Monitoring vital rates of migrant shorebird populations: the case of ‘wilsternetted’ Eurasian Golden Plovers

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Over the years, the purpose of the traditional wilsternetting technique of the northern Netherlands for trapping Eurasian Golden Plovers *Pluvialis apricaria* has changed from a hunting practice to bird ringing. In a companion paper, Piersma *et al.* (2005) examined the ringing data and recoveries for demographic trends from 1949 onwards. This paper examines the possibility of using the same data source for future monitoring of the population. Schemes monitoring the vital rates (survival rate, recapture probability, and recruitment) of migrant birds are rare. For two reasons, it is not immediately clear that effective monitoring is possible. First, hunting returns from outside The Netherlands have ceased so the data available for analysis are much reduced. Secondly, the very low probability of recapturing a ringed bird (*c.* 0.25%) leads to large standard errors of estimates of demographic parameters. For practical reasons, only triennial monitoring was considered for survival and recapture rates. Program MARK was used to estimate vital rates. A Monte Carlo simulation showed that a change in survival rate of 5% or more should be detected within six years if more than 3 000 birds were ringed per annum. The proposed monitoring methodology was applied to the historical data, using only the data available at the end of each three-year period. This test detected the changes in survival rate and recapture probability noted by Piersma *et al.* (2005). Reasonable consistency with earlier recruitment estimates was achieved despite the need to monitor this aspect on an annual basis. The parallel monitoring of recruitment through the juvenile proportion of catches is regarded as desirable, both to validate the methodology and for mutual checking between methods.

Key words: population monitoring – shorebirds – survival – recruitment – population dynamics – conservation

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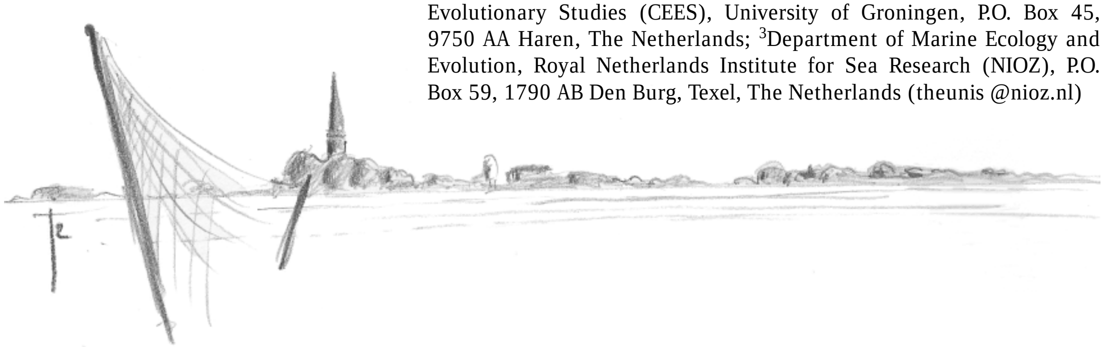

INTRODUCTION

Many of the world's shorebird populations appear to be in dire straits. According to an assessment by the International Wader Study Group, 96 of the 200 populations worldwide with known population trends show declines (i.e. 48%), with only 16% increasing (International Wader Study Group 2003). For most declining populations little is known about the demographic backgrounds (Piersma *et al.* 1997, Sandercock 2003, but see Parr 1992, Baker *et al.* 2004). Nevertheless, there are scientific, managerial, political and conservation values in both monitoring and understanding the fate of populations of migrant shorebirds, species with unique life-histories shared by many countries (Piersma & Baker 2000). Schemes monitoring the vital rates of migrant shorebirds are preciously rare, unlike similar schemes for breeding populations of landbirds (Baillie 1990). This is unfortunate, as shorebirds with their very specific habitat requirements and annual schedules can be ideal 'integrative sentinels' of the state of the environment over very large geographical scales (Piersma & Lindström 2004).

Here we present a realistic demographic monitoring scheme for Eurasian Golden Plovers *Pluvialis apricaria* staging in The Netherlands. This population historically has been netted by specialized bird trappers using a unique device, the 'wilsternet' (Jukema *et al.* 2001) and this trapping is likely to continue into the future. This volunteer trapping activity is conducted under the auspices of the Dutch Ringing Centre. 'Monitoring' is used here solely in the context of analysing these data to detect changes in vital demographic rates. This paper complements the demographic analysis presented by Piersma *et al.* (2005).

MATERIALS AND METHODS

Routine monitoring of vital rates, specifically survival and recruitment, implies regular reviews as more data come to hand. The work reported here, based on data analysed and assessed by Piersma *et al.* (2005), shows that survival has effectively remained constant over the last 36 years. Recruitment is more variable from year to year, presumably reflecting good and bad breeding years, but has not exceeded 0.7 – the number of new birds per bird present the previous year – in the last 30 years. Such a stable population would not seem to require frequent monitoring. Certainly, data are too sparse (*c.* 2 500 birds ringed per year with a recapture probability of 0.25%, Piersma *et al.* 2005) to support monitoring on an annual basis. Monitoring every five years, on the other hand, would be too infrequent as known large demographic changes in shorebird populations can happen within intervals shorter than five years (see Baker *et al.* 2004). We suggest that monitoring based on three-year periods would be appropriate, and the rest of this paper is written assuming this.

