An Assessment of the Success of a Recently Introduced Population of Campbell Island Teal (*Anas nesiotis*) on Codfish Island (Whenua Hou Nature Reserve) and Implications for Returning Teal to Campbell Island

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A thesis submitted in fulfillment of the requirements for the degree of Masters of Applied Science in Ecology

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By

P.J. McClelland

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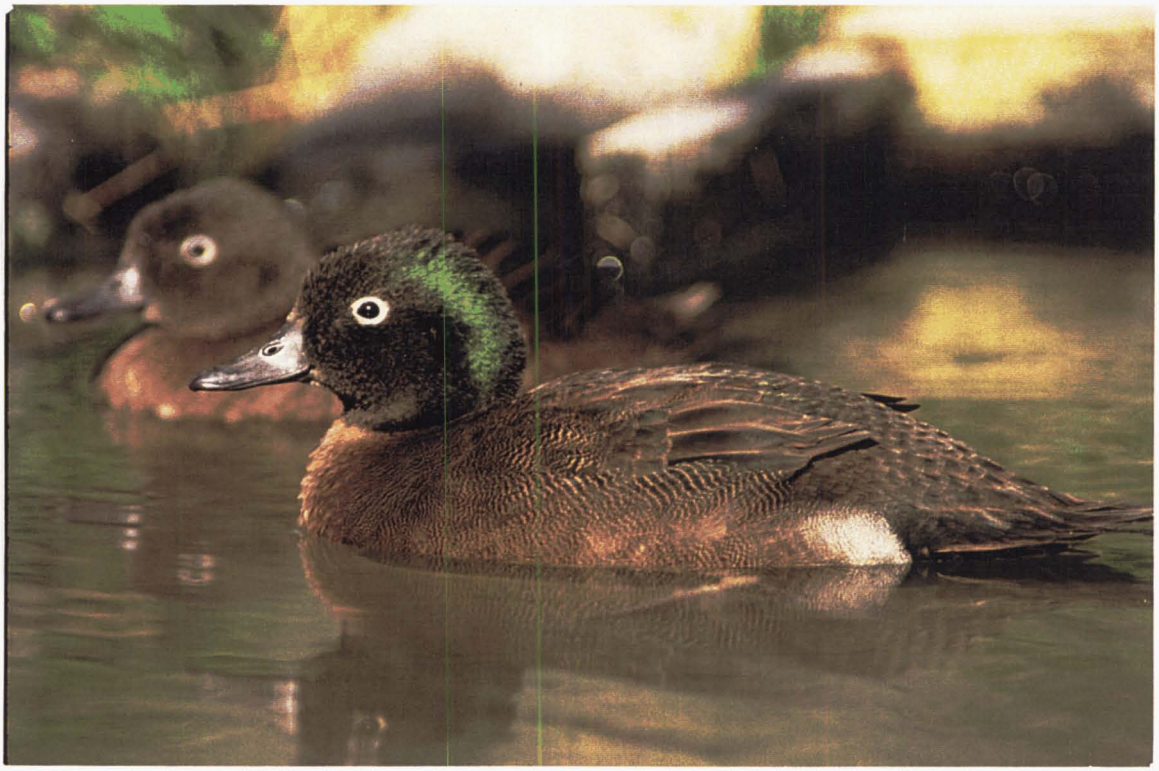
Frontispiece



Male Campbell Island Teal (*Anas nesiotis*) in breeding plumage.

Abstract of a thesis submitted in fulfillment of the requirements for the Degree of M.Appl.Sci.

An Assessment of the Success of a Recently Introduced Population of Campbell Island Teal (*Anas nesiotis*) on Whenua Hou Nature Reserve (Codfish Island) and Implications for Returning Teal to Campbell Island

by P.J. McClelland

Campbell Island Teal (*Anas nesiotis*) are a critically endangered species. The wild population in its natural range may be less than 30, although a captive breeding programme has raised more than 60 birds and the species is safe from extinction in the short to medium term.

Due to the isolation of, and the difficulty of access to, Dent Island in the Campbell Group, the sole surviving natural habitat, no detailed study of the behaviour and ecology of Campbell Island Teal in the wild has been undertaken. Although observations have been made of captive birds, the release of Campbell Island Teal onto Codfish Island (Whenua Hou Nature Reserve) provided the first opportunity to carry out a detailed ecological study of this species in the wild.

Aspects of the ecology of Campbell Island Teal (*Anas nesiotis*) were studied following two releases onto Codfish Island in 1999 and 2000, in order to assess the success of the releases in establishing a new population. A programme was designed to monitor the attempt to establish a self sustaining population of teal on Codfish Island, and to record how captive bred birds adapted to life in the wild by observing characteristics and behaviours of the teal that allowed them to establish a successful population. This information will be used to increase the chances of any future release of this species onto Campbell Island succeeding.

Birds were released at two sites on Codfish Island, with different sex and age ratios released in April 1999 and May 2000. The survival and dispersal of these birds was monitored using radio transmitters, with direct observations made on their behaviour and ecology. In these

respects, Campbell Island teal were found to be most similar to the Auckland Island Teal (*Anas aucklandica*).

During the three years of this study 24 birds were released, with individuals being monitored from one to three years. Forty two eggs were laid in 13 nesting attempts by eight different females, resulting in 36 ducklings hatched and 17 fledged. Only four adults are known to have died during this period although 11 other birds could not be located at the end of the study.

The dispersal of the birds from their release sites varied greatly, probably influenced by habitat quality, although this was not quantified. While the inability to track some individuals may mean that dispersal was greater than recorded, of those birds which could be tracked, juvenile males dispersed the farthest with three individuals moving more than 3km after fledging.

Hatching and fledging success were influenced by the age of the females and it appears that environmental factors, especially availability of suitable damp feeding areas for ducklings, were the main influences affecting fledging success.
factors

The dispersal of the teal, their habitat preferences and breeding success provide guidelines on where birds should be released on Campbell Island and the optimum age of birds to be released. The high adult survival rate and productivity of the captive bred birds indicates that, providing sufficient are released, the teal should establish rapidly on Campbell Island.

Key words – Campbell Island Teal; Codfish Island: Whenua Hou; Campbell Island; introduction; reintroduction; *Anas nesiotis;* translocation; conservation breeding biology; radio tracking.

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1 - Introduction

1.0 Campbell Island Teal

Campbell Island Teal are a small (male 371 ± 57g, female 301 ± 39g) flightless duck, which are endemic to the Campbell Island Group. They are a "dabbling" duck and feed by sieving plant matter and invertebrates from water and mud, although they have been recorded eating vegetation and seeds. (Williams and Robertson, 1996). Campbell Island Teal are largely nocturnal or crepuscular (Todd, 1996).

Campbell Island Teal are one of only four extant endemic subantarctic waterfowl, and one of only four extant flightless ducks, of which two are dabbling ducks.

1.1 Taxonomy

The evolution of the New Zealand Teal from the continental forms (Grey and Chestnut Teal) to the small island forms (Auckland and Campbell Island Teal) has been discussed by Williams *et al.* (1991), who compare morphological, ecological and behaviour characteristics of the five species.

Campbell Island Teal were initially described as a separate genus to both Auckland Island and Brown Teal (Fleming, 1935). They were later combined with Auckland Island Teal, with both being considered a subspecies of the New Zealand Brown Teal (Delacour & Mayr, 1945). It was not until 1946, following the capture of a second specimen, that Campbell Island Teal were recognised as a separate sub-species (Marples, 1946). During the following years various authors debated the status and relationship of the so-called Austral Teal (Delacour, 1956), namely Brown, Auckland and Campbell as well as Chestnut (*Anas castanea*) and Grey (*Anas gracilis*) Teals, with Marchant & Higgins (1990) separating the Campbell Island and Auckland Island Teal into different species. This separation was later supported by genetic studies.

Daugherty *et al.* (1999), using starch gel electrophoresis of blood proteins, have shown that the three populations are separate enough to each warrant full species status, and that the two subantarctic species were derived from two separate parallel colonisations direct from the New Zealand mainland i.e. from Brown Teal. Kennedy and Spencer (2000) used mitochondrial DNA to further confirm that the Campbell Island and Auckland Island Teals were separate species from Brown Teal and that all three had split off from the Chestnut Teal,

or more precisely their earlier shared ancestor, the Grey Teal, before colonising the two subantarctic island groups. However, they could not differentiate whether they were sequential or separate introductions from the New Zealand mainland. Comparisons in this paper, therefore, will be made between Campbell Island Teal and the more closely related Brown and Auckland Island Teals but not with Chestnut or Grey Teals.

Campbell Island Teal are closely related, and physically similar to, the flightless Auckland Island Teal which are endemic to the Auckland Islands, and to the New Zealand Brown Teal (*Anas chlorotis)* which is now restricted to remnant populations on Great Barrier Island and in Northland. These three species comprise the endemic New Zealand teals.

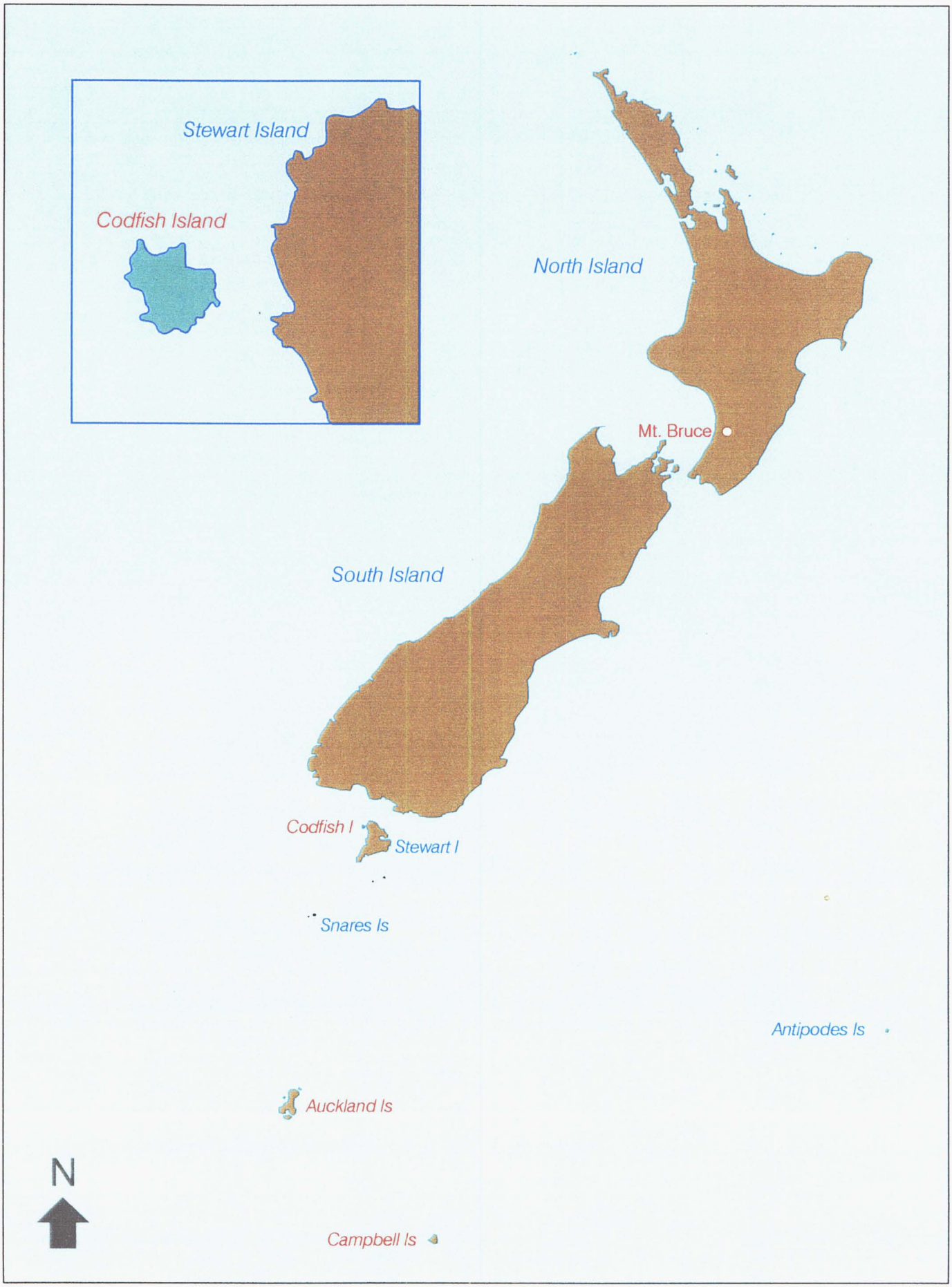
1.2 Dent Island – the last refuge

Since its discovery in 1886 until 1975, only 2 specimens of Campbell Island Teal had been collected, with very few additional sightings. The rediscovery of the species on Dent Island in 1975 led to the current recovery programme. The discovery and history of the species up to 1996 is covered in full by Williams and Robertson (1996) with more recent events by Gummer and Williams (1999).

It is likely that Campbell Island Teal were confined to Dent Island from soon after the discovery of Campbell Island in 1810, as rats (*Rattus norvegicus*) are known to have been well established by 1868 (Miskelly, 2000). The fact that no teal were observed by the James Clark Ross expedition in 1840 (Williams and Robertson, 1996) indicates that the teal were already very rare or extinct on the main island by this time. The sighting of teal at Campbell Island's Northwest Bay on at least one occasion shows that the birds could swim the 3km to the main island, but their failure to reestablish there is attributed to the continued presence of rats and cats (*Felis catus*) (Williams and Robertson, 1996).

All of the islets around Campbell Island which are believed to have sufficient habitat to hold even a small population of teal have been visited during the 25 years following the species' rediscovery but no other teal populations have been found. This means that the sole remaining population on Dent is likely to have been isolated for over 150 years.

Fig. 1: Map of New Zealand showing locations important to the Campbell Island Teal recovery programme.



Estimates of the size of the Dent Island population, which have been based on a range of survey techniques and encounter rates, as well as on calculations of the amount of available habitat, have varied significantly since the rediscovery of Campbell Island Teal. However, even the most optimistic estimate is less than 100 (McClelland, 1993) and possibly much less than 50 (Robertson, 1976 and Carroll, 1997) (Table 1). The low encounter rate on the island is likely to reflect both search effort, with most estimates done while the people involved were attempting to catch birds for the captive breeding programme, and observability, as it is nearly impossible to see teal under the tall tussocks, which dominate the ridges on the island.

TABLE 1: Population estimates of Campbell Island Teal on Dent Island.

Date of visit	Reference	Population estimate
1975	Robertson, 1976	30 –50 individuals
1984	Williams and Garrick, 1984	Less than 30 –50
1990	McClelland, 1993	Less than 100 (based on suitable habitat available)
1990	Goudsward, 1991	60
1996	Williams and Robertson	25-30 pairs plus some unattached birds, (based on available habitat
1997	Carroll, 1997	Very low- based on low encounter rate with trained locator dogs

The low numbers and very limited distribution of Campbell Island Teal have meant that it has been classified as endangered since its rediscovery. It is currently ranked as nationally critical (i.e. a population of < 250 mature individuals.), conservation dependent (i.e. likely to become extinct, if current management ceases), with only one location and a human induced distribution (Molloy *et al.*, 2001). Their status is unlikely to change until they have stable populations on at least two islands. This contrasts with Brown Teal, which are listed as nationally endangered, and Auckland Island Teal which are listed as not threatened although both species also have a human induced distribution.

Mini satellite DNA profiling was used to assess the genetic relationships of all wild caught birds in captivity. Nine birds shared 86 % of the bands appearing in their fingerprints, showing, as one would expect in a population of this kind, a high level of background

relatedness and suggesting that the Dent Island population was itself sourced from a very small number of founders (Lambert, 1997).

1.3 Previous research

As the isolation and rugged nature of Dent Island, along with the low numbers of teal, have prevented any effective study of the birds in the wild, the only prior research on the species had been carried out in captivity. Preddey (1995b) carried out an extensive study on Campbell Island Teal at the National Wildlife Centre, Mt Bruce, between 1993 and 1995. This behavioural study included observations of vocalisations, interactions, displays and breeding, which were compared to the other New Zealand and Australian teals and added greatly to the knowledge of the bird and it's breeding in captivity. Prior to 1994, when the first breeding in captivity occurred, no Campbell Island Teal eggs or ducklings had ever been seen.

As Auckland Island Teal had long been believed to be closely related to Campbell Island Teal, and are relatively common and easy to access in the wild, they have been used as an analogue species to obtain information required for the management of the Campbell Island Teal (Williams, 1997). The use of Auckland Island Teal as an analogue included studies of their habitat requirements in order to identify suitable islands for Campbell Island Teal introductions (Williams, 1992, 1997).

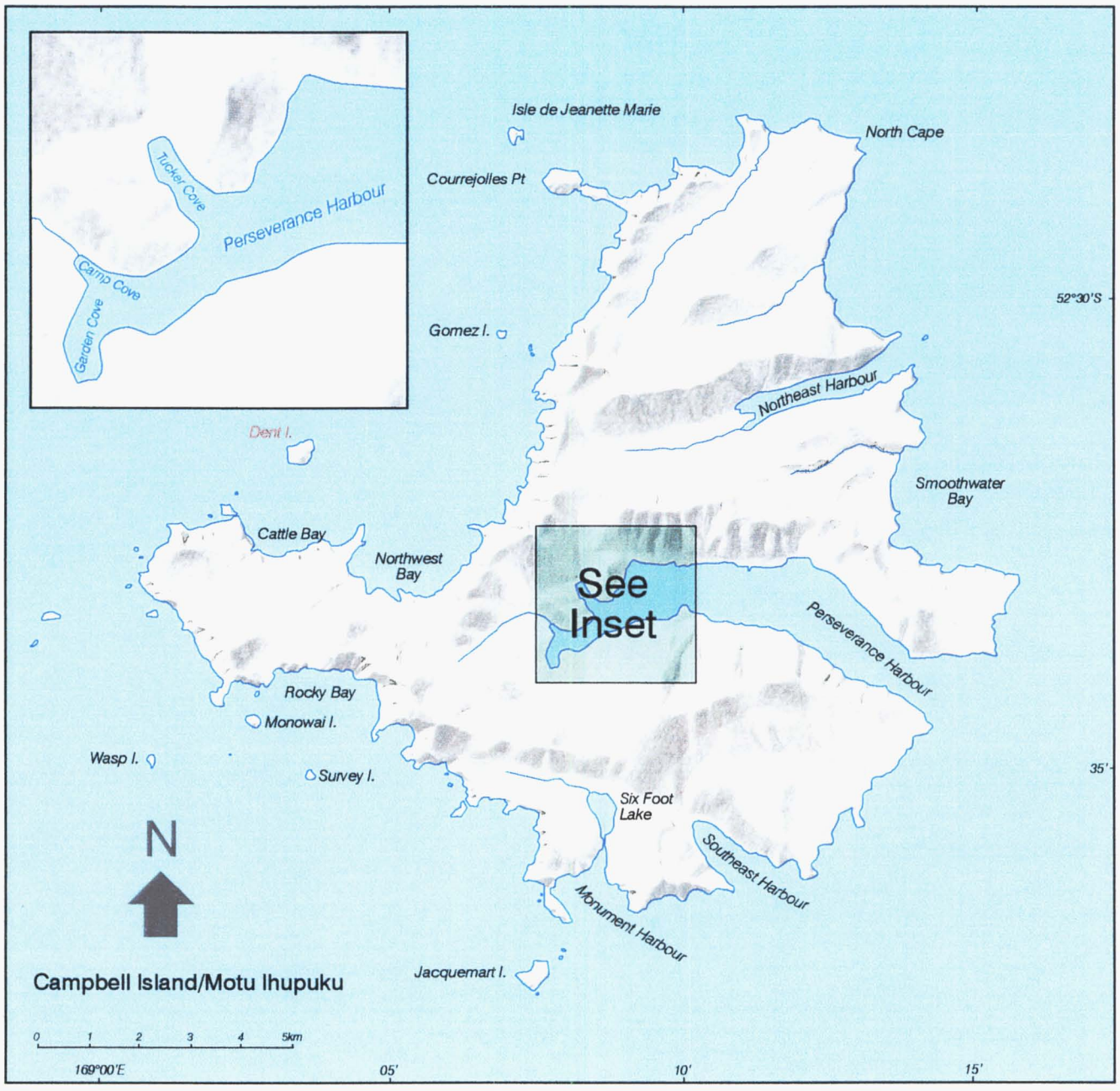
1.4 Habitat descriptions

1.4.1 Campbell Island

Campbell Island (Fig. 1) is situated 700km south of Bluff, New Zealand at 52^0 35' S and 169^0 10' E, and, along with its outliers, covers approximately 11300 ha. It is primarily covered in tussock grasses (*Poa spp*), with areas of megaherbs, (*Stilbocarpa polaris, Bulbinella rossii, Anistome latifolia, Phleurophyllum spp*) and *Dracophyllum spp*. The entire island was grazed by sheep until 1970, at which time eradication began. The last sheep were removed in 1991, which has allowed a dramatic increase in both the megaherbs and, more significantly, the *Dracophyllum* shrublands, which is rapidly recolonising many of the less exposed sites on the island.

The coastline ranges from sheer cliffs, exposed boulder beaches and rocky wave platforms, to sheltered harbours with gravel beaches and tidal mudflats, and a single sandy beach. The freshwater habitats consist of a range of streams, many of which are tidal in their lower reaches, and a single brackish lake (Williams and Robertson, 1996).

Fig. 2: Map of the Campbell Island group showing the location of Dent Island.



Potential predators of teal present are Brown skua (*Catharacta skua*), Black-backed gull (*Larus dominicanus*), and Northern giant petrel (*Macronectes halli*), although the latter is unlikely to be a significant predator of teal.

1.4.2 Dent Island

Dent Island is a steep sided, (from 25^0 to near vertical), islet, three km off the northwest coast of Campbell Island and just outside the relative shelter of Northwest Bay (Fig. 2). At 26 ha it is the largest of Campbell Island's outliers rising to 200m and predominantly covered in tussock (*Poa litorosa*) up to one metre in height, with *Poa foliosa* and megaherbs in the damper gullies and slip scars (Williams and Robertson, 1996). The coastline consists entirely of steep rocky slopes with a narrow band of Bull kelp (*Durvillea antarctica*) in the tidal zone. The only realistic access to the coast is via a steep rocky slope on the southeastern face. Standing water on the island is restricted to several small soaks along the gullies. These areas are also the preferred burrowing sites for White-chinned petrel (*Procellaria aequinoctialis*), the burrows of which usually have a water filled depression at their entrance which provides additional feeding areas for the teal. In addition to the White-chinned petrel there are a range of smaller seabirds, whose burrows honeycomb much of the island and provide refuge for the teal (Williams and Robertson, 1996). The northwestern side of the island is almost vertical and largely devoid of vegetation.

