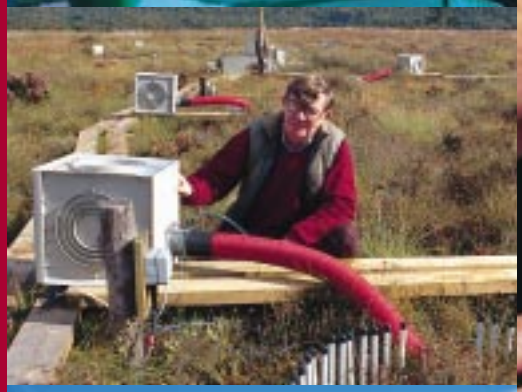
ENGLISH NATURE

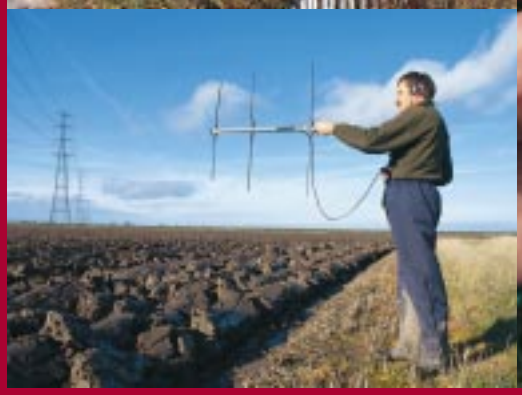
Report Number
589

Low tide survey of The Wash Special Protection Area

Final report of the winter 2002-2003 shorebird survey

English Nature Research Reports





working today
for nature tomorrow

English Nature Research Reports

Number 589

Low tide survey of The Wash Special Protection Area
Final report of the winter 2002-2003 shorebird survey

Mick Yates[1], Angus Garbutt[1], Ed Rispin[2] and Nigel Brown[1].

[1] CEH Monks Wood [2] CEH Dorset

ISSN 0967-876X

Intellectual Property Rights

Confidentiality Statement

'In accordance with our normal practice, this report is for use only of the party to whom it is addressed, and no responsibility is accepted to any third party for the whole or any part of its contents. Neither the whole nor any part of this report or any reference thereto may be included in any published document, circular or statement, nor published of referred to in any way without our written approval of the form and context in which it may appear.'

Acknowledgements

We gratefully acknowledge the permission given by the Commanding Officers of RAF Wainfleet and RAF Holbeach to access the RAF ranges on the Wash and to landowners for allowing us to cross their land to access the intertidal flats. It is a pleasure to acknowledge the staff of Eastern Sea Fisheries Joint Committee for providing safe access to the outer banks and both Essex and Suffolk Water Company and Black and Veatch Consulting Ltd (formerly Binnie, Black and Veatch) for allowing us to use data acquired as part of the study to monitor the Denver Licence Variation.

Summary

This report describes the methods used and the results of low tide surveys of shorebirds and wildfowl feeding and roosting on the intertidal mud- and sand-flats of the Wash Special Protection Area (SPA) made during winter 2002-03.

The entire area of intertidal mud- and sand-flats was surveyed at low tide and the numbers and distribution of feeding waders (Charadrii) and shelduck *Tadorna tadorna* and roosting wildfowl, sea ducks and waders were recorded and mapped. This is the first time any such survey has included all the intertidal mud- and sand-flat areas, previous ones having been confined to either the inner banks alone, or to the inner banks plus parts of the outer banks of the Wash.

Of the feeding birds, knot *Calidris canutus* were the most abundant. All species fed on both the inner and outer banks of the Wash apart from shelduck, ringed plover *Charadrius hiaticula* and black-tailed godwit *Limosa limosa* which occurred only on the inner banks. Golden plover *Pluvialis apricaria* was the most abundant wader roosting on the intertidal flats, while brent goose *Branta bernicla* spp *bernicla* was the most abundant of the wildfowl species and eider *Somateria mollissima* the most abundant sea-duck. All of the roosting birds were recorded on inner bank areas with the exception of a small number of eider that occurred on the outer banks.

Total numbers recorded in the low tide survey were compared with the WeBS high tide counts of the Wash made over the same time period as the low tide survey. Of the feeding birds, the numbers of shelduck, knot, dunlin, curlew and redshank recorded at low tide were very similar to those recorded at high tide. Fewer oystercatchers were recorded at high tide than at low tide while, in contrast, more ringed plover, grey plover, sanderling, black- and bar-tailed godwits and turnstone were seen at high than at low tide though the discrepancies in numbers of these species could be accounted for by anecdotal evidence with the exception of black-tailed godwit and grey plover. The correspondence between the numbers of roosting wildfowl, sea ducks and waders recorded at low tide and in the WeBS counts was expected to be poorer because not all species feed or roost within the area covered by either method. Even so there were good correspondences in the numbers for wigeon *Anas penelope*, mallard *Anas platyrhynchos*, eider and golden plover. Overall, the excellent correspondence between the low tide and the WeBS counts of the majority of the feeding wader species is particularly note worthy. It is very reassuring, given the size of the Wash and the differences between the methodologies, that the two estimates of the numbers using the Wash were so similar.

Comparisons were made between the current survey and four low tide surveys made of the inner banks of the Wash over the period 1985-1992 for shelduck and the seven most numerous waders that fed on the intertidal areas. The numbers of oystercatchers *Haematopus ostralegus*, grey plover *Pluvialis squartarola* and knot were all lower in the current survey than they had been in any of the previous ones while those of the remaining species were within the ranges previously recorded. No species was more numerous in the current survey than it had been in any of the previous ones.

At a Wash-wide scale, the distribution of the birds in the current survey showed little change from that in previous surveys. Indeed the most notable feature was the constancy in distribution. At a more local scale (1 km) some changes were apparent. These were probably

related to variations in abundance and distribution of the birds' invertebrate prey and to the normal process of sediment accretion at upper levels of the shore.

Comparisons were also made between the low tide surveys of the inner bank intertidal areas of the Wash as well as those adjacent to the river Great Ouse outfall that have been made from 1997 and both the WeBS Wash counts and UK index over the same period. The purpose of these comparisons was to put the annual changes in numbers recorded in these low tide surveys into a whole Wash and national perspective.

Changes in shelduck, oystercatchers and knot on the inner banks of the Wash, in the whole Wash and nationally were generally rather similar while the pattern of change in the remaining five wader species on the inner banks of the Wash differed either from those in the whole Wash or nationally or both. Generally the pattern of annual change in the Great Ouse study area, the whole Wash and nationally was similar for oystercatcher, grey plover, knot, dunlin, curlew and, to a lesser extent, redshank. Changes in shelduck and bar-tailed godwit numbers on the other hand varied more. This suggests that annual variations in numbers of some, but not all, species in the Great Ouse area is indicative of variations in the whole Wash and in turn in national numbers. There was evidence that the Great Ouse area is a preferred feeding area of bar-tailed godwit.

Contents

List of tables

List of figures

1. Introduction

The Wash is a large embayment on the east coast of England which, in winter, supports internationally important numbers of shorebirds. These shorebirds have been counted at their high tide roosts by the Wetland Birds Survey (WeBS) since 1975 and although these counts are invaluable in monitoring the numbers over-wintering on the Wash, they can provide only a limited indication of how, and in what numbers, the birds are distributed on their low tide feeding areas. Such information can only be determined by low tide surveys of the intertidal areas. Parts of the Wash have been surveyed at low tide in the past (Goss-Custard, and others. 1977, Goss-Custard, and others. 1988 and Yates, and others. 1996), but there have been no surveys of the entire intertidal area. Legislation to implement the European Union Habitats Directive now requires that such surveys are conducted in order to establish an up to date baseline against which any futures changes can be compared.

As a consequence, this study had the following objectives:

i. to establish an up to date baseline dataset of the numbers and distribution of the internationally important assemblages of non-breeding shorebirds in the Wash SPA to fulfil the condition monitoring requirements of the EU Habitats Directive.

ii. to compare this data with that acquired in previous low tide surveys of parts of the Wash and with high water roost counts that are made as part of the Wetland Birds Survey (WeBS).

In this report we describe the methods used and the results of low tide surveys of shorebirds and wildfowl feeding and roosting on the intertidal mud- and sand-flats of the Wash Special Protection Area (SPA) made during winter 2002-03. We compare the results with those of WeBS counts made during the same period, with those of four other low tide surveys of the inner banks of the Wash made by ourselves in winters 1985-7 (Goss-Custard, and others. 1988) and 1989-90, 1990-91 and 1991-92 (Yates, and others. 1996) and with those of surveys of the intertidal areas adjacent to the River Great Ouse outfall to the Wash that are undertaken as part of Essex and Suffolk Water Company's Denver Licence Variation (Binnie, Black and Veatch, 1997).

The results of this survey provide the first dataset that includes both bird numbers and distribution on the entire intertidal mud- and sand-flat area. Previous surveys have been confined to only parts of the Wash (Goss-Custard, and others. 1976, Yates and Goss-Custard, 1991 and Yates, and others. 1996). In so doing it will enable English Nature to implement the condition monitoring requirements for the Wash and North Norfolk Coast European marine site that are required by the EU Habitats Directive.

2. Methods

2.1 Survey methods

All areas were surveyed during spring tide periods, when on the Wash, low tide occurs around midday. We used the same survey methodology we had developed in our earlier low tide surveys (Yates and Goss-Custard, 1991 and Yates, and others. 1996). This involved the

surveyor walking an area of approximately 6km^2 during the period 2 hr before low tide to 2 hr after low tide and, with the aid of a telescope, counting and mapping the distribution of shorebirds. Counts were not made when the horizontal visibility was less than 1.5km, or in driving rain when it was difficult to keep the optics of the telescopes clear. Nor were counts made when the wind-speed exceeded force 7 on the Beaufort scale (>60kph) because experience had shown that in such conditions birds tended to shelter in the saltmarsh and in the lee of creek banks rather than feed on their normally preferred areas on the flats.

The route the surveyor took within a count area was determined primarily by the bird's distribution and chosen to minimise disturbance. The field maps that were used were drawn from recent aerial photographs so that the surveyor could safely negotiate the area and map the bird distribution accurately. Topographical features like creeks and variations in sediment and other surface features were usually sufficient to allow accurate mapping, but occasionally it was necessary to use hand-held GPS receivers to aid recording the birds' location. In most instances birds were counted individually but where there were more than a thousand of a single species in a tightly packed flock, for example flocks of roosting golden plover *Pluvialis apricaria* or feeding knot *Calidris canutus*, they were counted in multiples of five or ten.

Outer banks areas were accessed by boat and surveyed using the same survey method with only two slight modifications. First, the survey period was reduced to one and a half hours either side of low tide because the lower level of the outer banks meant they uncovered later on the ebb tide and covered earlier on the flood than the inner bank areas. Second, it was found that some smaller outer bank areas (for example, Thief Sand, Styleman's Middle and Blackguard Sand, Figure 2.1) could be viewed in their entirety from the elevated viewpoint provided by the anchored vessel making it unnecessary to survey on foot.

2.2 Areas surveyed

The intertidal mud- and sand-flat areas covered by our survey extended from the River Steeping, located to the south of Gibraltar Point on the Lincolnshire coast to Holme-next-the Sea on the north Norfolk coast and included all the outer banks within the Wash except for Outer Dogs Head (Figures 2.1 and 2.2). Saltmarsh areas were not surveyed as they required a totally different survey method that could not be implemented simultaneously with that used for the mud- and sand-flats.

2.3 Sequence in which areas were surveyed

Having established in our earlier surveys, by surveying adjacent areas on consecutive days, that there was little day to day variation in bird distribution, we were again able to adopt a stratified random procedure for the chronological sequence in which areas were visited. Areas were defined as those that could be surveyed by either two or three surveyors working side by side. Then, those areas to which access was restricted to weekends and public holidays were grouped in one stratum and the remaining areas in another. The sequence in which areas were visited was then randomised within each stratum. The only exception to this procedure involved the outer banks areas which had to be visited on days when boat access was available. Table 2.1 summarises the sequence of visits. Each area was visited once during the course of the survey.

Table 2.1 **The chronological sequence in which intertidal areas were surveyed. Refer to Figure 2.1 for the location of the areas.**

Survey week	Dates	Areas surveyed
1	15/11/02 17/11/02 18/11/02 19/11/02 20/11/02 21/11/02	Breast Sand downshore of Inner Trial Bank and Ongar Hill, Wainfleet Sand and Friskney Flats north, Leverton, Wrangle Flats, Butterwick north and Freiston, Black Buoy Sand, Snettisham and Stubborn Sand.
2	1/12/02 2/12/02 3/12/02 4/12/02 5/12/02 6/12/02	Maretail and Old South Middle, Friskney Flats south and Skullridge, Bulldog Sand, Peter Black Sand south and Heacham south beach, Gat Sand and Dawsmere east, Peter Black Sand north and Ferrier Sand, The Puff and Dawsmere
3	17/12/02 18/12/02 19/12/02 20/12/02	Hull Sand and Breast Sand east, Flats surrounding Outer Trial Bank and Breast Sand west, Butterwick, Daseley's Sand and Pandora Sand south.
4	30/12/02 31/12/02	Dawsmere west, Heacham north beach and South Sunk Sand.
5	1/02/03 3/02/03 5/02/03 6/02/03	Old South west, Roger/Toft Sand, Seal Sand and Thief Sand, Long Sand, The Ants and Inner Dogs Head.
6	17/02/03 18/02/03	Pandora Sand north, Blackguard Sand south and Styleman's Middle, Blackguard Sand north and Sunk Sand.
7	28/02/03	Hunstanton south to Holme-next-the-Sea.

2.4 Data transcription and collation

Field notes and maps were reviewed daily so surveyors could confer and address any queries and the bird numbers could be transcribed into digital files. Following each week of surveying, distribution maps were entered into digital form using Arcview GIS software by on-screen digitizing of mapped data and by linking the digital files containing bird numbers. This process was subject to quality assurance procedures whereby one surveyor checked the entries of another to ensure accuracy.

3. Results and discussion

In this section we present the results of the 2002-03 survey as tabulated data and, for the most numerous species, as maps showing their distribution in the Wash. We compare the numbers recorded with those for the whole Wash determined by WeBS counts made during the same period. We also compare the current survey's data with those of our four previous low tide surveys of the Wash and discuss possible reasons for any changes, as well as considering the low tide survey data collected as part of Essex and Suffolk Water Company's Denver Licence Variation monitoring study.

3.1 Bird numbers recorded in the 2002-03 low tide survey of the Wash

We have divided the birds into two groups that reflect their use of the intertidal areas. The first included shelduck and the 11wader species that were recorded feeding on the intertidal areas and the second group, the wildfowl, sea-ducks and waders that were recorded resting or roosting on those areas.

3.1.1 Feeding shelduck and waders

Of the feeding waders, knot was the most abundant and ringed plover the least so (Table 3.1). Apart from shelduck, ringed plover and black-tailed godwit which were recorded only on the inner, all species fed on both the inner and outer banks of the Wash. Of the total number recorded, 93% of the redshank, 88% of the dunlin and between 73% and 80% of the oystercatchers, grey plover, knot, bar-tailed godwit, curlew and turnstone were seen feeding on the inner banks. As the inner banks account for approximately 75% of the total area of mud- and sand-flats that are exposed at low water of ordinary spring tides it would appear that the latter six species were distributed between the inner and outer banks in proportion to the area available. Sanderling was the only species that was more numerous on the outer banks than on the inner ones, only 26% of the total being recorded on the inner banks.

3.1.2 Roosting wildfowl, sea-ducks and waders

Golden plover was the most abundant wader species roosting on the intertidal areas, while brent goose was the most abundant of the wildfowl species and eider the most abundant sea-duck (Table 3.2). All of the roosting birds were recorded on inner bank areas, or along the tide line of them, with the exception of a small number of eider that occurred on the outer banks.

Table 3.1 The numbers of feeding shelduck and waders recorded in the 2002-03 low tide survey of the Wash. (Number in parenthesis is the low tide count expressed as percentage of the WeBS total)

Bird species	BTO code	Inner banks	Outer banks	Whole Wash low tide total	Whole Wash WeBS total
Shelduck (*Tadorna tadorna*)	SU	7234	0	7234 (118)	6140
Oystercatcher (*Haematopus ostralegus*)	OC	14,459	5274	19,733 (126)	15,665
Ringed plover (*Charadrius hiaticula*)	RP	19	0	19 (19)	100
Grey plover (*Pluvialis squatarola*)	GV	1728	433	2161 (37)	5880
Knot (*Calidris canutus*)	KN	29,257	10,927	40,184 (103)	39,167
Sanderling (*Calidris alba*)	SS	25	70	95 (27)	354
Dunlin (*Calidris alpina*)	DN	21,863	2939	24,802 (98)	25,290
Black-tailed Godwit (*Limosa limosa*)	BW	304	0	304 (14)	2115
Bar-tailed Godwit (*Limosa lapponica*)	BA	4167	1266	5433 (44)	12,338
Curlew (*Numenius arquata*)	CU	1915	517	2432 (105)	2320
Redshank (*Tringa tetanus*)	RK	2412	186	2598 (107)	2424
Turnstone (*Arenaria interpres*)	TT	142	35	177 (43)	411

Table 3.2 **The numbers of roosting wildfowl, sea ducks and waders recorded in the 2002-03 low tide survey of the Wash. (Number in parenthesis is the low tide count expressed as percentage of the WeBS total)**

Bird species	BTO code	Inner banks	Outer banks	Whole Wash low tide total	Whole Wash WeBS total
Brent goose (*Branta bernicla* ssp *bernicla*)	DB	2953	0	2953 (21)	13,859
Wigeon (*Anas penelope*)	WN	2291	0	2291 (62)	3662
Teal (*Anas crecca*)	T	60	0	60 (5)	1312
Mallard (*Anas platyrhynchos*)	MA	1257	0	1257 (75)	1670
Pintail (*Anas acuta*)	PT	116	0	116 (28)	412
Scaup (*Aythya marila*)	SP	194	0	194 (9700)	2
Eider (*Somateria mollissima*)	E	1700	36	1736 (154)	1125
Scoter (*Melanitta nigra*)	CX	23	0	23 (12)	199
Red-breasted merganser (*Mergus serrator*)	RM	5	0	5 (14)	35
Golden plover (*Pluvialis apricaria*)	GP	16,670	0	16,670 (137)	12,150
Lapwing (*Vanellus vanellus*)	L	11,171	0	11,171 (44)	25,290

3.1.3 Comparisons with WeBS counts data

The main purpose of both WeBS counts and low tide counts is to estimate the numbers of birds that feed on the intertidal areas. Given that both methods differ markedly and are subject to error, and that neither estimate is necessarily more correct than the other, comparisons between the two are of particular value. This is because good correspondence stimulates confidence in the methodologies, while poor correspondence highlights the need for supplementary observations or reassessment of methods to account for discrepancies (Yates and Goss-Custard, 1991).

We compared the means of the November and December 2002 and January and February 2003 total WeBS counts of the Wash from Gibraltar Point to Hunstanton with low tide survey counts. Correspondence between counts of shelduck and feeding waders was expected to be good because they feed solely on the inter-tidal areas and roost in areas covered by the WeBS counts. On the other hand, we thought it unlikely that counts of roosting wildfowl, sea-ducks and waders would correspond as well because their feeding areas extend well beyond those surveyed on the intertidal flats and their roost sites probably extend beyond those areas covered by the WeBS counts.

