British Trust for Ornithology

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Evaluation of bird monitoring
requirements for
the United Kingdom's
non-estuarine coastline

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EXECUTIVE SUMMARY

Currently, the United Kingdom's non-estuarine wader population is under-surveyed. Owing to the importance of the UK's over-wintering wader population this situation needs to be changed.

Using the Winter Shorebird Count (WSC) database, which was collected during winter 1984/85, statistical simulations were carried out to ascertain the minimal amount of coastline which needs to be surveyed to produce reliable population estimates for non-estuarine species.

The information derived from the WSC database and the simulations enable a minimal sampling regime to be produced. Only two of the habitats recorded during the WSC, sand and bedrock, needed surveying.

The minimal sampling regime requires only 3417km of coastline to be surveyed. This produces population estimates which allow a 50% fluctuation in population size between two sampling periods to be estimated for Ringed Plover, Turnstone, Sanderling and Purple Sandpiper. This is only 30% of the coastline surveyed by the WSC.

It is important that future non-estuarine surveys have count sections of small, standard lengths. Including a few large count sections in the boot-strapped population estimates increased the estimate variance as the boot-strapped sample size became smaller.

1.   INTRODUCTION

The United Kingdom's coastline supports large numbers of waders throughout winter (Waters & Cranswick 1993). The majority of the UK's over-wintering waders are found within estuaries. Owing to the importance of many of the over-wintering sites and their vulnerability to developments, pollution and tourism, it is essential that wader populations on different estuaries are monitored.

The UK's wader populations have been monitored since 1969, initially by the Birds of Estuaries Enquiry (BoEE) and since 1993 by the Wetland Bird Survey (WeBS) which is run jointly by the British Trust for Ornithology (BTO), the Wildfowl & Wetlands Trust, the Joint Nature Conservancy Council and the Royal Society for the Protection of Birds. WeBS regularly records the number of waterfowl on estuaries, some inland wetlands, agricultural habitats and open coastlines.

One of the least surveyed habitats under WeBS is the non-estuarine coastline. Only 40 open coastline stretches are currently counted by WeBS, this being 329km or 2.5% of the UK's coastline. This monitors only a very small proportion of the non-estuarine wader population.

The problem of under-estimation of non-estuarine coastlines was even greater during the BoEE. In order to overcome this and provide a wader population estimate for non-estuarine coasts a one-off survey, the Winter Shorebird Count (WSC), was organised by the BTO and the Wader Study Group (Moser & Summers 1987). The WSC used 1500 volunteer wader counters and covered approximately 90% of the non-cliff coastline of the UK during winter 1984/85. The population estimates derived from the 1984/85 survey were subsequently used to produce estimates for over-wintering waders in the UK (Moser 1987).

The most recent estimate of UK wader populations (Cayford & Waters in press) was derived by comparing the data from the 40 non-estuarine sites counted by WeBS, with data from the same sites counted by the WSC. It was assumed that the population change which had occurred between the two surveys, on the 40 sites, had occurred throughout the whole non-estuarine population. The derived population estimate was the best that could be calculated using the current data. In order to produce better estimates, the WeBS partnership intends to organise a new non-estuarine survey with much greater coverage than that currently attained by WeBS. Prior to running the full survey, the BTO/WWT organised a pilot survey of waterfowl on the UK's non-estuarine coastal sites in the 1994/95 winter. The purpose of the pilot was to test the methodology and ascertain the amount of coverage required to produce reliable population estimates.

2.   METHODS

2.1   Calculating population sizes

Initial analysis of the WSC database, revealed discrepancies when compared to the wader totals given by Moser & Summers (1987). In order to overcome this, new wader totals were calculated from the WSC database for each coastal county in the UK. The population totals derived from the database are used as the basis of this study.

2.2   The key non-estuarine species

The information from the above analysis and information found in Waters & Cranswick (1993) and Cayford & Waters (in press), were used to identify which of the species recorded by the WSC make the most use of the non-estuarine habitat. These are species which have a major part of their population on non-estuarine habitats. These species (Ringed Plover, Turnstone, Sanderling and Purple Sandpiper) were regarded as the key non-estuarine species and receive most consideration within this report.

2.3   Sampling regime for Winter Shorebird Counts

The WSC as a one-off survey achieved excellent coverage of the UK's coastline. It is unlikely however, that an annual survey will ever be able to attain such coverage year after year or that finances will be available to cover the costs. It is, therefore, necessary to design a survey that has a more restricted sampling regime, yet produces accurate population estimates.

In order to calculate the minimal sampling regime necessary to produce reliable population estimates for a future survey, it was desirable to allocate sample sizes according to strata. The WSC database contains a number of possible strata (primary habitat, secondary habitat, slope, etc). It was decided that the most appropriate stratum to use was primary habitat, with the size of each sample being based on the relative length of each habitat. Two alternative strategies exist for allocating sample sizes, proportional allocation and optimal allocation.

Proportional allocation is the simplest approach to defining sample sizes for a sampling procedure and apportions the overall sample between strata proportionally to the size of each stratum. Using this

approach, the length of habitat sampled would be fixed for each habitat type (e.g. 20%) to produce a population estimate from a reduced sample of the available data.

