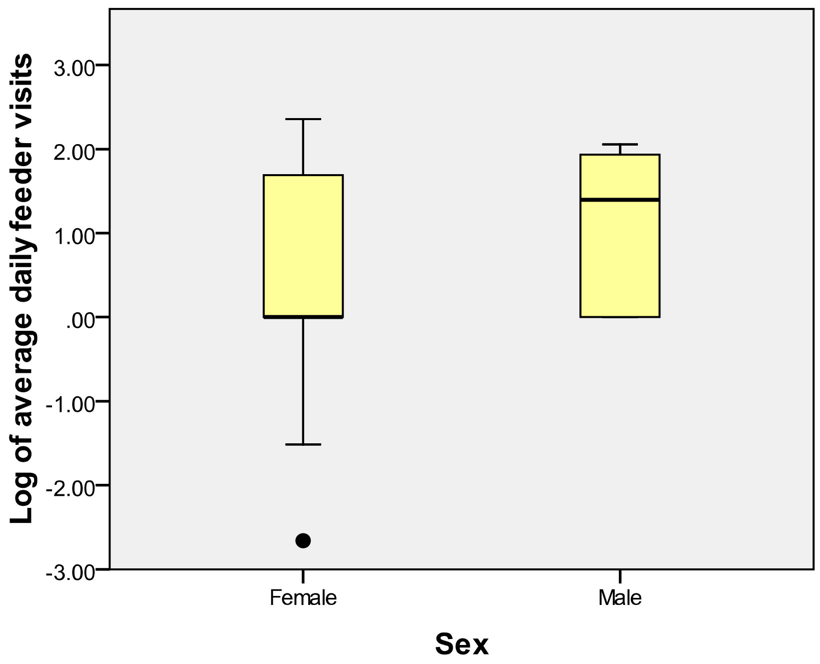

Fig 8. Comparison between sexes for the log of average daily feeder visits (feeds per day - fpd) across the three Tawharanui release groups.

2.4.4 Survivorship and condition of supplementary-fed pateke

Table 5 shows the results of the Mayfield method (Robertson & Westbrooke, 2005) used to analyse the radio-telemetry data. This provides a mortality rate, survival rate at six months post-release, and an estimated annual survival rate for each Tawharanui study group.

Table 5. Mortality, survival and estimated annual survivorship rates at six months post release, calculated using the Mayfield Method (Robertson & Westbrooke, 2005).

Cohort	Mortality rate (birds per year)	Survival Rate at 6mths post-release	Estimated annual survival rate (birds per year)
Tawharanui Feb 08	0.23	0.76	0.35
Tawharanui Feb 09	0.45	0.55	0.09
Tawharanui May 09	0.11	0.89	0.62

A Kaplan-Meier analysis was run to compare survivorship data recorded from daily telemetry fixes. Figure 9 shows a comparison of survival (figures were logged) for all three Tawharanui release groups across the first six months post release. This graph shows the group released with access to supplementary food, May 09 (red), to have a higher rate of survival within the first six months post release than the unfed groups, Feb 08 (blue) and Feb 09 (green). A series of deaths, many due to starvation (Table 7) (Alley, Gartrell, Morgan, Lenting, & Argilla, 2009), cause the steep decline in survivorship seen in the Feb 09 group (green). At three months post-release the statistical difference in survivorship between the three groups is near significant (Mantel-Haenszel test; $\chi^2 = 5.056$, $p = 0.08$). However at six months post-release there is no significant difference between the three groups detected

(Mantel-Haenszel test; $\chi^2 = 4.524$, $p = 0.104$).This suggests that provision if supplementary food may increase survivorship in the short term, however as in any natural uncontrolled environment there are many different factors influencing survival.

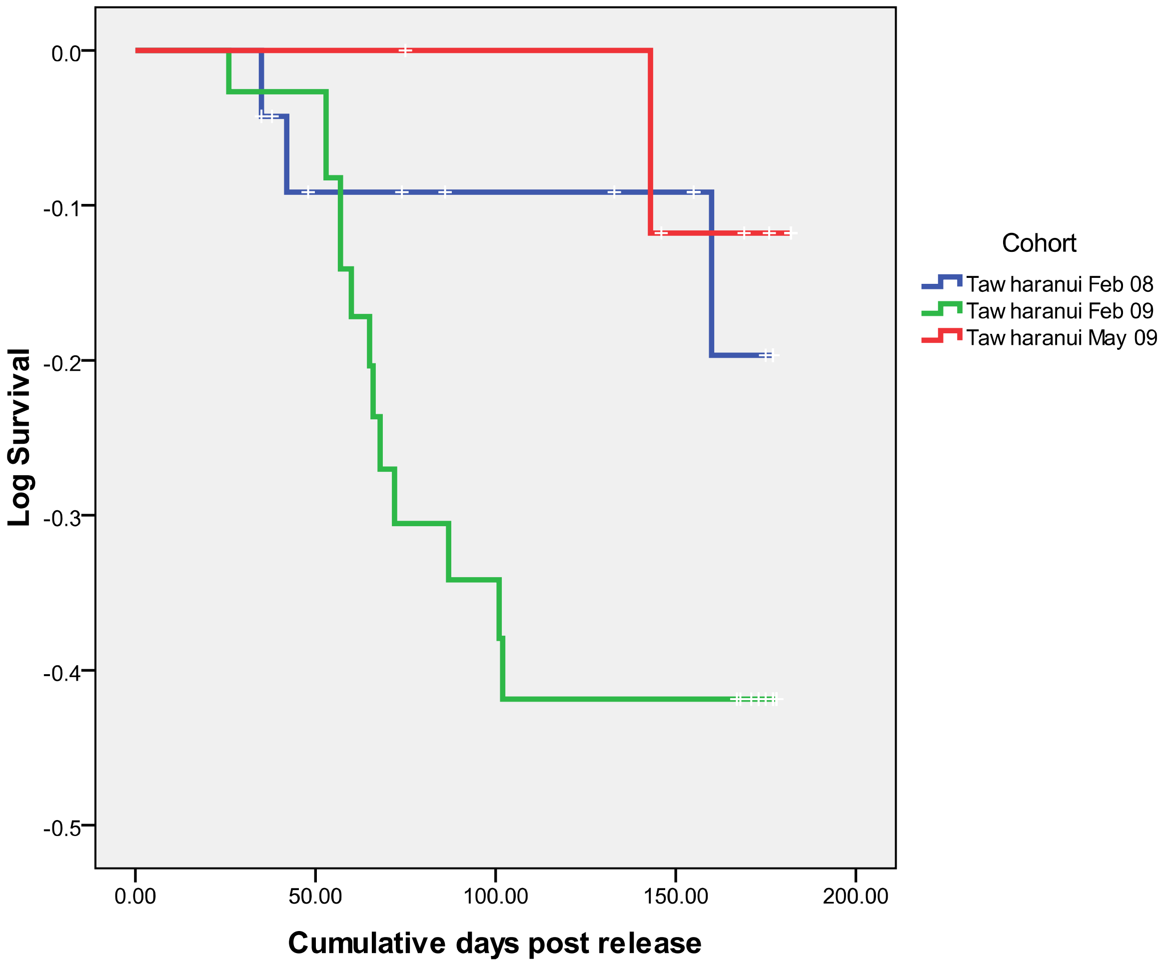

Fig 9. Comparison of log of survival for each of the three Tawharanui release groups studied.

Due to difficulties in recapturing pateke only four Tawharanui birds were caught and weighed post-release. These four birds had all increased in body weight (Table 6). The sample size however was too small to produce any conclusive results.

Table 6. Difference in weights and feeder use of pateke recaptured up to 3 months post-release

Location	Bird ID	Sex	Pre-release weight (g)	Re-capture weight (g)	% Body weight change	Mean # feeder visits per day
Tawharanui	14 / S88554	M	669	730	+ 9.1	7.3
Tawharanui	34 /S88556	F	566	600	+ 6	6.5
Tawharanui	62 / S88192	M	551	600	+ 8.9	10.4
Tawharanui	S88552	M	657	680	+ 3.5	14.4

All pateke carcasses retrieved were sent to Massey University's necropsy laboratory for analysis of cause of death. Where starvation was suspected a wing-fat analysis was undertaken using an ulna bone where available (Moore & Battley, 2003). Table 7 shows a comparison of the causes of death for pateke at each of the three releases. Starvation was seen as a cause of death only in birds which were not being given supplementary feed (n=1/5 in Tawh Feb 08, and n=6/11 in Tawh Feb 09). The death classified as 'other' was a bird killed by anticoagulant toxicity (suspected a pindone bait laid for rabbit control) (Alley, et al., 2009).

Table 7. Comparison of known causes of death for pateke at three Tawharanui releases

Causes of death (COD)	Tawharanui Feb 2008 (n = 5)	Tawharanui Feb 2009 (n = 11)	Tawharanui May 2009 (n = 1)
Predation; mammalian / unknown			
Avian predation and/or scavenge	1 (20%)	4 (36%)	
Starvation	1 (20%)	6 (55%)	
Road kill			
Unknown COD	2 (40%)		1 (100%)
Disease			
Trauma	1 (20%)		
Other		1 (9%)	

(Alley, et al., 2009)

2.5 Discussion

2.5.1 Relationship between supplementary feeder use and dispersal

Supplementary feeder stations have been used with anecdotal success in anchoring pateke to a desired management site at Moehau in the Coromandel (Caldwell, 2005, 2006, 2007). Other bird species, including the west Indian whistling duck (*Dendrocygna arborea*) (O'Brien, 1995; Staus, 1998) and trumpeter swans (Monnie, 1966) have formed breeding populations around sites where they are, or have previously been, supplementary fed. Supplementary feeding is a standard requirement for all current releases of captive-bred pateke with the aim of anchoring the birds to the release site, which is usually a predator controlled area. It is assumed that supplementary feeding will increase the chance of released individuals forming a stable and self-sustaining breeding population (Moore, 2003; O'Connor, et al., 2007; Pierce, et al., 2002).

The hypothesis that the use of supplementary feeders would result in reduced dispersal distances and thus increased residency at a chosen release site was found to hold true in the cases investigated during this research. However there are several factors discussed below that may confound results and which may influence any attempts to use supplementary food to anchor pateke to a desired release site.

Results derived from a combination of feeder use data collected by data-loggers, and regular telemetry monitoring at Tawharanui, showed a strong relationship between feeder use and dispersal. A strong negative correlation was seen whereby as feeder use declined, partially due to a change in availability, the average daily dispersal distance pateke travelled from the feeders and release site increased. This suggests that availability of supplementary feed may have had a strong influence on the dispersal of the supplementary fed Tawharanui birds.

In contrast, the two release groups which did not receive supplementary food, Feb 08 and Feb 09, showed significant differences in the rate of dispersal between phase one and two, but not between phases two and three. Individuals in these two groups moved away from the release area within the first time phase, whereas most of the supplementary fed birds (May 09) did not move away from the release site until the third phase, when supplementary food was no longer available. This suggests that availability of supplementary feed may lengthen the time released pateke remain at the release site, supporting the reported anecdotal success in using supplementary feeders to anchor pateke elsewhere (Caldwell, 2005, 2006, 2007). In addition, both the fed May 09 group and the un-fed Feb 09 release group showed shorter overall dispersal distances than the Feb 08 group. A significant difference in dispersal distances was found between the May 09 fed group and the un-fed Feb 08 group in phase one. When May 09 and Feb 09 were compared a significant difference was found in dispersal distances in both phase one and phase two. This again suggests that supplementary food may hold the birds to the release site for longer, but also suggests that conspecific presence may play a role in anchoring pateke to a release site.

It would be difficult to test how much influence conspecifics may have in anchoring pateke to a particular site due to numerous confounding factors, particularly the differences between sites such as resource availability and competition for resources. However experiments to attract ducks for hunting as sport demonstrate that numerous dabbling duck species show a strong attraction to artificial decoys and use the visual cue of conspecifics as an indicator of useful habitat (Ackerman, et al., 2006; C. A. Miller, 2002; Szymanski, 2004). Several other bird species have also been proven to be attracted to a site by either artificial decoys, such as fairy terns (*Sterna nereis*) (Jeffries & Brunton, 2001), or live decoys, as with kokako

(*Callaeas cinerea*) (Molles, et al., 2008). This theory is therefore worthy of further investigation.

There are several other factors which could not be controlled for that may have caused confounding effects in this study. Food is known to be a resource which plays a primary role in habitat selection and home range size of individuals (Boutin, 1990). What was not known in this study was the abundance and quality of food resources in the surrounding area, which may have been of either higher or lower value than the supplementary feed provided and which thus may have influenced the dispersal of individuals. The supplementary fed group (May 09) was released during late autumn, with the six months post-release monitoring occurring predominantly over winter and early spring. It is presumed that during winter and spring natural food resources are more plentiful and easily accessible. This is in contrast to the two un-fed groups (Feb 08 and Feb 09) which were released in late summer, with the six months post-release monitoring occurring predominantly over late summer and spring. These drier months in the early period post-release may have resulted in natural food being both less available and harder to access. This difference in release times may have indirectly caused a difference in dispersal, as well as in survivorship and condition of the three release groups.

Other aspects of habitat quality were not investigated, such as availability of territories, suitable breeding sites, availability of potential mates, or the influence of conspecifics, competitors or predators. Anecdotal evidence suggests that at one point there was competition for access to the supplementary feeder stations from pukeko (*Porphyrio porphyrio melanotus*) (Haliday, 2010; Stanes, 2010). All of these factors have the potential to influence habitat selection but could not be controlled for, and it is unknown how much they influenced the dispersal of the reintroduced pateke.

Dispersal of young from their natal group typically occurs at a certain time of year, developmental or life-stage, and to reduce possible dispersal due to 'natal habitat preference induction' (NHPI), Stamps and Swaisgood (2007) recommend releases be at the same time of year, developmental or life-stage as its wild counterpart would disperse. As previously discussed, captive-bred pateke are normally released in February and May each year when juveniles from first and second clutches reach an age suitable for release. In the wild, pateke flock together between January and March to create or strengthen pair bonds before moving to a breeding territory around April or May, with breeding anytime between May and October (O'Connor, et al., 2007). Therefore the time of release may have an effect on the behaviour of released pateke, and the behaviour of any resident pateke to the new arrivals. Stamp and Swaisgood's (2007) research would suggest therefore that the best time to release pateke would be at the time of natural flocking, January – March. This is worthy of further investigation.

It may also be useful to test whether keeping food available for released pateke over the period of first breeding season improves rates of residency and breeding success. Once a pair bond has formed and a territory chosen, the pair (particularly the female) will likely continue to return to that same territory to breed each year (Hogarth, 2010; O'Connor, et al., 2007). If managers can manipulate the birds to choose a territory within the protected area in which to breed in their first year by providing supplementary food nearby, the likelihood of a stable breeding population being formed may be increased (Brightsmith, et al., 2005; Monnie, 1966; Staus, 1998).

As previously discussed, there is the possibility that the presence of conspecifics may affect residency by acting as an anchor to the site. This is a factor which could not be controlled for in this study and which warrants further investigation. It could be that a combination of supplementary food and conspecific presence increases likelihood of residency. If this is the case, then it may be advisable for managers to provide food for a longer period for the initial group released to a site, which has no conspecifics to anchor them, and also possibly experimenting with decoys to anchor the birds in the first release at new sites.

In conclusion, the combination of two monitoring techniques; individuals' use of supplementary feeders, monitored via PIT tags and data-loggers, and regular radio tracking to monitor dispersal, provided evidence that pateke with access to supplementary food may stay in the released area for longer than those which receive no supplementary food. Con-specific presence may also influence pateke to remain in a release area. From a management perspective these results support the provision of supplementary feed at release sites, and suggest that the longer feed is provided for, and allowing pateke to wean themselves off the feed, the less dispersal. First releases of pateke to a new site where there are no other pateke to attract them to stay may benefit from providing supplementary food for longer that subsequent top-up releases.

2.5.2 Sex differences in feeder use and dispersal distances

Natal dispersal of birds tends to be female biased, as opposed to male biased in mammals (Greenwood, 1980; Iverson, Esler, & Rizzolo, 2004; Wolff & Plissner, 1998). This is due to many bird species having resource-defence mating systems, the resource-defending sex (often the male bird) remains philopatric, while the other sex disperses (Wolff & Plissner, 1998). In waterfowl however, pairing often occurs at flock sites during migration, and at traditional localised flocking sites, as in the case of pateke, therefore in waterfowl the female often returns to the natal site and is philopatric, taking the male with her. All seven Anatidae species, including pateke, have been shown to exhibit female philopatry and male dispersal (Baldassarre & Bolen, 2006; A. Clarke, Saether, & Roskaft, 1997; Hogarth, 2010).

At Tawharanui, of the initial reintroduction in Feb 08, the majority of individuals that dispersed long distances were males (Rickett, 2008). I investigated this further as male-biased dispersal and female philopatry is likely to skew the numbers in resident released groups of pateke, which may have a negative effect on breeding success and thus the overall success of the reintroduction long-term.

At Tahwaranui comparisons of dispersal in relation to sex showed significant differences in the distances dispersed between sexes for both the un-fed groups (Feb 08 and Feb 09), with males dispersing further than females (Fig 7). Birds in the supplementary fed group (May 09) however showed no significant difference between sexes in dispersal distances or feeder use. This suggests that supplementary feeding may be holding males in particular closer to the release site for longer.

2.5.3 Is survivorship increased and condition improved by supplementary feeding?

Duck species in general are reported to have a high rate of mortality post-release which may be mitigated by supplementary feeding (Moore, 2003; Moore & Battley, 2006). Numerous studies of other bird species (Liukkonen-Anttila, Putaala, & Hissa, 1999; Putaala & Hissa, 1993) also support the hypothesis that supplementary feeding can result in an increase in survival rate. A 21 year study of barn owls (*Tyto alba*) in Britain found consistently that birds which left the release site immediately had a lower likely survival rate within the first month compared with birds which remained in the release area and took advantage of supplementary feeding (Meek, et al., 2003). Research by Brightsmith et al (2005) suggested that increased survival of captive-bred scarlet macaws (*Ara macao*) was related to ongoing supplemental feeding. This also encouraged the birds to become anchored to the release site and to encourage social interactions around feeding sites, which increased their chances of forming a stable population. This however, is not always the case; Armstrong et al. (1999) found no evidence that supplementary food provided to translocated hihi (*Notiomystis cincta*) reduced mortality, however it did increase their reproductive output.

The results of this study suggest that supplementary feeding may play a role in increasing survivorship, however it is unclear to what extent due to the effects of factors which could not be controlled for in this study. The Tawharanui release group receiving supplementary food (May 09) had a lower mortality rate, higher survival over the six months post-releases, and higher estimated annual survivorship than the two release groups which did not receive supplementary food (Feb 08 and Feb 09) (Table 5). A Kaplan-Meier analysis (Fig 9) showed that the supplementary fed group had a higher survival rate than the un-fed Feb 08 group, and a marked difference to the un-fed Feb 09 group. However the Feb 09 release suffered from a high number of deaths after three months post-release, many of which were attributed to starvation or harrier involvement (Alley, et al., 2009). Mantel-Haenszel tests showed that at three months post release the difference between the three releases was not quite statistically significant at the 95% confidence level ($\chi^2 = 5.056$, $p = 0.08$), however it does suggest a very strong trend, and a larger sample size from repetitions of this study, or values of survivorship at one year post-release, may well give a statistically significant result.

A comparison of the causes of death of radio-tagged pateke from each of the three releases showed that starvation was a cause of death only in birds which did not have access to supplementary food; 20% (n=1) of known deaths at Tawharanui in 2008, and 55% (n=6) of known deaths at Tawharanui from the Feb 2009 release. This suggests that although overall it could not be statistically proven in this study that supplementary feeding increased survivorship, supplementary feed may play a key role in reducing starvation. However, differences in natural food availability, particularly in response to the time of year at which the releases were made, are unknown and may be confounding factors in these results.

Attempts were made to measure the condition of pateke released in May 2009, as measured by change in body weight, at approximately three months post-release. However the birds were difficult to recapture, so insufficient data was collected. What was found was that the Tawharanui May 09 supplementary fed group had gained body weight since release.