These expectations were indeed met (Tables 3.1 and 3.2). Correspondence between low tide and WeBS numbers of shelduck, oystercatcher, knot, dunlin, curlew and redshank inter-tidal was extremely good (Table 3.1), particularly in the case of the latter four species where the difference was less than 8%. The fact that around 4000 fewer oystercatchers were recorded in the WeBS counts can be accounted for by an uncounted roost that forms on the outer trial bank located on Breast Sand. We know from the low tide survey that some 3500 oystercatchers feed within 1.5k of the trial bank and are likely to roost there at high tide. The discrepancy in turnstone numbers can probably be accounted for by those that are known to feed at low in the vicinity of the port at Sutton Bridge (Smart and Gill, 2003). Far fewer ringed plover and sanderling were recorded in the low tide survey than in the WeBS counts

and we think the most likely explanation for this is that, because they are small birds that feed singly or in small groups, they may have been overlooked in the low tide survey. However, such an explanation is unlikely to apply to there being fewer grey plover, black-tailed and bar-tailed godwits recorded at low tide than in the WeBS counts. These species are too large, too numerous and in the case of godwits, too aggregated in flocks when feeding, for them to have been overlooked in the low tide survey. Anecdotal evidence suggests that the discrepancy between bar-tailed godwit counts could be explained by birds occurring in the roost sites on the east Wash that are thought to feed outside the Wash, probably along the North Norfolk coast (J. Scott, RSPB Snettisham, personal communication). We cannot, however, offer an explanation for the discrepancies in the numbers of grey plover and black-tailed godwit.

As was expected the correspondence between the low tide and WeBS counts of the roosting wildfowl, sea-ducks and roosting waders was poorer (Table 3.2) than those for feeding shelduck and waders. However, there were some encouraging agreements between counts of, for example, wigeon, mallard, eider and golden plover.

3.2 Bird distribution in the 2002-03 survey

We have summarised bird distribution in two ways. First, individual maps that show the location of the groups in which the species was recorded with the numbers present categorised as low, medium and high in the legend are presented (Figure 3.1a-k and Figure 3.2a-f) for feeding birds and roosting birds respectively. Second, the numbers of each species occurring in each of 75, 1km wide contiguous transects shown in Figure 3.4 and on individual outer bank areas are tabulated (Appendix 1) to give an indication of the along-shore distribution in numbers around the Wash. These transects were aligned in a shore normal direction (ie perpendicular to the marsh edge) which meant that in three areas of the Wash transects overlapped to accommodate changes in the direction of the shore line. The numbers of birds within each transect was determined by overlaying transect divisions on the bird distribution maps and allocating the bird groups to the appropriate transect. Where a bird group spanned transect boundaries it was assumed that the birds were evenly distributed within the group and their numbers were allocated to a transect in relation to proportion of the area group falling within each transect. If a bird group was located where transects overlapped the birds were allocated to both transects.

For the feeding birds we also comment on the association between their distribution and that of their main invertebrate prey species which was determined most recently in surveys made in 1998 and 1999 for English Nature (Yates, and others. 2002).

3.2.1 Feeding shelduck and waders

Shelduck (Figure 3.1a) fed on the muddier upper shore around the Wash and on mid and lower shore areas only where muddy sediments predominated, for example on Black Buoy Sand on the south-west side, Breast sand on the south-east side on Bulldog Sand on the east side. Their distribution was particularly associated with that of their prey, oligochaete worms and the mollusc, *Hydrobia ulvae*. They were most numerous on the south-west side of the Wash (Appendix 1).

Oystercatcher (Figure 3.1b) fed on the mid and lower shore areas and on the outer banks, where in the majority of cases their distribution was associated with that of their main prey,

the cockle (*Cerastoderma edule*). Only those groups on Gat, Roger/Toft and Hull Sand were associated with mussel beds. They were absent from a large area of the east side of the Wash spanning Bulldog and Peter Black Sand. There were particularly large numbers of oystercatcher on areas of Breast Sand adjacent to the River Nene outfall, on the outer banks Gat and Daseley's Sand and on Stubborn Sand.

Grey plover (Figure 3.1c) were widely distributed over mid and lower shore areas with the exception of Bulldog and Peter Black Sand on the east side where they occurred only at upper shore levels. None were recorded on Long Sand. On the predominantly sandy shore of the west side they were seen feeding on lugworm (*Arenicola marina*). They were particularly numerous on Friskney Flats, Roger/Toft Sand and Stubborn Sand.

Knot (Figure 3.1d) distribution was highly aggregated due in part to their feeding in large flocks. They were confined to Friskney Flats on the west side where flocks were recorded at all shore levels. On the south-west and -east sides they occurred at mid levels while on the east side and on the outer banks they fed at lower shore levels. Examination of shell fragments in their droppings suggested that in most areas they were feeding on cockle spat, though there was evidence of them feeding on *Macoma balthica* on areas of Black Bouy and Breast Sand. They were particularly numerous on the Puff area of the south-west side, on Stubborn Sand on the east side and along the northern tide-line of Seal Sand.

Sanderling (Figure 3.1e) were confined to the tide-line of inner bank areas on the west and east sides and to outer bank areas. Most were seen on Roger/Toft and Gat Sand.

Dunlin (Figure 3.1f) were widely distributed occurring at all shore levels except on Peter Black and Ferrier Sand where they occurred only at upper shore levels. None were recorded on Long Sand. They were particularly numerous on Black Bouy Sand, Breast Sand and Seal Sand.

Black-tailed godwit (Figure 3.1g) occurred in only two areas, the Puff area on the south-west side and on Bulldog Sand on the east side. They were most numerous on the latter area.

Bar-tailed godwit (Figure 3.1h) were widespread on the sandy mid and lower shore areas of the west, south-east and east sides and on the outer banks. Like grey plover, they were seen feeding on lugworm. They were most numerous on Friskney Flats, Stubborn and Roger/Toft Sand.

Curlew (Figure 3.1i) were very widespread occurring in all areas, except Long Sand, and on all levels of the shore. They were most numerous on Friskney Flats and Stubborn Sand.

Redshank (Figure 3.1j) occurred predominantly at lower shore levels, particularly on the sandy west side where they were concentrated at the mouths of the intertidal creeks and at upper shore levels adjacent to the saltmarsh. They were most numerous on Friskney and Wrangle Flats and Bulldog Sand. On the latter their distribution coincided with that of high densities of *Corophium*, a crustacean that is known to be a preferred prey of redshank.

Turnstone (Figure 3.1k) were sparsely distributed and occurred either along the tide-line or in association with mussel beds. Most were seen on the Puff area of the south-west side, by the east bank of the River Nene and mussel beds to the north of Hunstanton.

3.2.2 Roosting wildfowl, sea-ducks and waders

Brent goose (Figure 3.2a) was generally to confined upper shore areas adjacent to the saltmarsh on all sides of the Wash except the east. Few were recorded on the east side though, as elsewhere, they were seen roosting in the saltmarsh.

Wigeon (Figure 3.2b) were recorded roosting along the banks of or in intertidal creeks on most inner bank areas. The largest groups occurred on Wainfleet Sand on the west side, Black Buoy Sand on the south-west side and in Wolferton Creek on the east side.

Mallard (Figure 3.2c) like wigeon, roosted along the banks of intertidal creeks. The largest groups occurred on Skullridge on the west side, either side of the River Nene at Dawsmere and Breast Sand and along Wolferton Creek.

Eider (Figure 3.2d) were recorded along the tideline and in intertidal creeks of the west, south-west and -east sides and on Roger/Toft Sand. They were most numerous on the Friskney Flats, Skullridge and Wrangle Flats area of the west side.

Golden plover (Figure 3.2e) were recorded in low tide roosts on all sides of the Wash and occurred on the upper shore with the exception of one group that was recorded on the mid shore of Wainfleet Sand. They were most numerous on Wrangle Flats and Freiston on the west side, at Dawsmere on the south-west side, at Ongar hill on the south-east side and at Wolferton on the east side.

Lapwing (Figure 3.2f) like golden plover occurred on upper shore areas. They were most numerous on Friskney and Wrangle Flats and at Freiston on the west side, at Kirton and Dawsmere on the south-west side and on Bulldog Sand and at Wolferton on the east side.

3.3 Comparisons with previous low tide surveys of the Wash

In this section we compare the numbers and distribution of shelduck and the seven most numerous waders recorded in the current survey with those recorded in our low tide surveys of the Wash made in the winters 1985-7, 1989-90, 1990-91 and 1991-92. The inner bank areas extending from the River Steeping to Heacham south beach were covered by those earlier surveys so only those same areas are considered in these comparisons. They cover the intertidal area spanned by transects 1-66 in Figure 3.4.

As part of these comparisons we consider the low tide counts in relation to the whole Wash WeBS counts and the national index for the UK in order to put the annual changes in numbers recorded into a whole Wash and national perspective. We also consider the surveys of the inner bank areas adjacent to the river Great Ouse outfall (Figure 2.2) that have been made since winter 1997-98 as part of Essex and Suffolk Water Company's Denver Licence monitoring study. The objective of that on-going study is to determine any relationship between bird numbers and freshwater outflow into the Wash. A detailed analysis and review of that study is currently underway and will be reported elsewhere. Here we compared the Great Ouse surveys with the whole Wash WeBS counts and the UK index, again to put the annual changes in numbers recorded in the Great Ouse study area into both a whole Wash and national perspective.

3.3.1 Changes in total numbers on the inner banks

The numbers of oystercatchers, grey plover and knot were all lower in the current survey than they had been in any of the previous ones (Table 3.3), while those of the remaining species were within the ranges previously recorded. No species was more numerous in the current survey than it had been in previous ones. During the course of the 1989-1992 surveys all eight species had reached peak numbers in the area and only redshank numbers had attained a similar level in 2002-03.

Table 3.3 **The total numbers of feeding shelduck and seven wader species recorded on the inner bank areas of the Wash in low tide surveys made in winters 1985-87, 1989-90, 1990-91 and 1991-92 and in the current survey. The intertidal areas considered are those spanned by transects 1-66 in Figure 3.3.**

Species	Survey				
	1985-87	1989-90	1990-91	1991-92	2002-03
Shelduck	8168	8692	7607	6439	7234
Oystercatcher	14,231	13,151	16,727	16,743	12,915
Grey plover	1896	4403	4158	3303	1629
Knot	42,149	42,388	68,068	39,491	28,487
Dunlin	17,098	33,866	22,540	15,632	21,084
Bar-tailed godwit	2205	2676	3777	3568	2518
Curlew	1728	2113	1715	1525	1792
Redshank	1496	2260	2303	1226	2263

Comparisons between the low tide counts and both the whole Wash WeBS counts and the UK National index are shown in Figure 3.3. In all cases an index has been calculated by expressing total numbers in other years as a percentage of those in winter 1985-87. At the time of writing the WeBS UK index was not available for the winter 2002-03 so an estimate based on the average index for the winters 1996-97to 2000-01 was used.

Changes in shelduck, oystercatchers and knot on the inner banks of the Wash, in the whole Wash and nationally were generally rather similar. Having increased in the late 1980's, grey plover numbers on the inner banks have decreased relative to those in the whole Wash and nationally while the opposite occurred in bar-tailed godwit numbers. Dunlin numbers on the inner banks peaked in 1989 and then abruptly declined while in the whole Wash and nationally numbers continued to rise in 1990 but then declined. Curlew numbers on the inner banks showed a downward trend during 1989- 1991 whereas in the Wash and nationally numbers tended to increase. Both inner bank, whole Wash and national numbers of redshank varied similarly over the 1989-1990 period but the abrupt decline seen in the Wash in 1991 did not occur nationally.

3.3.2 Changes in distribution

We have summarised the changes in bird distribution by comparing the numbers of birds between the current survey and previous surveys in transects 1-66 (Figure 3.4). These comparisons give an indication of along-shore shifts in distribution between surveys.

Because the total numbers of birds in the Wash can vary annually, the numbers of birds within a transect in a given survey could change simply because bird numbers in the whole Wash had changed, rather than because there had been a change in along-shore distribution. To account for this we adjusted the numbers of each species to a base census which was our 1985-87 survey of the inner banks. The formula used was:

Annually adjusted number in a transect in year i = number in transect x (N/N_i)

Where N is the total number recorded in the base year and N_i is the total recorded in year i.

For each species, the annually adjusted numbers from our previous four surveys were averaged and then plotted against the adjusted numbers for the current survey (Figure 3.5a-h) to enable graphical comparison and the detection of local shifts in distribution around the Wash. Correlation analyses were also made on these data (Table 3.4) to give an indication of the similarity, or otherwise, of the Wash-wide scale of distribution.

Shelduck distribution in the 2002-03, though significantly correlated (p=0.048) with that averaged over the four previous surveys (Table 3.4), showed some changes (Figure 3.5a). Fewer birds were recorded on the mid region of the east shore spanned by transects 57-60 and on areas adjacent to the west bank of the Great Ouse than in the previous surveys.

Oystercatcher distribution in 2002-03 was highly correlated with the previous surveys (Table 3.4) over the inner banks. There was however a notable shift in its distribution on the west side of the Wash where the peak numbers shifted southwards from Friskney Flats (transects 5-7) to Wrangle Flats (transects 14&15). Elsewhere in the Wash, there was little change though the peak concentration in 2002-03 was in transect 46 to the east of the River Nene (Figure 3.5b). As was mentioned in section 3.2.1 this shift in distribution is most likely the result of changes in cockle abundance.

Grey plover distribution correlated well with that in previous surveys and showed little change on the south-east and east sides (Figure 3.5c). On the west side there had been a northward shift, while on the south-west side peak numbers occurred in the mid region in 2002-03 having been nearer the eastern and western extremities in previous surveys.

Knot distribution in 2002-03 correlated well with previous surveys and was particularly similar on the west, south-west and east sides (Figure 3.5d). On the south-east side there had been a westward shift in their distribution towards the Nene outfall.

Dunlin distribution was highly correlated with that in previous surveys (Figure 3.5e) which would, in part, be expected due to this species' widespread distribution in the Wash. On the mid region south-east side there was notable peak in numbers, elsewhere their distribution was very similar to that in the previous surveys.

Table 3.4 **Correlations between the annually adjusted numbers of birds in 66, 1km wide transects in the 2002-03 survey and the mean of those in the 1985-87, 1989-90, 1990-91 and 1991-92 surveys**

Species	Correlation coefficient	p value
Shelduck	0.244	0.048
Oystercatcher	0.66	<0.0001
Grey plover	0.38	0.002
Knot	0.393	0.001
Dunlin	0.509	<0.0001
Bar-tailed godwit	0.71	<0.0001
Curlew	0.417	<0.0001
Redshank	0.521	<0.0001

Bar-tailed godwit distribution was the best correlated with that in previous surveys of any of the species considered. There were only small local shifts in its distribution on the west and south-west sides (Figure 3.5f).

Curlew distribution was highly correlated with that in previous surveys over the inner bank area. Local shifts in distribution occurred on the south-west, -east and east sides (Figure 3.5g) where fewer birds on areas adjacent to the west bank of the Nene (transects 39-43) and either side the Great Ouse (transects 53-60).

Redshank distribution was also highly correlated with that in previous surveys. The main shifts occurred on the south-west side where fewer birds were recorded in the mid region and on the east side where the peak in distribution occurred on Bulldog Sand (transects 57-59) as opposed to on Stubborn Sand (transects 65&66) in previous surveys (Figure 3.5h).

3.3.3 The Great Ouse study area surveys

Two low tide surveys have been made of the Great Ouse study over the same November-February winter period every year since 1997. We compared the mean numbers of shelduck and the seven wader species considered in the previous section in these two surveys with the total Wash WeBS count for each winter to determine if relative changes in numbers in the Ouse area were similar to those in the whole Wash. We did this by expressing the 1997-98 to 2001-02 counts as a percentage, or index, of the 2002-03 counts for each data set (Figure 3.6). We also compared these indices with the UK index. Generally the pattern of annual change in the Great Ouse area, the Wash and nationally was similar for oystercatcher, grey plover, knot, dunlin curlew and, to a lesser extent, redshank, with the upward trends in grey plover being particularly similar. Changes in shelduck and bar-tailed godwit numbers on the other hand varied differently between the Great Ouse area and the Wash. In shelduck there was a downward trend in the Wash WeBs counts during the 1997-2003 period, whereas there was an upward trend in the Great Ouse ones, while in bar-tailed godwit there was an upward trend in Wash numbers until 2000 followed by a downward trend to 2002 but the opposite applied to their numbers in the Great Ouse. In both instances the changes in the Great Ouse area tended to reflect those in the national index. This suggests that annual variations in numbers of some, but not all, species in the Great Ouse area is indicative of variations in the whole Wash and that the Great Ouse area may be a preferred feeding area within the Wash.

It is known that intraspecific competition for food often causes birds to move from preferred feeding areas to less favoured and less competed areas, when the overall population size is high and thus competition between birds is more intense. By the same token, when overall numbers are low, most birds can feed in the few most preferred areas. So, as total numbers in an area such as the Wash increases and the birds spread out into more of the less favoured feeding areas, the proportion of the total numbers in an area may decrease if it is a preferred area, or increase if it not a preferred area. In the case of the Great Ouse area, this process would lead to the proportion of the birds in the area either increasing as the total Wash numbers increased if it was less favoured or decreasing if it was preferred.

We looked for evidence of this process by comparing the numbers in the Great Ouse areas, expressed as a percentage of the WeBS, with the total WeBS Wash count for each species (Figure 3.7). There was indeed statistically significant evidence of the Great Ouse area being a preferred feeding area for bar-tailed godwit as the proportion in the Great Ouse area declined as the total Wash numbers increased ($y = 25.8 – 0.0015x$, $p = 0.03$ $R^2 = 65\%$). The proportions of shelduck, oystercatcher and knot also showed similar declines though none was statistically significant.

4. General comments and conclusions

Perhaps the most notable feature of the Wash-wide distribution of birds feeding on the inner banks is its constancy. Certain areas, for which we use the term ‘bird-rich core areas’ are always occupied by large numbers of many species, for example on Friskney and Wrangle Flats, Maretail,and Breast and Stubborn Sands whereas some other areas are little used by any species, for example much of Peter Black Sand. This statement is true of all the surveys we have performed (Goss-Custard, and others. 1988 and Yates, and others. 1996) as well as the one performed in the 1970’s (Goss-Custard, and others. 1977). Both types of area occur at mid and lower shore levels and their locations have remained relatively unchanged. We have summarised graphically the location and extent of the ‘core’ areas in Figure 3.8 by combining all previous low tide survey data along with that from the current survey. Clearly, these bird-rich areas must have abundant densities of the birds’ invertebrate prey which in turn suggests that the sediments and hydrodynamics must also be favourable and relatively stable, at least over a time scale of decades. What is more, many of them either span intertidal creeks down which water is pumped from agricultural land (Figure 3.8) at times of high rainfall or are adjacent to river outfalls and it is possible that the input of freshwater may also influence their attractiveness as feeding areas as was suggested in work on the estuaries of Suffolk and Essex (Ravenscroft and Beardall, 2003). In contrast to ‘core’ areas, little used areas tend to have coarser sediments and impoverished invertebrate fauna, due, we presume, to greater and less stable hydrodynamic forces acting upon them.

Localised changes have occurred over the period of our surveys. Many, we suspect, reflect annual variations in invertebrate abundance to which the birds respond, indeed many of the shifts in distribution noted in section 3.3.2 may be due to such variation. In some, the normal accretionary processes of increased muddiness, rise in bed level, de-watering of sediment and ultimately the sea-ward progression of saltmarsh vegetation at upper shore levels, has probably led to some of the shifts in bird distribution. For example, the occurrence of fewer shelduck on the mudflats to the west of the Great Ouse in the current survey (Figure 3.5a) is probably due to the area having accreted so much that the mud is now hard and compacted making it unsuitable for them to feed.

Finally, the excellent correspondence between the low tide and the WeBS counts of the majority of the feeding wader species we considered is particularly note worthy. It is very reassuring, given the size of the Wash and the differences between the methodologies, that the two estimates of the numbers using the Wash are so similar.

5. References

BINNIE, BLACK, & VEATCH. 1997. Denver Licence Variation 1st Monitoring Group Meeting, Agenda and Reports. Redhill: Binnie, Black and Veatch.