An alternative method of assigning sample sizes is **optimal allocation**. This approach gives each stratum a different sample size depending on the variability of counts within each stratum. This would be done for each species separately such that each species would have a different sampling strategy across the strata. This method can also apportion samples according to cost. In the context of this study a species such as Sanderling, which is most commonly found on sand, would have a high variance on that habitat whereas on mud the variance would be low. Therefore a greater proportion of sand and a smaller proportion of mud would need to be surveyed. This approach is very species specific with each species requiring an optimally allocated sampling strategy and is best suited to species specific studies and cannot practically be used for surveys like the Winter Shorebird Count. It was therefore decided that the best approach was to use proportional allocation. Simulations in which various proportions of the UK coastline (5% to 80%), stratified by primary habitat, were sampled from the WSC database to produce a range of population estimates with confidence limits. Each simulation was carried out 999 times with replacement. The 5th and 95th percentiles were taken as the 90% confidence limits (Greenwood 1991)

By assigning a required level of precision for species estimates derived from the simulations, it was possible to specify the length of coastline which would need to be sampled to produce reliable population estimates for each habitat. For the purposes of this study, the acceptable mean deviation of a population estimate was defined as 25%. This would allow a 50% fluctuation in population size between two sampling periods to be detected. The mean deviation was taken as the average difference of the upper and lower 90% confidence limits from the actual estimate, as a proportion of that estimate. The **minimal sampling regime** for a non-estuarine survey was then chosen as the minimal length of each habitat which needed to be surveyed to provide estimates with a mean deviation of less than or equal to ±25% for the key non-estuarine species. Only habitats which supported at least 15% of the key non-estuarine species were considered. This is a generally conservative sampling strategy as should be required by the country agencies.

2.4   The precision of the minimal sampling regime

To establish how comparable population estimates based on the minimal sampling regime would be to a complete survey, a simulation which used the minimal sampling regime defined lengths of habitat was carried out.

This simulation mimicked 10 surveys by sampling the WSC database 10 times without replacement according to the minimal sampling regime. Each of the 10 samples was then resampled 99 times with replacement to allow 90% confidence limits to be calculated for each of the minimal sampling regime surveys. The 90% confidence limits make it possible to test the consistency of each minimal sampling regime survey against the "known" WSC population.

The WSC database contained a small number of count sections with a long coastal length. If sampled at random by the simulation they would have resulted in smaller samples sizes and therefore increased variance. To overcome this, sections which had a length in excess of 5km were removed. This resulted in the removal of 7.3% of bedrock and 3.5% of sand from the data sampled. This was considered justifiable as the length of coastline section in a future survey would be limited to 2km, as greater lengths would cause problems in future analysis of the data.

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3.   RESULTS

3.1   Population sizes

The wader totals recalculated from the WSC database are presented in Tables 3.1.1 and 3.1.2. There are a number of discrepancies in these results and those given by Moser & Summers (1987). The only discrepancy in the results obtained for England are for the wader totals of the Channel Islands. This is due to the absence of the Guernsey data from the WSC database. Guernsey was not surveyed as part of the WSC, instead data collected by high tide counts were used to produce the results (Moser & Summers 1987). As the entire coastline of the Channel Islands, of which Guernsey is only a small part, represents about 5% of England's total coastline, it is unlikely that this will greatly affect the results.

The main discrepancies in Scotland are recorded from Grampian, Highland, Shetland and Strathclyde. The data presented by Moser & Summers (1987) for Orkney, Lewis and Harris were not present in the WSC database, as they were collected by a different survey, using different methods. The discrepancies in the Grampian, Shetland and Strathclyde data are unlikely to have a major affect on the results of the study. The absence of the Orkney, Lewis and Harris data, may cause a slight bias to the results as large numbers of birds were recorded in these areas, particularly Turnstone, Curlew, Redshank and Purple Sandpiper. In view of this, estimates of the minimal sampling regime must be taken as minimum values.

3.2   Sampling effort and precision of population estimates

The results of the simulations for each of the key species, which sampled differing lengths of coastline, are presented as a series of graphs (Figures 3.2.1 to 3.2.4). It is apparent from these graphs (Figures 3.2.1 to 3.2.4) that the accuracy of the estimates improves with increasing length of coastline sampled. The graphs also give some indication of a species' habitat preference. Assuming that each species had no habitat association, then the proportion of a species population recorded on a certain habitat type should be the same as the proportion of habitat present. A larger proportion of a population recorded on a habitat might indicate some habitat preference.

3.3 Species accounts for the key non-estuarine species

3.3.1 Ringed Plover

Ringed Plovers are a widespread species occurring on most coastal sites, but in low numbers. The UK over-wintering population consists primarily of local breeders supplemented by birds from Northern Europe. The majority of Ringed Plovers are found on the sandier coastal areas (Prater 1981). The non-estuarine population is estimated at 19000, however the UK estuarine population is about 10000 (Cayford & Waters in press), making Ringed Plover a predominantly non-estuarine species. The Ringed Plover population total derived from the WSC was 15336 (Tables 3.1.1 and 3.1.2). Ringed Plovers had a strong association with sand in the WSC (Figure 3.2.1) where 64% of the birds were recorded and less association with bedrock, where only 18% were recorded. Only 18% of non-estuarine Ringed Plovers were found on boulders, cobbles, gravel or mud (Figure 3.2.1), therefore for this species these habitats were not considered as part of the minimal sampling regime (Table 3.2.1).

