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Using adult/juvenile ratios of waders in winter cannon net catches in Britain & Ireland to measure recruitment

Authors

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1. INTRODUCTION

The UK is of international importance for waders. Although relatively few species of waders breed here, many more are present during passage and in the winter. For such migratory species, the UK has obligations to protect both the birds and their habitat. The UK is a signatory to a number of international conservation conventions. Of particular importance in the context of waders are the EC Birds Directive, the EU Habitats and Species Directive and the 'Ramsar' convention on Wetlands of International Importance. This legislation requires the UK to identify habitats and sites important for birds and designate them for protection; as part of this it is essential to monitor populations to identify, and then monitor, important sites. In addition, the UK has ratified the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) of the 'Bonn' Convention on the Conservation of Migratory Species of Wild Animals. AEWA requires countries to conserve migratory waterbirds, identify sites and habitats used and ensure they are protected and managed appropriately. Again to fulfil these obligations the populations must be monitored.

Numbers of non-breeding waders present in the UK are monitored by the Wetland Bird Survey (WeBS) to assess the size of the non-breeding population, monitor trends in numbers and distribution and to assess the importance of individual sites. Monthly counts are made from September to March, although the annual index of abundance is based on the data for December to February. The annual index allows any changes in population size to be identified. Information on survival rates, productivity and dispersal allows the underlying causes of any such changes in populations to be investigated. When changes in demographic factors are identified, investigative research and subsequent conservation action can be focused on these areas. For long-lived species, changes in demography may be identified before changes in numbers (Baillie *et al* 1999). It is therefore important to monitor demographic factors as they may give the first warning of problems for a population that may lead to declines.

For migrant birds, the collection of demographic data may pose problems as there may not be access to information from both the breeding and wintering areas. For waders in the UK survival rates can be calculated from ringing and subsequent reports (recoveries) of ringed birds either recaught by ringers (at or away from the original site of ringing) or found dead. Ringing and recovery data can also provide information on movements between wintering sites. However, all individuals of some species breed outwith the UK and amongst other species, some individuals breed in the UK and others elsewhere. Many wader species occupy vast breeding ranges (Cramp & Simmons 1983), the breeding areas are often remote and wader chicks leave the nest shortly after hatching making the collection of extensive productivity information at breeding sites difficult.

In recent years information from various workers in the arctic describing and analysing breeding conditions has been gathered together in *Arctic Birds* (Soloviev & Tomkovich 1999, 2000, 2001, 2002, 2003). *Arctic Birds* gives reports from individual locations and summarises information on weather, rodent abundance, predators, distribution and numbers of breeding waterfowl and breeding success. However, figures for breeding success may only be available for a few sites (eg Soloviev & Tomokovich 2003). An alternative approach is to use adult/juvenile ratios on wintering grounds (ie recruitment into the wintering population) as a measure of productivity, which might provide a useful index. Indeed adult/juvenile ratios for Knot (*Calidris canutus*) have been used to investigate the contribution of survival and recruitment to population trends (Boyd & Piersma 2001) and data for Knot and Oystercatcher (*Haematopus ostralegus*) wintering on the Wash have been used successfully in a population model which suggested that recruitment rather than any long-term changes in survival had tended to drive population changes (Atkinson *et al* 2003).

Goose workers have used numbers of juveniles and older birds counted in autumn and winter flocks to assess productivity (eg Pink-footed Goose (*Anser brachyrynchus*), Fox *et al* 1989; Greylag Goose (*Anser anser*), Fox *et al* 1989; Barnacle Goose (*Branta leucopsis*) , Fox & Gitay 1991; Brent Goose (*Branta bernicla*), Ebbinge 1992, Ebbinge & Spaans 1995). Although they consider this may only give a crude assessment of annual productivity and be subject to bias, the information gained has been useful in giving information on changes in breeding productivity (Madsen *et al* 1999). Summers & Underhill (1987) also assessed productivity of Brent Geese from counts and extended this to counts and catches of wintering waders. In addition, Clausager (eg 2003) has collected adult juvenile/ratios from wings returned from quarry species.

Underhill *et al* (1989) used information from catches of Knot in South Africa and Britain and, more recently, Minton *et al* (2000, 2001, 2002a, 2002b, 2003a, 2003b) have derived an index of breeding success in the previous arctic summer from the proportion of juveniles in catches in Australia in the non-breeding season.

Using data from the non-breeding grounds has the advantage that all surviving offspring are included. This is particularly useful for precocial species where it is often difficult to estimate the numbers fledged (Crick & Baillie 1996). However, there are other problems in using these data. Waders wintering in one area may come from more than one breeding area so that any index may be sampling multiple populations. Unless there are similar changes in different breeding populations this would make any changes difficult to detect.

In addition, changes in the proportion of juveniles present may occur through the non-breeding period, thus it would be important to only compare samples from different years that were caught at the same time. The time period would have to be dictated by the behaviour of the birds, possibly with a narrow time frame in passage periods but a wider timeframe in the middle of the non-breeding season when populations tend to be stable.