GOSS-CUSTARD, J.D., JONES, R.E., & NEWBERRY, P.E. 1977. The ecology of the Wash. 1. Distribution and diet of wading birds (Charadrii). *Journal of Applied Ecology*, 14, 681-700.

GOSS-CUSTARD, J.D., YATES. 1988. *Wash birds and invertebrates*. London: ITE Report to the Dept of Environment.

POLLITT, M.S., and others. 2003. *The Wetland Bird Survey 2000-01 Wildfowl and Wader Counts*. Slimbridge: BTO/WWT/RSPB/JNCC.

RAVENSCROFT, N.O.M., & BEARDALL, C.H. 2003. The importance of freshwater flows over estuarine mudflats for wintering waders and wildfowl. *Biological Conservation*, 113, 89-97.

SMART, J., & GILL J.A. 2003. Non-intertidal habitat use by shorebirds: a reflection of inadequate intertidal resources? *Biological Conservation*, 111, 359-369.

YATES, M.G., & GOSS-CUSTARD, J.D. 1991. *A comparison between high water and low water counts of shorebirds on the Wash, east England*. Bird Study, 38, 179-187.

YATES, M.G., GOSS-CUSTARD, J.D., & RISPIN, W.E. 1996. Towards predicting the effect of loss of intertidal feeding areas on overwintering shorebirds (Charadrii) and shelduck (*Tadorna tadorna*): refinements and tests of a model developed for the Wash, east England. *Journal of Applied Ecology*, 33, 944-954.

YATES, M.G., GARBUTT, R.A., BARRATT, D.R., TURK, A., BROWN, N.J., RISPIN, W.E., MCGRORTY, S., LE V DIT DURELL, S.E.A., GOSS-CUSTARD, J.D., MURRAY, E. & RUSSELL, D. 2002. Littoral sediments of the Wash and north Norfolk Coast SAC: The 1998 and 1999 surveys of intertidal sediments and invertebrates. *English Nature Research Reports,* No. 470**,** 154.

List of figures

1990-91 and 1991-92. The vertical dashed lines indicate the outfalls of the rivers Witham/Welland, Nene and Great Ouse that separate the sides of the Wash as in Figure 3.3.
a, Shelduck,
b, Oystercatcher,
c, Grey plover,
d, Knot,
e, Dunlin,
f, Bar-tailed Godwit,
g, Curlew,
h, Redshank.

Figure 3.6 The numbers of shelduck and seven wader species at low tide in the Great Ouse study area and the whole Wash WeBS counts in winters 1997-98 to 2001-02 expressed as percentages (index) of those in winter 2002-03. The UK index is shown for comparison and is based on totals in winter 2000-01 (Pollitt, and others. 2003).

Figure 3.7 The percentage of total Wash numbers of shelduck and seven wader species (WeBS counts) that feed at low tide in the Great Ouse study area plotted against total Wash numbers. The decrease in the percentage of bar-tailed godwit feeding in the Great Ouse area relative to increasing Wash numbers is statistically significant ($p=0.03$, $R^2 =65.4\%$) indicating that the Great Ouse area is a preferred feeding area of that species.

Figure 3.8 The location and extent of the low-tide bird-rich 'Core' areas in the Wash. The inner bank 'Core' areas are based on a combination of data from all previous low tide surveys (Goss-Custard, and others. 1977, Goss-Custard, and others. 1988 and Yates, and others. 1996) and the current 2002-03 survey while the outer bank ones are based on data from the 1970's survey (Goss-Custard, and others. 1977) and the current survey. Areas which span inter-tidal creeks down which freshwater is pumped are shown by crosses.

Figure 2.1 Map of the Wash showing the place names used in the text.

Figure 2.2 **Map of the Wash showing the intertidal areas surveyed in 2002-03. The inner banks are shown by the light shading, the outer banks by the moderate shading and the inner bank and outer banks areas surveyed as part of the Essex and Suffolk Water's Denver Licence Variation monitoring study by the dark shading**.

Figure 3.1a-k Bird distribution in the 2002-03 survey. Feeding shelduck and waders
a, Shelduck,
b, Oystercatcher,
c, Grey plover,
d, Knot,
e, Sanderling,
f, Dunlin,
g, Black-tailed Godwit,
h, Bar-tailed Godwit,
i, Curlew,
j, Redshank,
k, Turnstone.

Figure 3.2a-f Bird distribution in the 2002-03 survey. Roosting wildfowl, sea-ducks and waders
a, Brent goose,
b, Wigeon,
c, Mallard,
d, Eider,
e, Golden plover,
f, Lapwing.

