Management of northern New Zealand dotterels on Coromandel Peninsula

J.E. Dowding

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ABSTRACT

The northern New Zealand dotterel (NNZD), *Charadrius obscurus*, is a threatened endemic shorebird that breeds mainly on sandy beaches of the North Island. At unmanaged sites, breeding success is usually low, and the population would decline without management. About 16% of the population breeds on Coromandel Peninsula. Many of these birds are managed by a partnership between the Department of Conservation (DOC), Newmont Waihi Operations, and local volunteers. This report was commissioned by DOC's Waikato Conservancy to review information on numbers and distribution of NNZD on Coromandel Peninsula, review data on the response of the population to management, assess the relative importance of different management actions and make recommendations for future management. Between 1996 and 2004 there was a very large increase in the NNZD population in the Coromandel area (up by 102 birds or 58%). The available evidence suggests that this increase was largely due to the protection programme. However, assessing the relative importance of different management actions (predator control, advocacy, fencing nests, and reducing losses to flooding) is difficult. For future management it is recommended that the current protection programme be continued, management requirements be reassessed following the NNZD census in 2011, long-term protection for key habitat be sought, applications for activities that may have adverse impacts on NNZD be opposed, options for the protection and stabilisation of the Matarangi Spit site be examined, minor changes to the way the minder network is organised be considered and breeding season monitoring and co-ordination of autumn flock counts be continued.

Keywords: New Zealand dotterel, *Charadrius obscurus*, threatened species, Coromandel Peninsula, recovery programme, conservation management, predator control, habitat protection

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1. Introduction

1.1 STATUS, DISTRIBUTION AND MOVEMENT PATTERNS

The New Zealand dotterel (*Charadrius obscurus*) is a threatened, endemic shorebird with a total population of about 1900 individuals (Dowding 2005). Internationally, the species is classified as Endangered (BirdLife International 2005).

There are two widely-separated subspecies (Dowding 1994). The southern New Zealand dotterel (*C. o. obscurus*) currently numbers about 250 individuals (M. Dobbins, DOC, Stewart Island, pers. comm.) and now breeds only on Stewart Island. It was formerly found throughout the South Island (Dowding 1999) and probably in some inland parts of the southern North Island (Dowding 1994). Nationally, it has a threat ranking of Category 1 Nationally Critical (Hitchmough & Bull 2004).

The northern New Zealand dotterel (*C. o. aquilonius*) is almost entirely coastal, and breeds mostly north of 39°S. A census in October 2004 gave a total of 1640 birds but some areas may not have been counted accurately, and the subspecies probably numbers closer to 1700 birds (Dowding 2005). Nationally, it is ranked Category 3 Nationally Vulnerable with qualifiers CD (Conservation Dependent) and ST (Stable) (Hitchmough & Bull 2004).

A study of dispersal (Dowding 2001) has shown that the northern New Zealand dotterel (NNZD) population consists of at least two sub-populations that are currently effectively isolated from each other. The NA sub-population consists of birds in Northland and Auckland, and probably includes the small number of birds remaining on the Waikato west coast. The CB sub-population consists of birds on Great Barrier Island, on Coromandel Peninsula, in the Bay of Plenty and around East Cape as far south as Portland Island. The NA sub-population is the larger, and includes about 70% of the total.

There are no obvious differences between birds of the two sub-populations, and it is not clear why or when this division arose (Dowding 2001). It may be that it is relatively recent and temporary, being the result of a combination of a low-density population (following a decline induced by the introduction of mammalian predators in the 19th century), a coastline around the Firth of Thames that has little high-quality breeding habitat, and behavioural traits (fidelity to the natal area). Whatever the cause, there is little or no effective dispersal between the sub-populations at present, and they constitute separate management units, i.e. management in one provides no benefit to the other (Dowding 2001).

Adult NNZD are normally relatively sedentary, making predictable annual movements from breeding site to flock site and back, with occasional feeding trips to nearby estuaries at any time of year. Juveniles and unpaired adults are much more mobile, and have been recorded covering large distances (Dowding & Chamberlin 1991; Dowding 2001).

1.2 THREATS

The main threats to the northern subspecies are predation, disturbance during breeding, loss or degradation of habitat, and natural phenomena (mainly storms and big tides, which cause loss of nests and small chicks) (Dowding & Davis, in press). The relative importance of these threats varies between sites and between years, but current evidence suggests that predation is usually the most important. In a two-year study at four unmanaged sites, 60% of all nesting attempts were lost to predation, with a further 17% lost to flooding (Dowding 1998). Adults are usually long-lived, but average breeding success is low at most unmanaged sites.

1.3 HISTORY OF MANAGEMENT

Management of northern New Zealand dotterels at breeding sites was undertaken at Ruakaka, Waipu, Mangawhai and South Kaipara Head by the New Zealand Wildlife Service in 1983, but did not include control of mammalian predators. Intensive management (including predator control) was first undertaken at Opoutere, Coromandel Peninsula, in the 1986/87 season. Since then, similar programmes have been initiated at other sites in Northland, Auckland, Coromandel and Bay of Plenty. These programmes aim primarily to increase breeding success; once established, they have been largely successful (e.g. Wills et al. 2003).

A recovery group for the species was set up by the Department of Conservation (DOC) in 1991 and a recovery plan was published (Dowding 1993). That plan has now expired; a revised plan has been drafted and is now about to be published (Dowding & Davis, in press).

On Coromandel Peninsula, management has been undertaken each season since 1986 at Opoutere. Formal management began at Waikawau Bay in 2001, after a number of seasons of less-intensive protection work by local volunteers (Todd 1988) and DOC staff. There has also been an increasing amount of protection work at other sites by volunteer 'minders' (Woolley 1995, 1999). The first attempt to monitor the NNZD population Coromandel-wide during the breeding season was made in 1998/99 (Woolley 1999). In recent years, a partnership between DOC, Newmont Waihi Operations, and minders has allowed for the expansion and co-ordination of protection and monitoring to cover most of the peninsula (Stewart 2004; Segedin 2005).

Management of NNZD at breeding sites typically consists of a number of actions. The main measures that are normally taken (Dowding & Davis, in press) include:

- Appointment of a warden.
- Signage and fencing of nesting areas to reduce trampling and disturbance.
- Measures to reduce loss of nests and small chicks to high tides and storm surges.
- Advocacy to raise awareness of threats to the species and explain the need for management.
- Predator control to reduce losses of eggs, chicks and adults to mammalian and avian predators.

Experimental release of captive-reared birds has occurred occasionally (including two releases at Matarangi Spit, Coromandel, of four birds in March 2000 and five birds in March 2001), but this is not a standard management technique and the captive-rearing programme has been discontinued.

As part of the recovery programme, a complete census of the NNZD population is carried out every 7 or 8 years. In some areas, counts of important post-breeding flocks have also been conducted annually. Following breeding, most NNZD move a short distance (typically > 30 km) to a traditional flock site. Numbers at these flocks peak between late January and April, and the first birds begin to return to their breeding sites from early May (Dowding & Chamberlin 1991). Counting of important flocks was included in the recovery programme as a means of monitoring the status of local populations between censuses (Dowding 1993).