These results generally suggest that providing supplementary food may reduce the chances of starvation in pateke post-release, and this should be further investigated with care taken to reduce confounding factors, such as differences in abundance of natural foods and time of year, in future pateke releases.

2.5.4 Conclusions

In conclusion, this study found that supplementary feeding lengthened the time newly-released pateke remained at the release site, and reduced the overall dispersal distance of individuals. Supplementary feeding also reduced male dispersal, which in turn should increase breeding success due to a better sex ratio within the managed release area. Supplementary food may also have positively influenced survivorship by lowering mortality and decreasing the chances of starvation during the immediate post-release period at Tawharanui. There are other factors, as discussed above, which were uncontrollable in this study, and which may have influenced the results. It is therefore recommended that further studies attempt to investigate or control for factors such as con-specific presence, seasonality, and availability of wild food sources.

PIT tags and data loggers successfully provided detailed information on feeder use by pateke 24 hours a day with minimal disturbance to the birds. There is potential for further development of PIT tag use for monitoring pateke, such as for flock counting.

Chapter 3

The effects of wing-clipping supplementary fed pateke on dispersal, condition and survivorship

3.1 Introduction

Wing-clipping is widely practised in avian husbandry. It is used to prevent birds from flying out of an area, eg.pet birds, some free ranging farm birds, or birds released onto lakes or ponds in gardens (Highfill, 1998; Willis & Ludlow, 2009).There has been little interest in looking at the impacts of wing-clipping on its recipients. When wing-clipping is used as a technique in the context of holding an endangered species in a desired management area, however, it is critical to undertake research into the welfare of the birds to ensure that there are minimal negative effects on survivorship and reproduction. In pateke wing-clipping can be used as a tool for conservation, as a method of increasing translocation success by limiting post-release dispersal and thus reducing any source-sink effects. Excessive dispersal can make monitoring difficult or impossible, and gauging the success of a translocation is difficult if the fate of released individuals is not known (Molles, et al., 2008).

There is very little published information on pateke home-range and dispersal, with most current information being anecdotal (Browne, 2010). A study by Dumbell (1987) described the Great Barrier Island population of pateke as being discrete to their individual valleys, with very little migration between valleys. At Mimiwhangata a study of flock sites and home-range behaviour found that sub-adult teal dispersed more widely than other age groups, particularly at night. Birds of all ages which regularly used flock sites returned to sites near their natal habitat at night to forage. This showed that pateke display significant site attachment behaviour, some of which may form when they are young (Fraser & Beauchamp, 2009).

Dispersal often results in pateke leaving predator controlled areas, greatly increasing their risk of mortality. This has been seen at both remnant sites such as Mimiwhangata (Fraser & Beauchamp, 2009) and at reintroduction sites such as Tawharanui Regional Park and Cape Kidnappers Wildlife Preserve (Maitland, 2008b; Rickett, 2008; Ward-Smith & McLennan, 2009). Wing-clipping captive-bred sub-adult pateke on release will leave them incapable of anything but a short flight until their first moult. It is assumed that in this time they will become site attached, establish pair bonds and breeding territories which may increase their chances of long-term residency at the reintroduction site and enable a stable breeding population to form.

Wing-clipping to limit dispersal for conservation benefit was first described in the US in the early 1960's (Monnie, 1966). Here trumpeter swans were reintroduced to their former range, wing-clipped, and held in captivity for a period of time in attempts to anchor the birds to the site. In this instance Monnie (1966) considered that wing-clipping to reduce dispersal immediately post-release was instrumental in establishing a breeding population. Monnie (1966) however, found that captive wing-clipped cygnets experienced a much higher rate of avian predation than wild fully-feathered trumpeter swans. Avian predation is a significant cause of mortality for pateke (Williams & Dumbell, 1996).

In another study of wing-clipping to reduce dispersal for conservation purposes Combreau & Smith (1998) found wing-clipping resulted in significant predation. In three treatments on Houbara bustards (*Chlamydotis undulata*), fully-feathered adults, wing-clipped adults, and fully-feathered chicks, it was found that wing-clipped adults suffered the highest predation and lowest success of the three groups (Combreau & Smith, 1998).

A third study by Rosvall (2009) experimentally wing-clipped male songbirds to investigate the effects of lowered male provisioning during breeding. The result was higher nestling mortality. The effects of wing-clipping on breeding success and provisioning have not been researched in detail in pateke, as they are predominantly ground-nesting and have precocial young, such negative effects as found by Rosvall would not be expected.

This study trials wing-clipping as a post-release management tool for retaining released pateke in chosen managed areas in the hope that they become site attached and form a sustainable breeding populations at those sites. In this study I also assessed whether wing-clipping in pateke resulted in an increased risk of mortality.

3.2 Aims and objectives

The aims of this part of the study were to;

1. Investigate the effectiveness of wing-clipping and supplementary feeding as techniques to increase residency of translocated pateke in a target area:

It is hypothesised that wing-clipped birds will have shorter dispersal distances compared with fully-feathered birds and therefore a higher rate of residency at release sites than fully-feathered birds. It is hypothesised that a greater use of supplementary feeders will result in lower dispersal and increased residency at the release site.

2. Investigate whether wing-clipping has any adverse effects on the birds receiving the treatment:

It is hypothesised that wing-clipped pateke will experience higher mortality and a lower physical condition compared with fully-feathered pateke.

3.3 Methods

3.3.1 Study site: Cape Kidnappers and Ocean Beach Wildlife Preserve, Napier

The Cape Kidnappers Sanctuary is situated on private land on Cape Kidnappers Peninsula in Hawkes Bay, approximately 20 km south of Napier. It includes the Ocean Beach dune system to the south. In 2007, the landowners built a 9.6 km predator-proof fence across the base of the peninsula, from coast to coast, isolating an area of over 2200ha. Two years of intensive pest control has resulted in pest species being held at very low levels, suitable for the reintroduction of endangered and threatened natives (Ward-Smith & McLennan, 2009). The fence had a couple of ‘leaky’ spots at the time of my research due to the gate not being in place and koru ends (a spiral in which pests become trapped or are turned back along the outside of the fence) (Plate 5). There was an intensive trapping network both throughout the interior of the sanctuary, and radiating out c.500 m around the ends of the fence-line, and along the edges of the four km access road into the sanctuary. Approximately 1200 mustelid traps (average of 1 trap per 1.8 ha) and 100 kill traps for cats were in operation within the 2200 ha protected area (Ward-Smith & McLennan, 2009).

Plate 5. 'Koru' shaped ends of Xcluder predator proof fence used at both Tawharanui and Cape Kidnapper's (Xcluder Pest Proof Fencing Ltd, 2010).

In the two years after February 2007, 278 cats, 12 ferrets, 21 stoats and 44 weasels were caught within the Sanctuary. No ferrets were trapped or tracked inside after August 2007. Forested blocks had a 50 x 100 m bait station network for rodent control. Tracking tunnel rates for rats were reduced in these areas from 29% in December 2006 to 1% in September 2008, and bimonthly monitoring from July 2007 to February 2009, shows that rodent indices did not exceed a 7% tracking rate (Ward-Smith & McLennan, 2009).

The peninsula and coastal wetland dune areas of the Sanctuary are within the natural range of pateke. Numerous sub-fossil pateke bones have been found in the dune system at Ocean Beach and anecdotal reports also suggest pateke were formerly prolific in wetland areas of Hawke's Bay (Ward-Smith & McLennan, 2009).

The Sanctuary contains a variety of habitat types suitable for pateke including pastures (predominantly sheep farming with some beef cattle) with an extensive cover of clover, native regenerating scrub and forest, exotic pines, extensive coastal habitat which is wet except for a month during the peak of summer, and a small stream harbouring numerous snails, boatman and bullies. The site also has two large ponds, both sufficiently large to sustain a flock of 50-80 birds, and numerous smaller ponds and dams suitable for breeding pairs. The Sanctuary also includes an international golf course which is lush year round, and which contains two well vegetated dams. Additional planting has been made around some stock dams to provide increased cover for pateke (Ward-Smith & McLennan, 2009).

In 2008 a first release of thirty pateke was made at Cape Kidnappers. The release site in 2008 was Double Dams, an area comprising of two large dams, flanked on one side with dense manuka and kanuka scrub, and on the other by forested gullies and paddocks. To the north and south of the dam damp boggy gullies extend approximately a kilometre in each direction.

The 2009 pateke release sites comprised of the original 2008 release site, Double Dams, and three other dams; the Large Cape Dam, the Small Cape Dam and Road Swamp (Fig 10). The Large Cape Dam is the second largest water body within the reserve after the Double Dams, and is surrounded by dense raupo and pine trees. This site was also home to dabchick (*Tachybaptus ruficollis*), a single black swan (*Cygnus atratus*), and the only known pair of pukeko (*Porphyrio porphyrio melanotus*) within the sanctuary. Up to six Australasian harriers (*Circus approximans*) were seen in the vicinity of this dam.

The Small Cape Dam is located c.300m from the Large Cape Dam. This dam is smaller, shallower, and a lot more open than the Large Cape Dam. The area around the dam had been replanted in the past 2-3 years, and there was dense kikuyu grass (*Pennisetum clandestinum)* and small shrubs along with some raupo along the banks. This dam was fenced off from stock.

The Road Swamp is a medium sized dam alongside the main access road to the workshops. There are three gullies feeding from it, which all provide long grass, seeps and streams and boggy areas amongst manuka scrub.

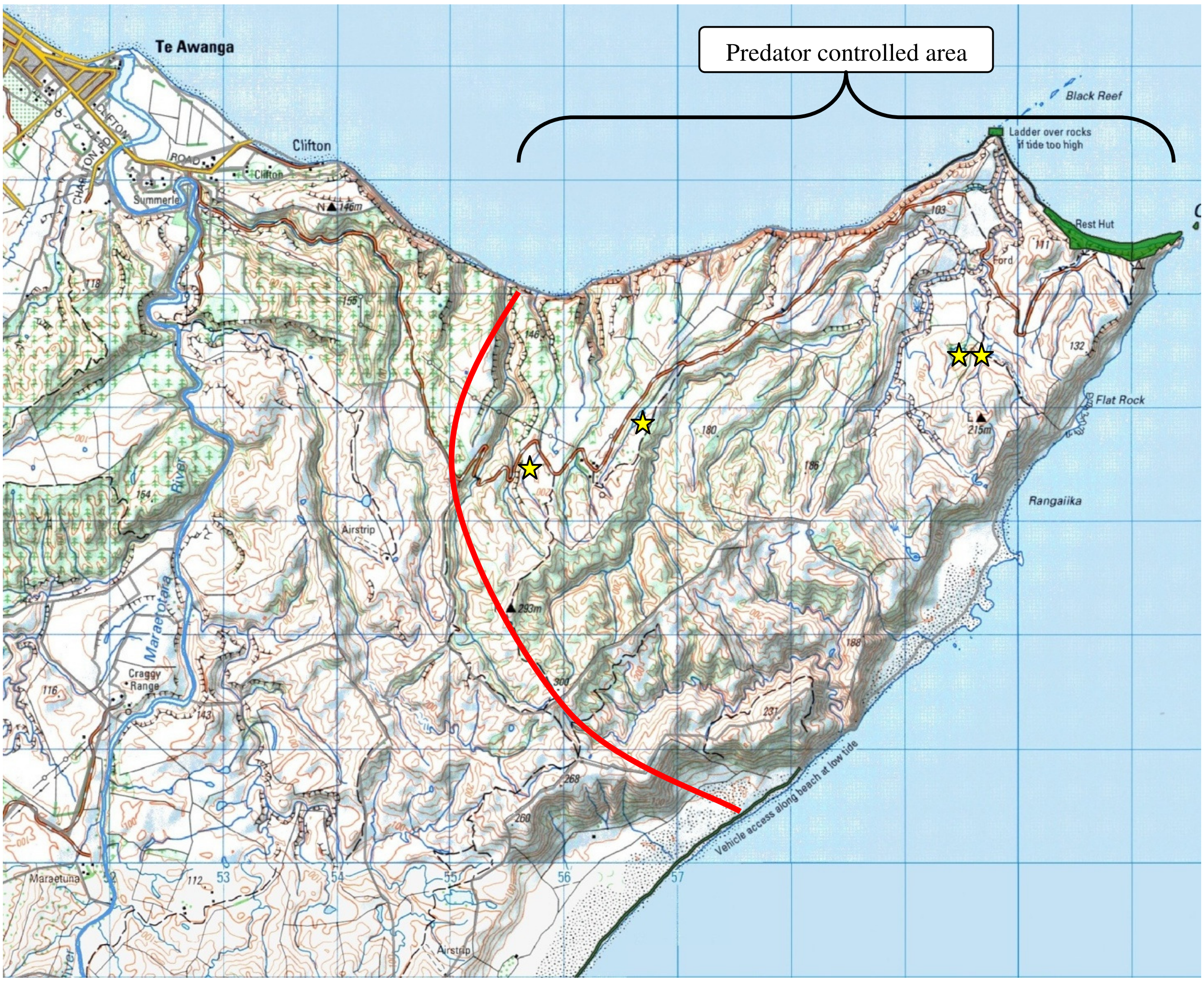

Fig 10. Map of Cape Kidnappers Wildlife Preserve, showing release sites (yellow stars), predator controlled area, and approximate location of fenceline (red line).

In May 2009 a second group of captive-bred pateke was released at Cape Kidnappers Wildlife Preserve as part of a three year plan to reintroduce pateke to the Hawkes Bay, an area of their former range. Fifty-eight pateke were released on May 15th 2009, of which 40 carried radio-transmitters and PIT tags. Of these 40, 20 of an equal male-female sex ratio were also wing-clipped to test whether wing-clipping may be a suitable post-release management tool for retaining released birds in a managed area (Table 8).

Table 8. Summary of pateke released at four sites at Cape Kidnapper's in May 2009

Cape Kidnapper's Preserve	Number of fully-feathered birds* Male/Female	Number of wing-clipped birds* Male/Female	# non-transmittered birds released	Total # birds at each site
Double Dam	1 / 4	4 / 1	9	19
Road Swamp	4 / 1	1 / 4	0	10
Small Cape Dam	3 / 2	2 / 3	0	10
Large Cape Dam	2 / 3	5 / 0	9	19
Total s:	20*	20*	18	**58**

*These 40 birds all carrying radio-transmitters and PIT tags

One supplementary feeder station was provided at each of the four release sites (3.3.5, pg74) providing freely available food for the entire duration of the feeder use study, which was ninety-one days. The feeder stations were placed on the banks of the dams, however due to regular fluctuations in water level after heavy rainfall these feeders were sometimes over shallow water. The first 46 days after release are referred to as phase 1. The period from day 47-73 are referred to as phase 2, and the period from day 74-91 are referred to as phase 3.

3.3.2 Wing-clipping

The left wing of twenty pateke was clipped to shorten all primaries and the first two secondaries (Plate 6). This was designed to render birds incapable of anything more than a very short flight until their first moult.

Plate 6. Wing-clipping a male pateke (Photo: J.Rickett)

3.3.3 Pre-release training

All captive-bred juveniles/sub-adults to be translocated were transferred to Peacock Springs in Christchurch for a six week disease screening and hardening-off period before release. This included being mixed with the other pateke they were to be released with, and being introduced to more wild type foods along with the supplementary feeder stations they would be provided with upon release. This was done to encourage natural foraging and to decrease the negative effects of the digestive morphology change, which can lead to starvation during early release (Moore, 2003; Moore & Battley, 2006).

3.3.4 Monitoring dispersal distances of pateke using radio-telemetry

Sirtrack '12 month two-way' transmitters with a 'time since death' function were used, attached by a backpack harness with a built-in linen thread weak-link. The transmitters were set at 40 pulses per minute, with a mortality mode of 80 pulses per minute (Plate 1).

Telemetry monitoring was undertaken approximately five days a week for the first three months post-release, which allowed dispersal distance over time to be measured. Telemetry monitoring attempted to pinpoint each individual's daytime roost which was then recorded. If a bird was not found at a roost near the release site or its last known site a wider search was made to locate its new position. Locations of roosts were recorded by GPS (See 3.3.7, pg75, for details of calculation of dispersal distances).

3.3.5 Monitoring feeder use of pateke using PIT tags

PIT tags used were Allflex brand, 11mm x 2mm, inserted subcutaneously into the fatty tissue in the base of the neck (Plate 2) as per the Department of Conservation's Standard Operating Procedure for PIT insertion (G. Taylor, 2008). Animal ethics permit number 09/42 (Appendix 1) was granted by the Massey University animal ethics committee (MUAEC) for insertion of PIT tags under DOC permit ECHB-25413-RES for Cape Kidnappers (Appendix 6).

Feeder use was monitored using data-loggers, as previously described in 2.3.4 (pg37). One supplementary feeder station was provided at each of the four Cape Kidnapper's release sites providing ad-lib food for the entire duration of the feeder use study, which was ninety-one days. The feeder stations were placed on the banks of the dams, however due to regular fluctuations in water level after heavy rain these feeders were sometimes over shallow water.

3.3.6 Monitoring weight as an indicator of condition

Six to nine weeks after release I attempted to recapture as many of the released pateke as possible to weigh them. I placed captured birds in cotton bags and weighed them using a 1kg spring-balance. I then calculated the percentage weight change from each individual's weight taken at Peacock Springs by DOC before release, and their re-capture weight. Weight changes could then be compared with records of each bird's use of the supplementary feeders, and between wing-clipped and fully-feathered pateke. Other measurements of body condition such as presence or absence of parasites, body fat indexing or for example wing or tarsus measurements, were not used as no pre-release data other than weight had been recorded in which to compare to. I re-captured some birds at night, when they were at their most active, by spot-lighting and hand-netting. Other birds were re-captured during the day using clap-traps baited with feed pellets.

3.3.7 Calculation of daily dispersal distances, feeder usage and survivorship

3.3.7.1 Daily dispersal distance

Dispersal distance was calculated by measuring the distance from the feeder at the individuals release site to that individual's day-time roost, as determined by radio-telemetry fixes. All measurements within a phase (Phase 1; days 1-46 after release, phase 2; days 47-73 after release, and phase 3; days 74-91 after release) for each individual were then added together and the total divided by the number of days within that phase that the bird was located (or, if it died, the number of days it was located up until it died). This gave a mean daily dispersal distance that the individual had moved from the feeder within that phase (See Appendix 4 for an example of this calculation). Therefore for each bird there are three average daily dispersal distances, one for each of the three time phases.

3.3.7.2 Daily feeder usage

Daily feeder use was calculated by dividing the total number of feeder visits within a phase by the number of days within that phase (Phase 1, 46 days; phase 2, 27 days; phase 3, 18 days; or, if the bird died, the number of days in the phase up until it died). This gave a figure of mean daily feeder usage for each phase for each individual bird (See Appendix 5 for an example of this calculation).

3.3.7.3 Survivorship

Survivorship was calculated following Robertson and Westbrooke (2005).

3.3.8 Statistical methodology

All statistical tests were conducted using SPSS version 17.0 (SPSS, 2009). Data was assessed for normality to establish whether parametric or non-parametric tests where appropriate. Hypotheses were tested at a 5% level of significance.

Data was logged for graphs in order to avoid large outliers skewing the appearance of the graphs.

Due to the failure of one data-logger, feeder use could not be analysed for birds released at the Double Dams. Therefore the following tests are run using a total of 30 released birds at three Cape Kidnappers sites; the Small Cape Dam, the Large Cape Dam and the Road Swamp.

3.3.8.1 Effect of wing-clipping on distances dispersed and feeder usage

The three Cape Kidnappers release sites were first analysed separately to see if there were any significant differences in the patterns of dispersal or feeder visits between sites across the three monitoring phases. The data was also split to compare wing-clipped and fully-feathered birds separately. Friedmans tests were run to look for differences between the three Cape Kidnappers release sites between the three monitoring phases, then Wilcoxon signed-ranks tests were run to look for differences between the phases; ie.phase 1 and 2, and phases 2 and 3 for each release site. It was possible to pool the data to increase the sample size for further statistical analysis.