There may also be biases in the catching data. For example, there tends to be a higher proportion of juveniles in small catches than in large ones (Boyd & Piersma 2001, pers obs). In addition, there may be an increased proportion of juveniles in a catch if there has been much disturbance of the birds prior to the catch. Also, there may be different proportions of juveniles in different habitats with adults in the more preferred areas (eg Swennen 1984, Durrell *et al* 1996). Differences in the proportion of juvenile waders in catches have been found to vary with catching method, with higher proportions in mist net than cannon net catches (Pienkowski & Dick 1976, Goss-Custard *et al* 1981, Insley & Etheridge 1997).

Differences in the distribution of adults and juveniles could also bias the proportions found. Such biases can occur at a macro (national or whole non-breeding area), local (within an estuary) or micro (within a flock) scale. Such biases may occur due to the non-breeding distribution of the species involved, the type and quality of habitats available in an area and the distribution of birds within a flock. For example, juvenile Redshank (*Tringa totanus*) in Scotland have been found to occupy less favoured habitats where they are more susceptible to predation while feeding over the high tide period (Hilton *et al* 1999). Also, juvenile birds tend to be on the periphery of flocks (pers obs). Migratory tendency within a species may also change over time (eg Oystercatcher, Lapwing (*Vanellus vanellus*) – Siriwardena & Wernham 2002) and could potentially lead to changes in the proportion of juveniles present in an area over time. All possible biases need to be investigated so that their effects can be taken into account when constructing an index.

Wader catching in Britain & Ireland

Well over a million individual waders have been caught and ringed in Britain & Ireland since the beginning of the Ringing Scheme in 1909. In the early years of the Scheme, most birds caught were nestlings but with the advent of mist nets in the 1950s and rocket and then cannon nets in the 1960s the proportion of full-grown birds caught for ringing has increased. Cannon nets are used to catch a relatively large number of birds at one time. A net or nets are usually set in an area where waders are likely to congregate in a roost at high tide. Ringers catching birds in cannon nets in Britain & Ireland are required to make a return for each catch giving the numbers of each species caught. In order to gather information for a recruitment index a form dividing the catch into adults, juveniles and birds of unknown age of each species was introduced in 1990. Since then the proportion of juveniles in cannon net catches has been collected for 3,156 different samples of 124,669 waders. All cannon net catches of waders in the database were made in Britain. Note that each catch may consist of a number of samples of different species.

2. METHODS

Although there are over 3,000 samples of waders for which the proportion of adults and juveniles have been recorded, many of these samples are during spring and autumn when there is most mixing of populations (Wernham *et al* 2002). Although there are still mixed populations in the winter, the mixing is reduced and movement between sites is at its lowest (Wernham *et al* 2002). Therefore only the 1,567 samples of 64,456 waders caught in the winter (November to March) were considered (Table 1). As few data were collected in the early winters, data from winter 1992/93 to 2002/03 were used. Species were included in the analysis if there were at least 40 catches in the 11-year study period. All samples were included, as recent analysis has shown no significant effect of disturbance on the proportion of juveniles in catches (M Collier pers comm). Four methods of calculating adult/juvenile ratios were examined using Dunlin (*Calidris alpine*) and Knot, for which there are large data sets, as trial species.

2.1 'Overall index'

Previous workers (eg Minton *et al* 2000, 2001, 2002b, 2002b, 2003a, 2003b) have summed all birds of each age category from all catches in a non-breeding period and used this to give an overall figure which they have used as an index of productivity where

$$\text{'Overall index'} = \frac{\text{Total number of juveniles caught in winter}}{\text{total number of adults plus total number of juveniles.}}$$

Calculating an 'overall' figure for each year produces a single estimate for each year and has the disadvantage that it does not allow statistical comparison of the between year index, although, in principle, errors could be estimated from a bootstrapping procedure.

2.2 'Pjuv index

An alternative index, that allows statistical testing of the mean can be calculated by taking the proportion of juveniles in each catch in a winter (termed pjuv) and then using the annual winter mean for pjuv across samples as the index so:

'Pjuv index' = mean of proportion of juveniles from each catch

However, unlike the 'Overall index' where the major contribution is from large catches, with small catches contributing little data, this method includes exactly the same contribution from all catches regardless of their size. It may be changed markedly if small catches are excluded as they tend to contain a higher percentage of juveniles (Boyd & Piersma 2001, pers obs). This may occur as large catches are often made at the more preferred roosting areas. In addition, small samples will normally be not the main species being caught but bycatch (ie a small number of one species present in a large catch that primarily contains a different species). Small samples may therefore be less representative of the population as a whole than large catches. Also it is statistically much more likely that a small sample could, by chance, contain either all juveniles or all adults than a large sample.

2.3 'Weighted index'

To weight the contribution of catches to the index by size catches by size, a further index was calculated giving a log 10 weighting to samples depending on their size, so:

'Weighted index' = mean of proportion of juveniles from each catch log10 weighted by size of catch.

