Evaluation of techniques for management of NZ dotterels

Short-term options for management of NZ dotterels on Stewart Island and a draft proposal for captive-rearing using North Island birds

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Summary

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The small population of NZ dotterels on Stewart Island is declining rapidly (probably because of predation by feral cats) and is critically endangered. For two seasons, cats have been controlled at Table Hill, the last major dotterel breeding site. A NZ dotterel recovery group meeting in May 1994 recommended (1) that the intensity of management at Table Hill be increased and (2) that a captive-rearing plan be drafted and trials undertaken with North Island birds.

1. Management on Table Hill

Short-term management options for the Stewart Island population are discussed. Specific recommendations and a provisional timetable for the 1994-95 season are presented. Cat control needs to be improved and rat control should begin on Table Hill. Certain egg transfers should take place (if opportunities arise) and cat-proof nest-cages should be installed over all nests found (if trials in the North Island give satisfactory results). Cross-fostering may be another option. It is hoped that nest-cages will be sufficiently effective to obviate the need for captive-rearing, but an outline for a captive-rearing strategy is suggested in case it does becomes necessary.

2. Captive-rearing trials

A proposal to trial captive-rearing procedures and test their success with North Island NZ dotterels is presented. For the 1994-95 season, eggs should be collected from a defined area on the North Auckland east coast and given to two institutions to captive-rear. Details of conditions used to captive-rear other charadriid plovers are given in an Appendix. Juveniles should be released at the Omaha flock in late January or February. Their survival and dispersal must be monitored as closely as possible. The programme should be reviewed after each season, but will probably need to continue for at least two seasons. Criteria for judging the outcome of the trials at various stages are discussed.

Background

The New Zealand dotterel (*Charadrius obscurus*) is an endemic shorebird with a total population of about 1400. There are two breeding populations separated by more than 1000 km; the northern population breeds around the coast of the North Island and the southern population now breeds only on Stewart Island. Because of substantial differences in morphology and ecology, it has recently been proposed that these populations be recognised as separate subspecies (Dowding, submitted for publication).

The Stewart Island population has declined rapidly over the past 40 years (Dowding & Murphy 1993), and currently numbers 60-65 birds (Dowding 1994). Because of high mortality of adult birds (believed to be caused largely by feral cats) and the existence of a severe gender bias (there appear to be few males remaining), the Stewart Island birds are critically endangered. The effective population size is probably no more than 30. The NZ dotterel recovery plan (Dowding 1993b) states that reversing the decline of this population/subspecies and preventing its extinction is the highest priority task in the species recovery programme.

In a bid to enhance adult survival and increase productivity, cat control has been undertaken for the past two seasons at Table Hill, the last remaining major breeding ground on Stewart Island. The 1992-93 season saw a rise in the population, the first for at least three years (Dowding 1993a). In 1993-94, a combination of factors made the programme less effective and a fall in the population resulted (Dowding 1994).

The recovery plan also states that a captive-breeding/rearing plan should be prepared, to be actioned if on-site management on Stewart Island does not halt the decline. Rearing trials should be undertaken using North Island birds as a surrogate population.

At the NZ dotterel recovery group (NZDRG) meeting held at Rotorua on 27 May 1994, it was recognised that the state of the Stewart Island population was still extremely precarious. All members of the NZDRG agreed that:

- the intensity of management on Table Hill should be increased
- a proposal to trial captive-rearing with North Island birds should be prepared immediately.

There was unanimous agreement that both the increased management effort on Table Hill and the captive-rearing trials should begin during the coming (1994-95) breeding season. The meeting resolved that I produce two documents, one discussing on-site options for Stewart Island and the other a draft proposal to trial captive-rearing techniques. This report combines these two tasks.

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Section 1. Short-term management options on Stewart Island

At their May 1994 meeting, the NZDRG agreed that on-site management (including predator control and nest manipulations) was the preferred management option for the southern population. In contrast to captive-rearing, this approach has a number of biological advantages, allowing birds to be raised in normal surroundings, on natural food and in the presence of adult NZ dotterels. On-site techniques are also normally much less expensive than captive-rearing or captive-breeding.

This section considers options for on-site management on Stewart Island, and makes specific recommendations for the 1994-95 season. Options for future seasons are discussed, including suggestions for a captive-rearing strategy should this become necessary.

1.1 Improvements to cat control

Measures to improve the efficiency of cat control were discussed by Dowding (1994). In the humid conditions on Table Hill, the 1080 leaches from present baits (or breaks down) between one and two months after installation, and fungal growth and fly-strike render baits unpalatable. Until ways are found to improve bait life, baits should be changed without fail every five-six weeks. In the longer term, efforts to make baits more durable must continue; if these are unsuccessful alternative baits or toxins may have to be considered.

1.2 Rat control

In contrast to the two previous seasons, rat density was particularly high on Table Hill during the 1993-94 season. There are a number of possible explanations for this - the previous winter was relatively dry and warm, or there may have been abundant food available to rats over winter (possibly from a podocarp or other mast). Either or both may have allowed increased rat survival over winter. It is also possible that two seasons of cat control have lowered cat density on Table Hill to the point where reduced predation on rats has allowed their numbers to rise. Rats are certainly the staple diet of cats on Stewart Island (Karl & Best 1982), but it is not known whether cats actually control rat density in this habitat.

Whatever the explanation, rats are clearly potential predators of NZ dotterel eggs (and quite possibly of adults) and control is therefore now highly desirable. If rats are poisoned from late winter (baits installed at the same time as cat baits), their numbers should be reduced to a level from which they will not be able to breed up to the density seen in 1993-94. Rats appear to be patchily distributed on Table Hill; because they may be locally numerous (and baits will be replaced only every six weeks), I suggest the use of large wax block anticoagulant baits, fixed in stations so they cannot be removed. Stations should be installed near cat-bait stations, so that cat and rat baits can be checked concurrently. With the use of anticoagulants to control rats, there is also the possible bonus of secondary poisoning of cats. Rat control should not be particularly expensive, but the initial cost of installing

stations may not have been budgeted for this season. Three possible options are as follows.