The pooled data was again split to compare wing-clipped with fully-feathered pateke. Mean daily feeder visits and mean daily dispersal distance was graphed to compare between monitoring phases, and Friedman's tests run to look for differences between the three phases. Spearman's rank tests were then run to look for correlations between daily feeder visits and daily dispersal distances. Wilcoxon signed-ranks tests were also run using the pooled data from all three of the Cape Kidnappers release sites to look for differences in mean daily feeder visits and mean daily dispersal distances between phases; ie. between phase 1 and 2, and between phases 2 and 3. The effect of wing-clipping on dispersal distances and feeder use was then investigated by comparing both the average daily feeder use and average daily dispersal distances between wing-clipped and fully-feathered birds for each separate phase (phase 1, phase 2, and phase 3) using Mann Whitney tests.

3.3.8.2 Survival and mortality of wing-clipped pateke

Survivorship was calculated following Robertson and Westbrooke's (2005) method. The Kaplan-Meiner (Pollock, Winterstein, Bunck, et al., 1989; Pollock, Winterstein, & Conroy, 1989) procedure was used to generate a graph comparing survivorship data for the first six months post-release, comparing wing-clipped to fully-feathered pateke. The Mantel-Haenszel (Robertson & Westbrooke, 2005) statistic was then run to find if there was a statistical difference in survivorship between these two treatment groups.

3.3.8.3 Weight as an indicator of condition

Since the sample size of data collected for condition as measured by weight change was small no statistical tests were run on this data set.

3.3.9 Experimental design

This study was undertaken as part of an existing series of translocations of captive-bred birds to Cape Kidnapper's Wildlife Preserve. As such some of the experimental design was already determined.

At Cape Kidnappers the release in May 09 was the second reintroduction, the first occurring in May 08. The 30 birds used in this study were released at sites where there were not believed to be any resident pateke from the previous release. Therefore they may not have been under the same pressures from conspecifics as the Tawharanui birds might have experienced.

At Cape Kidnappers supplementary food was provided all year round ad-lib, and birds were not weaned off or did not have supplementary food removed at any point. This means that Cape Kidnappers and Tawharanui cannot be directly compared. It is therefore recommended that to provide valid comparisons in any repeats of this experiment release times and feeding regimes need to be standardised and a control group added

The sample sizes in this study were also small (supplementary feeder use data from a total of 30 individuals at Cape Kidnapper's), with endangered species this often cannot be helped, however better planning to ensure appropriate numbers of birds are included in any future experimental releases is advisable to increase the power of statistical tests and also to allow for slippage in sample sizes due to deaths, missing birds, or failure of equipment (radio transmitters and/or PIT tags).

3.4 Results

3.4.1 Effect of wing-clipping on distances dispersed and feeder use

Data from three Cape Kidnapper's sites, the Small Cape Dam, the Large Cape Dam and the Road Swamp, was first looked at separately to see whether there were any significant differences in patterns of dispersal or feeder visits between sites across the three monitoring phases. Tables 9 and 10 compare distances dispersed, and mean daily feeder visits between the three sites for both fully-feathered and wing-clipped birds. From these tables it does not appear that there are any major differences between the three sites, and Friedman's tests were run to verify this.

At the Small Cape Dam there was a significant decrease in average feeder visits within the three monitoring phases for both wing-clipped (w/c) and fully-feathered (ff) birds (Friedman's tests: w/c; $\chi^2 = 9.5$, $p = < 0.05$, ff; $\chi^2 = 10$, $p = <0.05$). There was no significant increase in average daily distance dispersed within the three monitoring phases at the Small Cape Dam for either wing-clipped and fully-feathered birds (w/c; $\chi^2 = 2$, $p = 0.368$, ff; $\chi^2 = 0.5$, $p = 0.779$). At the Large Cape Dam there was a significant decrease in average feeder visits within the three monitoring phases for both wing-clipped and fully-feathered birds (w/c; $\chi^2 = 7.6$, $p = <0.05$, ff; $\chi^2 = 11.1$, $p = <0.005$). There was no significant increase in average daily distance dispersed within the three monitoring phases at the Large Cape Dam for fully-feathered birds (ff; $\chi^2 = 2.9$, $p = 0.232$). At the Road Swamp there was no significant decrease in average feeder visits within the three monitoring phases for either wing-clipped or fully-feathered birds (w/c; $\chi^2 = 4.9$, $p = 0.086$, ff; $\chi^2 = 2.667$, $p = 0.264$). There was also no significant increase in average daily distance dispersed within the three monitoring phases at the Road Swamp for the fully-feathered birds (ff; $\chi^2 = 4.0$, $p = 0.135$) (Table 11).

Table 9. Average distances dispersed (m) between the three Cape Kidnappers release sites across the three monitoring phases, split for wing-clipped and fully-feathered birds.

		Average daily dispersal distance (m)					
		Phase 1		Phase 2		Phase 3	
Site		Fully-feathered	Wing-Clipped	Fully-feathered	Wing-Clipped	Fully-feathered	Wing-Clipped
Large Cape	# of birds	*n* = 6	*n* = 4	*n* = 6	*n* = 4	*n* = 6	*n* = 4
	Average metres dispersed	174	125	104	125	2322	125
	Standard deviation	± 119	± 0	± 0	± 0	± 5450	± 0
Road Swamp	# of birds	*n* = 3	*n* = 3	*n* = 3	*n* = 3	*n* = 3	*n* = 3
	Average metres dispersed	1231	50	3443	50	3443	50
	Standard deviation	± 1623.3	± 0	± 2938.7	± 0	± 2938.7	± 0
Small Cape	# of birds	*n* = 5	*n* = 5	*n* = 5	*n* = 5	*n* = 5	*n* = 5
	Average metres dispersed	93	76	696	311.8	645	325
	Standard deviation	± 21	± 3.1	± 1078.2	± 521.7	± 968.5	± 454

Table 10. Mean daily feeder visits between the three Cape Kidnappers release sites across the three monitoring phases.

		Average daily feeder visits (fpd)					
		Phase 1		Phase 2		Phase 3	
Site		Fully-feathered	Wing-Clipped	Fully-feathered	Wing-Clipped	Fully-feathered	Wing-Clipped
Large Cape	# of birds	$n = 6$	$n = 4$	$n = 6$	$n = 4$	$n = 6$	$n = 4$
	Average fpd	1.08	1.28	0.09	0.04	0	0
	Standard deviation	± 1.1	± 0.8	± 0	± 0	± 0	± 0
Road Swamp	# of birds	$n = 3$	$n = 3$	$n = 3$	$n = 3$	$n = 3$	$n = 3$
	Average fpd	3.27	5.00	0.19	0.50	0.01	0.17
	Standard deviation	± 4.2	± 2.9	± 0.3	± 0.7	± 0.02	± 0.3
Small Cape	# of birds	$n = 5$	$n = 5$	$n = 5$	$n = 5$	$n = 5$	$n = 5$
	Average fpd	1.60	2.40	0	0.02	0	0
	Standard deviation	± 1.7	± 0.9	± 0	± 0	± 0	± 0

Table 11. Summary of results of Friedman statistics comparing the differences between the three monitoring phases for birds from all three Cape Kidnappers release sites.

		Mean number of daily feeder visits	*Average daily dispersal distance (m)*
		Significant difference Yes/No?	**Significant difference Yes/No?**
Wing-Clipped	Small Cape	Yes	No
	Large Cape	Yes	No
	Road Swamp	No	No
Fully-feathered	Small Cape	Yes	No
	Large Cape	Yes	No
	Road Swamp	No	No

Average daily dispersal distances between phases one and two, and phases two and three by both wing-clipped and fully-feathered birds were non-significant at any of the three release sites (Wilcoxon tests, Table 12). However at the Large Cape Dam a significant decrease was seen in the mean number of daily feeder visits of fully-feathered birds between phases one and two (Wilcoxon test: $z = -2.207$, $p < 0.05$), and a near significant decrease was seen in the wing-clipped birds ($z = -1.826$, $p = 0.068$). Average daily visits to the feeders at the Small Cape Dam decreased significantly between phases one and two for both wing-clipped and fully-feathered birds (Wilcoxon's tests: w/c; $z = -2.023$, $p < 0.05$, ff; $z = -2.023$, $p < 0.05$).

Table 12. Results of Wilcoxon signed-ranks tests for fully-feathered versus wing-clipped pateke at each of the three Cape Kidnappers release dams (Significant results highlighted yellow).

	Site	Mean number of daily feeder visits		Average daily dispersal distance (m)	
		P1 – P2	*P2 – P3*	*P1 – P2*	*P2 – P3*
Wing-Clipped	Small Cape	*n* = 5 Z = -2.023 P = 0.043	*n* = 5 Z = -1.000 P = 0.317	*n* = 5 Z = -1.342 P = 0.180	*n* = 5 Z = -0.386 P = 0.713
	Large Cape	*n* = 4 Z = -1.826 P = 0.068	*n* = 4 Z = -1.633 P = 0.102	*n* = 4 Z = 0.000 P = 1.000	*n* = 4 Z = 0.000 P = 1.000
	Road Swamp	*n* = 3 Z = -1.461 P = 0.144	*n* = 3 Z = -0.447 P = 0.655	*n* = 3 Z = 0.000 P = 1.000	*n* = 3 Z = 0.000 P = 1.000
Fully-feathered	Small Cape	*n* = 5 Z = -2.023 P = 0.043	*n* = 5 Z = 0.000 P = 1.000	*n* = 5 Z = -0.405 P = 0.686	*n* = 5 Z = -1.000 P = 0.317
	Large Cape	*n* = 6 Z = -2.207 P = 0.027	*n* = 6 Z = -1.633 P = 0.102	*n* = 6 Z = -1.604 P = 0.109	*n* = 6 Z = -1.342 P = 0.180
	Road Swamp	*n* = 3 Z = -1.069 P = 0.285	*n* = 3 Z = -1.069 P = 0.285	*n* = 3 Z = -1.342 P = 0.180	*n* = 3 Z = 0.000 P = 1.000

Since there were no large differences between the three separate release sites (Tables 9, 10, 11 and 12) the data for the three sites was then combined to increase the sample size from three small groups of ten birds per site to one group of thirty birds.

Fig 11 compares average daily dispersal distances and Fig 12 the average number of daily feeder visits split for fully-feathered and wing-clipped birds at all Cape Kidnappers sites combined across the three monitoring phases. Wing-clipped birds (Fig 11) had a lower average daily dispersal distance than fully-feathered birds.

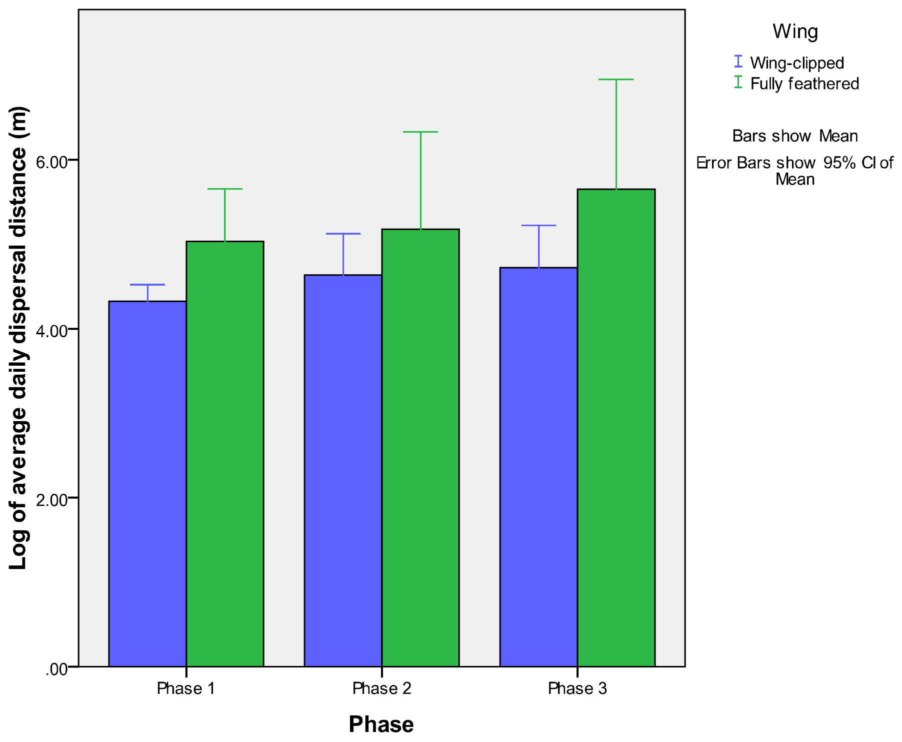

Figure 11. Log of mean dispersal distances, split for fully-feathered and wing-clipped birds across the three monitoring phases at Cape Kidnappers

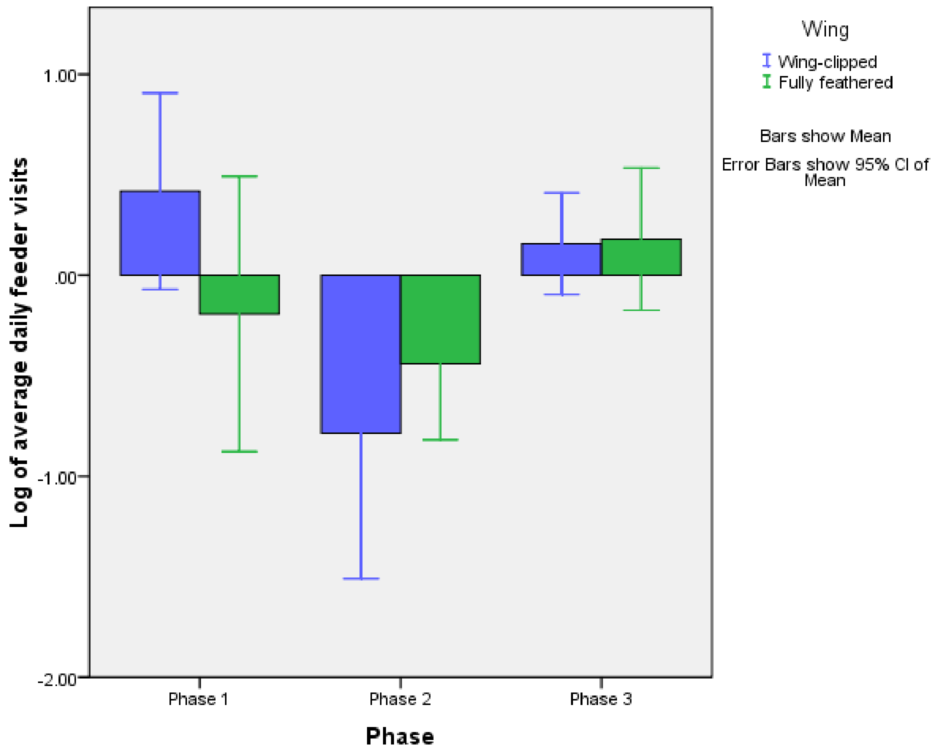

Fig 12. Log of mean number of feeder visits per phase between fully-feathered and wing-clipped birds at Cape Kidnappers.

Differences in average daily dispersal distances between the three phases were non-significant for both wing-clipped (Friedman's test: $\chi^2 = 2$, $p = 0.368$) and fully feathered birds ($\chi^2 = 4$, $p = 0.819$) when the three sites were combined. However significant differences were found between the three phases in daily feeder visits, both for wing-clipped ($\chi^2 = 21.3$, $p < 0.005$) and fully-feathered birds ($\chi^2 = 22.1$, $p < 0.005$).

A strong negative correlation is seen in average daily feeder visits over time for both the wing-clipped and fully-feathered birds (Spearman's tests; $r = -0.762$, $p <0.001$; $r = -0.846$, $p <0.001$) (Fig 13 and Table 13). There was also a weak positive correlation between average daily dispersal distances travelled by the fully-feathered birds ($r = 0.314$, $p <0.05$). However there was no significant difference between dispersal distances travelled over time for wing-clipped birds (r = 0.005, p = 0.975) (Fig 14 and Table 14).

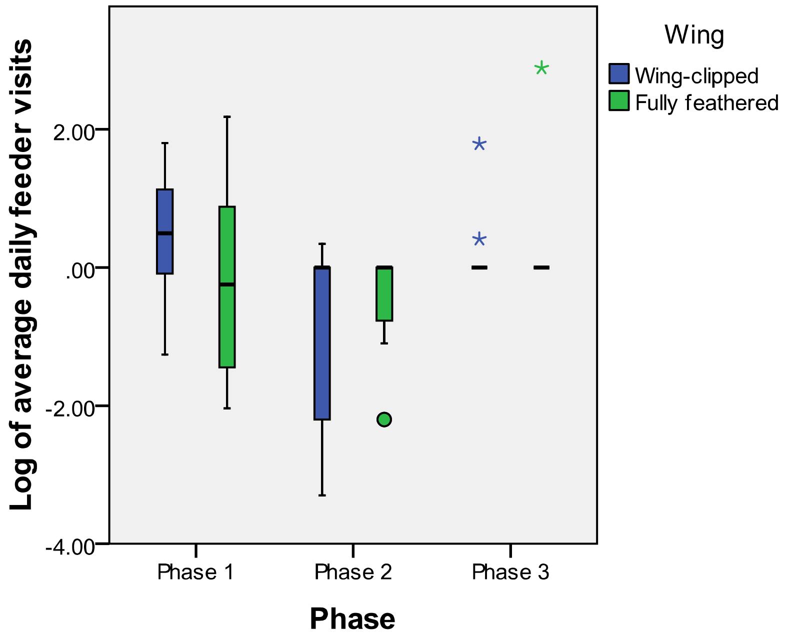

Fig 13. Log of average daily feeder visits at combined Cape Kidnapper's sites, split for wing-clipped and fully-feathered birds.

Table 13. Comparison of average daily feeder visits (fpd), the range of average feeder visits (fpd) and standard deviation (SD) across the three monitoring phases for the Cape Kidnappers May 09 release group, split for wing-clipping and fully feathered birds.

		Phase 1	Phase 2	Phase 3
Wing-clipped	Average daily feeder visits and range (fpd)	2.2 (0.28-6.07)	0.2 (0-1.41)	0.06 (0-0.67)
	Standard deviation (SD)	SD 1.8	SD 0.4	SD 0.18
Fully Feathered	Average daily feeder visits and range (fpd)	1.9 (0.13-8.85)	0.09 (0-0.48)	0 (0-0.06)
	Standard deviation (SD)	SD 2.6	SD 0.16	SD 0.01

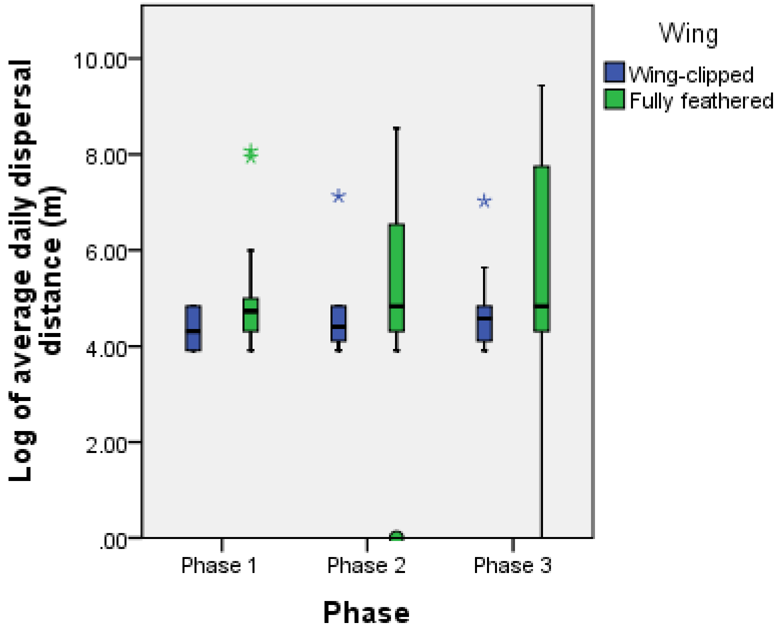

Fig 14. Log of average daily dispersal distance from the feeders (m) for combined Cape Kidnapper's sites, split for wing-clipped and fully-feathered birds.

Table 14. Comparison of average daily dispersal distance (m), the range of dispersal distances (m) and standard deviation (SD) across the three monitoring phases for the Cape Kidnappers May 09 release group, split for wing-clipping and fully feathered birds.