Thus a catch of a single bird contributes nothing to the index, and a catch of ten birds contributes only half as much as a catch of 100 birds. This approach uses all the data but allows the contribution of samples to vary in a standard way. To calculate a weighted mean, the proportion of juveniles in each catch was first calculated, then a model (SAS proc Genmod with a logit link to constrain the values between 0 and 1) using a log 10 weighting was run to produced predicted values of pjuv for each year.

2.4 'Binomial index'

As the 'Weighted index' method gives an arbitrary weighting to each catch, a binomial method was also used. This categorises each data point as either adult or juvenile and takes account of the size of the catch from which that data point comes as each bird caught enters the analyses as an individual.

Indices using the binomial model were calculated (SAS proc Genmod, logit link, binomial distribution) for all species for which there were at least 40 catches in the 11-winter study period (Oystercatcher, Ringed Plover (*Charadrius hiaticula*), Grey Plover (*Plucialis squatarola*), Knot, Sanderling (*Calidris alba*), Purple Sandpiper (*Calidris maritima*), Dunlin, Bar-tailed Godwit (*Limosa lapponica*), Curlew (*Numenius arquata*), Redshank and Turnstone (*Arenaria interpres*)). Indices were also calculated on a regional basis where there is evidence of mixed populations in the British Isles and there was sufficient data. Separate indices for the east and west were calculated for Oystercatcher, as the birds in the east tend to be from the 'Continental' breeding population (Low Countries and Scandinavia), while those in the west tend to be from the 'Atlantic' breeding population (Iceland, Faeroes and British Isles) (Sitters 2002). For Redshank the catches were divided into Scotland and England, as almost all Redshank wintering in Scotland are from the Icelandic breeding population (Summers *et al* 1988), while those in England and Wales are a mixture of Icelandic and British breeding birds (Norman & Coffey 1994, Mitchell *et al* 2000, Derrett & Smith 2001, Burton *et al* 2002, Clark 2002). There is some evidence to suggest that the Turnstone wintering in the east of the British Isles have a different breeding distribution to those wintering in the west (Whitfield 2002), but this could not be investigated as there were insufficient data for Turnstone.

Data from catches using both cannon nets and mist nets were available from the Wash, England. These were use to compare juvenile proportions derived from the two methods.

3. RESULTS

An index using the 'overall' proportion of juveniles amongst Dunlin when all samples in a winter are summed is shown in Figure 1. When samples of less than 10 and less than 20 birds were excluded there is little change in the 'overall index' as small samples are contributing little to the result. However, when the proportion of juveniles in each sample of Dunlin in a winter was calculated and then an overall mean taken ('pjuv index'), the difference between the indices when catches of less than 10 and less than 20 were excluded was much larger (Figure 2). This was a result of the small catches making a greater contribution to the index in this case. When a 'weighted proportion' index is used, the indices for all Dunlin caught and when samples of less than 10 and less than 20 are excluded are less disparate (Figure 3). The binomial index has the same mean as the 'overall mean' so no separate figure is given. The indices given by each of the methods are shown in figure 4. The results for Knot were similar to those for Dunlin. As confidence limits of the mean can be calculated for the binomial method and it uses all data, weighting it appropriately by catch size, this method was used for all further analyses.

Figure 5 shows the binomial index for all species. The graphs show that there were insufficient data for Grey Plover, Bar-tailed Godwit and Curlew.

Regional indices for Oystercatcher and Redshank are shown (with the binomial index for Britain) are shown in figures 6 and 7. For Oystercatcher it appears that a high proportion on juveniles in catches in the west was the major contribution to the high index in 1994/95. The high index in 1997/98 relates more to catches in the west, while that in 1999/00 is a result of high figures in both areas.

The patterns also vary for Redshank with a peak index in 1997/98 in England and Wales, but in 1999/00 in Scotland.

Significant differences between the proportion of juveniles in mist net and cannon net catches on the Wash were found for Grey Plover, Knot, Dunlin, Bar-tailed Godwit and Redshank (Figure 8).

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Species	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	Total
Oystercatcher			23	16	30	28	41	27	36	20	30	36	24	311
Ringed Plover		1	6	12	7	6	14	11	5	6	7	4	5	84
Golden Plover			1			2						2	1	6
Grey Plover	1		1	4	1	2	6	6	2	3	12	6	2	46
Lapwing			3	2	4	3	4				1	5	2	24
Knot	1	1	6	15	11	22	11	8	12	8	12	9	7	123
Sanderling			2	4	5	11	4	6	6	8	4	7		57
Little Stint													1	1
Curlew Sandpiper			1											1
Purple Sandpiper		2	7	6	2	3	4	5	6	2	2	7	4	50
Dunlin	1	2	14	28	17	18	25	23	19	24	26	20	13	230
Snipe										1	2			3
Black-tailed Godwit		1	3			1	3		2		3	2	1	16
Bar-tailed Godwit			4	1		6	8	4	7	2	7	11	5	55
Curlew Sandpiper		2	5	5	6	7	9	14	9	8	8	11	11	95
Spotted Redshank				1						2				3
Redshank			23	29	19	17	28	19	23	27	30	23	19	257
Greenshank					1									1
Turnstone	1	2	20	23	16	17	16	17	20	16	32	15	9	204
Total	4	11	119	146	119	143	173	140	147	127	176	158	104	1,567

