BTO Research Report No. 338

Towards Determining the Causes of Declines in Waterbird Numbers on the Stour and Orwell Estuaries SPA

Authors

M.J.S. Armitage, G.E. Austin, N.O.M. Ravenscroft* and M.M. Rehfisch
*** Ecological Research Associates (ERA)**

A report of work carried out by the British Trust for Ornithology
under contract to Posford Haskoning Ltd

August 2003

British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU
Registered Charity No. 216652

British Trust for Ornithology

Towards determining the causes of declines in waterbird numbers on the Stour and Orwell estuaries SPA.

BTO Research Report No 338

M.J.S. Armitage, G.E. Austin, N.O.M. Ravenscroft* and M.M. Rehfisch
*Ecological Research Associates (ERA)

Report of work carried out by The British Trust for Ornithology
under contract to Posford Haskoning

Published in December 2003 by the
British Trust for Ornithology, The Nunnery, Thetford, Norfolk IP24 2PU, U.K.

ISBN 1-904870-04-X

CONTENTS

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

SUMMARY

1. Using Wetland Bird Survey (WeBS) data and standardised procedures for identifying critical levels of change (Alerts), Armitage and Rehfisch (2002a) identified that 11 out of the 17 species cited for the Stour and Orwell Estuaries (Stour-Orwell) SPA were declining at the site. Eight of these had declined in number by more than 25% in the five-year period between 1994/95 and 1999/2000. The declines largely contrasted with the regional and national population trends and the Stour-Orwell SPA was identified as having an unusually high proportion of declining species compared to other estuarine SPAs in England and Wales. Further investigation into the possible causes of the declines was recommended.

2. Since those recommendations, count data for one more winter (2000/01) have become available. The Alerts for the site were reassessed with these new data, which resulted in Alerts for three species (Mute Swan, Wigeon and Grey Plover) no longer being triggered. No new Alerts for other species were triggered.

	5-year	10-year	25-year
Great Crested Grebe Podiceps cristatus	-		n/a
Cormorant Phalacrocorax carbo		-	n/a
Shelduck Tadorna tadorna	-		
Pintail Anas acuta	-		
Ringed Plover Charadrius hiaticula	-	--	
Dunlin Calidris alpina	-	-	
Black-tailed Godwit Limosa limosa	-		+
Redshank Tringa totanus	-	+	

(-- >50% decline, - 25-50% decline, + 33-100% increase, ++ >100% increase, otherwise considered stable)
These Alerts have been calculated for the period 1974/75 to 2000/01

Detailed investigation into the causes of the declines of these eight species is carried out in this report.

3. The declines of four (Pintail, Ringed Plover, Dunlin and Black-tailed Godwit) of the eight species considered to be declining on the Stour-Orwell SPA as a whole appear to be largely due to decreases occurring on the Orwell Estuary. The decline in Redshank on the SPA appears to be driven more by the decrease in numbers on the Stour estuary. The declines of Great Crested Grebe, Cormorant and Shelduck on the SPA are attributable to decreases in numbers on both component estuaries.

4. Trends in the numbers of the eight species at three estuarine SPAs nearby (Blackwater Estuary, Deben Estuary and Hamford Water) show no clear similarities to the trends at the Stour-Orwell SPA and therefore the state of the Stour-Orwell SPA does not appear to be representative of sites in the region. However, there are also no clear similarities between the trends at each of the comparison sites. There is some evidence that the declines in numbers of some species (Cormorant, Pintail, Ringed Plover and Redshank) at the Stour-Orwell SPA coincide with increases in their numbers at the nearby sites.

5. In addition to WeBS Core counts (counts of mainly roosting birds made at high tide), Low Tide Counts (counts of mainly feeding birds made two hours either side of low tide) have also been carried out at the Orwell Estuary since the mid 1980s by Suffolk Wildlife Trust. Thus it was also possible to assess trends in the number of feeding birds on the Orwell Estuary, as determined by Low tide Counts.

6. No major differences were found in the population changes recorded by the two count methods for six of the eight species considered: Cormorant, Shelduck, Pintail, Dunlin, Black-tailed Godwit and Redshank. For these species the factors driving the declines are likely to be predominantly related to the deteriorating condition of the intertidal (as birds tend to select roosts that are near foraging sites rather than *vice versa*) rather than deterioration in roosting conditions. The difference recorded for Great Crested Grebe is probably due to Low Tide Counts not being designed to monitor such a diving species. The difference recorded for Ringed Plover could be due to a proportion of the birds that feed at the Orwell estuary choosing to roost elsewhere.

7. The numbers of Cormorant, Ringed Plover, Dunlin and Redshank making use of the Orwell Estuary at low tide declined over much of the estuary. Especially between 1995/96 and 2000/01, the sectors at the mouth of the Orwell near Felixstowe, those furthest inland near Ipswich and the Cliff Quay outfall, and two sectors on the north bank of the Orwell between Felixstowe and Ipswich have recorded declines in several species.

8. Dredging at the mouth of the Stour and Orwell Estuaries is known to have caused changes in the hydrodynamics of the estuaries, especially the lower parts, where the area and exposure-time of the mudflats may have been reduced. The timing of the declines in the waterbird species assessed (as determined by Low Tide Counts) matches well with the timing of the approach channel dredging events, particularly the 1994 dredge. There is therefore correlative evidence that the effects of capital dredging on the Orwell estuary may have at least contributed to the observed declines in waterbird numbers at the estuary and thus on the Stour-Orwell SPA as a whole. However, there is no evidence that waterbirds on the Stour Estuary have been affected in the same way as the Orwell Estuary. The change in the treatment of discharges from the Cliff Quay outfall in 1995 may also have been a major contributor to the declines in waterbirds on the SPA, as will have the major declines in the freshwater inputs into the estuary. The loss to landclaim of Fagbury Flats in addition to other parts of the Orwell and the Stour estuaries will also have contributed to fewer birds being able to make use of the Stour-Orwell SPA. A long-term increase in disturbance caused by recreation could also have impacted on the waterbird numbers using the SPA.

9. Recommendations for further work: if sufficient birds have been ringed on the Stour-Orwell SPA, the possible relationship between dredging and waterbird survival could be demonstrated by analysis of ringing data collected at the site. The relationship between the change in sediments (as a consequence of dredging events) and waterbird numbers on the various Low Tide Count sectors could also help determine whether or not dredging is the cause of the declines. Finally, it should be possible to compare population trends of waterbirds on other sites where dredging occurs to similar sites where it does not occur. If dredging is responsible for some or all of the declines in waterbird numbers on the Stour-Orwell SPA, then a repeated pattern of declines would be expected on other sites where dredging occurs.

1. INTRODUCTION

Harwich Harbour Authority needs to assess whether dredging of the Stour and Orwell Estuaries SPA (Stour-Orwell SPA) could be having an impact on its waterbirds under Regulation 50 of the Habitats Directive. The Stour-Orwell SPA qualifies under Article 4.2 of the Directive (79/409/EEC) by supporting populations of international importance (greater than 1% of the international flyway population) of the following eight migratory species: Shelduck *Tadorna tadorna*, Pintail *Anas acuta*, Ringed Plover *Charadrius hiaticula*, Grey Plover *Pluvialis squatarola*, Dunlin *Calidris alpina*, Black-tailed Godwit *Limosa limosa*, Redshank *Tringa totanus* and Turnstone *Arenaria interpres*. The site also qualifies under the same Article by regularly supporting an assemblage of over 20,000 waterfowl. These include the nationally important populations (greater than 1% of the British wintering population) at the site of the following species: Great Crested Grebe *Podiceps cristatus*, Cormorant *Phalacrocorax carbo*, Mute Swan *Cygnus olor*, Dark-bellied Brent Goose *Branta bernicla bernicla*, Wigeon *Anas penelope*, Goldeneye *Bucephala clangula*, Oystercatcher *Haematopus ostralegus*, Knot *Calidris canutus* and Curlew *Numenius arquata*. Waterbird count data have been collected in the UK for over 30 years in a standardised manner as part of the Wetland Bird Survey (WeBS). The Alerts system provides a standardised technique with which to monitor changes in the numbers of wintering waterbirds in the UK over a range of spatial scales and time periods (Atkinson & Rehfisch 2000). Lapwing *Vanellus vanellus* is also cited as part of the assemblage qualification at the Stour-Orwell SPA, but the Alerts system does not cover this species, because standard WeBS counts cover only a small proportion of the population.

As a first step along the process of reviewing the impact of the dredging on bird populations, the WeBS Alerts system was used to describe the changes in waterbird numbers that have occurred on the Stour-Orwell SPA (Armitage & Rehfisch 2002a) and these were placed in a regional and national context. Site trends need to be placed in the context of national and regional trends to ensure that a decline on the site is not simply an artefact of factors that are operating outside of the site.

Seven out of the eight species cited for having populations of international importance on the Stour-Orwell SPA have declined by 25% or more over a five- (1994/95 to 1989/90), 10- (1989/90 to 1999/2000) or 25-year (1974/75 to 1999/2000) period. Six of these species have declined by more than 25% over the five-year period (Table 1.1).

	Species code	5-year	10-year	25-year
Great Crested Grebe	GG	-		n/a[1]
Cormorant	CA		-	n/a[1]
Mute Swan	MS	+		-
Dark-bellied Brent Goose	DB			++
Shelduck	SU	-		
Wigeon	WN	-		++
Pintail	PT	-		-
Goldeneye	GN			++
Oystercatcher	OC	+	++	++
Ringed Plover	RP	--	--	-
Grey Plover	GV	-		++
Knot	KN	++	++	++
Dunlin	DN	-	-	
Black-tailed Godwit	BW	-		++
Curlew	CU			++
Redshank	RK		+	-
Turnstone	TT	+		++

(-- >50% decline, - 25-50% decline, + 25-50% increase, ++ >50% increase, otherwise considered stable)
[1] Great Crested Grebe and Cormorant data not available for this period

Table 1.1 Summary of Alerts for the period 1974/75 to 1999/2000 for species cited on the Stour-Orwell SPA (Armitage & Rehfisch 2002a).

Four additional species with nationally important populations at the site, which form an important part of the assemblage population at the Stour-Orwell SPA, also declined by 25% or more over the three time periods. These declines largely contrasted with the regional and national population trends (Table 1.2) and this site was identified as having an unusually high proportion of declining species compared to other estuarine SPAs in England and Wales (Armitage *et al.* 2002b).

	Site trend	**National trend (GB)**		**Regional trend (Anglian)**	
		Increasing or stable	**Decreasing**	**Increasing or stable**	**Decreasing**
5-year trend	Increasing or stable	CA, CU, DB, GN, KN, MS, OC, **RK**, **TT**		CA, CU, DB, GN, KN, MS, OC, **RK**, **TT**	
	Decreasing	**BW**, **DN**, GG, **GV**, **PT**, **RP**, **SU**, WN		**BW**, **DN**, GG, **GV**, **PT**, **RP**	SU, WN
10-year trend	Increasing or stable	**BW**, CU, DB, GG, GN, **GV**, MS, OC, **RK**, **SU**, WN	KN, **PT**, **TT**	**BW**, CU, DB, GG, GN, **GV**, MS, **RK**, **TT**	KN, OC, **PT**, SU, WN
	Decreasing	CA, **DN**	**RP**	CA, **DN**, **RP**	
25-year trend[1]	Increasing or stable	**BW**, CU, DB, GN, **GV**, KN, OC, **SU**, **TT**, WN	**DN**	**BW**, CU, DB, **DN**, GN, **GV**, KN, OC, **SU**, **TT**, WN	
	Decreasing	MS, **RK**	**PT**, **RP**	MS, **PT**, **RK**, **RP**	

Table 1.2 Summary of comparisons between the site trend and the national and regional (EA Anglian region) population trends of cited species for the Stour-Orwell SPA. Note that these comparisons refer to Alerts assessed over the period 1974/75 to 1999/2000. Species in bold are those present at the site in internationally important numbers.

Thus, the site was considered to give cause for concern as the majority of waterbird species cited for the Stour-Orwell SPA have declined. Armitage and Rehfisch (2002a) recommended that further investigation should focus on habitat change or loss, changes in disturbance intensity and food availability. It was also recommended that population changes in other estuaries in the region should be assessed in order to determine whether the observed declines are specific to the site or have occurred over a wider scale, especially during the latter half of the 1990s, since when many of the species have been in decline. Other specific factors could be playing a role in these declines and should be taken into account. These include changes in water quality, climate change leading to a redistribution of waterbirds, dredging of sediments leading to a change in estuary suitability for certain species and waterbirds being attracted away from the Stour-Orwell SPA to other sites that may have become more attractive.

Objectives

1. To determine whether the declines in the **roosting** numbers of some species of waterbird identified for the Stour-Orwell SPA are occurring on one or both of the Stour and Orwell estuaries using WeBS Core data (counts made at high tide).

2. To determine whether these declines in the **roosting** numbers of some species of waterbird on the Stour-Orwell SPA are unique or whether they are also occurring on other regional estuaries.

3. To determine whether the numbers of **feeding** waterbirds are declining within the Orwell estuary as a single unit using Low Tide Count (LTC) data.

4. To determine where the numbers of **feeding** waterbirds are declining on the Orwell to help identify possible causes of the declines using LTC data.

5. To interpret the information obtained as a result of meeting objectives 1-4 and from questionnaires sent to site experts to identify any factors that may be leading to the waterbird declines on the Stour-Orwell SPA and, if necessary, to suggest work to confirm that these factors are responsible.

2. METHODS

2.1 Calculation of Alerts

Estimated average winter counts

Using the latest validated WeBS data (up to winter 2000/01), the estimated average winter counts of birds at a site are calculated using Generalized Additive Models (GAMs). Missing values, inevitable with large scale count data collected over many years, are accounted for by the GAM, which fits a model with site, year and month factors. For n years of data, when a GAM model is fitted using (n-1) degrees of freedom, the resulting values are equivalent to those that would have been obtained using the Underhill indexing method (Underhill & Prŷs-Jones 1994), formerly used by WeBS for generating annual indices, except that, unlike that method, poor quality but higher than average counts are excluded and thus not permitted to inflate the values. The latter is essential to ensure that the smoothed trends (see below), which are obligate in their use of GAMs, are based on the same data as the estimated average winter counts.