		Phase 1	Phase 2	Phase 3
Wing-clipped	Average daily dispersal distance and range (m)	80.8 (50-125)	184 (50-1245)	189.7 (50-1122)
	Standard deviation (SD)	SD 31.2	SD 335.5	SD 300.3
Fully Feathered	Average daily dispersal distance and range (m)	479.1 (50-3194)	1031 (50-5140)	1963.5 (50-12510)
	Standard deviation (SD)	SD 991.3	SD 1862.7	SD 3533.86

Neither fully feathered nor wing-clipped birds displayed any significant differences in average daily dispersal distances between phases 1 and 2 (Wilcoxon's tests; w/c; z = -1.342, p = 0.180, ff; z = -0.663, p = 0.508), and phases 2 and 3 (w/c; z = -0.368, p = 0.713, ff; z = -1.069, p = 0.285). However a significant difference in average daily feeder visits between phases 1 and 2 (z = -3.110, p = 0.002) was seen in wing-clipped birds, and between both phases 1 and 2 (z = -2.795, p = 0.005), and phases 2 and 3 (z = -1.997, p = 0.046) for the fully-feathered group (Table 15).

Table 15. Wilcoxon signed-ranks test for combined Cape Kidnapper's sites, showing differences between phases for mean daily feeding events and distance dispersed. Data is split for wing-clipped and fully-feathered birds.

Comparisons between phases					
Wing status		Phase2_totalfeeds - Phase1_totalfeeds	Phase3_totalfeeds - Phase2_totalfeeds	Phase2_distance - Phase1_distance	Phase3_distance - Phase2_distance
Wing Clipped	Z	-3.110	-0.946	-1.342	-0.368
	Asymp. Sig. (2-tailed)	0.002	0.344	0.180	0.713
Full Wing	Z	-2.795	-1.997	-0.663	-1.069
	Asymp. Sig. (2-tailed)	0.005	0.046	0.508	0.285

No significant differences were found in average daily feeder use between wing-clipped and fully-feathered birds in phase 1 (Mann Whitney U-tests: U = 78.5, p = 0.247), 2 (U = 82, p = 0.631), or 3 (U = 75, p = 0.404). No significant differences were found in average daily dispersal distances between wing-clipped and fully-feathered birds in phases 1 (Mann Whitney U-tests: U = 68.5, p = 0.064), 2 (U = 62.5, p = 0.256), or 3 (U = 59, p = 0.191) either. However, the difference between wing-clipped and fully-feathered birds' dispersal was almost significant different in phase 1 (U = 68.5, p = 0.064). This suggests that wing-clipping had no effect on average daily dispersal or average daily feeder visits when compared to the behaviour of fully-feathered birds. The near significant difference in phase one for dispersal may be caused by the few birds which dispersed long distances.

3.4.2 Survival and mortality of wing-clipped pateke

The Mayfield method (Robertson & Westbrooke, 2005) was applied to the Cape Kidnapper's May 2009 release group and estimated an annual mortality rate of 0.19 birds per year, and survival rate of 0.81 at 6 months post-release, and an estimated annual survival rate of 0.43 birds per year.

A Kaplan-Meier (Pollock, Winterstein, Bunck, et al., 1989; Pollock, Winterstein, & Conroy, 1989) analysis run to compare survivorship data for wing-clipped and fully-feathered pateke, as recorded from daily telemetry fixes, (Fig 15) showed that for each treatment group across the first six months post release, wing-clipped birds (blue) had slightly higher survivorship than fully-feathered birds (green). A Mantel-Haenszel (Robertson & Westbrooke, 2005) test showed that at both three and six months post release that there was no significant difference in survivorship between wing-clipped and fully-feathered pateke (3 months; $\chi^2 = 0.004$, $p = 0.947$; 6 months; $\chi^2 = 1.108$, $p = 0.292$).

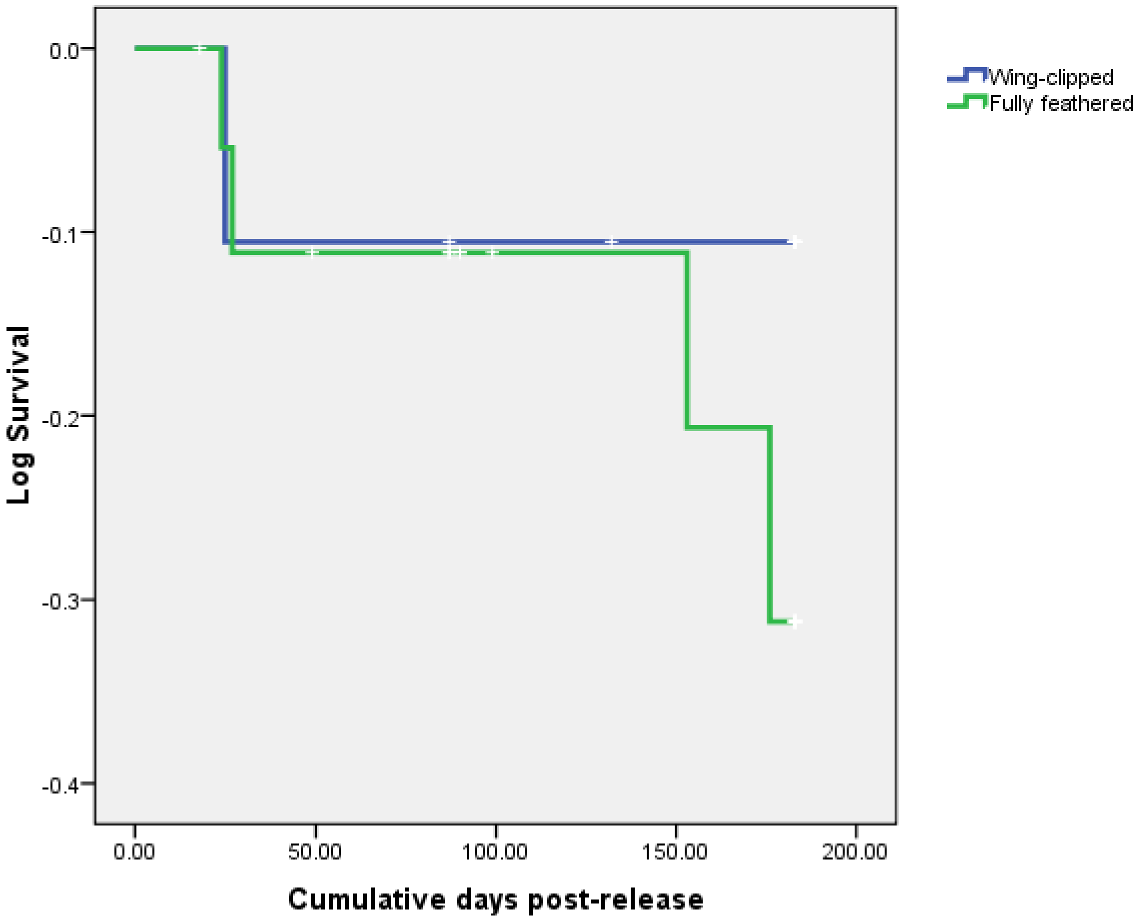

Fig 15. Comparison of survivorship of wing-clipped and fully-feathered pateke during a period of six months post release.

All pateke carcasses retrieved were sent to Massey University's necropsy laboratory for analysis of cause of death. Where starvation was suspected, a wing-fat analysis was undertaken using an ulna bone where available (Moore & Battley, 2003). Of the forty pateke with radio transmitters released at Cape Kidnappers in May 09, there were a total of eight known deaths (20% of all radio-tagged birds) within the park up to 8 months post-release. Of these four (50% of known dead inside reserve) were fully-feathered birds, and four (50%) wing-clipped. For two of the wing-clipped birds insufficient remains were recovered to allow a cause of death to be assigned (Table 16).

Table 16. Causes of known deaths within Cape Kidnappers Wildlife Preserve based on carcasses retrieved, up to 8 months post-release.

		Cause of death				
		Hit by car	**Cat predation**	**Harrier predation / scavenge**	**Unknown**	**Totals;**
Wing-clipped	Male		1			**1**
	Female		1		2	**3**
Fully-feathered	Male			1		**1**
	Female	2	1			**3**
	Totals:	**2**	**3**	**1**	**2**	**8**

(Alley, et al., 2009)

3.4.3 Weight as an indicator of condition

Due to difficulties in recapturing pateke for weighing post-release, only five birds were recaptured at Cape Kidnappers. Of these, two were fully-feathered, and three wing-clipped. All five birds had decreased in body weight post-release with the wing-clipped birds having each lost the same or a higher percentage of body-weight than the fully-feathered birds. The mean number of daily feeder visits was only available for three of the birds (the other two birds were Double Dam releasees and therefore due to failure of the data-logger at this dam information was unavailable) (Table 17). The sample size was too small to form any conclusions on differences in condition between wing-clipped and fully-feathered birds post-release.

Table 17. Difference in condition between fully-feathered and wing-clipped Cape Kidnapper's birds as measured by change in body-weight

Bird ID	Sex	Wing-clipped? Y/N	Pre-release weight (g)	Re-capture weight (g)	% Body weight change	Mean # feeder visits per day
48 / S88109	F	Y	643	600	- 6.7	2.4
20 / S88206	F	N	596	580	- 2.7	2.3
62 / S88204	M	Y	727	692	-4.8	1.8
16 / S86005	F	N	557	530	-4.8	No feed data available
30 / S88205	F	Y	607	530	-12.7	No feed data available

3.5 Discussion

3.5.1 Does wing-clipping have an effect on supplementary feeder use?

Both the wing-clipped and fully-feathered birds showed a significant decrease in feeder use soon after release (between phases one and two), and fully-feathered birds continued to decrease their feeder use significantly (between phases two and three). However there was no significant difference between wing-clipped and fully-flighted birds' use of feeders at any stage. This suggests that both wing-clipped and fully-feathered birds were increasingly utilising wild food sources rather than relying heavily on the supplementary feed, with wing-clipped birds using the supplementary feed for slightly longer than the fully-feathered group.

The significant decreases in feeder use for fully-feathered birds across all stages, coupled with a lack of dispersal, suggests that fully-feathered birds used the feeders less than wing-clipped birds, possibly because they could commute further to forage on natural food sources and therefore be less dependent upon supplementary food than wing-clipped birds. If this is the case then it may be that newly-released pateke were initially anchored by the supplementary food, but over time reducing their reliance on the feeders. A better insight of the proportion of the diet made up of wild sourced and supplementary food would require detailed analysis of faecal samples and invertebrate monitoring at foraging sites.

3.5.2 Does wing-clipping and supplementary feeder use have an effect on dispersal?

Of the twenty wing-clipped pateke released at Cape Kidnappers, only one moved more than 3km from the release site. This bird is suspected to have had some flying ability perhaps due to insufficient wing-clipping, due to the distance and terrain it covered in one night, which included crossing several deep gullies. Another wing-clipped male only dispersed away from his release site when pushed out by an aggressive breeding trio.

In this study I found that there was no significant difference in dispersal between the two treatment groups; wing-clipped and fully-feathered pateke. The Cape Kidnappers pateke did not disperse at a particular point in time, unlike Tawharanui where most birds dispersed during weaning and food removal. There was however a significant decrease in supplementary feeder use over time, whereby all Cape Kidnappers pateke reduced their feeding over time, but wing-clipped birds used feeders for longer. However feeder use does not appear to be correlated with dispersal distance for either treatment group. This suggests that at Cape Kidnappers dispersal might have occurred in response to a variable other than food. It is hypothesised that wing-clipped birds, which were not physically able to disperse very far from the release site, may have acted as an anchor to the fully-feathered birds, reducing their dispersal, by being conspecific attractants. Many duck species are attracted to areas with high densities of other ducks, and subject to the Allee effect where breeding depends on the population reaching a certain critical size (Ackerman, et al., 2006; C. A. Miller, 2002; Szymanski, 2004), and pateke, which flock annually (O'Connor, et al., 2007; Pierce, et al., 2006), are no exception to this rule. The subjects in this study were released in May, close to the beginning of their breeding season. It is possible that wing-clipped birds which could not disperse were forced to select territories within or close to the release area in which to breed. If so this may have reduced the dispersal of any fully-feathered mates.

Monitoring the wing-clipped population post their first moult, when flight will be restored, is beyond the timeframe of this study, yet of obvious importance. One of the reasons for the high success of a reintroduced population of trumpeter swans was that after wing-clipped swans regained their flight, they continued to return to the release site each year for breeding, thus forming a stable breeding population at the release site (Monnie, 1966). It is hoped that having pateke wing-clipped over a breeding season may help to enhance the fidelity with the release site as they will likely want to return to previously formed territories. However, if these individuals disperse to new territories once their flight feathers are restored, the effectiveness of this technique would be reduced.

3.5.3 Does wing-clipping have an effect on survivorship or condition?

Predation by introduced mammals is one of the pateke' greatest threats (Williams & Dumbell, 1996). Although the sample size is small, of the four pateke at Cape Kidnappers which are known to have been predated, these comprised of two wing-clipped and two fully-feathered birds. Fully-feathered pateke may be just as susceptible to predation as wing-clipped pateke. A study of houbara bustards found the wing-clipped group to suffer the highest predation and subsequently lowest success rate compared with groups of fully-feathered birds of the same age (Combreau & Smith, 1998). The difference between these two studies is that the houbara bustards suffered high predation from native predators. Pateke are most vulnerable to introduced predators. It would certainly not be recommended to release wing-clipped pateke into an area which did not have a high level of protection from introduced predators.

A Kaplan-Meier analysis (Fig 15) showed a trend at six months post-release which was tending towards wing-clipped birds having higher survivorship than fully-feathered birds, however there was no significant difference between the two treatment groups ($\chi^2 = 1.108$, $p = 0.292$). This suggests that if wing-clipping is to be used as a management technique for pateke in predator managed areas with sufficient food there should be no significant risk of lower survivorship.

A study which experimentally wing-clipped male songbirds to investigate the effects on male provisioning during breeding resulted in increased nestling mortality (Rosvall, 2009) and is presumably partially caused by the wing-clipped songbird not being able to find and supply as much food and protect the nest as normal. Pateke have precocial young and often do not need to fly to find and provide food for their young, so it is unlikely there would be such a defined negative response in duckling survival compared with Rosvall's songbirds. Breeding success is clearly an important parameter to measure when assessing the effects of wing-clipping on any species. Though not investigated in detail for this study due to time constraints, I did observe wing-clipped pateke at Cape Kidnappers mating and successfully breeding, with one wing-clipped polygynous male known to have aggressively held a territory in which he produced clutches with each of his two females, producing a total of 11 ducklings of which 9 are known to have fledged. It appears that in the pateke wing-clipping has not affected their ability to attract a mate and breed. Further investigation of breeding success should be undertaken in any future wing-clippping trials.

Attempts were made to measure the condition of wing-clipped and fully-feathered pateke, by assessing the change in body weight, at approximately three months post-release. Unfortunately the birds were very hard to recapture, and the commencement of the breeding season meant that the capture programme had to be stopped, so insufficient data was collected. Only five birds were recaptured, three of which were wing-clipped. All five birds had decreased in body weight, with the wing-clipped birds having the same or a higher percentage of body weight loss than fully-feathered birds. The small sample size prevented any meaningful analysis to compare weight with the number of feeder visits.

3.5.4 Conclusions

In conclusion, this study found that wing-clipping pateke exhibited very short dispersal distances, and the wing-clipped birds might have functioned as conspecific attractants to fully flighted pateke. Overall, in terms of both artificial feeder use and mortality, it does not appear that wing-clipping had any significant negative effect on the released birds in this study, and survivorship was slightly better in the wing-clipped birds. Further investigation of dispersal post first moult and of other factors of success such as breeding and home-range size is recommended in any further releases involving wing-clipped pateke.

Although this study comprised just one experiment with only fifteen wing-clipped participants I would recommend this method for future pateke releases as long as adequate measures are taken to ensure predators have been eradicated, and that close monitoring of the wing-clipped birds is undertaken.

Chapter 4

Summary and recommendations for management

4.1 Supplementary feeder use as a method to anchor pateke, reduce dispersal, and increase survivorship

Supplementary feeder use at Tawharanui increased the time newly-reintroduced pateke spent at the release site and decreased the distance in which they dispersed compared with two previously-released groups of pateke which did not receive supplementary food.

The results from this study suggest that supplementary feeding plays a role in anchoring pateke to a release site. Trends in dispersal from the three releases at Tawharanui also suggest that conspecific attraction may play a role in anchoring reintroduced birds. Over the three Tawharanui reintroductions, the dispersal distance progressively reduced for each release. These results suggest that it is probably a useful strategy to provide supplementary food to pateke when first released at sites that are unoccupied by pateke. This should help to maximise the chances of anchoring newly-released pateke to a new site.

Supplementary feeder use at Tawharanui also reduced the dispersal distances of male pateke significantly in compared with the dispersal of males in two previous releases with no supplementary food. This may result in increased chances for pateke to breed and increased genetic diversity. Pateke reintroductions are planned so that even numbers of males and females are released to maximise the chances for all birds to form pair bonds and breed.

Although male-biased dispersal is natural behaviour for pateke, excessive dispersal of males away from the release area to places with few or no pateke results in an imbalanced sex ratio at the release site and thus reduces the chance of successful pair formation. With more males breeding the founder population is bigger and therefore more genetically diverse population (assuming high diversity in the released population).

Currently the majority of pateke in the captive breeding programme are descended from Great Barrier Island birds which predominantly share one haplotypes, indicating a past bottleneck on the island (Bowker-Wright, 2008). Genetic diversity becomes further reduced when birds are moved from the wild to captivity, and again when they are reintroduced to the wild (Bowker-Wright, 2008). Low genetic diversity may render reintroduced pateke susceptible to inbreeding depression. Therefore the greater the number of individuals in the founder breeding population, the greater the chance of maintaining higher genetic diversity (Stamps & Swaisgood, 2007) and of establishing a viable population which survives long-term.

This study shows that there is a positive relationship between supplementary feeding and survival, with the release group receiving supplementary food experiencing lower mortality, higher survival and a higher estimated annual survival than those release groups which did not receive supplementary feed. A comparison of known causes of death also showed that starvation occurred only in those birds which did not receive supplementary food. Although not statistically significant, this suggests that supplementary feeding may have played a role in reducing starvation and increasing survivorship, as well as reducing dispersal away from release sites to places outside the managed areas where predation was more likely. However as discussed in chapter two, the effects of natural available food and linked with this, seasonality, are confounding factors which may have influenced this result.

The overall aim of pateke reintroductions is to establish stable breeding groups in protected areas, which can contribute to the recovery of the species. The benefits of supplementary feeding at Tawharanui; reducing dispersal, decreasing male dispersal, and positively influencing survivorship, mortality and starvation, show that this management technique makes a constructive contribution to the recovery programme. Further studies of supplementary feeder use and controlling for factors such as conspecific presence, competition and seasonality, carried out in conjunction with an analysis of availability and use of wild food sources, would further tease out the role and importance of supplementary feeding in anchoring pateke to a selected release sites.

High quality habitat with abundant natural food is a basic prerequisite for successful reintroductions. The selection of release sites has probably been quite subjective in the past. In some cases the abundance of hedgehogs before control has been used as an indicator of the number of invertebrates present (Ward-Smith, 2009). The quantity of natural foods available, and the difference in natural foods available at different times of year, was an unknown factor in this study, which may have influenced the results of both supplementary feeder use and dispersal. This aspect was not studied closely here due to a lack of time and resources. However it may highlight the reasons behind distance dispersed and declining reliance on supplementary feeders.

4.2 Wing-clipping pateke as a method of reducing dispersal

At Cape Kidnappers no significant negative effects such as increased reliance on supplementary feed, increased predation, decreased fecundity or dispersal away from the release site were found to inhibit wing-clipped pateke compared with fully-feathered birds. Only one of twenty wing-clipped birds moved more than 3km from its release site, showing that wing-clipping inhibited dispersal. Survivorship at six months post-release was slightly higher in wing-clipped birds than fully-feathered birds, suggesting that wing-clipping may increase annual survivorship. Moreover, of eight known deaths within the park boundary at Cape Kidnappers, half were wing-clipped birds, suggesting that there was no difference in mortality rates between wing-clipped and fully-feathered birds within a predator-controlled environment. Wing-clipped birds used the supplementary feeders for longer on average than fully-feathered birds, however their use of feeders did decrease over time, suggesting that the wing-clipped individuals were not reliant upon supplementary food and were able to adjust to wild food sources.