Table 1. Samples of waders caught in cannon nets by winter

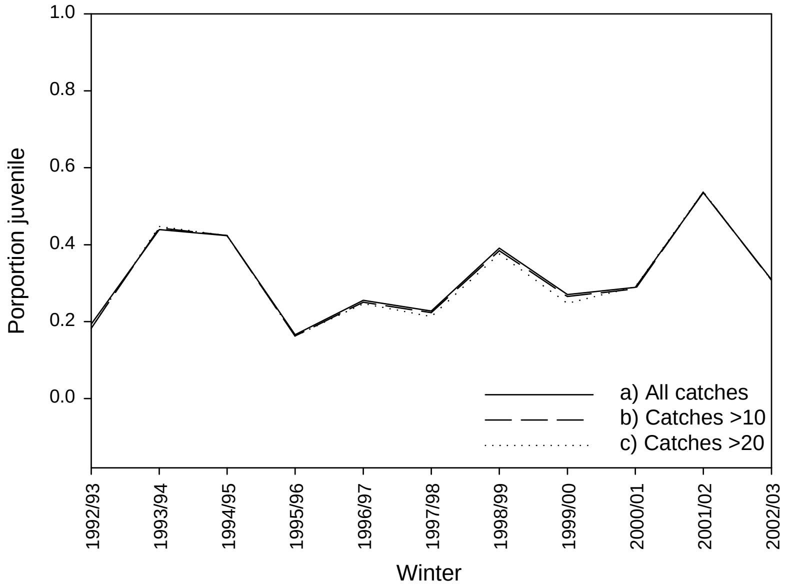

Figure 1. 'Overall index' **-** proportion of juvenile Dunlin calculated by summing all catches and calculating an overall mean: a) all catches; b) catches of more than 10 and c) catches of more than 20.

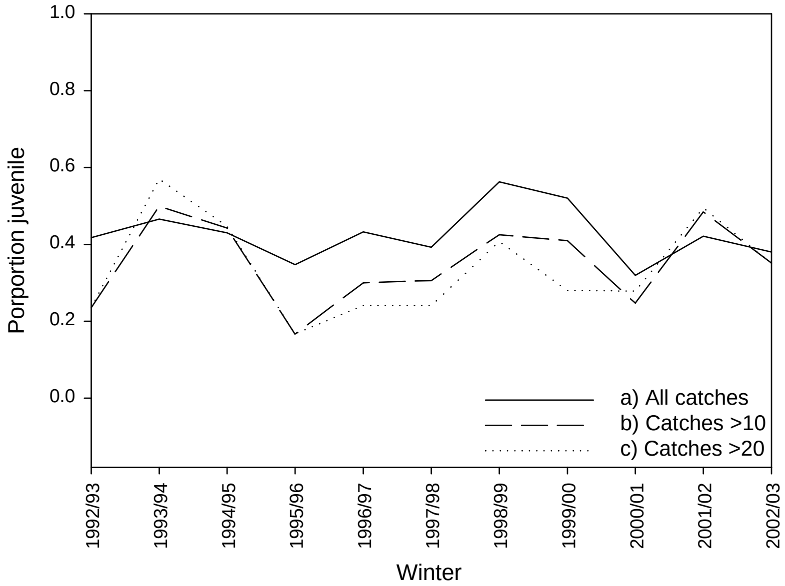

Figure 2. 'Pjuv index' – proportion of juvenile Dunlin calculated by taking the mean proportion of juveniles from each catch: a) all catches; b) catches of more than 10 and c) catches of more than 20.

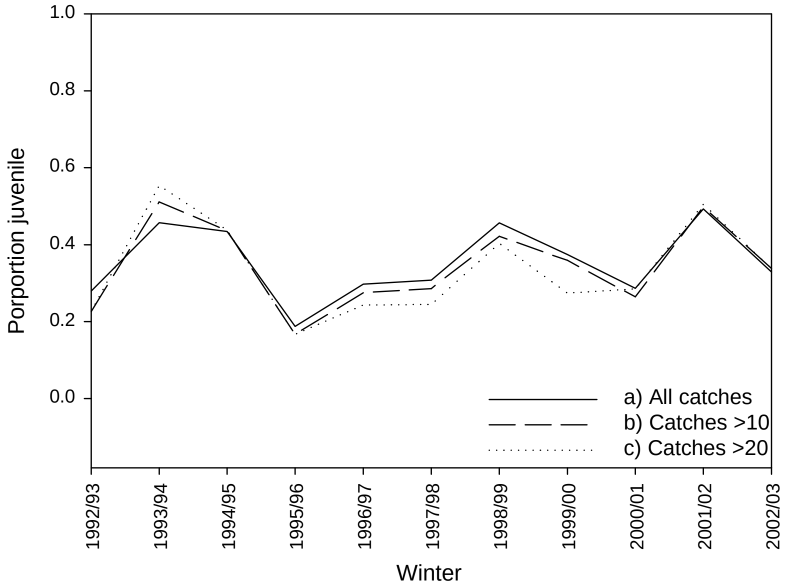

Figure 3. 'Weighted index' – mean proportion of juvenile Dunlin in catches weighted by catch size: a) all catches; b) catches of more than 10 and c) catches of more than 20.