Until recently, ring recoveries from hunted birds were routinely forwarded to the Dutch Ringing Centre, but this stream of information has come to a halt with little chance of revival (Piersma *et al.* 2005). The only data of which we can be confident are those curated by the Dutch Ringing Centre on numbers ringed and recaptured within The Netherlands. It is with these data from the ringing season of 1949/50 onwards that the proposed monitoring system is examined. The last recapture season considered is 2000/01. Note that ringing season (1 July one year to 30 June the next) rather than calendar year is used as the basis of ringing activity for reasons given in Piersma *et al.* (2005). Using both recaptures and recovery reports of dead birds it has been established that juveniles have a lower survival rate than adults and are more likely to emigrate (Piersma *et al.* 2005). This result cannot be estimated reliably with the small amount of recoveries-only data. Also, ageing of the majority of birds caught has only taken place since 1989/90. Consequently, age classes are not considered separately in the work reported here.

There is an immediate problem: recaptures are rare. Table 1 shows only 30 retraps in the 27 seasons up to 1973/74, 14 in the three years following, and an average of 15.6 per year over the next

22 years. Will these be sufficient to detect changes of concern in sufficient time to take appropriate management actions? This issue is examined by a Monte Carlo simulation exercise (programmed in QuickBASIC) in which a number of random samples of known properties are generated and examined to see if triennial monitoring detects the known changes in the survival probabilities on which the samples are based. Samples of 25 capture years, which give eight three-year recapture periods, are generated. A base survival rate of 75% is assumed for the first 12 years, and reductions of 2.5, 5, 7.5, and 10 percentage points are considered for the second 12 years. Four different annual catch sizes (i.e. numbers of birds ringed) of 2 000, 3 000, 4 000, and 5 000 birds are considered. A recapture rate of 0.25% is assumed throughout. These parameters can be considered typical of the Eurasian Golden Plovers staging in The Netherlands (Piersma *et al*. 2005). The combinations of survival rate reductions and sample sizes give a total of 16 samples. A recapture history is generated for every bird, recording recaptures when they happen, for every year until it dies. Five sub-samples are created for each sample representing what is known of the birds after 12, 15, 18, 21, and 25 capture years. The simulations provide information how long it takes to detect reductions in survival. A source of concern here is that the simulations represent an oversimplification of the natural world, in which survival probabilities vary from year to year for biological reasons, and that this variation is additional to the sampling variation modelled. A further series of analyses (not presented), in which changes in both survival and recapture rates were simulated, showed that this was not a real concern, possibly because of the very low recapture probability.

Table 1. Ringing totals of Eurasian Golden Plovers in The Netherlands from 1949/50 onwards in three-year periods. Same season retraps are not included. Note that the retrap percentage represents the number of retraps as a percentage of the number of birds captured.

Season		Total ringed	Total retraps	Annual average		Retrap
From	To			ringed	retraps	percentage
1949/50	1951/52	1871	0	624	0.0	0.00%
1952/53	1954/55	331	2	110	0.7	0.60%
1955/56	1957/58	2365	1	788	0.3	0.04%
1958/59	1960/61	2257	3	752	1.0	0.13%
1961/62	1963/64	3078	8	1026	2.7	0.26%
1964/65	1966/67	1255	4	418	1.3	0.32%
1967/68	1969/70	1146	4	382	1.3	0.35%
1970/71	1972/73	1626	4	542	1.3	0.25%
1973/74	1975/76	2760	4	920	1.3	0.14%
1976/77	1978/79	4540	14	1513	4.7	0.31%
1979/80	1981/82	6786	33	2262	11.0	0.49%
1982/83	1984/85	6688	48	2229	16.0	0.72%
1985/86	1987/88	5731	34	1910	11.3	0.59%
1988/89	1990/91	7861	46	2620	15.3	0.59%
1991/92	1993/94	8453	59	2818	19.7	0.70%
1994/95	1996/97	7810	45	2603	15.0	0.58%
1997/98	1999/00	6639	50	2213	16.7	0.75%
-	2000/01	3348	29	3348	29.0	0.87%

An examination of how the monitoring process would have performed is made on the real data obtained from the 1949/50 season onwards. In total, these data allow retrospective monitoring after 17 three-year periods. In both this and the Monte Carlo simulation exercise, the recaptures-only model of Program MARK (White & Burnham 1999) is used to examine if changes in survival rate and recapture rate have occurred. They are assumed to be detected if the Akaike Information Criterion (AIC; Cooch & White 2001) indicates that the model representing the change is more likely to apply than the model assuming no change. The survival rate considered here is apparent survival, as the recaptures-only model cannot distinguish between birds which have died and birds which have emigrated from the study area. Note that the recapture probability, i.e. the probability that a ringed bird available for recapture will be recaptured, is based on the complete recapture history and is not the same as the observed retrap rate indicated by the last column of Table 1.