Smoothed GAM trends

Natural temporary fluctuations in numbers, for example those caused by variation in the severity of conditions over the winter period, can differ in size and/or direction from longer-term trends, hindering their interpretation. Extreme values may trigger false Alerts due to misinterpretation of temporary, short-term declines as longer-term trends. Alternatively, long-term trends that may have led to Alerts being flagged could be obscured by short-term fluctuations. In order to avoid such misinterpretations and misidentifications when calculating Alerts, the Alerts System also uses GAMs to fit a smoothed trend curve to the estimated average winter counts. This it does by a reduction in the number of degrees of freedom available to the GAMs. As the number of degrees of freedom is decreased from (n-1) the trend becomes increasingly smooth until ultimately with one degree of freedom the smoothed curve becomes a linear fit. The WeBS Alerts System adopts a standard (n/3) degrees of freedom to produce a level of smoothing that, while removing temporary fluctuations not likely to be representative of long term trends, capture those aspects of the trends that may be considered to be important.

Changes in numbers calculated using values from a smoothed GAM trend are less likely to be due to the effects of temporary fluctuations in numbers, or to errors when sampling, than results produced were estimated average winter counts to be used. Thus, using GAMs reduces the probability that a decline from a short-lived unsustainable peak in numbers would be responsible for triggering an Alert. A decline from a period of sustained high numbers, however, would trigger an Alert using GAMs and clearly would be worthy of investigation. It should be noted that, because a standard degree of smoothing has been applied across all species and spatial scales, the arithmetic derivation could trigger Alerts for species showing large year-to-year fluctuations in numbers. In these cases, knowledge of their ecology and population dynamics is essential for correct interpretation.

Alerts

Proportional changes in the numbers derived from smoothed GAM trends over five-year, 10-year and 25-year time-frames are calculated by subtracting the smoothed GAM trend value at the start of the time-frame from the smoothed GAM trend value in the final winter. Currently, data prior to the winter of 1974/75 have been excluded, as coverage in the early days of WeBS was less extensive. To include these data would result in an unacceptably high proportion of missing counts, which not only influences the reliability of the entire fitted trend curve, but would also result in comparisons being made between the current value and a value not so much representing numbers in the early winters as it would long-term average numbers.

Calculated change values are expressed as a percentage of the estimated count at the start of the period. Larger values therefore indicate larger proportional changes in numbers, with positive values equating to relative increases in the numbers and negative values equating to relative decreases over the specified time period. These values are then categorised according to their magnitude and direction. Declines of between 25% and 50% inclusive are flagged as Medium Alerts and declines of greater than 50% as High Alerts. Although they will not promote discussion within this report, increases are also flagged in the appropriate tables. In order to facilitate comparison of decreases and increases in numbers, increases of between 33% and 100% are be described as Medium increases, while increases of greater than 100% are be described as High increases. This allows for the proportionally greater increase required to return numbers to their former level following a given decrease. Alerts are intended as advisory measures to trigger further investigation and should be interpreted with reference to the population dynamics and abundance of the species involved.

2.2 Determining Possible Causes of the Declines

To help determine the causes of the declines, a two-pronged approach was employed. The first approach involves interpreting existing data at a finer spatial scale than Armitage and Rehfisch (2002a) and also examining trends in the wider region.

Objective 1: There is evidence that the waterbird declines recorded for the Stour-Orwell SPA may largely be due to declines occurring predominantly on the Orwell Estuary. Thus, WeBS Core count data (counts of roosting birds at high tide) for the Stour-Orwell SPA were analysed separately for the Stour Estuary and the Orwell Estuary and comparisons were made between the trends and Alerts at each constituent estuary.

Objective 2: Interchange is known to occur between the Deben Estuary and Hamford Water SPAs and the Stour-Orwell SPA and it is possible that waterbirds have left the Stour-Orwell SPA to move into these two sites. Trends in waterbird numbers were assessed for the Hamford Water and the Deben Estuary SPAs and compared to the trends evident at the Stour-Orwell SPA. Waterbird trends were also calculated for the hydrologically broadly similar Blackwater Estuary SPA and compared to the Stour-Orwell SPA, as it would be expected that its waterbird population trends might be broadly similar to those of the Stour-Orwell SPA unless a Stour-Orwell specific factor was operating.

Objective 3: Trends in waterbird numbers were calculated for the Orwell Estuary as a single unit using the Low Tide Count (LTC) data available from Suffolk Wildlife Trust for winters 1984/85-1985/86, 1988/89-1992/93 and 1994/95-2002/2003. These were used to determine whether the declines in numbers of roosting birds on the Orwell are matched by similar declines in feeding waterbirds. If not, the observed declines may be due to factors lessening the attractiveness of the site to roosting birds that could, for example force the birds to roost elsewhere such as Hamford Water. If declines in feeding birds are larger than those of roosting birds, this could indicate that the cause is related to difficulties in foraging at the site. Similar analyses for the Stour Estuary could not be carried out, as LTC data only exist for the 1988/89-1992/93, 1996/97 and 1999/2000-2002/03 winters.

Objective 4: Waterbird trends were calculated for individual count sections using LTC data for the Orwell Estuary. Following standard Alerts protocol, changes in waterbird numbers over five- and 10-year periods were calculated for each count section and the trends were plotted. The graphs were then presented on a map of the Orwell count sections to help interpret the spatial distribution of the changes and thus identify if the waterbird declines have taken place in certain parts of the estuary rather than others.

In all instances, trends produced for interpretation take into account the timing of the three dredging events that occurred in 1984, 1994 and 1998-2000 to help identify whether changes in waterbird numbers occur following each dredging event. If not, the likelihood of dredging being responsible for the decline in waterbirds is lessened.

Objective 5: The second approach involved relating the spatially detailed population trends obtained above in Objectives 1 to 4 to information obtained regarding natural and man-made events that may have had an impact on bird numbers on the Stour-Orwell SPA. This latter information was obtained through a questionnaire circulated to professionals (staff from the Royal Society for the Protection of Birds (RSPB), Suffolk Wildlife Trust (SWT), English Nature (EN), Environment Agency (EA) etc.) and local experts (WeBS counters), discussions with these personnel, and from various reports commissioned by Environment Agency, English Nature and Harwich Haven Authority on potential impacts of developments and operations on the estuary.

3. RESULTS

3.1 Stour Estuary vs Orwell Estuary High Tide Alerts and High Tide Alerts at Other Regional Estuaries

The 17 species of waterbird cited for the Stour-Orwell SPA are considered in this comparison of the numerical trends recorded by Core counts (counts of mainly roosting birds made at high tide) on the SPA over five-, 10- and 25-year periods (Table 3.1.1 and Figure 3.1.1). Since the report by Armitage & Rehfisch (2002a), which identified the species that fired Alerts on the SPA based on Core count data up to 1999/2000, a further winter's data have become available for analysis (winter 2000/01). The effect of these new data on the Alerts is considered.

	5-year Alert			10-year Alert			25-year Alert		
	Alert	%	nos	Alert	%	nos	Alert	%	nos
Great Crested Grebe	-	-31	-71		-3	-5	n/a	n/a	n/a
Cormorant		-22	-40	-	-32	-69	n/a	n/a	n/a
Mute Swan		29	64		27	61		-16	-54
Dark-b Brent Goose		-12	-264		0	-8	++	273	1368
Shelduck	-	-30	932		-23	-655		1	11
Wigeon		-18	-707		-6	-197	+	52	1129
Pintail	-	-30	-156		-19	-83		-11	-45
Goldeneye		-21	-43		-7	-11	+	75	68
Oystercatcher		11	232	+	59	881	++	268	1739
Ringed Plover	-	-44	-174	--	-57	-290		9	19
Grey Plover		-3	-85		23	472	++	504	2124
Knot	+	52	1777	++	125	2904	++	821	4661
Dunlin	-	-36	-7421	-	-36	-7287		-16	-2565
Black-tailed Godwit	-	-48	-874		-13	-142	+	63	372
Curlew		11	178		19	283	++	138	1026
Redshank	-	-34	-1224	+	37	649		-20	-586
Turnstone	+	35	177		22	122	+	67	273

-- High Alert (greater than 50% decline), - Medium Alert (25-50% decline), + 33-100% increase, ++ greater than 100% increase, otherwise population considered stable
"%" percentage change, "nos" numerical change

Table 3.1.1 The five-, 10- and 25-year Alerts, percentage change and modelled numerical change of waterbirds on the Stour-Orwell SPA. These results are based on Core WeBS data for the period 1974/75 to 2000/01. The species considered are those cited for the Stour-Orwell SPA. It is not possible to assess 25-year Alerts for Great Crested Grebe and Cormorant as they only started being counted in 1983/84 and 1986/87, respectively.

Following discussion of trends of each species on the SPA, trends in the numbers of roosting birds on the Stour Estuary and the Orwell Estuary are compared, in order to determine whether there are any differences in the trends between the two estuaries (Table 3.1.2 and Figure 3.1.1).

For those species that have triggered an Alert on the SPA (for any time period based on Core count data to winter 2000/01), the numerical trends are examined on three estuarine SPAs nearby - the Blackwater Estuary, the Deben Estuary and Hamford Water - in order to determine whether the declines on the Stour-Orwell SPA are unique, or whether they are also occurring on other regional estuaries (Figure 3.1.2).

Great Crested Grebe

The number of Great Crested Grebes at the Stour-Orwell SPA has increased since this species was first recorded by WeBS, from 20-50 birds in the early 1980s to nearly 300 birds in 1995/96 (Figure 3.1.1a). In contrast to the national and regional trends, numbers declined in the latter half of the 1990s, triggering a five-year Medium Alert (Table 3.1.1). A small increase in numbers occurred in winter 2000/01.

The Stour holds five to six times the number of Great Crested Grebes than the Orwell and it therefore drives the trend in numbers on the SPA as a whole. Both estuaries show similar trends, however, with increases throughout the 1980s and early 1990s, followed by declines since the mid 1990s (Table 3.1.2 and Figure 3.1.1a).

The Blackwater Estuary holds approximately half the number of Great Crested Grebes that occur at the Stour-Orwell SPA and shows a similar trend in numbers, although the increase in winter 2000/01 was much larger (Figure 3.1.2a). Trends at the Deben Estuary and Hamford Water are not similar to the Stour-Orwell SPA, but the numbers of birds recorded there are an order of magnitude lower (Figure 3.1.2a). These nearby sites have not, therefore, compensated for the recent declines in Great Crested Grebe numbers evident at the Stour-Orwell SPA.

Cormorant

Since the mid 1980s, the number of Cormorants at the Stour-Orwell SPA has declined from approximately 250 birds to 150 birds in 1999/2000 (Figure 3.1.1b), triggering a 10-year Medium Alert (Table 3.1.1). A similar number was recorded in winter 2000/01. The national and regional trends are considered to be stable.

The number of Cormorants at the SPA is shared fairly evenly between the Stour Estuary and the Orwell Estuary, with both estuaries showing similar decreases of approximately 50 birds since the mid 1980s (Figure 3.1.1b and Table 3.1.2).

At the Blackwater Estuary, the number of Cormorants has fluctuated slightly, but remained stable over the five- and 10-year periods, with approximately 150 birds in 2000/01 (Figure 3.1.2b). Cormorant numbers at the Deben decreased from around 90 birds in the mid 1980s to 50 birds in the early 1990s, but have remained stable since then (Figure 3.1.2b). There has been an overall increase in the number of Cormorants recorded at Hamford Water, from a few birds in the mid 1980s to approximately 40 birds in 2000/01 (Figure 3.1.2b). The decline in Cormorant numbers at the Stour-Orwell SPA is not similar to, nor compensated for, at these local estuaries. It should be noted, however, that Cormorants have been recorded more inland in recent winters and there has been a large increase in the number of Cormorants at the nearby Abberton Reservoir, which may compensate for the loss of birds from the Stour-Orwell SPA.

Mute Swan

There has been a large decline in Mute Swan numbers at the Stour-Orwell SPA, from an average of 500 or so in the mid 1970s to approximately 280 in 1999/2000 (Figure 3.1.1c), which triggered a 25-year Medium Alert. Similar numbers were recorded in winter 2000/01, and because of this recent stability, the 25-year Alert is no longer triggered (Table 3.1.1).

The substantial decrease in Mute Swan numbers occurred particularly at the Orwell Estuary in the late 1970s, from over 300 birds to fewer than 50 birds in the early 1980s (Figure 3.1.1c). Since then, numbers have increased slightly. Following a decline in numbers on the Stour Estuary in the late 1980s and early 1990s, from over 200 birds to approximately 100 birds, numbers recovered in the latter half of the 1990s (Figure 3.1.1c). The long-term decline in numbers at the SPA is, therefore, largely attributable to the decline at the Orwell Estuary (Table 3.1.2). It should also be noted that declines of over 50% occurred on the Stour Estuary in the late 1960s as a result of the closure of a maltings factory, which used to discharge grain onto the estuary (Musgrove *et al.* 2001)

This species is not considered for further detailed analyses because the Alert at the Stour-Orwell SPA is no longer triggered.

Dark-bellied Brent Goose

Numbers of Dark-bellied Brent Geese have increased considerably at the Stour-Orwell SPA since the mid-1970s and no Alerts have been triggered for this species at the site (Figure 3.1.1d and Table 3.1.1). However, over the five-year period, there has been more than a 50% decline at the Orwell Estuary, representing a loss of over 400 birds (Table 3.1.2). This decline is, however, within the boundaries of past fluctuations. No such decline is evident at the Stour Estuary, which has maintained approximately 1500 birds in recent winters (Figure 3.1.1d).

This species is not considered for further detailed analyses because no Alerts are fired for the Stour-Orwell SPA.