Time limitations of this study meant that wing-clipped birds could not be monitored through the first moult (around Jan/Feb) when they would have regained their flight. Thus I was unable to assess whether with flight restored the wing-clipped birds would remain anchored to their release sites or whether they would disperse. Therefore we do not know whether this technique would be successful in the long-term.

All birds released were sub-adults, being up to a year old at the time of release. The long-term implications of wing-clipping comparatively young birds are unknown. Future research could investigate whether birds wing-clipped when they are young has any effects on their future behaviour, such as reluctance to fly when threatened by a predator, or to fly to search for food or better habitat. Wing-clipping is probably quite an effective tool for anchoring individuals in first introductions to new sites where no conspecifics are already present. Further studies should examine in more detail whether wing-clipped birds can perform a useful role in anchoring fully-feathered individuals in later releases.

The home-range size of pateke is not fully understood, and may vary between wild-born and captive-bred reintroduced birds. The pateke is a secretive nocturnal species which sometimes flies long distances at night, making them difficult to track at night in enough detail to gather home-range data with VHF transmitters. In the future GPS transmitters could be used on pateke to gain accurate home-range information. Good information on the home-range size would help managers to assess the impacts of various management techniques including habitat manipulations and creation, pest-control programmes (Browne, 2010; N. Miller, 2010; Pierce, et al., 2002), wing-clipping and supplementary feeding (Pierce, et al., 2002). Other benefits of knowing the size of the home range include knowing what habitats pateke prefer, and it would also enable more accurate estimation of carrying capacities of release areas for both wing-clipped and fully-flighted birds.

I recommend that wing-clipping should be used as a tool to decrease dispersal only at release sites free of introduced predators. Further research should be undertaken on wing-clipped pateke to assess further whether there are any negative impacts, and any further work should examine home-range, post-moult dispersal and feeding behaviour of both wing-clipped and fully-feathered pateke.

In summary in this study I found that wing-clipped pateke exhibited very short dispersal distances. That there was no significant difference in dispersal distances between wing-clipped and fully-feathered pateke at Cape Kidnappers suggest that the enforced presence of wing-clipped birds at a release site may act as a conspecific attractant to fully flighted pateke. I also found that wing-clipping does not appear to have any significant negative effect in terms of dependence on supplementary feed, mortality, or breeding success.

4.3 Alternative methods to reduce pateke dispersal and increase residency post-translocation

Methods other than supplementary feeding and wing-clipping could be used to anchor or attract birds to a specific location. These could include sound anchoring, decoys and conspecific presence. These techniques are further discussed in terms of their possible application to pateke recovery below.

4.3.1 Experience and habitat selection

Many of the release techniques that have been used in translocations and reintroductions have been experimental or unproven (Scott & Carpenter, 1987), with poor understanding of failures. Wolf et al. (1996) reported that the reasons for 90-100% of animal losses in translocations reviewed were unknown. To ensure effective conservation gains, and to reduce time and costs, techniques should be tested and refined at each stage of a reintroduction (Scott & Carpenter, 1987)

Rapid dispersal of releasees from a selected release site can contribute greatly to failure for several reasons; monitoring either becomes very difficult or impossible and therefore results are unknown, the fitness of any remaining group is decreased by a further reduction in genetic diversity and availability of mates, and dispersing animals often have a higher mortality rate. Some studies have reported a positive relationship between post-release dispersal and mortality (Stamps & Swaisgood, 2007), and anecdotally at least, this appears to be true for pateke (Maitland, 2008b; Rickett, 2008; Ward-Smith & McLennan, 2009).

Novel environments can elicit stress responses in a wide range of species, and often the response is for individuals to fly away or move about more (Rickett, 2007; Stamps & Swaisgood, 2007). This can account in some cases for dispersal of translocated individuals immediately after release to a seemingly suitable habitat (M. F. Clarke & Schedvin, 1997; Stephens & Sutherland, 1999). It has been suggested that there is a connection between dispersal and mortality. A study of NZ robin (*Petroica australis*) found that high initial dispersal correlated with high mortality (Armstrong, 1995a). This is also found to be the case for many pateke dispersing outside protected management areas, where they are much more susceptible to predation and other causes of mortality.

Historically there was little published on the success of releasing captive-bred species, which have been subject to a variety of differing rearing, learning and release techniques (Scott & Carpenter, 1987) although undoubtedly these factors may have an effect on individuals' behaviour upon release into the wild. A variety of rearing and learning techniques and environmental enrichments are employed by captive breeders to aid the survival of individuals upon release. These include fostering or cross-fostering eggs or nestlings, hand, parent, surrogate or puppet rearing of young, pre-release training, and either a hard or soft release into the wild (Scott & Carpenter, 1987).

Pateke have been reared in captivity by over 22 different captive facilities across New Zealand. Some are reared by private breeders, were the birds may not come into contact with more than one or two human carers. Birds from facilities such as zoos and aviary displays are often subject to a large volume of human noise, traffic and interaction, and in some cases, exposure to domestic and wild predators close to their enclosures. It is reasonable to assume that birds raised in these different environments will have different learning experiences and behave differently upon release into the wild.

As discussed previously (2.5.1) an increasingly occurring phenomenon, seen across many taxa including birds, is natal habitat preference induction (NHPI). This hypothesises that favourable conditions experienced by an individual in its natal habitat will act as cues which that individual may use to select a habitat when it disperses (Davis, 2010; Mabry & Stamps, 2008; Stamps & Swaisgood, 2007). This concept overlaps with other aspects such as habitat preference induction and habitat imprinting. The difference is the temporal context. NHPI develops during the natal stage, habitat imprinting occurs during a 'sensitive period', while habitat preference induction may occur at any life-stage when caused by a suitably strong stimulus. Unlike acclimatisation techniques however, NHPI may have a stronger influence than the short-term exposure of acclimatisation (Davis, 2010; Stamps & Swaisgood, 2007). NHPI can be used to investigate and understand dispersal of reintroduced animals and their habitat selection. A limiting factor to reintroductions is the tendency of many individuals to disperse from the management area soon after release. NHPI may explain this tendency and further research into this aspect could allow NHPI to be used to advantage by conservation managers (Davis, 2010; Stamps & Swaisgood, 2007). Studies of mallard, red squirrel (*Tamiasciurus hudsonicus*), black footed ferrets (*Mustela nigripes*) and lynx (*Lynx lynx)* have confirmed the theory of NHPI, however forced acclimatisation at a site, also known as soft release, where individuals are kept in enclosures in the selected habitat for a period prior to release, has also been shown at least to reduce the distance dispersed post-release by familiarising and habituating the individuals to the site (Stamps & Swaisgood, 2007). Natal dispersal typically occurs at a certain time of year, developmental or life-stage. To reduce possible dispersal due to NHPI Stamps and Swaisgood (2007) recommend releasees be liberated at the same time of year, developmental or life-stage as its wild counterpart would disperse. For pateke this suggests that the optimum time for release is during the flocking season, January – March.

It is thought that rather than spending much time and energy assessing potential habitats dispersers may rely on easily-detected conspicuous cues, such as visual or olfactory indicators of the presence of conspecifics, or indications of reproductively successful conspecifics such as nests or fledglings (Stamps & Swaisgood, 2007). This suggests that the use of decoys in particular may be useful in anchoring released species to desired areas.

Stamps and Swaisgood (2007) also recommend providing captive-bred individuals with food sources and structural features which they are most likely to encounter in the wild, prior to their release. Pateke bred at various captive breeding facilities around NZ are sent to Peacock Springs for a 'hardening off' period of approximately six weeks prior to release. This is done so that all individuals meet each other and are exposed to standardised food types and supplementary feeders in an effort to train them to feed on wild-type foods, and also to habituate the birds to features they may encounter at the release sites. It is thought that supplementary feeder stations may be a natal cue for pateke, or that imprinting upon the supplementary feeder stations will reduce post-release dispersal. The results of this study support this, showing that distance dispersed was related to feeder use, and that pateke reduced their dispersal distances when supplementary feed was provided (see Sec 2.4). However if natal experiences are more important to pateke than the familiarisation period at Peacock Springs, then cues will vary in accordance with the various breeding facilities birds have been born at. An investigation into the differences between breeding facilities and the subsequent behaviour of individuals sourced from different facilities, may provide some insight into the role of NHPI in pateke.

4.3.2 Conspecific attraction and the use of decoys to limit dispersal

As previously discussed, the experimental use of decoys as a management tool for reintroductions has resulted in numerous populations being successfully formed. Several species of birds have been attracted to new colonies, or to nest in certain protected areas, by the use of decoys imitating the bird and its gestures (Molles, et al., 2008; R. Podolsky & Kress, 1992; R. H. Podolsky, 1990; Reed, 1999; J. A. Stamps, 1988), and even white paint mimicking guano on rocks (Sarrazin, et al., 1996). An advantage of this technique is the low cost and so far, a high success rate (Sarrazin, et al., 1996).

At Tawharanui the birds in the supplementary fed group, May 09, dispersed shorter distances than those in the unfed group released in Feb 09, which in turn also dispersed shorter distances than the first unfed group to be released in Feb 08. It is possible that this was due to the anchoring effects of conspecifics, with each top-up release increasing the numbers of pateke and thus helping to reduce dispersal. At Cape Kidnappers it is thought that wing-clipped birds, which could not disperse easily from their release site, may have acted as conspecific attractants to the fully-flighted pateke. Anecdotal reports suggest that many reintroduced pateke that disperse, do so to water bodies where there are large numbers of ducks and/or decoys already present. Pateke have also been observed on several occasions interacting with decoys (Rickett, 2008, 2009). Flock sites, defined by Pierce et al. (2006) as a general area where more than two birds congregate during the day, particularly during the summer-autumn period, are thought to be of great importance to pateke, particularly post-breeding and during moult. Flocking provides pateke with the greater protection of numbers during the vulnerable period of moulting, and allows them to form new pairs and strengthen existing pair bonds (Fraser & Beauchamp, 2009).

A study of NZ fairy terns (*Sterna nereis*) reports that the terns were attracted to decoys, appearing to recognise them as conspecifics and mimicking their gestures (Jeffries & Brunton, 2001). Podolsky (1990) found in similar studies that 3-dimensional models attracted more attention than 2-dimensional models, and paired models more so than single models. Live decoys are also occasionally used. At a kokako (*Callaeas cinerea*) release site, a pair of captive kokako where kept in an aviary at the core of the target area to act as a conspecific presence and help anchor the birds to the site (Molles, et al., 2008). There is also evidence that newly-released birds appeared to be attracted to and interacted with both resident birds and fellow releasees, with birds preferring to forage in sight of others (Molles, et al., 2008).

Numerous studies have been published on the success of using decoys to attract ducks for game hunting, including spinning-wing decoys. Spinning-wing decoys are standard decoys which have a small motor to spin the blades of the 'wings'. One side of the 'wing' is painted white (for mallards) to mimic the flash of a duck flapping its wing, or to mimic a landing duck. The movement of the blades can also stimulate movement of stationary floating decoys. Thus this attracts ducks to the area (C. A. Miller, 2002; Szymanski, 2004).

A study of the attraction of nine species of dabbling ducks to spinning-wing decoys (SWDs) indicated that SWDs are strong attractants to all of the tested species, but that attraction varied between species and varied at different latitudes (Ackerman, et al., 2006). A study of mallards found that flocks of mallard were more likely to respond to SWDs than standard decoys, and that the size of flocks responding were also larger (Szymanski, 2004). Miller (2002) also reported a higher seasonal per hunter catch with SWDs than standard decoys.

The importance of gregarious behaviour of pateke at flock sites, and possible role of the Allee effect in pateke, coupled with the results of this and other studies (Jeffries & Brunton, 2001; Molles, et al., 2008; Szymanski, 2004), indicate that there is a strong likelihood that decoys and conspecific attraction could be effective conservation tools for ducks that are worthy of further investigation (Innes, et al., 2000).

4.4 Use of PIT tag technology for pateke management

PIT tags and data-loggers were very successful for monitoring feeder use at both Tawharanui and Cape Kidnappers, with feeder use being regularly detected in the majority of tagged birds from day two or three post-release, with minimum disturbance to the birds. Only one of 71 total birds tagged for this project is known to have lost its PIT tag, and 91.5% of all birds tagged (65/71) were recorded regularly using the supplementary feeders.

One data logger at Cape Kidnapper's failed at an unknown point during the study and therefore the information from this logger was deemed unreliable and omitted from the experiment. To minimise the loss of information I recommend that data loggers are checked and information is downloaded as frequently as possible in any future study.

A further concern was that the antennae gradually became less sensitive, meaning that some birds may not have been recorded using the feeders. I suspect this was due to slackening of the copper wire coils when the insulation tape binding them together loosened in the damp. Keeping the antennae out of the water should help to reduce this problem, along with better waterproofing of the bindings. Again regular checking and if need be, replacement of the antennae should reduce this problem.

I recommend that further trials be conducted to ascertain the effectiveness of remote monitoring of pateke using PIT tags and data loggers. This technology minimises disturbance by reducing the need to capture or sight individuals. As a cryptic, nocturnal species pateke are often hard to find and catch, and it is also often difficult to see colour bands to obtain a positive identification. The use of monitoring rafts has aided DOC staff at Mimiwhangata and Great Barrier Island (Browne, 2010; Sim, 2008) to read the colour bands of birds which might otherwise hide under banks or in dense vegetation. PIT tags and data loggers obviously have considerable value for continuous monitoring of more secretive birds with minimal disturbance.

I recommend that at sites where pateke are PIT tagged a feeder station should be set up to lure birds within range of an antenna and data logger, to allow recording of individual birds. This should provide information on exactly which birds are present. Information gathered remotely in this way could provide managers with useful information on population size, residency and feeding areas of individuals, and allow more effective management decisions.

I also recommend that a similar method be trialled to aid annual flock counts. Annual flock counts are made at all known pateke flock sites in February when most pateke congregate to moult and form or strengthen pair bonds. Flock counting enables managers to determine population size and composition. Currently flock counting is usually undertaken by flushing pateke and pushing them downstream past a second observer who counts, or a video camera. A series of antennae and data loggers could be set up at various points along the stream which could log the identity of pateke as they swim past. This would not only produce very accurate counts, but all of the individuals bearing PIT tags in a flock would be known allowing population demographics to be better understood.

4.5 Summary of recommendations for management

Based upon the results of this study I would make the following recommendations for pateke management;

Wing-clipping of pateke is a valuable management tool to aid in reducing dispersal to help form stable breeding populations of pateke. It should only be undertaken in areas free of introduced predators, or places with very good control of introduced predators. Further research should be undertaken to assess whether there are any negative effects of wing-clipping such as a reduced ability to disperse long-term. Further studies are needed of habitat use, home-range, and dispersal of wing-clipped pateke past their first moult.

Supplementary food is recommended to help reduce dispersal in newly-reintroduced pateke, especially of males. Supplementary feeding should continue at release sites as long as resources allow, especially for those reintroductions where there are no other pateke already. Where possible, supplementary feeding should extend through the first breeding season. Feeder use and dispersal should be monitored to ascertain whether feeding through the first breeding season helps to anchor pairs in territories at safe predator-managed sites.

This study found a positive relationship between supplementary feeding and increased survivorship; however I would recommend this is further investigated with future studies aiming to understand the role of confounding factors such as con-specific presence, seasonality, and availability of natural food resources.

I recommend that further research be undertaken into the home-range of pateke, their natural diet, and how the availability of wild food may affect dispersal and site selection post-release. This should guide future management decisions about which sites are most suitable for releases and what supplementary feeding may be required.

A comparative investigation of the breeding, dispersal, survivorship and recruitment of wild and captive-bred birds is recommended to assess the long term success of the reintroductions.

Experiments with decoys are recommended to assess the importance of conspecific presence in site selection and whether conspecific presence can be used to anchor pateke to a site is as suspected in this study.

It is recommended that the differences between captive breeding facilities and the subsequent behavior of birds from those different facilities be studied to investigate the role of natal habitat preference induction in pateke.

I recommend further study of the use of PIT tags for remote monitoring and flock monitoring. This technology has the potential to monitor pateke with minimal disturbance whilst providing accurate information on which individuals exist in a given population.

I recommend that in all translocations of pateke that transmitters are removed before they are due to expire, both as a welfare concern for pateke and so that they can be re-used and some financial outlay recouped.

Finally I recommend that all translocation sites should advocate to the general public information about the importance of pateke and wetland ecology, and encourage local people to take ownership and responsibility for the long-term survival of pateke.

References

Ackerman, J. T., Eadie, J. M., Szymanski, M. L., Caswell, J. H., Vrtiska, M. P., Raedeke, A. H., et al. (2006). Effectiveness of Spinning-Wing Decoys Varies among Dabbling Duck Species and Locations. *The Journal of Wildlife Management, 70*(3), 799-804.

Adams, N., Farnworth, M., Rickett, J., Parker, K., & Cockrem, J. (2008). Behavioural and corticosterone responses to capture and confinement of wild blackbirds (*Turdus merula*): Implications for avian translocations. Unitec, Department of Natural Sciences.

Alley, M., Gartrell, B., Morgan, K., Lenting, B., & Argilla, L. (2009). *Pathology reports*. Palmerston North: Institute of veterinary, animal and biomedical sciences, Massey Unviversity.

Armstrong, D. (1995a). Effects of familiarity on the outcome of translocations, a test using New Zealand robins. *Biological Conservation, 71*, 281-288.

Armstrong, D. (1995b). Effects of familiarity on the outcome of translocations; a test using saddlebacks *Philesturnus caruncula rufusater*. *Biological Conservation, 71*, 133-141.

Armstrong, D., Castro, I., Alley, J. C., Feenstra, B., & Perrott, J. K. (1999). Mortality and behaviour of hihi, an endangered New Zealand honeyeater, in the establishment phase following translocation. *Biological Conservation, 89*, 329-339.

Armstrong, D. P., Castro, I., Alley, J. C., Feenstra, B., & Perrott, J. K. (1999). Mortality and behaviour of hihi, an endangered New Zealand honeyeater, in the establishment phase following translocation. *Biological Conservation, 89*(3), 329-339.

Auckland Regional Council. (2003). *Regional parks management plan, volume 2, resource inventory*. Auckland: Auckland regional Council.

Baldassarre, G., & Bolen, E. (2006). *Waterfowl ecology and management* (Second edition ed.). Malabar, Florida: Krieger publishing company.

Battley, P. F., & Piersma, T. (2005). Adaptive interplay between feeding ecology and features of the digestive tract in birds. In J. M. Starck & T. Wang (Eds.), *Physiological and ecological adaptations to feeding in vertebrates*. New Hampshire: Science Publishers.

Beck, B. B., Rapaport, L. G., Stanley-Price, M. R., & Wilson, A. C. (1994). Reintroduction in captive-born animals. In G. Onley, G. Mace & A. Feistner (Eds.), *Creative conservation: Interactive management of wild and captive animals* (pp. 265-286). London: Chapman & Hall.

Berry, R. (1998). *Reintroduction of kaka (Nestor meridionalis septentrionalis) to Mount Bruce Reserve, Wairarapa, New Zealand*.

Boffa Miskell. (2001). *Auckland Regional Council; Tawharanui regional park wetland restoration*. Auckland: Boffa Miskell Ltd.

Booth, A. (2010). Personal Communication re pateke recovery group outcomes. Whangarei.

Boutin, S. (1990). Food supplementation experiments with terrestrial vertebrates: patterns, problems, and the future. *Canadian Journal of Zoology, 68*, 203-220.

Bowker-Wright, G. (2008). *Loss of genetic diversity with captive breeding and re-introduction: a case study on pateke/brown teal (Anas chlorotis).* Victoria University of Wellington, Wellington.

Brightsmith, D., Hilburn, J., del Campo, A., Boyd, J., Frisius, M., Frisius, R., et al. (2005). The use of hand-raised psittacines for reintroduction: a case study of scarlet macaws (Ara macao) in Peru and Costa Rica. *Biological Conservation, 121*, 465-472.