Any assessment of habitat use by teal on Dent Island would have been likely to have given a poor picture of the potential habitats that they may occupy, due to the limited standing water and very limited access to the coast.

1.4.3 Auckland Island Teal and Brown Teal habitats

Auckland Island Teal are found in a wide range of habitats, with the highest densities being found in Boat Bay, Ewing Island where the teal feed on the amphipods associated with a large build up of seaweed which washes ashore there. Teal are also found on various sheltered rocky coastlines, tidal mudflats, wave platforms and inland waterways. A study on Rose Island (Williams, 1997), found that even the birds which live in the middle of this 75ha island move out to the coast under cover of darkness to feed, and that most, if not all the teal, depend heavily on access to the coastline for food. The only likely exceptions are on 375ha Disappointment Island, where the teal which inhabit the higher slopes of the island have no easy access to the coast or any significant water source (Williams, 1997). However, this island has a very high density of burrowing seabirds (Williams, 1996), and it may be that arthropods

associated with them replace the need to forage on the coast. Auckland Island Teal are not present on the main island due to the presence of pigs and cats (Moore and Walker, 1991).

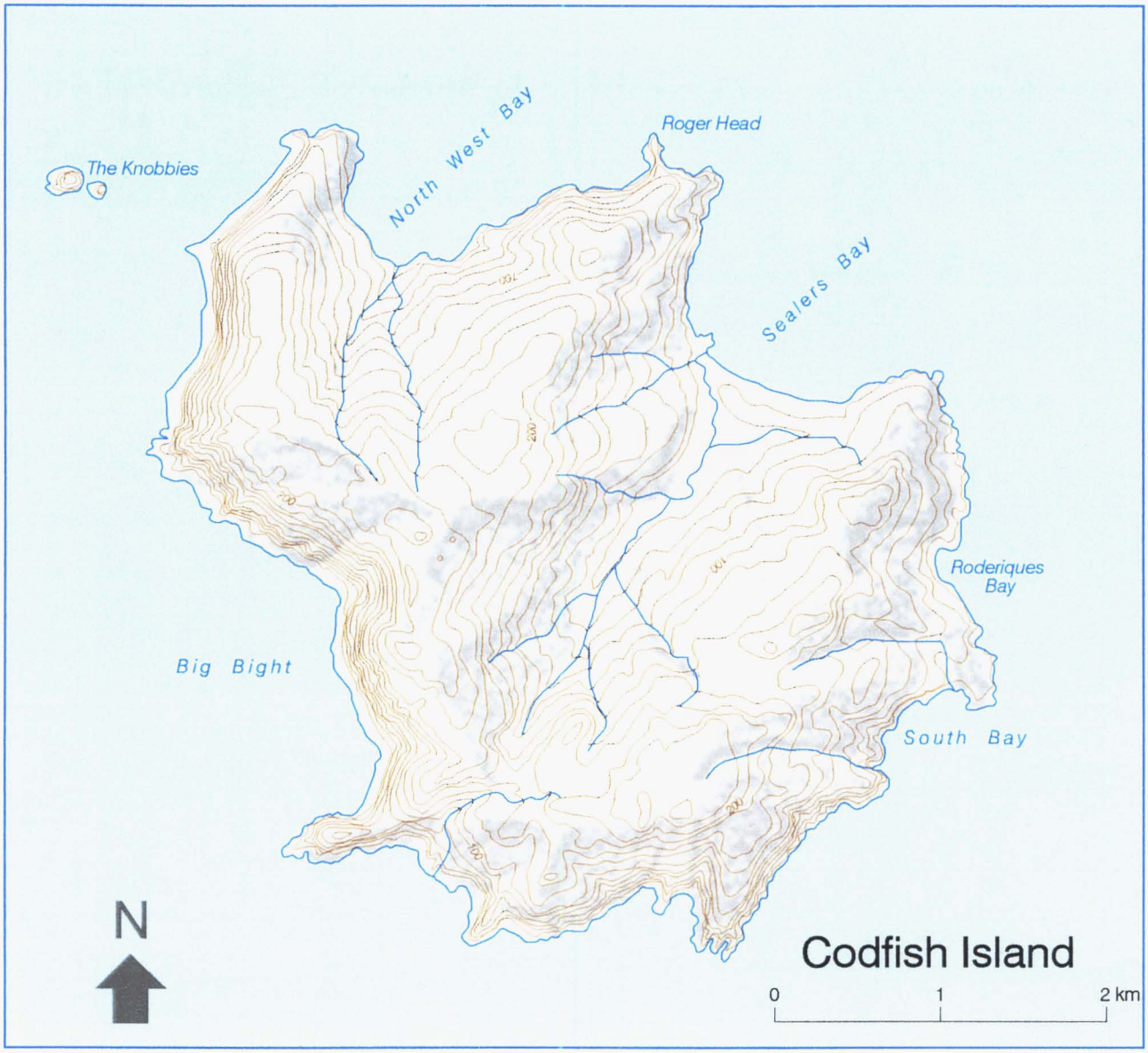
By the time of European settlement the range of Brown Teal had been greatly reduced from that shown in the fossil record (Hayes, 1981; Worthy, 2002). At this time they were found on the mainland on still or slow waters and made extensive use of the swamp forests and flax (*Phormium tennax*) covered margins (Williams, 1984) appearing to avoid the open water. The current populations utilise slow flowing streams, particularly in the tidal areas, and feed in boggy pasture or estuaries (Dumbell, 1987; Todd, 1976).

1.5 Study area - Codfish Island/ Whenua Hou

Codfish Island (Whenua Hou Nature Reserve) is situated 3km west of the northwest tip of Stewart Island. At 1396 ha it is the largest island outside of the Fiordland area, in a relatively natural state, in southern New Zealand. It is largely forested with podocarp/kamahi (*Podocarpus* and *Dacrydium spp /Weinmannia racemosa*) forest, with areas of pakihi (wetlands containing low shrubs) on the tops and "muttonbird scrub" (dense *Brachyglottis rotundifolia*) on the exposed slopes. There are several large seabird colonies, mostly sooty shearwater, (P*uffinus griseus*) and mottled petrel (*Pterodroma inexpectata*), primarily on the eastern and southern slopes. These colonies are dry in comparison to the white-chinned petrel colonies on Dent (pers. observation, 20 October 1999). Codfish Island has a cool temperate climate with moderate rainfall (mean 1595mm).

There are two main catchments on Codfish Island, the largest of which divides the island roughly in half and runs from the west to meet the sea at Sealer's Bay. The other stream flows out into Northwest Bay and is significantly smaller. Sealer's Bay on the east side of the island contains the only dune system on the island with a gently sloping sandy beach running north-south for approximately one km. While there are two other areas of sand exposed at low tide, (Northwest Bay and Roderiques Bay), most of the coast is sloping rock platforms and boulder beaches, the latter often at the base of a steep slope and with a band of Bull kelp (*Durvillea willana* and *D. antarctica*). Relatively little seaweed collects on any of the coastline and even the heavy concentrations of seaweed which can occasionally be found in some bays can be quickly swept clean by storms and hence rarely allow the build up of amphipod populations.

Fig. 3: Map of Codfish Island.



Sealer's Bay has the only semi-permanent standing water on the island with two dune ponds in the forest that vary greatly in size depending upon recent rainfall. Roderiques pond has an outflow which is frequently dry over at least parts of its length and flows out to the sea at the east end of Sealer's Bay while Norton's pond has no surface outfall.

The Sealer's Bay catchment also has the New Forest stream, a small, low gradient tributary, which runs parallel to the coast, meandering through the forest behind the dunes. During periods of little rain this stream can be as small as 50cm across, and in places dries up entirely, however following heavy rain an area of over 50m wide can be flooded. The same is true for the Sealer's Bay stream where, during spring tides and heavy rain, the stream can be over 100m wide and 50cm deep up to several hundred metres from the coast. None of the other streams are as prone to flooding, being more tightly contained within steeper banks and flowing straight into the sea without a sizeable area to backup into. The Sealer's Bay stream has a small sandy estuary at its mouth, with the shape of the river altering significantly depending on flows and recent sea conditions.

There are currently no introduced predators on Codfish Island and native predators are limited to Black-backed gulls (*Larus dominicanus*), morepork (*Ninox novaseelandiae*) and longfinned eel (*Anguilla diffenbachii*). Brown Teal were formerly present on Codfish Island but were last recorded in 1953 (Flemming, 1953). There was a possible sighting of Brown Teal on Codfish Island in 1994 (R. Cole, pers. comm., 20 July 2002). It is likely that the Brown Teal were a satellite population of the Stewart Island birds and that they died out when they could no longer be supplemented with birds from there.

1.6 Recovery planning and the captive breeding programme

Species recovery plans are used by the Department of Conservation to define the goals and objectives for the conservation of a species. A plan was approved for Campbell Island Teal (McClelland, 1993) which had set as its long-term goal the reintroduction of teal to Campbell Island. However, to protect the species in the shorter term it was determined that a captive population should be established. This took place with the capture of 11 birds (7 male and 4 female) during three expeditions between 1984 and 1990. In 1994 after 19 pair years of trying, the first ducklings were produced and since then in excess of 60 ducklings have been produced in captivity.

At the time of writing the recovery plan, the long-term aim of reintroducing the teal to Campbell Island appeared to be unlikely to be achieved in the near future. Holding the teal in captivity for a prolonged period raised the issue of a multigenerational captive population, which could have problems adapting to living in the wild (weather, predators, locating food, etc) when the opportunity for reintroduction finally eventuated. To avoid this, the recovery plan stated that a temporary population would be established on a "holding" island to allow birds to adapt and breed in the wild and hence increase the chances of success of any release onto Campbell Island. This population would also fulfill a shorter-term objective of the recovery plan, which was to establish a second island population as a backup to Dent Island until the teal could be released on Campbell Island.

The establishment of a population of Campbell Island Teal on a holding island was important for the following reasons:

- to establish a safe wild population of teal as a safeguard for the species prior to their reestablishment on Campbell Island;
- to provide information on teal survival, productivity, behaviour and habitat use on the holding island, relative to the age and sex ratio of the release birds and habitat at the release site, that allowed them to establish a successful population. This information would help maximise the chance of the Campbell Island release succeeding;
- to acclimatise birds to the wild prior to release on Campbell Island;
- to maximise the number of teal available for release onto Campbell Island.

"Marooning" on islands has long been considered a desirable option for preserving species prior to the long-term aim of restoring them to their former habitat (Williams 1977). It is only suitable for species with limited ability to disperse and requires an island suitable for their mid to long term survival.

All suitable New Zealand islands, free from mammalian predators and outside the current Brown Teal range, were considered for the introduction of Campbell Island Teal. Although guidelines for selecting suitable islands for the introduction of threatened species are available, including Craig and Veitch (1990), none was used in the selection process for Campbell Island Teal. By a process of elimination, including onsite inspections of several islands, Codfish Island was considered to be the best option, even though its habitat was very

different from Dent, Campbell Island and islands in the Auckland group which have teal present.

The criteria islands had to meet to be judged suitable for Campbell Island Teal included: large seabird colonies; sheltered bays with significant seaweed buildup or shallow tidal areas. Codfish Island did not provide these, but it did have a range of freshwater and coastal habitats, was free of introduced predators and was large enough to hold a significant number of birds.

1.7 Release onto Codfish Island

Two sites, Sealer's Bay and Northwest Bay, were selected for the releases onto Codfish Island. Penguin Bay, a small bay immediately west of Sealer's Bay, and only separated by a headland approximately 60m wide, was initially deemed a separate site, with one pair released there in 1999. Its close proximity to the Sealer's Bay site and the constant movement of birds between these two sites soon showed that it was effectively part of the Sealer's Bay site and will be treated as such in this thesis.

The first release in March 1999 consisted of 12 teal, eight female and four male with half of each sex being released at each site. The sex ratio was determined by the availability of suitable birds from captivity, not any desired release ratio.

In April 2000 a further 12 birds (eight male and four female) were released. To balance the sex ratio from the previous year, only two males and no females were released at Northwest Bay while six males and four females were released at Sealer's Bay. The decision not to release more birds at Northwest Bay was based partially on the difficulty of monitoring the birds there and also by the fact that more females had attempted to breed at Sealer's Bay.

An important factor for planning the reintroduction to Campbell Island is the age of birds used in the release. Birds with as wide a range of ages as possible were released on Codfish Island to determine if age affected survival, productivity or dispersal. The birds were as evenly balanced as possible between first year birds and older birds, up to five years old. (Table 2)

Fig. 4: Map of Codfish Island showing locations of 1999 and 2000 Campbell island Teal releases.

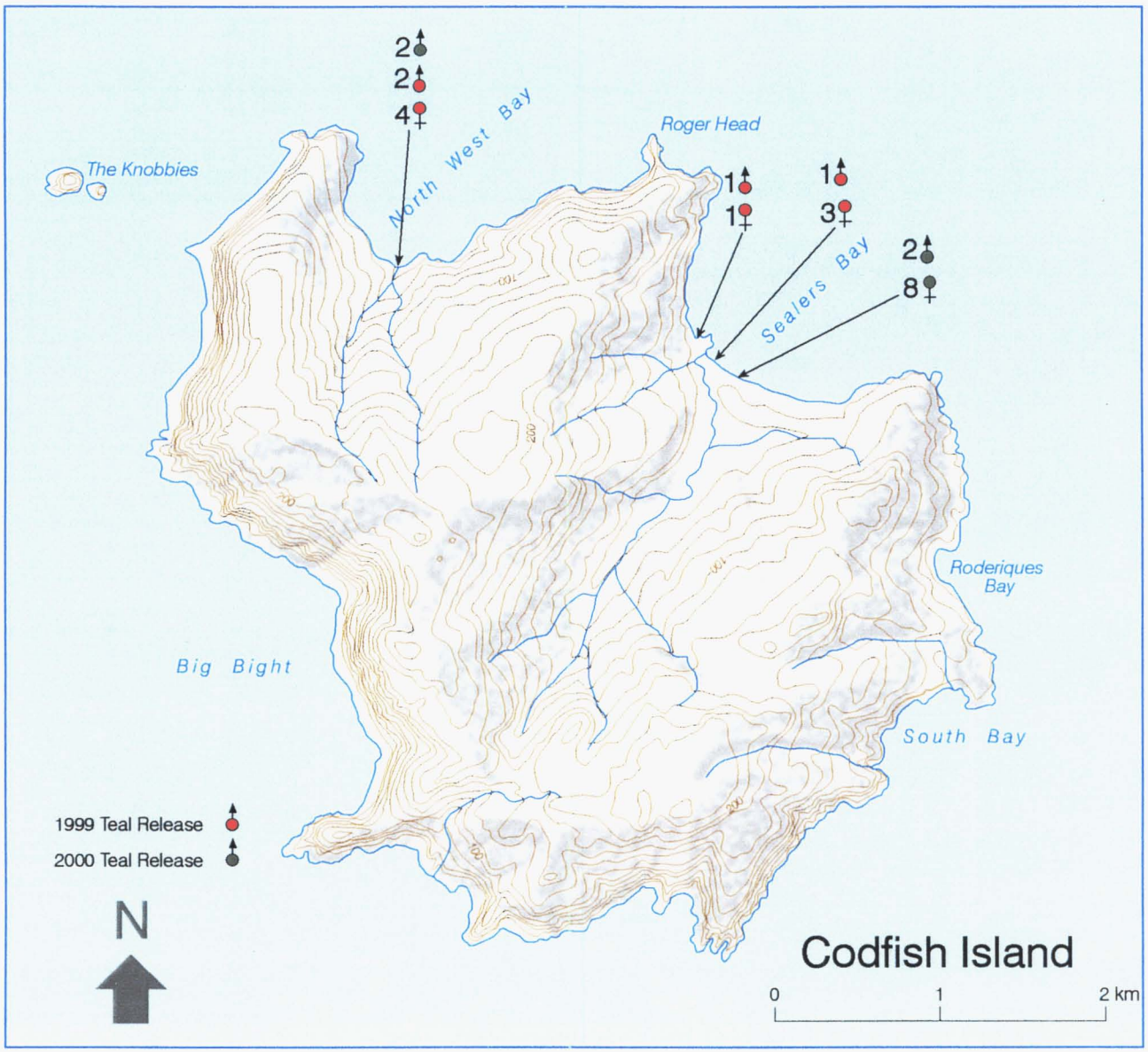


TABLE 2: The ages of Campbell Island Teal released on Codfish Island

		1999		2000		Total by site		Overall Total	
	Age of birds	Male	Female	Male	Female	Male	Female	Male	Female
Sealer's Bay (incl. Penguin Bay)	< 1 yr	1	2	3	2	4	4	5	7
	1-2 yr		1				1	1	1
	2-3 yr	1	1			1	1	2	2
	3-4 yr			2		2		3	
	4-5 yr			1	1	1	1	1	1
	5-6 yr				1		1		1
Northwest Bay	< 1 yr		3	1		1	3		
	1-2 yr	1				1			
	2-3 yr	1	1			1	1		
	3-4 yr			1		1			
	4-5 yr								
	5-6 yr								
Total		4	8	8	4	12	12	12	12

Birds were held in aviaries at the release site for up to 14 days to allow them to regain the weight lost during their transfer but they were not supplementary fed after release. The birds were transported from Mount Bruce (Fig. 1) by plane to Invercargill and then to the island by helicopter. Details of the releases are covered in Gummer (1999) and Barlow (2000a).

The release site for each bird was based on the desired sex ratio at each site and the order in which birds were ready for release, i.e. had regained any weight lost during transfer. Where possible, the birds to be released at each site each year were released at the same time to minimise the risk of dominance being established simply on order of release.

1.8 Thesis justification and objectives

Rationale for studying the release of Campbell Island Teal on to Codfish Island.

The aim of this research was to collect information on the demography, ecology, behaviour and breeding biology of wild Campbell Island Teal on Codfish Island and use this information to:

- evaluate the success of the Codfish Island release;
- identify key issues of relevance to the plan to release Campbell Island Teal on Campbell Island.

The objectives were to:

- Obtain information on the demography, ecology and behaviour of Campbell Island Teal following release onto Codfish Island by monitoring:
  - Survival
  - Dispersal
  - Habitat preferences
  - Productivity

- Compare the survival, dispersal and productivity of teal in two different habitats, and between birds of different ages and lengths of time in the wild.

- Evaluate the value of information gained in the release of Campbell Island Teal on Codfish Island in predicting the likely success of their planned release on Campbell Island and to provide guidelines to enhance the success of the Campbell Island release.

The very limited amount of research carried out on Campbell Island Teal to date meant that the top research priority for the long-term management of the species was a general study into the natural history of the species. Research of this nature is necessary as the first step in confirming the cause of decline of a species and prescribing its antidote (Caughley 1994). As such it lacks the quantitative nature of a study into a species about which more is initially known.

2 METHODS

2.1 Observations

2.1.1Observation periods

Observations were made by the author or assistants from April 1999 to April 2002 (Table 3).

TABLE 3: Periods during which the Campbell Island Teal on Codfish Island were monitored.

Start of period	End of period
2 April 1999- first release	26 April 1999
15 May 1999	26 May 1999
22 June 1999	1 July 1999
19 Aug 1999	31 Aug 1999
13 Oct 1999	2 Nov 1999
11 Nov 1999	2 Feb 2000
29 Feb 2000	16 Mar 2000
21 Mar 2000	28 Mar 2000
10 May 2000 – second release	19 June 2000
1 July 2000	25 July 2000
29 Oct 2000	9 Nov 2000
23 Nov 2000	26 Mar 2001
15 Aug 2001	29 Aug 2001
26 Nov 2001	18 Dec 2001
9 Jan 2002	20 Feb 2002
17 April 2002	26 April 2002

2.1.2 Timing of monitoring

All the birds were monitored sporadically for the year following their release with intensified effort, especially for the females, during the breeding season in an attempt to record laying, hatching and early duckling survival, although observer availability was also a factor. There were also opportunistic observations carried out by DoC staff members on the island, particularly during the first year of the study. Continued monitoring after the first year relied on the capture of birds to have their transmitters changed before the batteries ceased functioning.

2.1.3 Carrying out observations

Outside the breeding season the daily routine was to locate as many of the birds as possible and record their location and behaviour. If a bird could not be located on any given day it was given increased priority for the following days. Due to travel time, tidal constraints and the lower number of birds, tracking was not carried out as frequently at Northwest Bay as at Sealer's Bay. Once a bird was located it was observed for as long as was practical. If a bird was simply roosting with no other birds in the vicinity and this behaviour was unlikely to change, e.g. it was the middle of the day, observations would cease after two to five minutes.

If the bird was moving or interacting with other birds, observations would continue in order to record as wide a range of behaviours as possible. During the breeding season sighting of all ducklings was attempted every day, unaccompanied females every two-three days and males once a week. When possible, two observers were used to obtain accurate counts of ducklings, since the female and ducklings could very quietly be herded either past one observer or into more open country where the birds could be seen.

Binoculars were often required to confirm the identity of birds from their colour bands, particularly when more than one bird was present in the same vicinity. Binoculars were also beneficial when watching birds in more open areas, e.g. the Sealer's Bay estuary, so that observations could be carried out without disturbing the birds by approaching them.

2.1.4 Recording Observations

Once a bird was located, its location, habitat type and, if the bird could be seen, current behaviour, were recorded, either directly onto the data sheet (Appendix 1) or into a notebook to be transcribed onto a data sheet later. This data was later entered into an Access database. Behaviour was divided into the following categories: loafing, travelling (disturbed, i.e. movement caused by the observer, or undisturbed), preening/bathing, incubation, feeding, alarm, interaction with other birds and anything else. The last four all required the observer to record additional details about the behaviour, e.g. food type or what other birds were present. The weather at the time of the observation was also recorded. If the behaviour changed this was recorded, otherwise only a single record was made for each encounter. Instructions were supplied to all observers to ensure standardisation of records (Appendix 2).