1. The preferred option is to purchase purpose-built stations (e.g. those supplied by Tuff Plastics, Rotorua), which hold several large blocks of bait, protect them from the weather and do not allow them to be removed by rats. The stations are durable (designed to last 10-15 years) and cost $8-50 + GST per station.
2. Baits could be fastened down and stations improvised over them from inverted plastic liver pails or small buckets (with access holes cut in them), also fastened down. This should be cheaper than option 1, but stations would probably be much less durable and less convenient to check.
3. Re-use on Table Hill of the Novacoil stations from the Ulva Island eradication is a possibility. While it would save on initial set-up costs, the smaller baits used in these stations are removed by rats and they would be emptied quickly (particularly if rat density has remained higher than usual from last season). Control is therefore unlikely to be as effective. (It may however prove possible to modify the Novacoil stations so that block baits can be fixed in them.)

While it would be ideal to have a rat-bait station at each cat-bait station (206 in all), this may not be possible, at least in the first season. I suggest a minimum of 100 stations would be required, however. This would result in a station about every 110 m in the cordon, with some internal stations. Rats typically have home-ranges 100-300 m in length, so this spacing should exposed a high proportion of rats to baits.

- The Department should immediately begin considering the rat-bait station options, and planning and organising the rat control programme. Stations and baits need to be ready for transport to Table Hill in August, when the season's supplies and equipment are flown in.

1.3 Egg manipulations and nest protection

Egg transfers

Probably because of the shortage of male birds, a number of female-female (FF) pairs with infertile clutches have been found on Stewart Island (Dowding 1993). One option (favoured by the NZDRG) is to transfer first clutches from male-female pairs to FF-pair nests, in the hope that the male-female pair will re-lay and productivity will be increased.

There are two important caveats. First, we must be sure that both recipient birds are females - sexing NZ dotterels (particularly Stewart Island birds) is not yet reliable and birds must be examined in the hand and measured before there is any degree of certainty. Second, although observations to date suggest that 4-, 5- or 6-egg clutches are probably laid by two females, it is possible that a male has fertilised one or both of the females without pair-bond formation. It cannot safely be assumed therefore that all the eggs of a supernumerary clutch are necessarily infertile. All eggs in the recipient nest must be candled; if embryos are suspected in any of them, none of the eggs should be removed and that nest should not be used in a transfer.

Transfers should take place in the early part of the season only. The breeding season may not be as long on Stewart Island as in the North Island, and to avoid an increased risk of donor pairs not re-laying, I suggest that no transfers take place after the end of October. Another consideration is that rat (and possibly cat) densities will rise later in the season, and late clutches could be at higher risk.

In summary, I suggest that any intra-specific egg transfers on Table Hill during the 1994-95 season meet the following requirements:

- The recipient clutch must contain more than 3 eggs.
- There must be good reason to believe that both recipient birds are females.
- All eggs in the recipient clutch must be candled before removal.
- If any eggs in the recipient clutch appear fertile, the transfer should not take place.
- Any transfers should take place before the end of October.

Based on past experience, only one or two FF nests (and in the region of 4-6 male-female nests) are likely on Table Hill in a given season. In addition, transfers obviously require that donor and recipient nests are present simultaneously. Together, these facts suggest that opportunities for transfers are likely to be very limited; in any particular season there could be none. Transfers alone will therefore probably not advance the recovery programme sufficiently, and I believe that other measures are necessary in the short term.

Nest-cages

In the northern population, male birds undertake most of the night-time incubation (Dowding, unpublished data) and are therefore more at risk from predominantly nocturnal predators such as cats. There is no reason to believe that the situation on Stewart Island differs, and this is probably how the present gender bias in the southern population arose.

I suggest that during the 1994-95 season we test the effectiveness of cat-proof cages over nests in reducing predation. Clearly, birds must be prepared to accept cages and return to nests quickly; experience capturing birds in the North Island shows they will return to nests with a cage-trap over them. Nest-cages probably therefore only need be large enough to stop cats reaching eggs or incubating birds - I anticipate a diameter in the range 0.7-1.0 m would be sufficient. Obviously, the mesh of the cage must be of such a size that it allows birds free passage to and from the nest. Deblinger *et al.* (1992) and others tested various predator exclosures around nests of piping plovers (*C. melodus);* most of the exclosures were much larger than those proposed here, but the majority were very effective in increasing hatching rates.

Nest-cages should protect eggs and incubating birds from any large predators (cats, gulls, harriers, possums) but not from rats (or, in the North Island, from mustelids). If eggs are lost from caged nests (and there is no evidence that they have hatched), we will at least have our first evidence that rats are indeed active predators of NZ dotterels on Stewart Island. Chicks and adults will still be at some risk from cats for about the first week after hatching,

when chicks need to be brooded often (particularly at night), but overall the time during which adults and eggs are vulnerable should be much reduced.

I suggest preliminary trials be carried out in the North Island to test acceptance of nest-cages before they are installed on Stewart Island. Although there is some annual variation, many NZ dotterels in the Omaha study area (North Island) begin laying during the first two weeks of September. Trials could be carried out at Omaha (and possibly also at Tawharanui) during this period. Although acceptance of the cages would be the main focus of these trials, egg loss at both sites is high and it may also be possible to get some indication of their effectiveness (note however that predator regimes are different from those on Stewart Island). The trials would be complete before the proposed early October trip to Table Hill (see timetable in Sections 1.5 and 1.8).