1.4 SCOPE OF THIS REPORT

This report was commissioned by Waikato Conservancy, DOC. It aims to:

- Review information on numbers and distribution of NNZD on Coromandel Peninsula.
- Review data on the response of the NNZD population to management.
- Assess the relative importance of different management actions.
- Make recommendations for future management of NNZD on Coromandel Peninsula.

2. Methods

Information for this review was obtained from a variety of sources, including:

- Published papers in scientific journals.
- Unpublished reports by site wardens and co-ordinators.
- Personal communications from wardens, co-ordinators and others.
- Wader counts conducted by the Ornithological Society of New Zealand (OSNZ).
- Records from the Classified Summarised Notes (CSN) of *Notornis*.
- Results of the national NNZD censuses in October 1989, 1996 and 2004 which were used to examine trends in the population. Not all sites were counted in all three censuses, however, so in some cases 'comparison totals' (totals from all the sites counted in two consecutive censuses) were used to derive a percentage increase between counts,
- Results of incomplete post-breeding censuses carried out in March 1990 and March 1997, and flock counts carried out by volunteers in other years.
- Unpublished reports by the author.
- Unpublished data from the author's colour-banding study of survival, dispersal and movement patterns.

Localities mentioned in the text are shown in Fig. 1.

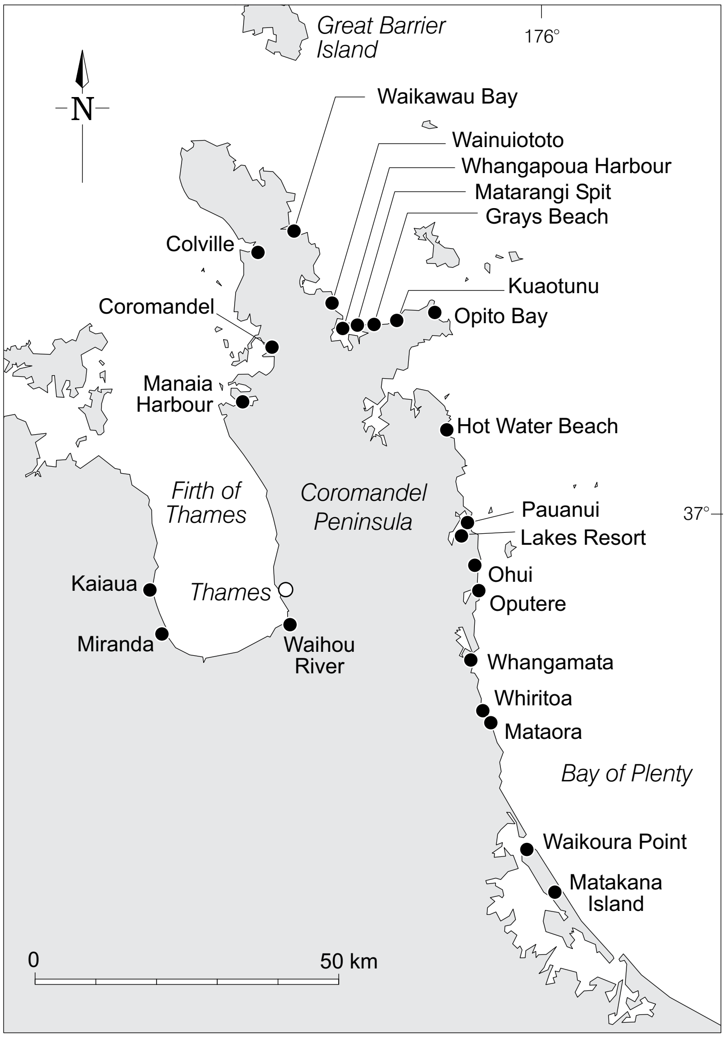

Figure 1. New Zealand dotterel localities in Coromandel Peninsula area.

3. Results

3.1 MOVEMENT PATTERNS AND LINKS TO OTHER AREAS

As noted above, NNZD on Coromandel Peninsula are part of the Coromandel-Bay of Plenty sub-population. The boundary between this and the Northland-Auckland sub-population lies roughly on the western side of the Firth of Thames (Dowding 2001). There is occasional movement of birds westwards from Coromandel to the west side of the Firth (Kaiaua-Miranda area), but this is believed to be very limited.

The population of NNZD on Great Barrier Island (GBI) is apparently linked to the mainland only through Coromandel Peninsula. There is a record of a bird banded on GBI being seen at Colville and then back on GBI, and another of a bird banded as a chick at Opoutere that bred on GBI (Dowding 2001). There are no records of movement between GBI and the North Auckland-Northland coast, in spite of the fact that many more birds have been banded there than on Coromandel.

To the south, there is considerable exchange of birds between the Coromandel east coast and the Bay of Plenty. A study of natal dispersal of chicks colour-banded at Opoutere between 1988 and 1996 showed that about 20% of them bred in the Bay of Plenty (at least five of them on Matakana Island), with the remainder breeding on Coromandel Peninsula or GBI (Appendix 1C in Dowding 2001). One bird widowed at Opoutere in November 2002 dispersed to Maketu, and now breeds there. There is also dispersal in the other direction. At least four chicks banded in the Bay of Plenty have bred on Coromandel; three banded on Matakana Island bred at Waihou River, Opoutere, and Pauanui, while one from Waiaua Spit, Opotiki, has bred at Ohui. There have been many other records of pre-breeding movements by wandering juveniles between the Coromandel east coast and the western Bay of Plenty (JED, unpubl. data).

3.2 CHANGES IN NUMBERS AND DISTRIBUTION

3.2.1 Breeding season numbers and distribution

The gross totals of NNZD counted on Coromandel Peninsula have increased at each national census. Numbers rose from 128 birds in 1989 to 176 in 1996, an increase of 37.5 %. However, it should be noted that there was greater coverage in 1996, and when only sites counted on both occasions are considered, totals are 128 (1989) and 149 (1996), an increase of 16.4%.

Between 1996 and 2004, numbers increased by 58% from 176 to 278. Most of the same sites were counted in 1996 and 2004, and the comparison totals yield a similar increase of 56.3% (from 174 to 272).

As breeding habitat, NNZD favour sandy beaches (particularly at stream or river mouths), sand spits at the mouths of estuaries, and shell banks and sandbars in harbours. They are generally absent or scarce on long stretches of rocky coastline. The west coast of Coromandel has less of this favourable habitat than the east, and this is reflected in the numbers of NNZD on the peninsula's west and east coasts. In 2004, 59 birds were recorded on the west coast (21% of the total), and 219 on the east coast (79%). The increase in numbers between 1996 and 2004 was also greater on the east coast (67.2%) than on the west coast (23.3%).

Relatively few sites contributed to the large increase seen between 1996 and 2004. A list of all Coromandel sites with increases of five birds or more in that time is shown in Table 1.

The increases at these ten sites total 100 birds, out of the net increase of 102 birds Coromandel-wide during this period. All but one of the ten sites are on the east coast.

A large proportion of the increase has been on a relatively localised section of the east coast. The total number of birds counted on the stretch of coastline from Wainuiototo (New Chums Beach) to Opito Bay rose about four-fold from 19 in 1996 to 77 in 2004. More than half of this increase occurred at a single site (Matarangi Spit), but there were increases at nine of the ten sites in this area, and four sites showed increases of five birds or more (Table 1).