As the standard NZMS map grid reference did not allow the precision desired for recording the locations, two specialised systems were used:

a) the island was broken into 14 blocks (Fig 5) which provided information on movement between sites;
b) a grid of approximately 6m x 6m squares was laid over the Codfish Island topographical map and this was used to give exact locations with a simple two letter/number code and was used for determining smaller scale movements (Fig 6).

Fig. 5: Map of Codfish Island showing blocks used to record the locations of Campbell Island Teal.

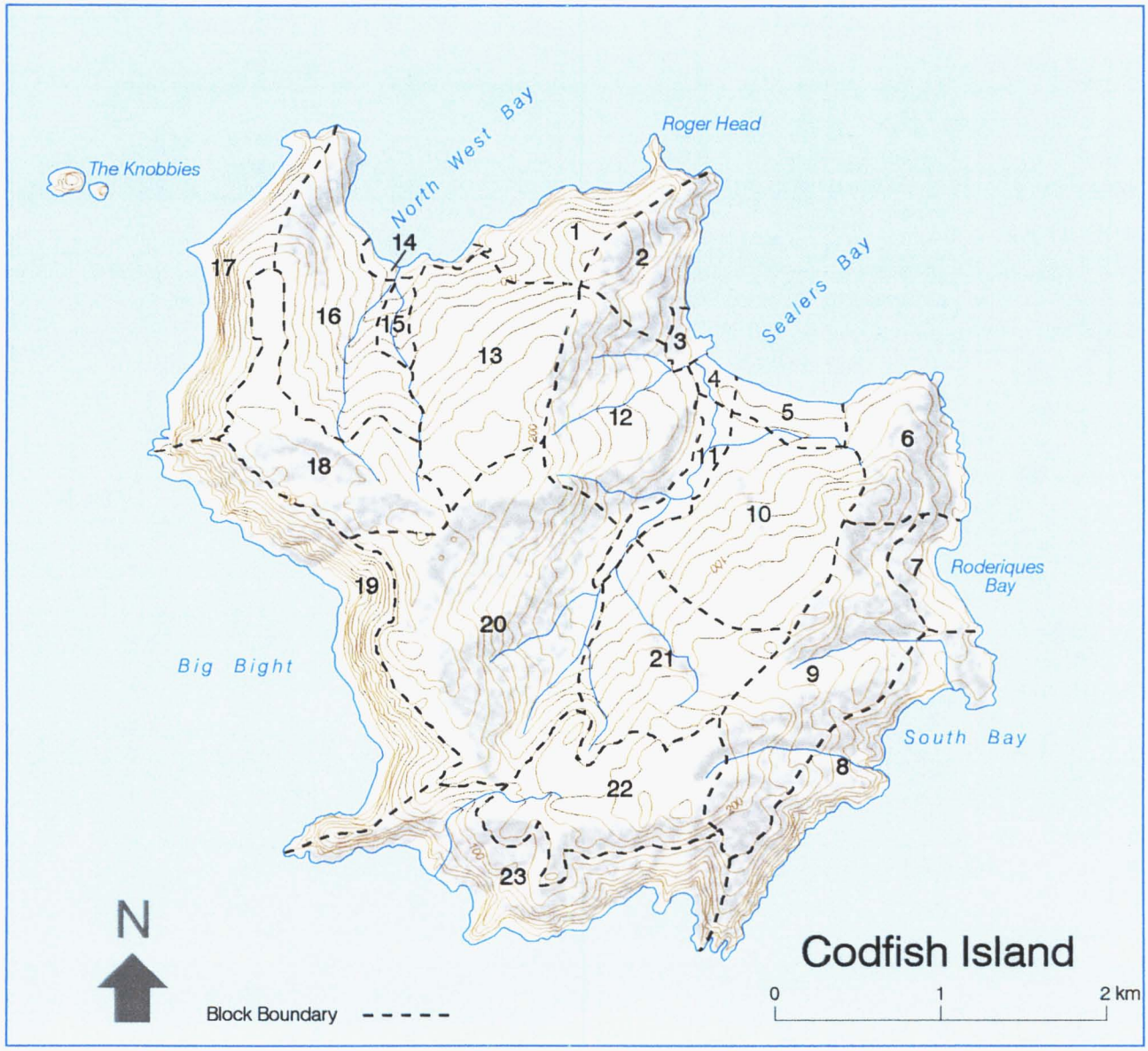
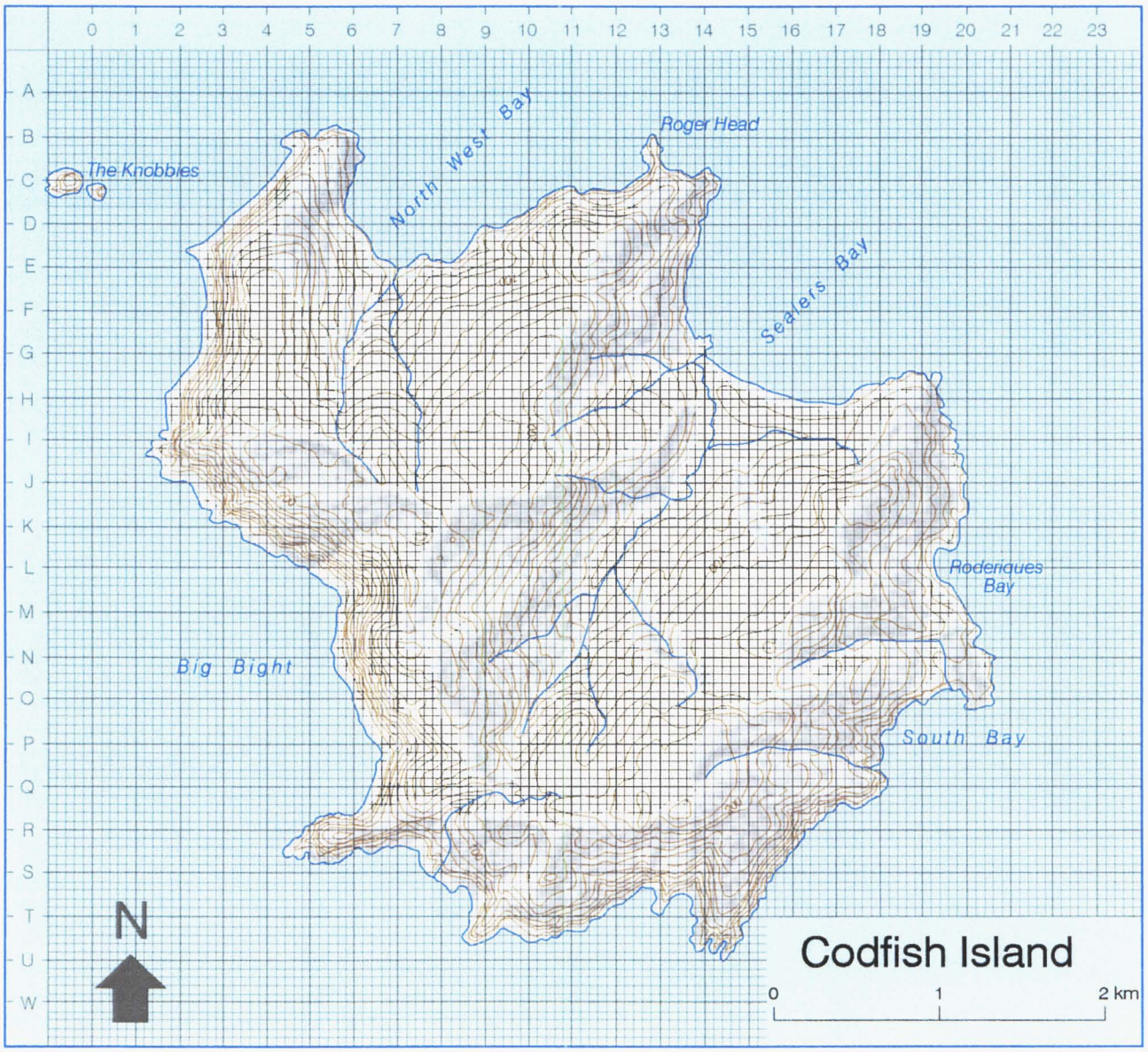


Fig. 6: Map of Codfish Island showing grid squares used to record locations of Campbell Island Teal.



2.2 Access to sites

The main sites, Northwest Bay Stream and Sealer's Bay, were accessed via the well established track network on the island (Fig. 7). The signal from the birds could frequently be detected from the main tracks but if the observer could not locate a signal they would then check known teal sites, for example the dune ponds, around the coast and up the streams. While access to most sites at Sealer's Bay was physically possible at all times of the day or night, safety requirements meant that access to steeper country was largely restricted to the daylight hours. This was the case for most of Northwest Bay, where the country away from the stream was too dangerous for night observations. Access around the coast at Northwest Bay was only possible at mid to low tide or through steep bushed terrain, which was often hazardous. Dense areas of undergrowth, most notably water fern (*Histiopteris incisa*), made observations of teal impractical at some sites.

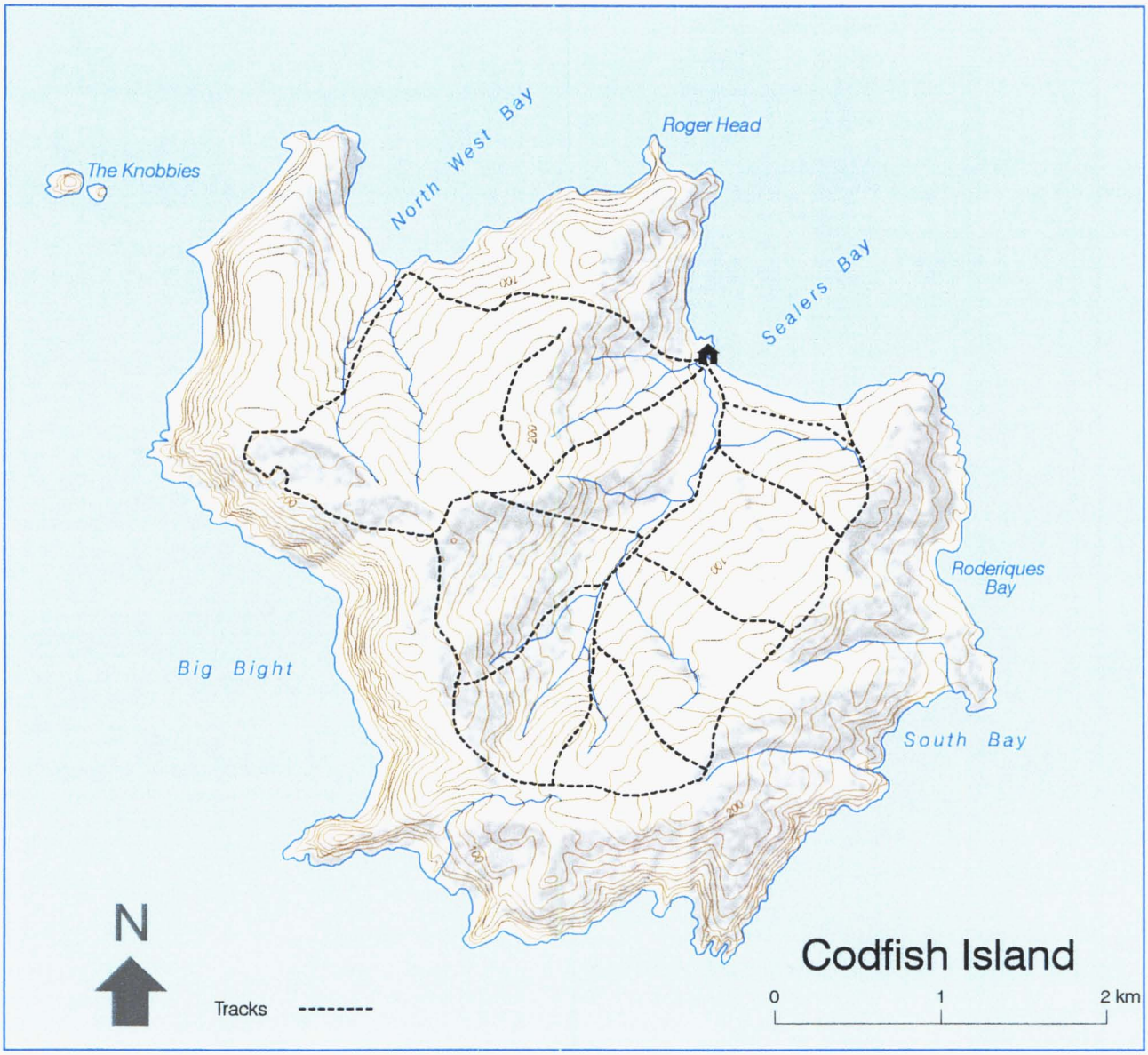
2.3 Radio tracking

Radio transmitters were attached to all released birds to monitor their survival and dispersal. The transmitters were custom-built backpack (model TPI273) radio transmitters manufactured by Sirtrack®. They were a single stage transmitter, with long life option pulsing at 25 beats per minute, running on an EPX76 cell which gave a normal life expectancy of 16 months, although this was reduced to 12-14 months by the cooler temperatures encountered in southern New Zealand. The transmitters had a 180mm whip antenna, and were harness mounted using two loops around the chest and abdomen. The harness was a Sirtrack® adaptation of one designed by Karl and Clout (1987). A standard handheld TR4 receiver manufactured by Telonics, Arizona USA and collapsible three element Yargi aerial were used to track the birds. All teal were assigned their own individual transmitter frequency, which ranged from 10 to 98 kHz on the 160 band.

As many birds as possible were recaptured in March/April each year to change their transmitters. At this time any juveniles which could be caught also had transmitters attached. The greatest effort was put into catching females and unbanded juveniles as these were the most important individuals for monitoring the productivity of the population. Birds were located and caught by using a combination of radio tracking, a certified teal locator dog and a team of three to five people using hand nets and, for birds on the streams, wader nets slung across the stream

When first attempting to locate a specific teal, tracking began at the site where they were last recorded and then at suitable sites up to 100m away. If the bird was not located, sites

Fig. 7: Map of Codfish Island showing access tracks.



previously frequented by the bird were checked. If this also failed, the bird's transmitter frequency would be tried at suitable locations while trying to find other birds.

The distance over which a transmitter could be detected varied greatly depending on the habitat. When in open country, e.g. the Sealer's Bay beach, a signal could be picked up from up to 500m away. The other extreme was birds among the large boulders at Northwest Bay, where on at least one occasion a signal could not be detected from less than 20m as it was being shielded by the rocks. Under normal circumstances, e.g. in the forest, signals could be picked up from 50 -100m depending upon the density of the understory.

Once a signal was detected, it would be followed until the location of the bird could be ascertained. In open areas this would be by sighting the bird, although if the bird was in dense cover it was usually by triangulating the signal. The alternatives were to wait until the bird moved or to move in slowly until the bird was seen. As the latter usually meant disturbing the bird, it was only used as a last resort. If the bird was not actually sighted, it was presumed that the bird was alive at that time. If the signal did not move for two to three days an attempt was made to "flush" the bird, or if that was not practical, the signal would be traced directly to its source after approximately seven days in order to confirm whether the transmitter was still on the bird and whether the bird was alive.

As extensive searches were made for any birds which could not be located during normal transmitter checks, it is believed that most, if not all, of the birds which could not be found had dispersed into areas where their signal could not be detected, or their transmitter had died prematurely. If the birds had died their signal would still have been able to be detected as shown by the four females which were found dead.

Radio tracking was, with only rare exceptions, used to locate the birds as accurately as possible with the actual location confirmed by sighting the bird. This meant that many of the problems associated with more detailed use of radio tracking, e.g. for home range analysis such as the distance from the animal, the nature of the terrain, vegetation and atmospheric conditions (Harris *et al.* 1990), were not an issue for this study. Even when birds were not actually sighted, an accurate fix was obtained by approaching the birds closely.

A helicopter was used on two occasions, and a fixed wing plane on another, to try and detect transmitters which could not be located during ground tracking. Aerial searches involved the

tracker sitting in the front seat of the machine with a receiver and aerial and directing the pilot as they flew around the coast.

2.4 Locating nests

During the breeding season from late October to February, the females would be located as frequently as possible. If they were not seen, their location was triangulated and the bird left undisturbed. When a signal was recorded at the same site for more than four days it was assumed she was on a nest and the site was marked and monitoring continued. After seven to ten days, if the site could be pinpointed accurately enough, the location would be checked when the bird was off the nest, allowing confirmation of the nest and a count of the eggs. If the nest could not be checked at this time, an attempt would be made once the ducklings hatched to see if any eggs remained in order to record clutch size.

2.5 Bands

To assist in differentiating between individuals, especially when either they had no transmitter or more than one bird was in the same vicinity, each bird had an individual colour band combination. This consisted of two plastic wrap-around bands and an individually numbered metal C size band supplied by the Department of Conservation's Banding Office. Records of all birds banded are held by that office. (Appendix 3 Band numbers and bird names).

3 SURVIVAL

3.1 Introduction

In order to determine whether the introduction of Campbell Island Teal to Codfish Island is likely to establish a self-sustaining population, the birds were monitored for three years following the first release in 1999. Both the birds that were released and those which fledged on the island were monitored. The information gained was used to determine if there was any difference in survival between: sexes; different age classes (from one to six years of age); and between the two releases, the first when no teal were already present and the second adding to the first release birds.

By comparing the survival of captive bred birds released into the wild under the above criteria, this work will help in the selection of birds for the proposed reintroduction on to Campbell Island and for planning how that reintroduction should take place. The parameters will include the number and age of the release group as well as guiding the selection of release sites and the level of resources that should be put into catching birds from the wild for the release rather than using "cheaper" captive bred birds.

3.2 Duration of transmitters on teal

During the 62 "teal" years on Codfish Island that this project covered, (one teal year equals one bird on the island for one complete year), 40 teal years were theoretically able to be monitored using radio tracking. The other 22 teal years were from birds which did not have a working transmitter. During the 3 years of the study only four different individuals without a working transmitter were identified by reading their colour bands thus emphasising the importance of having transmitters on the birds.

3.3 Survival – results

3.3.1 Duration of monitoring

The total cumulative length of time that the teal on Codfish Island had transmitters attached to enable monitoring for this study is made up of:

1. Adult birds (i.e. birds one year or older) released on Codfish Island which could potentially have been monitored for at least one year.
   Total 24 teal years (12 male and 12 female)
2. Birds which have been able to be monitored for more than one year, i.e. have had their transmitters changed once or more.

Total 12 teal years (two male and 10 female)

3. Birds which hatched on Codfish Island, were likely to fledge and were able to be tracked after they were one year old.

   Total five years. (three male and two female)

This gave a total of 41 teal years of individual birds with radio transmitters attached (24 female years and 17 male years). During this time only four birds are known to have died (all female), although it is possible some of the 14 teal which had transmitters but could not be located, also died during this period. Six of the "lost" birds were at Northwest Bay where the birds dispersed more widely and tracking was difficult, and two others were males from the second release which are likely to have been pushed out of the core area by existing territorial males. 75% of the birds at Northwest Bay could not be located compared to only 19% of those at Sealer's Bay. The monitoring periods are given in Appendix 4

3.3.2 Survival of teal in their first year post release

TABLE 4: Survival of Campbell Island Teal at the end of the first year after their release on Codfish Island

	Confirmed alive		Presumed alive		Confirmed dead	
Release site	Male	Female	Male	Female	Male	Female
NW Bay	1	3	3	1	0	0
Sealer's Bay	7	6	1	0	0	2

Only two females out of the 24 teal released (12 males and 12 females), were confirmed dead at the end of their first year on the island, both by accidents. Of the 12 birds released in April 1999, only three birds (one male and two females at Northwest Bay) could not be located 12 months later. All other birds lived for at least one full year after release. Of the 12 birds released in May 2000, the only two males released at Northwest Bay and one of the males at Sealer's Bay disappeared within two months of release (Appendix 5), presumably dispersing to sites where they could not be located.

3.3.3 Survival of released birds by sex

In addition to the four females confirmed dead, three others could not be located during their second year on the island, two of which were at Northwest Bay, but there was no evidence to suggest that they died.

During the three years of this study no adult males were found dead but eight of the 12 males could not be located at the end of the period including three of the four released at Northwest Bay. These birds disappeared between one and 34 months after release.

3.3.4 Survival of teal fledged on Codfish Island

"Adult" is defined as a bird that fledged on the island and is believed to have survived to independence.

TABLE 5: Campbell Island Teal fledged on Codfish Island and the years they could be located.

	Sealer's Bay				Northwest Bay			
	1999	2000	2001	2002	1999	2000	2001	2002
Morgan M	-	-	Y	Y	-	F		
Scodie F	-	-	-	-	-	F	-	-
Ultra F	-	F	Y	Y	-	-	-	-
Murray M	-	-	Y	-	F	-	-	-
Fiddich M	_	-	-	-	F	-	-	-

F = year Fledged

Y = bird recorded

None of the birds fledged on Codfish Island which then had a transmitter attached are known to have died, although two out of five could not subsequently be located.

Five birds, three males and two females, are known to have fledged during this study. This does not include the 11 birds which were likely to have fledged during the last season of the study but were not followed to independence. The five birds which fledged in 2000 and 2001 seasons all had transmitters attached for at least one year although two, (one male and one female) could not be located one year after fledging. Both were fledged at Northwest Bay but the male moved to Sealer's Bay soon after fledging.

All the birds that fledged on Codfish Island, except for one female, hatched at Northwest Bay, and three of the males moved to Sealer's Bay where at least two were integrated into the breeding population.

3.3.5 Status of birds at April 2002 when monitoring stopped

TABLE 6: Status of Campbell Island Teal on Codfish Island at April 2002 when monitoring stopped.

	Confirmed alive		Presumed alive		Confirmed dead	
Release site	Male	Female	Male	Female	Male	Female
NW Bay	1	0	3	3	0	1
Sealer's Bay	3	4	5	1	0	3
Fledged	2	1	1	1	0	0

In addition to the birds which died or could not be located after their first year on the island, a further female at Northwest Bay and four males at Sealer's Bay could not be located two years after the second release (Appendix 5) and two more females had died, also from accidental (human induced) causes (Appendix 6). There was no relationship between the age of the birds or time since release and their death.

3.4 Discussion

3.4.1 Survival of teal in their first year after release and over the duration of the study.

Nine out of 24 birds could not be located at the end of their first year, two others had lost their transmitters but were identified by their colour bands. While it is possible that some birds may have died down burrows or at other locations where their signal could not be detected, it is more likely that they moved to inaccessible areas of the island where they could not be located, as it was not possible to check a significant proportion of the coastline adequately.