Shelduck

Shelduck numbers have fluctuated at the Stour-Orwell SPA between approximately 2000-4000 birds on average (Figure 3.1.1e). A decline, since a peak in the mid 1990s triggered a five-year Medium Alert (Table 3.1.1), although it is within past fluctuations at the site. Numbers in winter 2000/01 were similar to the previous winter. Shelduck numbers have declined in the Anglian region over the five- and 10-year periods.

Recent trends on the Stour Estuary and Orwell Estuary are similar, with both estuaries showing declines since the early 1990s, although Shelduck numbers are generally higher on the Stour Estuary (Figure 3.1.1e). Numbers on the Orwell, however, have been particularly low in recent winters compared to the previous 15 years triggering a five-year High Alert on this estuary (Table 3.1.2).

The Blackwater Estuary and Hamford Water hold similar numbers of Shelduck as the Stour-Orwell SPA. Both of these sites have shown increases since the latter part of the 1980s. As at the Stour-Orwell SPA, however, both sites have experienced slight declines in recent winters (Figure 3.1.2c). Shelduck numbers at the Deben Estuary increased considerably during the 1970s and early 1980s. Since then, numbers have stabilised with the site supporting approximately 800 birds on average each winter (Figure 3.1.2c). The decrease in numbers at the Stour-Orwell SPA is therefore not compensated for at these sites.

Wigeon

Numbers of Wigeon at the Stour-Orwell SPA increased from around 2000 in the mid 1970s to 4500 in the mid 1990s (Figure 3.1.1f). A subsequent decline until winter 1999/2000 triggered a five-year Medium Alert. A small increase in numbers were recorded in winter 2000/01, and because of this, the Alert is no longer triggered (Table 3.1.1).

The overall increase in Wigeon numbers on the SPA is largely due to increases at the Orwell Estuary, although the Stour Estuary holds approximately twice as many birds. Declines in numbers between 1994/95 and 1999/2000, which triggered the original Alert, have been experienced on both estuaries (Figure 3.1.1f and Table 3.1.2).

This species is not considered for further detailed analyses because the Alert at the Stour-Orwell SPA is no longer triggered.

Pintail

Following an increase in the number of Pintail at the Stour-Orwell SPA between the mid 1980s and the mid 1990s, reaching approximately 550 birds (Figure 3.1.1g), there has been a decline that triggered a five-year Medium Alert (Table 3.1.1). Over the same five-year period, the regional and national indices have been stable. The number recorded at the SPA in winter 2000/01 was slightly higher than that in the previous winter.

Until the last five-year period, the trend on the Stour-Orwell SPA followed that on the Stour Estuary (Figure 3.1.1g). In contrast to the decline on the SPA in recent years, however, numbers on the Stour Estuary have been stable. On the Orwell Estuary, Pintail numbers increased considerably since the mid 1970s, reaching a peak of over 300 birds in the early 1990s. Since then, however, numbers have declined to former levels (Figure 3.1.1g) triggering High Alerts on the Orwell Estuary over all three periods (Table 3.1.2). This has triggered the five-year Medium Alert on the SPA.

The number of Pintail at the Blackwater Estuary fluctuates considerably between winters, but there has been an overall increasing trend since the mid 1970s, with approximately 200 in 2000/01 (Figure 3.1.2d). At the Deben Estuary, numbers have increased since the mid 1970s to around 80 birds in 2000/01, although highest numbers were recorded in the mid 1980s (Figure 3.1.2d). Numbers at Hamford Water, however, have decreased and show a similar trend to the Stour-Orwell SPA in the last five-year period (Figure 3.1.2d). The loss of birds from these two sites in recent winters may be compensated for by increases at the Blackwater and Deben Estuaries.

Goldeneye

Numbers of Goldeneye fluctuated markedly between winters, but have generally increased at the Stour-Orwell SPA since the mid-1970s (Figure 3.1.1h) and no Alerts have been triggered for this species at the site (Table 3.1.1). A five-year High Alert was triggered on the Orwell Estuary, but the long-term trend is one of increase on this estuary (Table 3.1.2).

This species is not considered for further detailed analyses because no Alerts are fired for the Stour-Orwell SPA.

Oystercatcher

Numbers of Oystercatcher have increased considerably at the Stour-Orwell SPA from an average winter count of approximately 600 in the mid-1970s to nearly 2500 in recent winters (Figure 3.1.1i). No Alerts have been triggered for this species at the site (Table 3.1.1). This increase is mostly due to the increase from approximately 150 birds to over 1500 birds observed at the Stour Estuary, although a long-term increase has also occurred at the Orwell Estuary (Figure 3.1.1i).

This species is not considered for further detailed analyses because no Alerts are fired for the Stour-Orwell SPA.

Ringed Plover

Ringed Plover numbers increased at the Stour-Orwell SPA throughout the 1970s and 1980s, peaking at approximately 750 birds in 1988/89 (Figure 3.1.1j). A considerable decline to just over 100 birds in 1999/2000 triggered five- and 10-year High Alerts. An increase in the number of birds in winter 2000/01 has reduced the five-year Alert to Medium status (Table 3.1.1). Although in the long-term Ringed Plover have declined nationally, at the regional scale, they have increased, contrasting with the trend at the Stour-Orwell SPA.

Similar numbers of Ringed Plover are recorded on each of the Stour and Orwell Estuaries. The number of Ringed Plover at the Orwell Estuary increased substantially during the late 1970s and early

1980s, but has declined to low levels since then (Figure 3.1.1j and Table 3.1.2). At the Stour Estuary, the increase in numbers continued until the early 1990s before also declining (Figure 3.1.1j). Both estuaries are therefore responsible for the Alerts triggered for the SPA, although the trends on the Orwell Estuary may be having the greater influence.

Unlike at the Stour-Orwell SPA, Ringed Plover numbers at the Blackwater Estuary, Deben Estuary and Hamford Water have increased over the 10-year period (Figure 3.1.2e). These increases may compensate for the decreases at the Stour and Orwell Estuaries.

Grey Plover

Numbers of Grey Plover have increased considerably on the Stour-Orwell SPA from less than 500 in the mid 1970s to around 3000 in the early 1990s (Figure 3.1.1k). A subsequent decline until 1999/2000 triggered a five-year Medium Alert. A considerable increase occurred in winter 2000/2001 and the Alert is no longer triggered Table 3.1.1).

The Stour Estuary held over 2000 birds in winter 2000/01, nearly 10 times as many as are recorded on the Orwell Estuary. The trend on the SPA is therefore largely driven by changes in Grey Plover numbers on the Stour Estuary, although the trend on the Orwell Estuary is also similar (Figure 3.1.1k).

This species is not considered for further detailed analyses because no Alerts are fired for the Stour-Orwell SPA.

Knot

Numbers of Knot have increased considerably on the Stour-Orwell SPA from approximately 500 in the late 1970s to around 5000 in recent winters (Figure 3.1.1l). No Alerts have been triggered for this species at the SPA (Table 3.1.1).

The Stour Estuary held approximately 4500 birds in winter 2000/01, nearly 10 times as many as are recorded on the Orwell Estuary (Figure 3.1.1l). The trend on the SPA is therefore largely driven by changes in Knot numbers on the Stour Estuary. Numbers on the Orwell Estuary peaked at over 1200 birds in the mid 1980s, declined to near absence in the early 1990s and subsequently increased to approximately 450 birds in 2000/01.

This species is not considered for further detailed analyses because no Alerts are fired for the Stour-Orwell SPA.

Dunlin

For much of the 1980s and first half of the 1990s, over 20000 Dunlin were present at the Stour-Orwell SPA during most winters (Figure 3.1.1m). A subsequent decline to approximately 13000 birds in 1999/2000 triggered a five-year Medium Alert (Table 3.1.1). This contrasts with the stable national and regional populations. There was a small increase in numbers at the SPA in winter 2000/01.

The Stour Estuary generally holds more birds than the Orwell Estuary. During the 1980s and early 1990s, the Stour Estuary typically held between 8000-15000 birds while the Orwell Estuary typically held between 5000 and 10000 birds. Over the five-year period, both estuaries have experienced declines, with a decrease of over 4500 birds at the Orwell Estuary and of over 2500 birds at the Stour Estuary (Figure 3.1.1m and Table 3.1.2). Both estuaries have therefore contributed to the decline on the SPA as a whole.

The Blackwater Estuary holds similar numbers of Dunlin as the Stour-Orwell SPA. Numbers there have shown an overall increasing trend since the mid 1970s, although there was a decrease during the mid 1990s and then high numbers recorded again in 2000/01 (Figure 3.1.2f). The Deben Estuary shows an underlying stable trend but holds fewer birds, typically fluctuating between about 1500 and 3000 (Figure 3.1.2f). As at the Blackwater Estuary, there was a large number of birds present in winter 2000/01. At Hamford Water, Dunlin numbers showed a decline from the mid 1970s to the mid 1980s, followed by a period of increase with numbers ranging from 2000-8000 during this period (Figure 3.1.2f). As at the Stour-Orwell SPA, numbers have declined again at Hamford Water in the last five-year period. There is no evidence that changes in the numbers of Dunlin at these three local estuarine SPAs have accounted for the recent declines at the Stour-Orwell SPA, nor are the trends at these sites similar.

Black-tailed Godwit

The number of Black-tailed Godwit at the Stour-Orwell SPA increased throughout the 1980s and early 1990s with an exceptional peak of over 2400 birds in 1995/96 (Figure 3.1.1n). By 1999/2000, numbers declined to approximately 1000 birds, triggering a five-year Medium Alert (Table 3.1.1). The decrease in number continued in winter 2000/01. This contrasts with continuing increases in the numbers at a national and regional scale.

The majority of Black-tailed Godwit at the Stour-Orwell SPA occur on the Stour Estuary; hence the trend on the SPA largely reflects that on the Stour Estuary (Figure 3.1.1n). This species only began to use the Orwell Estuary in the mid 1980s. During the 1990s, between 100 and 400 birds occurred on the Orwell Estuary, although in 2000/01 very few were observed, which has resulted in firing five- and 10-year Alerts on the Orwell Estuary (Table 3.1.2). This decline on the Orwell Estuary has contributed to the continued decline on the SPA as a whole.

The Deben Estuary also experienced declines since peak numbers in the mid 1990s, although the Deben Estuary supports smaller numbers than the Stour-Orwell SPA (Figure 3.1.2g). The Blackwater Estuary typically held between 100 and 400 birds each winter in the 1990s, but in 2000/01, an average of approximately 1200 was recorded (Figure 3.1.2g). Following a decline during the 1990s, there were also higher numbers of Black-tailed Godwit recorded at Hamford Water in 2000/01 (Figure 3.1.2g). There is no evidence that changes in the numbers of Black-tailed Godwit at these SPAs have accounted for the recent declines at the Stour-Orwell SPA, nor are the trends similar.

Curlew

Curlew numbers at the Stour-Orwell SPA have increased throughout the period since the mid 1970s (Figure 3.1.1o). No Alerts were triggered for this species at the SPA (Table 3.1.1). The trends on the component estuaries are similarly increasing (Figure 3.1.1o) and no Alerts have been triggered for either estuary (Table 3.1.2).

This species is not considered for further detailed analyses because no Alerts are fired for the Stour-Orwell SPA.

Redshank

Numbers of Redshank have typically fluctuated between 1500 and 4000 at the Stour-Orwell SPA (Figure 3.1.1p). The decline since a small peak in numbers in the mid 1990s triggered a five-year Medium Alert (Table 3.1.1). Numbers in 2000/01 were slightly lower than in 1999/2000, but were higher than on several occasions in the late 1980s and early 1990s. The declines at the site contrast with the stable national and regional trends.

The Stour Estuary and the Orwell Estuary have held similar numbers of Redshank, but numbers on each estuary fluctuated considerably (Figure 3.1.1p). No Alerts were triggered for any period on the Orwell Estuary (Table 3.1.2). The decline evident on the SPA as a whole is due to the decline on the Stour during the five-year period (Table 3.1.2).

Unlike at the Stour-Orwell SPA, the Blackwater Estuary and the Deben Estuary have shown long-term increases in numbers of Redshank and now hold similar numbers to the Stour-Orwell SPA (Figure 3.1.2h). At Hamford Water, Redshank numbers declined from nearly 2000 birds to just over 100 birds during the 1980s, but increased again during the 1990s to previous levels (Figure 3.1.2h). The continued increases observed at the Blackwater Estuary and the Deben Estuary may account for the loss of Redshank at the Stour-Orwell SPA.

Turnstone

The underlying trend in Turnstone numbers at the Stour-Orwell SPA is one of increase, particularly during the last five-year period, with over 600 birds on average over the recent winters (Figure 3.1.1q). No Alerts have been triggered for this species at the SPA (Table 3.1.1). The increase on the SPA is due to the considerable increase in numbers on the Stour Estuary (Figure 3.1.1q). In contrast, the Orwell Estuary has shown a large decline (Figure 3.1.1q), triggering Alerts over the five- and 10-year periods (Table 3.1.2). The Stour Estuary may, therefore, be compensating for the loss of birds from the Orwell Estuary.

This species is not considered for further detailed analyses because no Alerts are fired for the Stour-Orwell SPA.

In summary: the declines of four (Pintail, Ringed Plover, Dunlin and Black-tailed Godwit) of the eight species considered to be declining on the Stour-Orwell SPA as a whole may be largely due to decreases occurring on the Orwell Estuary. The decline in Redshank on the SPA appears to be driven more by the decrease in numbers on the Stour estuary. The declines of Great Crested Grebe, Cormorant and Shelduck on the SPA are attributable to decreases in numbers on both component estuaries.