Assuming cages are accepted by North Island birds, I suggest they be installed over all nests found on Table Hill during the October 1994 trip. However, nest-cages may also provide some protection in the absence of cat control and could be installed at a few sites other than Table Hill at virtually no extra cost. I therefore suggest that any nests found on Blaikies Hill and Mt Rakeahua be caged also; both sites are accessible during trips to Table Hill. Cages installed in October could be removed during the proposed December trip and stored (hidden) at each site for use in subsequent seasons.

Judgement will sometimes need to be exercised when installing cages. Conditions on Stewart Island can be severe and eggs probably cool quickly when not incubated, so cages need to be prefabricated and fitted as quickly as possible. If it is very cold, it may be prudent not to disturb birds by installing a cage, but this must be balanced against the continued risk of predation at an unprotected nest. If any particular bird appears reluctant to accept a cage, some discretion will be required in deciding whether to remove it and how quickly. In some cases it may be possible to increase acceptance by installing the cage gradually (perhaps adding sections each day until complete). It may be that a larger cage, with the walls further from the nest, is less threatening and more readily accepted by some birds (some information on this may be gained during the Omaha trials).

1.4 Summary of recommendations for 1994-95 season

- Ensure that cat baits are renewed regularly.
- Begin rat control on Table Hill.
- Test acceptance of nest-cages in the North Island during September.
- If appropriate, install cages over nests on Stewart Island in October.
- Transfer early fertile clutches on Table Hill to FF pairs where possible (*but note caveats*).
- Consider a cross-fostering trial using banded dotterels if the opportunity arises (see details in Section 1.6, *Cross-fostering*).
- Assess results after 1994-95 season and make recommendations for the following season.

1.5 Provisional timetable for 1994-95 season

Mid-late August - Stewart Island Field Centre (SIFC) staff load existing cat-bait stations around Table Hill and install and load rat-bait stations.

Mid-September - JED constructs prototype nest-cages and tests them in the Omaha-Wade River study area.

Early October - JED and 1 SIFC staff member to Table Hill. Latter services bait stations and departs (c 3-4 days WP); JED checks birds present (noting recruitment), bands unbanded birds where possible, searches for nests, conducts any appropriate egg manipulations, installs nest-cages and studies reaction of birds to them. JED checks Blaikies Hill and Mt Rakeahua, installs nest-cages where appropriate (14 days).

Mid-late November - SIFC services bait stations.

Early-mid December - JED to Table Hill. Checks birds present, attempts to assess success of first clutches, bands any chicks present, removes nest-cages, searches for later nests/re-nests and installs nest-cages at any found.

January - SIFC services bait stations.

February - SIFC empties bait stations.

March - JED conducts annual census and check of banded birds.

Tentative dates for these trips are shown in Section 1.8.

1.6 Future options

On-site hatching

The first option to consider is the artificial incubation of eggs on-site. If the use of nest-cages (or other evidence) suggests that rats are a significant predator of eggs, clutches could be removed and incubated artificially on Table Hill. If parents are kept on nests (with dummy eggs), hatching eggs can be returned to them for chick-rearing. While this option may be cheaper than captive-rearing away from Table Hill, it would nevertheless require an increase in facilities and resources. An incubator and generator would be required, as well as extra accommodation, and skilled personnel would need to be present over a period of several months. For such an outlay, the returns (in terms of increased productivity) would be slight. If rats are predators of adult birds, this scheme would not improve survival of males.

Captive-rearing

I believe the establishment of a captive-rearing unit on Table Hill itself would be impractical and expensive. In this option therefore, eggs would be collected from Table Hill (and hopefully elsewhere), captive-reared at an appropriate existing facility, and released on Stewart Island. This is the most expensive option considered here, but would be cheaper than a captive-breeding programme (see Section 2.1).

Well before captive-rearing becomes necessary, a suitable facility must be identified. It seems unlikely at present that birds could be reared on Stewart Island, and although it is

desirable to keep transfer times (of eggs from the breeding grounds and juveniles to the release site) to a minimum, there appear to be relatively few options in the southern South Island. Possibilities (in order of increasing distance from Stewart Island) include:

1. The Department should check for any private zoos and aviculturalists in Otago and Southland who may be prepared to assist.
2. The two Departmental captive-rearing units in the southern South Island should also be considered; it may prove relatively inexpensive to expand facilities at Burwood Bush or Twizel. The latter has considerable experience in rearing waders. As eggs only would be brought in, disease risks are likely to be small.
3. Facilities in the central South Island (e.g. Orana Park or Peacock Springs, Christchurch).
4. The National Wildlife Centre, Mt Bruce, which has experience rearing plovers.
5. If rearing has to take place in the North Island, the institutions that undertake the North Island trials should be considered. In particular, Auckland Zoo (if they become involved in the programme) would be well located; transfers to Invercargill are likely to take no longer from Auckland than from Mt Bruce.

- I recommend that the Department begins consideration of possible sites for captive-rearing of Stewart Island birds in the near future.

The only safe and rapid method of removing eggs from Table Hill is by helicopter. This would clearly be expensive but with adequate planning only one or two trips are likely to be necessary. As they are discovered, nests could be protected temporarily (by caging and installation of bait stations nearby), then collected and removed in one flight. Given the number of pairs now on Table Hill, it seems unlikely that more than about 4 clutches would be available for rearing from any one collection, unless searches are also made further afield.

If Stewart Island birds are captive-reared, I suggest they be released at the Mason Bay flock, probably in late January or February. Release at Awarua Bay, while logistically simpler, may increase the risk of birds dispersing around the South Island coast and failing to discover the Stewart Island breeding grounds. There is some evidence that juveniles and bereaved adults may be emigrating from Stewart Island, presumably searching for mates. The risk of emigration clearly needs to be reduced as far as possible. Release at Mason Bay would require the use of a fixed-wing aircraft from Invercargill.