The Pradel, or temporal symmetry, models in Program MARK (Pradel 1996) can be used to estimate recruitment. Indeed, one of the models simultaneously estimates survival, recapture, and recruitment rates, the very vital rates which we wish to know. Unfortunately, the very small numbers of retraps lead to unreliable model statistics. This was confirmed by G.C. White (pers. comm.) and means that it is not possible to rank Pradel model results by any of the test statistics generated. The model referred to above can, however, be used to give estimates of recruitment by constraining survival and recapture rates to the estimates obtained by the recaptures-only model. Two differences between the recruitment estimates and other estimates discussed here are, first, that rigorous standard errors are not available and, secondly, that it makes sense, given what is known about year to year breeding success (Jukema *et al.* 2001), to estimate separate annual recruitment rates, rather than an average over three years.

RESULTS

Simulations

The process adopted in examining these simulated data sets is a simplified version of the monitoring process proposed. The 15-year sub-sample was examined to see if survival in the last three years differed from that in the first 12. If it did, the change in survival is considered detected. If it did not, the 18-year sub-sample was examined to see if survival in the last three years differed from that in the first 15. If it did, … and so on. Once a change is detected, previous three-year periods where no change was detected are re-examined using the most recent recapture histories to see whether they are more consistent with the changed survival. A change is considered to be detected if the probability of the model with change, relative to the model without change, is greater than 90%.

Fig. 1 illustrates some general points about the simulations. It is drawn for the case where the annual samples are of 2 000 new birds and there is a survival rate drop of 7.5 percentage points half way through the 24-year period. The line with the

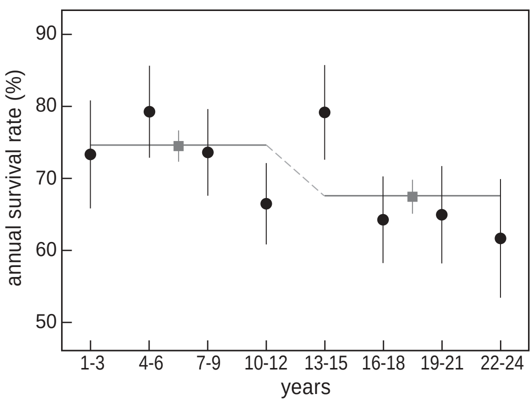

Figure 1. Example of simulated survival rates of Eurasian Golden Plovers over the years. Initial survival rate is set at 0.75, subsequent survival rate is 0.675, and recapture probability is 0.0025. Annual sample 'ringed' in the simulation is 2 000. See text for further explanation. The vertical bars are the upper and lower 95% confidence limits of the survival rate estimates.

square symbols gives the average sample survival rates over the first and second 12-year periods; these conform closely to the prior probabilities from which they were sampled. The line with round symbols gives the average sample survival rates over each of the eight three-year periods. It is evident that these averages can differ substantially from their expected values. Indeed the picture would look rather more like expected if the fourth and fifth three-year periods were reversed. Applying the process described above, a change in survival rate was detected after year 21. “Back-tracking” shows that the year 16 to 18 data are more consistent with the three-year periods that follow it than with those that precede it. The reason for this is that later recaptures provide more information about birds’ survival in the period.

Table 2 gives the estimated survival rates for all the cases considered. It illustrates how variable three-year estimates can be in relation to the prior probabilities from which they were generated. The table also shows clearly how standard errors of estimates decrease with increasing catch sizes and increase as the number of recapture years after each period is becoming shorter (i.e. only partial recapture histories). Nevertheless, the table shows that changes will be detected quickly if samples and the survival rate change are not too small. Survival rate reductions to 0.725 are usually not detected. None of the results for a sample size of 2 000 birds per year could be considered satisfactory, as changes were only detected nine or more years after a drop in the underlying survival rate. We conclude therefore that survival rate reductions of more than 5% should be detectable with annual catches of 3 000 birds or more usually within six years. Looking back, the previous three-year period showed evidence of the change in all but one case.

Table 2. Monte Carlo simulation of survival of Eurasian Golden Plover by period. Asymptotic standard errors in parentheses. Survival rate is set at 0.75 for years 1 to 12, and as indicated for other years. Boldface indicates that changes were detected. Underlined indicates that estimates were not detected as changes at first examination, but later data showed that they were more consistent with a change.

N birds ringed	Survival rate as set for years > 12	years 1 to 12	years 13 to 15	years 16 to 18	years 19 to 21	years 22 to 24
2000	0.725	0.756 (0.021)	0.734 (0.051)	0.717 (0.057)	0.780 (0.065)	0.701 (0.075)
2000	0.700	0.754 (0.022)	0.841 (0.059)	0.587 (0.055)	0.839 (0.078)	0.554 (0.077)
2000	0.675	0.734 (0.022)	0.747 (0.055)	0.648 (0.059)	**0.646 (0.066)**	**0.615 (0.081)**
2000	0.650	0.751 (0.021)	0.752 (0.052)	0.687 (0.058)	0.645 (0.063)	0.665 (0.080)
3000	0.725	0.759 (0.017)	0.662 (0.039)	0.766 (0.051)	0.639 (0.049)	**0.648 (0.064)**
3000	0.700	0.765 (0.018)	0.674 (0.042)	**0.651 (0.049)**	**0.690 (0.054)**	**0.716 (0.066)**
3000	0.675	0.744 (0.018)	0.628 (0.040)	**0.693 (0.049)**	**0.661 (0.051)**	**0.598 (0.061)**
3000	0.650	0.738 (0.019)	0.703 (0.044)	0.670 (0.052)	**0.568 (0.053)**	**0.624 (0.070)**
4000	0.725	0.744 (0.015)	0.721 (0.035)	0.697 (0.040)	0.690 (0.042)	0.748 (0.053)
4000	0.700	0.749 (0.015)	0.714 (0.036)	**0.704 (0.041)**	0.711 (0.043)	0.736 (0.054)
4000	0.675	0.767 (0.015)	0.676 (0.036)	**0.684 (0.043)**	**0.679 (0.045)**	**0.753 (0.057)**
4000	0.650	0.762 (0.015)	0.685 (0.038)	**0.601 (0.041)**	**0.747 (0.050)**	**0.637 (0.055)**
5000	0.725	0.741 (0.013)	0.714 (0.031)	0.754 (0.037)	0.762 (0.039)	0.689 (0.046)
5000	0.700	0.745 (0.014)	0.657 (0.031)	**0.672 (0.036)**	**0.761 (0.040)**	**0.725 (0.046)**
5000	0.675	0.747 (0.014)	0.711 (0.033)	**0.656 (0.036)**	**0.726 (0.041)**	**0.669 (0.048)**
5000	0.650	0.752 (0.014)	0.700 (0.034)	**0.601 (0.037)**	**0.653 (0.042)**	**0.706 (0.052)**