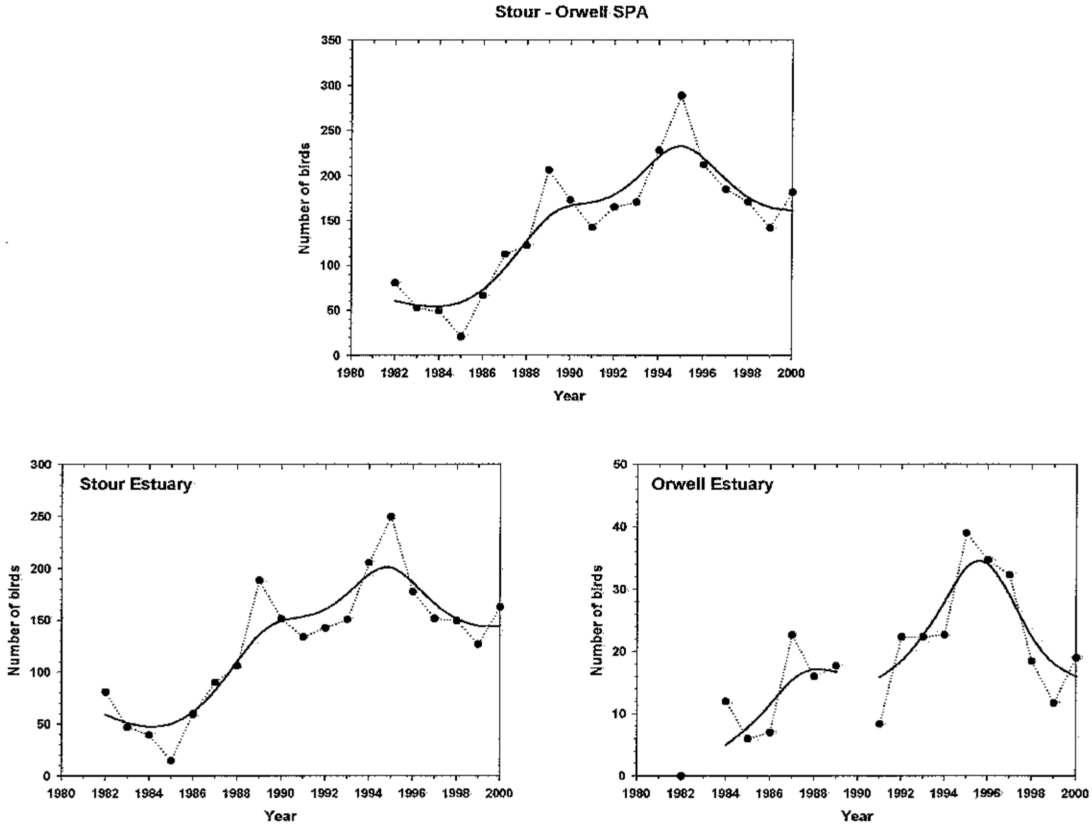
Trends in species numbers at the three estuarine SPAs nearby show no clear similatrities to the trends at the Stour-Orwell SPA and therefore the state of the Stour-Orwell SPA does not appear to be representative of other sites in the region. There is some evidence that the declines in numbers of some species (Cormorant, Pintail, Ringed Plover and Redshank) at the Stour-Orwell SPA may coincide with increases in their numbers at some of the nearby sites. However, there are also no clear similarities between trends at each of the three SPAs nearby, therefore all four sites may be acting independently.

	5-year Alert						10-year Alert						25-year Alert					
	Stour			Orwell			Stour			Orwell			Stour			Orwell		
	Alert	%	nos	Alert	%	nos	Alert	%	nos	Alert	%	nos	Alert	%	nos	Alert	%	nos
Great Crested Grebe	-	-28	-56	--	-52	-18		-3	-5		-2	0	n/a	n/a	n/a	n/a	n/a	n/a
Cormorant		-16	-13	-	-28	-30	-	-39	-44		-23	-23	n/a	n/a	n/a	n/a	n/a	n/a
Mute Swan		25	39	+	43	28		27	40		32	23		12	20	-	-37	-55
Dark-b Brent Goose		13	164	--	-54	-441		5	64		-19	-87	++	394	1176	+	72	158
Shelduck		-9	-177	--	-62	-769		-6	-104	--	-53	-523		15	228	-	-29	-186
Wigeon		-8	-176	-	-30	-509		-14	-341		13	131		19	347	++	322	885
Pintail		3	10	--	-89	-157	+	78	156	--	-93	-280		-2	-7	--	-70	-46
Goldeneye		16	17	--	-67	-69		3	3	-	-26	-12	+	98	62	+	79	15
Oystercatcher		0	-1	+	35	231	+	45	468	+	83	406	++	876	1362	+	82	402
Ringed Plover		-22	-51	--	-69	-117	-	-47	-158	--	-72	-131	++	149	109	--	-58	-73
Grey plover		-4	-94		3	6		29	537		-20	-48	++	544	2006	++	262	138
Knot	+	45	1510	+	78	206	++	138	2799	+	75	203	++	1324	4494	++	106	243
Dunlin		-19	-2659	--	-70	-4857		-18	-2407	--	-70	-4788		7	696	--	-57	-2680
Black-tailed Godwit	-	-45	-737	--	-72	-141		-10	-97	-	-47	-48	+	46	282	++	>1000	54
Curlew		18	177		0	2		27	240		7	40	++	127	638	++	165	389
Redshank	-	-45	-1094		-12	-146	+	49	442		28	238		-22	-386		-7	-81
Turnstone	+	44	164		12	15	+	46	172	-	-26	-49	++	272	395	-	-45	-116

-- High Alert (greater than 50% decline), - Medium Alert (25-50% decline), + 33-100% increase, ++ greater than 100% increase, otherwise population considered stable
"%" percentage change, "nos" numerical change

Table 3.1.2 The five-, 10- and 25-year Alerts, percentage change and modelled numerical change of waterbirds on the Orwell and Stour Estuaries separately. These results are based on Core WeBS data for the period 1974/75 to 2000/01. The species considered are those cited for the Stour-Orwell SPA. It is not possible to generate 25-year Alerts for Great Crested Grebe and Cormorant as they only started being counted in 1983-84 and 1986-87, respectively.

a. Great Crested Grebe



b. Cormorant

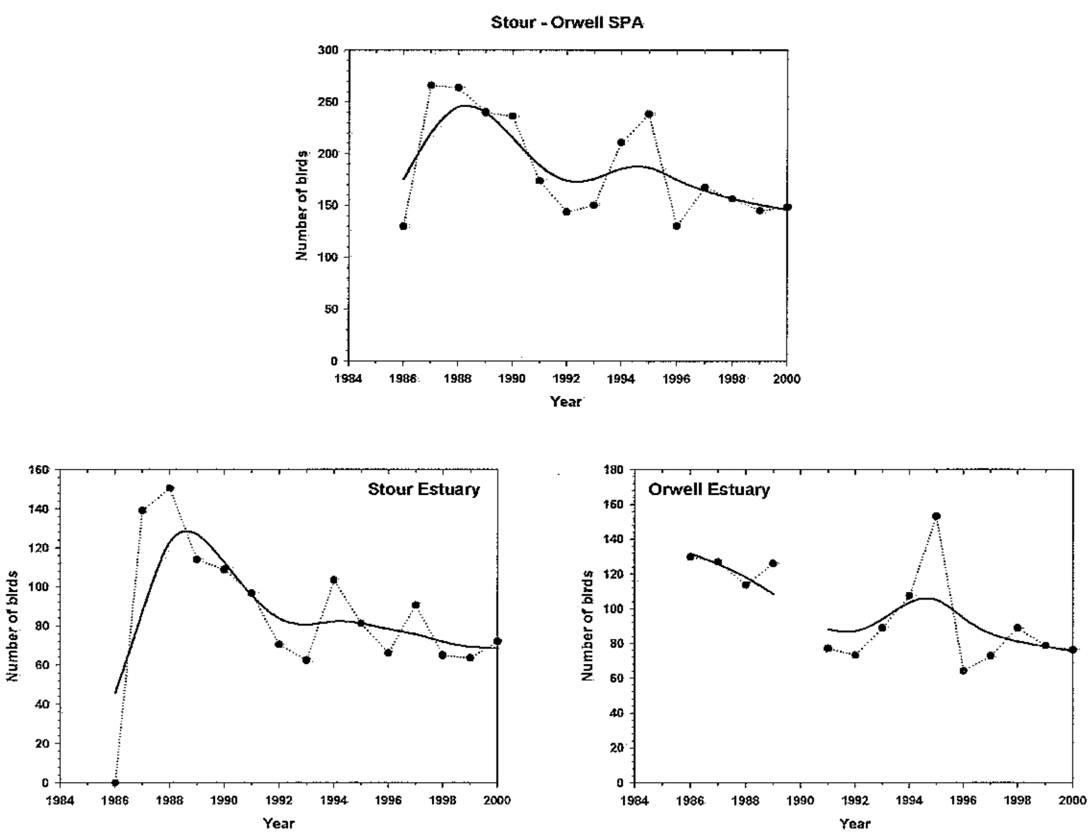
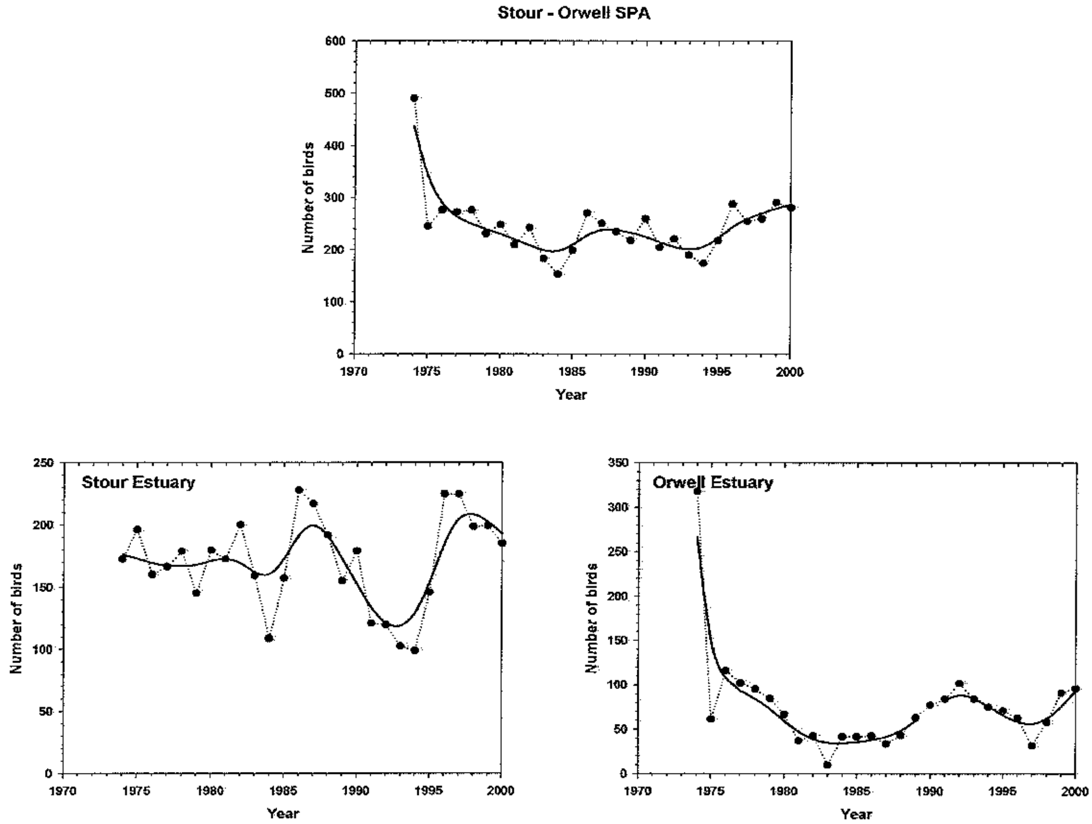


Figure 3.1.1 Trends in the numbers of birds (based on Core counts) at the Stour-Orwell SPA, and the Stour Estuary and Orwell Estuary separately for species that are cited at the Stour-Orwell SPA. Points joined by the dotted line are estimated average winter counts, the solid line represents the smoothed trend.