If captive-rearing of southern birds does become necessary, a likely outline of the programme (based on current knowledge) appears to be as follows:

- Late September-October - first clutches are collected and taken to an appropriate facility for captive-rearing.
- November-December - Late nests and re-nests on Table Hill (and possibly elsewhere) are either (a) protected by on-site techniques to be reared in the wild, or (b) collected for a second round of captive-rearing.
- Late January-February - first group of captive-reared juveniles are released at Mason Bay.
- March - if applicable, second group of captive-reared juveniles released at Mason Bay.

Cross fostering

Banded dotterels (*C. bicinctus*) also breed in Table Hill and the possibility of cross-fostering should be kept in mind. Banded dotterels could be given one or two NZ dotterel eggs to incubate and raise (as they are a much smaller bird, they may not be able to incubate a full clutch of three NZ dotterel eggs). There is a risk of imprinting problems, but waders are precocial and there is evidence from a study of killdeers (Powell & Cuthbert 1993) that cross-fostering of plovers can be successful. Banded dotterel nests containing NZ dotterel eggs would have to be caged (assuming caging is successful). Again, the number of transfers possible on Table Hill in any season is likely to be limited and this technique would probably have little impact on overall productivity. It would be inexpensive, however.

It may be possible to undertake an experimental transfer during the 1994-95 season without jeopardising nests on Table Hill. If a NZ dotterel nest is found on Blaikies Hill in October, two eggs could be removed and transferred to a banded dotterel nest on Table Hill. Blaikies Hill is outside the protected area and nests there are less likely to succeed. All banded dotterel eggs would need to be removed from the recipient nest, in case they hatched first and the NZ dotterel eggs were abandoned. In December, it may be possible to determine whether chicks were raised successfully, and (ideally) band any such chicks. If any banded cross-fostered chicks fledge, it may be possible to gauge whether they are mal-imprinted by checking whether they join a banded dotterel or NZ dotterel post-breeding flock. The presence of conspecifics on the breeding grounds may help to reduce imprinting problems.

Use of volunteers

At the May 1994 meeting, the NZDRG raised the possibly of involving volunteers in the recovery programme on Stewart Island. It should be possible to use volunteers in some parts of these programmes, but they would need to be reasonably skilled in general wildlife management techniques and would probably need to be given some specific training. It should also be made very clear that conditions on the Tin Range can be severe, and good survival skills and equipment and a good level of fitness are therefore essential. At present, the programme on Stewart Island is still largely experimental and techniques being used are changing every season; in general, it seems likely that volunteers will be more useful once a regular regime is established.

It would certainly be possible for single volunteers to accompany a SIFC staff member to assist with cat and rat bait changes (at present there is only accommodation for two on Table Hill). Pairs of volunteers could conceivably undertake the changes without supervision, but the Department would have to be consider a number of factors. These include (a) poison regulations and the unsupervised use of 1080 by volunteers, (b) the need for good navigational skills in poor weather, (c) locating the bait stations - there are currently 206 in an area of 3 sq km, and a route would need to be clearly marked. Volunteers could also assist by recording band sightings and behavioural observations.

One task, searching for nests either for caging or egg collection, is a vital part of virtually any of the management options discussed here, but it does require expertise and care. By comparison with North Island nests, those on Stewart Island are in very large territories, are extremely well camouflaged and are usually difficult to locate. Over-long searches by inexperienced personnel will jeopardise nests by keeping incubating birds off them for long periods. This would be highly undesirable on Table Hill while on-site management was being undertaken. However, if captive-rearing is undertaken, volunteers could usefully search for nests in other parts of the island (e.g. Doughboy Hill, southern Tin Range, Mt Anglem).

1.7 Conclusion

There is reason to believe that improvement of present predator control, coupled with the initiation of egg manipulations and nest protection, will improve the outlook for the southern population. If cats are the main predator, nest-cages should be particularly helpful because they will address the two main aims of the Stewart Island recovery programme - increasing adult male survival and improving productivity.

If all goes according to plan, these improvements to the Table Hill protection programme will make a large difference at relatively little extra cost. Hopefully, they will increase survival and productivity to the point where the captive-rearing plan no longer needs to be actioned.

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1.8 Appendix: Provisional Stewart Island management timetable, 1994-95

Exact dates will depend on times of high water; 1994-95 tide tables were not available at the time of writing.

Dates outlined = bait changes by SIFC staff, dates shaded = fieldwork by JED.

Mo	Tu	We	Th	Fr	Sa	Su	
1	2	3	4	5	6	7	
8	9	10	11	12	13	14	
15	16	17	18	19	20	21	AUG
22	23	24	25	26	27	28	
29	30	31					
			1	2	3	4	
5	6	7	8	9	10	11	
12	13	14	15	16	17	18	SEP
19	20	21	22	23	24	25	
26	27	28	29	30			
					1	2	
3	4	5	6	7	8	9	
10	11	12	13	14	15	16	OCT
17	18	19	20	21	22	23	
24	25	26	27	28	29	30	
31							
	1	2	3	4	5	6	
7	8	9	10	11	12	13	
14	15	16	17	18	19	20	NOV
21	22	23	24	25	26	27	
28	29	30					
			1	2	3	4	
5	6	7	8	9	10	11	
12	13	14	15	16	17	18	DEC
19	20	21	22	23	24	25	
26	27	28	29	30	31		
						1	
2	3	4	5	6	7	8	
9	10	11	12	13	14	15	JAN
16	17	18	19	20	21	22	
23	24	25	26	27	28	29	
30	31						
		1	2	3	4	5	
6	7	8	9	10	11	12	
13	14	15	16	17	18	19	FEB
20	21	22	23	24	25	26	
27	28						
		1	2	3	4	5	
6	7	8	9	10	11	12	
13	14	15	16	17	18	19	MAR
20	21	22	23	24	25	26	
27	28	29	30	31			

Section 2. Draft proposal for captive-rearing of North Island birds

2.1 Background

This programme must be designed quite specifically to test only those procedures that are likely to be used with Stewart Island birds. There was agreement among NZDRG members that if on-site management is not sufficiently effective, the preferred option is captive-rearing (as opposed to captive-breeding). I agree with the Recovery Group for a number of reasons.