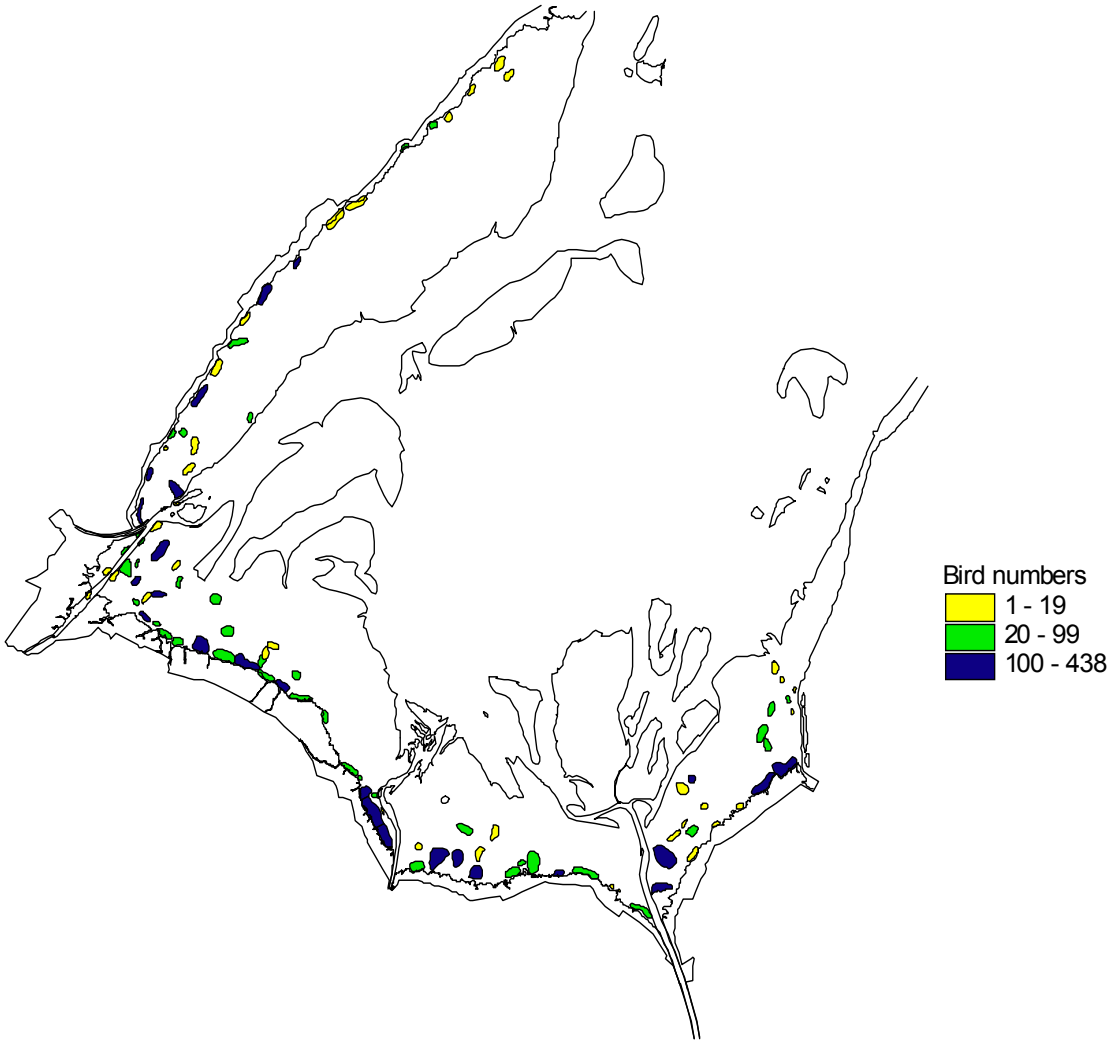


Figure 3.1a Shelduck distribution

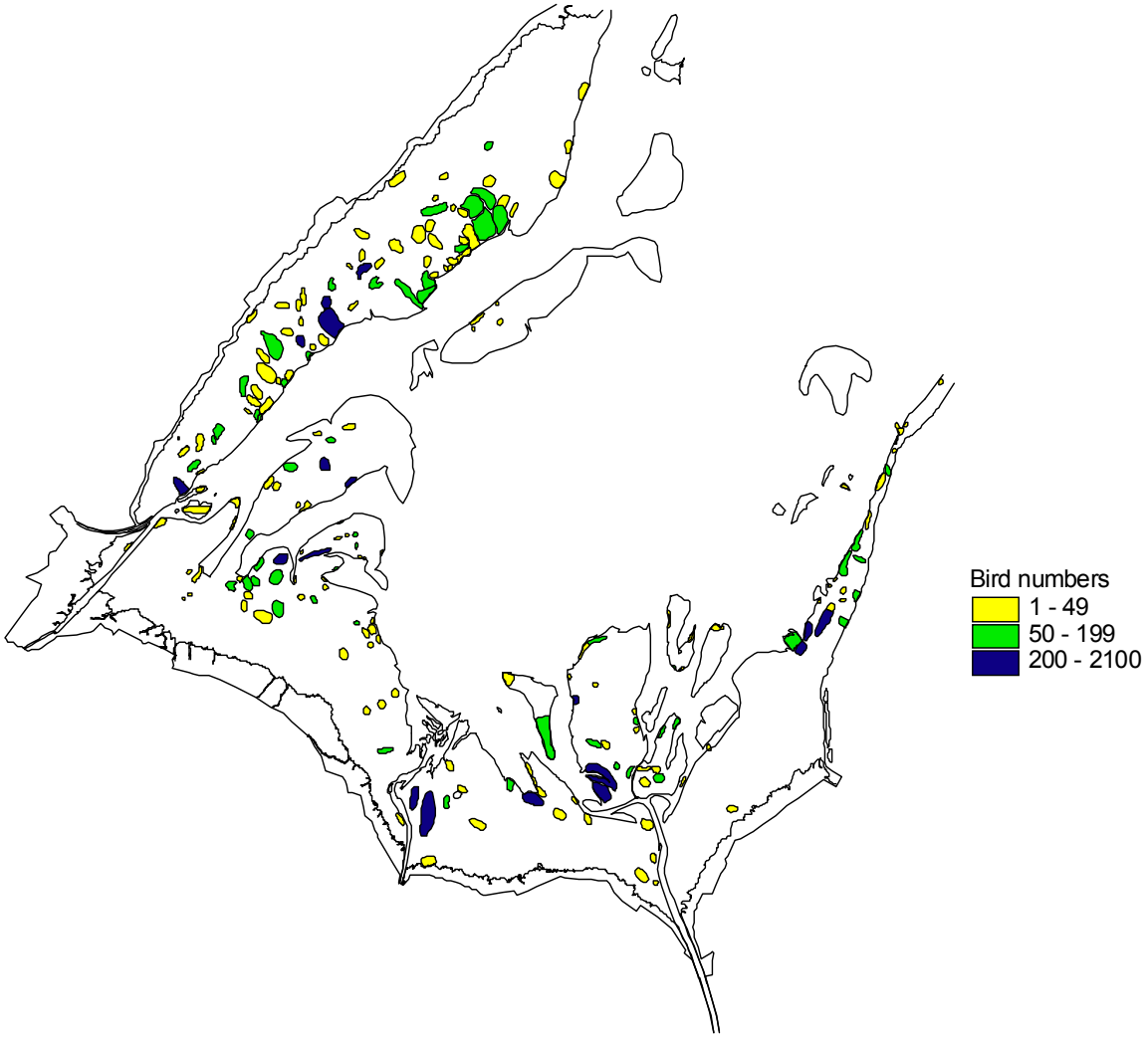


Figure 3.1b Oystercatcher distribution

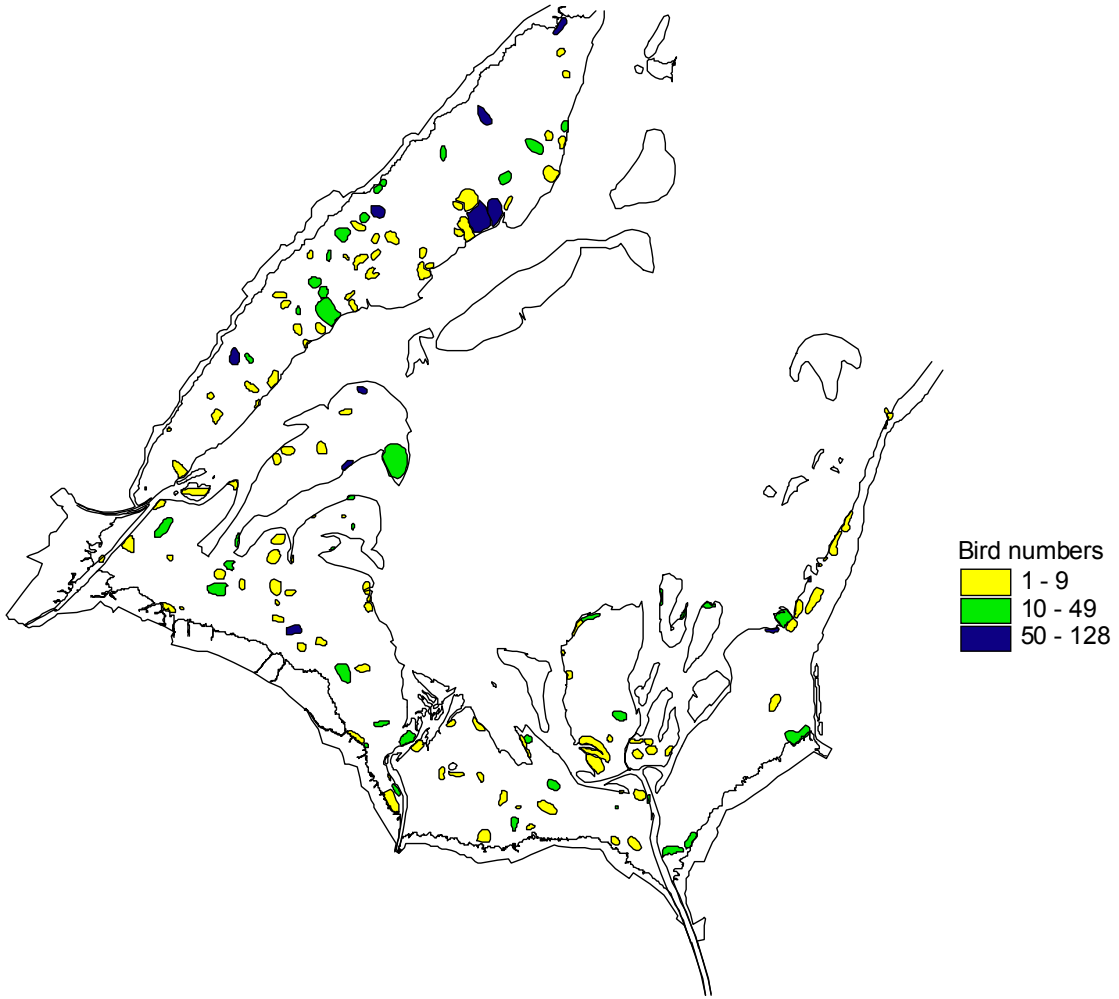


Figure 3.1c Grey plover distribution

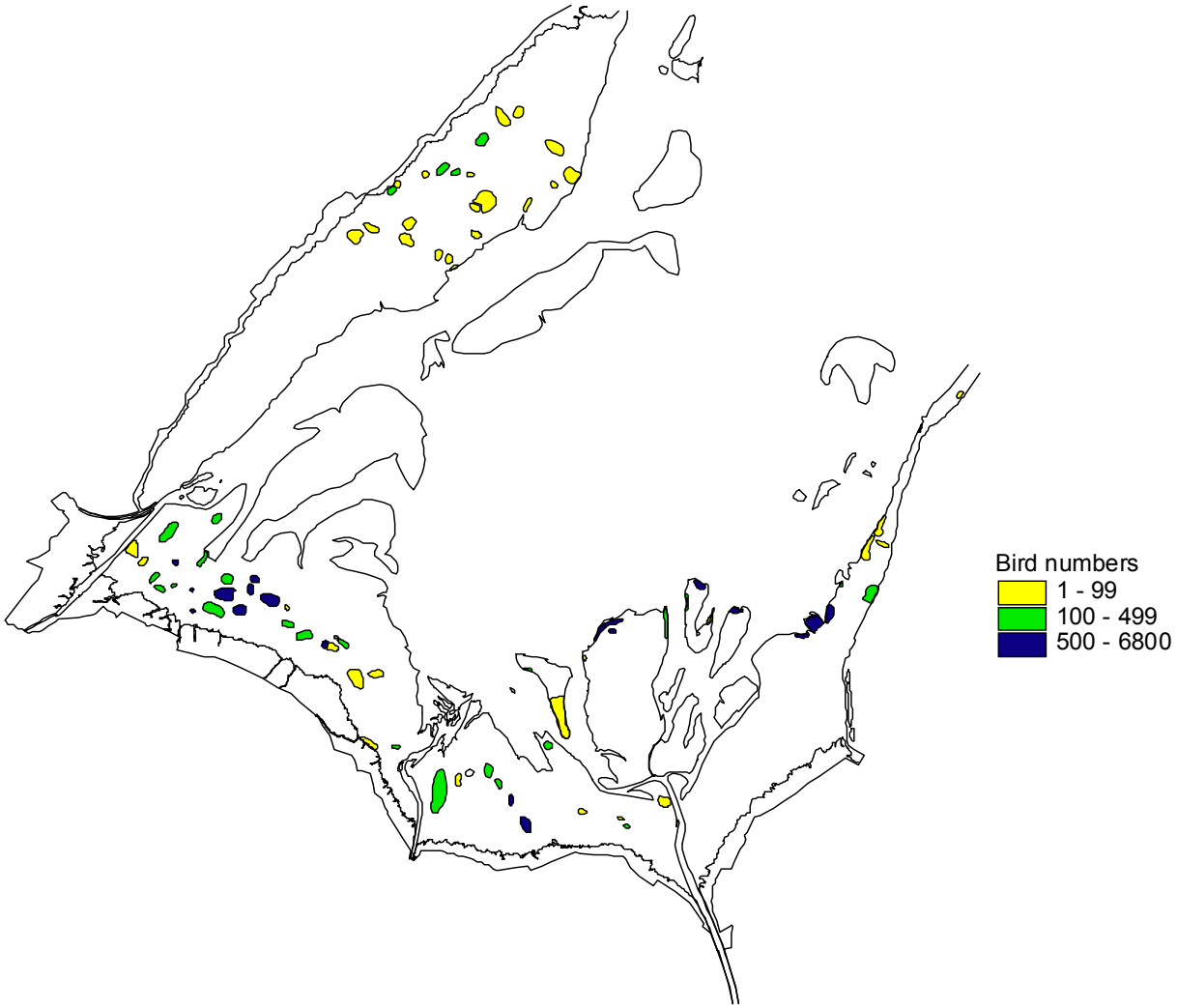


Figure 3.1d Knot distribution

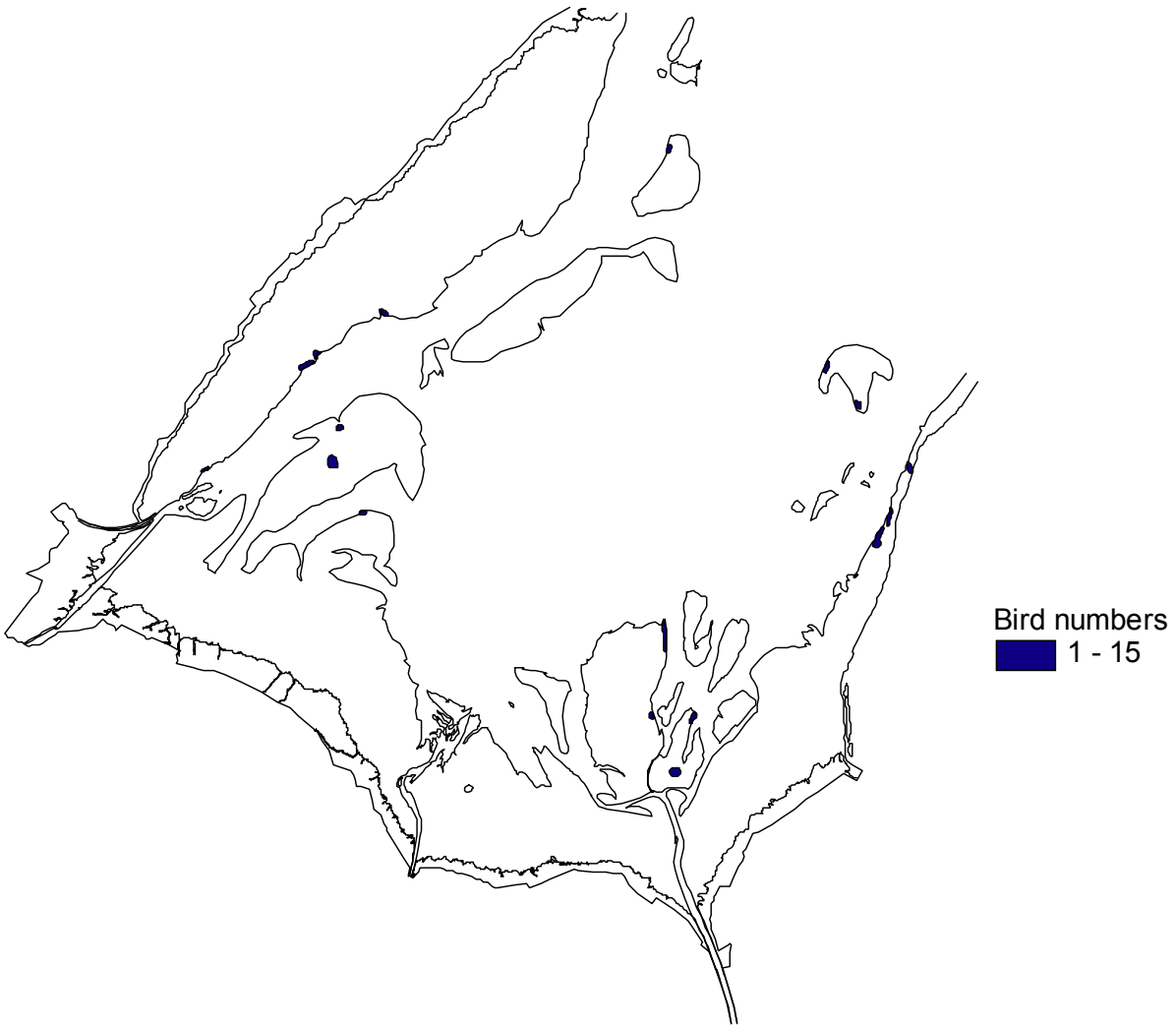


Figure 3.1e Sanderling distribution

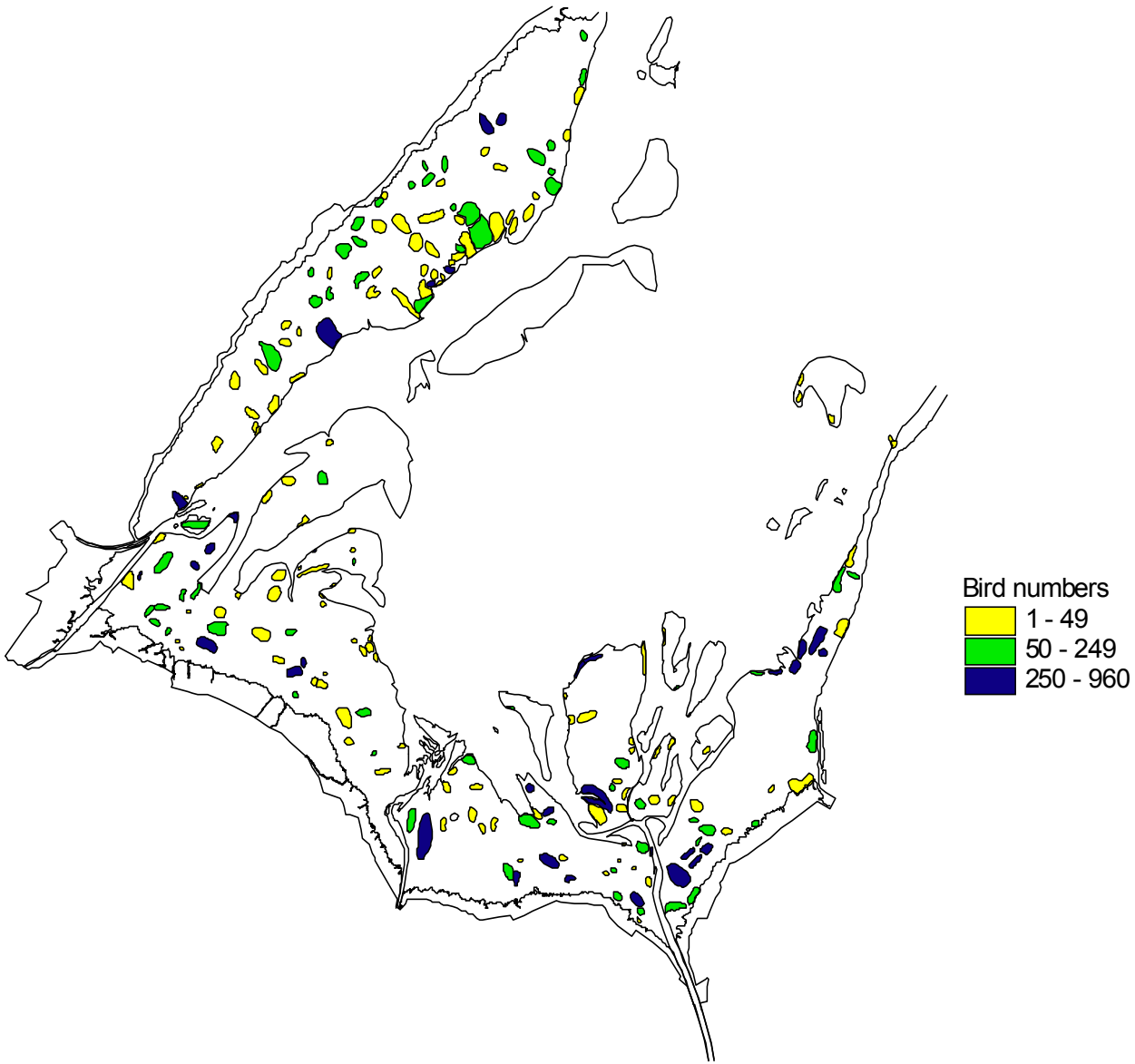


Figure 3.1f Dunlin distribution

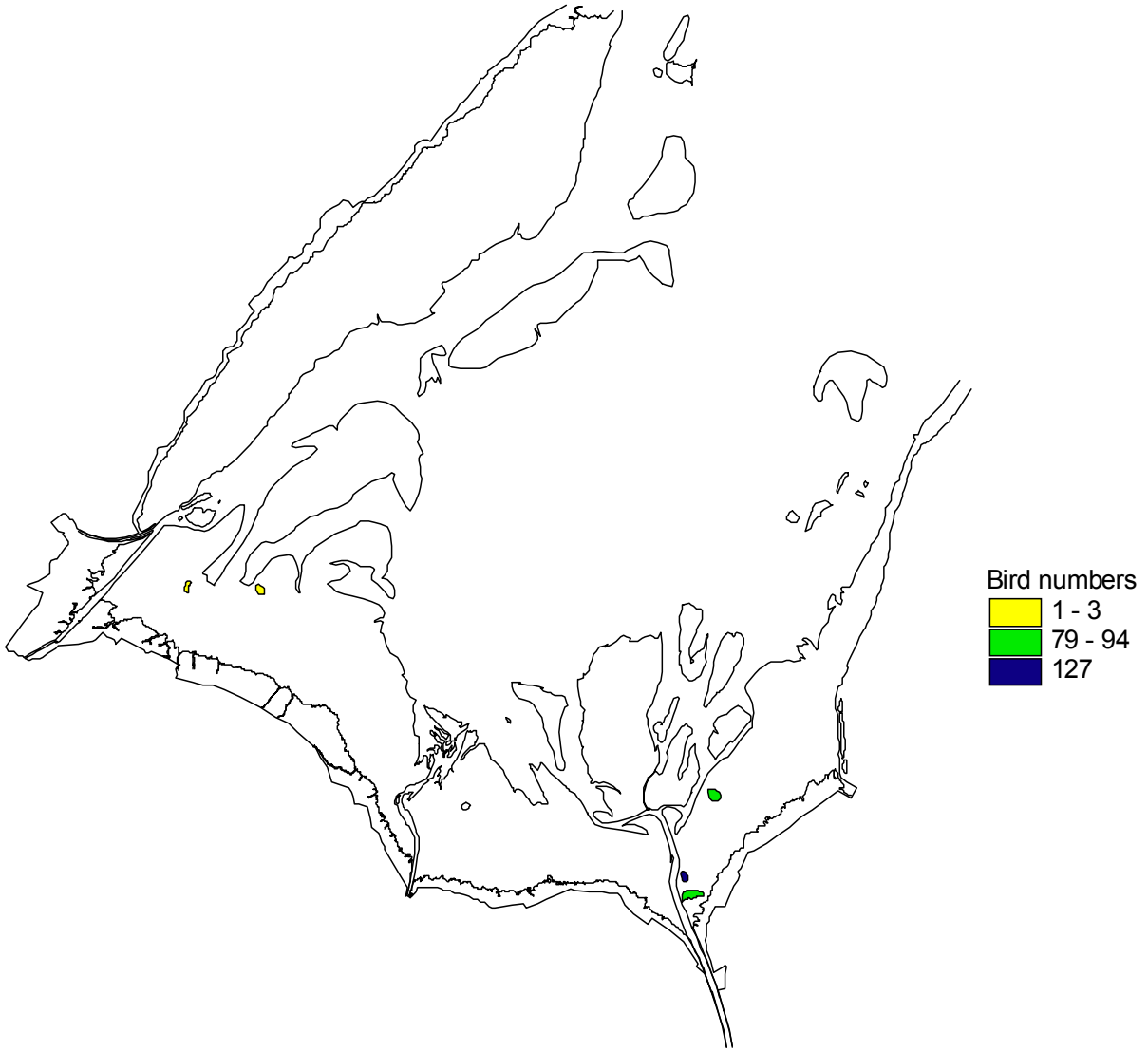


Figure 3.1g Black-tailed godwit distribution

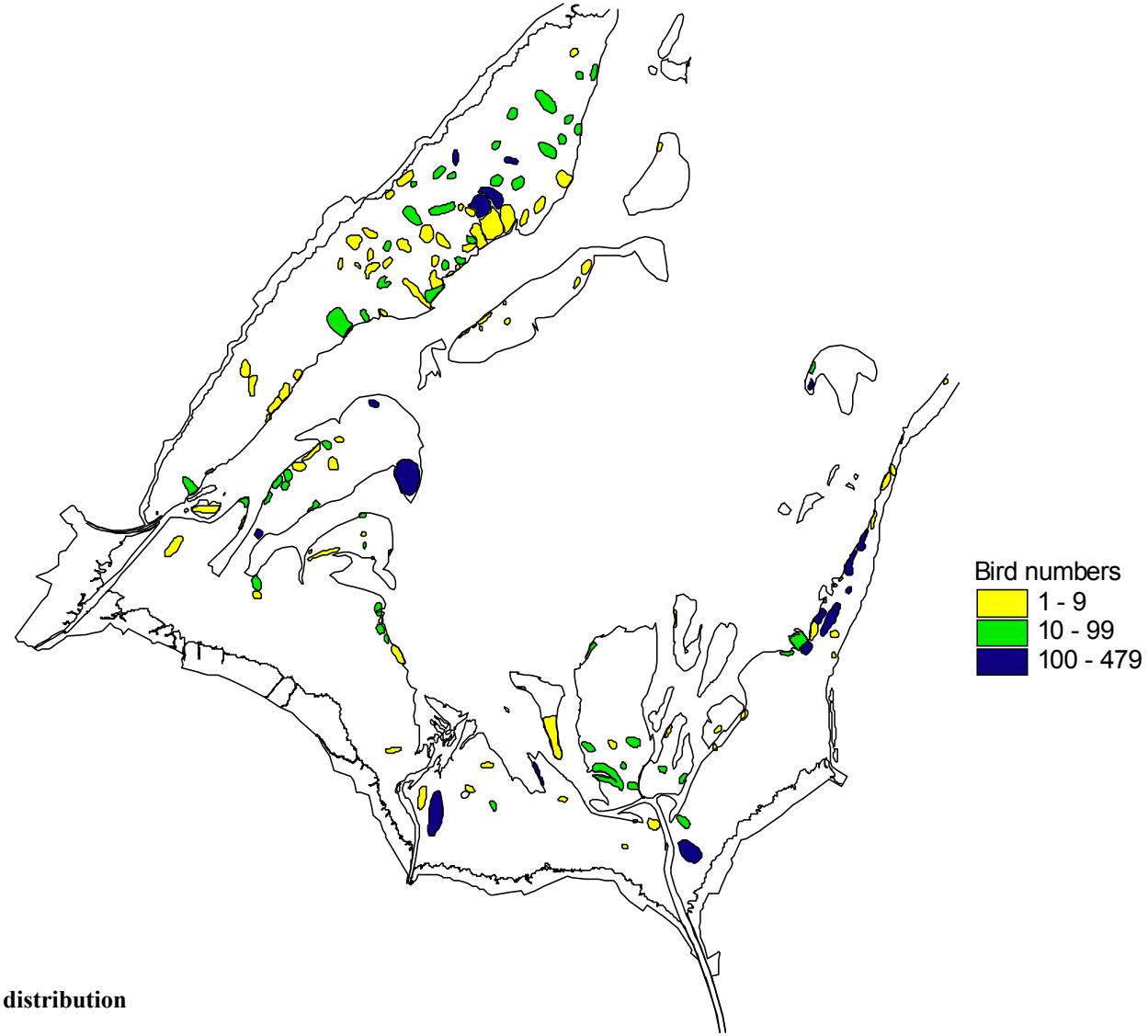


Figure 3.1h Bar-tailed godwit distribution

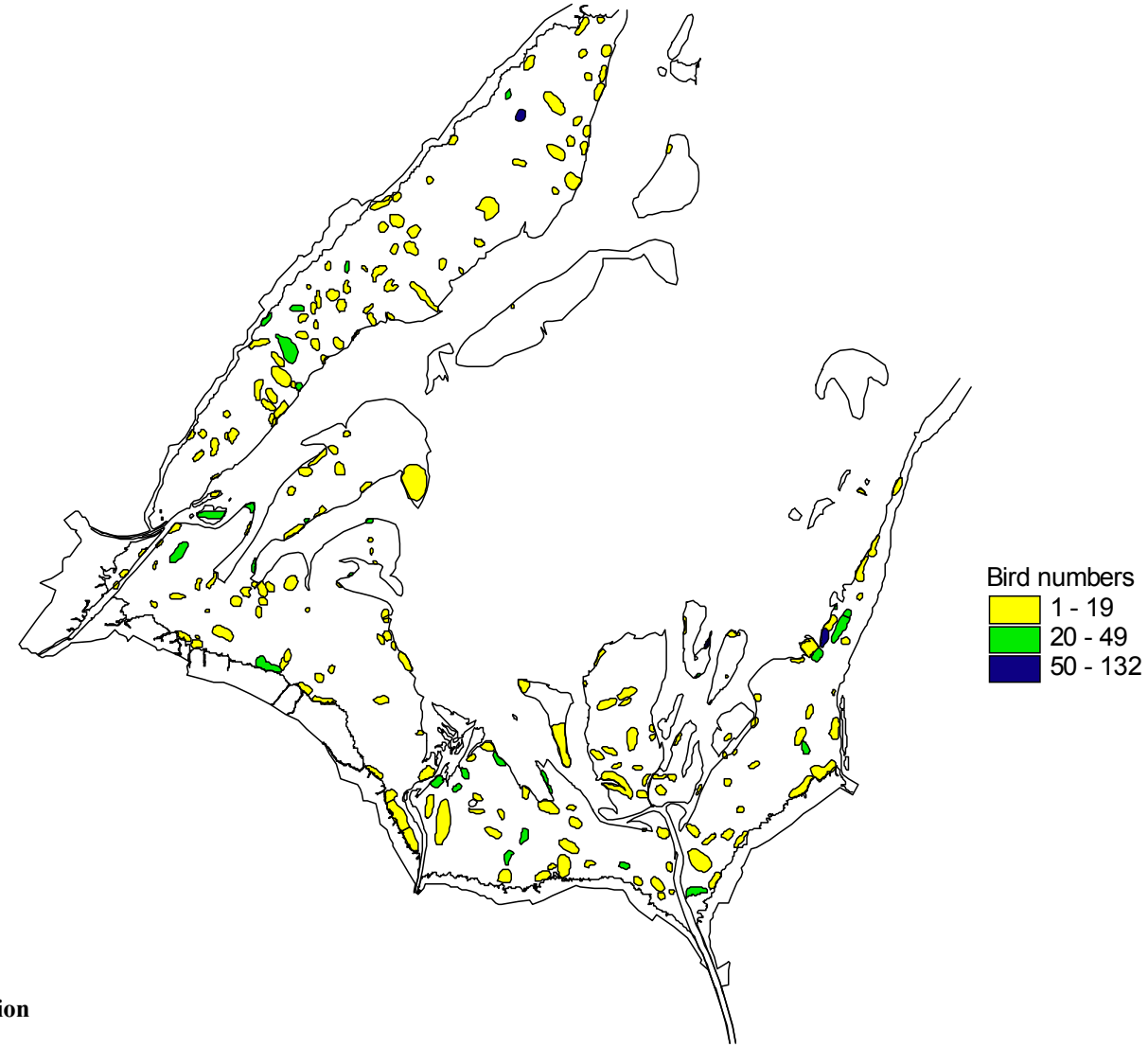


Figure 3.1i Curlew distribution

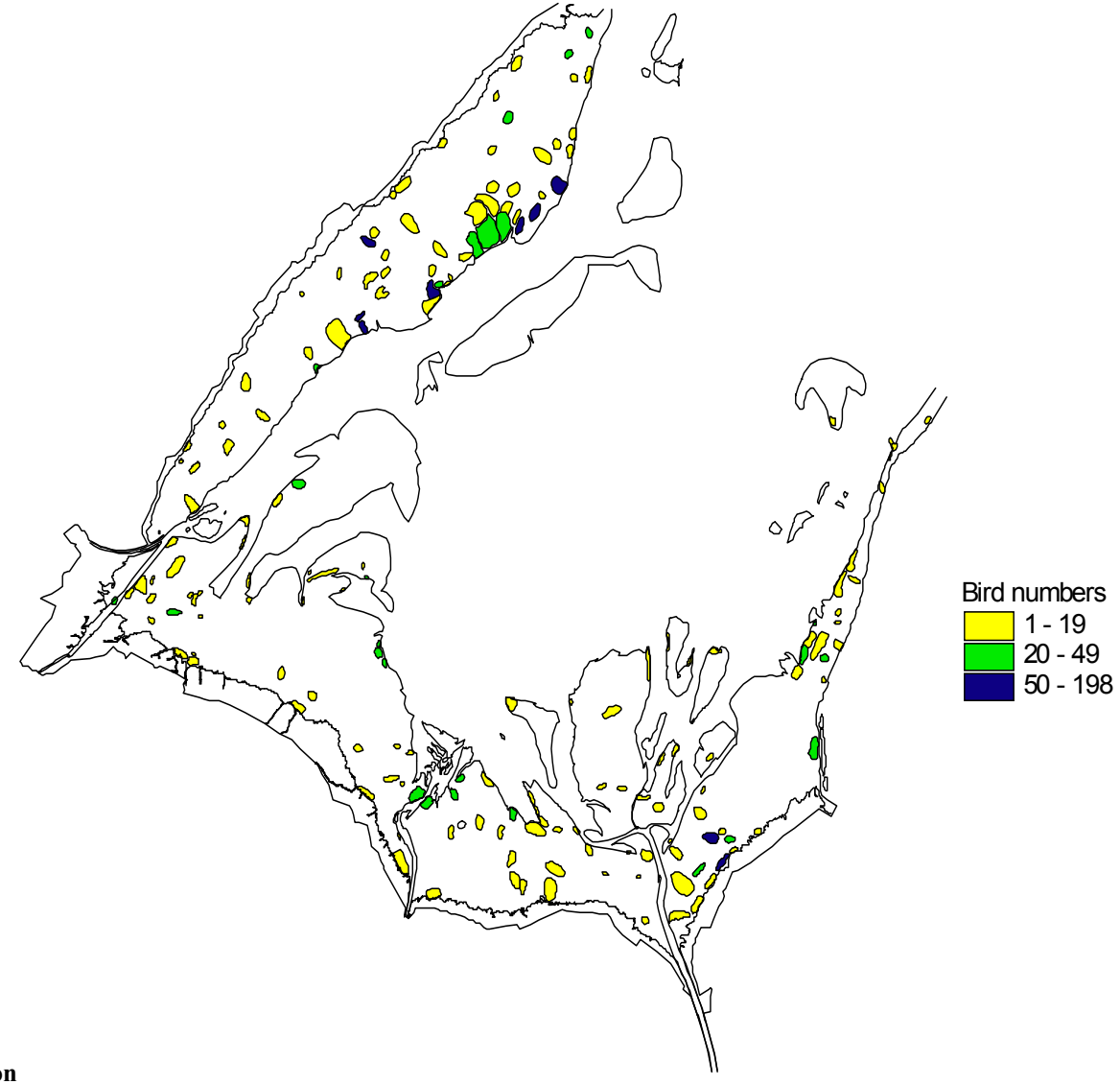


Figure 3.1j Redshank distribution

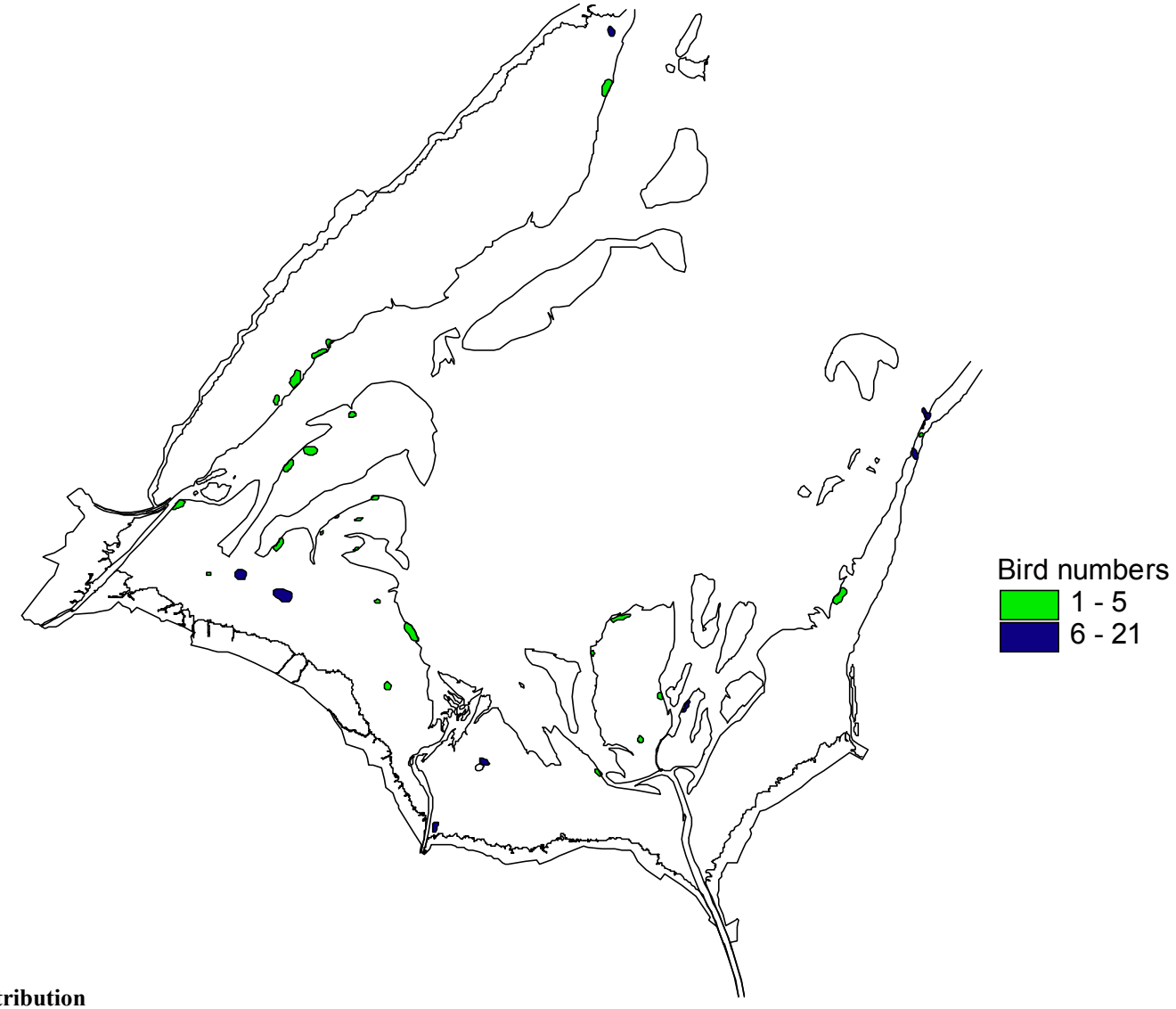


Figure 3.1k Turnstone distribution