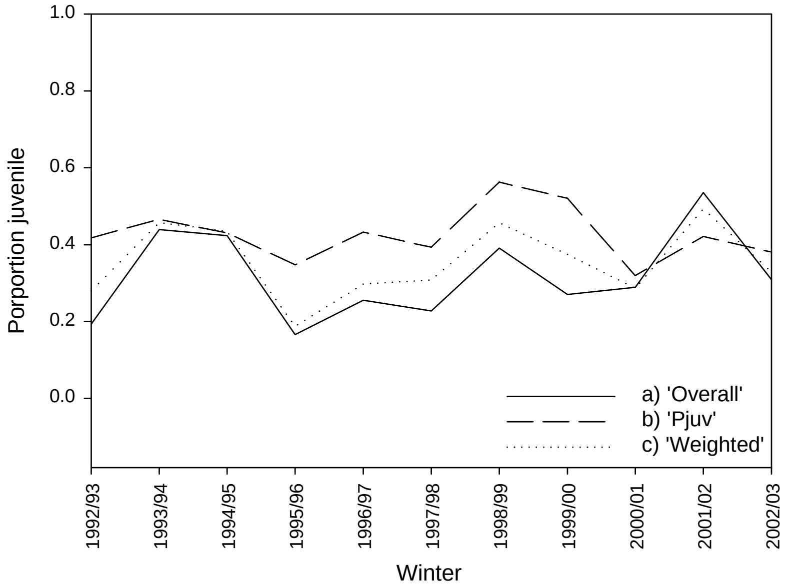

Figure 4. A comparison of the 'overall', 'pjuv' and 'weighted' indices. The 'binomial index' gives the same mean as the 'overall index'.