1. If the programme is confined to captive-rearing (and assuming that all birds raised are released), then birds only need to be held from about October to February. It would therefore not be necessary to house and feed adults on a year-round basis.
2. It is by no means certain that dotterels will breed in captivity. Without taking breeding adults into captivity from the wild, we would have to wait two (or more) years to find out.
3. In addition, it would obviously only be possible to hold a small breeding stock and the genetic diversity of the released progeny would thus be limited. By taking clutches from marked birds (see below) we could ensure that eggs are taken from different pairs each season. If we do captive-rear Stewart Island eggs in future, we would obviously take them from as many different pairs as possible.
4. Captive-rearing is a flexible option in that it can be undertaken or not each season at short notice, simply by deciding whether or not to collect eggs. Captive-breeding is less flexible; (a) the death of even one or two individuals in the breeding stock may have a substantial impact on productivity, and (b) if no offspring are required in any season birds would have to be held in single-sex groups; because sexing of NZ dotterels is not reliable, they may have to be held individually.
5. Captive-rearing can produce more young than captive-breeding and leaves the maximum number of individuals in the wild (Powell & Cuthbert 1993).

A pilot captive-rearing trial was undertaken during the 1993-94 season at Otorohanga, using 11 eggs collected from the Coromandel east coast. Hatching success was high but chick-rearing was less successful, and at the time of writing four birds remain alive. Some details of the hatching and rearing conditions used at Otorohanga are given in Section 2.6.

The Department should decide the fate of the birds remaining at Otorohanga in the near future. As there is presently no intention of attempting to captive-breed Stewart Island birds, there seems little point in establishing a breeding colony of North Island birds. Ideally, they should be released as soon as possible (to increase the sample size available for later monitoring), but this will require thorough disease checks.

2.2 Captive-rearing of other charadriid plovers and black stilt

There appear to have been relatively few attempts to captive-rear other charadriid plovers.

1. Malone & Proctor (1966) gave a detailed description of conditions for rearing killdeers (*C.*

vociferus) in captivity, and noted that they were very easy to rear and keep.

2. Page *et al.* (1989) reared snowy plovers (*C. alexandrinus nivosus*), released them, and reported that some paired and bred successfully in the wild. Of the 22 eggs which hatched in captivity, all were reared to release age.
3. Shore plovers (*Thinornis novaeseelandiae*) have been successfully reared in captivity at the National Wildlife Centre (Aikman 1993 and pers. comm.).
4. Detailed information is also available on captive-rearing (and captive-breeding) of black stilts (*Himantopus novaezelandiae*) (Reed 1994 and pers. comm.).

Hatching and rearing protocols for these species are compared in Section 2.6.

2.3 Proposal

Locations for rearing

Otorohanga Zoological Society now have some experience in attempting to rear NZ dotterels and should be asked to continue participating in the programme. I suggest that the Department also approach Auckland Zoo and ask if they would be willing to assist. There are two main reasons why a second institution should be involved if possible.

1. During their pilot study, Otorohanga raised relatively few chicks to release age. Data from a second institution would provide an insight into whether there are inherent difficulties in rearing NZ dotterels or whether conditions used at Otorohanga are not yet optimal.
2. The use of two institutions should roughly double the number of birds that can be reared and thus increase sample sizes for later monitoring. I believe this is particularly important in the 1994-95 season (see below -*Number of clutches to be taken*).

The relative proximity of Auckland Zoo to the proposed egg collection area and release site would be an obvious advantage.

Egg collection

If captive-rearing of Stewart Island birds is undertaken, there will be few nests available and entire clutches will almost certainly have to be taken if sufficient eggs are to be collected. We therefore need to test the effect of removing entire clutches, to be sure that removal of eggs will not cause desertion of territories, or disruption of the pair bond (there is currently no evidence for this, but it should be checked). The Mangawhai-Omaha-Wade River study area described by Dowding & Chamberlin (1991) is an appropriate area to collect eggs; birds are already marked and studying response will be relatively easy. In many parts of the study area, egg survival has been extremely low over the past five years and collection will make little or no difference to natural productivity (the captive-rearing programme should, however, effectively make productivity very much higher than usual in the area). In addition, several sites in this study area have been identified where nests are routinely inundated by spring tides. Clutches at these sites will be salvaged where possible.

If monitoring during the 1994-95 season shows that there are no adverse effects of

removal of entire clutches, single eggs could be removed from some nests in subsequent seasons. This would cause much less disruption (birds would not have to re-lay), and would have virtually no effect on natural productivity - it is extremely rare for NZ dotterels to raise three chicks to fledging at unprotected sites. Entire clutches should still be collected from nests threatened with inundation.

I recommend that collection preferably take place between mid-September and mid-October (some latitude is necessary however, because of annual variation in laying dates, weather conditions, etc.). Eggs would then hatch between early October and early November, chicks would fledge between mid-November and late December, and birds would be held until release (probably in late January - see *Release conditions* below).