TABLE 1. COUNTS OF NNZD FROM SITES ON COROMANDEL PENINSULA THAT SHOWED AN INCREASE OF 5 BIRDS OR MORE BETWEEN 1996 AND 2004.

SITE	1989 COUNT	1996 COUNT	2004 COUNT	INCREASE 1996–2004
Manaia Harbour	0	0	10	10
Waikawau Bay	5	12	20	8
Matarangi Spit and Beach	6	6	40	34
Grays Beach	NC	2	7	5
Kuaotunu	2	0	6	6
Opito Bay	3	2	7	5
Hot Water Beach	2	4	10	6
Pauanui Spit and Beach	1	0	9	9
Ohui	4	3	10	7

NC = no count.

3.2.2 Key breeding sites

The New Zealand dotterel recovery plan (Dowding & Davis, in press) defines key breeding sites for the taxon as those regularly holding ten pairs or more. At present, Waikawau Bay and Opoutere reach this threshold. There is some doubt about the exact number of pairs breeding at Matarangi, but it appears likely to exceed ten pairs soon, if it has not already.

3.2.3 Numbers of breeding pairs

Some counts of breeding pairs are available for five sites (Waikawau, Matarangi, Pauanui, Ohui, and Opoutere) over the past 20 years; these are shown in Appendix 1. There are numerous gaps in the dataset, but trends are reasonably clear at all five sites.

At Waikawau, there were 2–4 pairs in the late 1980s. There was a modest increase in the 1990s to 4–6 pairs, with a rapid increase to 9–11 pairs since about 2000.

At Matarangi, there were 4–8 pairs until 2003/04. In 2004, there was a sudden increase to 8–15 pairs.

At Pauanui, there was probably 1 pair (or none) for most of the 1990s. In the last two years there has been a rapid increase on Pauanui Beach and Spit, as well as colonisation of the Pauanui Waterways (1 pair) and nearby Lakes Resort (3–4 pairs).

At Ohui, there were 3 pairs throughout the 1990s. Numbers rose to 5 pairs in 2001 and peaked at 7 pairs in 2002, probably as a result of overflow from Opoutere (Dowding 2003). In 2003, some birds moved from Ohui to Lakes Resort and the Ohui population appears to have stabilised at 3–5 pairs.

At Opoutere, there were about 8 pairs in the late 1980s and early 1990s. This increased to 10–12 pairs in the mid-1990s, and peaked at 15–16 pairs between 1998 and 2002. In the past two seasons, the number of pairs has fallen again to 10–11.

3.2.4 Flock counts

There are currently six main post-breeding flocks of NNZD on Coromandel Peninsula. Counts of these flocks are shown in Appendix 2. Flock counts inevitably fluctuate from year to year, for a number of reasons.

- Many juveniles accompany their parents to their usual flock. Flock size will therefore change depending on annual differences in productivity locally.
- Individual counts can be affected by a wide range of factors including weather, tide height, and level of disturbance on the day.
- When breeding continues late at any site, birds may not be at a flock site when counts are made. Exceptionally late chicks may not fledge until early April (Pye & Dowding 2002), by which time most flock counts have been completed.
- While adults very rarely move between flocks, the arrival and departure of small groups of transient juveniles can cause changes in numbers at any time (Dowding & Chamberlin 1991).

Five-year average counts (which should smooth these fluctuations to some extent) are shown in Table 2.

Numbers at three of the flocks (Coromandel, Colville and Whangamata) appear to be relatively stable. Numbers at Opoutere probably rose between 1991–1995 and 1996–2000, but have been stable since then. There have been large increases recently at Matarangi and Pauanui.

3.2.5 Key flocking sites

The New Zealand dotterel recovery plan (Dowding & Davis, in press) defines key flocking or feeding sites for the taxon as those regularly holding 30 birds or more (Action 3.3). Based on 2001–2005 means, four of the six flocks listed in Table 2 currently exceed this threshold (Colville, Matarangi, Pauanui and Opoutere). Recent counts from the Coromandel flock are required; if it has shown a sustained increase since the 1999 count of 29 birds, it will also qualify as a key site.

Summing the latest available count from each flock (data from Appendix 2) gives a total of 255 birds. Post-breeding flock totals include juveniles of the year and are always somewhat higher than breeding season totals; however, the recent flock total of 255 constitutes about 92% of the breeding season total in October 2004. It should also be noted that some birds in the southern section on the east coast (e.g. birds breeding at Mataora) visit the flock at Waikoura Point, Matakana Island. With the exception of these birds, and the few pairs that probably remain on territory all year (Dowding & Chamberlin 1991), it appears that the six flocks listed in Table 2 hold the large majority of the Coromandel NNZD population in autumn.

TABLE 2. FIVE-YEAR AVERAGES OF AUTUMN COUNTS OF NEW ZEALAND DOTTERELS AT THE SIX MAIN FLOCK SITES ON COROMANDEL PENINSULA.

	AVERAGE COUNTS OVER FIVE-YEAR PERIODS		
FLOCK SITE	1991–1995	1996–2000	2001–2005
Coromandel	23.5	26.7	ID
Colville	29.8	28.5	32.0
Matarangi	61.3	66.2	89.2
Pauanui	ID	21.8	36.5
Opoutere	25.7	32.7	33.7
Whangamata	19.0	21.5	21.0

ID = insufficient data.
Raw data are shown in Appendix 2.

3.2.6 Productivity estimates

The usual measure of success at breeding sites is the level of productivity, i.e. the average number of chicks fledged per breeding pair. Data on productivity are available in some seasons for Waikawau, Ohui and Opoutere; these are shown in Appendix 3.

When considering the data in Appendix 3, a number of caveats should be borne in mind. Determining productivity clearly requires accurate estimates of both the number of chicks fledged and the number of pairs present at a site at the beginning of the breeding season. Neither is always as easy to determine as it sounds, particularly where pairs are at high density (such as on sand spits or the wide sand-flats around stream mouths). A range of factors can affect reported productivity estimates, including:

- At most Coromandel sites few or none of the birds are banded, and individuals or pairs can be lost (especially early in the season) and replaced without this being detected. The NNZD breeding season is protracted, and nesting can begin in September (Pye & Dowding 2002). A lack of monitoring early in the season can result in an underestimate of the number of pairs attempting to breed, and a corresponding overestimate of productivity. For example, the number of pairs in 2004/05 was recorded as those breeding from November (Segedin 2005).
- Particularly at sites where monitoring is not frequent, the number of chicks fledged can be over-estimated because (a) juveniles can be highly mobile, and a sighting of a juvenile at a site (particularly late in the season) may not mean that it was produced at that site, and (b) unfledged or recently-fledged chicks still at their natal site are also very mobile and at larger sites with a high density of pairs they may be seen well away from their natal territories, and counted in two (or even more) locations.
- Late in the season, adults in pale eclipse plumage may be very difficult to distinguish from juveniles, even for experienced observers.
- There has been an understandable tendency occasionally at some managed sites to be optimistic about the number of chicks fledging when there is doubt.
- In some cases, monitoring has ended in late January or early February, which can also lead to uncertainty; for example, at Opoutere in 1991/92 there were 16 chicks present when the ranger left on 7 February, but only 6 were fledged at the time.
- There are occasionally discrepancies between wardens' reports and summary reports (usually produced later) in numbers of pairs and/or numbers of chicks fledged at a site. Whether these are valid corrections based on later information, or simply the result of transcription errors, is usually unknown.