If all the birds which could not be located (14) are considered as dead, then the survival rate would be 33%. If those same birds are considered as alive then the survival rate would be 83%. The range for survival at Northwest Bay was 12.5% to 87.5%, while for Sealer's Bay it was 77.8% to 81.3%. This difference in ranges for the two areas may reflect the ability to locate birds or it may be an indication of the habitat suitability through either birds dying or leaving the area. There was no observable difference in survival between either age classes or order of release.

3.4.2 Survival of teal fledged on Codfish Island

While a very small sample, the known minimum survival rate (three from five), and lack of confirmed deaths, indicates that survival of post independent juveniles on Codfish Island is high and that there are sufficient resources, food and territories, for them. There have been no comparative studies of the recruitment rate of either Auckland Island or Brown Teal.

3.4.3 Longevity of Campbell Island Teal

The life expectancy of Campbell Island Teal in the wild is unknown but wild caught birds have been recorded as living to over 15 years old in captivity (Barlow 2000). As the first captive-bred birds were only hatched in 1994 it is not known how long a captive-bred bird may live.

The oldest males currently on Codfish Island are five years old. One bird (Norton) was two when released in 1999 while two other birds were three years old when released in 2000 and all were still alive in April 2002. The oldest females currently on Codfish Island are five years old. One bird (Paris) was three when released in 2000 and was recorded in April 2002, while the oldest known breeding female is Venus who was one year when released in 1999 and fledged ducklings in 2002. Beryl and Puiseux were six and five respectively when they died, both by human induced accidents. A wild female caught as an adult was still productive after ten years in captivity.

The longevity of the birds is of direct relevance to their likelihood of successfully establishing new populations. Put simply, the longer a bird lives, assuming it is productive for the majority of that time, the more offspring it will produce. In the case of the Campbell Island reintroduction, the longer the birds live and breed, the faster the population is likely to become established and reach a safe level. Relevant information on Auckland Island and Brown Teal is limited as the longevity of Auckland Island Teal is also based on captive birds. Brown Teal have a maximum recorded age of 6 years in the wild (Heather and Robertson, 1996).

3.4.4 Implications of survival on establishing new populations.

Anatids, especially dabbling ducks, are wide-spread on islands around the world. These range from full species and possibly genera, to local races of more common continental species (Weller, 1980). While in some cases it is likely that island populations are supplemented by

continued invasions from other sources, particularly for islands close to and down wind of larger continental populations, other islands are so isolated that invasions are likely to be rare events. In these cases the birds which arrive must be able to utilise the available resources, which for smaller islands and those on which another species is already established may be very limited. Dabbling ducks are especially good at this, being able to utilise a wide range of coastal and freshwater habitats.

There is little information on the number of individuals which were likely to have been involved in successful, and unsuccessful, colonisation attempts but the genetic information from Campbell Island Teal indicates that the founder population for Campbell Island may have been as low as 1 female and 1 –2 males (M. Williams pers. comm., 12 September 2002). The observation that Laysan Teal on Laysan Island recovered from a low of fewer than 10 individuals (Reynolds, 2000) shows that waterfowl can establish from very small founder populations. Of course this does not take into account the high number of failed invasions that must also have occurred. Also, it is likely that many island populations of waterfowl, as with other classes of birds, have died out "naturally" to be replaced by other, or in some cases the same species. (Salomonsen, 1976 in Weller, 1980) at a later date. This indicates that while an island population may establish from a small founder group, the more birds present increase the chances of the population establishing and then surviving for the medium to long term.

3.4.5 Implications of survival rate for a release on Campbell Island

The high survival rate of both sexes, and all age classes released on Codfish Island, regardless of whether teal were already present or not, means that age does not have to be a major factor in selecting the birds for Campbell Island. This information will allow those planning that release to work on what is logistically best rather than having to plan to release any particular age class. The ability to use young birds without compromising the reintroduction is important for Campbell Island Teal, as it is difficult to hold birds together after they are approximately eight months old.

This study showed that teal could be released into an already occupied site providing adequate habitat was available, i.e. follow up releases, if necessary for Campbell Island, could be planned in advance. It is likely that the survival rate for Campbell Island Teal on Campbell Island would be significantly lower than Codfish Island due to pressure from predators. Skua are known to prey on adult teal (Williams and Robertson, 1996), and with many of the

feeding areas not being under a forest canopy, the teal will be more exposed. This could be compensated for, at least in part by increasing the number of birds to be released.

4 Dispersal and habitat use

4.1 Introduction

Monitoring the dispersal of any recently introduced species to a new habitat can provide information on habitat preferences and possible densities of that species in the new habitats. For the release of Campbell Island Teal on to Codfish Island, two sites were selected which incorporated a range of habitat types. Monitoring the movements of the teal after release allowed a comparison of the relative suitability of the two release sites on Codfish Island and the range of habitats used by the teal. This provided important information for selecting the release sites for any future reintroduction to Campbell Island.

The information gained also provided additional information on the range of habitat types in which the teal can live and breed. Dispersal was compared between the two sites, and between the two releases, the first when no teal were present and the second when birds were released into an established population. The latter was to gain information on the possible impacts/ benefits of follow up releases on Campbell Island. The dispersal of males was compared to females and also the dispersal of juveniles post fledging was recorded.

Knowing the likely mode of dispersal on Codfish Island is important. If the birds disperse around the coast there are considerable stretches of the Campbell Island coastline which are likely to severely constrain the dispersal of the birds, if not prove impassable, due to the long distances along very exposed coast with no landing sites. Restricted movement may have benefits for the initial establishment of the population by confining birds to a particular site and hence making them more likely to encounter a mate, but it could also mean that if all the birds are released at one site, other suitable sites may not be colonised quickly. If the birds disperse across land then the whole island opens up more rapidly but there is a risk of the birds being at low density with consequential impacts on productivity.

4.2 Results

4.2.1 Post Release Dispersal of Adults

First release at Northwest Bay

Following the release of four males and two females at Northwest Bay, the dominant pair of Jacques (M) and Hinemoa (F) settled into the main stream while Fizeau (M), Monowai (F) and Puiseux (F) moved north around the coast. Galathea (F) moved approximately 500m northwest along the coast when the last contact with her took place. Puiseux lived by herself

approximately1.5 km northeast of the release point during her first year on the island. One month after release Jacques and Hinemoa left the stream and probably moved south as this was the direction from which their signals were last recorded. At this time Fizeau and Monowai occupied the stream site with Monowai nesting that summer.

Twelve months after taking over the stream territory, Monowai could not be located and Puiseux paired with Fizeau and took over the stream territory for the following two years. No birds were recorded more than 100m inland at Northwest Bay or the same distance up the main stream from the stream mouth.

First release at Sealer's Bay

At Sealer's Bay all the birds remained around the lower reaches of the Sealer's Bay Stream for approximately four weeks. They then started to explore the main catchment, including New Forest Stream and discovered Norton's pond. All six of the birds lived predominantly in the lower Sealer's Bay Stream area and would frequently travel up the main stream. One female would make excursions up to 1.5km upstream for up to five days, but the majority (75%) stayed in the lower 500 metres. All six birds at this site, but especially Col (F) and Falla (F) routinely moved between Sealer's Bay and Penguin Bay. These movements occurred mainly at night when the birds were feeding and the birds nearly always returned to Sealer's Bay before dawn.

Second release at Northwest Bay

In order to balance the sex ratio, only two males were released at Northwest Bay during the second release in May 2000. Neither of these birds could be located after June 2000. There was no apparent affect on the resident birds at the main stream mouth (Puiseux and Fizeau).

Second release at Sealer's Bay

Six males and four females were released at Sealer's Bay during the second release. As birds from the first release already occupied the territories around the lower stream, birds dispersed more widely and more rapidly following this release. One pair of newly released birds (Buttercup (F) and Gomez (M)) rapidly took up residence on the rocky coast at the east end of the bay, which had not previously been utilised by teal. Another female (Paris) moved about a great deal and frequently could not be located for a week or more before appearing back near the eastern end of the beach or on the New Forest Stream – she did not breed. The other

Fig. 8: Map of Sealers Bay, Codfish Island, showing location names used in this thesis.

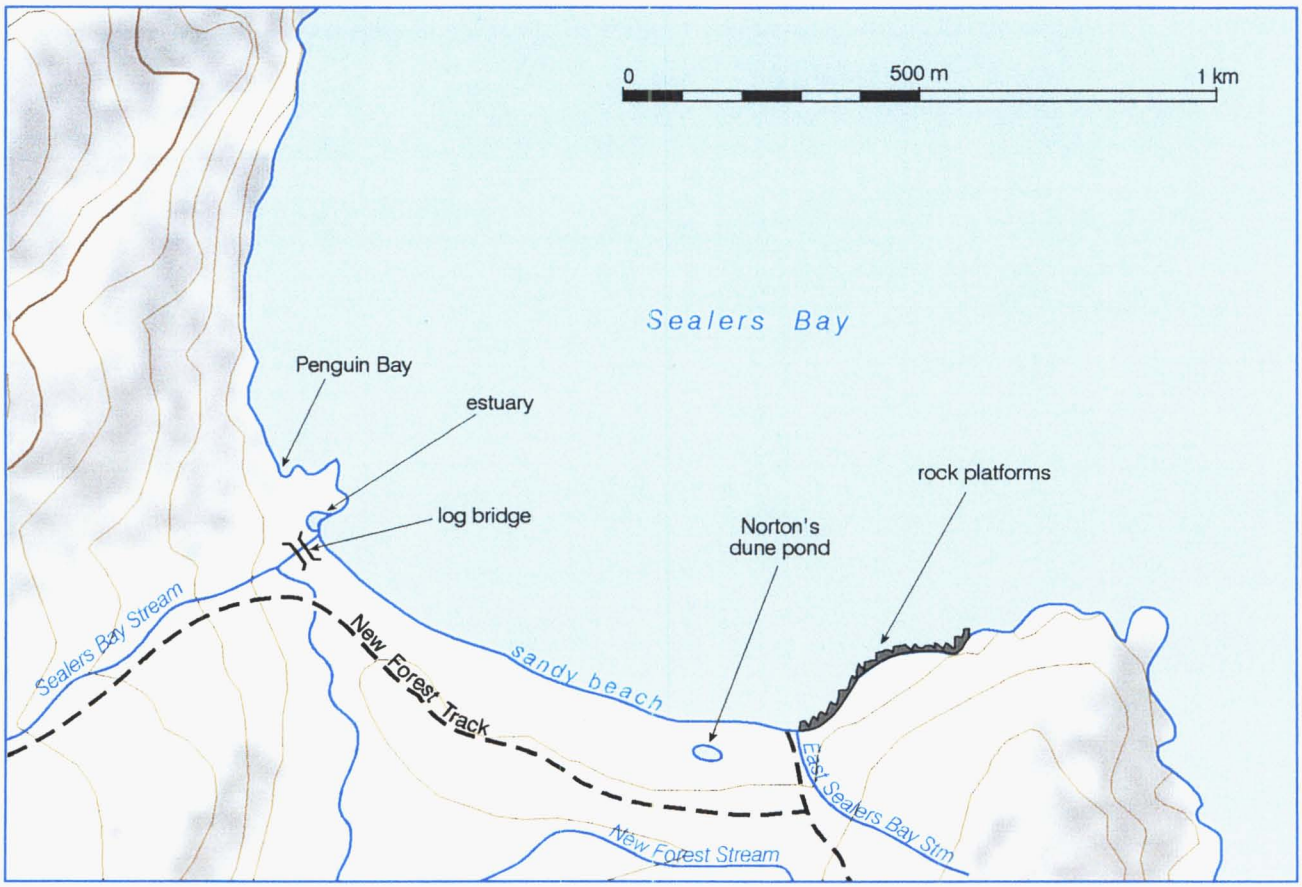
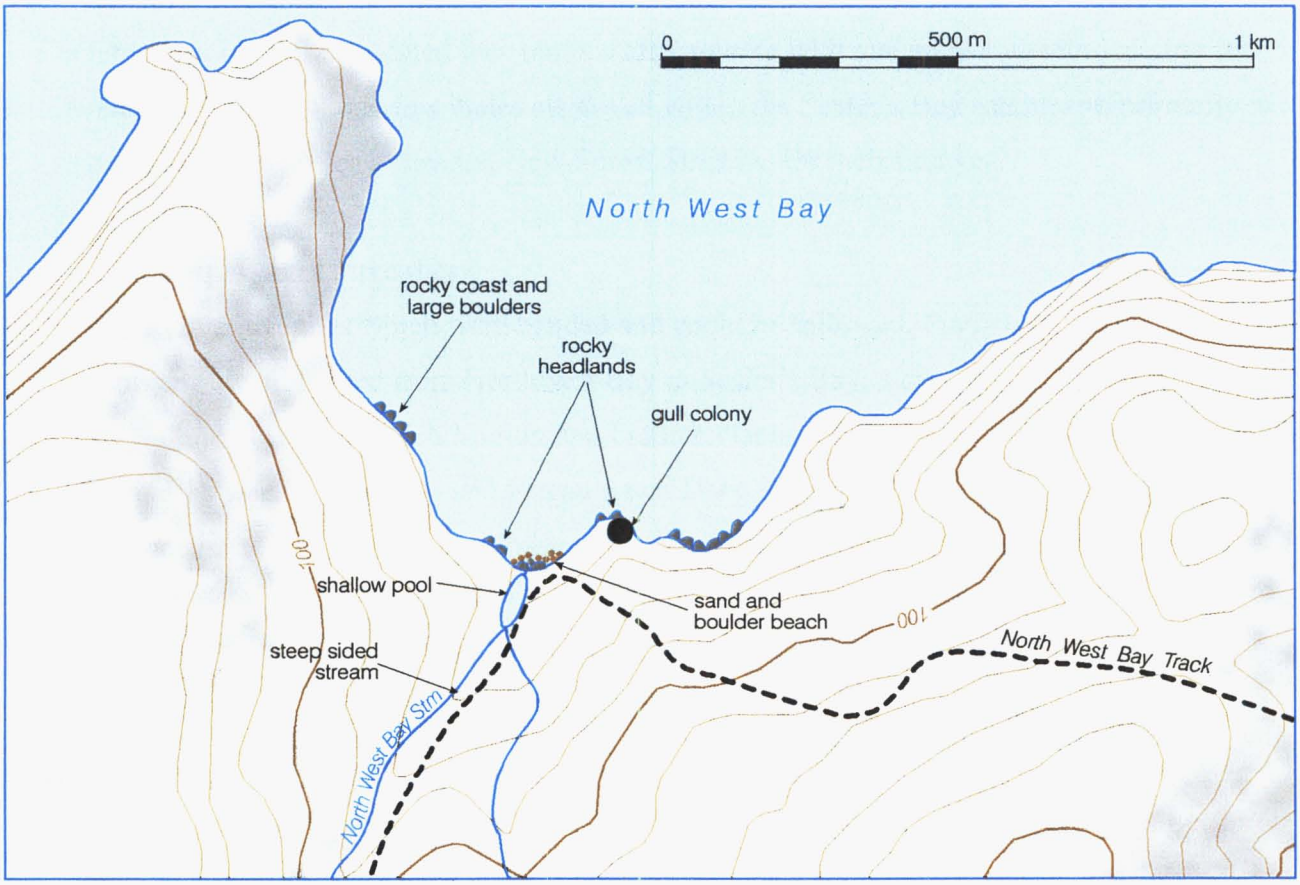


Fig. 9: Map of North West Bay, Codfish Island, showing location names used in this thesis.



females moved around the main stream/New Forest Stream. Three birds, two male and one female, could not be located four months after release with one male not recorded after its release. The other four new males all stayed within the Sealer's Bay catchment, primarily in the area of the Sealer's Bay and New Forest Streams, for their first year.

4.2.2 Dispersal of Juveniles

Of the five juveniles which were banded and could be followed, Fiddich (M), Murray (M) and Morgan (M) all moved from Northwest Bay to Sealer's Bay, a distance of approximately 4 km. While the age at which Murray and Fiddich dispersed is unknown, Morgan was between 14 and 18 weeks. Monowai and Fizeau's two 1999/2000 season juveniles were not seen after independence and neither were Puiseux and Fizeau's three 2000/2001 ducklings.

The records of juvenile movement are largely based on unbanded birds. All of the females at Sealer's Bay were monitored over the 1999/2000 season and all breeding attempts recorded. This compared to Northwest Bay where several birds could not be tracked and hence not all breeding could be accounted for. This meant that when unbanded birds appeared at Sealer's Bay they were likely to have been from either Hinemoa and/or Galathea and possibly sired by Jacques at Northwest Bay, none of which have been recorded since before the 1999/2000 breeding season.

4.2.3 Ongoing Dispersal.

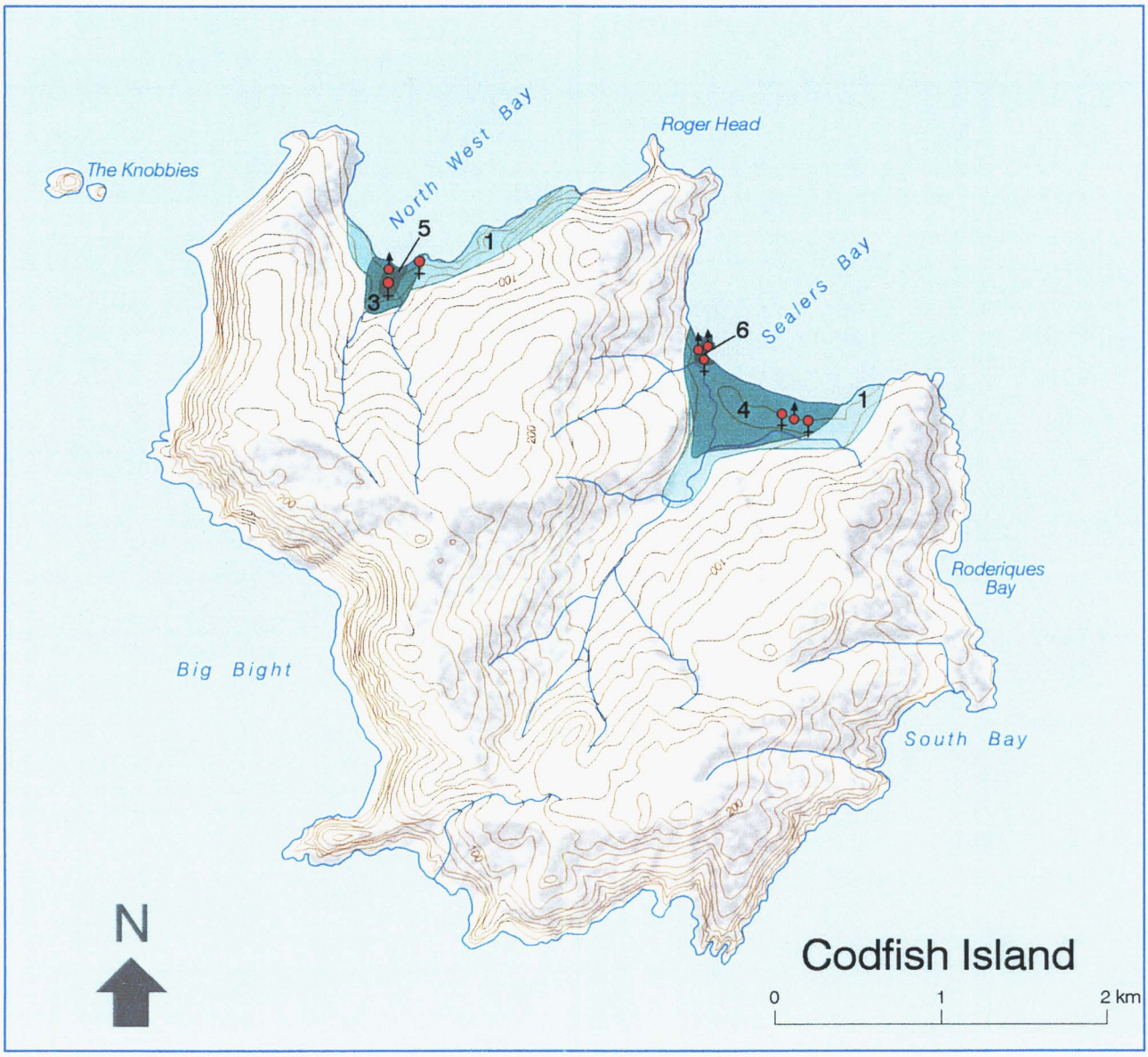
At Sealer's Bay, birds routinely moved the 60m between Sealer's Bay and Penguin Bay but there was no evidence that they moved further around the coast. At least four different birds utilised the rock platform at the east end of Sealer's Bay, but they were never recorded more than 300m along the coast from the end of the beach. Following the second release a pair took up residence in this area of rock platform but other birds would still move through it. At Northwest Bay the only birds which could be located during the second and third year of the study, were the pair at the release site.

As with the initial dispersal, the short-term movements of birds at Sealer's Bay were primarily along waterways. Birds regularly travelled 500 – 1000 m along the main and New Forest Streams in a 24 hour period, mainly at night. For example, birds would regularly travel from the Sealer's Bay Stream Estuary to Norton's pond one night and then back again the following evening. Norton (M) travelled this distance on one occasion, (approximately 700m in a straight line) in less than 30 minutes. There was no apparent ongoing movement around

the coast except at night to feed. No birds were recorded away from streams/ wetlands or the coast during this study. Movement at Northwest Bay was apparently primarily along the coast as no birds were recorded inland at this site.

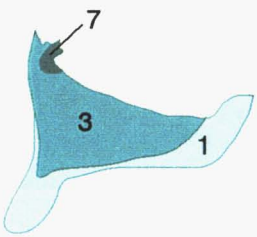
No adults were recorded moving between Sealer's Bay and Northwest Bay.

Fig. 10: Map of Codfish Island showing areas explored by all trackable birds in the six months following the first release in April 1999 and their core site at the end of this period.