3.3.2 Turnstone

Turnstones are present on almost all of the UK's coastline (Prater 1981) at both estuarine and non-estuarine sites. Turnstones do not breed in Britain, so the over-wintering population is made up solely of immigrants, mainly from Eastern Canada and Greenland (Prater 1981). The non-estuarine Turnstone population is estimated at 51300 birds which is much larger than the estuarine estimate of 13000 (Cayford & Waters in press). A population total of 26823 was derived form the WSC (Tables 3.1.1 and 3.1.2). Turnstone were not associated with any particular habitat types, although slightly higher than average numbers were recorded on sand (Figure 3.2.2). Boulders, cobbles, gravel and mud supported 22% of the non-estuarine Turnstone population (Figure 3.3.2) and were therefore not included in the minimal sampling strategy.

3.3.3 Sanderling

Sanderlings have a very restricted breeding range in the high arctic. Outside the breeding season Sanderlings have a worldwide distribution. In the UK Sanderlings are widespread, occurring at low numbers in most coastal areas, although a preference is shown for sandier stretches (Prater 1981). The estuarine population of Sanderling is estimated at about 5500 and the non-estuarine population is almost 18000 (Cayford & Waters in press). These over-wintering population estimates are dwarfed by the numbers of birds recorded in spring and autumn whilst on passage (Prater 1981). The Sanderling population estimate derived from the WSC was 8431 (Tables 3.1.1 and 3.1.2). Sanderling had a strong

association with sand, indeed 82% of the Sanderling population was found there (Figure 3.2.3), and thus sand is the only habitat included in the minimal sampling regime.

3.3.4 Purple Sandpiper

Purple Sandpipers breed in Arctic regions from Western Canada to Central Siberia. Purple Sandpipers are the most northerly wintering wader species, found almost exclusively on rocky shores. In the UK, the highest concentration of this species is along the north-east coast (Prater 1981). Purple Sandpiper can possibly be regarded as the only truly non-estuarine species of wader in the UK. The estuarine population is estimated at 720, whereas the non-estuarine population is estimated at 20600 (Cayford & Waters in press). The WSC database Purple Sandpiper total was 8081 (Tables 3.1.1 and 3.1.2), which is low due to the absence of the Orkney data (see Section 3.1). The rockier habitats held most of the Purple Sandpiper population (82%), however many were also recorded on sand (15%) (Figure 3.2.4). Boulders, cobbles, gravel and mud were not included in the minimal sampling regime as these hold less than 15% of the Purple Sandpiper population (Figure 3.2.4).

3.4 Sampling regime for future surveys

The length of each habitat which needs to be surveyed for the key non-estuarine species to produce estimates with a mean deviation of 25% is given in Table 3.4.1. Derived from the data in Table 3.4.1 is the minimal sampling regime required to produce the desired population estimates for all the key non-estuarine species. The minimal sampling regime is the proportion of each habitat type which needs to be surveyed to produce population estimates with a mean deviation of less than 25% for the key non-estuarine species. Only habitats which support more than 15% of the non-estuarine species population have been included.

The results from the simulation using the minimal sampling regime to produce an overall estimate for the UK's non-estuarine coastline are given in Table 3.4.2. The 90% confidence intervals of each of the ten runs of the minimal sampling regime simulation held the WSC population estimates of Ringed Plover, Turnstone, Sanderling and Purple Sandpiper.

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4. DISCUSSION AND CONCLUSIONS

As a "one-off" survey the Winter Shorebird Count achieved impressive coverage of the UK's coastline. There is currently, however, a shortfall in our knowledge of the UK's over-wintering wader populations caused by insufficient surveys of the non-estuarine wader population being carried out. Presently it is not possible to assess the importance of non-estuarine coasts to waterfowl through time. Forty open coastline stretches are surveyed as part of WeBS but many of these are at the mouths of estuaries and may thus be unrepresentative. Clearly this situation needs to be improved and the proposed non-estuarine survey will overcome this if the new survey confirms that it is feasible to sample a proportion of the UK coastline and yet obtain satisfactory population estimates. If this is the case then it may be possible to routinely count a proportion of the UK coastline as part of WeBS.

Strong habitat associations were found in the key non-estuarine species. The strongest associations were between Ringed Plover and sand (64% of the population), Sanderling and sand (82%) and Purple Sandpiper and bedrock (56%). Turnstone did not show any evidence of strong habitat selection. This would have important consequences when choosing sampling strategies for species specific surveys and has allowed the recommended sampling strategy to be based on sand and bedrock.

The simulations which sampled varying proportions of primary habitat provided information on the amount of habitat that needed to be surveyed to produce precise population estimates for a range of species. Generally, the most common primary habitats (e.g. bedrock and sand) produced the more precise estimates when only small proportions were sampled. This is also true for primary habitats which support a major proportion of the population of a particular species' population (e.g. Sanderling on sand) where precise estimates were obtained when small proportions of the habitat were sampled (Figures 3.2.1 to 3.2.4).