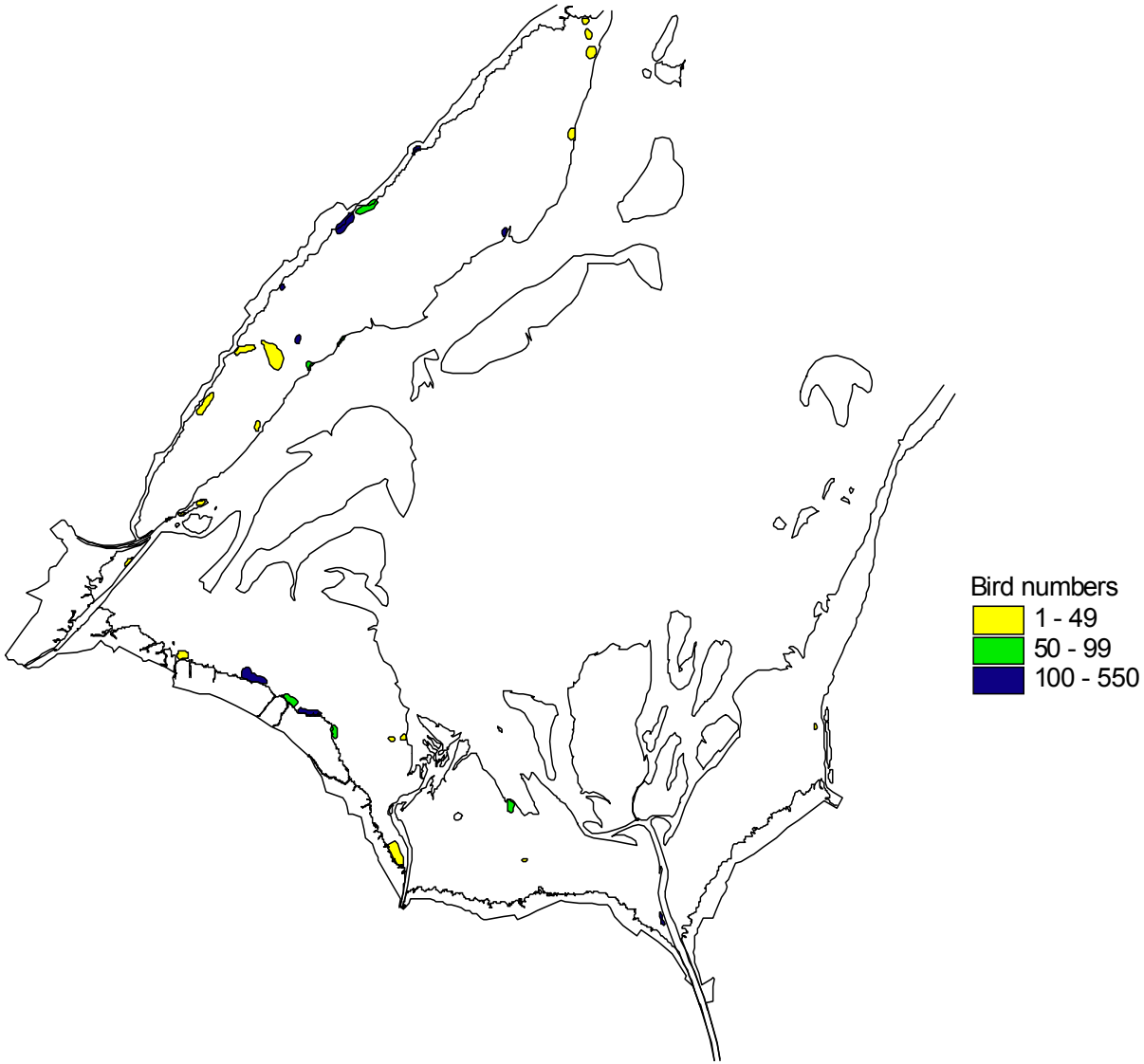


Figure 3.2a Brent goose distribution

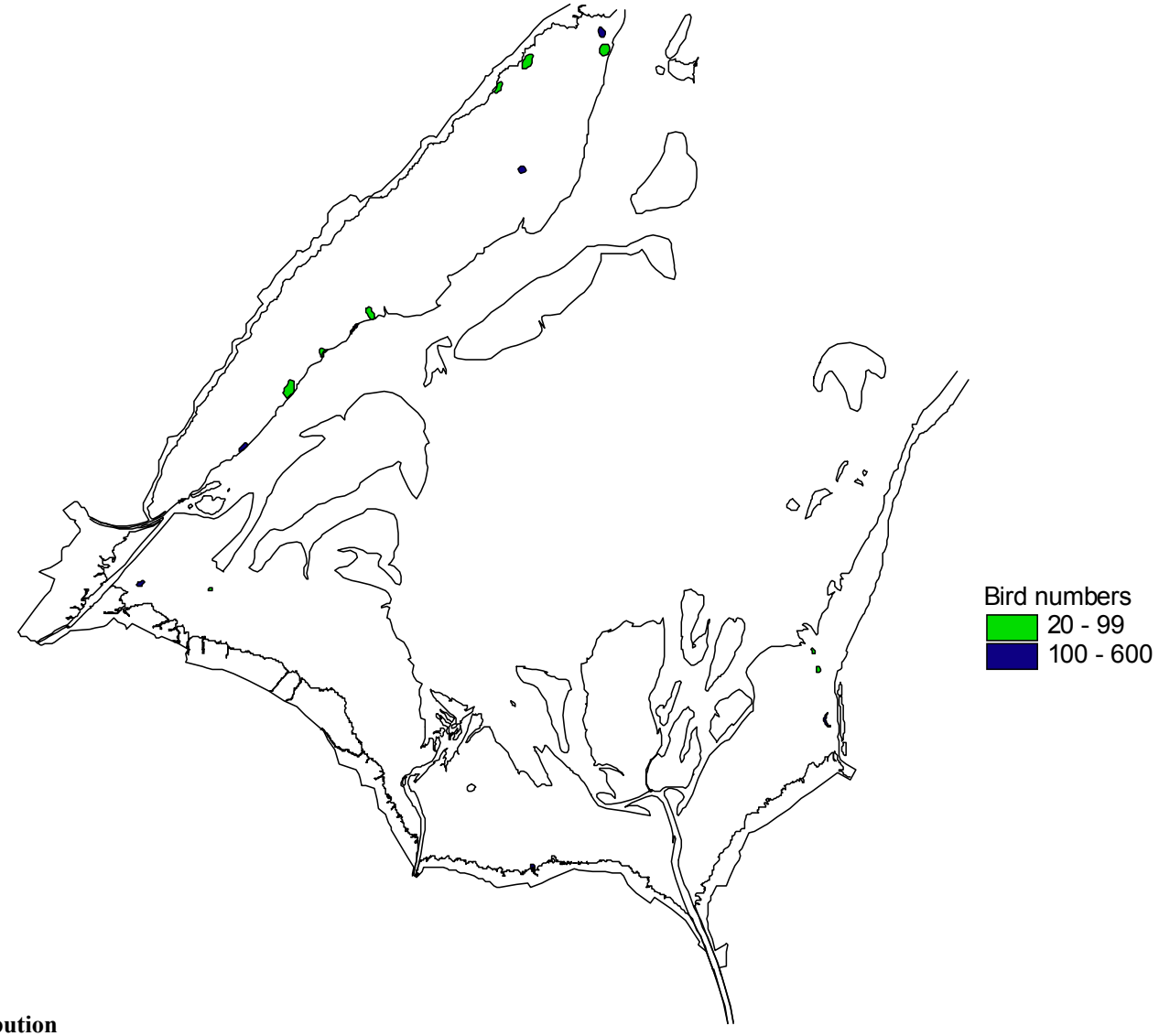


Figure 3.2b Wigeon distribution

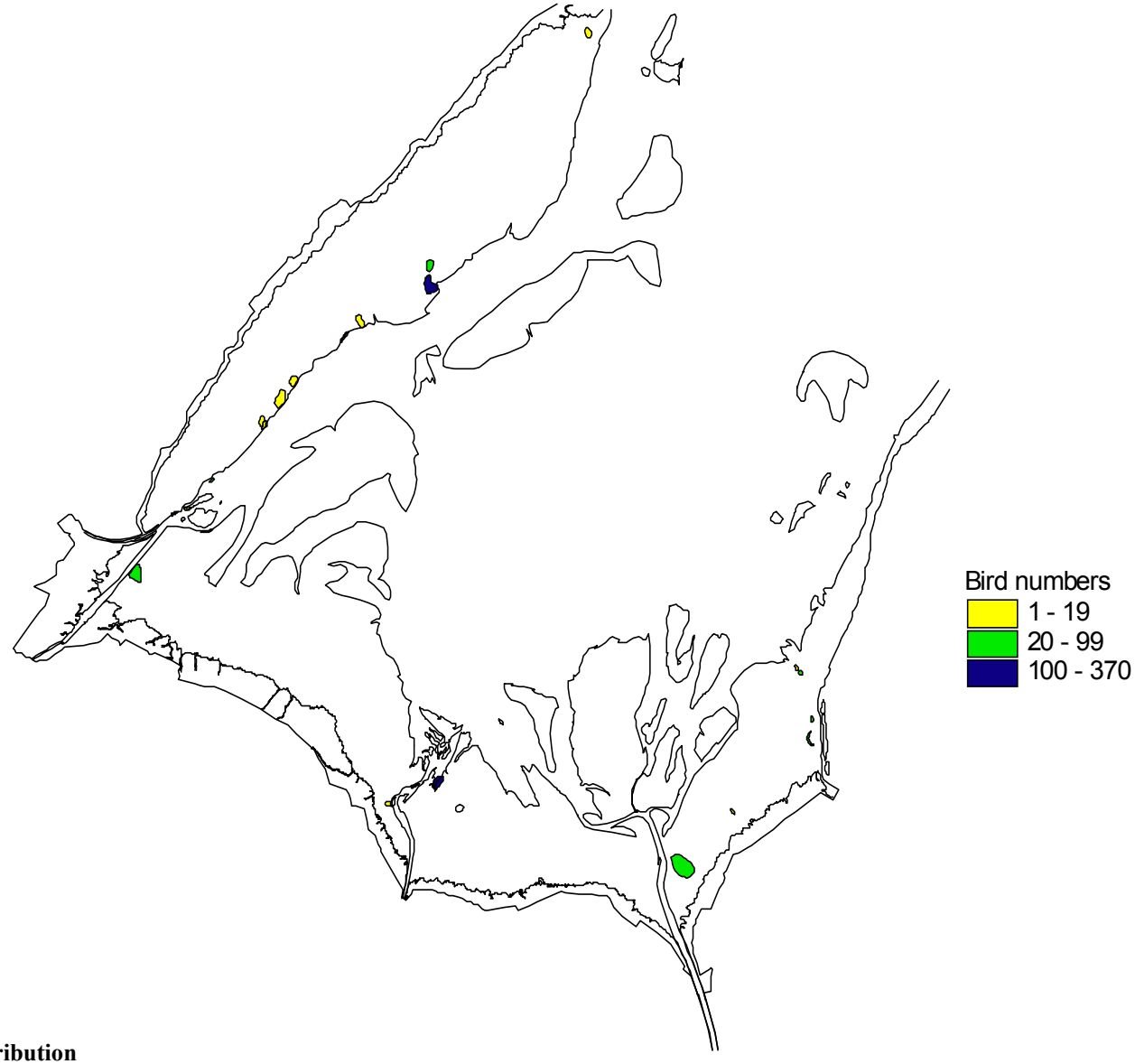


Figure 3.2c Mallard distribution

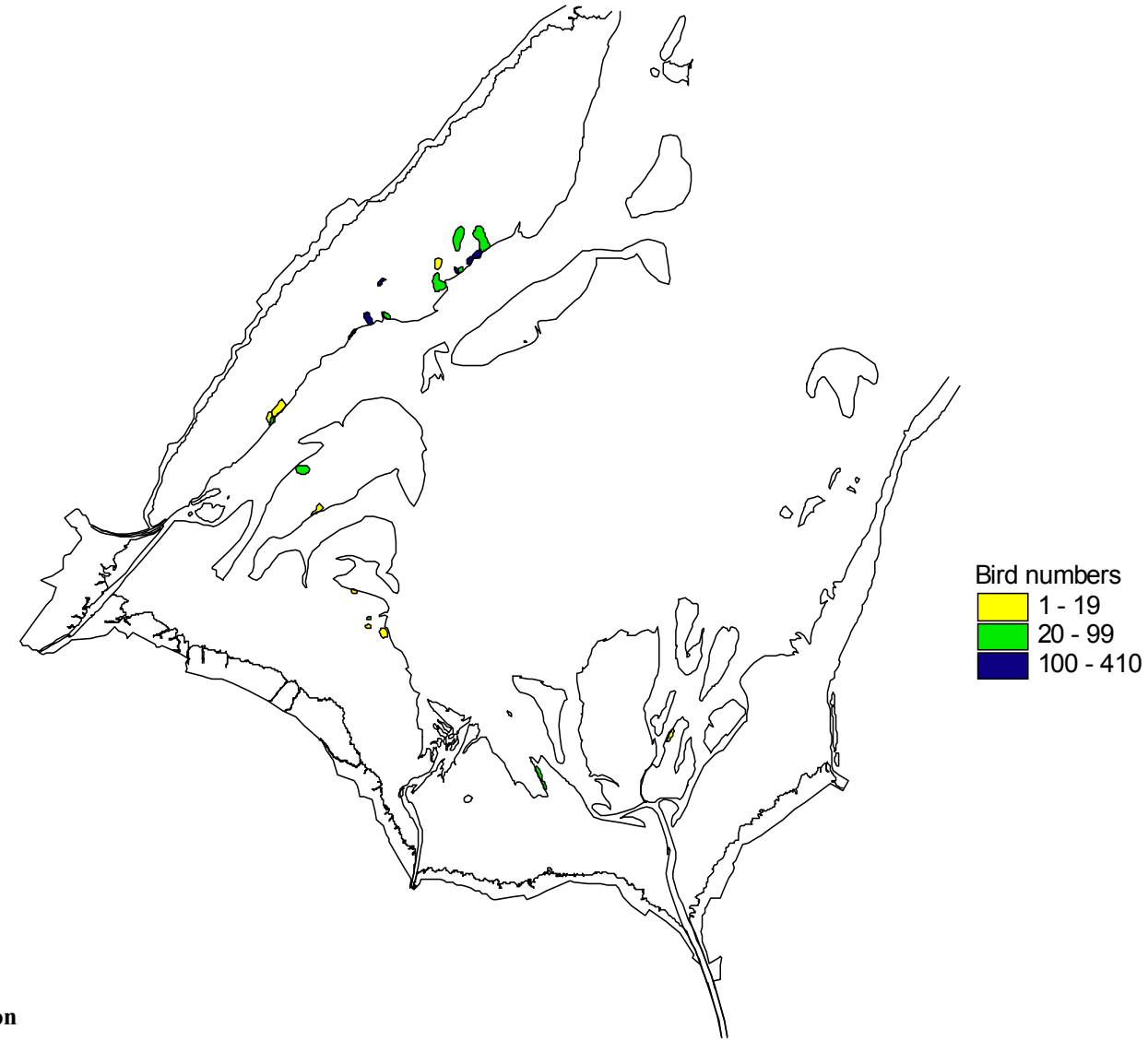


Figure 3.2d Eider distribution

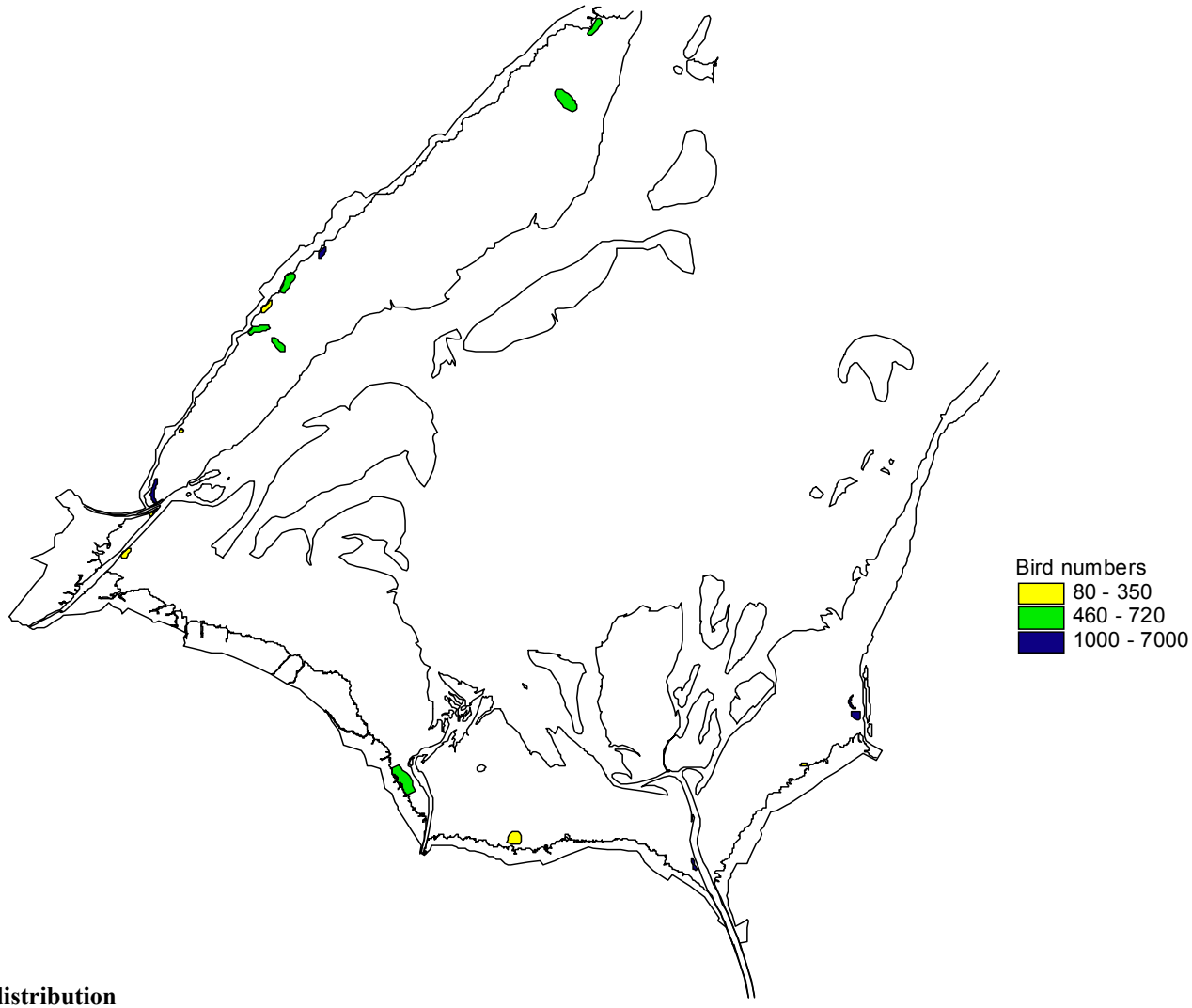


Figure 3.2e Golden plover distribution

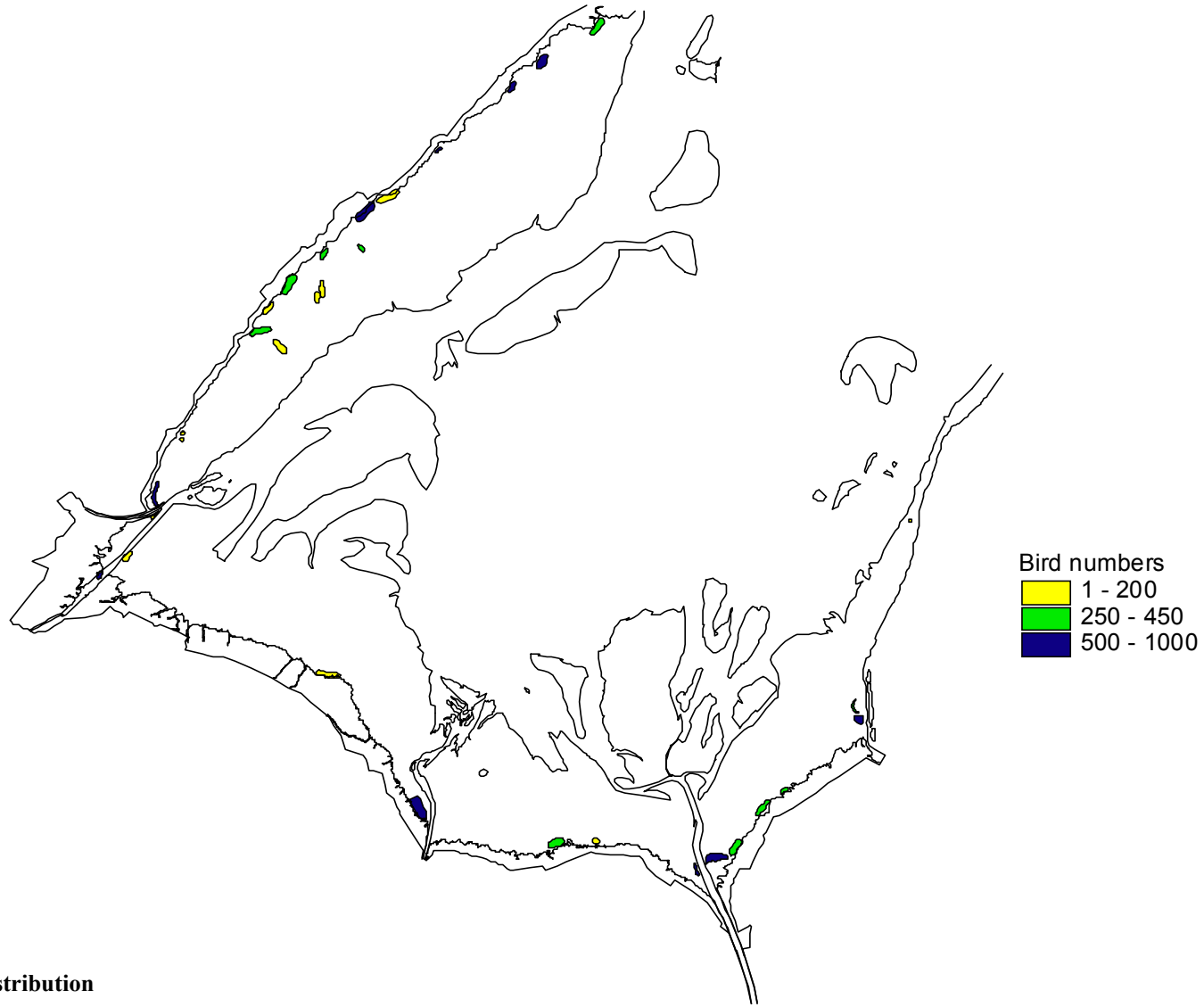


Figure 3.2f Lapwing distribution

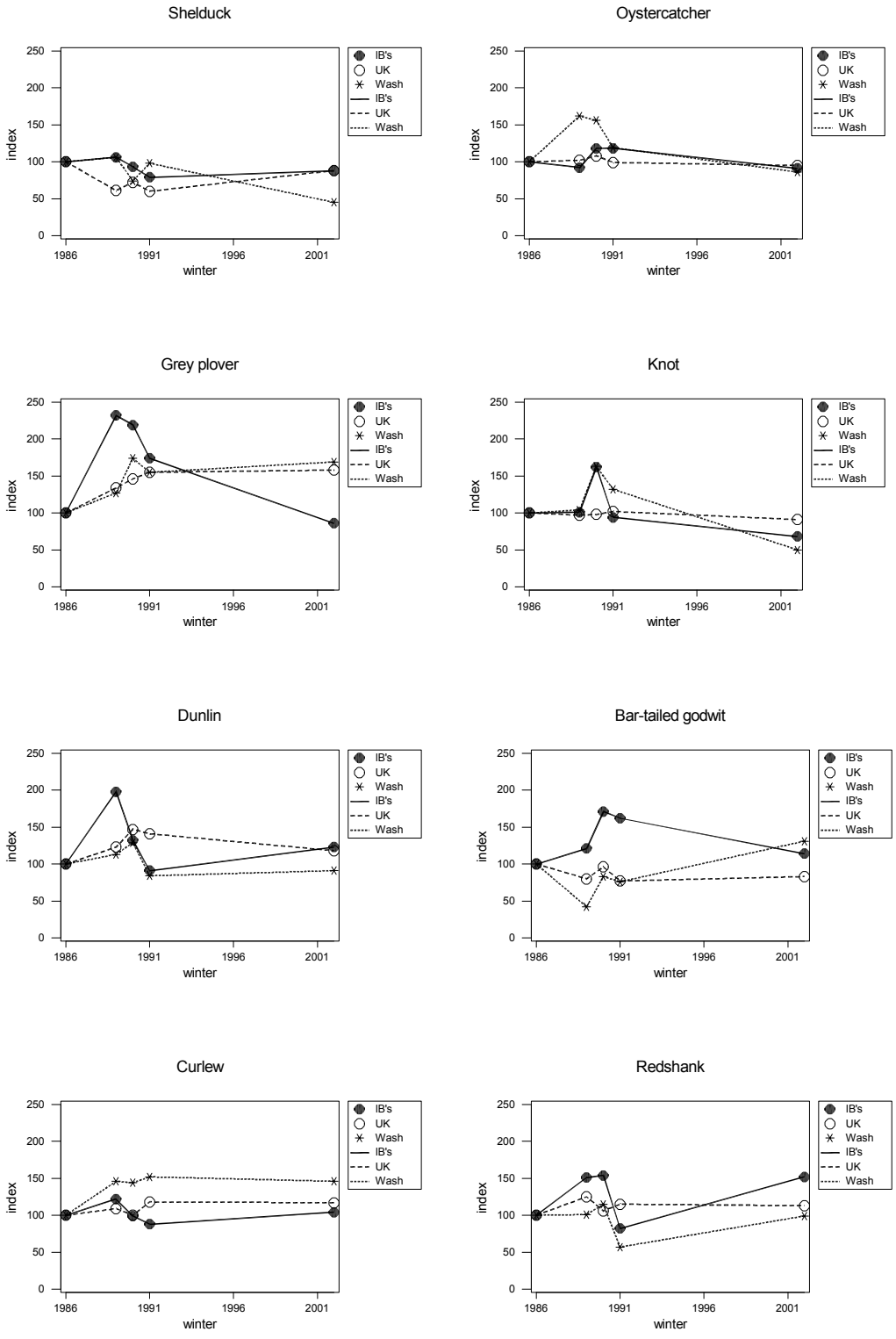


Figure 3.3 An index of numbers of shelduck and seven wader species in winters 1985-85, 1989-90 to 1991-92 and 2002-03 on the inner banks of the Wash (IB's), in the whole Wash and in the UK. The index is the percentage of the mean total in winters 1985-87. Whole Wash and UK data are derived from WeBS 2000-01 (Pollitt, and others. 2003). The UK index for 2002-03 was estimated by averaging that for 1996-2001.