Number of clutches to be taken

The long-term aim of these trials is to determine whether captive-rearing could increase the number of birds breeding on Stewart Island. Although the ability to survive is obviously important, we ultimately need to know whether captive-reared NZ dotterels can form pair-bonds and breed in the wild. Most North Island NZ dotterels do not breed in their first year and it will therefore be at least two years before we know whether our trials are successful.

Given the status of the southern population, it seems vital that we gain as much information as possible from our first cohort, and this will require an adequate sample size. At least for the first season, I therefore recommend we give a maximum of 12 eggs (4 clutches) each to Otorohanga and Auckland Zoo. I foresee little problem in finding 8 clutches from areas where predation is very high and from sites that will be inundated. Considering the delay before the success of the trials can be gauged, the Department may wish to consider authorising the collection of a small number of further clutches later in the first season if fertility of earlier eggs is low, to ensure that sufficient birds are released in the first cohort.

Depending on results from the first season, decisions can be made about numbers of clutches to be collected in subsequent seasons.

Rearing conditions

To a large extent the precise rearing conditions used will be governed by the facilities and expertise of the institutions involved, but the conditions described for other waders (Section 2.6) may provide some guidelines. Other points which may need to be considered are:

1. NZ dotterels are considerably larger than the other plovers described above (average adult weight of North Island birds is 145 g), and will require more space as chicks grow.
2. One NZ dotterel died at Otorohanga when it caught a leg in the wire-netting of the cage. Malone & Proctor (1966) fixed boards around the bases of cages to reduce entanglement, but their birds were wing-clipped and could not fly. As NZ dotterels chicks in captivity approach fledging, they should be watched; if there appears to be a risk of injury from birds flying into the mesh of the cage, consider lining with shade cloth or other material.

3. There are always potential imprinting and taming problems associated with captive-rearing. Page *et al.* (1989) reported that captive-reared snowy plovers were very tame for some time after release, but became more wary later in their first year. Some contact with people is inevitable during rearing, but should be reduced where possible. NZ dotterels should be held in off-display aviaries as far as possible. Apart from reducing taming and mal-imprinting, these conditions should also reduce stress.
4. Pens used for rearing obviously need to be predator-proof; small chicks will be very vulnerable to rats and mustelids.
5. Birds will need to be able to fly to feeding grounds immediately after release; they should therefore be held in a large aviary for several weeks before release, so as to have as much flight practice as possible.

Feeding

In the wild, NZ dotterels prey on a wide variety of animals, mostly invertebrates. As can be seen from the protocols in Section 2.6, a wide range of food items has also been given to captive-reared charadriids; the precise diet is therefore unlikely to be critical. However, it appears that a plentiful supply of small live invertebrates (e.g. tubifex worms, mayflies, caddisfly or damselfly larvae) may be very important in the first few days (or first week) after hatching, when some species may be reluctant to take artificial food.

Before release, captive-reared birds must be able to capture larger live prey with some efficiency. Sandhoppers (*Talorchestia* spp.) are a very common prey item of northern birds and should not be too difficult to collect (from clumps of seaweed on beaches). I suggest that sandhoppers (or another suitably-sized moving prey item) be provided as part of the diet for several weeks before release.

Disease precautions

In the wild, NZ dotterels mix regularly with other waders (including international migrants) and there is currently no reason to believe that the wild population is particularly at risk from diseases acquired from other wild birds. However, precautions must clearly be taken to minimise the disease risk to the wild population from captive-reared birds. The following are minimum requirements, and the Department may wish to impose others.

1. The Department should inspect facilities and declare them satisfactory before eggs are supplied.
2. Wherever possible NZ dotterels should be kept isolated from other species, and must be kept isolated from exotic bird species.
3. The Department must be notified immediately if birds are found injured, sick or dead. Any birds dying *must* be autopsied by a qualified pathologist to determine the cause of death. All eggs that fail to hatch *must* be checked to determine whether they were infertile (if fertile eggs do not hatch incubation conditions may have been inappropriate).

4. All birds must be screened before release and (as far as is practical) declared free of diseases that could be transmitted to the wild population. The precise requirements (which organisms should be tested for, test methodologies, who should conduct them, etc.) should be discussed by the Department's Disease Co-ordinator and other qualified experts and included in permit conditions.

Release strategy

I suggest that birds be kept in captivity for at least 3-4 weeks after they can fly. This should help to ensure that the birds are carrying some fat reserves (they are likely to be relatively inefficient foragers in the wild initially) and may allow greater development of flight muscles. Wild juveniles do not normally leave their parents immediately once they can fly. The extra period in captivity will also mean that birds can be released in groups at a post-breeding flock; in the North Auckland area, these have usually begun to form by late January. I believe that release at post-breeding flocks is preferable for a number of reasons.

1. Captive-reared birds have the opportunity to learn certain information and skills from the wild birds in the flock. These might include location of feeding areas, behaviour in social interactions, response to predators and other threats, and the concept of territoriality.
2. Flocks appear to be the normal place for juveniles at this time of year; most wild juveniles spend their first autumn and winter either at one flock or moving along the coast from flock to flock (Dowding & Chamberlin 1991).
3. Experience with other plovers has shown that releases at flocks are successful. Page *et al.* (1989) released snowy plovers in groups at an autumn flock site; some remained near the release site all winter, while others dispersed gradually. A number of the captive-reared birds were later found breeding successfully. Powell (1991) reported that captive-reared killdeers joined flocks of wild killdeers and interacted appropriately.

It seems highly unlikely that resources will be available to construct aviaries at the proposed release site, so hard releases will be necessary. If mortality of released birds in the first (1995) cohort is very high during the first few weeks or months, soft releases may have to be considered in future seasons.