Brittas, R., Marcstrom, V., Kenward, R. E., & Karlbom, M. (1992). Survival and breeding success of reared and wild Ring-Necked Pheasants in Sweden. *The Journal of Wildlife Management, 56*(2), 368-376.
Browne, T. (2010). Personal Communication. Whangarei.
Caccamise, D. F., & Hedin, R. S. (1985). An aerodynamic basis for selecting transmitter loads in birds. *The Wilson Bulletin, 97*(3), 306-318.
Caldwell, R. (2005). *Moehau Pateke Project 2004-5 Annual Report*: Department of Conservation.
Caldwell, R. (2006). *Moehau Pateke Project 2005-6 Annual Report*: Department of Conservation.
Caldwell, R. (2007). *Moehau Pateke Project 2006-7 Annual Report*: Department of Conservation.
Charalambidou, I., Santamaria, L., Jansen, L., & Nolet, B. A. (2005). Digestive plasticity in Mallard ducks modulates dispersal probabilities of aquatic plants and crustaceans. *Functional Ecology, 19*, 513-519.
Clarke, A., Saether, B., & Roskaft, E. (1997). Sex-biases in avian dispersal: a reappraisal. *Oikos, 97*, 429-438.
Clarke, M. F., & Schedvin, N. (1997). An experimental study of the translocation of noisy miners *Manorina melanocephala* and difficulties associated with dispersal. *Biological Conservation, 80*, 161-167.
Combreau, O., & Smith, T. R. (1998). Release techniques and predation in the introduction of Houbara bustards in Saudi Arabia. *Biological Conservation, 84*, 147-155.
Curry, R. L. (2008). Marking procedures. Retrieved 07/08/2008, 2008, from http://www.nmnh.si.edu/BIRDNET/GuideToUse/MARKING.HTM
Davis, J. M. (2010). Habitat Imprinting. In D. B. Michael & M. Janice (Eds.), *Encyclopedia of Animal Behavior* (pp. 33-37). Oxford: Academic Press.
Dumbell, G. (1987). *The ecology, behaviour and management of New Zealand brown teal, or pateke (Anas aucklandica chlorotis).* University of Auckland, Auckland.
Dunn, E. H., & Tessaglia, D. L. (1994). Predation of Birds at Feeders in Winter. *Journal of Field Ornithology, 65*(1), 8-16.
Empson, R. (2001). *Release of brown teal in Karori Wildlife Sanctuary*. Wellinton: Karori Wildlife Sanctuary.
Empson, R. (2004). *Brown teal at Karori Wildlife Sanctuary 2002-2004*. Wellinton: Karori Wildlife Sanctuary.
Evans, K. (2008). Personal communication. In J. Rickett (Ed.). Auckland.
Evans, K. (2010). Brown Teal, *Anas chlorotis*. 2010, from www.brownteal.com
Fischer, J., & Lindenmayer, D. B. (2000). An assessment of the published results of animal relocations. *Biological Conservation*(96), 1-11.
Fitts, S., Paul, W., & Mech, L. (1985). Can relocated wolves survive? *Wildlife Society Bulletin, 13*, 459-463.
Fraser, J., & Beauchamp, T. (2009). Use of flocks, roosts and breeding areas by brown teal (*Anas chlorotis*) at Mimiwhangata Farm, Northland, New Zealand 1996-2000.
Gillies, C. A., Leach, M. R., Coad, N. B., Theobald, S. W., Campbell, J., Herbert, T., et al. (2003). Six years of intensive pest mammal control at Trounson Kauri Park, a Department of Conservation "mainland island", June 1996–July 2002. *New Zealand Journal of Ecology, 30*, 399-420.
Godfrey, J. D., Bryant, D. M., & Williams, M. J. (2003). Radio-telemetry increases free-living energy costs in the endangered Takahe *Porphyrio mantelli*. *Biological Conservation, 114*(1), 35-38.

Green, R. E. (1997). The Influence of Numbers Released on the Outcome of Attempts to Introduce Exotic Bird Species to New Zealand. *Journal of Animal Ecology, 66*(1), 25-35.
Greene, B. (1996). *Brown teal (Anas aucklandica chlorotis) release at Tawharanui, 1995*. Auckland: Auckland Regional Council.
Greenwood, P. (1980). Mating systems, philopatry and dispersal in birds and mammals. *Animal Behaviour, 28*, 1140-1162.
Griffith, B., Scott, M. J., Carpenter, J. W., & Reed, C. (1989). Translocation as a specie conservation tool; status and strategy. *Science, 245*. Retrieved from www.sciencemag.org
Guyn, K. L., & Clark, R. G. (1999). Decoy trap bias and effects of markers on reproduction of northrn pintails. *Journal of Field Ornithology, 70*(4), 504-513.
Haliday, J. (2010). Personal communication regarding interactions of pateke and pukeko. Auckland.
Hay, R. (2002). Retrieved March 14th, 2006, from http://72.14.203.104/search?q=cache:DHRMIzCWTIoJ:www.cites.org/eng/com/AC/18/E18-08-1.doc+pateke,+indeterminate+species&hl=en&gl=nz&ct=clnk&cd=3
Heather, B., & Robertson, H. (2005). *The field guide to the birds of New Zealand* (Revised Edition ed.). Auckland: Penguin Group (NZ).
Highfill, C. (1998). Wing-clipping. *Winged Wisdom*.
Hitchmough, R., Bull, L., & Cromarty, P. (2007). *New Zealand threat classification system lists, 2005*. Wellington: Department of Conservation.
Hogarth, I. (2010). Personal Communication. Whangarei.
Innes, J., Jansen, P., & Baucke, A. (2000). *Audit of the Brown Teal Recovery Programme*. Wellington: Department of Conservation.
Isaac, J., Johnson, C., Grabau, P., & Krockenberger, A. (2004). Automated feeders: new technology for food supplementation experiments with mammals. *Wildlife Research, 31*, 437-441.
IUCN. (1998). *IUCN/SSC guidelines for re-introductions*. Gland & Cambridge: IUCN.
IUCN. (2008). Anas chlorotis. *IUCN Red-list of Threatened Species* Retrieved 09/07/2010, 2010, from www.iucnredlist.org
Iverson, S., Esler, D., & Rizzolo, D. (2004). Winter philopatry of harlequin Ducks in Prince William Sound, Alaska. *The Condor, 106*(3), 711-715.
Jamieson, I. G., Wallis, G. P., & Briskie, J. V. (2006). Inbreeding and Endangered Species Management" Is New Zealand Out of Step with the Rest of the World? *Conservation Biology, 20*(1), 38-47.
Jamieson, I. G., & Wilson, G. C. (2003). Immediate and long-term effects of translocations on breeding success in Takehe *Porphyrio hochstetteri*. *Bird Conservation International, 13*, 299-306.
Jeffries, & Brunton, D. (2001). Attracting endangered species to 'safe' habitats; responses of fairy tersn to decoys. *Animal Conservation, 4*, 301-305.
Ji, W., & Clout, M. (2006). Conservation - applied ecology. In T. McIntyre (Ed.), *Biology Aotearoa, unique flora, fauna and fungi*. Auckland: Pearson Education New Zealand.
Kennedy, M., & Spencer, H. G. (2000). Phylogeny, biogeography, and taxonomy of Australasian teals. *The Auk, 117*(1), 154-163.
Kitaysky, A., Wingfield, J. C., & Piatt, J. (1999). Dynamics of food availability, body condition and physiological stress response in breeding Black-legged Kittiwakes. *Functional Ecology, 13*, 577-584.

Liukkonen-Anttila, T., Putaala, A., & Hissa, R. (1999). Does shifting from a commercial to a natural diet affect the nutritional status of hand-reared grey partridges *Perdix perdix*? *Wildlife Biology*(5), 147-156.
Lovegrove, T. G. (1996). Island releases of saddlebacks Philesturnus carunculatus in New Zealand. *Biological Conservation, 77*(2-3), 151-157.
Mabry, K., & Stamps, J. (2008). Dispersing brush mice prefer habitat like home. *Proceedings of The Rpyal Society; Biological Sciences, 275*, 543-548.
Maitland, M. (2008a). Personal communication. Auckland.
Maitland, M. (2008b). *Tawharanui Open Sanctuary Pateke (Anas chlorotis) Reintroduction: 2008*. Auckland: Auckland Regional Council & Tawharanui Open Sanctuary Society Inc.
Maloney, R. F., Caldwell, R., Gummer, H., & O'Conner, S. M. (2006). *Assessment of sites suitable for the establishment of further Pateke (Brown Teal) populations throughout New Zealand. Version 2: 2006 update.*
May, R. (1991). *The role of ecological theory in planning re-introduction of endangered species.* Paper presented at the Zoological Society of London Symposia, London.
Mayfield, H. F. (1975). Suggestions for calculating nest success. *Wilson Bulletin, 87*, 456-466.
Meek, W. R., Burmanb, P. J., Nowakowskic, N., Sparksa, T. H., & Burmanb, N. J. (2003). Barn owl release in lowland southern England; a twenty-one year study. *Biological Conservation, 109*, 271-282.
Miller, C. A. (2002). Use of Battery-Operated Rotating-Wing Decoys Among Illinois Duck Hunters. *Human dimensions of wildlife, 7*, 139-140.
Miller, N. (2006). *Pateke Release Site Assessment: Tawharanui Regional Park*: Department of Conservation.
Miller, N. (2010). Communication regarding habitat manipulations and pest-control operations at Mimiwhangata Whangarei.
Molles, L. E., Calcott, A., Peters, D., Delamare, G., Hudson, J., Innes, J., et al. (2008). "Acoustic anchoring" and the successful translocation of North Is kokako (Callaeas cinerea wilsoni) to a New Zealand mainland management site within continuous forest. *Notornis, 55*, 57-68.
Molloy, J., Bell, B., Clout, M., de Lange, P., Gibbs, G., Given, D., et al. (2002). *Classifying species according to threat of extinction, a system for New Zealand.*
Monnie, J. B. (1966). Reintroduction of the Trumpeter Swan to Its Former Prairie Breeding Range. *The Journal of Wildlife Management, 30*(4), 691-696.
Moore, S. J. (2003). *Brown Teal (Pateke) diet and it's consequences for releases.* Massey University, Palmerston North.
Moore, S. J., & Battley, P. F. (2003). The use of wing remains to determine condition before death in brown teal (Anas chlorotis). *Notornis, 50*(3), 133-140.
Moore, S. J., & Battley, P. F. (2006). Differences in the digestive organ morphology of captive and wild Brown Teal (Anas chlorotis) and implications for releases. *Bird Conservation International, 16*, 253-264.
Moore, S. J., Battley, P. F., Henderson, I. M., & Webb, C. J. (2006). The diet of brown teal (Anas chlorotis). *New Zealand Journal of Ecology, 30*(3), 397-403.
Nunes, C. A., Benford, R., & Balda, R. P. (2006). Effects of harness attached radio transmitters on pinyon jays. Avian cognition laboratory, Department of Biological Sciences, Northern Arizona University.
NWTNZ. (2008, 14th October 2008). The national wetland trust, New Zealand. 2010, from http://www.wetlandtrust.org.nz

O'Brien, F. (1995). *Ecology of the West Indian whistling-duck on Grand Cayman: a study of a wild population of Dendrocygna arborea under human influence.* Queen's University of Belfast, Belfast.
O'Connor, S. M., Maloney, R. F., & Pierce, R. J. (2007). *Pateke (Anas chlorotis) recovery plan, 2005 - 2010*. Wellington: Department of Conservation.
Parsons, S., & Galbraith, M. (2006). Diversity of New Zealand's terrestrial and freshwater fauna. In T. McIntyre (Ed.), *Biology Aotearoa, unique flora, fauna and fungi*. Auckland: Pearson Education New Zealand.
Peters, M., & Clarkson, B. (Eds.). (2010). *Wetland restoration, a handbook for New Zealand freshwater systems*. Lincoln: Manaaki Whenua Press.
Pierce, R. J., Maloney, R. F., Neill, E., & O'Conner, S. M. (2006). *National Guidelines for Monitoring Pateke (Brown Teal) - Third Edition 2006*. Rotorua: Department of Conservation.
Pierce, R. J., Maloney, R. F., & O'Conner, S. M. (2002). *National Pateke Release Strategy 2002 - 2006*. Wellington: Department of Conservation.
Podolsky, R., & Kress, S. W. (1992). Attraction of the Endangered Dark-Rumped Petrel to Recorded Vocalizations in the Galapagos Islands. *The Condor, 94*(2), 448-453.
Podolsky, R. H. (1990). Effectiveness of Social Stimuli in Attracting Laysan Albatross to New Potential Nesting Sites. *The Auk, 107*(1), 119-124.
Pollock, K. H., Winterstein, S. R., Bunck, C. M., & Curtis, P. D. (1989). Survival analysis in telemetry studies: the staggered entry design. *Journal of Wildlife Management, 53*, 7-15.
Pollock, K. H., Winterstein, S. R., & Conroy, M. J. (1989). Estimation and analysis of survival distributions for readio-tagged animals. *Biometrics, 45*, 99-109.
Putaala, A., & Hissa, R. (1993). Mortality and reproduction of wild and hand-reared grey partridge in Tyrnava, Finland. *Suomen Riista*(31), 13-18.
Reed, J. M. (1999). Review: The Role of Behavior in Recent Avian Extinctions and Endangerments. *Conservation Biology, 13*(2), 232-241.
Rickett, J. (2007). Effects of captivity on behaviour and body condition of wild caught Blackbirds (*Turdus merula*). Unpublished Undergraduate negotiated animal study. Unitec, School of Natural Sciences.
Rickett, J. (2008). The dispersal and habitat use of pateke released at Tawharanui Regional Park, Auckland. Unpublished special topic report for PGDip in Conservation Biology. Massey University.
Rickett, J. (2009). Auckland.
Ritchie, J. (2002). *Tawharanui open sanctuary; the establishment of a mainland island at Tawharanui Regional Park; operational plan 2000 - 2005*. Auckland: Natural Logic Environmental Management Ltd for Auckland Regional Council.
Robertson, H. A., & Westbrooke, I. M. (2005). *A practical guide to the management and analysis of survivorship data from radio-tracking studies*.
Rosvall, K. A. (2009). Do males offset the cost of female aggression? An experimental test in a biparental songbird. *Behaviuoral Ecology*.
Sarrazin, F., Bagnolini, C., Pinna, J. L., & Danchin, E. (1996). Breeding biology during establishment of a reintroduced Griffon Vulture *Gyps fulvus* population. *Ibis, 138*, 315-325.
Sarrazin, F., & Barbault, R. (1996). Reintroduction: challenges and lessons for basic ecology. [doi: DOI: 10.1016/0169-5347(96)20092-8]. *Trends in Ecology & Evolution, 11*(11), 474-478.
Scott, J. M., & Carpenter, J. W. (1987). Release of Captive-Reared or Translocated Endangered Birds: What Do We Need to Know? *The Auk, 104*(3), 544-545.

Seddon, P. J. (1999). Persistence without intervention: assessing success in wildlife reintroductions. *Trends in Ecology & Evolution, 14*(12), 503-503.
Seddon, P. J., & Maloney, R. F. (2003). *Campbell Island teal reintroduction plan*. Wellington: Department of Conservation.
Sillero-Zubiri, C., & Macdonald, D. (1997). *Status survey and conservation action plan: The Ethiopian Wolf*: IUCN/SCC Canid Specialist Group.
Sim, J. (2008). Personal Communication. Auckland.
Smith, K. G., & Clark, J. D. (1994). Black bears in Arkansas: characteristics of a successful translocation. *Journal of Mammalogy, 75*(2), 309-320.
SPSS. (2009). SPSS Statistics 17 (Version 17).
Stamps, & Swaisgood, R. (2007). Someplace like home: experience, habitat selection and conservation biology. *Applied Animal Behaviour Science, 102*, 392-409.
Stamps, J. A. (1988). Conspecific Attraction and Aggregation in Territorial Species. *The American Naturalist, 131*(3), 329-347.
Stanes, A. (2010). Personal communication regarding pateke and pukeko interactions. Auckland.
Stanley-Price, M. R. (1989). *Animal re-introductions: the Arabian oryx in Oman*. Cambridge: Cambridge University Press.
Staus, N. L. (1998). Habitat use and home range of West Indian Whistling-Dcuks. *The Journal of Wildlife Management, 62*(1), 171-178.
Stephens, P. A., & Sutherland, W. J. (1999). Consequences of the Allee effect for behaviour, ecology and conservation. *Trends in Ecology & Evolution, 14*(10), 401-405.
Stoinski, T. S., Beck, B. B., Bloomsmith, M. A., & Maple, T. L. (2003). A behavioural comparison of captive-born reintroduced Golden Lion Tamarins and their wild-born offspring. *Behaviour*(140), 137-160.
Sutherland, W. J. (Ed.). (2004). *The conservation handbook: research, management and policy*. UK: Blackwell Science Publishing.
Szymanski, M. L. (2004). *Effects of spinning-wing decoys on flock behaviour and hunting vulnerability of local and migrant mallards and other ducks in Minnesota.* Louisiana State University Agricultural and Mechanical College, Louisiana.
Tavecchia, G., Viedma, C. B., Martínez-Abraín, A., Bartolomé, M., Gómez, J., & Oro, D. (2009). Maximizing re-introduction success: Assessing the immediate cost of release in a threatened waterfowl
Biological Conservation, 142, 3005-3012.
Taylor, G. (2008). *Implanting passive intergrated transponders (PIT tags) into birds: draft standard operating procedure*. Wellington: Department of Conservation, Research and Development Group.
Taylor, S. S., Jamieson, I. G., & Armstrong, D. P. (2005). Successful island reintroductions of New Zealand robins and saddlebacks with small numbers of founders. *Animal Conservation, 8*, 415-420.
Teixeira, C., De Azevedo, C., Mendl, M., Cipreste, C., & Young, Y. (2007). Revisiting translocation and reintroduction programmes: the importance of considering stress. *Animal Behaviour, 71*, 1-13.
TOSSI. (2006). Tawharanui open santuary society inc. 2006, from www.tossi.org.nz
Townsend, A., de Lange, P., Duffy, C., Miskelly, C., Molloy, J., & Norton, D. (2008). *New Zealand Threat Classification System Manual*.
Tuberville, T., Clark, E., Buhlmann, K., & Gibbons, J. (2005). Translocation as a conservation tool: site fidelity and movement of repatriated gopher tortoises (*Gopherus polyphemus*). *Animal Conservation, 8*, 349-358.
Ward-Smith, T. (2009). Personal Communication. Napier.

Ward-Smith, T., & McLennan, J. (2009). *Draft: Cape Kidnappers and Ocean Beach Wildlife Preserve pateke project report 2008-2009*. Napier.

Williams, M. (2001). Productivity and survival within 2 declining populations of brown teal (Anas chlorotis). *Notornis, 48*, 187-195.

Williams, M., & Dumbell, G. (1996). *Brown Teal (Pateke) Anas chlorotis Recovery Plan*. Wellington: Department of Conservation.

Willis, K., & Ludlow, R. (2009). *Raising chickens for dummies*. New Jersey: Wiley Publishing Inc.

Wingfield, J. C., Hunt, K., Breuner, C., Dunlap, K., Fowler, G. S., Freed, L., et al. (1997). Environmental stress, field endocrinology, and conservation biology. In J. R. Clemmons & R. Buchholz (Eds.), *Behavioural approaches to conservation in the wild* (pp. 95-131). Cambridge: Cambridge University Press.

Wolf, M. C., Griffith, B., Reed, C., & Temple, S. A. (1996). Avian and mammalian translocations: update and reanalysis of 1987 survey data. *Conservation Biology, 10*(4), 1142-1154.

Wolff, J., & Plissner, J. (1998). Sex biases in avian natal dispersal: An extension of the mammalian model. *Oikos, 83*(2), 327-330.

Worthy, T. (2002). The fossil distribution of brown teal (Anas chlorotis) in New Zealand. Palaeofaunal Surveys,.