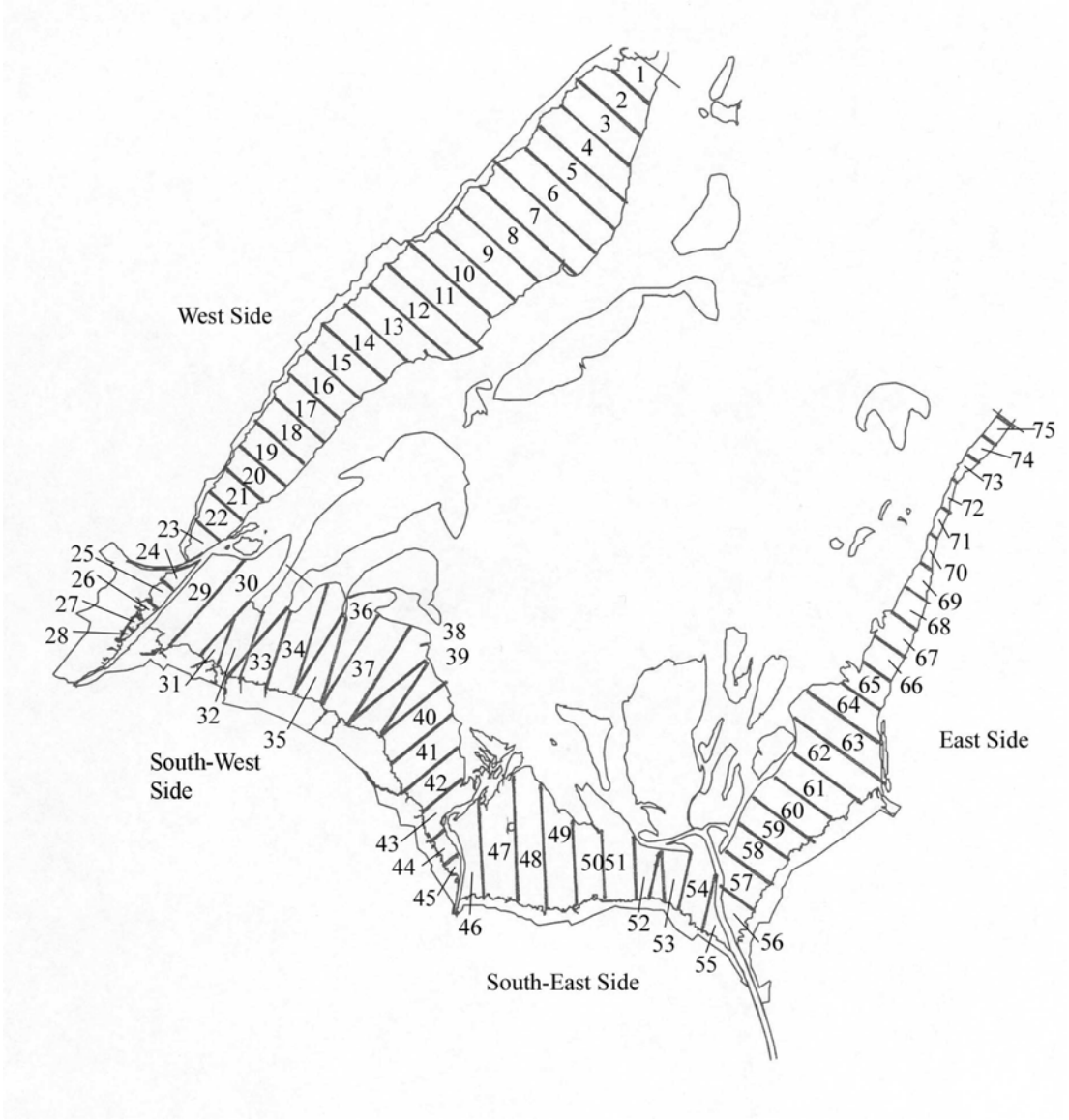


Figure 3.4 The inner banks of the Wash divided into 75, 1km wide contiguous transects that were used to summarise the along-shore distribution of birds. The west side of the Wash was spanned by transects 1-28, the south-west by transects 29-45, the south-east by transects 46-55 and the east side by transects 56-75.

Figure 3.5 a-h Comparisons between the numbers of shelduck and seven wader species recorded in 66, 1km wide transects around the Wash in the 2002-03 survey (solid line, closed symbols) and the mean of the numbers recorded in surveys made in winters 1985-7, 1989-90, 1990-91 and 1991-92 (dashed line, open symbols). The vertical lines indicate the location of the outfalls of the rivers Witham/Welland, Nene and Great Ouse that separate the sides of the Wash as in Figure 3.3.