In summary, accurate determinations of productivity require regular visits to a site from September to at least February (and sometimes March), as well as a considerable degree of monitoring expertise.

In spite of these reservations, some conclusions can be drawn from the data in Appendix 3. At Opoutere, no chicks fledged for the three seasons immediately before the appointment of a full-time warden in 1986. Chicks have fledged in all seasons since 1986/87; average productivity during the 14 seasons for which complete data are shown in Appendix 3 was 0.62 (range 0.13–1.29).

At Waikawau, productivity was highly variable in the mid-1980s, with no chicks fledged in some seasons and very high productivity in others. Since more intensive management began, productivity has been high and consistent; during the five years for which complete data exist since 1998/99, productivity has averaged 0.77 (range 0.64–1.00).

At Ohui, productivity data exist for the past eight seasons. With the exception of 2000/01, when no chicks fledged, productivity has been reasonably high and consistent. Since 1997/98, it has averaged 0.78 (range 0.00–1.33).

The average productivity values from these three sites appear to be typical of those for the peninsula as a whole. Data are available from sites around Coromandel Peninsula for three seasons (Table 3).

Appendix 2 of Segedin (2005) lists the trapping regime at all sites during the 2004/05 season. This allows a Coromandel-wide comparison of productivity at trapped and untrapped sites in one season. Sites labelled 'Kiwi', 'Yes', 'Locals', and 'Iain' were considered trapped, and sites labelled 'No' were considered not trapped. Sites labelled 'Part' were omitted from the analysis. A number of sites lacked information on number of pairs or number of chicks fledged, and were also omitted. At 15 sites without trapping, productivity averaged 0.96 chicks fledged per pair; at 22 sites with predator control productivity averaged 0.81. This difference was not significant (Mann-Whitney, $Z = 1.36$, $P = 0.174$). However, one untrapped site (Pauanui Beach and Spit) biased this result substantially, because it accounted for 13 of the 22 chicks fledged at all untrapped sites. If Pauanui is omitted, productivity at untrapped sites averaged 0.56.

Data from table 2 of Stewart (2004) can be used to examine the impact of a warden or minder on productivity in 1998/99. Productivity averaged 0.80 at sites with a minder, which was significantly higher than the average of 0.20 at sites without a minder (Mann-Whitney, $Z = 2.42$, $P = 0.015$). In 2003/04, there were too few unmanaged sites to allow a meaningful comparison.

However, both these analyses are compromised by the fact that management regimes varied between sites. Many managed sites had both a warden/minder **and** predator control, some had one and not the other, while some had 'part' minder and/or predator control. Information on both trapping regime and minder presence is available for 2004/05 (Segedin 2005), but when sites with only minder or predator control, and sites with 'part' minder or control are omitted, there are too few sites without any management to allow a valid comparison between fully-managed and unmanaged sites.

TABLE 3. ESTIMATES OF NNZD PRODUCTIVITY ON COROMANDEL PENINSULA IN 1998/99, 2003/04 AND 2004/05.

SEASON	SITES	PAIRS	CHICKS FLEDGED	PRODUCTIVITY	SOURCE
1998/99	22	60	39	0.65	Woolley (1999)
2003/04	56	92	62	0.67	Stewart (2004)
2004/05	43	126	101	0.80	Segedin (2005)

4. Discussion

4.1 RESPONSE OF THE POPULATION TO MANAGEMENT

Is the large recent increase in the Coromandel NNZD population a response to the protection programmes that have been undertaken on the peninsula? The usual measure of success in these programmes is the level of productivity achieved at a site. It should therefore be possible to assess the effectiveness of the programmes by comparing average productivity at managed and unmanaged sites. For a number of reasons, demonstrating a difference is much more difficult than it might appear:

- In many cases, deciding whether a site should be considered managed or unmanaged is difficult. Outside those formally managed by the Department, many sites have different management regimes, with different combinations of actions undertaken; often, the precise regime is not recorded and its effectiveness cannot be assessed. In some cases, the effectiveness of an action (such as predator control) may vary considerably between sites.
- Productivity at a site can vary widely between seasons, even with the same management regime in place (e.g. Opoutere, see Appendix 3). This can be a result of many factors, some of which cannot be controlled by management; they include severe weather, the presence of a trap-shy predator, and changes in density of NNZD pairs or other species.
- The small number of pairs at some sites increases the variability in productivity. Most sites on Coromandel that currently receive no form of management have only one pair.
- There can be difficulties in estimating productivity accurately, especially when visits to a site are infrequent and only cover part of the breeding season (see section 3.2.6 above).
- In the case of Coromandel, so few pairs now receive no form of management (Segedin 2005), that meaningful comparisons between managed and unmanaged sites are no longer possible.

In summary, the high degree of variation in productivity that is often seen, even at managed sites, makes it particularly difficult to demonstrate that management results in significantly higher productivity. However, some comparisons are possible; these and a number of other ways of assessing the impact of management on Coromandel are explored below.

4.1.1 Comparison among North Island regions

Gross totals from the October 2004 census allow broad comparisons between regions with managed sites and those without. Where there has been no management (Waikato west coast, Northland west coast), numbers are declining or stable. Where there has been management (Northland east coast, Auckland west coast and east coast, Coromandel Peninsula, Bay of Plenty coast), numbers have increased in all areas except Northland east coast, where they are stable. These results are in broad agreement with changes seen between the 1989 and

1996 censuses (Dowding 1997), which suggested that the locations of the main managed sites (nearly all on the North Island east coast) may slowly be changing the overall distribution of the taxon (Dowding 2001).

The increase of 102 birds on Coromandel between 1996 and 2004 was the highest of all regions by far, and occurred during a period when protection programmes (of varying intensities) have targeted a higher proportion of pairs than in any other region. Over all regions, about 20% of NNZD pairs were formally managed in 1998/99 (Dowding & Murphy 2001). In the same season, 75% of pairs monitored by Woolley (1999) on Coromandel Peninsula had wardens or minders; in 2004/05, at least 87% of the 126 pairs monitored had some predator control (Segedin 2005).

4.1.2 Timing of the increase on Coromandel

The possibility that management may have contributed to the increases in total breeding season numbers and counts at flock sites appears to be supported by the timing of the increases.

While protection programmes have been introduced gradually to an increasing number of sites over the past 20 years, management and monitoring of a high proportion of the sites and pairs on the peninsula has largely occurred since about 1995. This period of wide-scale management coincides with the very large increase in spring census totals (section 3.2), and with big increases at two of the peninsula's six flock sites (Table 2). At Opoutere, where management has been in place since 1986, the increase in average flock size came earlier, before 1995 (Appendix 2).

4.1.3 Numbers of pairs at managed sites

Natal-site fidelity in NNZD is relatively low; overall, about 18% of chicks that survive to breeding age return to their natal site to breed (Dowding 2001). A rapid build-up of breeding pairs at a managed site as a result of management at that site would not therefore be expected, as most chicks produced will breed elsewhere. However, the large majority (93%) of NNZD breed within 70 km of their natal site, so most birds produced on Coromandel will breed somewhere on the peninsula. This is broadly in line with the changes in numbers seen in the 2004 census; most of the sites that have shown large increases (Table 1) have not had intensive management for long, and have probably been populated to some extent by birds produced at the large managed sites, such as Opoutere and Waikawau.