c. Mute Swan



d. Dark-bellied Brent Goose

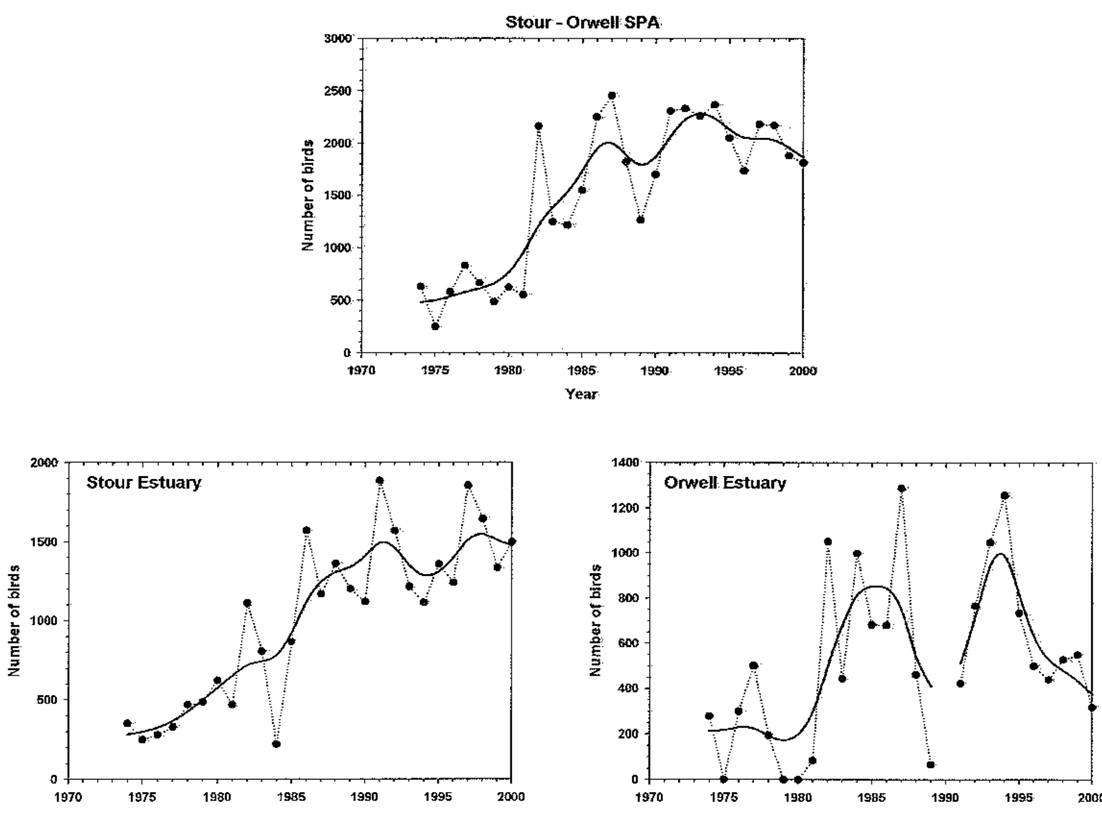
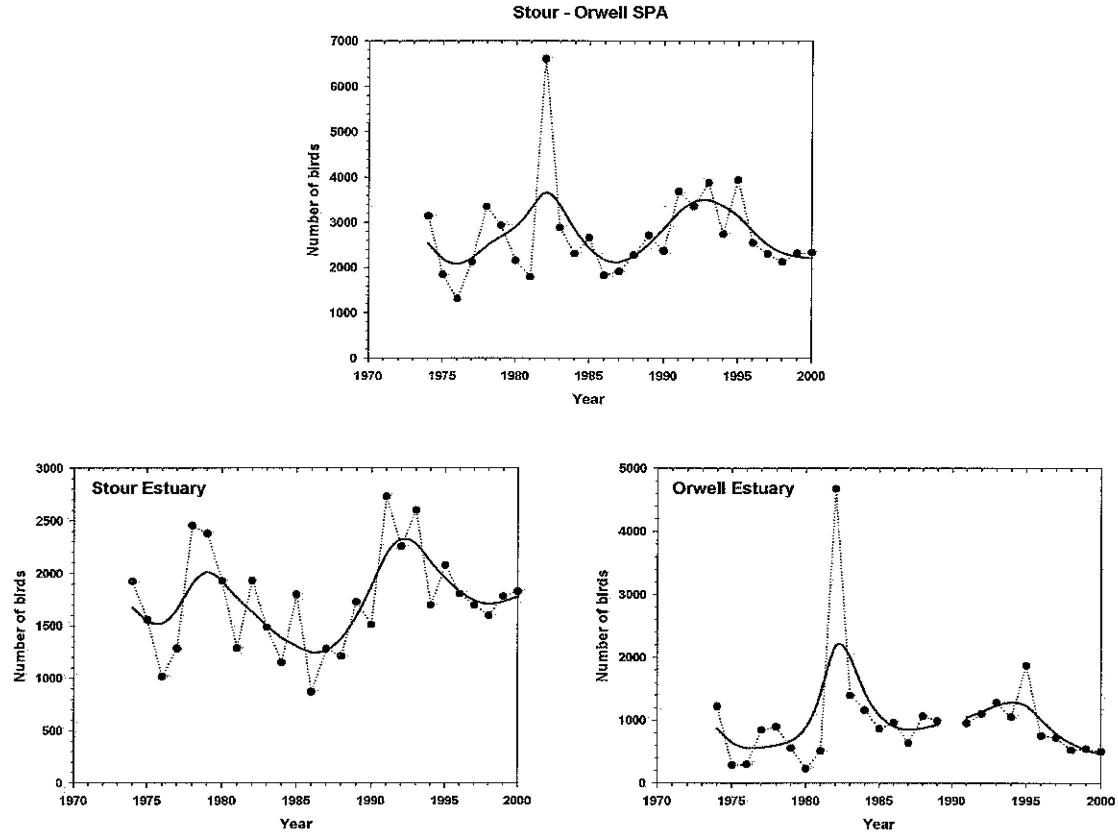


Figure 3.1.1 continued

e. Shelduck



f. Wigeon

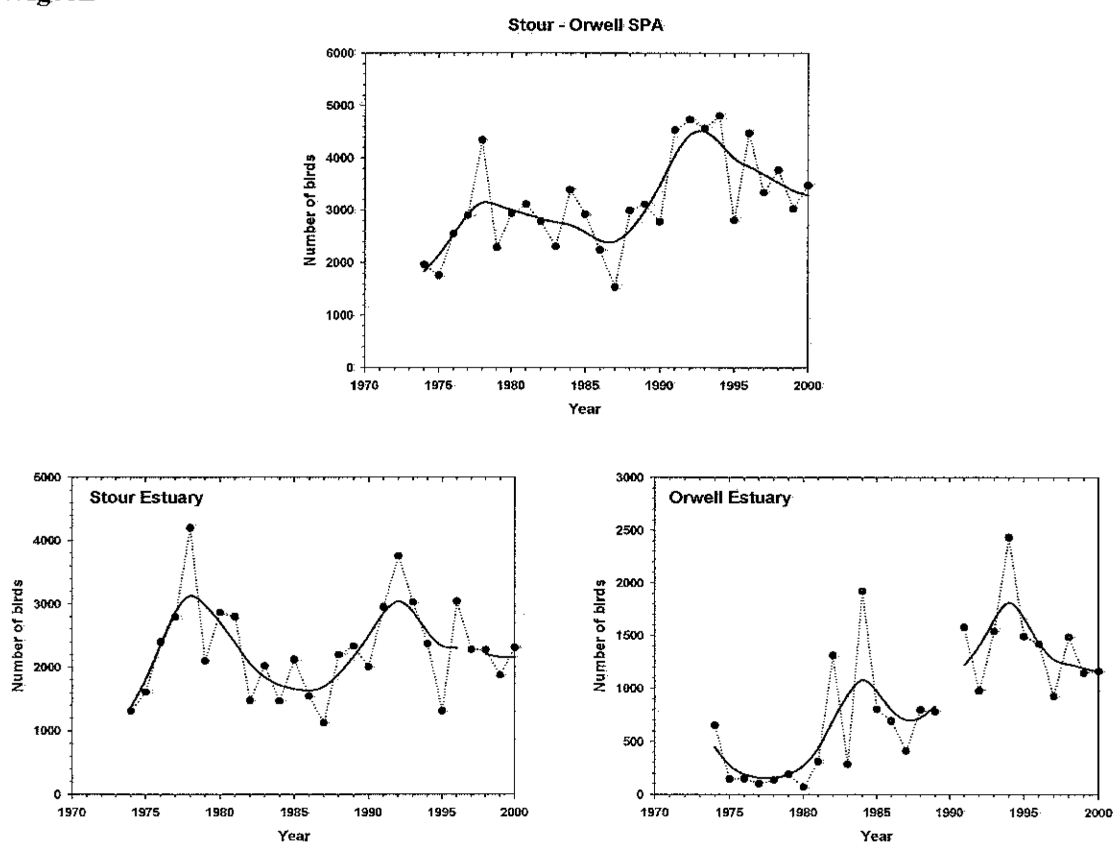
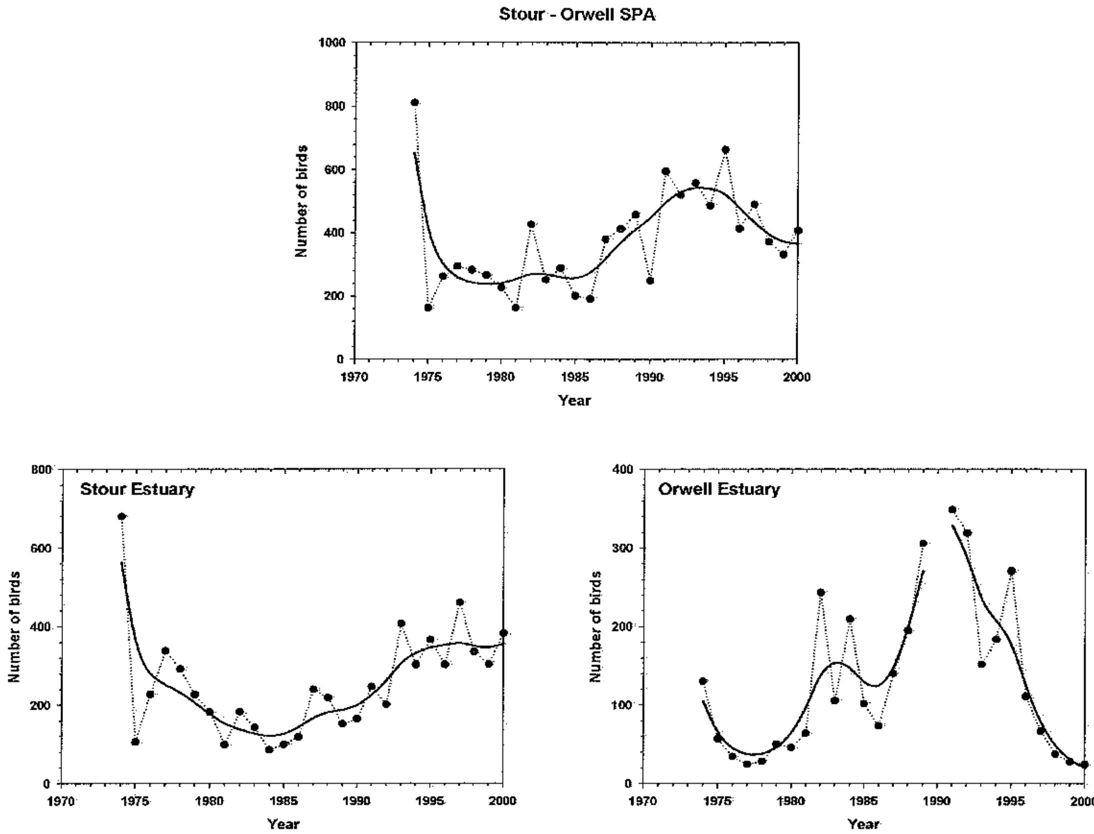


Figure 3.1.1 continued

g. Pintail



h. Goldeneye

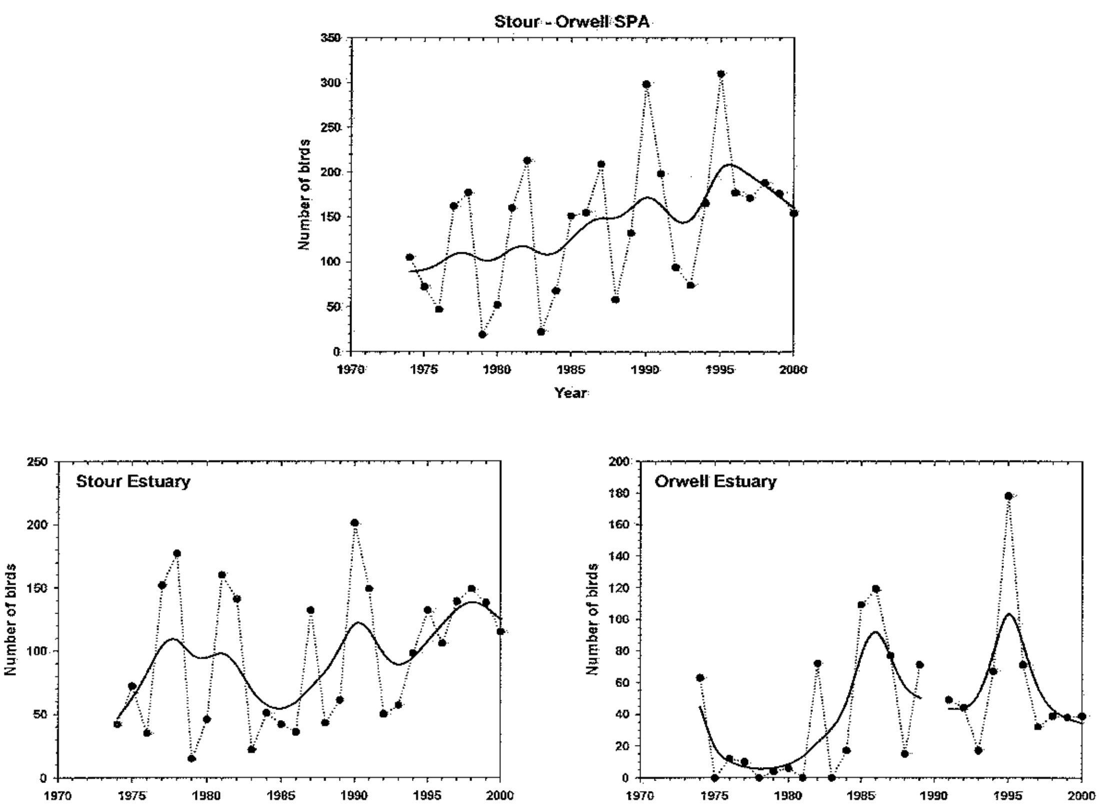
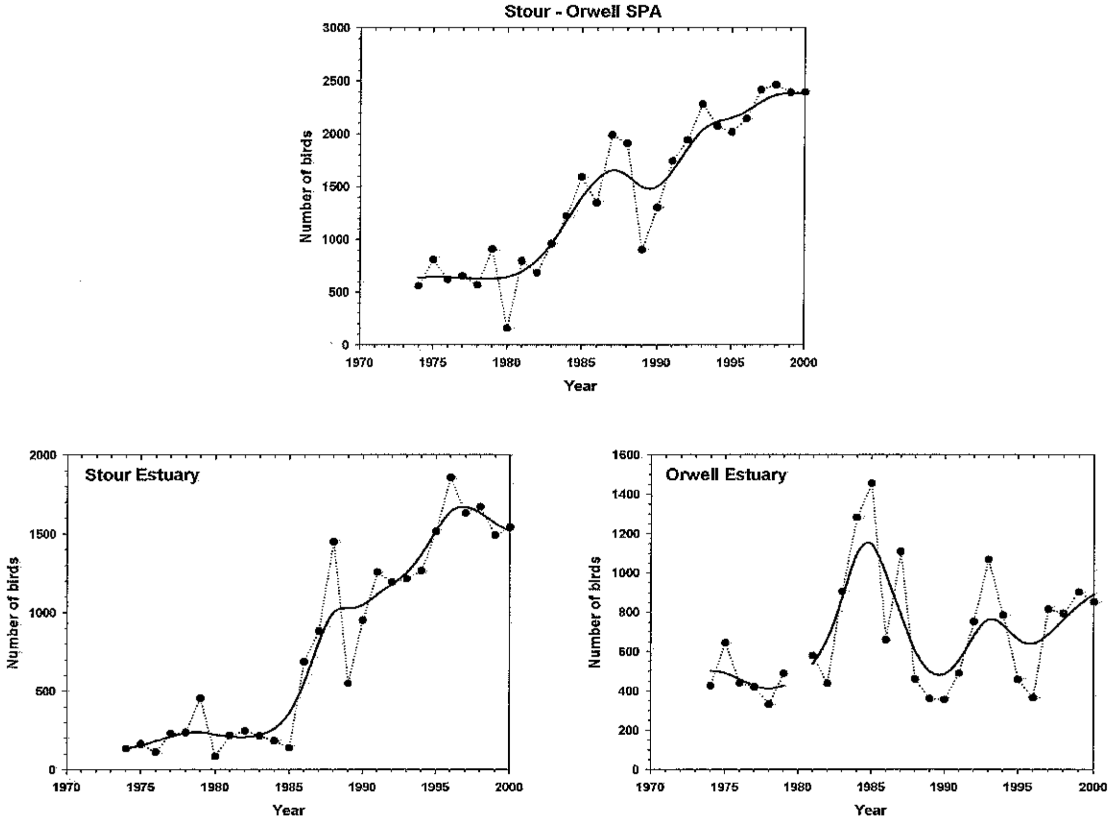