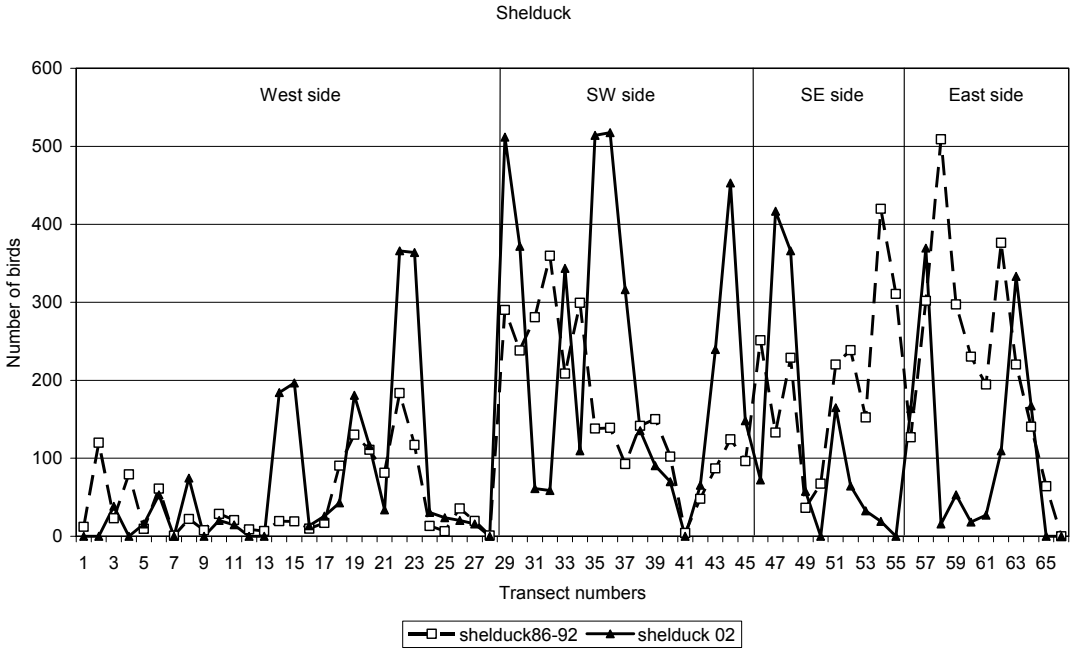


Figure 3.5a Shelduck

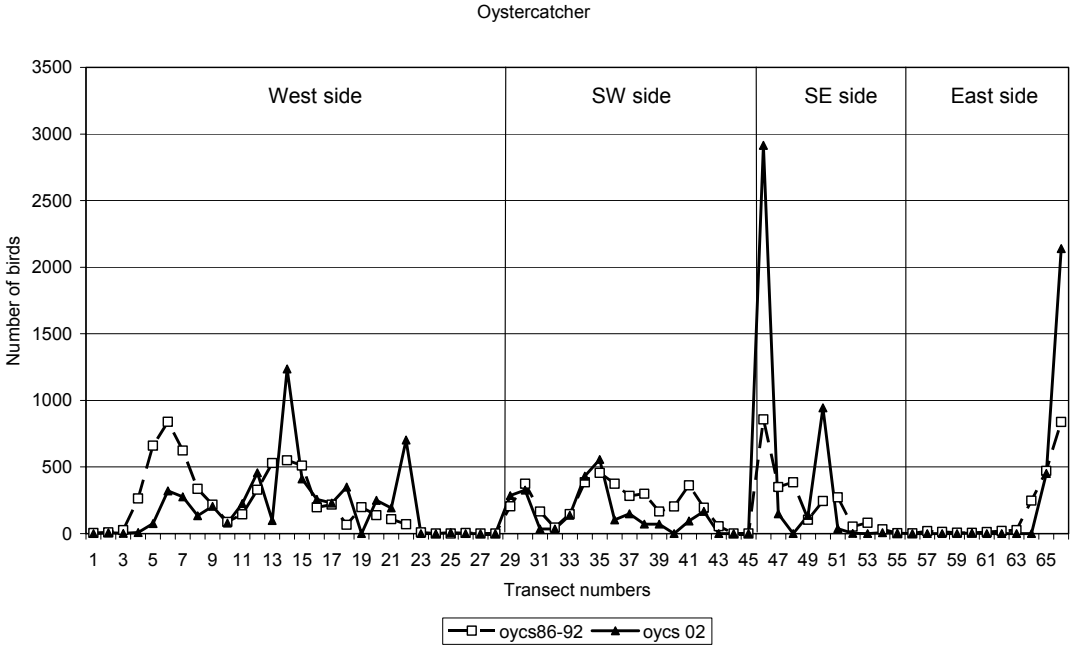


Figure 3.5b Oystercatcher

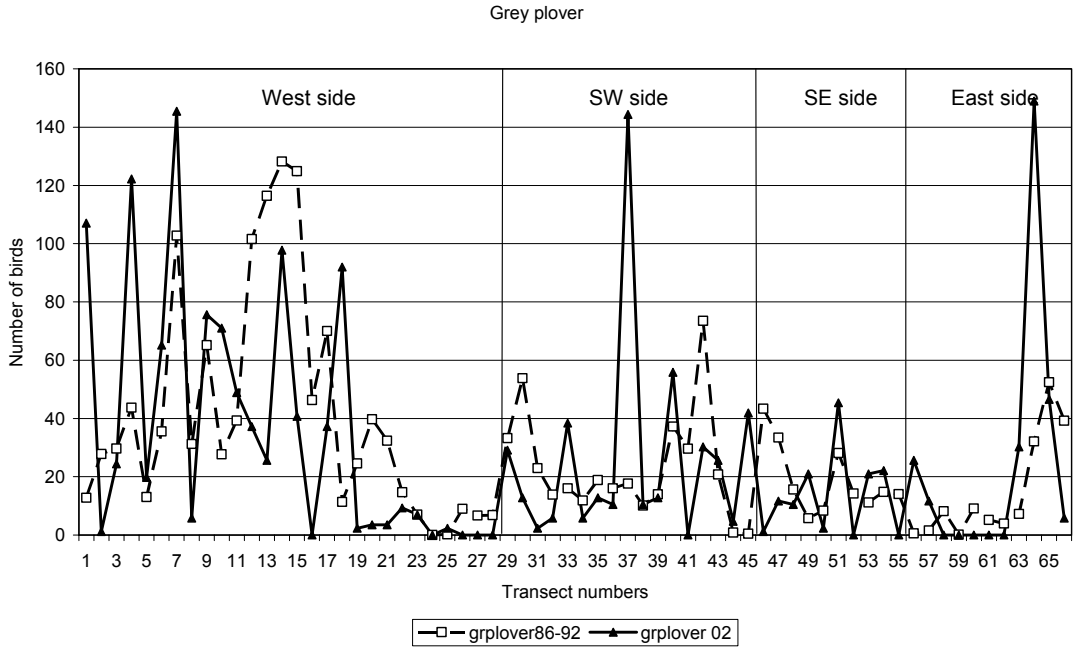


Figure 3.5c Grey plover

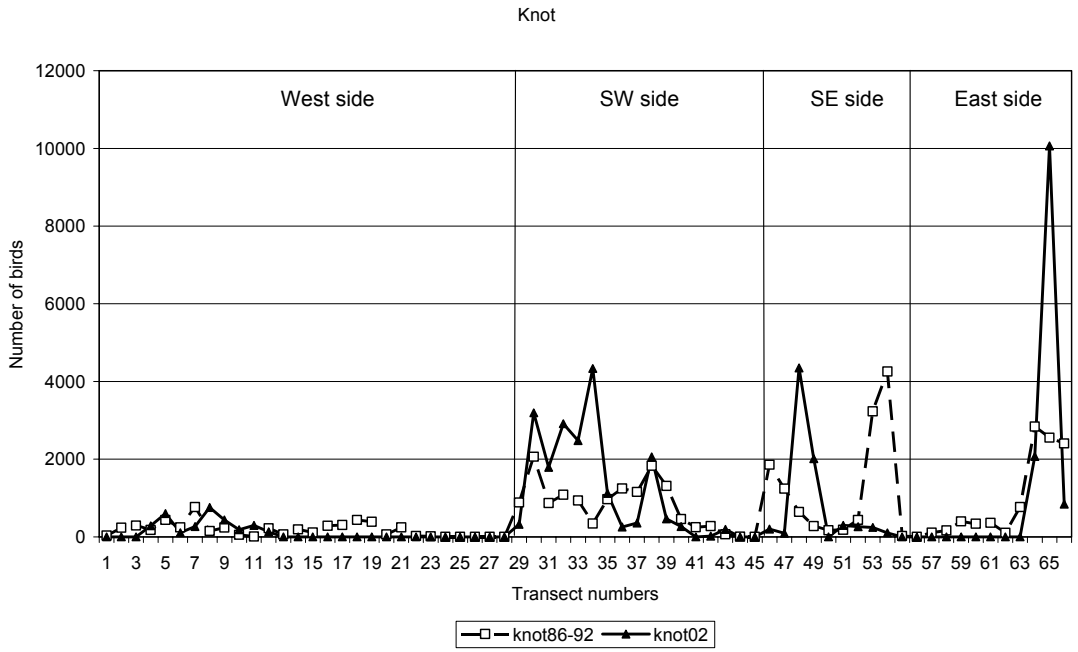


Figure 3.5d Knot

Figure 3.5 contd. Comparisons between the numbers of shelduck and seven wader species recorded in 66, 1km wide transects around the Wash in the 2002-03 survey (solid line, closed symbols) and the mean of the numbers recorded in surveys made in winters 1985-7, 1989-90, 1990-91 and 1991-92 (dashed line, open symbols). The vertical lines indicate the location of the outfalls of the rivers Witham/Welland, Nene and Great Ouse that separate the sides of the Wash as in Figure 3.3.

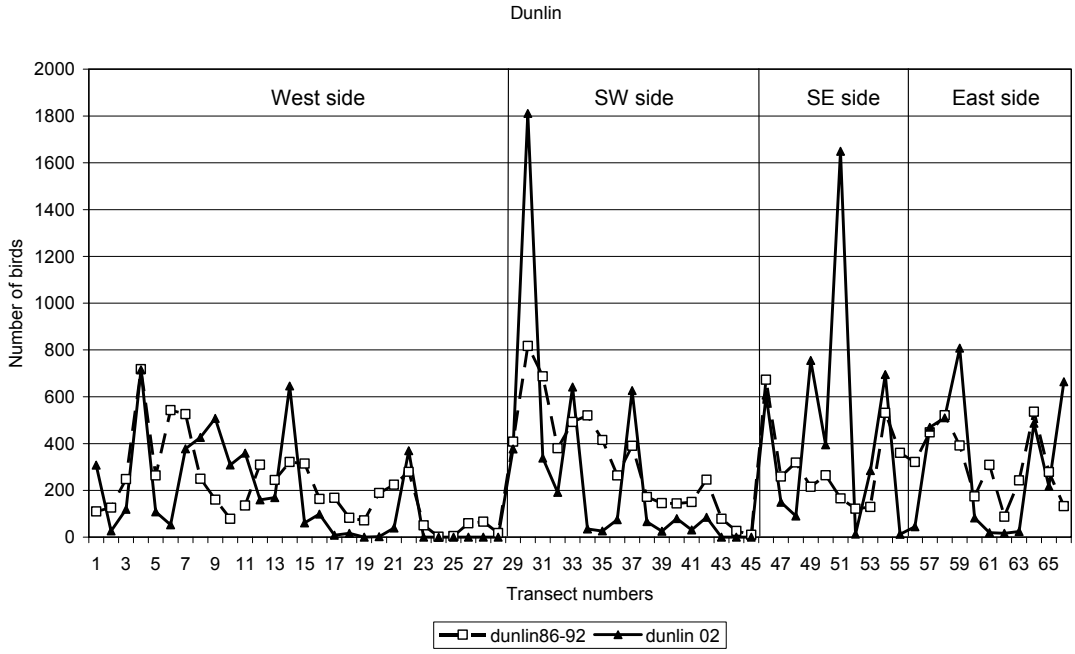


Figure 3.5e Dunlin

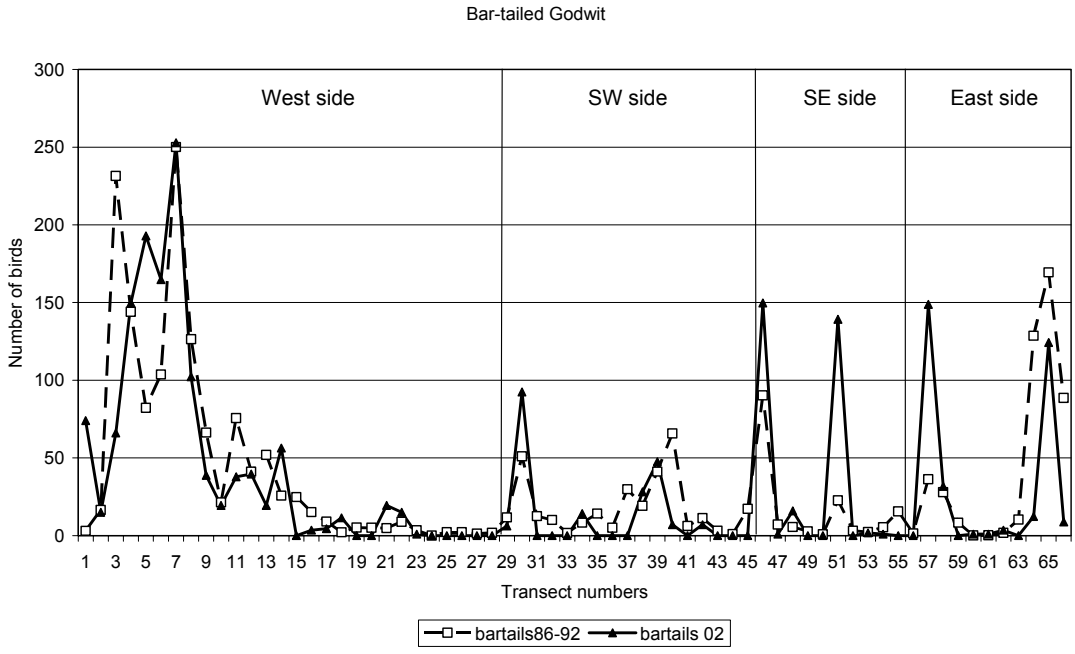


Figure 3.5f Bar-tailed godwit

Figure 3.5 contd. Comparisons between the numbers of shelduck and seven wader species recorded in 66, 1km wide transects around the Wash in the 2002-03 survey (solid line, closed symbols) and the mean of the numbers recorded in surveys made in winters 1985-7, 1989-90, 1990-91 and 1991-92 (dashed line, open symbols). The vertical lines indicate the location of the outfalls of the rivers Witham/Welland, Nene and Great Ouse that separate the sides of the Wash as in Figure 3.3.

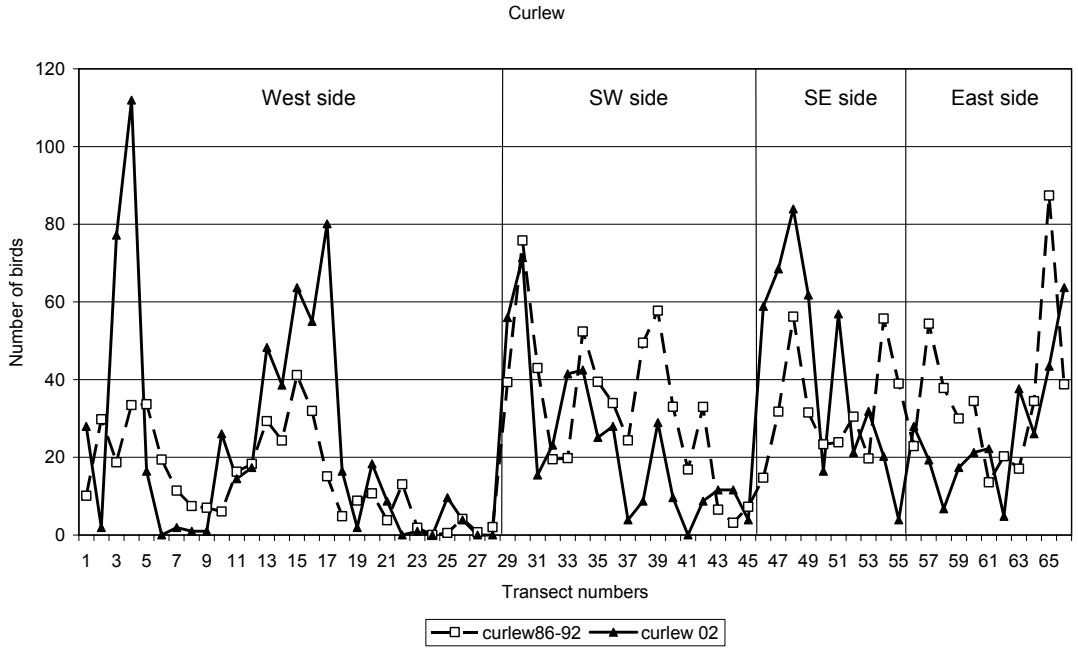


Figure 3.5g Curlew

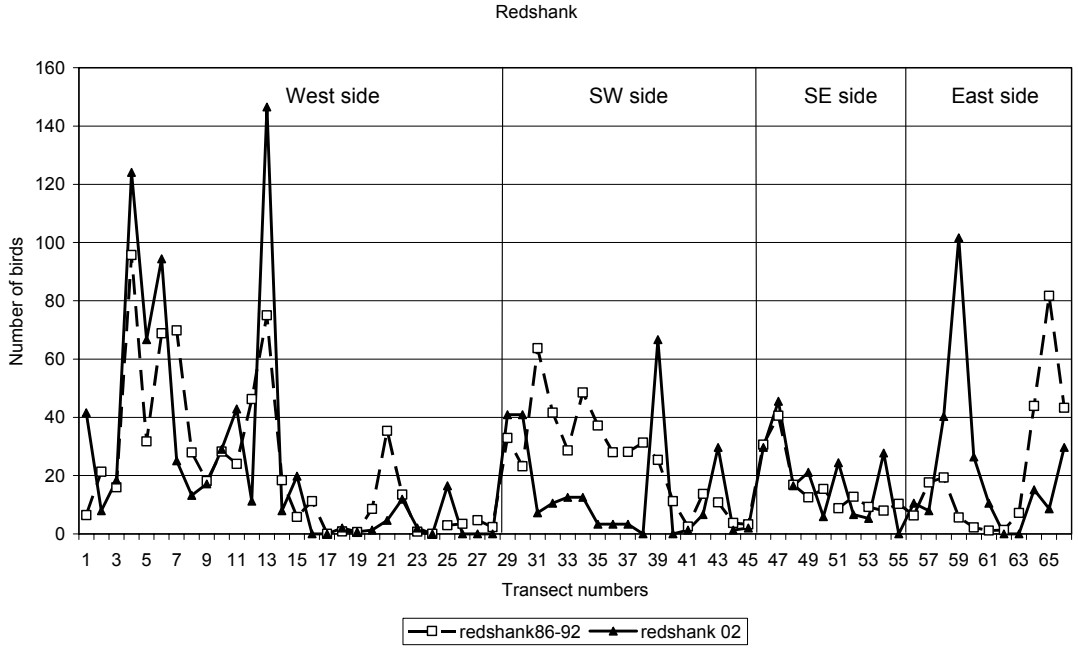


Figure 3.5h Redshank

Figure 3.5 contd. Comparisons between the numbers of shelduck and seven wader species recorded in 66, 1km wide transects around the Wash in the 2002-03 survey (solid line, closed symbols) and the mean of the numbers recorded in surveys made in winters 1985-7, 1989-90, 1990-91 and 1991-92 (dashed line, open symbols). The vertical lines indicate the location of the outfalls of the rivers Witham/Welland, Nene and Great Ouse that separate the sides of the Wash as in Figure 3.3.