Retrospective monitoring of real data

SURVIVAL PROBABILITY

Survival estimates are given in Table 3. The upper part of the table gives the estimates, the lower part gives their standard errors. Each row gives results of the most likely model based on the AIC at the end of the period indicated in the left-hand column. For example, at the end of season 1970/71, Table 3 shows the estimates of annual survival were 0.5 (or 50.0%) up to the end of period 5 (i.e. end of 1964/65) and 0.717 from then up to the end of period 7 (i.e. end of 1970/71).

The development of the estimates for a given range of periods as more information becomes available is obtained by looking down the appropriate column. Table 3 contains two instances where the development led to big changes in survival estimates. At the end of period 6, the estimate for period 6 could not be distinguished from that of the periods which preceded it. By the end of the following period, a clear increase in the survival rate was detected. It was then found that the survival rate over period 6 was more consistent with that of period 7 than it was with that over the first five periods. A different sort of situation arose at the end of period 14 when a reduction in survival rate for this period (to 61.3%) was detected. This reduction was maintained to the end of the following period (period 15). At the end of period 16, however, it was found that there was no support for considering survival in the six years of periods 14 and 15 to be different from that of the preceding 24 years and the following three. The survival rate stayed steady, latest estimate 52.6%, up to the end of period 5, 1962/63 to 1964/65, when it suddenly increased dramatically to the currently estimated 0.735. Piersma *et al.* (2005), who identified the same change in 1963/64 using complete recapture histories, provide further discussion on the possible reasons for this change.

Standard errors decrease, as expected, as more data come to hand. Those for survival rates for periods 1 to 5 stabilise at about 0.07. This is quite high and a consequence of the relatively small numbers of ringed birds and recaptures before 1979/80 (Table 1). It is promising to realise, however, that any future changes in survival rate have to be assessed against the survival rate for periods 6 to 17, and standard errors over this period are much lower (currently at 0.014). In consequence, smaller changes in survival rate become detectable as shown, for example, by the estimates at the end of periods 14 and 15.

RECAPTURE RATES

The estimates of recapture rates are given in Table 4, which is designed as Table 3. The first point to note is that recapture rates are very low, rarely exceeding 0.0025 and dropping to around 0.0005 on occasion. At such low levels, it is perhaps not surprising that recapture rates show more variability than survival rates, particularly in the early years of smaller samples. From 1977/78 (period 10) onwards, recapture rates have been consistently higher than before, except for the last two periods (16 and 17). The 1977/78 increase, but not the 1995/96 decrease, was detected by Piersma *et al.* (2005) using complete recapture histories. Standard errors are high for these periods and future data might lead to change in these estimates. Also, the possibility that these low rates are due to late booking of recaptures cannot be eliminated.

RECRUITMENT

Breeding success, the primary component of recruitment, of Eurasian Golden Plovers is known to be highly variable from year to year, as it is for all arctic breeders (Boyd & Piersma 2001, Jukema *et al.* 2001). Accordingly, estimates of annual recruitment are given in Table 5. Standard errors are not given because they are not known nor can they be calculated. This is because, as described in Materials and Methods, it is not possible to determine the 'best' model which estimates survival, recapture, and recruitment simultaneously. The recruitment estimates are therefore based on the best model found for survival and recapture estimation.

Table 5 differs from Tables 3 and 4 in that the latest model is found by reading down the columns and the development of estimates over time for a

Table 3. Effectiveness of monitoring during three-year periods of survival rates of Eurasian Golden Plovers staging in The Netherlands, based on applying the proposed monitoring methodology to historical data. The upper part of the table gives the survival estimates based on the best model using all the data available to the end of the period indicated in the left-hand column. The lower part gives their standard errors.