Figure 3.1.1 continued

i. Oystercatcher



j. Ringed Plover

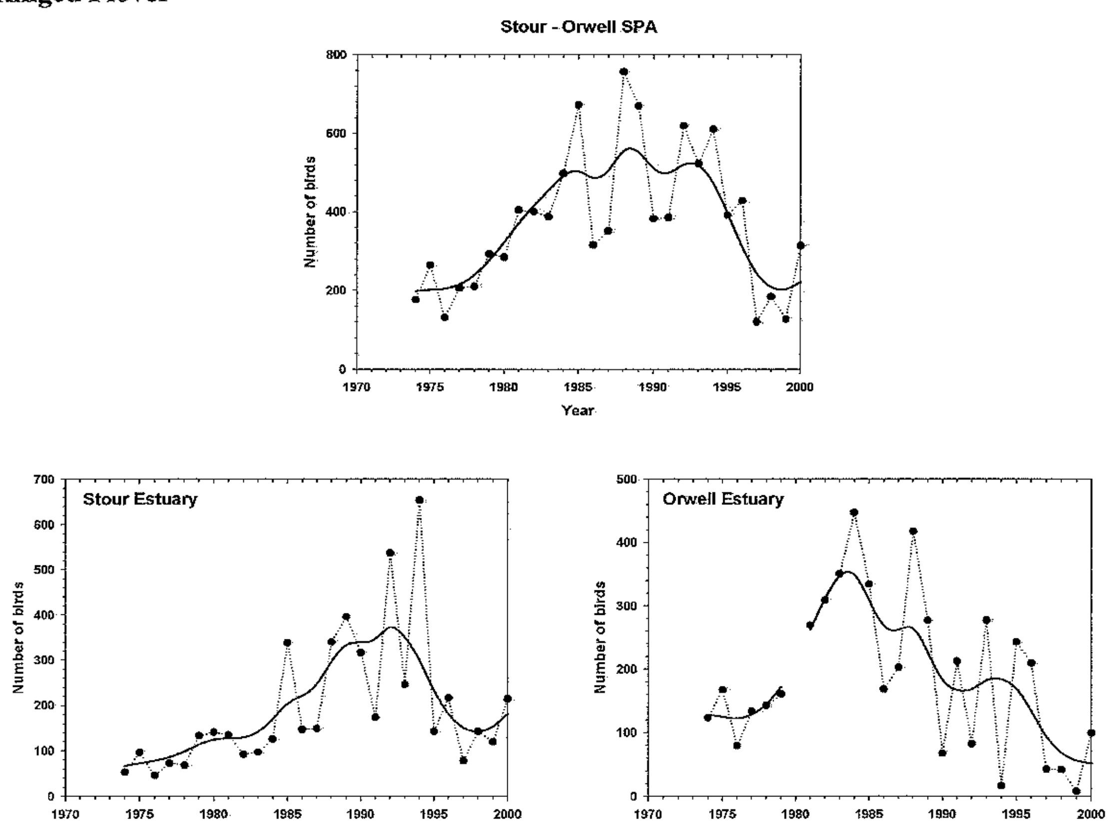
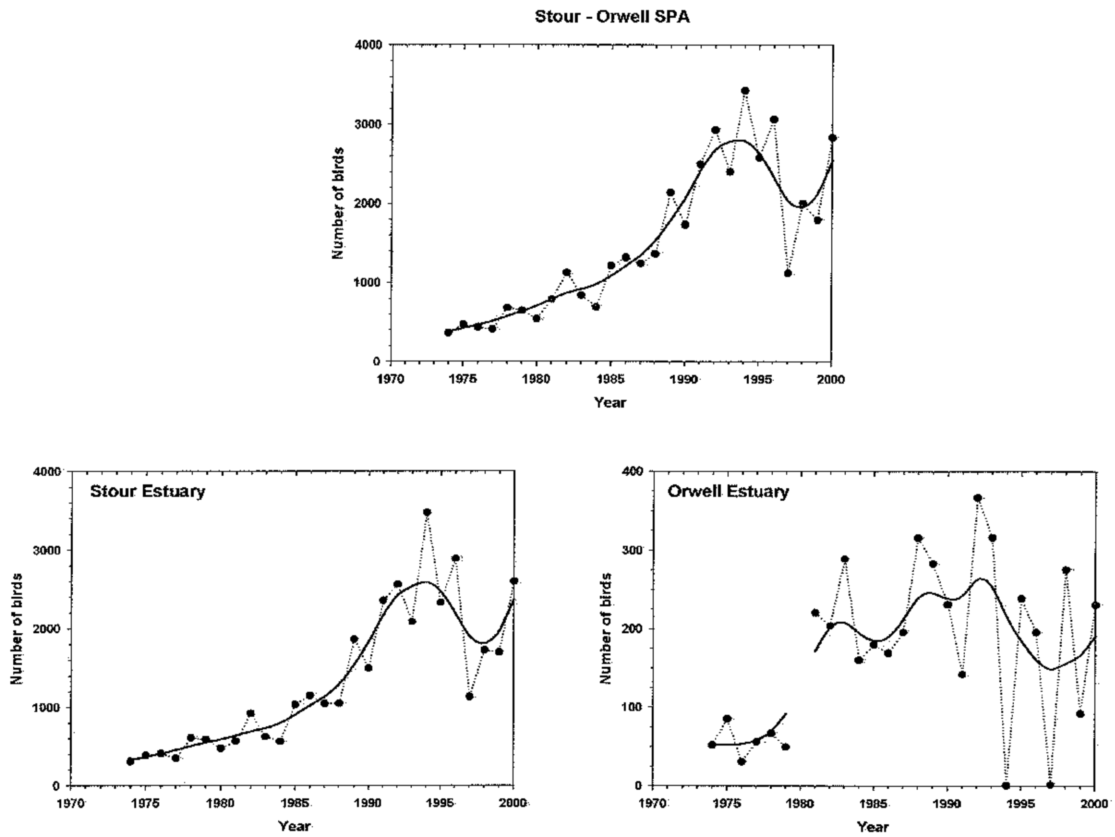


Figure 3.1.1 continued

k. Grey Plover



l. Knot

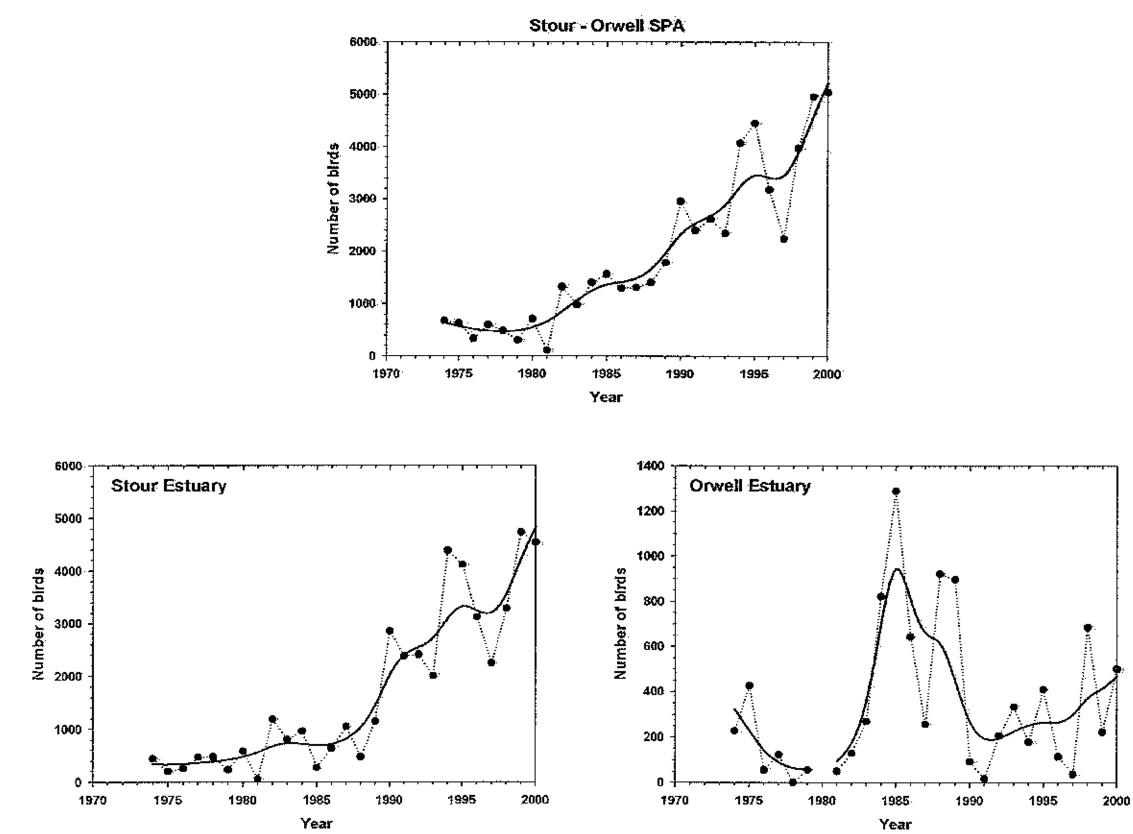
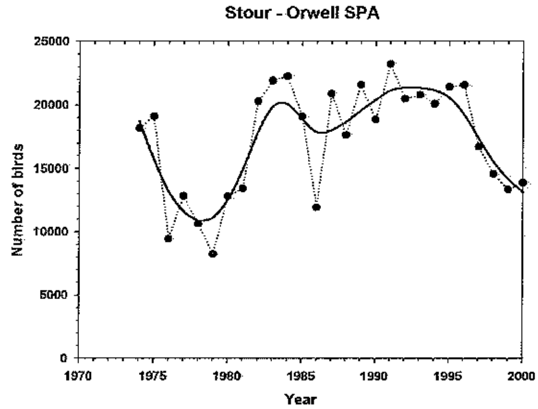
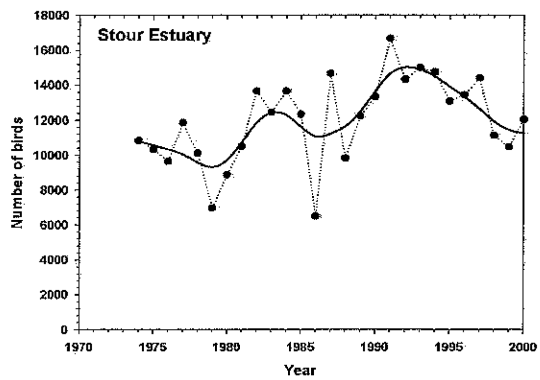
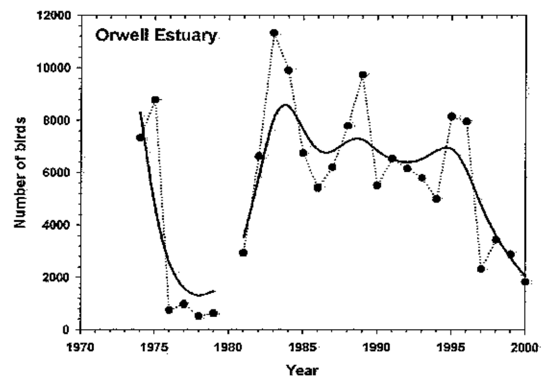