However, other factors may also influence the number of pairs breeding at a site:

- The degree of natal-site fidelity may be affected by the availability of space at a site (Dowding 2001). Opoutere, for example, peaked at about 15 pairs between 1998 and 2002 (Appendix 2), and that level was probably the site's carrying capacity at that time; the decline to 10–11 pairs in the past two seasons may be the result of increasing competition for resources with the growing number of pairs of variable oystercatchers (VOC, *Haematopus unicolor*).

- Changes in the extent of breeding habitat at a site can affect recruitment. During the early-mid 1990s for example, Matarangi Spit eroded significantly and the number of pairs fell to 4–5; the recent increase there may be partly the result of accretion of sand and a larger area of suitable nesting habitat.

4.1.4 Productivity at managed and unmanaged sites

While productivity at managed and unmanaged sites on Coromandel does not appear to have been very different in recent years (section 3.2.6), data from other regions suggest much lower levels at sites with limited management or none. Although there are annual fluctuations, productivity at unmanaged sites typically averages about 0.00–0.30; at managed sites it is typically 0.50–1.00.

- Productivity at a total of 17 unmanaged sites in Auckland and North Auckland averaged 0.23 over a 3-year period, with annual averages of 0.07, 0.34 and 0.25 (Dowding 1998).
- At Karikari and Puwheke Beaches, Northland, productivity was 0.09 and 0.00 respectively in the 1998/99 season without management (Syddall 1999). In 1999/00, an intensive protection programme was undertaken at Karikari, including predator control from August to the end of January, fencing, signage and advocacy. In spite of this, five pairs of NNZD and four pairs of VOC hatched no chicks and productivity for both species was 0.00 (Syddall & Cawte 2000).
- In the first two seasons of the protection programme on Matakana Island, predator control was carried out for only one month each season; in those two seasons, productivity was 0.26 and 0.30. When management was undertaken for most or all of the season, productivity ranged from 0.74 to 1.08 (Wills et al. 2003). Wills et al. (2003) also showed that NNZD in managed areas of Matakana Island hatched significantly more clutches than those in unmanaged areas.

On Coromandel, a before-and-after comparison at Opoutere suggests that management has resulted in an increase in productivity there. In the three seasons before a full-time warden was appointed, no chicks fledged; since then, some chicks have fledged in every season (section 3.2.6).

4.1.5 Conclusion

These lines of evidence, coupled with the fact that a very high proportion of the Coromandel NNZD population now receives some form of management, suggest that the various protection programmes in place on the peninsula are largely responsible for the recent dramatic increase in the population. Based on known patterns of natal dispersal (Dowding 2001), local production has almost certainly been boosted by immigration from the highly successful Matakana Island programme in the western Bay of Plenty. However, this is presumably balanced to some extent by dispersal in the opposite direction. What is not clear yet is why productivity at unmanaged Coromandel sites has been so high in recent years compared with that in other regions.

4.2 RELATIVE IMPORTANCE OF MANAGEMENT ACTIONS

As noted above, management of NNZD at breeding sites typically consists of five main actions, namely appointment of a warden, fencing off nesting areas, reducing losses to flooding, advocacy, and predator control.

Assessing the relative importance of these different components is extremely difficult. To date, there have been no well-designed, replicated studies looking at the effectiveness of different management regimes. In any case, such experiments would probably be compromised by (a) the relatively small number of pairs at many sites, and (b) the differences (often substantial) between sites in a range of variables, such as predator guild, predator density, level of disturbance, susceptibility to flooding, density of potential competitors (such as variable oystercatcher), etc. In most cases, therefore, management simply attempts to address all the major threats at a site without assessing the effectiveness of each action. However, limited information is available on the effectiveness of some measures.

4.2.1 Predator control

In two studies outside the Coromandel region, there have been demonstrable benefits of predator control. On Matakana Island, Wills et al. (2003) found that a significantly greater proportion of nests in unmanaged habitat failed as a result of predation than those in managed habitat. At unmanaged sites in Auckland and North Auckland, Dowding (1998) found that 60% of all nesting attempts were lost to predators. This suggests that effective predator control should increase hatching rates at least. In a before-and-after comparison at Omaha Spit, predator control improved average nest survival time, significantly increased the proportion of eggs that hatched, and increased productivity (Dowding 1998).

In contrast, data in Segedin (2005) appear to show little or no impact of predator control on productivity at Coromandel sites (section 3.2.6 above). Hansen (2005) noted that the benefits of predator control were not evident at Waipu and Mangawhai Wildlife Refuges, but concluded that the quality of data was not adequate to address the question.

4.2.2 Fencing off nesting areas

Fences are generally respected by the public (Wills et al. 2003), and are assumed to reduce crushing of nests and disturbance. However, whether this provides a benefit depends largely on the relative importance of the various threats at a site; for example, where levels of predation are high there may be little or no benefit. At Omaha Spit, a fence and minder regime was in place for several years before predator control began. In those years, predation levels were high and the fence did not increase productivity (Dowding 1998). At three Northland sites, there was no obvious benefit of fencing nesting areas but (as above) this result could have been due to the poor quality of the data (Hansen 2005).

While high levels of disturbance seem very likely to have a negative impact on breeding success, this is difficult to establish. Productivity at high-disturbance and low-disturbance sites during one season was compared by Cumming (1991). Productivity was higher on average at low-disturbance sites, but the difference was not significant. Lord et al. (1997) showed that at Opoutere, chicks spent less time feeding when disturbance levels were high, but whether this resulted in fewer chicks fledging was not determined; chicks do much of their feeding at night (when disturbance levels are normally very low), and may thereby be able to compensate for daytime disturbance.

4.2.3 Reducing losses to flooding

It would seem obvious that saving any nest from flooding is likely to increase breeding success. However, whether there is a benefit depends, again, on whether other threats are more important causes of loss at a particular site. On Matakana Island, for example, Wills et al. (2003) found that of nine nests shifted to avoid flooding, eight survived, but five of these were subsequently lost to predation or crushing.

4.2.4 Advocacy

Assessing the impact of advocacy is particularly difficult, because it may well have long-term, wider-scale benefits, but these are not immediately demonstrable at a single site. On-site advocacy by wardens, coupled with signage, media releases and other types of advocacy, almost certainly reduce human disturbance, but the benefits of that (in terms of productivity) have not yet been quantified.

Questionnaires or surveys of beach-users may provide some information on whether advocacy actually affects human behaviour and reduces disturbance. A survey of beach-users at Waipu and Ruakaka Wildlife Refuges, Northland, both of which have breeding NNZD and long-running protection programmes, was undertaken in 1998/99 (Bridson 2000). It found that infrequent or first-time users of a beach, and younger visitors, were less likely to see signs, less likely to detect a distressed or disturbed shorebird, and less likely to move away when they did detect a distressed bird. The survey did not ask specifically about the effectiveness of a warden, or advocacy measures other than local signs. However, most people were aware that nesting shorebirds were protected, almost all agreed with the fencing-off of nesting areas, and most agreed that dogs were a threat to shorebirds (Bridson 2000). These are all points that have been made repeatedly over the years in the Waipu-Ruakaka area in talks, media releases and pamphlets (as well as on signs); this suggests that wider publicity may be having an impact on human behaviour.