Release site

In the first season of the trial at least, I suggest that all birds reared be released at Omaha Spit, North Auckland. This site has a flock of 45-50 birds each autumn and a large tidal estuary adjacent to the spit is used as a feeding ground by many waders. The main advantage of Omaha however, is that it lies at the centre of a study area that is regularly monitored; it will therefore be possible to monitor survival and dispersal of captive-reared juveniles in the immediate area with little extra effort. Flock sites to the north (Mangawhai, Waipu, Ruakaka) and to the south (Wade River) are also monitored less frequently. If other release sites are considered, there must be regular monitoring at the release site itself and at other likely sites

for a considerable distance either side.

Numbers at Omaha are monitored regularly, and as soon as the flock has formed (usually by late January), captive-reared birds can be released at any time. If any late clutches are reared, releases could occur until late March or early April.

Duration of the programme

As discussed earlier, there will be a considerable delay before the programme can be properly evaluated but there is an urgent need for information. I therefore recommend that large cohorts be reared and released for the next two seasons (1994-95 and 1995-96), rather than releasing smaller cohorts over a longer period. All survivors of these two cohorts will have reached breeding age by spring 1997, but they will not all necessarily be breeding then. In any case, the programme must be evaluated each season by the NZDRG, who should make recommendations for the following season to the Director, PSPD.

Evaluation

There is little point in undertaking these trials unless rearing and release strategies are carefully and critically evaluated, and detailed records are kept by all concerned (Scott & Carpenter 1987). An end-of-breeding-season (EOBS) report should be required from each institution in autumn, in time for consideration by the NZDRG at its annual meeting. Until procedures become routine, EOBS reports should include all relevant details of hatching and rearing conditions, hatching and rearing success, reasons for any deaths, any injuries or sickness (with treatment and outcome), results of disease checks and any problems noted.

All birds released must be individually colour-banded. Regular searches for these birds are absolutely essential, and because sample sizes will be small, the evaluation of the programme depends entirely on the magnitude of the search effort. The obvious difficulty is knowing the fate of released birds - very few corpses are ever found, and birds missing from the release site may either be dead or have dispersed. Survival values based on sightings of live birds will therefore be minima.

The following criteria are suggested as guidelines for measuring the success of the trials at various stages.

1. *Hatching success.* Quantitative limits cannot be set for hatching success, because it will depend on fertility of the eggs collected as well as the incubation conditions. If fertile eggs fail to hatch however, incubation conditions must be re-examined.
2. *Rearing success.* This is the number of birds reared to release age (fledging plus about 4-8 weeks) as a percentage of eggs that hatched. In the case of other waders, this has been high - about 78% for killdeers (Powell & Cuthbert 1993), 100% for snowy plovers (Page *et al.* 1989), 98% for shore plovers (H. Aikman, pers. comm.) and about 95% for black stilts (C. Reed, pers. comm.). I suggest that rearing success of 75% or more be considered satisfactory. If rearing success is 60% or less, rearing conditions must be re-examined.

3. *First-winter survival* (for the 1994-95 cohort, this is the proportion of released birds known to be alive in August-September 1995). I suggest that survival of 50% or more should be considered highly satisfactory; survival of 20% or less would give cause for concern, and would reinforce the suggestion that a large cohort should again be reared and released in the 1995-96 season.
4. *Survival to breeding age* (for the 1994-95 cohort, this is the proportion of released birds known alive in August-September 1996). Preliminary data show that wild-bred juveniles have a minimum survival from fledging to breeding age of approximately 40% (Dowding, unpublished data). Survival of 30% or higher would be very satisfactory for captive-reared birds.
5. *Ability to breed.* Ultimately, the success of the programme will be demonstrated by the finding of one or more captive-reared birds breeding in the wild. Obviously the more of these birds found breeding, the more successful the programme; however, the sample size remaining at this stage is likely to be very small and it is therefore virtually impossible to provide a quantitative criterion.

2.4 Conclusions

In summary, I suggest that for the 1994-95 season, the following programme is undertaken.

- Entire clutches should be collected from the Mangawhai-Omaha-Wade River study area in late September and/or October. Effects of collection should be monitored.
- Four clutches (up to 12 eggs) each be given to Otorohanga and Auckland Zoo (if the latter agrees to participate) to rear.
- If declared free of disease, captive-reared juveniles should be released at the Omaha Spit flock in late January or early February. Survival and dispersal must be monitored closely.

The programme should proceed on a season-by-season basis, and be reviewed by the NZDRG at its annual meeting. It is likely that at least two seasons will be required to rear and release sufficient birds for the trials to be assessed.

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2.6 Appendix: Outlines of captive-rearing protocols used with waders

The author of this report has copies of the documents from which the information below was taken. These are available to institutions undertaking captive-rearing if required.

Species: NZ dotterel (*Charadrius obscurus*)

Source of information: Otorohanga (Eric Fox, pers. comm.)

Incubation temperature: 37.2°C.

Relative humidity: 40-60%.

Other incubation conditions noted: Rotarex force air incubator.

Care of hatchlings: Placed in a brooder box under a heat lamp. Height of lamp adjusted to give temperature of 30-35°C. Base of brooder covered with sterilised soil. Shallow tray of water provided.

Care of older chicks: No information given.

Food: Finely-grated tofu, finely-grated boiled egg yolk, finely-cut ox heart, finely-diced corn and peas, mealworms and waxmoth larvae, aquatic insects (seeded into the tray of water), sandhoppers. Small locusts supplied as chicks grew.

Problems noted: Some chicks acquired a blocked vent; if not cleared can quickly lead to weakening and death.

Species: Shore plover (*Thinornis novaeseelandiae*)

Source of information: Aikman (1993 and pers. comm.)

Incubation temperature: 37.2°C, reduced to 36.1°C when chicks entered aircell.