Period	Period number	Survival Rate up to season end in periods		
		1 to 5	6 to 17	14 to 15
Estimates				
1950/51 to 1952/53	1	No model		
1953/54 to 1955/56	2	0.680	.	.
1956/57 to 1958/59	3	0.489	.	.
1959/60 to 1961/62	4	0.549	.	.
1962/63 to 1964/65	5	0.475	.	.
1965/66 to 1967/68	6	0.446	0.446	.
1968/69 to 1970/71	7	0.500	0.717	.
1971/72 to 1973/74	8	0.504	0.756	.
1974/75 to 1976/77	9	0.539	0.831	.
1977/78 to 1979/80	10	0.531	0.806	.
1980/81 to 1982/83	11	0.529	0.790	.
1983/84 to 1985/86	12	0.528	0.774	.
1986/87 to 1988/89	13	0.527	0.754	.
1989/90 to 1991/92	14	0.527	0.748	0.613
1992/93 to 1994/95	15	0.527	0.752	0.650
1995/96 to 1997/98	16	0.527	0.737	.
1998/99 to 2000/01	17	0.526	0.735	.
Standard errors				
1950/51 to 1952/53	1	No model		
1953/54 to 1955/56	2	0.444	.	.
1956/57 to 1958/59	3	0.281	.	.
1959/60 to 1961/62	4	0.141	.	.
1962/63 to 1964/65	5	0.111	.	.
1965/66 to 1967/68	6	0.087	0.087	.
1968/69 to 1970/71	7	0.075	0.109	.
1971/72 to 1973/74	8	0.073	0.098	.
1974/75 to 1976/77	9	0.070	0.083	.
1977/78 to 1979/80	10	0.069	0.048	.
1980/81 to 1982/83	11	0.069	0.035	.
1983/84 to 1985/86	12	0.069	0.028	.
1986/87 to 1988/89	13	0.070	0.023	.
1989/90 to 1991/92	14	0.070	0.021	0.067
1992/93 to 1994/95	15	0.070	0.019	0.044
1995/96 to 1997/98	16	0.070	0.016	.
1998/99 to 2000/01	17	0.070	0.014	.

Table 4. Effectiveness of monitoring during three-year periods of recapture probabilities of Eurasian Golden Plovers staging in The Netherlands, based on applying the proposed monitoring methodology to historical data. The upper part of the table gives the recapture probability estimates, the lower part gives their standard errors. Each row gives the best model indicated by the AIC using all the data available to the end of the period indicated in the left-hand column. Recapture probabilities apply to the period(s) indicated in the left hand column.

Period	Period number	Recapture probability up to season end in periods						
		1 to 3	4 to 7	8 to 9	10 to 14	15	16	17
Estimates (multiplied by 1000)								
1950/51 to 1952/53	1	No model	.	.	.	.	.	.
1953/54 to 1955/56	2	0.579	.	.	.	.	.	.
1956/57 to 1958/59	3	0.774	.	.	.	.	.	.
1959/60 to 1961/62	4	0.634	2.057	.	.	.	.	.
1962/63 to 1964/65	5	0.813	2.345	.	.	.	.	.
1965/66 to 1967/68	6	0.901	3.012	.	.	.	.	.
1968/69 to 1970/71	7	0.746	2.051	.	.	.	.	.
1971/72 to 1973/74	8	0.737	1.909	0.493	.	.	.	.
1974/75 to 1976/77	9	0.657	1.539	0.350	.	.	.	.
1977/78 to 1979/80	10	0.673	1.638	0.393	1.968	.	.	.
1980/81 to 1982/83	11	0.678	1.692	0.420	2.126	.	.	.
1983/84 to 1985/86	12	0.680	1.741	0.450	2.220	.	.	.
1986/87 to 1988/89	13	0.681	1.802	0.490	2.443	.	.	.
1989/90 to 1991/92	14	0.682	1.821	0.502	2.534	.	.	.
1992/93 to 1994/95	15	0.682	1.810	1.810	0.495	3.713	.	.
1995/96 to 1997/98	16	0.683	1.855	0.525	2.532	2.532	1.679	.
1998/99 to 2000/01	17	0.683	1.863	0.530	2.561	2.561	1.701	3.263
Standard errors (multiplied by 1000)								
1950/51 to 1952/53	1	No model	.	.	.	.	.	.
1953/54 to 1955/56	2	0.860	.	.	.	.	.	.
1956/57 to 1958/59	3	0.865	.	.	.	.	.	.
1959/60 to 1961/62	4	0.469	1.451	.	.	.	.	.
1962/63 to 1964/65	5	0.563	1.227	.	.	.	.	.
1965/66 to 1967/68	6	0.590	1.316	.	.	.	.	.
1968/69 to 1970/71	7	0.470	0.732	.	.	.	.	.
1971/72 to 1973/74	8	0.462	0.649	0.407	.	.	.	.
1974/75 to 1976/77	9	0.408	0.491	0.206	.	.	.	.
1977/78 to 1979/80	10	0.418	0.471	0.195	0.568	.	.	.
1980/81 to 1982/83	11	0.421	0.477	0.198	0.407	.	.	.
1983/84 to 1985/86	12	0.423	0.489	0.208	0.338	.	.	.
1986/87 to 1988/89	13	0.424	0.508	0.224	0.316	.	.	.
1989/90 to 1991/92	14	0.425	0.513	0.229	0.296	.	.	.
1992/93 to 1994/95	15	0.424	0.509	0.509	0.225	0.783	.	.
1995/96 to 1997/98	16	0.425	0.523	0.237	0.241	0.241	0.307	.
1998/99 to 2000/01	17	0.426	0.525	0.239	0.228	0.228	0.304	0.477

Table 5. Monitoring of annual recruitment. The unit of recruitment is the number of new birds in the population one year for each bird in the population in the previous year. Standard errors are not calculated. Dashes indicate that recruitment could not be estimated.