4.2.5 Conclusion

In summary, no robust studies of the impact of different management actions have yet been possible. It is likely, however, that because of the many differences between sites and years, there will be substantial spatial and temporal differences in the effectiveness of different measures. No one prescription will therefore be universally effective and, ideally, specific information on local threats is desirable, at least for important breeding sites. Experience suggests, for example, that where predation levels are high, measures such as fencing and moving nests to higher ground will have no measurable advantage. When predators are effectively controlled, however, these actions may improve breeding success.

The fact that NNZD re-lay (up to three times) after nest loss complicates this issue further; high productivity is the main measure of management success, so if a second or subsequent nesting attempt is successful, any benefit of saving the first nest from crushing or flooding is largely obscured.

4.3 FUTURE MANAGEMENT ON COROMANDEL PENINSULA

4.3.1 Continuation of current management

The current management regime consists of DOC managing two key NNZD breeding sites (Waikawau and Opoutere/Ohui), and providing co-ordination, advice, materials and trapping support to a network of minders who managed birds at 16 further sites in 2004/05 (Segedin 2005). This model appears to be working very well, and most aspects of the programme are not in obvious need of change. Numbers and distribution of birds are changing however, and there will need to be periodic assessments of where resources are best targeted. For example, Matarangi Spit has almost certainly become a key breeding site in the past season and more intensive management is justified. Pauanui Beach and Spit is also now a breeding site of international importance for the taxon (with almost as many breeding pairs as Opoutere and Waikawau), and management there should be intensified from 2005/06.

Modelling suggests that, overall, the NNZD population must achieve average productivity of about 0.32 to remain stable in numbers (JED, unpubl. data). Productivity on Coromandel is clearly very much higher than this, and the population has the capacity to continue growing rapidly. Some sites (e.g. Opoutere and Ohui) are probably already at (or close to) carrying capacity, so increases in numbers can be expected at sites where habitat is available; such an increase is currently evident in the Whangapoua-Opito Bay area. It should be noted that any site with a wide, sandy beach will attract birds, even if predation and disturbance levels are high.

4.3.2 Habitat protection

The NNZD programme on Coromandel Peninsula has clearly fulfilled the immediate objectives of raising productivity and increasing the regional population. The major task in the medium and long term is to protect habitat of suitable quality and in sufficient quantity to sustain that population. About 80% of the entire NNZD population is found on the east coast of the North Island between North Cape and East Cape. Most parts of this coastline (including Coromandel) are experiencing steadily increasing levels of development (particularly housing and marinas), and increasing levels of recreational use. Both have the potential to degrade dotterel habitat. Particular emphasis now needs to be placed on long-term protection of key breeding sites and key flocking/feeding sites; these are identified in sections 3.2.2 and 3.2.5 above. Action 3.4 of the recovery plan (Dowding & Davis, in press) states that during the life of the plan (i.e. by 2014), statutory or other protection (e.g. via reserve status, local bylaws, covenants, etc.) should be sought for these key sites.

Of the three key breeding sites for NNZD on Coromandel Peninsula at present, Opoutere and Waikawau already have refuge or reserve status. Consideration should now be given to similar status for the tip of Matarangi Spit. This site is also a key flocking site, with the fourth-largest flock in the taxon's entire range (Dowding & Moore 2006). Even before the large increase in breeding pairs in spring 2004, it was recognised as one of 19 sites nationally that are of particular importance to indigenous shorebirds. In addition to its value as a breeding and flocking site for NNZD, Matarangi Spit and the adjacent inter-tidal areas of Whangapoua Harbour are a site of international significance for the variable oystercatcher, as well as being used by 1000 or more Arctic migrant shorebirds annually (Dowding & Moore 2006). Given that Matarangi Spit is an internationally important wetland for two endemic taxa under Criterion 6 of the Strategic Framework of the Ramsar Convention on Wetlands (1971), it is surprising that the site was not listed by Cromarty & Scott (1996).

Matarangi Spit appears likely to have the highest number of NNZD pairs of any Coromandel site in the near future, if it has not already. Consideration should be given to installing sand fences to stabilise mobile sand on the spit and encourage further accretion. This technique has worked well at other sites, such as Omaha Spit, North Auckland.

In addition to the long-term protection afforded by reserve or refuge status, habitat can also be protected by challenging consent applications. Action 3.1 of the recovery plan (Dowding & Davis, in press) advocates opposition to 'any activity that may have potential or actual adverse impacts on northern New Zealand dotterels at any breeding site that contains seven pairs or more, or any flocking or feeding site that regularly contains 17 birds or more'. These figures represent 1% of the breeding and total populations respectively in October 2004 (Dowding 2005).

4.3.3 The minder network

The NNZD population is widely and rather thinly spread around the North Island coastline, and DOC can therefore realistically only manage a small number of key sites. Management by other agencies, community groups and individuals is required (Dowding & Davis, in press). Minders are an essential part of NNZD management on Coromandel (Stewart 2004; Segedin 2005) and elsewhere because they provide resources (mainly labour) that DOC cannot. The management actions required for recovery are well known, and most of the management techniques required are relatively simple.

The minder network on Coromandel is now well-developed and extensive. The recovery plan aim of having at least 15% of the NNZD population managed by agencies other than DOC by 2014 (Action 4.2, Dowding & Davis, in press) has already been well exceeded in this region. The Coromandel network can therefore serve as a model for other regions as they identify opportunities and build structures to co-ordinate non-DOC management of the taxon (Action 4.1, Dowding & Davis, in press).

The Coromandel minder network should continue to be co-ordinated by DOC. Supervision by DOC ensures that appropriate and acceptable methods of managing, monitoring and reporting are used, and that these standards are maintained when there is turn-over in the minder network. The Department of Conservation is an appropriate focal point for advocacy, training, and data storage and is also well-placed to provide minders with regular updates on research findings and management techniques.

Minor changes to the way the network is co-ordinated may have a number of benefits. Any of the following actions may be useful:

- Establish an informal email newsletter circulated to minders three to four times a year.
- Hold an annual meeting/workshop for minders lasting one full day (or preferably overnight). This would increase contact between minders and generate cohesion among members of the network. Experience at the Miranda Naturalists' Trust workshops on NNZD management shows that, following those workshops, many minders stay in contact with each other, sharing experiences, techniques and solutions to problems. The meeting would provide an opportunity to discuss results from the previous season, raise enthusiasm for the coming season, and provide training or updating.
- Consider issuing minders with T-shirts and/or hats with a distinctive Dotterel Watch design and DOC and Newmont logos. These would serve as an additional advocacy tool, and make minders (and the programme) identifiable to members of the public at relatively low cost.
- I note that in 2004 the programme co-ordinator did not begin until 25 October (Segedin 2005). Nesting by NNZD begins in September, and appointment of the co-ordinator in that month would have two obvious benefits. First, a visit to all minders in September would be a concrete demonstration of support for the minder network just before most nesting begins, and would serve to identify and/or remedy any on-site problems (such as a shortage of fencing materials or signs). Second, a Coromandel-wide survey in September would provide a more accurate assessment of the number of pairs attempting to breed in any season.