Appendix 1

Massey University Animal Ethics Committee

Application for research or testing procedures using live animals

AEC/13 (Amended 01/09)

Massey University
Animal Ethics Committee

To: Secretary
Animal Ethics Committee
Room 2.02, Old Main Building
Turitea, Palmerston North

Please send this original (1) application plus fourteen (14) copies
Application due Wednesday of week prior to meeting

APPLICATION FOR APPROVAL OF PROPOSED RESEARCH, TESTING OR TEACHING PROCEDURES USING LIVE ANIMALS

1. CHIEF APPLICANT: *(Staff Member only)*

(a) **Name** Dr Weihong Ji
Qualifications PhD
Position Senior Lecturer
Inst/Sch/Dept Institute of Natural Sciences, College of Sciences

2. OTHER APPLICANTS: *(see Code, Section 3.2, for those who should be listed)*

(a) **Name** Jennifer Rickett
Qualifications BAAT (Now known as BASc)
Position MSc Candidate

(b) **Name** Assoc. Prof Dianne Brunton
Qualifications BSc, MSc, PhD
Position Associate Professor

(c) **Name**
Qualifications
Position

OFFICE USE ONLY

Date Received: 05 MAY 2009

Copy for: Date sent: 23-7-09
Applicant ✓
Head of Institute/Department
Office

Protocol No: 09/42

Decision:
MASSEY UNIVERSITY ANIMAL ETHICS COMMITTEE APPROVED
Date: 15-5-09

P.R. Wilson

(d)	**Name**	
	Qualifications	
	Position	
(e)	**Name**	
	Qualifications	
	Position	
(f)	**Name**	
	Qualifications	
	Position	

3. DETAILS OF PROJECT:

(a) **Title** Effect of supplementary feeding on pateke survivorship and residency post-release

(b) **Type of project**

- **Research** [x]
- **Testing** [ ]
- **Teaching** [ ]

Paper Number(s):

(c) **Commercial sensitivity status**

- **No** [x]
- **Yes** [ ]

(d) **Does the project involve use of native species?**

- **No** [ ]
- **Yes** [x]

If yes, has DoC approval been:

- **Sought but not yet granted** [x]
- **Granted** [ ]

Permit Number(s):

4. JUSTIFICATION OF PROJECT:

(a) **What are the expected benefits of the proposed work and how will the new knowledge be communicated to others?** *(Benefits may include improved basic knowledge, improved animal health, teaching)*

Pateke (*Anas chlorotis*) have been described as a cryptic species and this is reflected in the dearth of knowledge regarding their basic ecology and demography. The inability to secure self-sustaining breeding populations at historic locations by introducing captive bred birds is likely a reflection of lacking the necessary knowledge for their management. This study will investigate habitat preference, dispersal, flock ecology and the effect of supplementary feeding on the home range, dispersal and survival of captive bred pateke. It will not only contribute to theory of conservation ecology, but also provide important information for conservation management of this species.

The research outcomes of this project will be reported via an MSc thesis, scientific conferences and scientific journals.

(b) **Why is it necessary to use animals for this activity?** *(The term "animal" is defined in the Code of Ethical Conduct, Item 10)*

This study investigates the use of supplementary feeding as a technique to increase survivorship and residency of released captive bred pateke. Therefore it is necessary to use pateke that released into the wild for this study.

5. **DESCRIPTION OF PROCEDURES AND MANIPULATIONS:** *("Manipulation" is defined in the Code of Ethical Conduct, Item 10)*

(a) **Give a brief description of your trial design/teaching demonstration.** *(One or two paragraphs)*

This study will investigate habitat preference, dispersal, flock ecology and the effect of supplementary feeding on the home range, dispersal and survival of translocated captive bred pateke. Releases of captive pateke by community organisations to protected mainland sites, Tawharanui and Cape Kidnappers Wildlife Preserve provide the opportunity for this research. Forty pateke have been released at Tawharanui Regional Park and another 80 will be released, 20 at Tawharanui and 60 at Cape Kidnappers. 50 of these individuals will be fitted with radio transmitters. Pateke survival, movement and habitat selection will be investigated by monitoring these radio tagged birds at the two sites.

To monitor the frequency of visiting supplementary food stations by translocated pateke, we seek permission to fit a passive integrated transponder (pit tag) to each bird before releasing. A data logger and antennae will be set up around supplementary feeding stations. This will record each individual bird as they use the feeder station, providing 24hr monitoring with accurate individual identification. Feeder use data collected via this method will be used to assess the effectiveness of using supplementary feeding to aid survivorship and in-park residency.

(b) **How many animals will you use and how have you determined the number of animals to be used? Where a power analysis is appropriate, provide details to justify animal numbers. If a power analysis is not required, explain why.**

Option 1 (Simple Model) (click here for calculator)

Variable (eg, Weight)	Means or Expected Difference	SD	Type 1 error (ά)	Type 2 error (β)	Power	Number of animals needed

Option 2 (Complex Model)
60 captive bred pateke will be used in this study. This is the total number of birds available to be released.

(c) **Describe the manipulations to be performed on the animals.**

Allflex 11mm x 2mm pit tags will be used for this study. The pit tag will be inserted subcutaneously in to fatty tissue under the skin at the base of the neck or on the mantle, as described in DOC SOP DOCDM-266902 relating to the use of PIT tags in native species. This technique has been used previously for Whio and mallard ducks. All techniques will be performed by specifically trained personnel (Andrew Glaser and /or Amy Whitehead) and trainees include Jennifer Rickett, under supervision.

(d) **How will the proposed manipulation affect the well-being of the animals?**

This handling may increase stress levels in the birds, however this is only temporary and the process will be done quickly and efficiently. The insertion of the pit tags will add around a minute or two to the processing time which they will already be going through regardless of this research.

Use of pit tags will ultimately reduce future manipulations as monitoring can occur without direct human presence.

(e) **Describe any restraint applied to the animals.**

The birds are captive bred and up to this stage will have lived only in a captive environment and therefore be used to some level and human contact and handling. The birds will be manually restrained whilst the pit tags are inserted, and handled by/under the supervision of DOC approved handlers.

6. CARE OF ANIMALS:

(a) **What access will the animals have to water?**

Full access apart from the handling time for processing/transport to site

(b) **Describe the feeding regimen for the animals.**

As per normal prior to release whilst in captivity, once released the birds will have access to several feeders of two different designs, containing teal pellets as they have been fed in captivity. Natural food will also be available to them.

(c) **From where will the animals be obtained?**

All birds are captive bred by Duck's Unlimited approved breeders in conjunction with the DOC.

(d) **Where will the animals be kept throughout the study period?**

N/A

(e) **Who is responsible for the routine care and health surveillance of the animals?**

Whilst in captivity the facilities keepers, when released, food will be provided by Jennifer Rickett and the reserve teams, and health surveillance will be minimal, intervention may occur if visual signs of ill health are seen.

(f) **If the Chief Applicant is unavailable, who will make decisions if emergency care is required?**

Park rangers/management in conjunction with advice from the pateke recovery team.

7. FATE OF ANIMALS:

<u>Note</u>: If any animal is either euthanased or dies due to the unexpected side effects of approved manipulations, the animal should be subjected to a post-mortem examination by an experienced person. The results of the post-mortem must be communicated to the Massey University Animal Ethics Committee along with any modifications put in place to minimise the occurrence of similar events to other animals.

(a) **What will happen to the animals at the completion of the study?**

The animals are part of a translocation programme and therefore will remain living in the wild, with the aim of the birds remaining in the managed area's into which they are released.

(b) **If any animals are to be euthanased, describe the method.**

Not Applicable

8. ALLEVIATION OF IMPACT OF MANIPULATIONS:

(a) **What features of the manipulations minimise their impact on the animals?**

The use of pit tags allows permanent individual identification to be made without having to capture and handle the animal in the future, therefore reducing the chances of stressing the bird again.

(b) **If blood samples are to be collected, stipulate volume per sample and frequency of sampling.**

Not Applicable

(c) **Stipulate the use (and dose rate and route of administration) of any anaesthesia, analgesia, sedative, tranquilliser or other pharmacological agent applied to reduce the impact of manipulations on the animals.**

Not applicable

(d) **What frequency of monitoring is to be maintained?**

It is aimed to monitor all birds daily for the first 2 months post release, and 3-4 times weekly in the 3rd month. After this monitoring is aimed for weekly.

(e) **What advice regarding identification of any expected adverse effects will be given to staff responsible for the ongoing care of the animals?**

If ill health is visually observed an attempt will be made to capture and check the bird. If mortality occurs, as will be noted by two-stage radio transmitters, the carcass will be recovered and sent for necropsy. Other than this the birds are to be left to themselves to create a self-sustaining wild population.

9. EXPERIENCE OF APPLICANTS:

(a) **What is the experience of the applicants with the techniques being used in this project?**

Dr Weihong Ji has more than 20 years experiences of researches in ecology and behavioural ecology involving various animals including birds. She has extensive experience in handling animals, including birds.

Jennifer Rickett has been involving in monitoring translocated Pateke and has experiences in handling pateke and radio telemetry.

A/P Dianne Brunton, Sarah's co-supervisor, is a behavioural ecologist who specialises primarily in birds. She has many years of experience in student supervision, capture, handling, banding and blood sampling of birds.

Pit tag insertion will be undertaken by a DOC appointed personnel with experience in handling pateke and whio. Inserters and trainers will be Andrew Glaser and/or Amy Whitehead, approved whio handlers and PIT tag inserters.

(b) **If an applicant is using a technique with which he/she has no previous experience, what training will be provided?**

Full supervision by an approved handler with pit tag insertion experience, Andrew Glaser and/or Amy Whitehead. Training will include practice on frozen poultry, practice on a non native duck, observation of insertion into pateke before supervised insertion.

(c) **List the people providing professional services and the services provided.** *(These personnel need not be applicants - see Code of Ethical Conduct, Item 3.2)*

Andrew Glaser and/or Amy Whitehead as approved PIT tag inserters for whio and competent handlers of pateke.

10. USE OF RESTRICTED DRUGS:

(a) Personnel who are **not** registered veterinarians and who wish to administer prescription veterinary or human medicines must read the Code of Practice for the Use of Veterinary and Human Medicines in Research, Testing and Teaching Organisations. This code is available at:
http://www.royalsociety.org.nz/Site/About/Our_structure/advisory/anzccart/code.aspx
One of the requirements of the code is that each research group (where non-veterinarians use prescription medicines) must have an Institutional Operating Plan (IOP). The IOP outlines how the group will comply with the code's requirements. To assist with the preparation of an IOP, a template can be downloaded here.
Personnel must also complete the following:
I/We declare that I/we have read the above code and will comply with its requirements.

_______________________ _______________________

_______________________ _______________________

Date: ______________

11. SIGNATURES OF APPLICANTS:

(a) I have read the Massey University Code of Ethical Conduct for the Use of Live Animals for Research, Testing and Teaching and agree to comply with its requirements throughout the duration of the proposed procedures;

(b) To the best of my knowledge, this protocol or one substantially like it has not been declined by another Animal Ethics Committee.

Note: Carefully read (a) and (b) above before signing

Signature(s) of Applicant(s)	Printed Name(s) of Applicant(s)
	JENNIFER RICKETT
	Weihong Ji
	Dianne Brunton

Date: 28 April 2009

12. **APPLICANT CHECKLIST**

The following checklist must be completed by the applicant prior to endorsement by the Designated Signing Authority:

- ☐ Appropriate research title when evaluated against methodology
- ☐ Justification and methodology written in terms readily understood by lay members of committee
- ☐ Clear distinction between justification and research methodology
- ☐ Concise wording and information relevant to animal ethics
- ☐ Clearly explained experimental design
- ☐ Complete power analysis to determine necessary number of animals required
- ☐ Provision of all signatures in correct sections
- ☐ Provision of heading details (chief applicant, institute, project title) (MAF statistics form)
- ☐ Grading of manipulations (MAF statistics form)
- ☐ Provision of completion date (MAF statistics form)

13. **APPROVED BY DESIGNATED SIGNING AUTHORITY:**

I have read this application and agree that it meets the intent and spirit of the Massey University Code of Ethical Conduct for the Use of Live Animals for Research, Testing and Teaching:

Signed: G. Schmidt-Adam Date: 01.05.09

Name: G. Schmidt-Adam

Institute: INS

14. MAF STATISTICS FORM:

Please ensure that an "Animal Use Statistics" form is completed and attached.

Notes:

(a) The staff member with signing authority delegated from MUAEC must not sign his/her own application in Section 13 above. Please obtain the signature of another staff member with delegated authority.

(b) Any departure from an approved protocol that adversely affects the welfare or increases the number of animals must be approved by the Chair of MUAEC acting with authority vested through paragraphs 3.13 and 3.14 of the Code of Ethical Conduct. However, in the case of modifications of a minor nature only, these may be approved in writing by any staff member with delegated signing authority. A description of such minor modifications (including approval) shall be submitted to the Secretary of MUAEC who will attach it to the original protocol and note it on the agenda for the next meeting. Further copies shall be attached to the protocols held by the Institute and the Chief Applicant.

ANIMAL USE STATISTICS
APPLICATION/FINAL RETURN FORM
(Amended 01/09)

Protocol ID
09/42

If more than one animal type is required, then fill in one form for each type.

Application: When applying to the AEC for approval of a manipulation, the applicant should complete Box 1 and enter in Boxes 2 to 7, in the *'Planned'* column (P), the appropriate figures for the number of animals required.

Final Return: When the manipulation is completed, Boxes 2 to 10 should then be completed in the *'Used'* column (U) by entering appropriate figures for the number of animals which were actually used.

Chief Applicant: Dr Weihong Ji

Inst/Sch/Dept: Ecology and Conservation Group, Institute of Natural Sciences, College of Sciences

Title of Project: Effect of supplementary feeding on pateke survivorship and residency post-release

1. Animal type: Birds *(see bottom of this form)* Code: 1r

2. Source of animals (number)

		P	U
Breeding unit	a	80	
Commercial	b		
Farm	c		
Born during project	d		
Captured	e		
Imported	f		
Public sources	g		
TOTAL = A			

3. Status of animals (number)

		P	U
Normal/conventional	a		
*SPF/germ free	b		
Diseased	c		
Transgenic/chimaera	d		
Protected species	e	80	
Unborn/pre-hatched	f		
Other	g		

** Specific pathogen free*

4. Main category of manipulation/use (enter the total from 2 above in one box only)

		P	U			P	U			P	U
Teaching	a			Basic biological research	e			Production of biological agents	j		
Species conservation	b	80		Medical research	f			Development of alternatives	k		
Environmental management	c			Veterinary research	g			Other	m		
Animal husbandry	d			Testing	h						

Appendix 2

Department of Conservation

High Impact Research and Collection Permit;

Tawharanui Regional Park

National Permit Number: AK-23882-FAU

Her Majesty the Queen, acting by and through the Minister of Conservation (the Grantor) GRANTS to Jennifer Rickett (the Permit Holder) a Permit under Section 53 of the Wildlife Act 1953 and Section 49 and 50 of the Reserves Act 1977 subject to the details and conditions listed in Schedule One and Two.

Attach original application form to the approve permit.

Schedule One

(1) **Permit Holder and field assistants involved**

Applicant: Jennifer Rickett
Supervisors: Dr Weijong Ji and Dr Diane Brunton
Park Managers / co-ordinators: Matt Maitland, Tamsin Ward-Smith and Travis Cullen. Approved PIT tag inserter and trainer(s) – Andrew Glaser and/or Amy Whitehead Trainee PIT taggers: Kevin Evans, Nigel Miller, Anne Richardson and applicant

(2) **Approved activity (including approved quantities) and reasons for undertaking the research**

Permit to collect, capture, handle release Pateke as follows:

- To investigate the use of supplementary feeding as a technique to increase survivorship and residency of released captive bred pateke.

(3) **Approved research /collection methods**

Each released bird (20 to Tawharanui) is to be fitted with a pit tag prior to release. Insertion will occur during routine pre-departure/release checks of these birds. Insertion will be undertaken by Amy Whitehead and/or Andrew Glasener, approved PIT tag inserters for Whio. Training will also be given by these approved people to 2-3 other handlers and myself. Insertion will be made subcutaneously into the base of the neck, as per DOC SOP, DOCDM266902. A data logger and antennae will be set up around supplementary feeder stations. This will record each individual bird as they use the feeder station, providing 24 hr monitoring with accurate individual identification minus observer effect. Feeder use data collected via this method will be compared to post-dispersal movements to assess the effectiveness of using supplementary feeding to aid survivorship and in-park residency.

(4) **Approved Site(s)**

Tawharanui Regional Park, Tokatu Peninsula, Auckland.
Auckland Regional Council Parkland and Open Sanctuary

(5) **Approved Date(s)**

May 12th 2009 to February 2010

Schedule Two

1. The Permittee shall pay the Concession Fee (GST inclusive) of $ Nil, together with the application processing fee deposit in advance to the Grantor in the manner directed by the Grantor.

2. The Permittee shall contact the local Area Manager prior to undertaking the activity in the area, in particular to ascertain any "no-go" areas, which may include areas of concern to tangata whenua. Permission to cross private land shall be obtained from the landowner prior to the conduct of this activity.

3. This Permit does not confer on the Permittee any interest in the Site, nor does it derogate in any way from the rights of the public to use and enjoy the whole or any part of the Site.

4. The Permittee shall indemnify the Grantor against all claims by any person in respect of any injury, loss or damage (including fire damage) caused by or arising out of any act or omission of the Applicant, its servants, agents, contractors, clients or invitees, or otherwise caused as a consequence of its use of the Site or as a result of the conduct of the concession activity.

5. The Permittee shall conduct the activity in a safe and reliable manner and shall comply with all statutes, bylaws and regulations, and all notices and requisitions of any competent authority relating to the conduct of the collecting activity.

   (a) The Permittee shall prepare a contingency plan for dealing with any mishap that may occur during the operation of collecting activities under this permit, including the recovery of sick or injured persons.

   (b) The Permittee acknowledges that the Grantor accepts no responsibility for the safety of the Permittee.

6. The Permittee shall not erect or bring onto the Site(s) (or any other land administered by the Grantor) any structure, install any facility, or alter the Site(s) in any way without the prior written consent of the Grantor).

7. The Permittee shall not, unless authorised in writing by the Grantor, interfere with, remove, damage, or endanger the natural features, animals, plants or historic resources in any area administered by the Grantor, or bring any plants or animals to the Landing Site(s), or deposit debris, rubbish, or other dangerous or unsightly matter, or contaminate any body of water. The Applicant shall ensure that its clients and invitees do not carry out any acts prohibited under this clause.

8. The Permittee shall not transfer, sublet, assign or otherwise dispose of the interest granted by this Concession.

9. The Grantor may terminate this Concession if the Permittee breaches any of the terms of this document or if the activity causes any unforeseen or unacceptable effects to the Grantor.

10. The Permittee shall comply with all reasonable notices and directions of the Grantor concerning the activities conducted by the Applicant on land administered by the Grantor. While conducting this activity, the Permittee shall carry this permit with them at all times.

11. Use of aircraft in support of the Concession Activity is subject to separate approval. Vehicles shall only be operated on formed roads.

12. The Permittee shall take all waste and rubbish out of the Site and dispose of it in an environmentally sound manner away from public conservation lands. The Permittee must adhere to the Environmental and Water Care Code while conducting the activity, attached hereto.

13. Samples are to be collected away from tracks, huts, picnic areas or areas of high public use and as far as practicable, out of sight of the public. Wherever practicable, the Permittee shall use access routes to the collection areas that avoid damage to natural features.

14. The Permittee shall not collect samples from biologically sensitive areas, or in such quantities that the taking would unduly deplete the population or damage any other ecological associations.

15. All material collected shall remain the property of the Crown. The Permittee shall comply with any reasonable request from the Grantor or tangata whenua for access to any of the collected samples. Any surplus material is to be stored and the Department of Conservation is to be consulted on ultimate disposal of such material.

16. The Permittee shall not donate, sell or otherwise transfer to any third party any material, including any genetic material, or any material propagated or cloned from such material, collected under this permit, or any information obtained as a result of research done on such material or undertake any other activity with the sample not expressly approved herein; without the written permission of the Grantor in consultation with tangata whenua. Notwithstanding the preceding constraint, the Permittee may publish the results of such research results arising from the collection of the plants.

17. No material collected pursuant to this permit may be used for commercial purposes or patenting of plant varieties or registration of intellectual property rights on any derivatives.