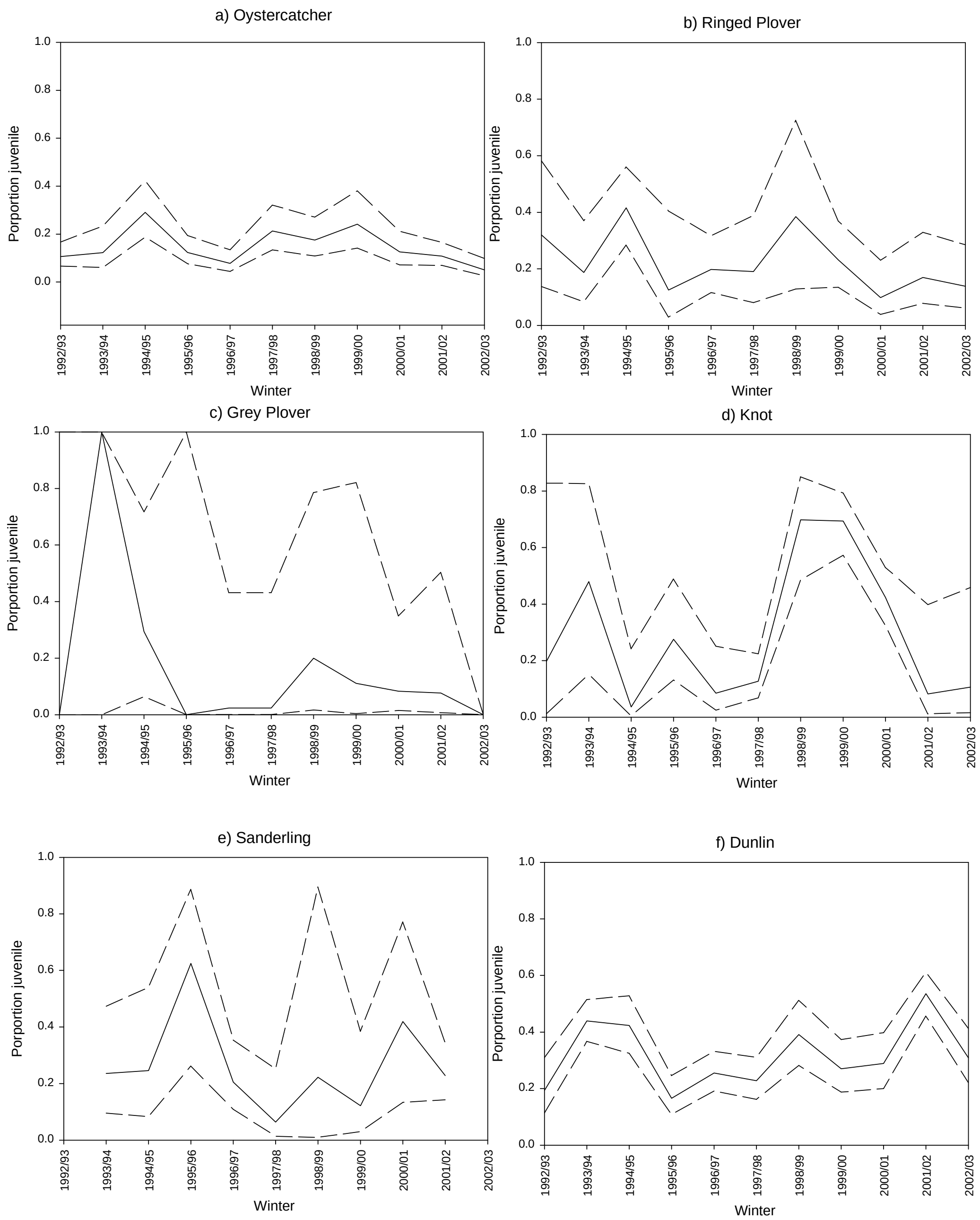

Figure 5. 'Binomial index' – mean proportion of juvenile waders in catches weighted by catch size for :
a) Oystercatcher; b) Ringed Plover; c) Grey Plover
d) Knot; e) Sanderling; f) Dunlin; g) Bar-tailed Godwit, h) Curlew
i) Redshank and j) Turnstone (Purple Sandpiper to add).

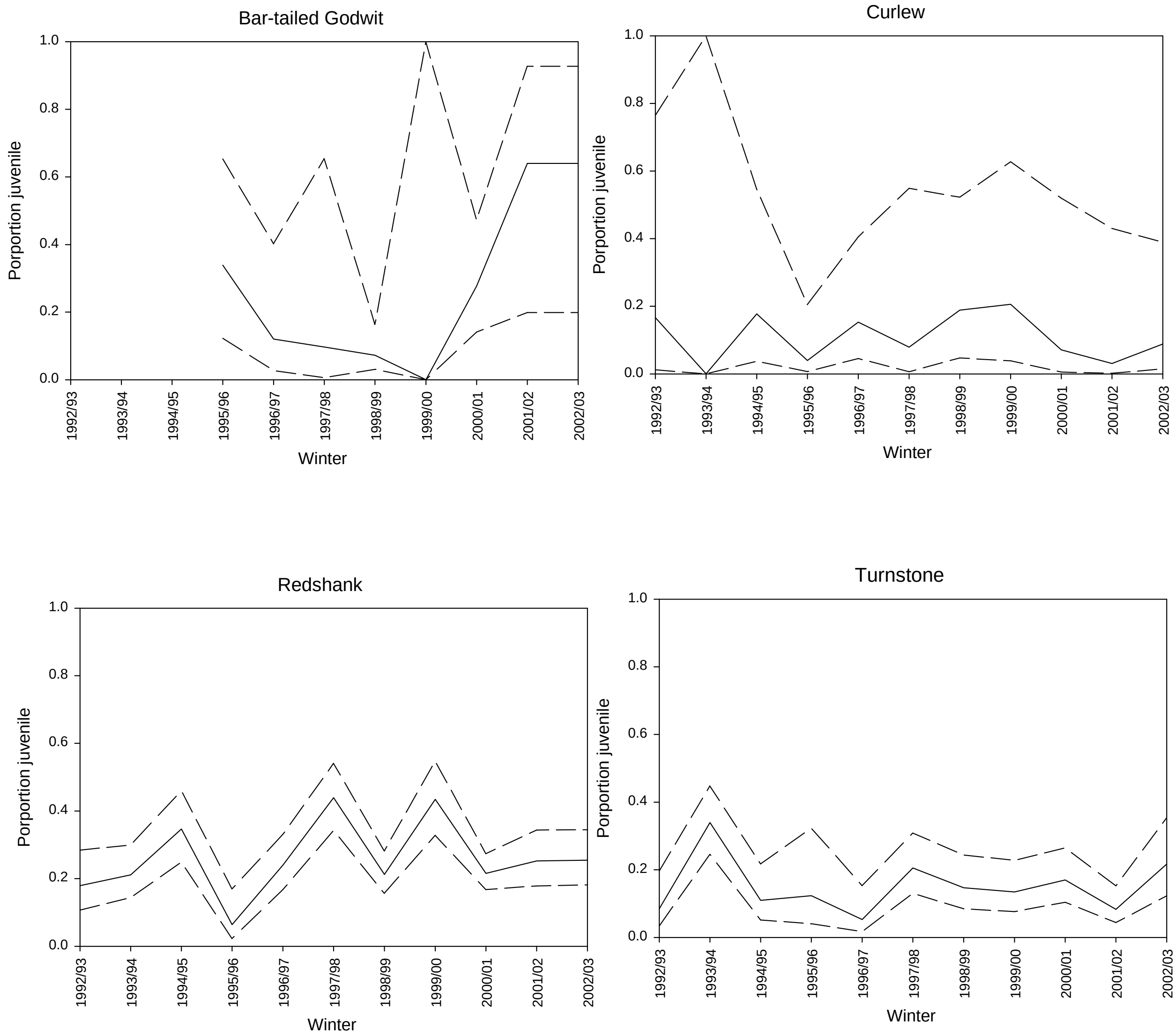

Figure 5. (cont) 'Binomial index' – mean proportion of juvenile waders in catches weighted by catch size for :
a) Oystercatcher; b) Ringed Plover; c) Grey Plover
d) Knot; e) Sanderling; f) Dunlin; g) Bar-tailed Godwit, h) Curlew
i) Redshank and j) Turnstone (Purple Sandpiper to add).