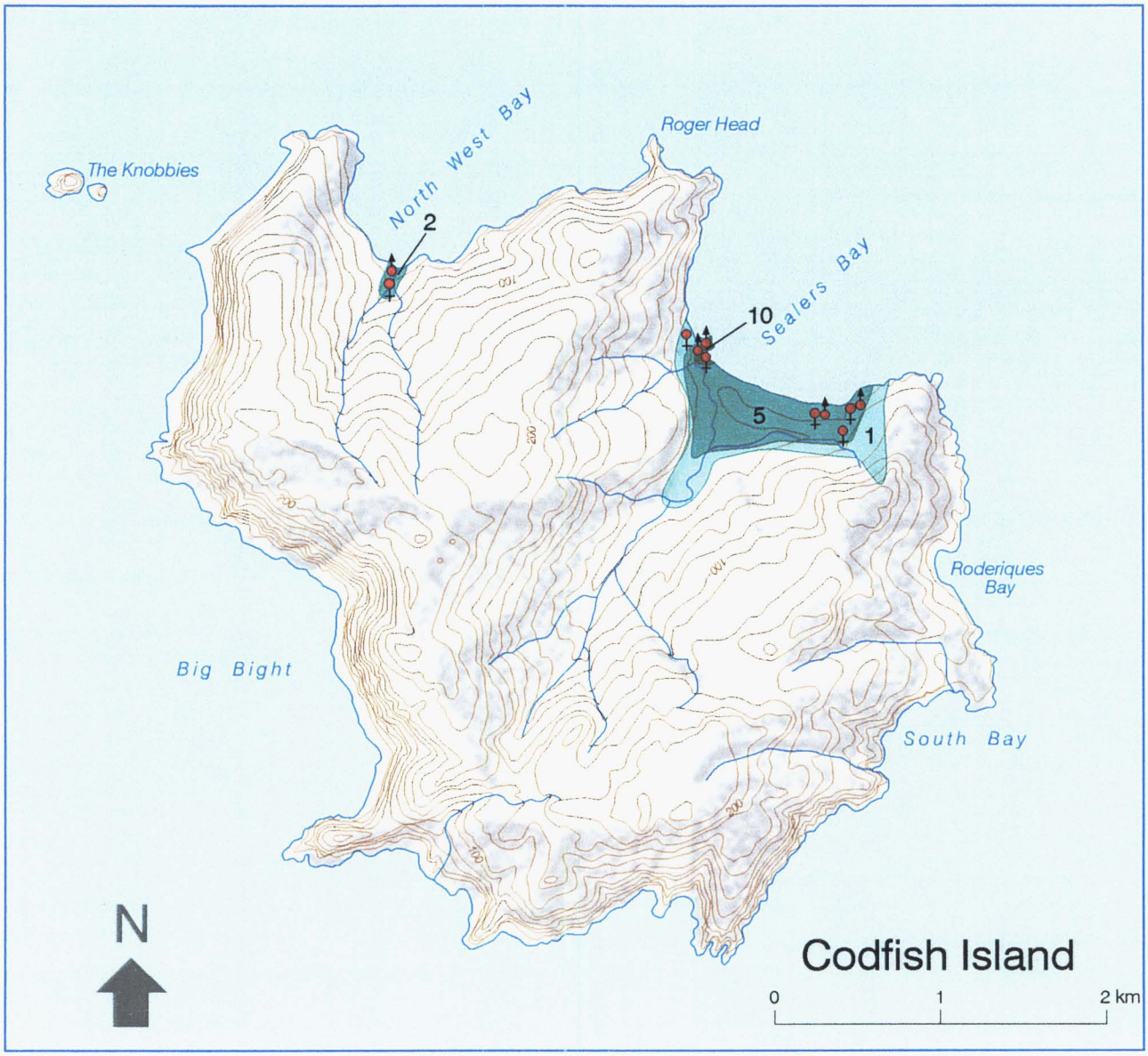
Key

Where each bird was living predominantly at the end of six months post release. NB: There was still significant movement after this time.



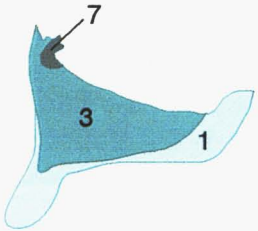
Number of individual teal that were recorded within each area in the six monthsfollowing releases.

Fig. 11: Map of Codfish Island showing areas explored by all trackable birds in the six months following the second release in May 2000 and their core site at the end of this period. This includes the birds from the first release.



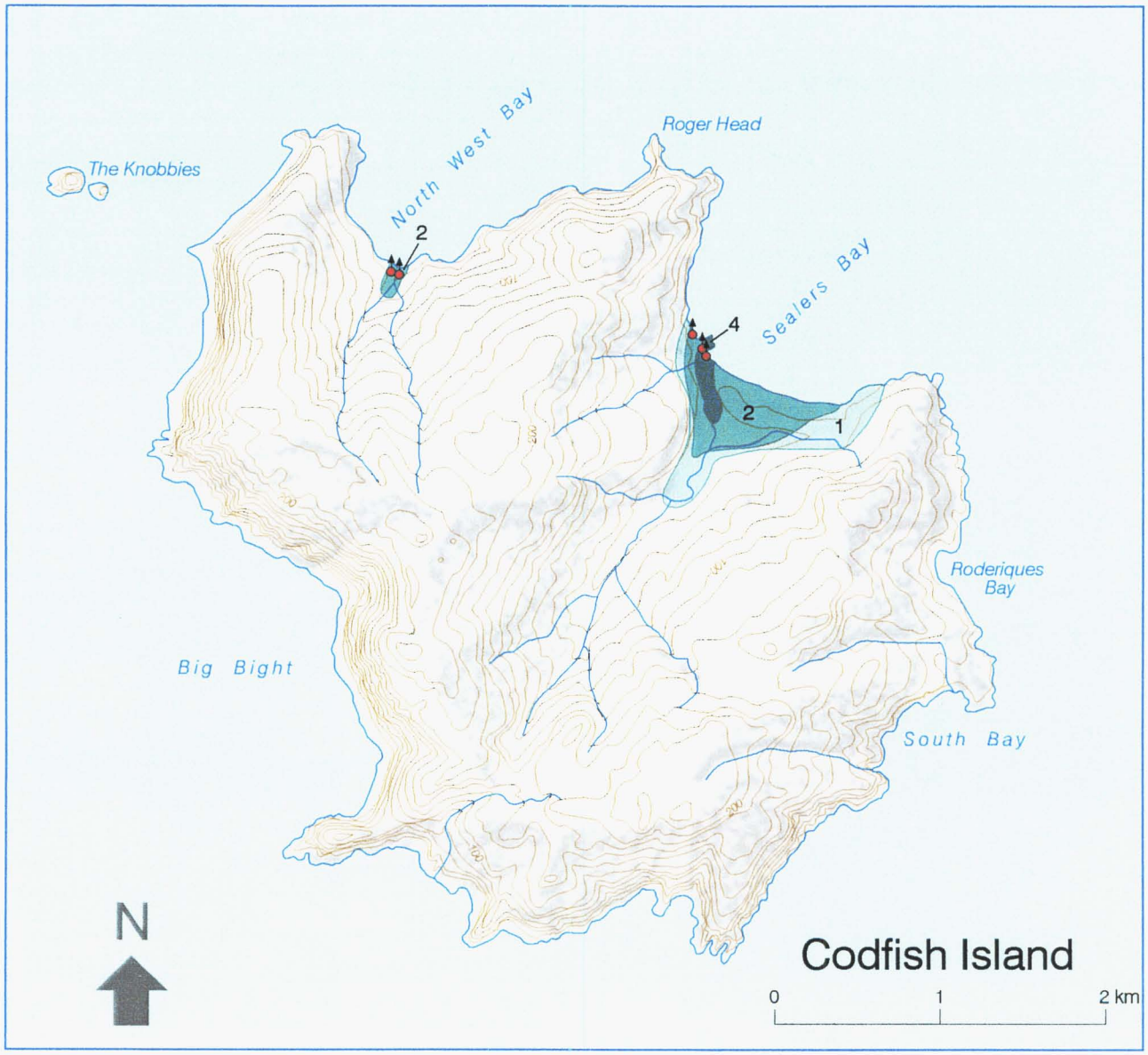
Key

Where each bird was living predominantly at the end of six months post release. NB: There was still significant movement after this time.



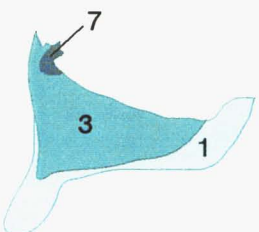
Number of individual teal that were recorded within each area in the six monthsfollowing releases.

Fig. 12: Map of Codfish Island showing areas explored by all trackable males in the six months following their release (includes both first and second releases) and their core site at the end of this period.



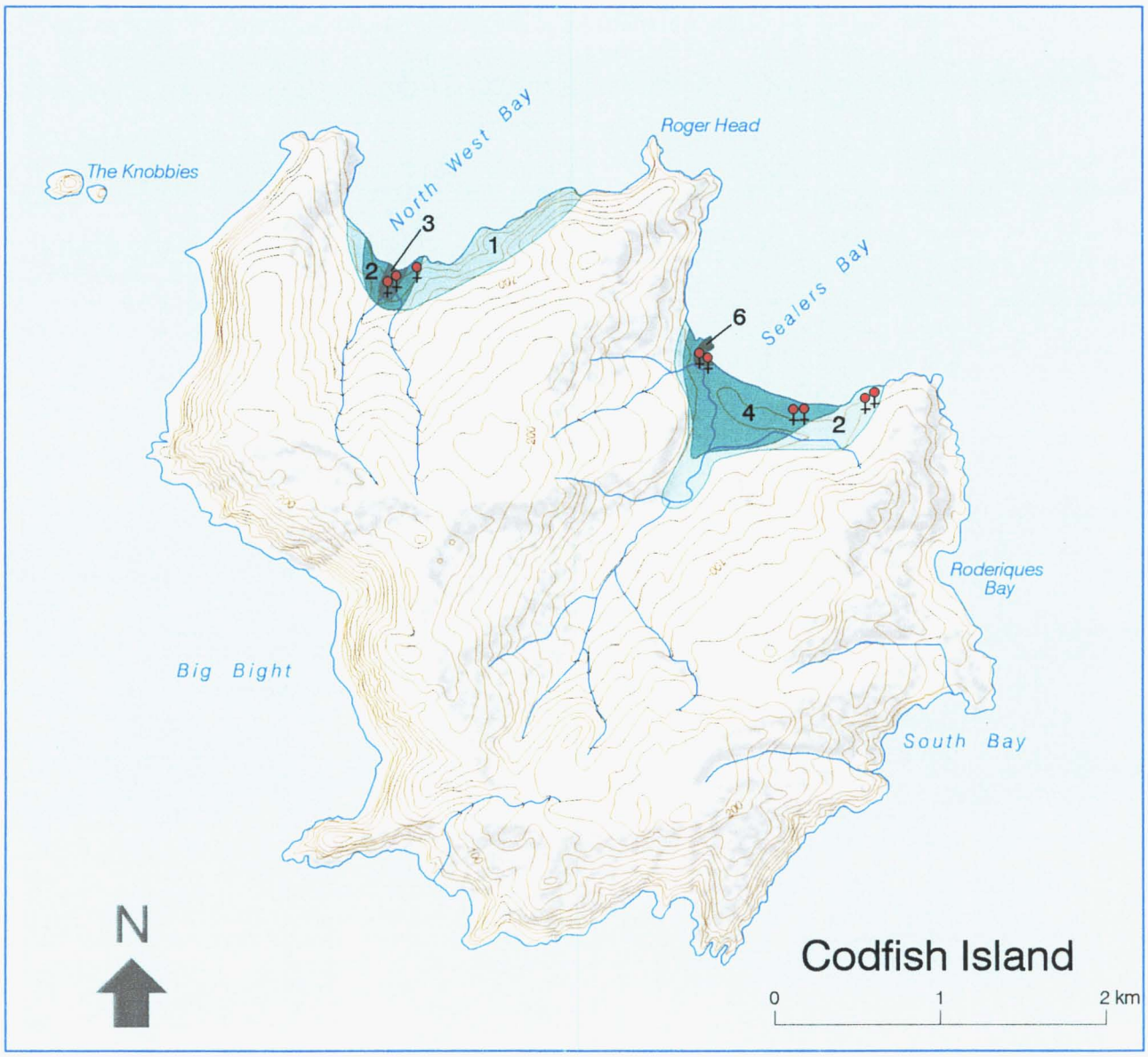
Key

Where each bird was living predominantly at the end of six months post release. NB: There was still significant movement after this time.



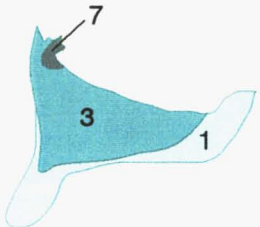
Number of individual teal that were recorded within each area in the six monthsfollowing releases.

Fig. 13: Map of Codfish Island showing areas explored by all trackable females in the six months following their release (includes both first and second releases) and their core site a the end of this period.



Key

Where each bird was living predominantly at the end of six months post release. NB: There was still significant movement after this time.



Number of individual teal that were recorded within each area in the six monthsfollowing releases.

4.3 Discussion

4.3.1 Dispersal over land

There was no evidence to suggest that birds moved any significant distance across land as no birds were recorded more than 100m from water, be it the coast, a stream, or a pond. However, there was evidence that birds would explore across shorter distances of dry land. Birds frequently moved across the neck between Sealer's Bay and Penguin Bay and, as Norton's pond is landlocked, the teal had to cross at least 30m of land to find it.

4.3.2 Dispersal along water bodies and around the coast.

It was apparent that the main means of dispersal/movement for the teal at Sealer's Bay was along water bodies, even very small streams that were partially or even largely dry where the birds had to walk for considerable distances (> 1 km). All the streams used were of low gradient. There appeared to be little or no movement along the streams at Northwest Bay. This may be because the steeper nature of streams in this catchment did not provide feeding habitat to lead birds upstream.

While adults were frequently encountered on the coast, especially at night, these excursions appear to have been solely for feeding. The only definite evidence of adult teal travelling any distance around the coast was at Northwest Bay where three individuals were recorded up to 2 km away from the release site (furthest fixes being 0.5 (F), 1.5(F), and 2.0km(M) respectively). The female which had travelled 1.5km returned to the release site, while the other two birds could not be relocated and are believed to have travelled further around the coast. There is additional circumstantial evidence of coastal movements, specifically the "disappearance" of six out of the eight birds released at Northwest Bay. As no birds were recorded inland it is assumed that the birds rapidly dispersed around the coast to sites where they could not be located.

It would appear that, since the birds at Sealer's Bay did not disperse nearly as often or as widely as those at Northwest Bay, the movements were determined either by availability of food resources or size of territories. It appears that Northwest Bay stream could only support one territory and hence all other birds had to move further around the coast. Williams (1995) looked at territory size for Auckland Island Teal and found that it was closely related to available food supply with some territories in areas with an abundance of food being as small as $40m^2$.

4.3.3 Ongoing movements

There was a large variation in the ongoing movements of individual teal after their first six months on the island. Most of the birds which had taken up territories near the release sites stayed there. However, at least two individuals, one male and one female, at Sealer's Bay frequently could not be located for several days before appearing back in the vicinity of their release site. As it was known that the birds' transmitters were working, it appears that they were leaving the search area. Of the birds which were unable to be located after the initial dispersal, (arbitrarily taken as six months after release), none could be located at a later date. This indicates that they were either established at a site where they could not be detected or that they were dead.

4.3.4 Differences in dispersal between different aged birds.

There was no observable difference in the dispersal patterns of birds older than juveniles. Three juveniles caught at Sealer's Bay in April 2001, Ultra (F), Murray and Fiddich, are all believed to have been hatched at Northwest Bay the previous season. Murray was first recorded at Sealer's Bay in November 2000 in breeding plumage and, therefore, was definitely from the previous breeding season. The age for the other two birds is based upon the lack of juvenile notches in their tail feathers, indicating that they had undergone nuptial moult (Preddey and Fraser 2001), and thus were not juveniles from the 2000/2001 season. In captivity this moult was recorded five months after hatching. Cloacal examination of Fiddich showed a small penis typical of a juvenile teal. The plumage condition of Ultra and Fiddich indicated that neither were from the current season. The wider dispersal of juveniles was possibly due to parents driving fledglings away from their natal site, although this was not observed. There is no published data on the movements of juvenile Auckland Island or Brown Teal to compare this with. The known dispersal of one juvenile soon after independence indicated that there was insufficient suitable habitat at the Northwest Bay site for more than one pair of teal.

4.3.5 Differences in dispersal between males and females

Males dispersed more rapidly and possibly more widely than females as a higher percentage of males could not be relocated in their first year on the island. Following the second release of two males at Northwest Bay one bird was never seen after release while the other stayed in the vicinity for seven weeks before disappearing. Neither bird was recorded in the preferred habitat at the mouth of the stream, which was already occupied by the dominant pair.

4.3.6 Comparison of dispersal with other island waterfowl and the other endemic New Zealand Teals.

Most information on dispersal of waterfowl is for flighted species which can move large distances quickly and relate to larger scale dispersal rather than the small scale dispersal patterns covered in this study. There is no comparable information for the three other extant flightless waterfowl, two of which are coastal/marine species with the other being the Auckland Island Teal. A major factor in the dispersal of island waterfowl, along with locating food, is likely to be the effect of territoriality, which varies greatly between species (Weller, 1980) and is interlinked with food supply, with birds needing to defend territories large enough to contain sufficient food resources for raising ducklings.

Williams (2001) studied some aspects of the dispersal of Brown Teal in Northland, although that species' ability to fly, and the largely modified habitats where the research was carried out mean that it is of little relevance to this study. There have been no studies on the longer term dispersal of Auckland Island Teal although Williams (1997) found that birds would often move more than 400m and that all birds moved to the coast to feed at night. Campbell Island Teal also rely on the coast, however, not all birds used the coast consistently.

4.3.7 Implications of dispersal for a Campbell Island release

The observations carried out on Codfish Island indicate that birds released on Campbell Island are unlikely to cross between catchments, at least not until densities reach such a point that birds are forced out of preferred areas. This would mean that in order to get the birds established at more than one site, releases should take place at several locations.

4.4 Habitat Use

4.4.1Northwest Bay

None of the birds at Northwest Bay were ever located more than 100m from the coast and rarely more than 50m. They utilised the lower reaches of the main stream, with the dominant pair frequently being encountered on the shallow (< 0.5 metre) pool under a low forest canopy (six-eight metres) near the outfall onto the beach. Other birds were recorded on the coastline or in the vegetation near the coast, including being under large boulders and using boulder and rock platform coasts. As neither of the two males that were released at Northwest Bay as part of the second release could be relocated after a month, no comparison of habitat use at this site between the two releases could be made.

4.4.2 Sealer's Bay

At Sealer's Bay, birds utilised a wide range of wetland or coastal habitats. Birds utilised the lower 1.5 km of the Sealer's Bay Stream, although along most of this length feeding was restricted to the banks. They also moved freely over the ephemeral wetlands whenever there was water, or at least mud, present. This included the "Hine Kite" wetland behind the estuary and the New Forest Stream, which dried up along most of its length during the first two summers of this study. Even when the New Forest Stream was largely dry, teal would use this watercourse to gain access to Norton's pond in the dunes. After the second release when birds dispersed more widely, at least one bird (Venus) found a second larger dune pond, which also largely dried up during the summer. At the same time at least three birds started to utilise rock platforms, and were seen feeding in the tidal pools and brackish pools in the splash zone. Many birds fed along the coastal area including the sandy beach, which had only isolated and transitional patches of beachcast seaweed on it. They also fed on the dunes, where it is presumed that they were feeding on pingao (*Desmoschoenus spiralis*) seeds, and along the boulder beach in Penguin Bay. On one occasion a bird was seen in the sea by the rocky coastline adjacent to the western end of Sealer's Bay.

There was an observable increase in the range of habitats used by the teal from the first release to the second. Specifically a pair (Buttercup and Gomez) took up residence on the rocky coastline at the east end of Sealer's Bay, a habitat type which had only infrequently been used by first release birds. This pair were always found either on the rocks or in the adjacent shrublands. Following the second release there was increased use of apparently sub optimal habitats, e.g. Penguin Bay Stream, which is likely to have been due to the increased number of teal causing an expansion in the species' core range, with subordinate birds being "forced' to utilise less desirable habitats. The pairs at these two sites both bred successfully showing that, while the habitat may not be as preferred as that at the Sealer's Bay Stream, it was still suitable for the teal.

The only bird which took up a territory solely based on inland waterways was a female (Venus) with small ducklings which had nested away from the coast. All the other birds that used either the dune ponds or travelled up the streams, frequently returned to the coast.

There was no observable change in the habitat use of the core areas of Sealer's Bay Stream/ New Forest Stream and Norton's pond between the first and second release, although in some cases there was a change in the individual birds using the habitat.

4.4.3 Seasonal change in habitat use.

The most obvious change in the seasonal use of particular habitats was the use of shallow ephemeral wetlands such as the "Hine Kite" swamp and the New Forest Stream which would dry up during prolonged periods without rain. At these times the birds had to utilise either different habitat types, e.g. coastal or, to a lesser extent, the main stream, or the same type of habitat at a different site, e.g. the grey water outfall from the hut which has created a permanent "wetland". This change in use of sites appeared to be driven by the rainfall, since during the wet summer of 2001- 02 teal continued to use the habitats that they had abandoned in previous summers. For the birds which frequented the more stable coastal and larger stream habitats, such as Northwest Bay and Sealer's Bay Streams, there was no observable change in habitat use during the year.

There were also seasonal changes in habitat use by particular birds which appear to have been caused by changes in the behaviour of the birds rather than any change in the habitat. The most obvious example was when females with ducklings became more secretive and utilised shallow wetlands more, even if they had not usually done so before. Females without ducklings showed no change in habitat use. During the breeding season, as the dominant birds defended territories, subordinate birds were forced to use feeding areas on the fringes or outside those territories, e.g. further up the main stream at Sealer's Bay.

4.4.4 Differences in habitat use between birds of different ages

There was no observable difference in habitat use by the different aged birds, although this may partially be due to the small sample size. Differences in habitat use appeared to be related to dispersal, which was a factor of territoriality, i.e. the first birds released, regardless of age, took up territories in what is believed, based on the productivity or number of birds that used those sites, to be the best habitat. Second release birds had no choice but to take up sub-optimal territories unless they could displace the established birds. In some cases this meant that younger birds which held territories excluded older birds from an area.