The minimal sampling regime suggested by this study requires only 3417km of the UK coastline to be surveyed, based on the data available in the WSC database. This is 70% less than the amount sampled during the WSC, which sampled 11253km of coast. If less precise estimates were required for the range of key non-estuarine species, then a smaller length (or proportion) of coastline would require surveying. For some species-specific surveys the length of coastline that needs to be surveyed is much less than the minimal sampling regime.

The population estimates derived from the WSC database for Ringed Plover, Turnstone, Sanderling and Purple Sandpiper, were contained within the 90% confidence limits produced by the simulations using the minimal sampling regime. Provided that these species are counted on the proportion of

habitat specified by the minimal sampling regime, reliable population estimates for these species could be produced using a survey that is smaller than the original 1984/85 Winter Shorebird Count and that may be small enough to be routinely incorporated into WeBS.

An important consideration for future non-estuarine surveys is to ensure that the section lengths are kept standard and ideally small (ie 1km to 2km), otherwise there could be serious implications for any analyses which use statistical simulations.

ACKNOWLEDGEMENTS

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County	Oyster-catcher	Lapwing	Ringed Plover	Grey Plover	Golden Plover	Turnstone	Curlew	Bar-tailed Godwit	Redshank	Knot	Dunlin	Sanderling	Purple Sandpiper	Snipe	Greenshank
Somerset	228	0	42	6	1	117	252	0	84	5	407	23	2	0	0
Devon	1251	59	25	26	42	200	291	4	35	0	32	113	30	1	1
Cornwall & Scilly	2128	6	499	287	25	1573	617	89	79	20	430	485	231	3	11
Dorset	157	0	7	0	0	46	7	0	8	0	0	3	16	0	0
Hampshire	106	27	13	4	0	150	5	0	25	0	250	62	2	0	0
Isle of Wight	205	11	291	67	2	24	42	109	125	0	110	235	17	0	0
Channel Isles	1012*	2*	181*	450*	8*	563*	99*	112	67*	0*	1853*	133*	7*	0	0
W. Sussex	179	0	160	230	0	7	0	0	10	0	360	130	4	0	0
E. Sussex	28	0	47	28	0	276	31	6	36	0	240	1	37	0	0
Kent	2432	0	218	392	0	715	228	275	425	787	3484	832	51	0	0
Essex	4	0	30	47	0	59	3	31	27	1	314	440	13	0	0
Suffolk	1	0	0	0	0	25	0	1	1	2	8	8	20	0	0
Norfolk	12	0	43	14	2	163	4	10	49	6	38	212	10	0	0
Lincolnshire	1	0	25	13	0	0	8	2	29	0	182	164	0	1	0
Humberside	38	0	140	3	0	519	0	0	182	13	144	364	144	0	0
N. Yorkshire	1026	9	17	13	0	639	47	0	605	29	748	146	238	0	0
Cleveland	1402	0	94	1	0	446	29	11	234	1310	900	639	162	0	0
Durham	31	0	19	0	0	76	0	0	34	0	0	123	36	0	0
Tyne & Wear	121	0	87	1	1081	174	5	0	190	0	351	182	98	0	0
Northumberland	1462	219	369	122	41	1274	95	73	606	662	1194	438	501	1	0
Cumbria	4240	145	125	6	469	246	723	2	303	0	217	75	19	0	0
Isle of Man	601	934	286	21	120	290	3206	12	284	1	137	0	27	0	0
England Total	16665	1412	2718	1731	1794	7582	5692	737	3438	2856	11399	4808	1665	6	12

Table 3.1.1   Wader totals derived from the 1984/85 Winter Shorebird Count database for England. * Denotes a difference from the value given by Moser & Summers (1987).

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County	Oyster-catcher	Lapwing	Ringed Plover	Grey Plover	Golden Plover	Turnstone	Curlew	Bar-tailed Godwit	Redshank	Knot	Dunlin	Sanderling	Purple Sandpiper	Snipe	Greenshank
Borders	187	29	12	0	0	126	44	0	79	0	0	0	25	0	0
Lothian	1908	120	218	46	507	1300	292	93	564	882	494	0	516	0	0
Fife	869	378	168	15	853	711	560	10	469	53	508	0	153	8	0
Tayside	898	20	30	21	15	210	90	5	169	43	76	20	79	0	0
Grampian	2940*	26	275*	48*	341*	2847*	1000*	1055*	1236*	193	1287*	48*	1607	14	0
Highland	6479*	154*	1114*	10*	251*	2194*	3480*	136	1603*	58	433	12	1575	163	6
Orkney	NO DATA														
Shetland	41*	109*	137*	1*	89*	1230*	367*	0	407*	20*	15*	0	288*	214*	0
Uists	1800	276	4139	208	522	2567	1290	2489	945	19	3103	2388	1193	43	43
Lewis & Harris	NO DATA														
Strathclyde	13933*	1685*	3863*	83*	450*	3139*	9795*	186	2623*	286*	2856	501*	536*	24*	25
Dumf. & Gall.	1076	701	424	1	75	343	815	6	278	7	716	1	18	16	4
Scotland Total	30131	3498	10380	433	3103	14667	17733	3980	8373	1561	9488	2970	5990	482	78
Clwyd	1105	169	29	0	0	186	57	0	154	27	26	173	25	0	0
Gwynedd	4787	956	559	99	375	990	2530	28	751	52	1781	50	67	7	10
Dyfed	4449	824	63	173	55	220	606	59	35	47	842	315	65	7	6
Glamorgan	4666	8	125	85	7	593	240	0	95	106	528	45	5	0	2
Wales Total	15007	1957	776	357	437	1989	3433	87	1035	232	3177	583	162	14	18
Derry	134	44	30	0	1	104	38	10	95	0	0	64	69	0	0
Antrim	702	573	226	0	0	452	549	12	358	0	425	4	22	0	0
Down	2693	4906	1206	41	1611	2029	1631	166	1043	17	2963	2	173	15	5
N. Ireland Total	3529	5523	1462	41	1612	2585	2218	188	1496	17	3388	70	264	15	5
UK Grand Total	65332	12390	15336	2562	6943	26823	29076	4991	14342	4644	27452	8431	8081	738	113