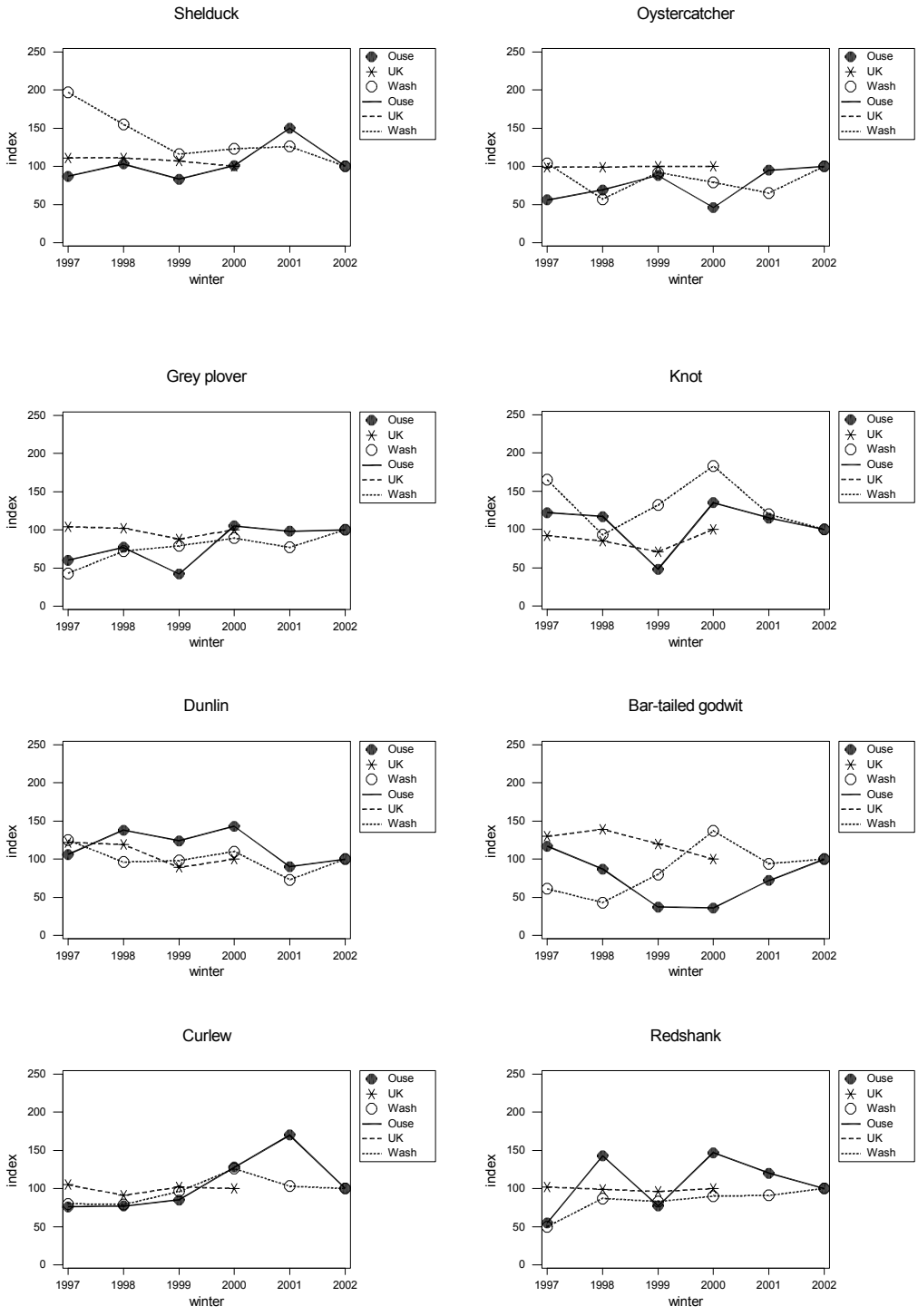


Figure 3.6 The numbers of shelduck and seven wader species at low tide in the Great Ouse study area and in the whole Wash WeBS counts in winters 1997-98 to 2001-02 expressed as a percentage (index) of those in winter 2002-03. The UK index is shown for comparison and is based on totals in winter 2000-01 (Pollitt, and others. 2003).

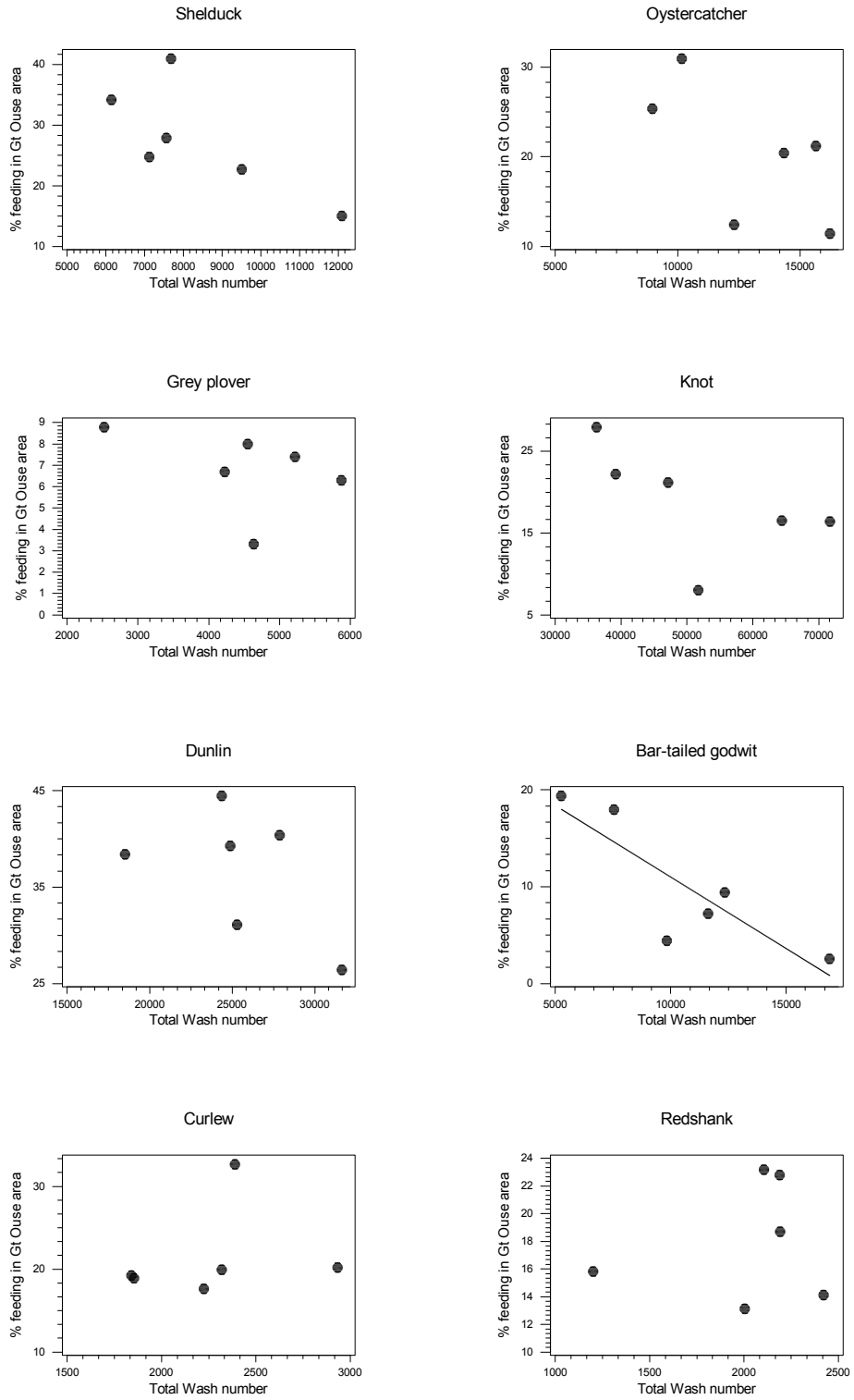


Figure 3.7 The percentage of total Wash numbers of shelduck and seven wader species (WeBS counts) that feed at low tide in the Great Ouse study area plotted against total Wash numbers. The decrease in the percentage of bar-tailed godwit feeding in the Great Ouse area relative to increasing Wash numbers is statistically significant (fitted line y = 25.8-0.0015x p=0.03, R^2 =65.%) indicating that the Great Ouse area is a preferred feeding area of that species.

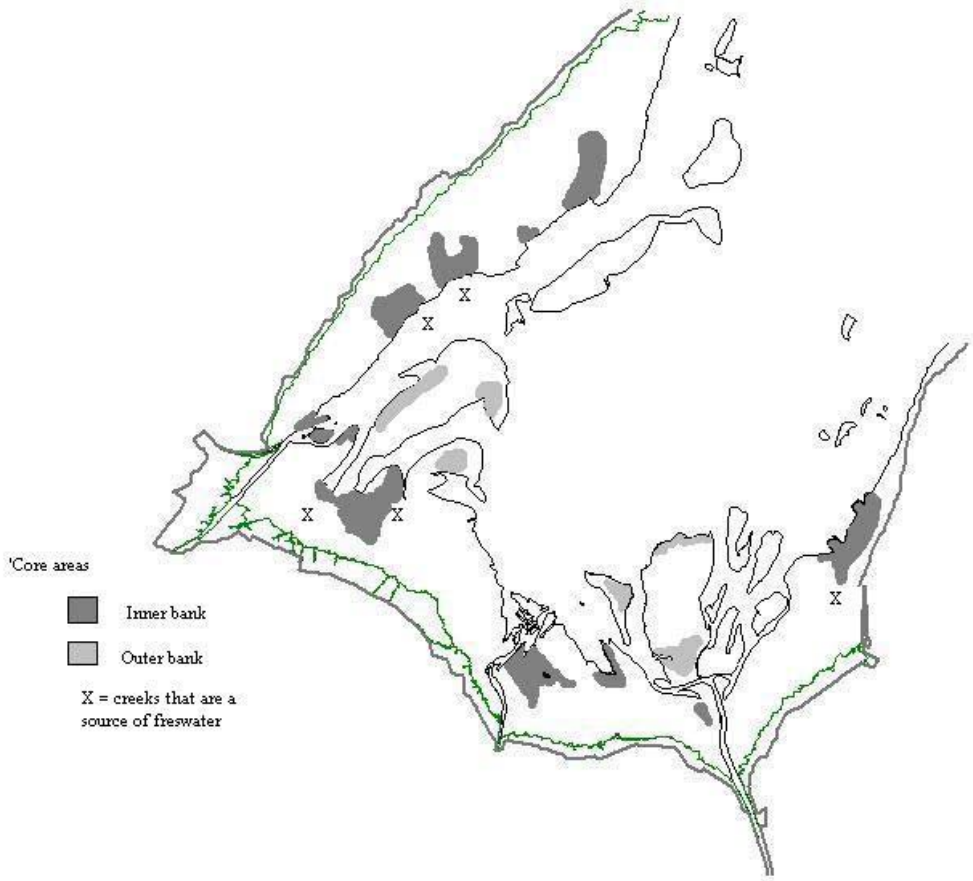


Figure 3.8 The location and extent of the low-tide bird-rich 'Core' areas in the Wash. The inner bank 'Core' areas are based on a combination of data from all previous low tide surveys (Goss-Custard, and others. 1977, Goss-Custard, and others. 1988 and Yates, and others. 1996).and the current 2002-03 survey while the outer bank ones are based on data from the 1970's survey (Goss-Custard, and others. 1977) and the current survey. Areas which span inter-tidal creeks down which freshwater is pumped are shown by crosses.

Appendix 1

The numbers of each bird species occurring in each of 75, 1km wide contiguous transects shown in Figure 3.3 and on individual outer bank areas in the 2002-03 survey. The west side of the Wash is spanned by transects 1-28, the south-west by transects 29-45, the south-east by transects 46-55 and the east side by transects 56-75.

Transects were aligned in a shore normal direction (ie perpendicular to the marsh edge) which meant that in three areas, two on the south-west and one on the south-east side of the Wash, transects overlapped to accommodate changes in the direction of the shore line. The numbers of birds within each transect was determined by overlaying transect divisions on the bird distribution maps and allocating the bird groups to the appropriate transect. Where a bird group spanned transect boundaries it was assumed that the birds were evenly distributed within the group and their numbers were allocated to transects in relation to the proportion of group's that fell within each transect. If a bird group was located where transects overlapped the birds were allocated to both transects.

Appendix 1	**West side transects**																											
Transect	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
Feeding ducks and waders																												
Shelduck	0	0	34	0	14	47	0	66	0	18	13	0	0	163	174	12	23	38	160	103	30	773	322	27	21	18	14	0
Oystercatcher	0	6	1	7	68	292	251	121	186	72	205	416	89	1123	373	233	208	318	0	227	175	0	0	0	7	0	0	0
Ringed plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Grey plover	92	1	21	105	17	56	125	5	65	61	42	32	22	84	35	0	32	79	2	3	3	8	6	0	2	0	0	0
Knot	0	0	0	194	404	72	179	512	294	123	198	89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sanderling	0	0	0	0	0	0	0	0	0	0	0	0	5	0	1	2	0	0	0	0	1	0	0	0	0	0	0	0
Dunlin	380	33	147	883	133	65	467	526	627	381	444	197	208	798	75	122	11	20	0	3	48	456	0	0	0	0	0	0
Black-tailed godwit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bar-tailed godwit	84	17	75	170	219	187	287	116	44	22	43	45	22	64	0	4	5	13	0	0	22	17	1	0	0	0	0	0
Curlew	29	2	80	116	17	0	2	1	1	27	15	18	50	40	66	57	83	17	2	19	9	0	1	0	10	4	0	0
Redshank	63	12	28	188	101	143	38	20	26	44	65	17	222	12	30	0	0	3	1	2	7	18	3	0	25	0	0	0
Turnstone	10	4	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0	0	0	0	0	0	0	0	0	0
Roosting wildfowl/waders																												
Brent goose	120	0	18	0	0	0	120	550	0	55	230	0	0	80	595	17	31	33	30	0	38	15	17	0	15	0	0	0
Wigeon	355	0	60	0	119	0	0	0	0	0	0	0	0	180	94	0	20	0	0	157	0	46	93	0	0	0	0	0
Teal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0
Mallard	10	0	0	0	0	0	0	0	0	92	165	0	0	35	0	3	18	20	0	8	54	51	86	0	0	0	0	0
Pintail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	2	5	0	0	0	0	0
Scaup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eider	0	0	0	0	0	0	0	52	312	200	20	410	60	140	0	0	0	58	0	0	0	0	0	0	0	0	0	0
Scoter	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	11	2	0	0	4	0	0	0	0	0	0	0
Red-breasted merganser	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Golden plover	480	0	720	0	0	0	0	0	0	0	0	0	0	1000	610	120	960	0	0	0	300	0	7000	0	0	0	0	0
Lapwing	400	0	1180	0	0	0	0	590	0	43	520	0	0	325	370	192	480	0	0	0	400	0	500	0	0	0	1000	0

Appendix 1 contd	**South-west side transects**																
Transect	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**
Feeding ducks and waders																	
Shelduck	453	329	54	52	304	97	455	458	280	120	80	62	0	58	212	401	131
Oystercatcher	259	296	31	31	125	392	506	93	135	65	64	0	86	151	0	0	1
Ringed plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grey plover	25	11	2	5	33	5	11	9	124	9	11	48	0	26	22	4	36
Knot	219	2157	1210	1970	1675	2930	755	170	240	1389	314	181	0	14	128	0	0
Sanderling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dunlin	466	2236	418	236	792	43	33	92	774	82	32	98	38	105	0	0	0
Black-tailed godwit	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Bar-tailed godwit	7	105	0	0	0	16	0	0	0	32	54	8	0	8	0	0	0
Curlew	58	74	16	24	43	44	26	29	4	9	30	10	0	9	12	12	4
Redshank	62	62	11	16	19	19	5	5	5	0	101	0	2	10	45	2	3
Turnstone	1	0	4	4	18	4	8	0	0	4	0	0	2	0	0	0	0
Roosting wildfowl/waders																	
Brent goose	0	0	23	29	0	0	260	261	0	226	138	62	0	44	0	0	23
Wigeon	600	0	33	33	0	0	0	0	0	0	0	0	0	0	0	0	0
Teal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mallard	20	14	0	0	0	0	0	0	0	0	0	0	0	0	132	18	0
Pintail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scaup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eider	0	0	0	0	0	0	0	0	5	26	15	0	0	0	0	0	0
Scoter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-breasted merganser	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Golden plover	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	650	0
Lapwing	150	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	800

Appendix 1 contd	**South-east side transects**									
Transect	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**
Feeding ducks and waders										
Shelduck	64	369	324	51	0	146	57	29	17	0
Oystercatcher	2650	135	0	124	858	34	1	0	6	3
Ringed plover	0	0	0	0	0	0	0	0	0	0
Grey plover	1	10	9	18	2	39	0	18	19	0
Knot	137	64	2938	1360	0	200	177	163	70	0
Sanderling	0	0	0	0	0	0	0	0	0	0
Dunlin	750	184	111	932	488	2036	16	351	858	15
Black-tailed godwit	0	0	0	0	0	0	0	0	0	0
Bar-tailed godwit	170	1	18	0	0	158	0	2	1	0
Curlew	61	71	87	64	17	59	22	33	21	4
Redshank	45	69	25	32	9	37	10	8	42	0
Turnstone	14	10	0	0	0	2	0	0	0	0
Roosting wildfowl/waders										
Brent goose	0	0	0	78	0	0	0	0	0	300
Wigeon	0	0	0	120	0	0	0	0	0	0
Teal	0	0	0	0	0	0	0	0	0	0
Mallard	370	0	0	0	0	0	0	0	0	0
Pintail	54	0	0	0	0	0	0	0	30	0
Scaup	72	0	0	0	0	60	0	0	0	0
Eider	0	0	0	0	0	40	0	0	0	0
Scoter	0	0	0	0	0	0	0	0	0	0
Red-breasted merganser	0	0	0	0	0	0	0	0	0	0
Golden plover	0	0	80	0	0	0	0	0	0	1000
Lapwing	0	0	0	180	0	160	0	0	0	500

Appendix 1 contd	East side transects																			
Transect	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**
Feeding ducks and waders																				
Shelduck	145	327	14	47	16	24	97	295	148	0	0	0	0	0	0	0	0	0	0	0
Oystercatcher	0	0	0	0	4	0	0	0	0	411	1945	435	98	151	111	6	57	45	2	1
Ringed plover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	7
Grey plover	22	10	0	0	0	0	0	26	128	40	5	62	12	9	4	0	0	12	0	0
Knot	0	0	0	0	0	0	0	0	1400	6800	570	444	261	23	28	0	0	2	0	12
Sanderling	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	6	2	0	0	0
Dunlin	55	580	630	997	102	24	20	30	601	269	820	595	7	138	32	0	0	6	0	0
Black-tailed godwit	206	0	0	94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bar-tailed godwit	0	169	36	0	1	1	4	0	14	141	10	539	701	246	148	2	8	1	0	4
Curlew	29	20	7	18	22	23	5	39	27	45	66	94	25	3	0	0	1	0	0	0
Redshank	16	12	61	154	40	16	0	0	23	13	45	81	13	15	6	0	5	11	0	1
Turnstone	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	14	36	0	0
Roosting wildfowl/waders																				
Brent goose	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Wigeon	0	0	0	0	0	0	0	0	269	80	0	0	0	0	0	0	0	0	0	0
Teal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mallard	0	24	0	0	12	0	0	0	74	15	0	0	0	0	0	0	0	0	0	0
Pintail	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scaup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0
Eider	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scoter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-breasted merganser	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Golden plover	0	0	0	0	0	300	0	2000	2000	0	0	0	0	0	0	0	0	0	0	0
Lapwing	690	310	0	450	300	0	0	600	400	0	0	0	0	0	90	0	0	0	0	0

Appendix 1 contd	Outer bank areas										
Area	**Inner Dogs Head**	**Long Sand**	**Roger/Toft Sand**	**Gat Sand**	**Thief Sand**	**Seal Sand**	**Daseley's Sand**	**Pandora Sand**	**Blackguard Sand**	**Styleman's Middle**	**Sunk Sand**
Shelduck											
Oystercatcher	0	4	1241	1179	121	686	1488	413	124	18	0
Grey plover	0	0	245	44	0	44	18	18	52	12	0
Knot	0	0	0	0	175	8031	0	0	1481	1240	0
Sanderling	4	0	15	15	0	13	0	3	0	0	20
Dunlin	0	0	147	652	60	1058	671	207	69	9	66
Bar-tailed godwit	1	39	576	86	19	127	98	138	2	0	180
Curlew	6	1	143	73	7	44	38	16	157	32	0
Redshank	0	0	30	75	2	3	4	32	8	28	4
Turnstone	0	0	5	12	0	5	1	12	0	0	0
Roosting wildfowl											
Eider	0	2	29	0	0	0	0	5	0	0	0

ENGLISH NATURE

English Nature is the Government agency that champions the conservation of wildlife and geology throughout England.

This is one of a range of publications published by:
External Relations Team
English Nature
Northminster House
Peterborough PE1 1UA

www.english-nature.org.uk

Cover printed on Character Express, post consumer waste paper, ECF.

ISSN 0967-876X

Cover designed and printed by Status Design & Advertising, 2M, 5M, 5M.

Front cover photographs:
Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888