4.4.5 Diet

While the diet of Campbell Island Teal in the wild is unknown, their behaviour of dabbling in mud and the range of invertebrates that they will accept in captivity, including earthworms and amphipods, indicates that invertebrates are a major component of their diet. They have also been recorded eating seaweed (*Ulva spp*) and the seeds of *Juncus* rushes (Williams and

Robertson, 1996). The stomachs of two ducklings from separate clutches which were found dead only contained grass seeds probably from hook grass (*Uncinia spp*) (C. West pers. comm., 8 March 2001). On Codfish Island teal were observed most commonly feeding in shallow mud in wetlands although they were also seen probing along the banks of the streams and bobbing for food in the Sealer's Bay estuary. Birds were also seen feeding in rock pools, among drift kelp, and along the tide line on Sealer's Bay. At least two separate birds were observed in the sand dunes eating pingao seeds. Birds were also seen eating Yorkshire fog (*Holcus lanatus*) and *Carex suppressa* seeds as well as one observation of a bird eating dandelion (*Taraxacum officinale*) petals. A young abandoned duckling was observed "feeding" on a fresh dead fish. In comparison Auckland Island Teal eat algae, sea lettuce, aquatic and terrestrial invertebrates (Todd, 1996), and they also frequently sieve mud and probe for invertebrates in rotten banks of seaweed. The Brown Teal diet is probably mostly invertebrates insects, worms, insect larvae, marine molluscs and small crustaceans (Marchant and Higgins, 1994).

The wider range of food types eaten by the Campbell Island Teal and Auckland Island Teal concurs with Lack (1970) and Weller (1980) who found that most island waterfowl have wider feeding habits than their respective continental forms. This wide range of food types that Campbell Island Teal will eat indicates that foraging should not be an impediment for the establishment of the Campbell Island population for, with the rats removed, there are only Mallard ducks to compete with and a wide range of food should be available in the range of habitats.

4.4.6 Implications of the habitat use studies for planning a release on Campbell Island.

My observations on Codfish Island, along with observations of Auckland Island and Brown Teal, indicate that Campbell Island Teal can successfully live and breed in a wide range of habitats, but that there is a strong preference for, if not reliance, on water. This will guide the selection of the release sites on Campbell Island to those that have either streams or suitable areas of sheltered coast. There is no shortage of such sites on Campbell Island with at least Perseverance Harbour and Northwest Bay appearing capable of holding sizeable populations. Also the varied diet of the species indicates that food should not be a limiting factor for the establishment of the new population.

5 Breeding and Productivity

5.1 Introduction

The breeding biology of Campbell Island Teal is the most studied aspect of the biology of this species. However, even the information on this aspect of their biology is limited and is based on observations in captivity. The release onto Codfish Island provided the opportunity for a comparison of clutch size, hatching rate and fledging rate to be made between birds of different ages and in different habitat types. The release also allowed the collection of information on mate fidelity, nest site selection, participation of males in incubation and duckling care, age of first breeding, level of parental care and habitat preferences for adults and ducklings in the wild.

In this chapter productivity, including duckling survival, is compared against each of the following factors :

- between sites,
- between years,
- age of the mother,
- how long the mother had been on Codfish Island,
- prior breeding experience.

The information collected was used to assess the success or otherwise of the Codfish Island introduction. It is also important for planning the Campbell Island release as it will help managers optimise the age and number of birds for release and to choose the release site. By basing the selection of the birds for any future releases on the information gained, the productivity of the release population can be maximised in order to have the population establish as rapidly as possible. This is important, as obtaining the birds for release on to Campbell Island has significant logistical and cost implications. If one year old birds are likely to be as or nearly as productive as older birds it means that the number of birds to be released is not constrained by the available holding capacity.

5.2 Results

5.2.1 Summary of Breeding attempts on Codfish Island from 1999/2000 to 2001/2002.

TABLE 7: Summary of Campbell Island Teal breeding attempts on Codfish Island from 1999/2000 to 2001/2002

	Sealer's Bay	Northwest Bay	Total
Number of breeding attempts	11	3	14
Number of females involved	5	2	7
Total eggs laid	35	10	45
Total ducklings hatched	27	9	36
% hatched (of eggs laid)	77	90	80
Number fledged	10	9	19
% fledged (of those hatched)	37	100	53

In the 1999/2000 and 2001/2002 seasons, there were a total of 14 nesting attempts by seven individual females. The females that nested laid an average of 3.5 eggs per clutch (range = 2 – 5), and hatched an average of 2.8 ducklings, (range = 2 - 5) This gave an 80% hatching rate. Only two out of 14 clutches fledged all the ducklings hatched while two other clutches lost one duckling in the nest at hatching and fledged the rest of the brood. All clutches hatched at least one duckling, showing that all of the females which are known to have attempted to breed were fertile. Eight of the 14 clutches (57%) which successfully hatched at least one duckling, raised at least one duckling to fledging. Of the 36 ducklings which hatched during the three breeding seasons, 53% fledged. All of the ducklings lost were less than 11 days old with the average age of loss being 5.4 days (n = 16) range 1-11. Full data on each breeding attempt is given in Appendix 7.

5.2.2 Breeding results by season

The five females that could be followed consistently through the 1999/2000 breeding season (four at Sealer's Bay and one at Northwest Bay) had a total of four nests (three at Sealer's Bay and one at Northwest Bay) and produced a total of fourteen eggs. Clutches ranged from three to five eggs. Nine eggs hatched, at least one from each nest, but all except two ducklings died within a few days of hatching. The two ducklings that survived were both from the same clutch at Northwest Bay and were at a site where it was very difficult to get any clear observations of their behaviour.

Eight females were monitored in 2000/2001 (seven at Sealer's Bay and one at Northwest Bay) and five females nested (four at Sealer's Bay and one at Northwest Bay). A total of 12 eggs were laid and 11 hatched. However, only four ducklings were fledged (two at Sealer's Bay

and two at Northwest Bay). This included a juvenile who was near fledging when she was killed in a burrow cave-in along with her mother, and a sibling who was not recorded after the mother was killed.

Six females were followed through the 2001/2002 breeding season (five at Sealer's Bay and one at Northwest Bay). Five nested and laid a total of 19 eggs of which 16 hatched and 13 ducklings were fledged (survived until May when they were banded). This included five ducklings, which were the offspring of Puiseux at Northwest Bay who died by accident shortly before the ducklings were due to fledge. Only three of these ducklings were observed at any one time but it is believed likely that all five survived.

TABLE 8: Productivity of Campbell Island Teal on Codfish Island from 1999/2000 to 2001/2002

Year	# nests	Ave clutch size (total number of eggs)	Hatching rate	Fledging rate (of hatching)
1999/2000	4	3.5 (14)	64% (n=9)	22% (n=2)
2000/2001	5	2.4 (12)	91% (n=11)	36% (n=4)
2001/2002	5	3.8 (19)	84% (n=16)	81% (n=13)

While there is relatively little difference in clutch size and hatching rate between the years, there was a large increase (125%) in the fledging rate in 2001/02 from the previous highest (Table 8).

5.2.3 Comparison of productivity between Sealer's and Northwest Bays

TABLE 9: Comparison of the productivity of Campbell Island Teal at Northwest Bay and Sealer's Bay, Codfish Island.

	Number of nests	Ave clutch size (total eggs)	Ave hatching	No fledged (from those that hatched)
Northwest Bay	3	3.3 (10)	3 (90%) n= 9	9 (100%)
Sealer's Bay	11	3.2 (35)	2.4 (84%) n = 27	10 (37%)
Total	14	3.2 (45)	2.7 (87%) n= 36	19 (53%)

Despite there being fewer nesting attempts at Northwest Bay and far fewer eggs laid, there was a much higher breeding success with a total of nine ducklings fledged from ten eggs at Northwest Bay and ten ducklings fledged from 35 eggs at Sealer's Bay (Table 8).

5.2.4 Productivity relative to the age of the mother

TABLE 10: Clutch size of Campbell Island Teal on Codfish Island for different aged mothers showing the number of clutches of that size for each age class.

	Age of female				
	1	2	3	4	Total
Clutch size					
1	-	-	-	-	-
2	1	1	1	-	3
3	3	3	2	-	8
4	-	-	-	-	-
5	-	1	-	2	3
Average	2.8 (n=4)	3.2 (n=5)	2.7 (n=3)	5.0 (n=2)	3.2 (n=14)

TABLE 11: Hatching rate of Campbell Island Teal on Codfish Island for different aged mothers, showing the number of ducklings hatched from each clutch.

	Age of female				
	1	2	3	4	5
	# hatched from each clutch				
Clutch size					
1				-	-
2	2	2		2	-
3	1 2 2	3 3 2	2		-
4	-	-	-	-	-
5		4		-3	5
Average (n=14)	64% n= 4	91% n= 4	75% n=2	71% n=2	100% n=2

TABLE 12: Fledging rate of Campbell Island Teal on Codfish Island for different aged mothers, showing the number of ducklings fledged from each brood for females of each age class.

	Age of female				
	1	2	3	4	5
	# fledged from each clutch				
# hatched per clutch	-	-	-	-	-
1 (n = 0)	0(total fledged =0)	-	-	-	-
2 (n = 3)	0, 0, 2 (total fledged =2)	0, 0, 2 (total fledged =2)	0- (total fledged =0)	2 (total fledged=2)	-
3 (n = 8)		2, 2, (total fledged=4)	2 (total fledged=2)	2 (total fledged =2)	-
4 (n = 0)	-	-	-	-	-
5 (n = 3)	-	-		-	5 (total fledged=5)
Average (n=14)	29% n=4	50% n=5	25% n=2	80% n=2	100% n=1

There was no pattern to clutch size, hatch rates or fledging rates relative to the age of the mother, although one year old birds were consistently at or near the lower end of the scale for all stages of productivity. The data in tables 10 –12 indicates that one year old birds can successfully hatch and fledge young, however they will fledge fewer young than older birds.

5.2.5 Productivity relative to how many years the mother has been on Codfish Island

TABLE 13: Productivity of Campbell Island Teal on Codfish Island relative to how many years the mother has been on the island.

Number of years since females release	Number of nests	Total number of eggs (Ave)	Hatching success (%)	Fledging success(%) (from hatched)
One	5	16 (3.2)	11 (68)	2 (18)
Two	5	13 (2.6)	12 (92)	6 (50)
Three	3	13 (4.3)	10 (76)	9 (90)
Total	13	42 (3.2)	33 (78)	17 (52)
Mean	4.3	14 (3.7)	11 (78.7)	5.7 (52.7)

The length of time that the female had been on Codfish Island appeared to co-relate to the fledging rate of any of the factors considered. While the sample size was small, especially for birds in their third year on the island, the fledging rate consistently increased. The table does not include the female fledged on the island as she had an additional year to acclimatise to the island prior to her first opportunity to breed.

5.2.6 Difference in fledging rate between years for those females which nested in two or more consecutive years

TABLE 14: Fledging rate of Campbell Island Teal on Codfish Island for females that nested in consecutive years

Female	1999/2000			2000/2001			2001/2002		
	Hatched	Fledged	%	Hatched	Fledged	%	Hatched	Fledged	%
Venus	4	0	0	2	0	0	3	2	67
Falla	1	0	0	2	0	0	2	2	100
Glacier	2	0	0	3	2	67			
Buttercup				2	0	0	2	2	100
Puiseux				2	2	100	5	5	100

Of the five females that bred in two or three consecutive years, four had an increased fledging rate in the second or third year (Table 14). Three of those increases were during the final year when environmental conditions were better, and two of the females had also had two previous years where they had not fledged a single duckling. None of the females had bred in captivity before release.

5.3 Discussion

5.3.1 Difference in productivity dependent upon site

There was both a greater average clutch size and a higher hatching rate at Northwest Bay than Sealer's Bay, although the largest difference was in the fledging rate. The low sample size makes quantifiable comparisons difficult, but there is a strong indication that it is the habitat quality that is the dominant factor in duckling survival as both females that bred at Northwest Bay fledged their full broods. Specifically it is feeding habitat that is the major difference between the two release sites, e.g. the Northwest Bay Stream is shallow, provides good dabbling margin for ducklings and did not dry up during the study, while the streams at Sealer's Bay are either deep with minimal suitable margin, e.g. exposed muddy areas where the teal have been observed dabbling, or are small and dry up in dry periods.

It should be noted that these results may be biased as only the female at the "preferred site", the main stream mouth, at Northwest Bay, was able to be tracked each year. Females at other less optimal locations may also have bred, and may have had lower survival. In comparison Sealer's Bay, all the females including those in sub-optimal habitats, could be monitored.

5.3.2 Difference in productivity between years

While there was relatively little difference in clutch size and hatching rate between the years, there was a large increase (125%) in the fledging rate for 2001-02, 92%, from the previous highest, 28% . The increase is believed to relate to the availability of suitable feeding sites for ducklings during the first two summers there was little rain and the shallow ephemeral wetlands/shallow streams utilised by the females with ducklings dried up. In the third summer this did not happen and there was good feeding habitat for all the ducklings.

5.3.3 Productivity dependent upon age of mother or how many years the mother has been on Codfish Island.

One year old birds are consistently at or near the lower end of the scale for all stages of productivity: clutch size, hatching and fledging. The percentage of ducklings fledged rose from 18% to 55% from one year old birds to two year old birds, however, it then dropped again for the following years. No birds less than four years old managed to fledge their whole brood but some four and five year old birds also lost their full broods. The fact that the last year of the study was by far the most productive in terms of ducklings fledged is unlikely to be due to the increasing age of the females as a two year old female also raised her full brood that year in her first breeding season. It is more likely that the difference is due to the better environmental conditions for duckling survival that year.

While there is no pattern to either the clutch size or the hatching rate relative to the length of time post release for females, there is a constant and significant increase in the fledging rate. The data set is still very small (total of 13 nests and three breeding seasons), and may simply reflect the better year for duckling survival in 2001/2002. The increased duckling survival may also possibly be due to the increased age/breeding experience of the mothers as opposed to simply the increased time on the island, although this is not supported by information on age and breeding experience of females at the time of release.

5.3.4 Fledging rate relative to the previous breeding experience of the females

Although the sample size is small, it would appear that prior breeding experience does not enhance a captive bred teal's chances of fledging ducklings. Of the two females which had bred before release, one did not attempt to breed in her first year on the island and then was killed before her second season. The other did not attempt to breed during the two seasons she was on the island. Of the 10 released females of varying ages which had not bred in captivity, only one is not known to have attempted to breed since release. All the birds which could be

monitored for their first season (seven) attempted to breed while one (Puiseux) did not breed until her second year when she was able to move into the preferred habitat at Northwest Bay.

5.3.5 Duckling survival

Of the 36 ducklings hatched between 1999 and 2002, 19 definitely survived to fledging and three others are likely to have survived. While there appears to be a significant difference in duckling survival between the two sites it is important to note the inability to monitor any birds at Northwest Bay other than those at the "preferred" site (the main stream). In comparison, all the females at Sealer's Bay, including those in poorer habitat, were monitored, and this is likely to have biased these results. It is known that other teal, in addition to those included in this data, nested and fledged ducklings at Northwest Bay as there were juveniles which could not be accounted for from any known nest, but no data is available on those nesting attempts. It is possible to conclude that the main site at Northwest Bay provides a better habitat for raising ducklings than does Sealer's Bay as the female at the Northwest Bay site consistently fledged ducklings, even though the individual bird changed. In comparison duckling survival for the first two years at Sealer's Bay was extremely low.

Studies of Auckland Island Teal (Williams, 1995; 1997) indicated that duckling survival in the wild was low. Williams (1995) found an average brood was 2 (range 1-4) with most broods only having one duckling. A study of wild Brown Teal (Williams, 2001) found an average of 2-3 ducklings per pair per year although this included some second clutches and was in highly modified habitat. In comparison Campbell Island Teal averaged 1.35 ducklings fledged per brood (range 1-5).

The low fledging rate of Campbell Island Teal has been identified by this study as a major cause for the low productivity of the species and it is likely that this is due at least in part to poor parental care, with many ducklings becoming separated from their mother especially with larger broods. Several females were observed to leave their brood unattended for more than 15 minutes, during which time the brood could become dispersed and individuals lost. While it was frequently difficult or impossible to follow females with ducklings due to the secretive nature of the females, good observations of one female, (Venus), were made in 1999/2000. She hatched five ducklings, but from five days after hatching she lost one duckling on average every two days until they had all disappeared. She was observed to frequently leave the ducklings while she was feeding and then return 10 – 20 minutes later. The ducklings often did not stay together during these periods and it is likely that it was then

that ducklings were lost. The same cause of brood loss has been observed in Auckland Island Teal (Williams, 1992) and it is likely that this is due in part to the dense vegetation found in the habitats frequented by both species. As birds released on Campbell Island will also have to contend with dense vegetation, it is likely to also be a problem at that site. The situation is quite different for Brown Teal where duckling loss was due to habitat loss and increased exposure to predators (Williams, 2001).

Another likely cause of duckling loss was the dry conditions experienced on the island during the first two years of the study, when many of the muddy "dabbling" areas at Sealer's Bay dried up. There was a greatly increased survival rate during the third year when it was wetter over the duckling rearing period.

The age at which most of the ducklings on Codfish Island were lost corresponds with that found by Williams (1995) for Auckland Island Teal on Ewing Island, where five broods were followed and of those four were reduced to a single duckling within 10 days. The fifth brood of four ducklings all survived to 28 days when observations ceased. The same was found to be the case for Brown Teal on Great Barrier Island (Barker and Williams 2000) where six out of 10 broods disappeared entirely within 1-3 days of hatching.

5.3.6 Clutch size and double clutching

There was no significant change in clutch size between the three seasons monitored. Clutch size appeared to increase significantly once the females reached four years of age, however, as the monitoring stopped at this point and the sample size is so small, this may be coincidence as the average clutch size for the previous age class (three years) was the lowest recorded. There is insufficient data to do a meaningful comparison between the two release sites but there does not appear to be a significant difference between the two.

There was no evidence of double clutching by any females on Codfish Island in contrast to teal in captivity, where double clutching for both Campbell Island and Auckland Island Teal has been recorded on several occasions (Anon, 1999/2000/2001/2002), most commonly when eggs were infertile or were removed. The absence of double clutching in Campbell Island Teal, even when the entire brood was lost soon after hatching, contrasts with the limited information on Auckland Island Teal in the wild. It is likely that Auckland Island Teal will renest if the brood is lost early (Williams, 1995). Brown Teal in the wild are also known to

frequently renest (Williams, 2001). The difference between the three species may reflect the shortened breeding seasons for the subantarctic teal or show that food is a limiting resource.

5.3.7 Nest Site Selection

Of the 14 nests found during the study, 11 (79 %) were under flax (*Phormium tenax*), and two (14 %) were under astelia (*Astelia nervosa*). All but one nest were in cavities at the base of these plants, the other was overhung by drooping leaves. All the nest sites gave good cover from aerial predators, with the one nest which was an open bowl being under a low canopy of scrub. Most only had one entrance which would have made them very vulnerable to mammalian predation. All sites were dry, being either on sandy ground or well above watercourses.

There was no discernable pattern to the aspect, slope or elevation of the sites selected. Most of the nest sites were < 30m from either freshwater or the sea, but two nests were more than 100m away from the nearest water. Other nests were also on steep (inaccessible to humans) slopes with seemingly difficult access to feeding areas. The nest sites selected on Codfish Island plus observations of Auckland Island Teal (Williams, 1995), which showed that while tussock and fern are the most common sites for nests, the teal will utilise a wide range of sites that provide overhead cover, indicate that suitable nesting sites will not be a limiting factor on Campbell Island.