Figure 3.1.1 continued

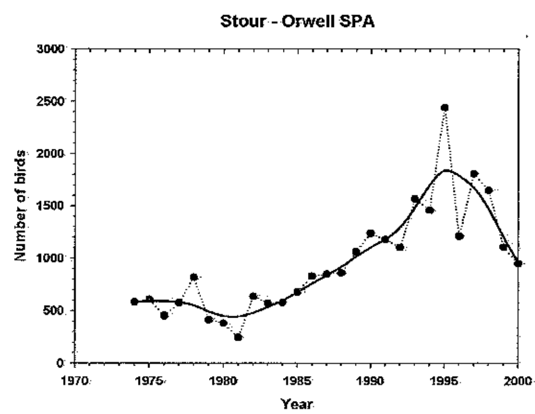
m. Dunlin

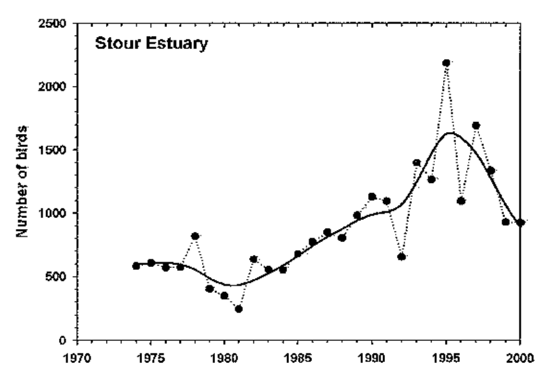






n. Black-tailed Godwit





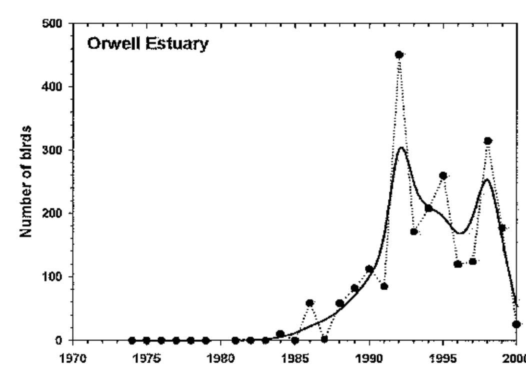
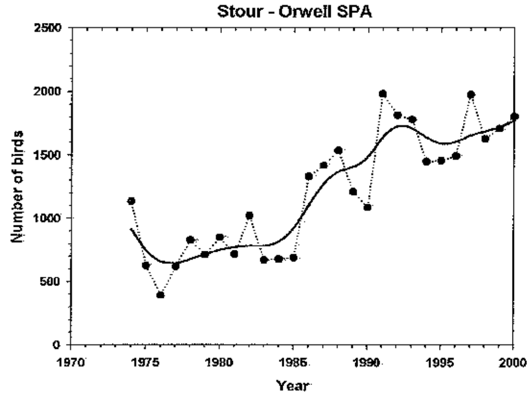
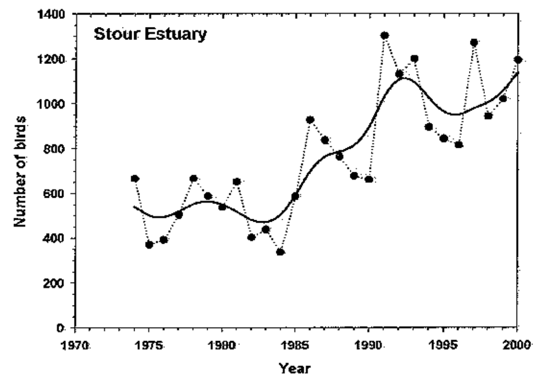
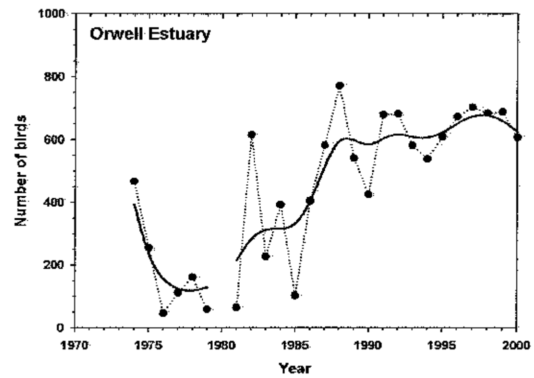


Figure 3.1.1 continued

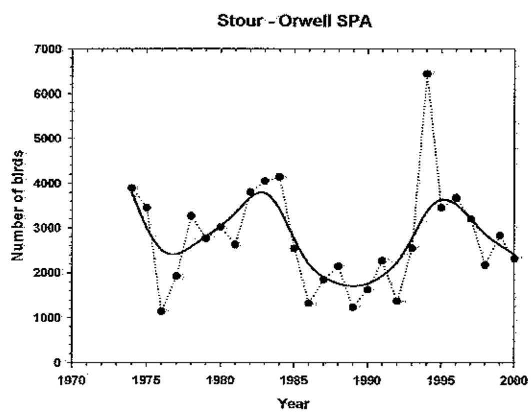
o. Curlew

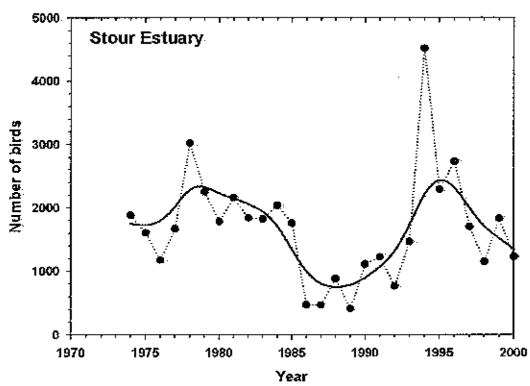






p. Redshank





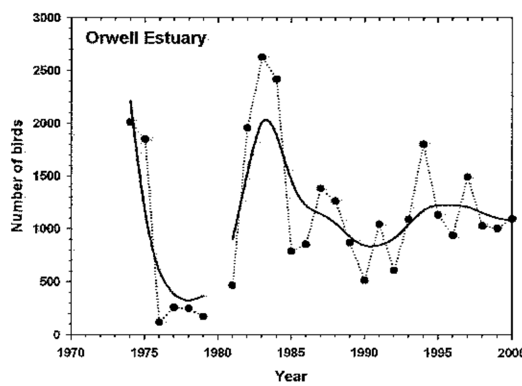
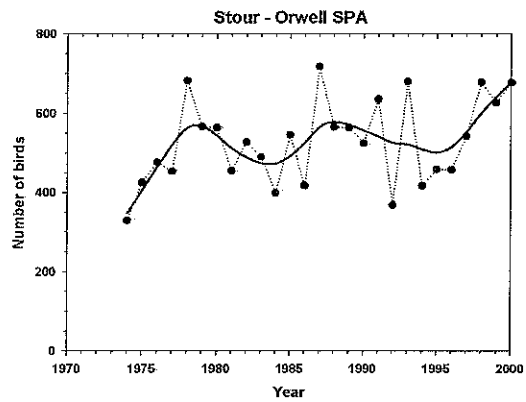
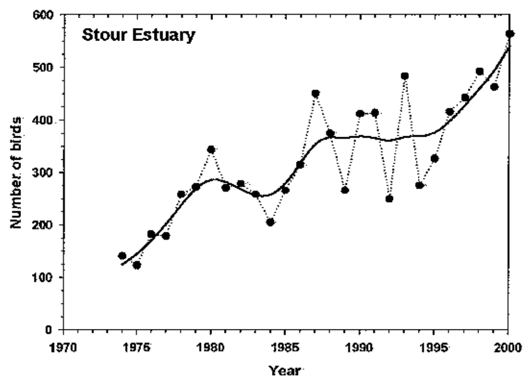


Figure 3.1.1 Continued.

q. Turnstone





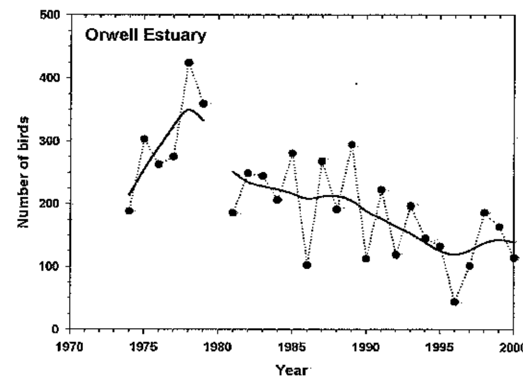
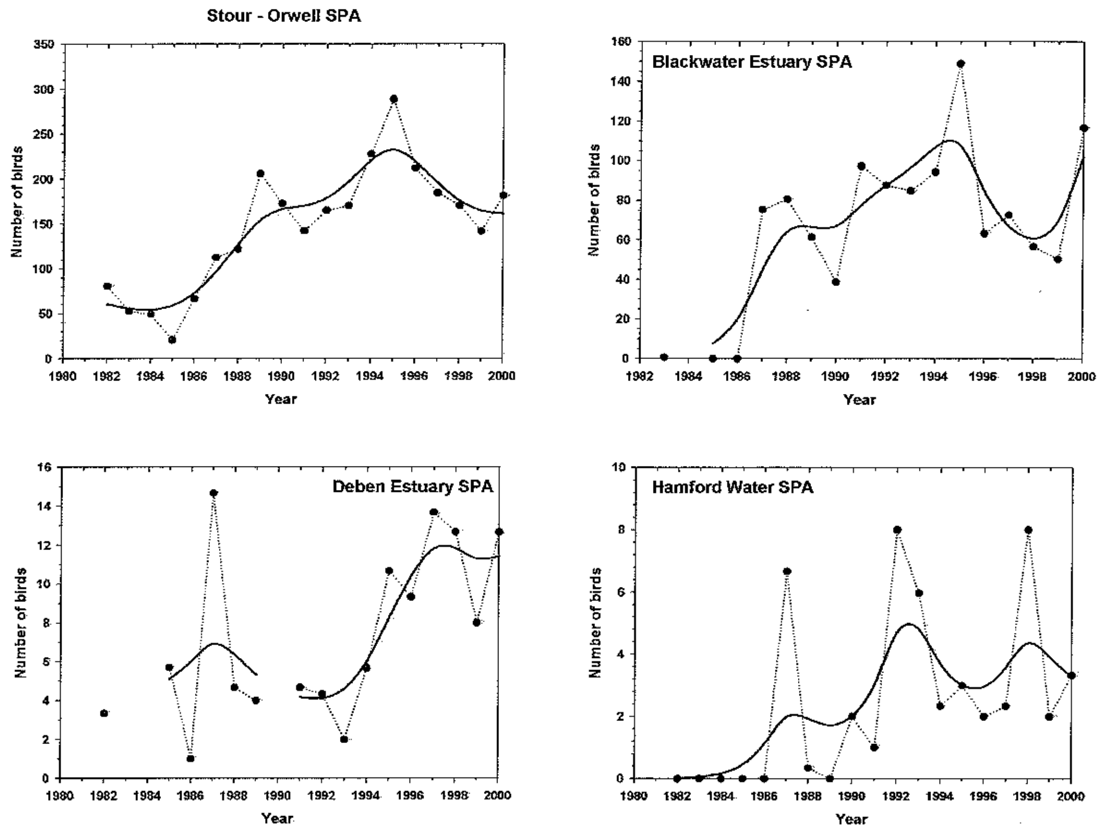


Figure 3.1.1 continued

a. Great Crested Grebe



b. Cormorant

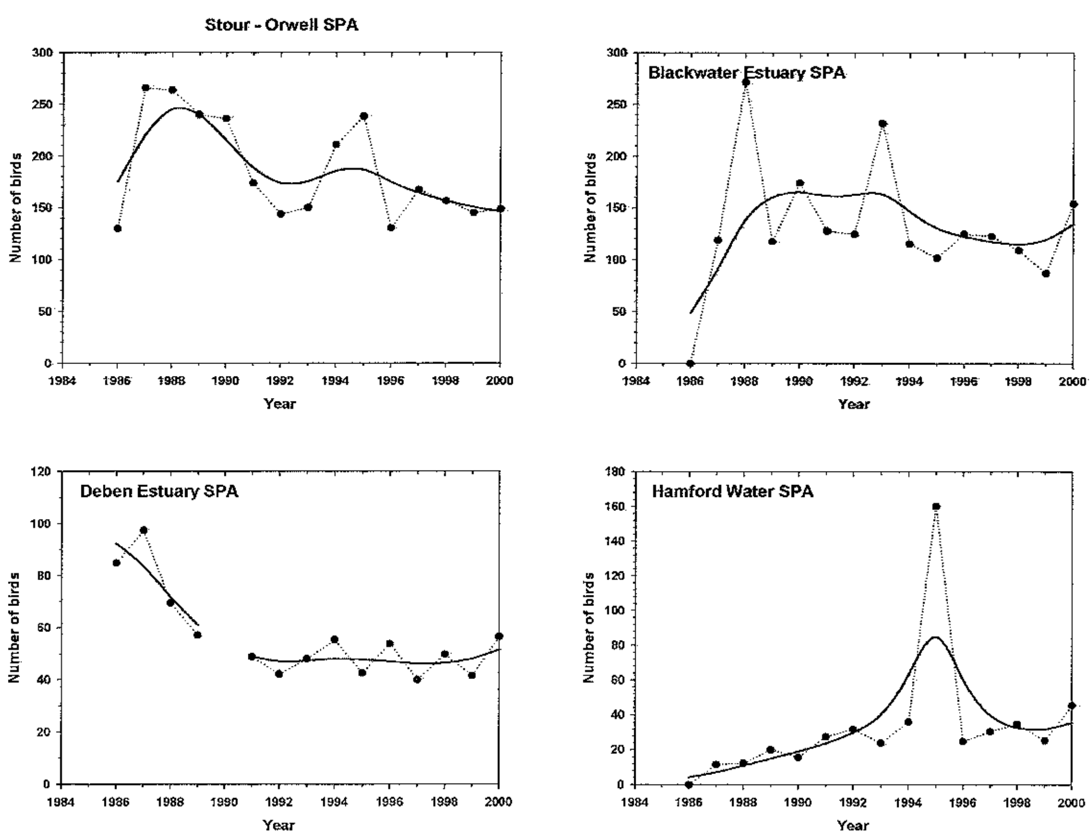
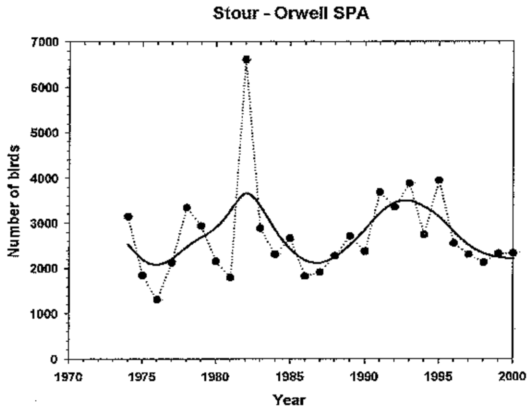
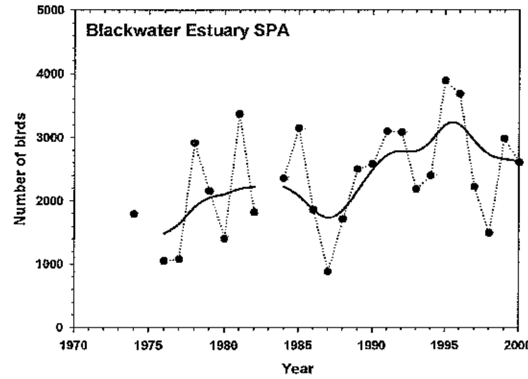
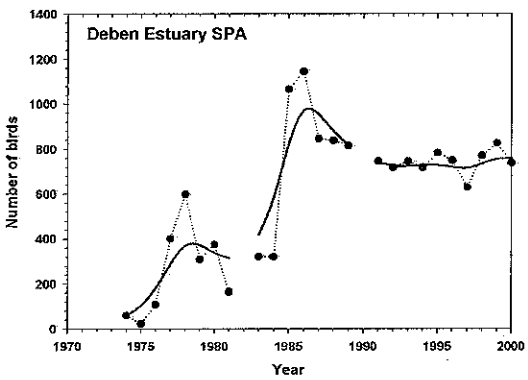