Season	Season	Annual recruitment after season number															
	No.	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51
1950/51	1	0.38	0.57	0.51	0.58	0.61	0.56	0.55	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
1951/52	2	0.38	0.57	0.51	0.58	0.61	0.56	0.55	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
1952/53	3	0.38	0.57	0.51	0.58	0.61	0.56	0.55	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
1953/54	4	0.38	0.57	0.51	0.58	0.61	0.56	0.55	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
1954/55	5	0.38	0.57	0.51	0.58	0.61	0.56	0.55	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
1955/56	6	0.38	0.57	0.51	0.58	0.61	0.56	0.55	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
1956/57	7	.	1.68	1.54	1.72	1.79	1.66	1.65	1.56	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
1957/58	8	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958/59	9	.	1.19	0.22	0.52	0.54	0.46	0.48	0.42	0.38	0.42	0.41	0.39	0.39	0.39	0.38	0.38
1959/60	10	.	.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1960/61	11	.	.	0.79	1.01	0.99	0.98	1.01	1.00	0.93	0.98	0.97	0.95	0.94	0.95	0.93	0.93
1961/62	12	.	.	1.49	1.26	1.32	1.18	1.17	1.07	1.11	1.10	1.10	1.11	1.11	1.11	1.11	1.11
1962/63	13	.	.	.	-	-	-	-	-	-	-	-	-	-	-	-	-
1963/64	14	.	.	.	-	0.05	-	-	-	-	-	-	-	-	-	-	-
1964/65	15	.	.	.	0.28	0.31	0.20	0.19	0.10	0.13	0.12	0.12	0.13	0.13	0.13	0.13	0.13
1965/66	16	.	.	.	.	1.02	0.75	0.71	0.63	0.73	0.68	0.69	0.71	0.72	0.72	0.73	0.73
1966/67	17	.	.	.	.	0.65	0.38	0.34	0.26	0.36	0.31	0.32	0.34	0.35	0.35	0.36	0.36
1967/68	18	.	.	.	.	0.60	0.32	0.24	0.09	0.28	0.17	0.20	0.24	0.25	0.25	0.28	0.28
1968/69	19	.	.	.	.	.	-	-	-	-	-	-	-	-	-	-	-
1969/70	20	.	.	.	.	.	0	0	0	0	0	0	0	0	0	0	0
1970/71	21	.	.	.	.	.	1.75	1.56	1.24	1.66	1.40	1.47	1.57	1.59	1.59	1.64	1.66
1971/72	22	.	.	.	.	.	.	2.22	2.54	1.96	2.30	2.19	2.07	2.04	2.06	1.98	1.96
1972/73	23	.	.	.	.	.	.	0.19	0.11	0.21	0.15	0.17	0.19	0.19	0.19	0.20	0.21
1973/74	24	.	.	.	.	.	.	1.31	1.49	1.34	1.28	1.30	1.32	1.32	1.32	1.33	1.34
1974/75	25	.	.	.	.	.	.	.	0	0.32	0.15	0.23	0.29	0.30	0.08	0.31	0.32
1975/76	26	.	.	.	.	.	.	.	0	0	0	0	0	0	0	0	0
1976/77	27	.	.	.	.	.	.	.	0.85	0.11	0	0	0.03	0.04	0	0.10	0.11
1977/78	28	.	.	.	.	.	.	.	.	0	0	0	0	0	0	0	0
1978/79	29	.	.	.	.	.	.	.	.	0	0	0	0	0	0	0	0
1979/80	30	.	.	.	.	.	.	.	.	0.35	0.20	0.26	0.31	0.32	0.20	0.35	0.35
1980/81	31	.	.	.	.	.	.	.	.	.	0.58	0.60	0.62	0.62	0.62	0.64	0.64
1981/82	32	.	.	.	.	.	.	.	.	.	0.18	0.21	0.24	0.25	0.25	0.26	0.27
1982/83	33	.	.	.	.	.	.	.	.	.	-	-	-	-	-	-	-
1983/84	34	.	.	.	.	.	.	.	.	.	.	0.40	0.44	0.45	0.45	0.47	0.47
1984/85	35	.	.	.	.	.	.	.	.	.	.	0.27	0.31	0.32	0.32	0.33	0.34
1985/86	36	.	.	.	.	.	.	.	.	.	.	0	0	0	0	0	0
1986/87	37	.	.	.	.	.	.	.	.	.	.	.	0.66	0.68	0.68	0.71	0.72
1987/88	38	.	.	.	.	.	.	.	.	.	.	.	0	0	0	0	0
1988/89	39	.	.	.	.	.	.	.	.	.	.	.	0.20	0.21	0.21	0.23	0.24
1989/90	40	.	.	.	.	.	.	.	.	.	.	.	.	0.76	0.76	0.64	0.64
1990/91	41	.	.	.	.	.	.	.	.	.	.	.	.	0.92	0.84	0.69	0.69
1991/92	42	.	.	.	.	.	.	.	.	.	.	.	.	-	0.09	-	-
1992/93	43	.	.	.	.	.	.	.	.	.	.	.	.	.	0.85	0.58	0.59
1993/94	44	.	.	.	.	.	.	.	.	.	.	.	.	.	-	-	-
1994/95	45	.	.	.	.	.	.	.	.	.	.	.	.	.	0.71	0.45	0.46
1995/96	46	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.14	0.14
1996/97	47	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.86	0.63
1997/98	48	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0
1998/99	49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
1999/00	50	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.54
2000/01	51	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0.33