Fig. 14: Map of Sealers Bay, Codfish Island, showing locations of nest sites

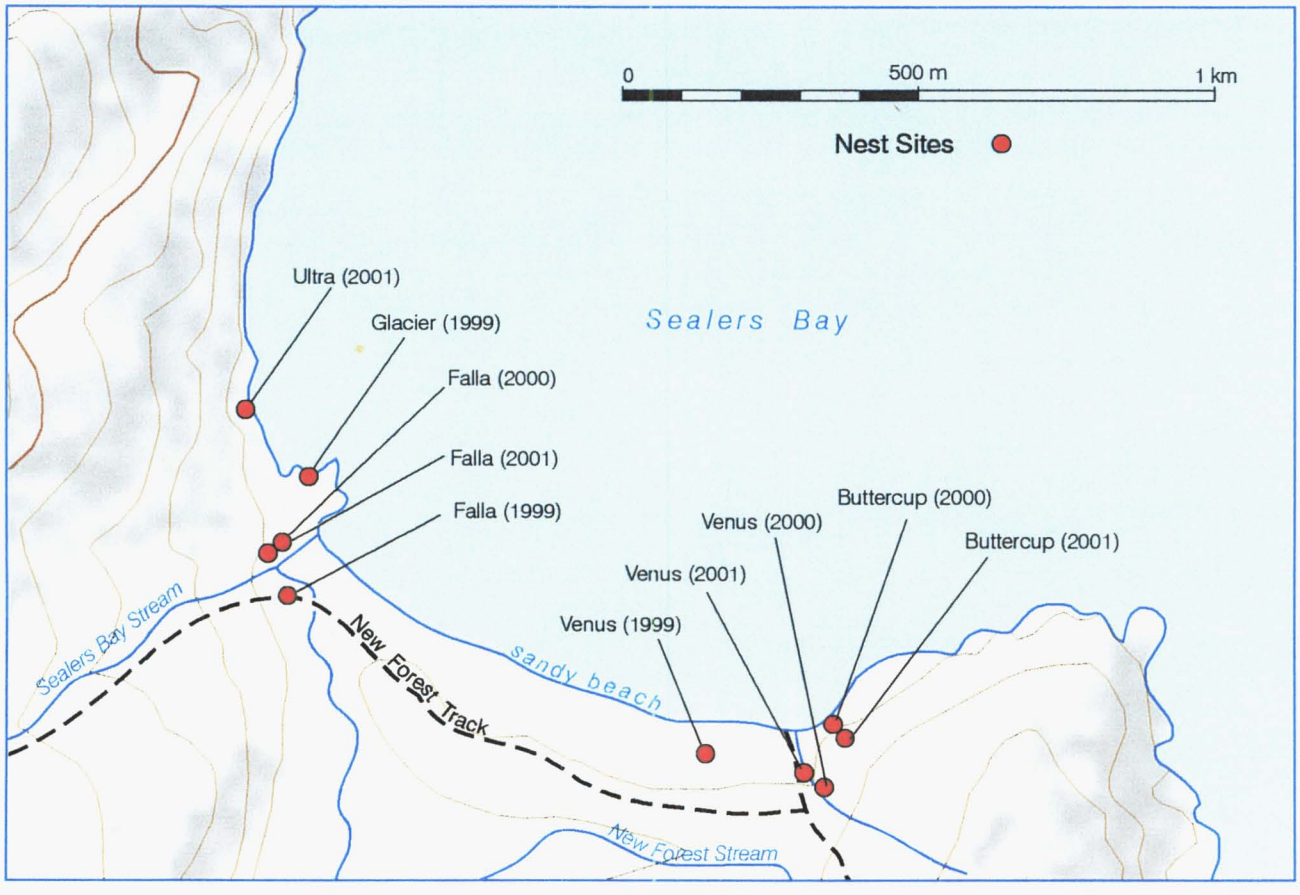
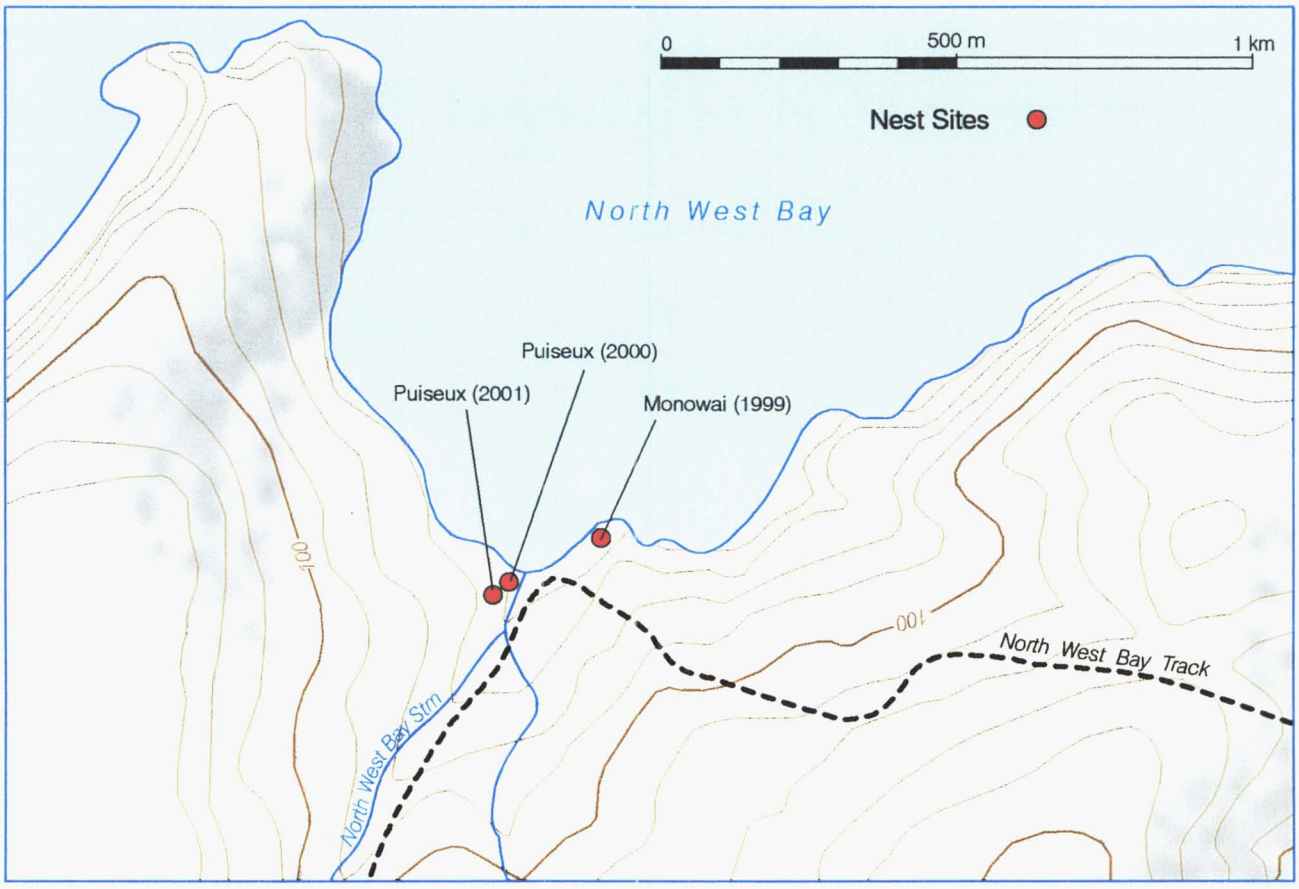


Fig. 15: Map of North West Bay, Codfish Island, showing locations of nest sites.



6 General behaviour

6.1 Introduction

The rugged nature and inaccessibility of Dent Island and the generally secretive nature of Campbell Island Teal has made any comprehensive work on teal in their natural environment impractical. This has meant that nearly all previous information on Campbell Island Teal behaviour has been gained from observing birds in captivity (Preddey, 1995b) or from inferring likely behaviour from Auckland Island Teal. This chapter adds significantly to that information, and, given that the planned introduction to Campbell Island will be both of birds direct from captivity and by transferring wild birds from Codfish Island, it is important to have as much information on the behaviour of the captive bred birds as possible, e.g. predator avoidance and territorial aggression. This will allow an assessment of the likely survival of captive bred and wild-bred birds released on Campbell Island. It is recognised that the behaviour of the teal recorded on Codfish Island may in fact not be representative of the species as a whole since Codfish Island is significantly different from Dent and Campbell Islands. The release situation is unnatural due to density of birds, sex imbalance etc, and they originate from a small founder population, e.g. it could be that the more mobile, or slower, birds were collected thus affecting the behaviour of the new population.

6.2 Observations

6.2.1 Interactions with humans

There was a huge variability in the response of birds to contact with humans. Most birds were constant in their behaviour throughout the year but some females became more wary when they had ducklings. The extremes were a female (Venus) who would openly take her brood within three metres of the observer if the observer remained relatively still, to birds that would move away as soon as they became aware of the presence of the observer, e.g. Glacier (F). Most birds could be approached to within three to five metres and they would simply observe any person approaching. If that "safety distance" was breached they would move quietly away.

Some non-breeding birds would actively approach people even to the point of pecking at their boots. As no supplementary feeding of the teal has been allowed since release this behaviour either reflects a real lack of fear of humans or is a result of the captive raised birds still associating humans with food. There was no observable difference in the behaviour of male

teal to humans between breeding and non-breeding periods, or with the age of the birds or how long they had been on the island.

Birds which frequently encountered humans, such as those at the Sealer's Bay estuary, were observed to have a reduced safety distance with some birds voluntarily coming into close proximity to humans. These birds would routinely have 10-20 human encounters per day and were also the ones people photographed and observed recreationally. Other birds, which did not interact with humans so frequently, were more wary. The birds appeared to feel safer on water than on land as they would go onto water if approached too closely.

6.2.2 Territorial interactions between teal

As with Auckland Island Teal (Williams, 1995), territories were defined as "defended areas" which were fixed geographic areas, rather than a set distance around moving birds. However there appeared to be more flexibility in Campbell Island Teal territories than Williams recorded for Auckland Island Teal. For example, a pair of birds (Norton and Falla) which were dominant at the estuary were occasionally recorded feeding >300m up the stream, which was outside the area from which they normally excluded other birds. Also one female regularly crossed through another pair's territory from her nest site to her favoured feeding area. If she encountered the territorial female on the way she would be pursued until out of the territory. While it was not observed, it is likely that the dominant female killed, or at least indirectly caused the death of, at least one and probably both of the brood of the subordinate female as she was seen chasing the female and neither five day old ducklings were seen alive after that.

While some birds, both male and female, did defend territories this was only observed at the most preferred sites, i.e. the Sealer's Bay estuaries. The birds at this site would actively defend their territory, chasing away any other teal which entered it. Birds in poorer habitats, e.g. Norton's pond, did not behave this way and females were observed roosting within three metres of each other. No male interactions were observed at any of these secondary sites. All observed territorial disputes, where the sex of both birds could be determined, were between birds of the same sex. This is the same as for Auckland Island Teal where both sexes defend the territory (Williams, 1995) but differs from Brown Teal where the males alone defends the territory (Williams, 2001) evicting juveniles as well as other males.

Females were never observed defending nest sites, probably because they selected sites away from roosting areas and hence avoided confrontation.

The only sites where more than two birds were recorded in close vicinity (<3 m) without any interaction were at the Sealer's Bay Estuary and Norton's Pond and then only outside the breeding season. At the estuary site several birds, males and/or females could be present within a 20m radius but only two birds would ever be obvious, any other birds would generally be roosting in the long grass adjoining the stream. It is probable that the "resident" or "dominant" birds were aware of the other birds' presence, but it appeared that the resident birds accepted the intruders if they did not blatantly show themselves. During the breeding season the dominant bird of both sexes was observed to chase other birds out of the area.

Understanding the territorial behaviour of this species will allow an estimate to be made of possible carrying capacity of a range of release sites on Campbell Island, which will in turn guide how many teal should be released at each site so as to ensure that the teal's breeding success is not negatively affected by their density.

6.2.3 Territoriality in the three endemic New Zealand teals

Williams (1995) recorded two categories of pairs for Auckland Island Teal; territorial, which had a fixed location and drove other birds away; and subordinate, which were harassed by territorial pairs and did not raise ducklings. There was no evidence of this second category on Codfish Island. This may have been due to the imbalance in sex ratios the first year and having sufficient area for all pairs to establish territories.

Williams (1995) found that in addition to food, territories for Auckland Island Teal had to have sites where the birds could rest safely and not be seen, e.g. beneath fallen logs, in petrel burrows, or beneath thick fern or tussock etc. They also needed a protected site to bask in the sun. All the defended territories on Codfish Island also had these properties, although the birds appeared to make little use of the safe sites.

Males on Codfish Island showed ownership of the territory by making themselves obvious, e.g. standing on the log bridge in the Sealer's Bay stream where any birds on the water would see them. Similar behaviour has been observed for Auckland Island Teal (Williams, 1995) with territorial males making themselves very conspicuous, especially those around the coast.

The Brown Teal's more dispersed breeding, often well away from the communal flocking sites, may explain why they do not display this behaviour.

6.2.4 Flocking

Flocking was occasionally observed at Sealers Bay and then only outside the breeding season. This behaviour appeared to be more due to reduced aggression allowing birds to be in closer proximity to with one another, rather than what is normally regarded as flocking for a food source or mutual safety. This differs from Auckland Island Teal where birds frequently form flocks, consisting mainly of both juveniles and adult males, even in the breeding season (Williams, 1995). The difference may be the relatively low density of adults, and small number of juveniles in the Codfish Island population. Brown Teal also frequently form winter flocks of largely non-breeding individuals, as most birds lay from June to October, but have been recorded flocking at most times of the year (Dumbell, 1987).

6.2.5 Interaction between ducklings.

There was no observable interaction between ducklings within the same brood. They fed independently and did not appear to respond to each other's calling, even when they became separated from the brood. There were no observed encounters between two broods of ducklings.

6.2.6 Anti-predator behaviour

There are no terrestrial predators on Codfish Island which would affect teal. The aerial predators, harrier hawk, (*Cirus approximans*) black backed gull and morepork, are in low numbers on Codfish Island and there were no observations of interactions between teal and these species. There were very few occasions where predator avoidance was observed. A female (Monowai) and her two ducklings were on the Northwest Bay stream when a bellbird (*Anthornis melanura*) flew over making loud wing beats. Both juveniles (approximately eight weeks old) immediately dived under the water, the female did not show any such response. On several occasions kaka (*Nestor meridionalis*) activity near the stream caused the teal present to issue alarm calls and move to cover.

When in the sea the teal have only been observed close to the shore, thus it is unlikely that any marine predator large enough to prey on even a duckling would have been encountered. However, there are longfinned eels in Sealer's Bay, and probably also Northwest Bay, streams which could easily prey on a duckling, and potentially even an adult. While no direct

evidence of such predation was observed, an attentive female (Falla) lost three ducklings on the stream over two years including one at 11 days old.

6.2.7 Nocturnal behaviour

While the teal did feed during daylight hours this was primarily in sites with over-head cover, e.g. in the dune ponds and up the streams. Birds were occasionally observed feeding during the day in the Sealer's Bay estuary and rock pools (above the high tide level) at the east end of Sealer's Bay but on these occasions they were always < 5m from cover. The primary activity during the day was either roosting or territorial disputes when another bird entered their territory. When feeding at night the birds would move considerable distances from cover (50m+). While no records of behaviour according to the phase of the moon or cloud cover were made, it was noted that birds were active regardless of either of these factors.

Being unable to effectively observe the teal during darkness restricted the behavioural component of this study as nocturnal behaviour is a significant part of the ecology of many waterfowl species (Myrfyn, 1990), including both Auckland Island (Williams, 1997) and Brown Teal (Williams, 2001), and is likely to be based on predator avoidance rather than an inability to obtain enough food during the day.

6.2.8 Use of burrows

While some teal frequently roosted in dense grass or under overhangs, only limited use of sooty shearwater (*Puffinus griseus*) and little blue penguin (*Eudyptula minor*) burrows was recorded. All birds recorded using burrows were females with ducklings at foot. On Dent Island, which is densely burrowed by seabirds, the teal frequently retreated down burrows when they felt threatened (Goudswaard, 1991). The same behaviour has been recorded for Auckland Island Teal where birds use burrows and also a range of other sites that provide shelter, e.g. logs and rock piles (Williams, 1995).

The restricted use of seabird burrows for shelter by the teal on Codfish Island may be due to a scarcity of seabird burrows over most of the Sealer's Bay site; the difficulty in locating birds when they were in burrows; or that the birds were simply not used to going into burrows. The most likely cause for the restricted use of burrows on Codfish Island is that seabird colonies generally do not correspond with the teal territories. This means that the birds have to make greater use of dense vegetation. The same will be true on Campbell Island where there are currently few if any seabird burrows near the likely release sites.

7 General Discussion

7.1 Determining the success of the Codfish Island Introduction

The introduction of Campbell Island Teal to Codfish Island has been deemed successful as it met the following criteria:

- there was a high survival rate of birds released on the island;
- the released birds bred successfully;
- the teal appear likely to establish a self-sustaining population;
- the captive raised and wild bred birds are exhibiting predator avoidance, albeit at a very basic level;
- the release has shown that captive bred teal can be successfully released into the wild.

The characteristics of Campbell Island Teal that allowed them to establish a successful population on Codfish Island were:

- the high survival rate of the released birds;
- their adaptability to utilise a range of aquatic habitats;
- their ability to breed at one year of age;
- their ability to disperse over large areas to locate suitable habitats.

Factors which restricted the success of the teal on Codfish Island were:

- reliance on freshwater dabbling areas which frequently dried up, reducing duckling survival;
- poor parenting, including lack of male participation in raising the brood, which may have lead to increased loss of ducklings;
- small clutch size and low fledging rate for the first two years.

As well as allowing the success of the Codfish Island introduction to be gauged, this study has provided a large amount of basic biological and ecological information on Campbell Island Teal which was previously lacking. Although, by its nature this information is non-quantitative, it is an important base for the ongoing management of the species and its habitat (Caughley, 1994).

7.2 Modeling the likelihood of the Codfish Island population becoming self-sustaining

The establishment of a self-sustaining population of Campbell Island Teal on Codfish Island following the release of 24 birds would give a strong indication that the release of sufficient

teal on Campbell Island, (allowing for the greater area they can disperse over on Campbell Island), would also result in a long term population. To gauge whether the Codfish Island population is likely to be self-sustaining the productivity and mortality of the released birds were modelled.

7.2.1 Annual production

Production was calculated for all age classes each year and then averaged across those classes to calculate the annual production for that year.

$$\text{Productivity} = Fi \times Di \times \Sigma (Ai \times Ci + Ai{+}1 \times Ci{+}1 \ldots\ldots) \times H \times E \times B$$

Where

Fi = number of females in age class i

Di = proportion of females of age class i that attempted to breed

Ai = probability that a female aged i attempting to nest

Ci = average clutch size for age class I

H = nest success rate

E = survival of eggs to hatching

B = survival of ducklings to fledging

From (Johnson et al 1992)

TABLE 15: Annual production of Campbell Island Teal on Codfish Island.

Year	Production per female across all age classes	Number of females involved
1999	1.34	4
2000	1.1	5
2001	6.94	5
Ave	3.13	4.66
S.D	3.303	

Given that there are at least four, and possibly more than 10, productive females on the island the average productivity will be a minimum of 12 ducklings per season and possibly in excess of 30.

7.2.2 Annual Mortality

Mortality was modelled for both minimum survival, i.e. any bird which was not confirmed alive was presumed dead, and for maximum survival, i.e. any bird which was not confirmed dead was presumed alive. The reality will be somewhere in between but it is not possible to

gauge where. The fact that all four birds which were confirmed dead, died of human related causes suggests that the survival rate is likely to be at the higher end of the scale.

Mortality $M = (N(t) - N(t+1)/ Nt$

Where N(t) = the number of birds aged t

TABLE 16: Mortality rate of adult teal on Codfish Island.

Year	Worst case scenario	Best case scenario	Ave
2000	0.33	0	0.165
2001	0.33	0.125	0.228
2002	0.5	0.04	0.27
Ave	0.39	0.06	0.225
S.D.	0.38	0.04	

Allowing for a minimum of 13 adult teal on Codfish Island, the average annual mortality will be between 0.78 and 5.07 birds. However, it is likely that there are significantly more ducks present on the island which not only means that the mortality rate will be lower, i.e. closer to the best case scenario, but that the impact of losing a given number of ducks each year will be less.

7.2.3 Is the population likely to be self-sustaining?

The results show that, on average over the three year period of this study, the number of fledged ducklings did exceed mortality. There were obvious differences between years, for example 2002 was far more productive than 2000 or 2001. It is the frequency with which these good years occur that will govern whether the capacity of the island is reached and, if so, when. In a worst case scenario where these good years are very rare, i.e. less than every fifth year, the population may in fact decrease. Four productive females producing an average of 1.1 young per year would only give 4 – 5 ducklings while in a worst case scenario for mortality you could lose five adults. The severity of the effect would depend upon the gain or loss of females, it would possible for the population to become technically extinct, i.e. no females in three years.

No modelling was carried out to predict if the Codfish Island population's viability would have been significantly enhanced by further releases as has been recommended for all introductions by Armstrong and Ewen (2001).

7.3 Use of captive breeding for release in other waterfowl recovery programmes

Other waterfowl recovery programmes that have involved the release of captive bred birds into the wild include: white headed duck (*Oxyura leucocephala*) in Spain, Giant Canada Goose (*Branta canadensis maxima*) in North America and the Aleutian Canada Goose (*Branta canadensis leucopareia*) on the Aleutian Islands, and Brown Teal and to a lesser extent Blue duck (*Hymenolaimus malacorhynchos*) in New Zealand. The Aleutian goose programme which also involved the removal of predators from islands within their previous range (Black, 1991), has been very successful with the birds recovering to the point where they are no longer considered endangered (United States Environmental Protection Agency, 2001).

7.4 Benefits of using Codfish as a holding island

As well as having a wild population to safeguard the species, the use of Codfish Island as a staging post has been important in overcoming the risk of domestication and for providing information to maximise the chances of success of the reintroduction on to Campbell Island.

While it was initially planned to remove all Campbell Island Teal from Codfish Island once they were established on Campbell Island, it was soon obvious that the nature of the habitat and the dispersal of the birds would make this at best, a very difficult and expensive exercise and at worst probably impossible. Despite the inherent problems the Department of Conservation decided to continue with the releases. As many teal as possible will be removed as part of the transfer to Campbell Island and a decision made at that time as to the future of any remaining birds. If all the birds can not practically be removed, Codfish Island may end up supporting a second wild population which will provide an additional safeguard for the species.

7.5 Why Campbell Island Teal established on Codfish Island when Brown Teal became locally extinct.

The success of the Campbell Island Teal introduction to Codfish Island when Brown Teal became locally extinct raises the issue of what the difference was, and whether Codfish Island could be used as a haven for Brown Teal, if and when Campbell Island Teal were removed. It is possible that the Brown Teal on Codfish Island were only a small satellite population of those on the Stewart Island mainland which may not have been self sustaining and died out

once they could no longer be supplemented from the Stewart Island population. It is also possible that the weka and kiore (*Rattus exulans*) affected the Brown Teal, however Brown Teal have survived on Kapiti Island in the presence of both these species as well as Norway rats and on Great Barrier Island in the presence of ship rats (*Rattus rattus*), kiore and cats. This indicates that it may be either differences in habitat use or Campbell Island Teal's inability to disperse off the island.

7.6 Release on to Campbell Island

7.6.1 Is Campbell Island suitable for the reintroduction of teal

Because the introduction to Codfish Island was monitored in the way that it was, the Department of Conservation will be able to plan the Campbell Island release to maximise its chances of success while using the minimum possible resources.

One of the most important issues for the Campbell Island release is deciding whether the site has suitable habitat for the teal (Armstrong and Ewen 2001). Black (1991) also states that re-introductions (releases) should only take place when the habitat is capable of sustaining a viable population and the original constraining factors no longer operate. There is little doubt that introduced cats and rats caused the extinction of the teal on Campbell and these have all been removed. Campbell Island offers a wide range of habitats, including streams, tidal mudflats and a lake, as well as sandy beaches and both sheltered and exposed rocky coasts. These habitats are all used by Campbell Island Teal on Codfish Island as well by Auckland Island Teal (Moore and Walker, 1991). This range of habitats combined with the large area available should ensure that food, nesting areas and territorial conflict are not likely to be a cause of failure of the reintroduction.

It is a reasonable assumption that because the teal released on Codfish Island have done so well, and appear to have become a self sustaining population, they will be better adapted to life on Campbell Island than birds directly from captivity. The ability to release wild bred/living birds as well as captive bred birds should significantly increase the chances of success of the releases. Wild to wild transfers have been shown to have a greater chance of establishing than captive to wild transfers (Griffith *et al.*, 1989, Beck *et al.*, 1994, Ginsbwerg, 1994, Miller *et al.*, 1994 in Curio, 1998). This, combined with the high survival rate of the captive bred birds released on Codfish Island, suggests that teal will do well on Campbell Island.

7.6.2 Comparison of habitat types

As Campbell Island Teal have never been confirmed as being resident on Campbell Island (Williams and Robertson, 1996) it is important to look at the factors that make both Codfish and Dent Islands suitable and confirm that those factors are present on Campbell Island.