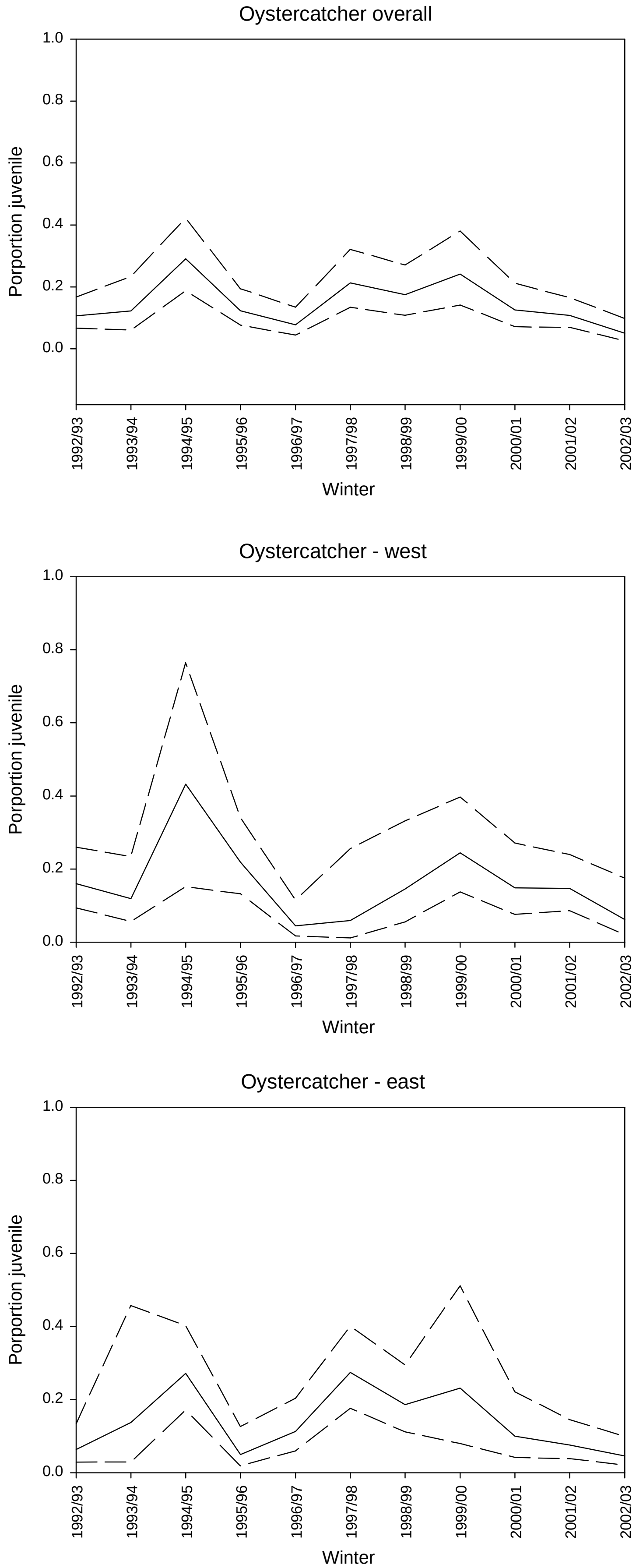

Figure 6. Overall and regional binomial index for Oystercatcher

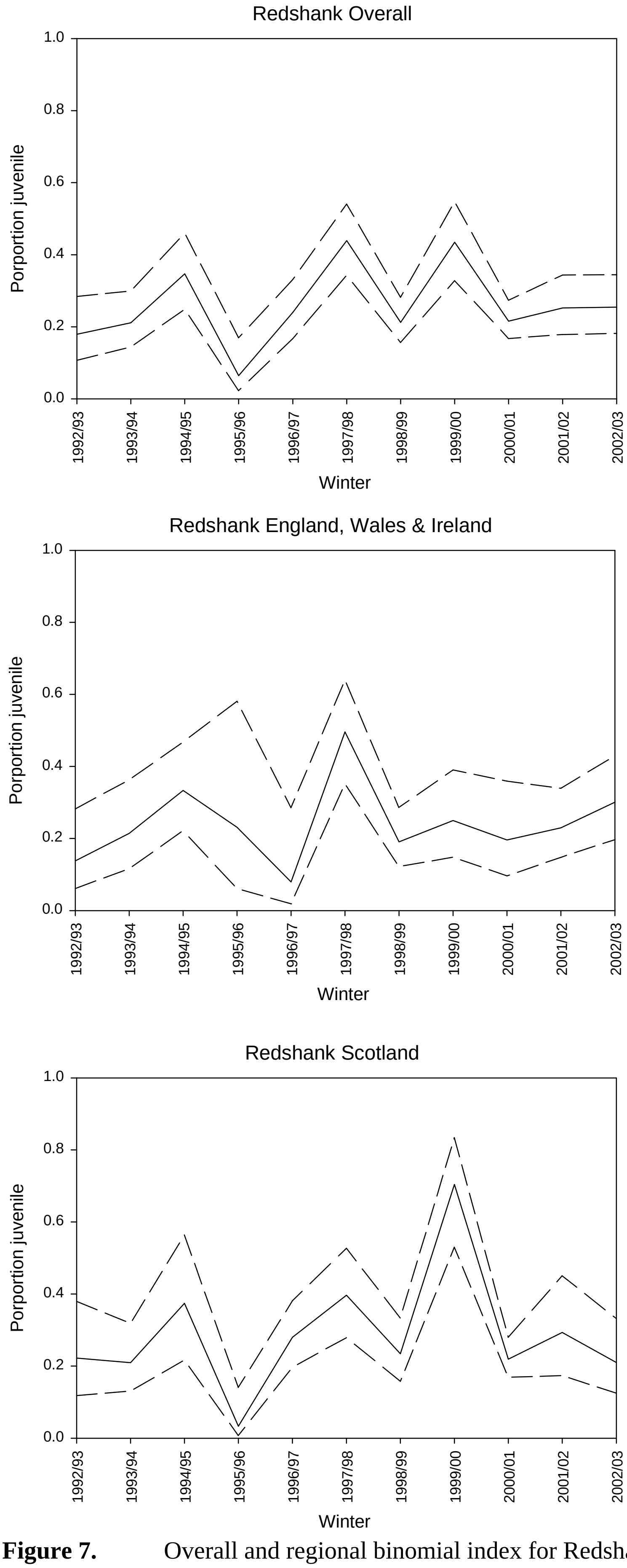

Figure 7. Overall and regional binomial index for Redshank