season is given by reading along the appropriate row. The number estimated as recruitment for a season is the number of new birds that will be present the following season for each bird present in the current season. The table shows much year to year variation in recruitment ranging from none in some seasons to nearly 2 in one extraordinary season (1971/72). The table also shows, however, that the estimates stabilise very quickly: invariably the second estimate made for a season is little different from the latest estimate. Often, the first estimate is too. This means that we will lose little information by only looking at the latest recruitment estimates, those in the right hand column of the table. Fig. 2 gives a plot of these against time. This shows large fluctuations in annual recruitment rates before the mid-1970s. Three of the four highest rates occurred in a four year period in the early 1970s. This was followed by a five year period of low recruitment since when a much more steady picture has emerged, albeit one with some annual fluctuations.

DISCUSSION

There is no doubt that the small numbers of recaptures of ringed birds, currently about 15 – 20 a year, restrict the possibilities for monitoring the population. Baillie (1990), working with data on passerines from the British Constant Effort Sites Scheme, reports sufficient data on several species to allow detailed modelling of survival in relation to external variables (covariates) and argues that monitoring should be about detecting differences between actual performance and model predictions. With the small samples available here this cannot be considered. Even if samples were larger, limited knowledge of causes of mortality at all stages of the birds' life cycle (e.g. breeding, migration, over-wintering) and environmental changes (e.g. hunting practices, global warming) would preclude the approach that Baillie (1990) proposes.

Nevertheless, by considering data in three-year periods, it is possible to monitor in such a way that changes in both survival and recruitment are detected. The simulations are of a very simple, somewhat unrealistic situation, which has the advantage that the underlying processes are completely understood. The results suggest that changes in survival rate of more five percentage points will be detected within six years if 3 000 or more birds are ringed annually. Changes of a given size will be detected sooner by larger catch sizes which will contain more retraps. Obviously, large changes are expected to be detected sooner than small ones.

Repeating the simulations a large number of times would enable more precise estimation of what size changes would be detected when. Such a series could also inform on how often the monitoring would report an incorrect result, either

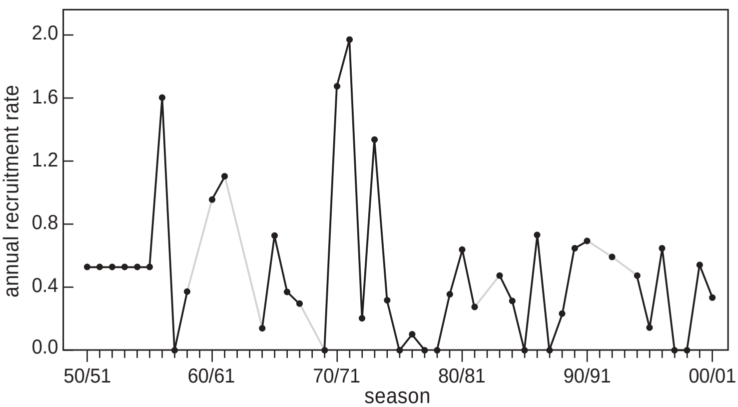

Figure 2. Annual recruitment rates of Eurasian Golden Plovers over the years, based on Table 5. Grey lines cover years with no estimates.

detecting a change when none had occurred (Type 1 error) or detecting no change when one had occurred (Type 2 error). It is clear from the simulations (Fig. 1) that both types of error can occur with retrap samples of the size available here. Burgman (2000), discussing Population Viability Analysis, argues that monitoring methods must consider both types of error and the specification of effect sizes in the design stage. Such considerations do not apply here as the unique trapping methodology and protocols have been so long established.

Given the long-term stability of survival rates, any detected change, particularly a reduction in survival rates, would be expected to trigger an immediate investigation into causes. Such an investigation could consider circumstances of immediate relevance (e.g. changes in hunting controls in different countries, an inclement winter); these sorts of information are not readily available when considering past data. A possible case where some history might be relevant relates to the recruitment surge in the early 1970s. This occurred at a time when many countries were placing increasing restrictions on hunting. Jukema *et al.* (2001) suggest that part of this recruitment surge could have been caused by such restrictions being imposed in countries between the breeding grounds and The Netherlands, especially Denmark, leading to a discontinuous increase in the survival of recently fledged, southward migrating, young birds in their first stopover areas.

The monitoring considered here has considered the data in three-year periods and assumed that the actual monitoring calculations would be undertaken every three years. Considerations of value and cost will determine in practice how frequently the monitoring is done. Annual monitoring could be done but at some cost and, on present information, little value. More frequent monitoring would be justified if there is other information suggesting that vital rates are changing.