Table 3.1.2   Wader totals derived from the 1984/85 Winter Shorebird Count database for Scotland, Wales and N. Ireland. * Denotes a difference from the value given by Moser & Summers (1987).

	Primary Habitat	
Species	Bedrock	Sand
Ringed Plover	30% 1648km	40% 751km
Turnstone	20% 1099km	40% 751km
Sanderling	**	40% 751km
Purple Sandpiper	40% 2197km	65% 1220km
Minimal Sampling Regime	40% 2197km	65% 1220km

Table 3.4.1   The proportion and length of each habitat that must be surveyed to produce population estimates with a mean deviation of less than 25% for the key non-estuarine species. These values are derived from 999 repeated simulations using a bootstrapping method. ** Only habitats which support greater than 15% of a species population have been included. (For explanation of Minimal Sampling Regime see Section 3.4 in text).

Simulation Run	Ringed Plover (15336)	Turnstone (26823)	Sanderling (8431)	Purple Sandpiper (8081)
1	13458-18995	23401-31735	6923-11500	5678-9916
2	13043-18407	23401-31367	6857-11377	5698-9639
3	12235-18136	22704-31066	6825-11172	5667-9497
4	12451-18106	22634-30750	6806-11247	5565-9301
5	12495-18106	22393-30279	6621-11172	5492-9217
6	12549-18276	22497-30234	6656-11345	5414-9169
7	12670-18361	22509-30234	6662-11345	5415-9169
8	12772-18317	22501-30005	6594-11266	5415-9126
9	12792-18285	22393-29791	6617-11277	5462-9221
10	12804-18316	22463-29788	6617-11322	5383-9172

Table 3.4.2   The 90% confidence limits produced by sampling the WSC database 10 times using 99 runs of a simulation, for each of the key non-estuarine species using the minimal sampling strategy. The WSC population totals are given in parentheses.

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RINGED PLOVER

Bedrock

5493km (56%)

18%

PERCENTAGE DEVIATION

% COASTLINE SAMPLED

Boulders

958km (10%)

6%

PERCENTAGE DEVIATION

% COASTLINE SAMPLED

Cobbles

706km (7%)

4%

PERCENTAGE DEVIATION

% COASTLINE SAMPLED

Gravel

525km (5%)

5%

PERCENTAGE DEVIATION

% COASTLINE SAMPLED

Sand

1877km (19%)