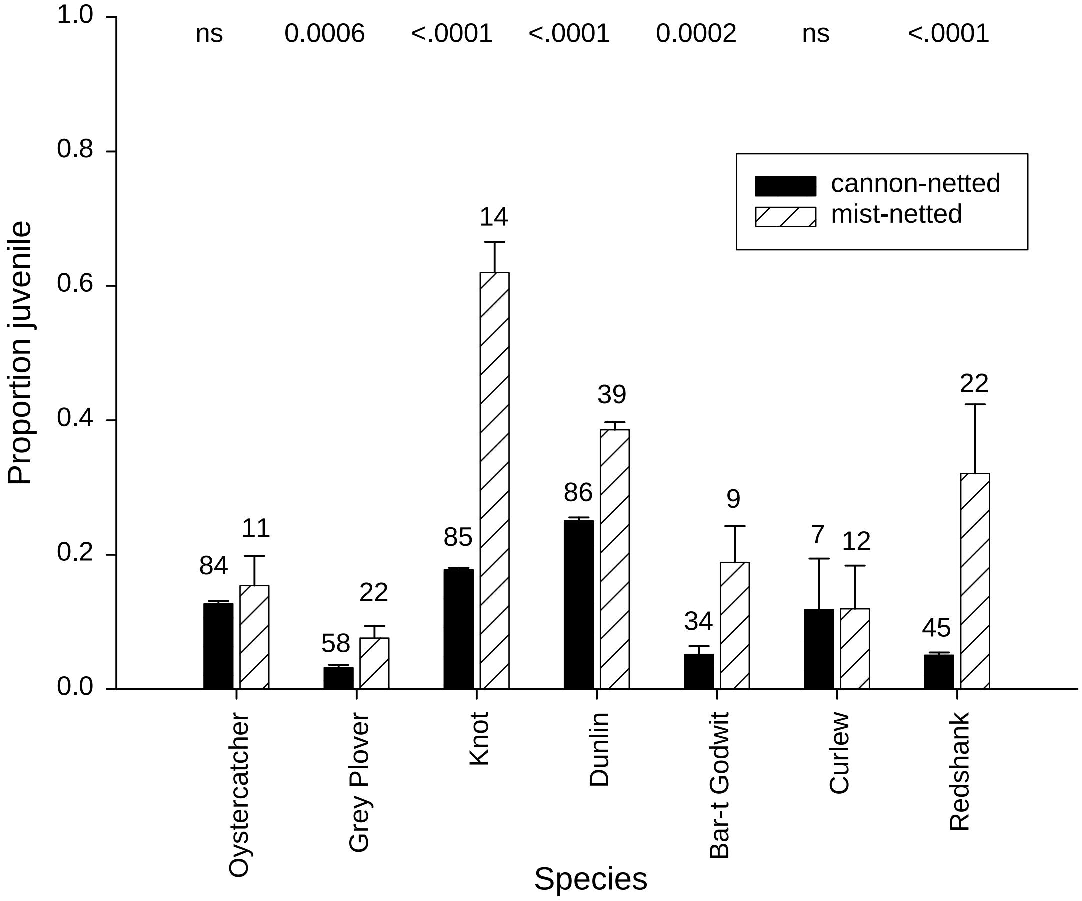

Figure 8. Proportion of juvenile waders in mist net and cannon net catches on the Wash 1980 to 1999.
Sample sizes (number of catches) are given at the top of the graph.