The monitoring of recruitment rates is not satisfactory as, due to unreliable parameter estimates derived from the models, estimates of survival and recapture rates from the survival are hard-wired into the recruitment model. In consequence, satisfactory estimates of recruitment rate standard errors are not available. The estimates are, however, the best we can come up with and seem, as far as we can judge, reasonable. Piersma *et al.* (2005) report on the effect of these estimates on population growth. They also show that the juvenile proportion of annual catches is a reasonable approximation to annual recruitment. This method has not been validated, nor are there sufficient Eurasian Golden Plover data yet to hand to do so. Monitoring on this model, run in parallel with that described here, is recommended. If nothing else, it would highlight any differences between the methods.

There is no easy way to see how the monitoring of vital rates can be improved. The obvious answer, supported by the simulations, is to catch more birds and gain more retraps. There are limits to the extent to which this can be achieved given the voluntary nature of the trapping effort and the often inclement conditions in which trapping is undertaken (55% of new birds and 72% of retraps are trapped in October through February, the coldest and windiest months of the year in The Netherlands). Annual catch totals between 2 000 and 3 000 have been maintained in recent years (U. Rijpma and F. Tuinstra, pers. comm.), but loudspeakers playing plover-calls at the net-site may boost these numbers. As a result of this study most wilsternetters now complete a daily log sheet with numbers of unringed and retrapped birds captured and all factors relevant to catching them e.g. catching effort, use of decoys and other lures, weather conditions. It is hoped that analysis of these sheets will identify means by which catching effectiveness can be enhanced.

Ringing and recapturing is not, of course, the only method that can be used for estimating vital rates. For example, Warnock *et al.* (1997) and Brochard *et al.* (2002) colour-banded shorebirds and used resightings rather than recaptures to estimate survival rates of Dunlin *Calidris alpina* and Red Knot *Calidris canutus*, respectively. Validating such an approach in the case of Eurasian Golden Plovers would not be cheap, would not be easy, and would not be quick. Ringing the birds would be the easiest bit. Finding the resources, both financial and people, to scour the polders looking for small numbers of colour-marked birds in a large population could be difficult, especially as the rather short legs of Eurasian Golden Plovers usually remain hidden in the grass and stubble on fields where they occur. Guaranteeing the long-term continuance of the program, an essential requirement if this method were to replace ringing with metal bands, would require a major commitment.

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SAMENVATTING

De laatste 25 jaar is het vangen van Goudplevieren ('wilsters') *Pluvialis apricaria* met een 'wilsternet' niet langer een jachtmethode, maar een manier om meer over deze vogels te weten te komen. In aansluiting op het voorafgaande artikel, waarin veranderingen over 50 jaar in overleving en populatiegrootte van de in Nederland doortrekkende Goudplevieren worden geanalyseerd, geven we hier een antwoord op de vraag of we met de huidige vanginspanning op een doeltreffende manier de vinger aan de pols van de Nederlandse populatie Goudplevieren kunnen houden. In tegenstelling tot veel kuststeltlopers is het voor de wijdverspreid in het binnenland voorkomende steltlopersoorten, zoals Goudplevieren, vrijwel ondoenlijk om via jaarlijkse tellingen de grootte van de populatie bij te houden. Het is niet zonder meer duidelijk dat met het vangen en ringen van 2000-3000 Goudplevieren per jaar de populatie wel goed kan worden gevolgd, omdat (1) er de laatste jaren vrijwel geen terugmeldingen meer komen van buiten Nederland (waarschijnlijk een gevolg van een verminderde jachtdruk en het niet langer insturen van ringwaarnemingen door Franse en Spaanse jagers) en (2) de kans om een geringde Goudplevier terug te vangen zo klein is (*ca.* 0,25%). Met behulp van simulaties en het relatief gebruiksvriendelijke computerprogramma 'MARK' voor het schatten van overleving, terugvangkansen en aanwas hebben wij onderzocht of het mogelijk is om met de huidige vanginspanning de demografische veranderingen bij Goudplevieren ook in de toekomst te volgen. Wij zijn daarbij uitgegaan van driejaarlijkse perioden voor het volgen van de overleving. De simulaties laten zien dat bij een terugvangkans van 0,25% en de vangst van 3000 nieuw te ringen Goudplevieren per jaar, een totale verandering van 5% in de jaarlijkse overleving binnen zes jaar (d.w.z. over twee driejaarlijkse perioden) aangetoond kan worden en met een kans van tweederde zelfs binnen een periode van drie jaar. Vervolgens hebben we de geschiktheid van de voorgestelde wijze van monitoren van de populatie getoetst aan de bestaande ring- en terugmeldingsgegevens (1950-2001). Het bleek dat er retrospectief goede schattingen gemaakt konden worden van de veranderingen in overleving, terugvangkansen en aanwas. Wij komen tot de conclusie dat met het jaarlijks vangen en ringen en het op leeftijd brengen van 2500 Goudplevieren (en liefst 500 meer) eventuele veranderingen in aanwas, overleving en populatiegrootte snel opgespoord en gedocumenteerd kunnen worden. De inspanningen van de 'wilsterflappers' vormen dus een uitstekende methode om het wel en wee van een belangrijke en kenmerkende vogelsoort van de Noord- en West-Nederlandse graslandgebieden te volgen.

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