64%

PERCENTAGE DEVIATION

% COASTLINE SAMPLED

Mud

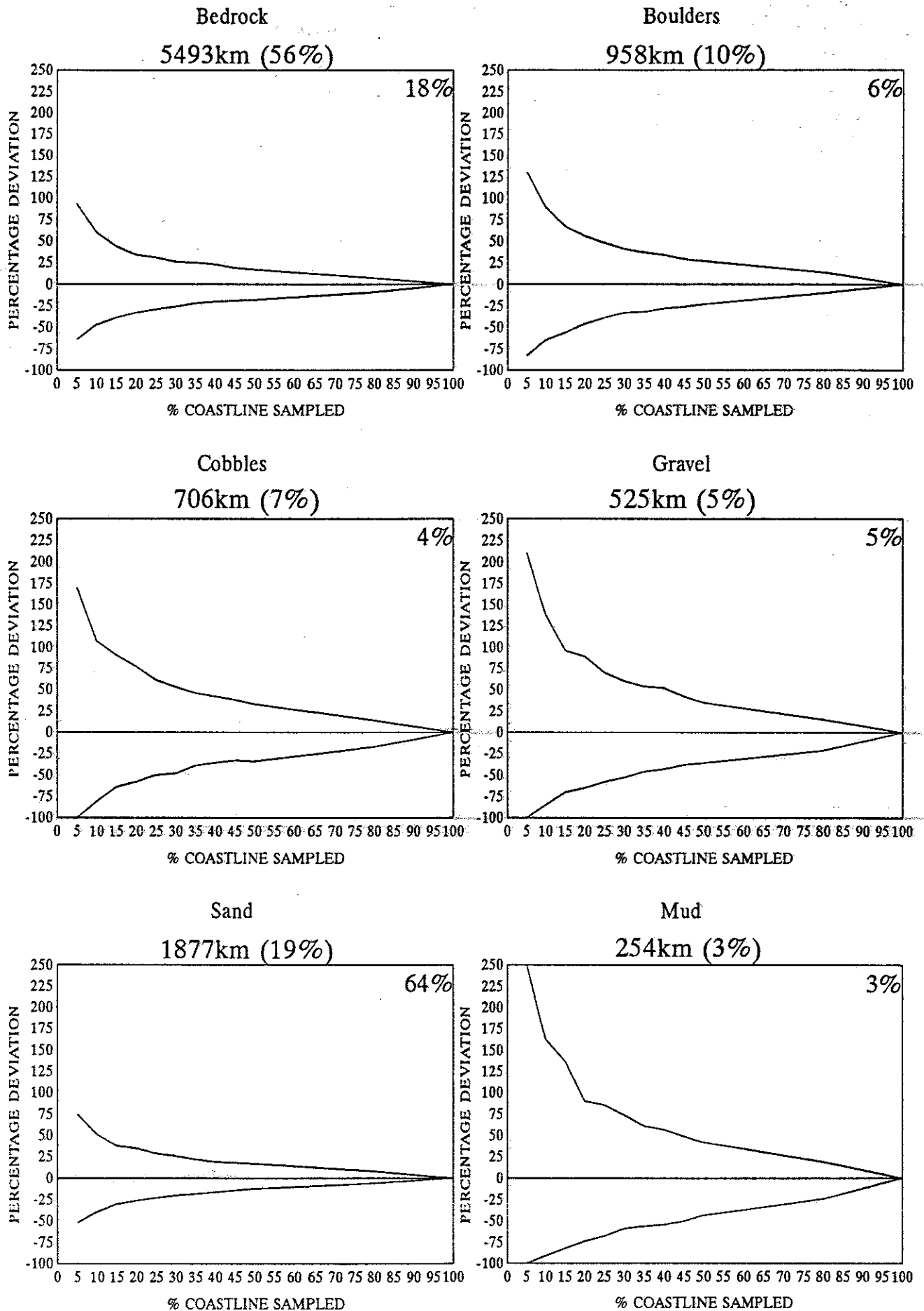**254km (3%)**

3%

PERCENTAGE DEVIATION

% COASTLINE SAMPLED

Figure 3.2.1 The effect of varying the proportion of habitat sampled on the percentage deviation from ⁺' population estimate of Ringed Plover. The percentage of Ringed ⌐   ₁N=15336) found on each habitat type is given.

TURNSTONE

Bedrock
5493km (56%)

50%

Boulders
958km (10%)

14.5%

Cobbles
706km (7%)

3%

Gravel
525km (5%)

3%

Sand
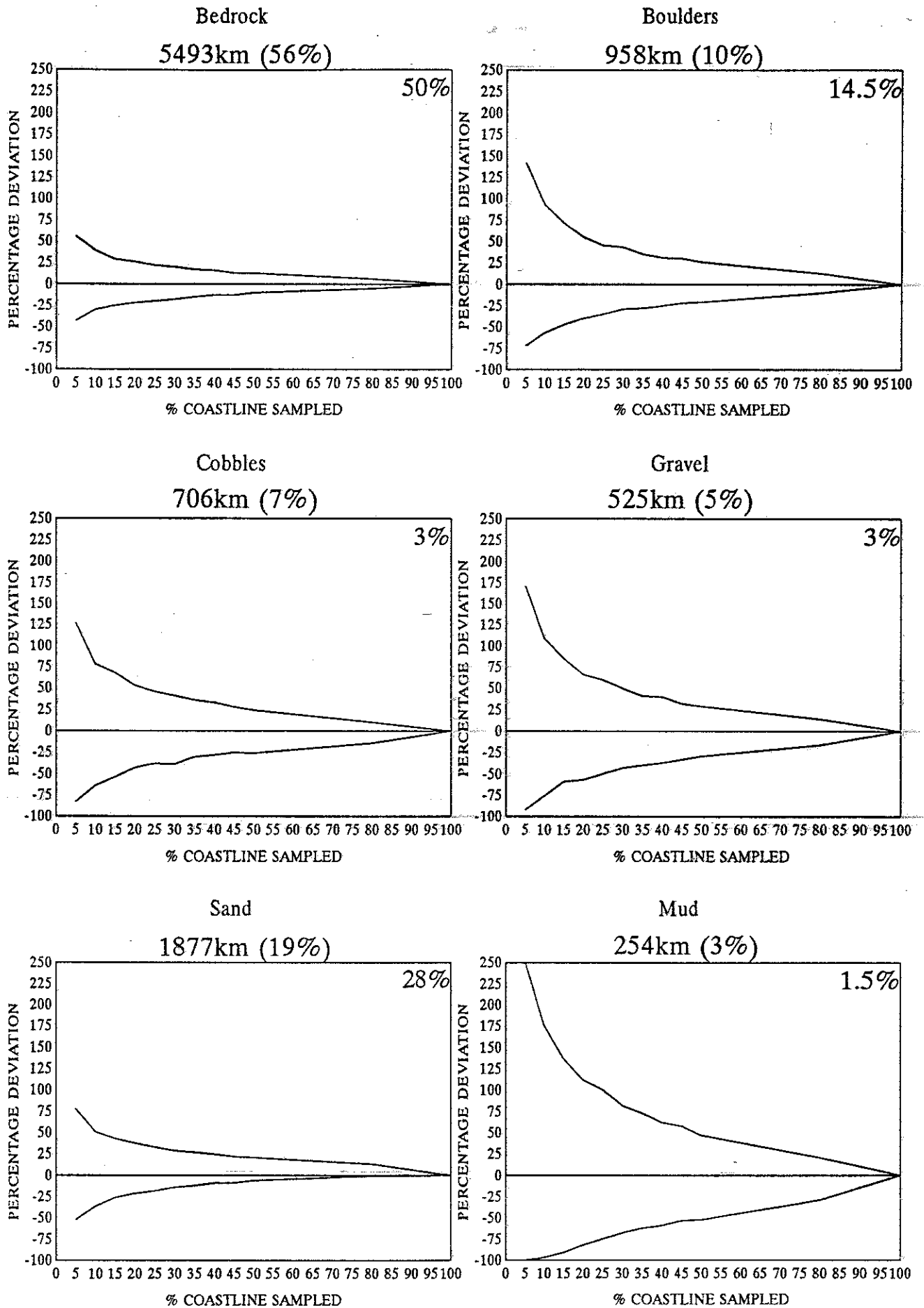### 1877km (19%)