Relative humidity: 63%, reduced to 53% when chicks entered aircell.

Other incubation conditions noted: Turnex incubator, eggs turned every half hour.

Care of hatchlings/young chicks: Transferred to a still air incubator at 27.6°C for 8-20 hours, then moved (in broods) to brooders. Chicks had access to 130 W heat light on the floor, changed for heat lamps suspended from the roof at day 6. Small cardboard boxes and tussocks were available for cover.

Care of older chicks: Heat lamps were turned off after 10 days, depending on outside temperature. After about 30 days, chicks were released into the flock aviary.

Food: From day 1, chicks were offered chick crumble, Go-Cat, Wombaroo mix, fresh water and a range of live invertebrates, including water boatmen, brine shrimps, mealworms, waxmoth larvae and whiteworms. They fed on live insects from day two and began eating artificial food from day three.

Problems noted: Early problems with incubation temperature have been resolved. Some deaths of first-winter and adult birds have occurred, apparently from heart problems (it was suggested these may have been stress-related).

Species: Killdeer (*C. vociferus*)

Source of information: Malone & Proctor (1966)

Incubation temperature: 102-103°F (38.9-39.4°C)

Relative humidity: Not given.

Other incubation conditions noted: Each day eggs were turned twice, cooled once for 5 minutes, and sprinkled once very lightly with water.

Care of hatchlings: Until 2 weeks old, chicks were kept in cardboard boxes with a 60-watt lamp reflected downwards 1 ft (305 mm) above the birds. Brown paper on the floor was changed twice daily.

Care of older chicks: After 2 weeks, chicks were moved outside during the day; after 3 weeks chicks were outside all the time. Outdoor enclosures had 150-watt projector lamps suspended 2 ft (610 mm) above the ground. Pens had soil bases covered in straw.

Food: Earthworms, cut into small pieces and dropped in a shallow container of water, were described as an excellent first food for hatchlings. From the fourth or fifth day, a mixture of equal parts mashed boiled egg and cat food was given, and dry crumbled game-bird food was always available. Mealworms replaced earthworms as live food from 1 to 3 weeks, after which only cat food and dry game-bird food were provided. Water was always available and contained an antibiotic (terramycin).

Problems noted: Occasionally hatchlings were partially crippled or too weak to stand. Isolated in small boxes with food, water and warmth, they recovered within two or three days. Otherwise the species was easy to rear and keep.

Species: Killdeer (*C. vociferus*)

Source of information: Powell (1991) and Powell & Cuthbert (1993)

Incubation temperature: 39°C.

Relative humidity: Not given.

Other incubation conditions noted: None.

Care of hatchlings: Placed in a box, kept at 35°C. On the day after hatching, sibling groups were placed in outdoor pens.

Care of older chicks: Outdoor pens had concrete floors covered with sand, with scattered driftwood and rocks. Heat lamps were placed at one end of the pens. Visual contact with chicks in neighbouring pens elicited escape behaviour (chicks tried to squeeze through the mesh), so edging 30 cm high was placed around the bottom of each pen.

Food: Hatchlings given tubifex worms in shallow pans of water. Chicks given tubifex worms, mealworms, earthworms, and crumbled moist cat food. Chicks also fed on insects attracted to the heat lamps.

Problems noted: Two eggs failed to hatch and two chicks died while hatching; poor humidity regulation during incubation may have been responsible.

Species: Snowy plover (*C. alexandrinus nivosus*)

Source of information: Page et al. (1989).

Incubation temperature: 37.6°C.

Relative humidity: 80-85%.

Other incubation conditions noted: Marsh Roll-X incubator with automatic rotation.

Care of hatchlings: Little information; kept in groups of 4-6 to a cage.

Care of older chicks: Placed in a plastic-mesh flight cage with adult and young conspecifics, a killdeer and a stilt.

Food: Hatchlings fed tubifex worms in an aqueous solution of minerals and vitamins, mealworms, thawed krill, and crickets. No information given on food for older chicks.

Problems noted: None. Hatching success slightly lower than in the wild but rearing very successful - all 22 eggs hatched were raised to fledging and released.

Species: Black stilt (*Himantopus novaezelandiae*)

Source of information: Reed (1994 and pers. comm.)

Incubation temperature: 37.2-37.5°C

Relative humidity: 50%, raised to 84% as soon as eggs begin chipping.

Other incubation conditions noted: Rotorex incubator with automatic turning once an hour, in a temperature-controlled room at 18-22°C.

Care of hatchlings: Brooded at 37.5°C when first hatched, either under a heat lamp or a heated model stilt. Temperature is gradually lowered. Brooder units are 1.2 x 1.2 m, aviaries had a 1.8 x 1.0 m sheltered area for very young chicks

Care of older chicks: Chicks had access from brooder units to outdoor aviaries. Sheltered area extended to 1.8 x 4.0 m when chicks were 1-2 weeks old. Heat lamps turned off by 30 days. After fledging, chicks were transferred to larger aviaries, measuring about 100-200 sq m, with a maximum height of 3-4 m.

Food: A good supply of live aquatic invertebrates (small mayflies, caddisfly and damselfly larvae are suitable) is essential for the first few days. Most chicks begin taking artificial food within a week. Artificial food is minced beef heart (1 kg) mixed with Wombaroo insectivore-rearing mix (400 g).

Problems noted: Some chicks may not take artificial food but can usually be induced to do so by mixing in mealworms. Chicks not adapting to the artificial diet are likely to become malnourished and die. Some of the disease and injury problems encountered with black stilts are described by Reed (1994). Broken bills and legs were the commonest injuries, probably sustained as birds flew around their aviaries in response to either staff entering to feed them or harriers overhead.

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