4.3.4 Monitoring

As noted above, the current Coromandel protection programme should continue to operate in the medium term. The next national NNZD census is scheduled for October 2011, and this will provide a good opportunity to assess future management requirements. Annual survival of adult NNZD is high in both managed and unmanaged areas (JED, unpubl. data), suggesting that management has little impact on this demographic. However, if productivity on Coromandel remains high but growth in the region's population has slowed (or stopped) by 2011, this will suggest that the NNZD population is approaching (or at) the carrying capacity of the peninsula.

At that point, a decision on whether to reduce the level of management would be required. On the one hand, it would be safe (in a regional context) to reduce management because the Coromandel population could be sustained by considerably lower levels of productivity than are seen at present. On the other hand, continued production of large numbers of juveniles would provide birds for adjacent regions, (mainly GBI, South Auckland and Bay of Plenty) through emigration. If there was substantial movement across the Firth of Thames as a result, the division between the two sub-populations may break down.

Between now and the 2011 census, monitoring should continue on broadly similar lines to that undertaken in the 2003/04 and 2004/05 seasons. The co-ordinator of the minder network should record the numbers of pairs breeding at each site, preferably early in the season. Productivity and details of the management regime at each site should also be recorded. Continuing to build up this dataset may aid future assessments of the effectiveness of management.

Autumn flock counts provide another simple measure of trends in the population, and the six main flocks should be counted annually (preferably in March) and checked for banded birds. Most of the flocks are already counted by minders or other volunteers (Appendix 2), but there are gaps in the data. Co-ordination and recording of the counts by one person is highly desirable.

4.3.5 Variable oystercatchers

Nationally, the variable oystercatcher (VOC) is increasing rapidly in numbers (Dowding & Moore 2004). In the North Island, VOC and NNZD both favour sandy beaches for nesting; both taxa are present at many sites, and their territories commonly overlap. Where both are at high density, aggressive interactions between them are not uncommon. At Opoutere and elsewhere, there are now many documented examples of VOC usurping NNZD nests and killing NNZD chicks, and one case of a VOC killing an adult NNZD. As numbers of both taxa seem very likely to continue to rise on the Coromandel coastline, these interactions may have an increasing impact on density and breeding success of NNZD at some sites. The recent fall in the number of NNZD pairs at Opoutere may be due in part to competition from the growing number of VOC pairs on the sand spit. In the short term, this situation should be monitored by recording the numbers of pairs of NNZD and VOC at the larger breeding sites (Waikawau, Matarangi Spit, and Opoutere Spit) annually. There is anecdotal evidence that much of the problem is caused by a few highly aggressive individual VOCs. In some cases, consideration may need to be given to identifying and removing such individuals where they persistently reduce NNZD productivity.

5. Recommendations

- Continue the current *NZ Dotterel Watch* protection programme on Coromandel Peninsula.
  Justification: The partnership between DOC, Newmont Waihi Operations and Coromandel residents is proving highly successful. Large numbers of chicks are fledging and the region's NNZD population is growing rapidly. No major changes to the programme are required in the short term.
- Re-assess management requirements for NNZD on Coromandel Peninsula following the national census in October 2011.

Justification: If the population continues to grow at the current rate, carrying capacity of the peninsula may be approached or reached by 2011. At that time, a decision will be required on whether to continue the existing protection programme or reduce the intensity, frequency or extent of management actions.

- Maintain a list of key breeding, flocking and feeding sites on Coromandel Peninsula and seek statutory or other long-term protection for these by 2014.

  Justification: Actions 3.3 and 3.4 of the recovery plan (Dowding & Davis, in press).

- Oppose applications for resource consents that may affect any breeding site with 7 or more pairs of NNZD, or any flocking or feeding site with 17 or more birds.

  Justification: Action 3.1 of the recovery plan (Dowding & Davis, in press).

- In the near future, examine options for the long-term protection of the western end of Matarangi Spit.

  Justification: The western end of Matarangi Spit and the adjacent intertidal feeding areas are key breeding, flocking and feeding sites for NNZD, are of international significance to the variable oystercatcher, and are used by 1000 or more Arctic migrant shorebirds annually.

- Consider measures to stabilise the tip of Matarangi Spit and encourage accretion of sand.

  Justification: The site has (or probably will have) the largest number of NNZD pairs on Coromandel Peninsula. In the past, it has suffered substantial erosion. Stabilisation should help to maintain a larger area of suitable habitat and reduce future erosion.

- Consider minor changes to the way in which the minder network is co-ordinated and supported.

  Justification: Measures are suggested that should serve to increase contact and support between DOC and the minders and thereby strengthen the network. It is conceivable that in the longer term the minder network will manage most of the Coromandel population; in that event, a more formal structure will be useful.

- Continue monitoring numbers of pairs, productivity, and management regime at sites around the peninsula annually; co-ordinate autumn counts of the six main flocks annually.

  Justification: Monitoring provides information on numbers and distribution between national censuses, and informs annual management decisions about where to apply resources.

- Monitor variable oystercatcher numbers at key NNZD breeding sites; consider removing aggressive individuals if necessary.

  Justification: Numbers of variable oystercatchers are increasing rapidly; at some breeding sites, this may have a negative impact on NNZD productivity and may reduce the carrying capacity of the site for NNZD.

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Appendix 1

NUMBERS OF PAIRS OF NNZD BREEDING AT FIVE SITES ON COROMANDEL PENINSULA

There are numerous gaps (and possibly a few doubtful counts) in the dataset (see Table A1.1), but overall trends are generally clear. Where a range of values is given, there is doubt about the number of pairs actually attempting to breed.

TABLE A1.1 NUMBERS OF PAIRS OF NNZD BREEDING AT FIVE SITES ON COROMANDEL PENINSULA OVER THE PAST 20 YEARS.

SEASON	SITE				
	WAIKAWAU	MATARANGI	PAUANUI	OHUI	OPOUTERE
1985/86	4	–	–	–	–
1986/87	3	–	–	–	–
1987/88	3	–	–	–	7
1988/89	–	–	–	–	9
1989/90	2	7	1	4	8
1990/91	–	–	–	–	–
1991/92	2	8	1	3	8
1992/93	–	–	–	3	–
1993/94	–	–	–	–	–
1994/95	–	4	–	3	10
1995/96	5	5	–	–	11
1996/97	6	–	0	–	11
1997/98	–	–	–	3	12
1998/99	4	5	1	3	15
1999/00	–	–	–	3	15
2000/01	–	6	–	3	16
2001/02	11	–	–	5	15
2002/03	9	–	–	7	15
2003/04	9	4	3	5	11
2004/05	10	8–15	7	5	10

Appendix 2

COUNTS OF POST-BREEDING FLOCKS OF NNZD ON COROMANDEL PENINSULA

Counts of the six main post-breeding flocks of NNZD on Coromandel Peninsula, 1985–2005. Only counts made between 01 February and 30 April are included in Table A2.1; where more than one count exists in a year, the highest is used. Sites are ranked by the mean of the four most recent counts ('Recent mean'). CSN = Classified Summarised Notes of *Notornis*. Other unpublished records probably exist and it would be useful to include them.