28%

Mud
254km (3%)

1.5%

Figure 3.2.2 The effect of varying the proportion of habitat sampled on the percentage deviation from the population estimate of Turnstone. The percentage of Turnstone (N=8431) found on each habitat type is given.

SANDERLING

Bedrock
5493km (56%)

10%

Boulders
958km (10%)

2%

Cobbles
706km (7%)

<1%

Gravel
525km (5%)

<1%

Sand
1877km (19%)
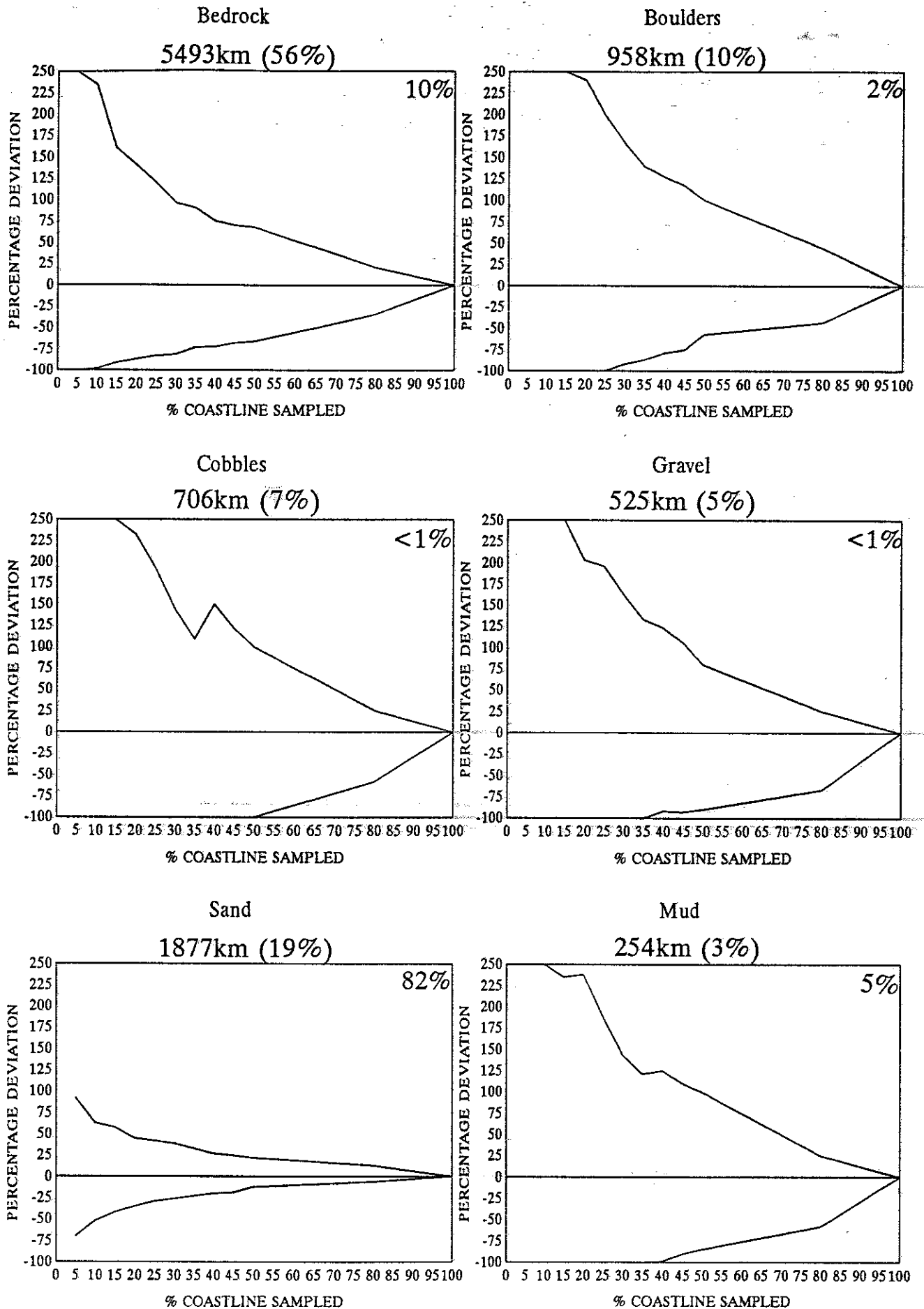

82%

Mud
254km (3%)