On Dent Island the teal feed in the shallow seepage channels that are present in gullies, and in shallow pools at the mouths of white-chinned petrel burrows. Auckland Island Teal predominantly feed around the coast (Williams, 1995). A similar feeding habitat to that used on Dent is also used by the teal on Codfish Island, specifically the shallow water and damp mud in the smaller streams and wetlands. There are a range of similar areas on Campbell Island, both freshwater (streams), and coastal (tidal mudflats). However, the mudflats on Campbell Island do not have any overhead cover to shelter the birds from aerial predators. This does not appear to affect Auckland Island Teal, which feed on open mudflats on the north side of Adams Island.

In addition to the mudflats, other habitats found around the coast of Campbell Island are also likely to be utilized by the teal. It is assumed that the steep and high energy nature of the coastline around Dent Island means that the bird's use of this habitat is severely restricted and the food sources there are limited. The lack of records of Auckland Island Teal from similar coastlines backs up this belief. On Campbell Island, as with most other larger islands, there is a range of other coastal types which are less active and are likely to provide suitable feeding areas. These include rock platforms of various gradients, and a range of boulder, stone and sandy beaches. That some of the teal at Northwest Bay on Codfish Island lived for at least a year in this habitat type shows that teal can survive there for at least limited periods, and they can probably breed there.

The use of Auckland Island Teal as an analogue for Campbell Island Teal is also useful when it comes to use of forested areas. On Dent there is no woody vegetation while on Campbell Island *Dracophyllum,* which from a teal's perspective is effectively forest, is recolonising areas previously covered in tussock. That both Auckland Island Teal and the Campbell Island Teal on Codfish Island move freely through the forest, primarily up the streams, indicates that teal on Campbell Island will also use this habitat for shelter and, where suitable, feeding.

On Dent Island Campbell Island Teal have frequently been observed on exposed rocks or patches of bare ground from which they can view their surroundings (Williams and

Robertson, 1996). The same behaviour has been seen on Codfish Island, especially on the log bridge at Sealer's Bay. However, as not all areas frequented by the teal have suitable viewing sites, it is probable than this makes a site desirable but is not necessary.

7.6.3 Selection of release site on Campbell Island.

The Campbell Island Teal released on Codfish Island have shown that they can not only survive but can flourish in a range of habitats, although inability to monitor all the birds has meant that we cannot compare the different sites as well as was desired. The most likely site for release is Perseverance Harbour where a larger number of birds (>50) could be released to utilise the tidal areas and adjacent streams. There is also plenty of nesting cover in this area as there is over the entire island. While this is an area frequented by visitors to the island, the birds have shown that they are unlikely to be affected by the presence of humans as long as people do not approach any wildlife closer than five metres.

7.7 Selection of birds for release

7.7.1 Age classes for release

As there was no difference in the survival of the different age classes released on Codfish Island, and there are significant financial saving in not holding birds in captivity for any longer than necessary, it is preferable to release the maximum number of birds on Campbell Island regardless of their age and it is likely that most of these will be juveniles.

The information collected on Codfish Island also shows that productivity does increase with age, but that prior breeding experience is not a prerequisite for the Campbell Island release. Therefore while it is desirable to have older birds, especially females, it is not an overriding factor.

7.7.2 Size of the founding population.

Given the size of Campbell Island and the area that is believed to be suitable habitat, in excess of 30km of coastline as well as a range of freshwater habitats, it is desirable to release as many birds as possible. These could either be concentrated at one site, probably Perseverance Harbour, or split between there and other sites. Armstrong and Ewen (2001) showed that for most successful introductions, multiple follow up releases were required. Given the size of Campbell Island and the presence of skua, which the released teal will not previously have encountered, there should be at least one follow up release into the other sites to ensure the introduction succeeds and to speed up the colonisation of all the suitable habitats.

It is generally accepted in New Zealand that a release into a new habitat should consist of at least 40 individuals (Armstrong and McLean, 1995), with the likelihood of an introduction succeeding increasing as a function of the founder group size (Griffith *et al.*, 1989), unless intensive post release management is undertaken. As no post release management of teal is proposed for Campbell Island due to the expense and logistical difficulties, the release should consist of as many birds as possible to maximise the chances of the reintroduction succeeding.

7.7.3 Prerelease training of birds

As it is not possible to carry out any actions to protect the teal on Campbell Island, other than removing skua, which would not be acceptable, there is the option of "training" birds to avoid predators as has been done for other species with varied success, e.g. Takahe (*Phorphyrio mantelli*) which were trained to avoid stoats (*Mustela erminea*) (Holzer *et al.*, 1995). Training would, however, require a significant amount of resources and the observations of both captive bred and wild bred birds on Codfish Island would indicate that they are still innately aware of aerial predators

7.7.4 Implications for other species

It is likely that much can be learnt from the recovery programme for Campbell Island Teal, which could be used for other endangered species, especially waterfowl. A prime example is the Laysan duck (*Anas layanensis*) which is also restricted to one small island and requires at least one additional habitat to secure its future. Unlike Campbell Island Teal, Laysan duck can fly, but like the teal they have evolved in the absence of mammalian predators and hence are reluctant to take to the air. The initial stages of a recovery programme for the species are currently underway with research into the limiting factors for the species (Reynolds 2000) although unlike Campbell Island Teal, it is likely that bird numbers, approximately 300, would permit a direct transfer from the wild to the new site.

7.8 Problems encountered

Several problems were encountered during various stages of this study, some of which affected the results, and others which would simply have made the work easier had they not occurred.

7.8.1 Transmitters

The backpack transmitters appeared to have been of little hindrance to the teal, i.e. they could

still move through very dense cover, although one female (Puiseux) was found dead with her harness tangled in a bush.

The main problem with the transmitters was aerials breaking, meaning that the signal could only be detected at close range, sometimes as little as 10m. While the life expectancy of the transmitter was given as 16 months, some of the transmitters in this study lasted less than 12 months. The manufacturer believes that this is due to the colder temperatures at Codfish Island compared to the northern areas where the same transmitters are used on Brown Teal.

The kakapo (*Strigops habroptilus*) on Codfish Island are also located using radio transmitters on the same band as the teal. When within receiving range, the kakapo transmitters often had a stronger signal than the teal transmitters, thus the kakapo signal could override the teal signal resulting in the observer unknowingly tracking a kakapo rather than a teal.

The 2002 transmitter change was carried out in mid-late April rather than late March as had been the case in 2001. This month's difference meant that fewer fledgling ducklings were with their mother as they were in the previous year, meaning that catching the fledglings was much harder as it relied solely on the dog being able to pick up their scent rather than being able to radiotrack the mother and find her ducklings as well. Also adult birds did not use the Sealer's Bay stream as much at this later stage.

The Campbell Island Teal proved harder to catch than Brown Teal or Auckland Island Teal in their native habitat. This difference is believed to be more due to the origin of the birds i.e. captive-bred birds being more wary, than any difference between the species or site (J. Fraser pers. comm., 14 September 2002).

7.8.2 Night vision gear

Night vision gear, ITT Night Mariner with 1 x magnification, was trialled as a way of obtaining improved observations of the birds' behaviour at night. Both white light and red light, i.e. a torch covered with red cellophane were trialled in an attempt to improve the results from this technique. While it was found to work moderately well in open areas, on the beach or Sealer's Bay estuary, even when used with an artificial light source it was of little use under the forest canopy. This gave a large bias in the sampling towards "open area" behaviour and hence the equipment was only used infrequently to pinpoint birds and not to observe behaviour. It was found that a red light source had little observable effect on the teal and

could be used to help pinpoint teal under the canopy but was not sufficient to carry out observations.

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Appendices

Appendix 1

Field recording form used for this study.

Survival and Habitat use of Campbell Island Teal on Codfish Island

Recording Form

Date_____ Observer/s_____ Daylight_____

Bird #	Time	Weather	Area	Grid ref	Habitat Type	Behaviour	Bird Seen Y/N	Observations

Appendix 2

Instructions for recording observations in this study.

TEAL RECORDING FORM INSTRUCTIONS

Daylight – if observing at dawn or dusk record this:

Birds

Number 1 – 12

Time

Time of observation (24 hr clock)

Weather

F = Fine C = Cloudy PC = Partly cloudy

- Rain LR = Light rain HR = Heavy rain
- Wind LW = Light wind SW = Strong wind NW – Calm
- Air temp. CT = Cold WT = Warm HT = Hot

E.g. C,HR,SW,CT Or F,LW,WT

Habitat type

S = Sea (in the water)

FW = in stream (in water)
B = on coast
NFW = near fresh water (in the immediate vicinity of a stream, i.e. within 5M)
FT = Under forest (away from water)
P = in Pakahi
SH = under shrubland (away from water)

- If you think it fits more than one category put them both down e.g. if in the stream mouth as it passes over the beach FW,B.

Area

Number as per map 1 – 23

Grid Ref.

As accurate as possible from supplied map (NB not standard topo map). Should be 4/5 digit number e.g. Summit-Obs rock track junction is 102I0, Northwest Bay stream mouth 70E0 etc.

Behaviour

F = Feeding

L = Loafing (resting/sleeping)
T = Travelling
- (NB DT = disturbed travel i.e. the bird has moved away from the observer

A = Alarm (notes under observation required)
I = Interaction with other birds (expand in notes under observation)
P = Preening / Bathing
B = Incubating
Anything else – note under observations

Observations	Anything of note including:-	Predators present include SBBG Food types Other teal – interactions, Human interactions – attracted to human
	Anything else worth noting…	Continue notes on the back if necessary Cross reference time of observations if you do so.

Full notes are very important – continue on next line(s) if you need to.

NB – if doing multiple observations of the same bird, you only need to record the weather, area, grid ref. Habitat type if it changes from the one above.

Appendix 3

Campbell Island Teal on Codfish Island band combinations and numbers

Name	sex	Band No	Colour band	Release site	Released	Hatched	Died
Jaques	M	S48580	Y/W -M	NW	1999		
Fizeau	M	S48589	W/R-M	NW	1999		
Norton	M	S48582	R/G-M	S	1999		
Col	F	S48584	M-R/Y	S	1999		
Puiseaux	F	S48586	M-G/W	NW	1999		2002
Venus	F	S48588	M-W/G	P	1999		
Terror	M	S73208	G/Y-M	P	1999		
Falla	F	S73211	M-Y/G	S	1999		
Glacier	F	S73210	M-B/R	S	1999		2001
Hinemoa	F	S73205	M-W/Y	NW	1999		
Monowai	F	S73206	M-R/W	NW	1999		
Galathea	F	S73207	M-Y/R	NW	1999		
Gomez	M	S48577	R/O-M	S	2000		
Eboule	M	S48583	O/R-M	S	2000		
Armstrong	M	S73229	B/G-M	S	2000		
Bailey	M	S73218	O/W-M	S	2000		
Azimuth	M	S48575	Y/B-M	S	2000		
William	M	S73222	O/G-M	S	2000		
Wasp	M	S48579	B/Y-M	NW	2000		
Murray	M	S74704	Y/R-M			99/00?	
Fiddich	M	S74702	W/R-M			99/00?	
Buttercip	F	S73220	M-G/R	S	2000		
Paris	F	S48574	M-W/O	S	2000		
Acaena	F	S73216	M-G/B	S	2000		2001
Beryl	F	S48571	M-B/W	S	2000		2001
Ultra	F	S74701	M-Y/Y			99/00?	
Morgan	M	S70611	R/Y-M			99/00	
Skodie	F	S70612	M/RG			99/00	
Juv- Fiz/Puis?		Not banded				2001	
Juv- Fiz/Puis?		Not banded				2001	
Juv- Fiz/Puis?		Not banded				2001	

Appendix 4

Presence of transmitters on teal during the study.

Bird	1999	2000	2001	2002	Years with tx
Venus	Released	Changed	Changed	Changed	3
Falla	Released	Changed	Changed	Changed	3
Col	Released	Changed	Changed	Changed	3
Glacier	Released	Changed	-Dead	-	2
Norton	Released	Changed	Lost tx	-caught- no tx	2
Terror	Released	Changed	Removed	- still alive	2
Hinemoa	Released – bird lost during year	- lost	- lost	- lost	1
Monowai	Released – bird lost during the year	- lost	- lost	- lost	1
Galathea	Released – bird lost during year	- lost	- lost	- lost	1
Puiseux	Released	Changed	Changed	Dead	3
Jacques	Released – bird lost during the year	- lost	- lost	- lost	1
Fizeau	Released	Changed	-seen	Seen	2
Aceana	-	Released	- lost	Dead	1
Beryl	-	Released	- lost	Dead	1
Buttercup	-	Released	Changed	Changed	2
Paris	-	Released	-lost	- lost	1
Acheron	-	Released	- lost	- lost	1
Armstrong	-	Released	Removed	-lost	1
Azimuth	-	Released	- lost	- lost	1
Bailey	-	Released	Removed	- lost	1
Eboule	-	Released	Removed	- lost	1
Gomez	-	Released	Removed	- lost	1
Wasp	-	Released	- lost	- lost	1
William	-	Released	- lost	- lost	1
Morgan	-	Bred- New tx	Tx lost	Caught– no tx	1
Skodie	-	Bred–New tx	- lost	-- lost	1
Fiddich	-	-	Bred – New	- lost	0
Ultra	-	-	Bred – New	Changed	1
Murray	-	-	Bred – New	- lost	0
Aysha	-	-	-	Bred –New	-
Genie		-	-	Bred –New	-
Petal	-	-	-	Bred –New	-
Selley	-	-	-	Bred –New	-
Vivian	-	-	-	Bred –New	-

Bird	1999	2000	2001	2002	Years with tx
Austin	-	-	-	Bred –New	-
Kurt	-	-	-	Bred –New	-
Pete	-	-	-	Bred –New	-

Appendix 5

Survival of all adults on Codfish Island, both those released and those bred on the island.

Bird	Sex	Release Site	DOB	Age at release	Date released/ hatched	Date last seen	Age last seen	Status at the end of the study
Venus	F	PB	18 Dec 97	1	April/ 99	April 02	4.2	Confirmed alive
Falla	F	SB	28 Dec 98	0	April/ 99	April 02	3.2	Confirmed alive
Col	F	SB	10 Nov 96	2	April/ 99	April 02	5.2	Confirmed alive
Glacier	F	SB	28 Dec 98	0	April/ 99	Mar 01 (dead)	2.2	Confirmed dead
Norton	M	SB	29 Nov 96	2	April/ 99	April 02	5.	Confirmed alive
Terror	M	PB	17 Dec 98	0	April 99	Feb 02	3	Confirmed alive
Hinemoa	F	NWB	15 Nov 98	0	April/ 99	April 99	.5	Presumed alive
Monowai	F	NWB	15 Nov 98	0	April/ 99	Mar 00	1.5	Presumed alive
Galathea	F	NWB	17 Dec 98	0	April/ 99	Mar 00	1.5	Presumed alive
Puiseux	F	NWB	10 Nov 96	2	April/ 99	Feb 02 (dead)	5	Confirmed dead
Jacques	M	NWB	13 Dec 96	2	April/ 99	April 99	3.5	Presumed alive
Fizeau	M	NWB	18 Jan 97	2	April/ 99	Feb 02	5	Confirmed alive
Aceana	F	SB	16Dec 99	0	May/00	Nov 00 (dead)	1	Confirmed dead
Beryl	F	SB	9Nov94	5	May /00	Mar 01 (dead)	6	Confirmed dead
Buttercup	F	SB	25Jan 00	0	May /00	April /02	2.2	Confirmed alive
Paris	F	SB	15Nov95	4	May /00	April /02	7.2	Presumed alive
Acheron	M	NWB	3Jan 00	0	May /00	May 00	.5	Presumed alive
Armstrong	M	SB	3Jan 00	0	May /00	Mar 01	1	Presumed alive
Azimuth	M	SB	15Nov95	4	May /00	Nov 00	5	Presumed alive
Bailey	M	SB	16Dec 99	0	May /00	April 01	2.5	Presumed alive
Eboule	M	SB	10Nov9	3	May /00	April	5.5	Presumed

Bird	Sex	Release Site	DOB	Age at release	Date released/ hatched	Date last seen	Age last seen	Status at the end of the study
			6			01		alive
Gomez	M	SB	16Dec 96	3	May /00	April 02	5.5	Confirmed alive
Wasp	M	NWB	16Dec 96	3	May /00	June 00	4.5	Presumed alive
William	M	SB	25Jan 00	0	May /00	April 01	1.2	Presumed alive
Morgan	M	NWB	H 99/00	N/A	H 99/00	April 02	2	Confirmed alive
Skodie	F	NWB	H 99/00? 00/01?	N/A	H 99/00? 01/00?	Mar 00	1	Presumed alive
Fiddich	M	NWB?	H 99/00? 00/01?	N/A	H 99/00? 00/01?	April 01	2	Presumed alive
Ultra	F	SB	H 99/00?	N/A	H 99/00?	April 02	2	Confirmed alive
Murray	M	NWB?	H 99/00?	N/A	H 99/00?	April 01	1	Confirmed alive

Key

SB = Sealer's Bay

PB =Penguin Bay

NWB = Northwest Bay

? = probable location of hatching even though the bird was caught and banded at a different site.

Appendix 6

Causes of death for birds released on to Codfish Island.

Of the 24 birds released on Codfish Island, four were confirmed to have died during the three years of this study. These were all by misadventure:

1. Aceana	Female	- caught by leg (band) in fork of flax branch
2. Glacier	Female	- suffocated in petrel burrow, along with one fledgling, when roof caved in.
3. Beryl	Female	- caught in rat snap trap in trap tunnel.
4. Puiseux	Female	- caught in bush by transmitter harness.

Unfortunately all were females with a proven breeding record either on Codfish Island or previously in captivity.

Appendix 7

Productivity of Campbell Island Teal on Codfish Island.

		1999/2000					2000/2001					2001/2002				
Bird	Bred before Release	Mate	# eggs	# hatched	# fledged	Age	Mate	# eggs	# hatched	# fledged	age	Mate	# eggs	# hatched	# fledged	Age
Col	Same sex pair	Terror (after Venus had gone down)	-	-	-	3	Norton				4	Norton				5
Puiseux	Same sex pair					3	Fizeau	2 - none in nest after hatching)	2	2	4	Fizeau	5	5	5	5
Venus	N	Terror	5	4	0	2	Terror	3	2 (lost 2 ducklings – 1 caught))	0	3	Terror	5	3	2	4
Falla	N	Norton	3	1	0	1	Morgan	2	2	0	2	Morgan	3	3	2	3
Glacier	N		3	2	0	1		3	3 (- 1 died in nest)	2	2	Female dead				
Hinemoa	N	Jacques?	?	?		1					2					3
Galathea	N		?	?		1					2					3
Monowai	N	Fizeau	3	2	2	1					2					3
Paris	Y										5					6
Aceana	N							dead			2					3
Beryl	Y										6	dead				
Buttercup	N						Gomez	2	2	0	1	Gomez	3	2	2	2
Ultra	N											Murray	3	3	2	2
Total			11	9	2			12	11	4			19	16	13	

Birds recorded as 1 year old were in fact approximately four months old at release, i.e. the progeny from the breeding season immediately past.

Appendix 8

Duckling survival / fledging rate

Survival of Campbell Island Teal ducklings bred on Codfish Island.

Year	Mother	Hatch date of mother	Bred before release?	Age of mother	Site	Date hatched	Number in brood	Date last seen	Age last seen	Banded ?	Confirmed dead?
99/00											
	Venus	18Jan 97	N	2 (3?)	SB	22 Dec 99	5	22 Dec 99	1 day		Dead
							5	27 Dec 99	5 days		Dead
							5	30 Dec 99	8 days		Dead
							5	2 Jan 00	11 days		Dead
							5	3 Jan 00	12 days		Dead
	Falla	28Dec 98	N	1	SB	30 Dec 99	1	4 Jan 01	5 days		Dead
	Monowai	15Nov 98	N	1	NWB	30 Dec 99	2	Fledged	NA	Yes	
							2	Fledged	NA	Yes	
	Glacier	28Dec 98	N	1	SB	7 January 00	2	24 Jan 01	17 days		Dead
							2	26 Jan 01	19 days		Dead
0 0/01	Venus	18Jan 97	N	3	SB	12 Jan 01	2	27 January 01	14 days		Dead
							2	28 January 01	16 days		Dead
	Falla	28Dec 98	N	2	SB	11 Feb 01	2	17 February 01	6 days		Dead

Year	Mother	Hatch date of mother	Bred before release?	Age of mother	Site	Date hatched	Number in brood	Date last seen	Age last seen	Banded ?	Confirmed dead?
							2	22 February 01	11 days		Dead
	Puiseux	10Nov96	Lesbian pair	4	NWB	22 Jan 01	2	Jan 01	NA	Fledged	N
							2	Jan 01	NA	Fledged	N
	Buttercup				SB	15 February 01	2	19 March 01	4 days	Dead	Dead
							2	20 March 01	5 days		Dead
	Glacier	28 Dec 98	N	2	SB	9 January 01	2	13 Feb 01	35 days	Killed	Dead
							2	27 Feb 01	49 days	Fledged	
	Unknown	?	?	?	NWB	?	?	?	?	Ultra	
	"	?	?	?	NWB	?	?	?	?	Fiddich	
	"	?	?	?	NWB	?	?	?	?	Murray	
01/02	Venus	18Jan 97	N	4	SB	8 January 02	2	April /02	NA	Fledged	
							2	April /02	NA	Fledged	
	Falla	28Dec 98	N	3	SB	10 January 02	2	April /02	NA	Fledged	
							2	April /02	NA	Fledged	
	Buttercup	25Jan	N	1	SB	17	2	April	NA	Fledged	

Year	Mother	Hatch date of mother	Bred before release?	Age of mother	Site	Date hatched	Number in brood	Date last seen	Age last seen	Banded ?	Confirmed dead?
		00				January 02		/02			
							2	April /02	NA	Fledged	
	Ultra	1999/2000	N	1	SB	18 January 02	2	April /02	NA	Fledged	
							2	April /02	NA	Fledged	
	Puiseux	10Nov96	Lesbian pair	5	NWB	29 January 02	5	April /02	NA	Fledged	
							5	April /02	NA	Fledged	
							5	April /02	NA	Fledged	
							5	Feb 02	NA	Fledged ?	
							5	Feb 02	NA		
	Unknown										

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