TABLE A2.1. COUNTS OF THE SIX MAIN POST-BREEDING FLOCKS OF NNZD ON COROMANDEL PENINSULA, 1985–2005.

YEAR	COUNT	SOURCE AND NOTES
Matarangi		
1989	68	G. Taylor (DOC Wellington, pers. comm.)
1991	64	G. Taylor et al. (CSN *Notornis 39(3)*)
1992	51	B. Woolley (OSNZ Waikato, pers. comm.)
1994	72	B. Woolley (OSNZ Waikato, pers. comm.)
1995	61	B. Woolley (OSNZ Waikato, pers. comm.)
1996	72	B. Woolley (OSNZ Waikato, pers. comm.)
1997	70	National census (J.E. Dowding, unpubl. data)
1998	55	B. Woolley (OSNZ Waikato, pers. comm.)
1999	56	B. Mackereth (Whitianga, pers. comm.)
2000	78	B. Mackereth (Whitianga, pers. comm.)
2001	100	B. Woolley (OSNZ Waikato, pers. comm.)
2002	62	B. Woolley (OSNZ Waikato, pers. comm.)
2003	80	W. Hare (OSNZ Waikato, pers. comm.)
2004	104	B. Woolley (OSNZ Waikato, pers. comm.)
2005	100	B. Mackereth (Whitianga, pers. comm.)
Recent mean	**87**	
Pauanui		
1985	16	D. Lawrie (CSN *Notornis 33(2)*)
1990	20	National census (J.E. Dowding, unpubl. data)
1997	23	National census (J.E. Dowding, unpubl. data)
1998	27	B. Woolley (OSNZ Waikato, pers. comm.)
1999	20	B. Woolley (OSNZ Waikato, pers. comm.)
2000	16	B. Woolley (OSNZ Waikato, pers. comm.)
2002	27	Owen (2003)*
2003	27	Larcombe (2004)†
2004	49	T. Wilson (Tairua, pers. comm.)
2005	43	J.E. Dowding (unpubl. data)
Recent mean	**37**	

Table A2.1 continued on next page

Table A2.1 continued

YEAR	COUNT	SOURCE AND NOTES
Opoutere		
1989	28	G. Taylor (DOC Wellington, pers. comm.)
1990	18	National census (J.E. Dowding, unpubl. data)
1993	21	B. Woolley (OSNZ Waikato, pers. comm.)
1995	30	B. Woolley (OSNZ Waikato, pers. comm.)
1996	34	B. Woolley (OSNZ Waikato, pers. comm.)
1997	28	National census (J.E. Dowding, unpubl. data)
1999	36	B. Woolley (OSNZ Waikato, pers. comm.)
2001	34	W. Hare (OSNZ Waikato, pers. comm.)
2003	37	B. Woolley (OSNZ Waikato, pers. comm.)
2004	30	B. Woolley (OSNZ Waikato, pers. comm.)
Recent mean	**34**	
Colville		
1985	26	D. Lawrie (CSN *Notornis 33(2)*)
1990	41	National census (J.E. Dowding, unpubl. data)
1991	25	A. & J. Piesse (CSN *Notornis 39(3)*)
1993	44	B. Woolley (OSNZ Waikato, pers. comm.)
1995	26	B. Woolley (OSNZ Waikato, pers. comm.)
1996	36	G.R. Parrish (CSN *Notornis 44(2)*)
1997	36	National census (J.E. Dowding, unpubl. data)
1998	17	B. Woolley/B. Seddon (OSNZ Waikato, pers. comms) Separate counts, both 17
1999	25	Y. Forbes (per B. Woolley, OSNZ Waikato, pers. comm.)
2001	32	B. Woolley (OSNZ Waikato, pers. comm.)
Recent mean	**28**	
Coromandel		
1990	19	National census (J.E. Dowding, unpubl. data)
1991	22	B. Seddon (OSNZ Waikato, pers. comm.)
1992	25	A. & J. Piesse (CSN *Notornis 41(1)*)
1997	25	National census (J.E. Dowding, unpubl. data)
1998	26	Anon. per B. Woolley (OSNZ Waikato, pers. comm.)
1999	29	B. Woolley (OSNZ Waikato, pers. comm.)
Recent mean	**26**	
Whangamata		
1989	15	G. Taylor (DOC Wellington, pers. comm.)
1990	17	National census (J.E. Dowding, unpubl. data)
1993	24	B. Woolley (OSNZ Waikato, pers. comm.)
1994	17	B. Woolley (OSNZ Waikato, pers. comm.)
1995	16	B. Woolley (OSNZ Waikato, pers. comm.)
1996	15	B. Woolley (OSNZ Waikato, pers. comm.)
1997	16	J.E. Dowding (unpubl. data)
1999	24	B. Woolley (OSNZ Waikato, pers. comm.)
2000	21	J.E. Dowding (unpubl. data)
2001	21	B. Woolley (OSNZ Waikato, pers. comm.)
Recent mean	**21**	

* Owen, K.L. 2003: Statement of evidence of Keith Leslie Owen for Director-General of Conservation. Evidence to hearing by Waikato Regional Council and Thames-Coromandel District Council in the matter of an application for resource consents by Tairua Marina Ltd and Pacific Paradise Ltd.

† Larcombe, M.F. 2004. Statement of evidence of Michael Francis Larcombe. RMA 971/03.

Appendix 3

ESTIMATES OF NNZD PRODUCTIVITY AT THREE SITES ON COROMANDEL PENINSULA

Estimates of productivity (average number of chicks fledged per breeding pair) at three sites on Coromandel Peninsula, 1983/84–2004/05 (Table A3.1). Data are mostly from unpublished reports by site wardens (some values have been adjusted in the light of later information) and from Todd (1988)*. Where there is doubt about the exact number of chicks fledged (e.g. when chicks remain unfledged at the end of monitoring), the minimum number definitely known to have fledged is used. A dash (–) indicates that no records were available.

* Todd, W.T. 1988: Observation reprt: Bird species, Waikawau Bay, Coromandel Peninsula, 1987/88 season. Unpublished report to Department of Conservation, Waikato Conservancy, Hauraki Area Office, Thames.

TABLE A3.1 ESTIMATES OF NNZD PRODUCTIVITY AT THREE SITES ON COROMANDEL PENINSULA, 1983/84–2004/05. (AVERAGE NUMBER OF CHICKS FLEDGED PER BREEDING PAIR.)

	SITE		
SEASON	WAIKAWAU	OHUI	OPOUTERE
1983/84	–	–	0.00
1984/85	0.00	–	0.00
1985/86	2.50	–	0.00
1986/87	0.00	–	–
1987/88	2.33	–	1.29
1988/89	–	–	1.00
1989/90	–	–	1.25
1990/91	–	–	–
1991/92	–	–	0.75
1992/93	–	–	–
1993/94	–	–	–
1994/95	–	–	–
1995/96	–	–	0.55
1996/97	–	–	0.18
1997/98	–	1.00	0.58
1998/99	1.00	1.33	0.53
1999/00	–	0.67	1.13
2000/01	–	0.00	0.38
2001/02	0.64	0.80	0.13
2002/03	0.78	1.14	0.13
2003/04	0.67	0.60	0.82
2004/05	0.90	0.33	0.90