18. Any taxon, which is new to science, shall have holotype specimens and a voucher specimen lodged with a registered New Zealand herbarium, recognised national invertebrate collection or equivalent appropriate collection. The Permittee shall notify forthwith the Grantor and local tangata whenua of any such finds.

19. Where obligations bind more than one person, those obligations shall bind those persons jointly and separately.

20. If requested, the Permittee shall keep the Grantor and tangata whenua informed on the progress of this research. Upon completion of the research, the Permittee shall forward a copy of the research findings, reports and publications to the Grantor's office from where this permit was issued. The Permittee acknowledges that the Grantor may provide copies of these findings to tangata whenua.

21. The Permittee shall comply with the activity provisions on the attached schedule at all times.

22. **Special Conditions**

1. Any action under this authority may only be undertaken with the prior notification and consent of the Department of Conservation (DOC) Area Manager at Warkworth.
2. The research shall be carried out strictly in accordance with section (1)(3) of this permit.
3. The Permittee must follow the procedures that are advised by the DOC Programme Managers (Biodiversity), at the Warkworth Area Office to prevent the introduction of disease, rodents, insect or weed species to the sites listed in Schedule 1. The Permittee will ensure that all field equipment is cleaned with Virkon or Trigene and uncontaminated by dirt, animal or plant material prior to entering the sites and if it has come into contact with wildlife, sterilised with anti viral solutions. Equipment must also be sealed in containers so both the Permittee and DOC can be certain it is free of rodents and invertebrates. Boots and clothes must be completely free of mud and seeds.
4. The Permittee must not impact on any absolutely protected wildlife, or other research or management activities at the sites.
5. PIT tag insertion: • The Permittee and assistants shall carry out PIT tagging of pateke in accordance with the department's Standard Operating Procedure for pit tagging blue duck and mallard. • The birds must only be handled by people experienced in the capture and handling of birds and PIT tag inserting shall only be carried out by experienced persons or by trainees supervised by experienced persons.

6. If any adverse effects of the PIT tag insertion in Schedule 1(3) are detected, the activity must cease immediately and the birds must be released or treated as appropriate.
7. All birds must be handled as carefully as possible, but if any bird should die, a DOC ranger must be called.
8. Due care must be taken not to step on rocks or logs that may have wildlife sheltering underneath and do not turn over any rocks/logs if it will cause excess damage to habitat.
9. Pursuant to clause 20 of Schedule 2, the Permittee shall provide a report on the study, to the Community Relations Officer – Concessions, Auckland Conservancy Office and the Ranger – Biodiversity – Warkworth Area Office. This report shall be submitted no more than 2 months after completion of the research.

SIGNED by		SIGNED by	
Dated		Dated	

[name of delegate]_________________________ACTING BY AND THROUGH THE MINISTER OF CONSERVATION ("The Grantor")

AS APPLICANT

In the presence of		In the presence of	
Witness Signature		Witness Signature	
Occupation		Occupation	
Address		Address	

Environmental Care Code

Protect Plants and Animals
Treat New Zealand's forest and birds with care and respect. They are unique and often rare.

Remove Rubbish
Litter is unattractive, harmful to wildlife and can increase vermin and disease. Plan your visits to reduce rubbish, and carry out what you carry in.

Bury Toilet Waste
In areas without toilet facilities, bury your toilet waste in a shallow hole well away from waterways, tracks, campsites and huts.

Keep Streams and Lakes Clean
When cleaning and washing, take the water and wash well away from the water source. Because soaps and detergents are harmful to water life, drain used water into the soil to allow it to be filtered. If you suspect the water may be contaminated, either boil it for at least three minutes, or filter it, or chemically treat it.

Take Care With Fires
Portable fuel stoves are less harmful to the environment and are more efficient than fires. If you do use a fire, keep it small, use only dead wood and make sure it is out by dousing it with water and checking the ashes before leaving.

Camp Carefully
When camping, leave no trace of your visit.

Keep to the Track
By keeping to the track, where one exists, you lessen the chance of damaging fragile plants.

Consider Others
People visit the back-country and rural area for many reasons. Be considerate of other visitors who also have a right to enjoy the natural environment.

Respect Our Cultural Heritage
Many places in New Zealand have a spiritual and historical significance. Treat these places with consideration and respect.

Enjoy Your Visit
Enjoy your outdoor experience. Take a last look before leaving an area; will the next visitor know that you have been there?

Protect the environment for your own sake, for the sake of those who come after you, and for the environment itself.

Water Care Code

Find Out First
Find out and follow the regulations governing recreational use of waterways and access. They are designed to minimise conflict between users and protect everyone's health and safety.

Stay on Established Tracks and Use Existing Facilities
By using existing facilities, where these are provided, you run less chance of disturbing wildlife and damaging riverbanks and foreshores.

Take Care of Your Gear
Careless use of equipment can harm wildlife and other users.

Remove Rubbish
Litter is unattractive, harmful to wildlife and pollutes water. Plan your visit to reduce rubbish, and carry out what you carry in.

Dispose of Toilet Waste Properly
Improper disposal of toilet waste can contaminate water, damage the environment and is culturally offensive. Use disposal facilities where provided or bury waste in a shallow hole at least 50 metres away from waterways.

Be Careful with Chemicals
Use chemicals sparingly, and refuel with care. Dispose of cooking or washing water well away from the source.

Respect Our Cultural Heritage
Many New Zealand waterways have special cultural, spiritual or historical values. Treat these places with consideration and respect.

Take Only the Food You Need
When taking food from the sea or freshwater, don't overdo it. Sustain life in our waterways by taking only what you need and no more than the legal limit.

Consider Plants and Animals
Remember we are only visitors to water environments. Other animal and plant species live there all the time.

Consider Other People
Respect other visitors … everyone has the right to enjoy the environment in safety.

Appendix 3

Set-up of data-logger and downloading information

Data-loggers were produced by the electronic technician's team in the research development and improvements division of the Department of Conservation. Antennas were made from 0.56 mm copper wire coiled 22 times around a board of nails set to create a circle 30cm in diameter. The copper wire was then wrapped in electrical tape with a 1m long 'tail' of wire left out to connect to the data logger. Antennae must maintain at a frequency of between 132500Hz and 135500 Hz (134900Hz is optimal) to accurately record PIT tags in birds passing through the antenna.

Read period was set to zero and re-read to one minute. This meant that when a tag was read it would not be read again for another minute. Different tags read in the same minute would be recorded once each also. Start time was set at 8.00 am and end time at 7.59am to record continuously across 24 hours. Data was downloaded using RFIDmobile software written by the research, development and improvements division of the Department of Conservation. Outputs detailed date, time of recording, and PIT tag numbers. Additionally detail of start and stop time, logger name and a list of all PIT tags recorded were provided (see example below).

Example of RFID data logger output box

```
RFID logger download at 08-13-2009 9:21:57 PM
Logger time: 13/08/09 21:21:39
Logger Name: Feeder1Tawh
Start Time: 0800
Stop time: 0759
Bytes stored: 5% used
Read period:  0
Sleep Period:  0
ReRead Period:  0
----------------------------------------
Feeder1Tawh,31/5,,
Feeder1Tawh,31/5,17:55, 9104738788
Feeder1Tawh,31/5,18:42, 9104738788
Feeder1Tawh,31/5,20:59, 9104738788
Feeder1Tawh,31/5,21:08, 9104738788
Feeder1Tawh,31/5,21:09, 9104738788
Feeder1Tawh,31/5,21:47, 9104738788
Feeder1Tawh,31/5,22:51, 9104738788
Feeder1Tawh,31/5,23:03, 9104738788
Feeder1Tawh,1/6,,
Feeder1Tawh,1/6,1:41, 9104738788
Feeder1Tawh,1/6,4:04, 9104738788
Feeder1Tawh,1/6,4:05, 9104738788
Feeder1Tawh,1/6,4:14, 9104738788
Feeder1Tawh,1/6,5:53, 9104738788
Feeder1Tawh,1/6,6:32, 9104738788
Feeder1Tawh,1/6,6:41, 9104738788
Feeder1Tawh,1/6,,
Feeder1Tawh,1/6,,
Feeder1Tawh,1/6,,
Feeder1Tawh,1/6,12:37, 9106577492
Feeder1Tawh,1/6,12:38, 9106449593
Feeder1Tawh,1/6,12:38, 9106577492
Feeder1Tawh,1/6,17:57, 9104738788
9104738788
9106577492
9106449593
```

Appendix 4

Example of average daily dispersal distance calculation

	Bird ID	29	33	39	50	57	66	83	85	93	95
1	17-May	50	50	50	50	50	50	50	50	50	50
2	18-May	50	50	50	50	50	50	50	50	50	50
3	19-May	50	50	50	50	50	50	50	50	50	50
4	20-May	50	50	50	50	50	50	50	50	50	50
5	21-May	50	50	50	50	50	50	50	50	50	50
6	22-May	Not	tracked								
7	23-May	50	50	50	50	50	50	50	50	50	50
8	24-May	50	50	50	50	50	50	50	50	50	50
9	25-May	50	50	50	50	50	50	50	50	50	50
10	26-May	50	50	50	50	50	50	50	50	50	50
11	27-May	50	50	50	50	50	50	50	50	50	50
12	28-May	50	50	50	50	50	50	50	50	50	50
13	29-May	50	50	50	50	50	50	50	50	50	50
14	30-May	Not	tracked								
15	31-May	Not	tracked								
16	1-Jun	50	50	50	50	50	50	50	50	50	50
17	2-Jun	50	50	50	50	50	50	50	50	50	Not found
18	3-Jun	50	50	50	50	50	50	50	50	50	5140
19	4-Jun	50	50	50	50	50	50	50	50	50	5140
20	5-Jun	50	50	5140	50	50	50	50	50	50	5140
21	6-Jun	Not	tracked								
22	7-Jun	50	50	5140	50	50	50	50	50	50	5140

23	8-Jun	50	50	5140	50	50	50	50	50	50	5140
24	9-Jun	Not	tracked								
25	10-Jun	50	50	5140	50	50	Dead	50	50	50	5140
26	11-Jun	50	50	5140	Dead	50	Dead	50	Dead	50	5140
27	12-Jun	50	50	5140	Dead	50	Dead	50	Dead	50	5140
28	13-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
29	14-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
30	15-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
31	16-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
32	17-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
33	18-Jun	Not	tracked								
34	19-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
35	20-Jun	Not	tracked								
36	21-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
37	22-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
38	23-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
39	24-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
40	25-Jun	Not	tracked								
41	26-Jun	Not	tracked								
42	27-Jun	Not	tracked								
43	28-Jun	Not	tracked								
44	29-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
45	30-Jun	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
46	1-Jul	50	50	5140	Dead	Dead	Dead	50	Dead	50	5140
	Total distance	**1750**	**1750**	**98460**	**1000**	**1100**	**950**	**1750**	**1000**	**1750**	**108590**
	Days	**35**	**35**	**35**	**20**	**22**	**19**	**35**	**20**	**35**	**34**
	Mean	**`50**	**50**	**2813**	**50**	**50**	**50**	**50**	**50**	**50**	**3194**

Appendix 5

Example of average daily feeder use calculation

		Bird ID									
Day		40	44	48	53	55	62	64	68	70	86
1	17-May	0	0	0	0	0	0	0	0	0	0
2	18-May	0	0	0	0	0	0	0	0	0	0
3	19-May	0	0	0	0	0	0	0	0	0	0
4	20-May	0	0	0	0	0	0	0	0	0	0
5	21-May	0	0	0	0	0	0	0	0	0	0
6	22-May	0	0	0	0	0	0	0	0	0	0
7	23-May	0	0	0	0	0	0	0	0	0	0
8	24-May	0	0	0	0	0	0	0	0	0	0
9	25-May	0	0	0	0	0	0	0	0	0	0
10	26-May	0	0	0	1	0	0	0	0	0	0
11	27-May	0	0	0	0	0	0	0	0	0	0
12	28-May	0	0	0	1	1	5	2	6	0	1
13	29-May	0	0	6	1	0	3	0	0	0	0
14	30-May	0	0	6	0	0	3	2	2	0	2
15	31-May	0	0	1	0	0	0	0	0	0	0
16	1-Jun	0	3	2	1	1	0	3	0	1	3
17	2-Jun	3	3	7	1	2	10	8	2	5	3
18	3-Jun	0	1	0	0	1	4	3	0	0	3
19	4-Jun	0	0	0	0	0	1	0	0	0	0
20	5-Jun	0	0	0	0	0	0	0	0	0	0
21	6-Jun	0	0	1	0	0	4	1	0	0	0
22	7-Jun	0	0	0	0	0	2	0	0	0	0

23	**8-Jun**	0	0	0	0	0	0	0	0	0	0
24	**9-Jun**	0	0	0	0	0	1	0	0	0	0
25	**10-Jun**	0	0	0	0	0	0	0	0	0	0
26	**11-Jun**	0	0	0	0	0	1	0	0	0	0
27	**12-Jun**	0	0	0	0	0	0	0	0	0	0
28	**13-Jun**	0	0	0	0	0	0	0	0	0	0
29	**14-Jun**	0	0	0	0	0	0	0	0	0	0
30	**15-Jun**	0	0	0	0	0	0	0	0	0	0
31	**16-Jun**	0	0	0	0	0	0	0	0	0	0
32	**17-Jun**	26	0	4	4	2	3	6	0	0	11
33	**18-Jun**	26	0	19	0	17	15	11	18	0	8
34	**19-Jun**	23	0	13	0	15	16	10	24	0	12
35	**20-Jun**	24	0	10	0	7	11	8	2	0	14
36	**21-Jun**	20	0	13	9	0	7	7	13	0	8
37	**22-Jun**	33	0	15	19	0	6	4	20	0	9
38	**23-Jun**	19	0	11	5	0	12	3	19	0	6
39	**24-Jun**	20	0	15	0	0	14	9	0	0	13
40	**25-Jun**	0	0	5	11	0	7	8	0	0	5
41	**26-Jun**	0	0	19	24	0	18	0	9	0	3
42	**27-Jun**	0	0	0	0	0	0	0	0	0	0
43	**28-Jun**	0	0	0	0	0	0	0	0	0	0
44	**29-Jun**	0	0	0	0	0	0	0	0	0	0
45	**30-Jun**	0	0	0	0	0	0	0	0	0	0
46	**1-Jul**	0	0	0	0	0	0	0	0	0	0
Phase 1	**Total**	**194**	**7**	**147**	**77**	**46**	**143**	**85**	**115**	**6**	**101**
	Mean	4.22	0.15	3.20	1.67	1.00	3.11	1.85	2.50	0.13	2.20

Appendix 6

Department of Conservation

High Impact Research and Collection Permit;

Cape Kidnappers Wildlife Preserve

Department of Conservation

esearch and
Permit

National Permit Number: ECHB-25413-RES
DOC File: NHS-12-12

Her Majesty the Queen, acting by and through the Minister of Conservation (the Grantor) GRANTS to Massey University (the Permit Holder) a Permit under Section 53 of the Wildlife Act (1953) subject to the details and conditions listed in Schedule One and Two.

Schedule One

(1) **Permit Holder and field assistants involved**

Jennifer Rickett

(2) **Approved activity (including approved quantities) and reasons for undertaking the research**

Inserting PIT tags into 60 brown teal (pateke) for investigating the use of supplementary feeding post-translocation for captive-bred pateke.

(3) **Approved research / collection methods**

Inserting PIT tags into brown teal before translocation

(4) **Approved Site(s)**

Cape Kidnapper's and Ocean Beach Preserve [private land].

(5) **Approved Date(s)**

12 May 2009 to 28 February 2010

Schedule Two

1. The Permittee shall pay the Concession Fee (GST inclusive) of $NIL, together with the application processing fee deposit in advance to the Grantor in the manner directed by the Grantor.

2. The Permittee shall contact the local Area Manager prior to undertaking the activity in the area, in particular to ascertain any "no-go" areas, which may include areas of concern to tangata whenua. Permission to cross private land shall be obtained from the landowner prior to the conduct of this activity.

3. This Permit does not confer on the Permittee any interest in the Site, nor does it derogate in any way from the rights of the public to use and enjoy the whole or any part of the Site.

4. The Permittee shall indemnify the Grantor against all claims by any person in respect of any injury, loss or damage (including fire damage) caused by or arising out of any act or omission of the Applicant, its servants, agents, contractors, clients or invitees, or otherwise caused as a consequence of its use of the Site or as a result of the conduct of the concession activity.

5. The Permittee shall conduct the activity in a safe and reliable manner and shall comply with all statutes, bylaws and regulations, and all notices and requisitions of any competent authority relating to the conduct of the collecting activity.

   (a) The Permittee shall prepare a contingency plan for dealing with any mishap that may occur during the operation of collecting activities under this permit, including the recovery of sick or injured persons.

   (b) The Permittee acknowledges that the Grantor accepts no responsibility for the safety of the Permittee.

6. The Permittee shall not erect or bring onto the Site(s) (or any other land administered by the Grantor) any structure, install any facility, or alter the Site(s) in any way without the prior written consent of the Grantor).

7. The Permittee shall not, unless authorised in writing by the Grantor, interfere with, remove, damage, or endanger the natural features, animals, plants or historic resources in any area administered by the Grantor, or bring any plants or animals to the Landing Site(s), or deposit debris, rubbish, or other dangerous or unsightly matter, or contaminate any body of water. The Applicant shall ensure that its clients and invitees do not carry out any acts prohibited under this clause.

8. The Permittee shall not transfer, sublet, assign or otherwise dispose of the interest granted by this Concession.

9. The Grantor may terminate this Concession if the Permittee breaches any of the terms of this document or if the activity causes any unforeseen or unacceptable effects to the Grantor.

10. The Permittee shall comply with all reasonable notices and directions of the Grantor concerning the activities conducted by the Applicant on land administered by the Grantor. While conducting this activity, the Permittee shall carry this permit with them at all times.

11. Use of aircraft in support of the Concession Activity is subject to separate approval. Vehicles shall only be operated on formed roads.

12. The Permittee shall take all waste and rubbish out of the Site and dispose of it in an environmentally sound manner away from public conservation lands. The Permittee must adhere to the Environmental and Water Care Code while conducting the activity, attached hereto.

13. Samples are to be collected away from tracks, huts, picnic areas or areas of high public use and as far as practicable, out of sight of the public. Wherever practicable, the Permittee shall use access routes to the collection areas that avoid damage to natural features.

14. The Permittee shall not collect samples from biologically sensitive areas, or in such quantities that the taking would unduly deplete the population or damage any other ecological associations.

15. All material collected shall remain the property of the Crown. The Permittee shall comply with any reasonable request from the Grantor or tangata whenua for access to any of the collected samples. Any surplus material is to be stored and the Department of Conservation is to be consulted on ultimate disposal of such material.

16. The Permittee shall not donate, sell or otherwise transfer to any third party any material, including any genetic material, or any material propagated or cloned from such material, collected under this permit, or any information obtained as a result of research done on such material or undertake any other activity with the sample not expressly approved herein; without the written permission of the Grantor in consultation with tangata whenua. Notwithstanding the preceding constraint, the Permittee may publish the results of such research results arising from the collection of the plants.

17. No material collected pursuant to this permit may be used for commercial purposes or patenting of plant varieties or registration of intellectual property rights on any derivatives.

18. Any taxon, which is new to science, shall have holotype specimens and a voucher specimen lodged with a registered New Zealand herbarium, recognised national invertebrate collection or equivalent appropriate collection. The Permittee shall notify forthwith the Grantor and local tangata whenua of any such finds.

19. Where obligations bind more than one person, those obligations shall bind those persons jointly and separately.

20. If requested, the Permittee shall keep the Grantor and tangata whenua informed on the progress of this research. Upon completion of the research, the Permittee shall forward a copy of the research findings, reports and publications to the Grantor's office from where this permit was issued. The Permittee acknowledges that the Grantor may provide copies of these findings to tangata whenua.

21. The Permittee shall comply with the activity provisions on the attached schedule at all times.

22. **Special Conditions**

SIGNED by		SIGNED by	

Dated		Dated	

KERRY P. HOGAN

ACTING UNDER DELEGATED AUTHORITY FROM THE DIRECTOR GENERAL OF CONSERVATION

("The Grantor")

AS APPLICANT

In the presence of		In the presence of	
Witness Signature		Witness Signature	
Occupation		Occupation	
Address		Address	