5%

Figure 3.2.3 The effect of varying the proportion of habitat sampled on the percentage deviation from the population estimate of Sanderling. The percentage of Sanderling (N=8431) found on each habitat type is given.

PURPLE SANDPIPER

Bedrock
5493km (56%)

Boulders
958km (10%)

Cobbles
706km (7%)

Gravel
525km (5%)

Sand
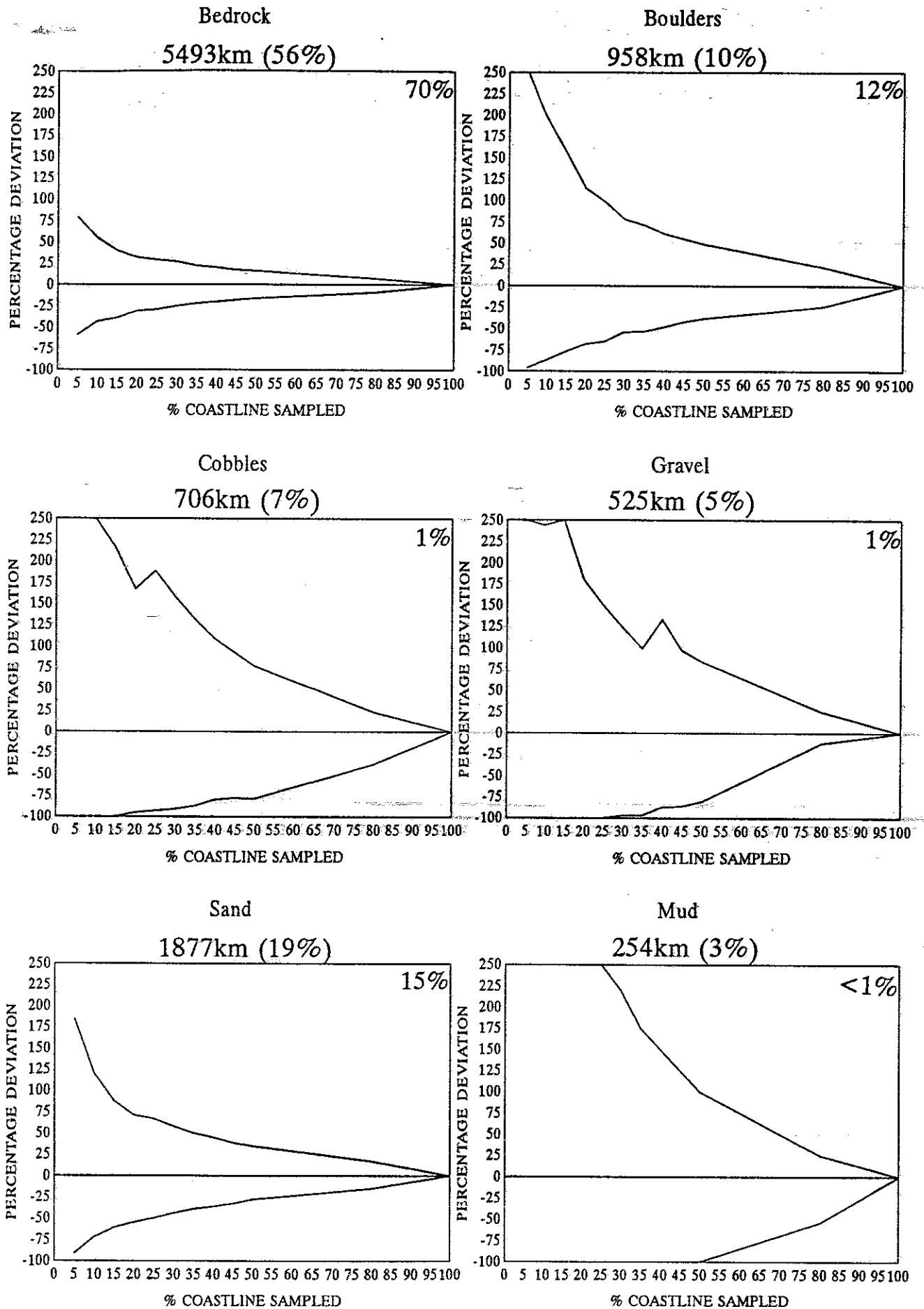## 1877km (19%)

Mud
254km (3%)

Figure 3.2.4 The effect of varying the proportion of habitat sampled on the percentage deviation from the population estimate of Purple Sandpiper. The percentage of Purple Sandpiper (N=8081) found on each habitat type is given.