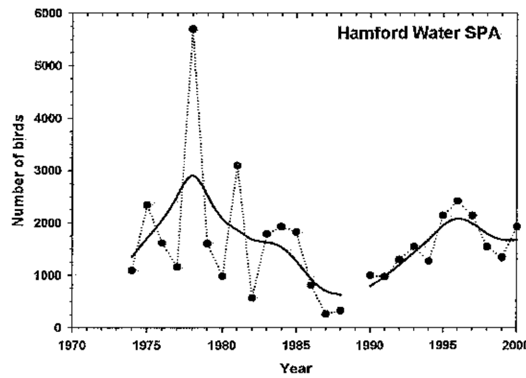
Figure 3.1.2 Trends in the numbers of birds (based on Core counts) at the Stour-Orwell SPA, Blackwater Estuary, Deben Estuary and Hamford Water for species that have triggered Alerts at the Stour-Orwell SPA. Points joined by the dotted line are estimated average winter counts, the solid line represents the smoothed trend.

c. Shelduck

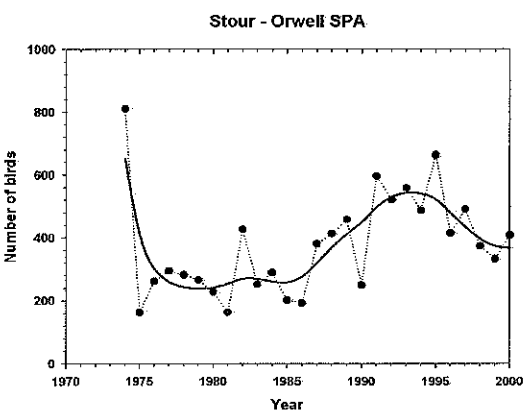


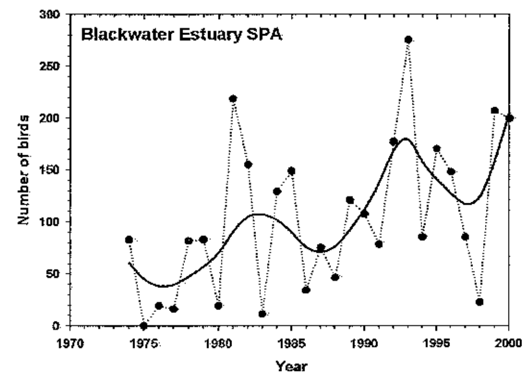


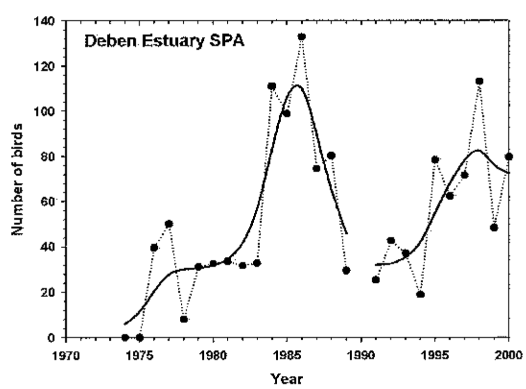




d. Pintail







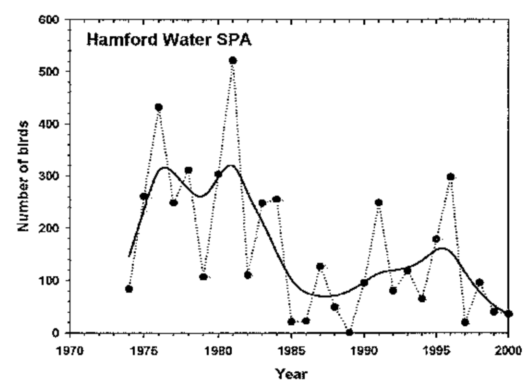
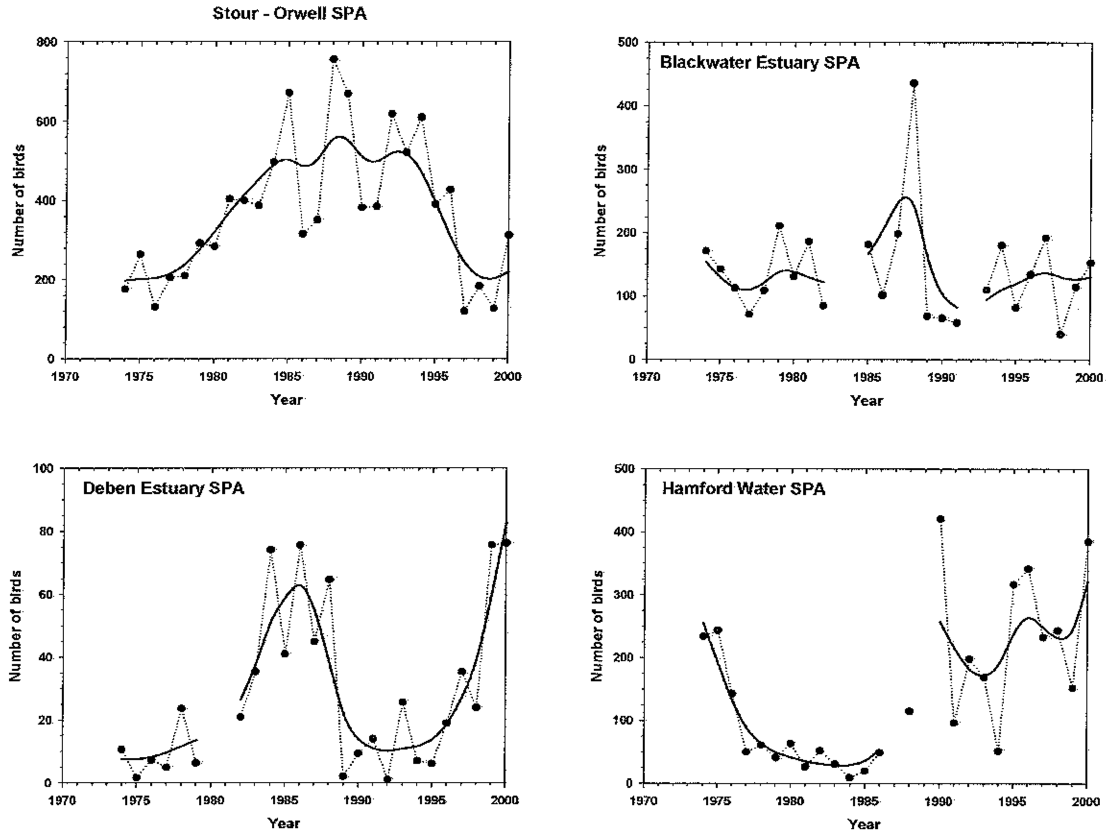


Figure 3.1.2 continued

e. Ringed Plover



f. Dunlin

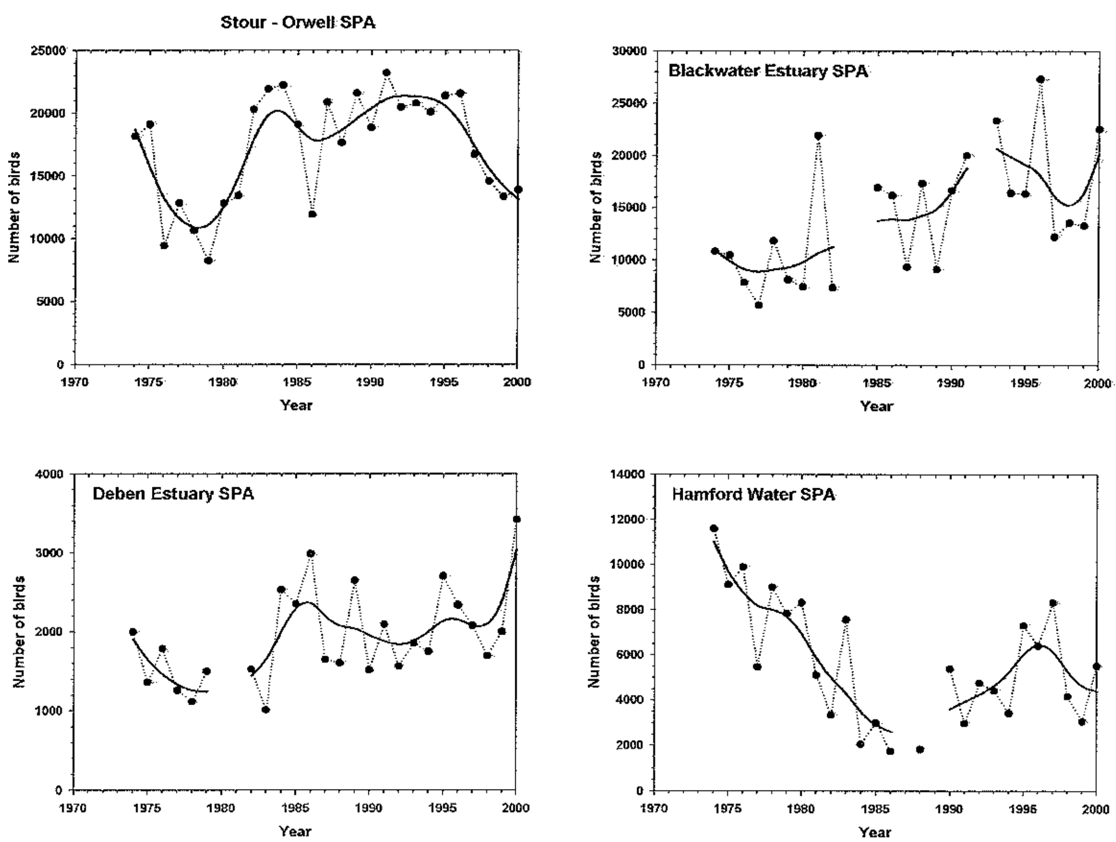
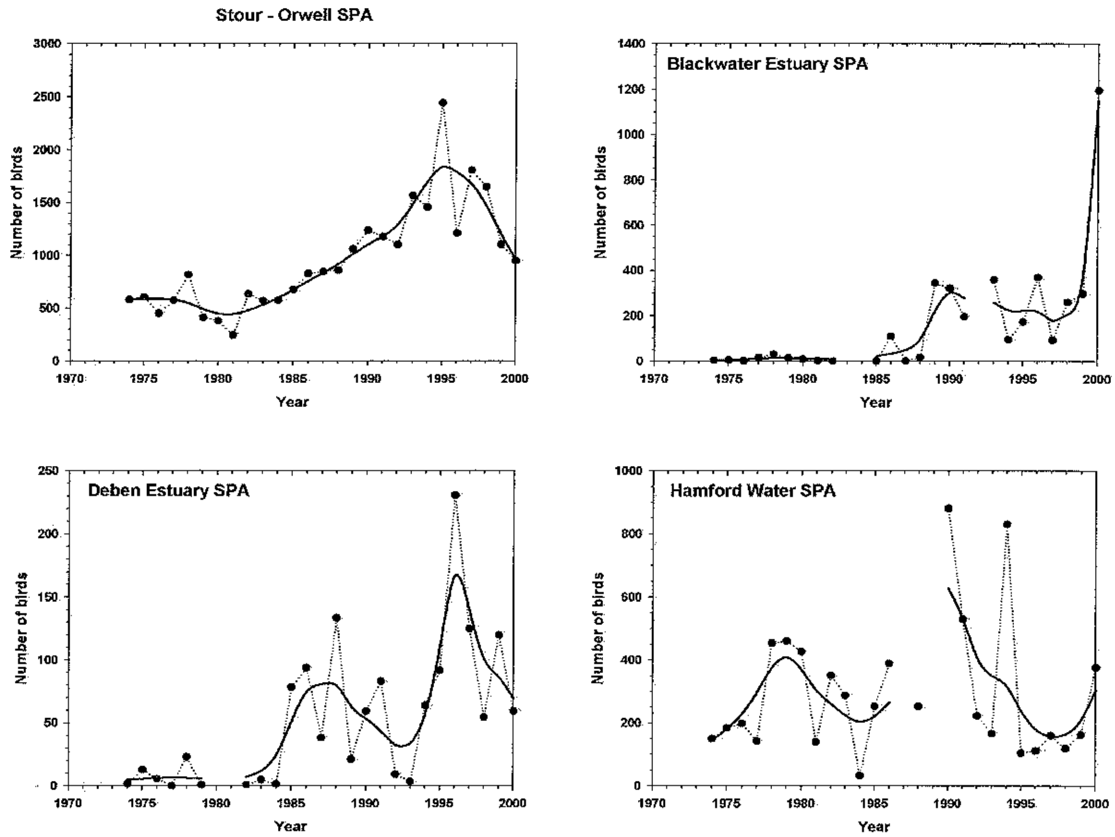


Figure 3.1.2 continued

g. Black-tailed Godwit



h. Redshank

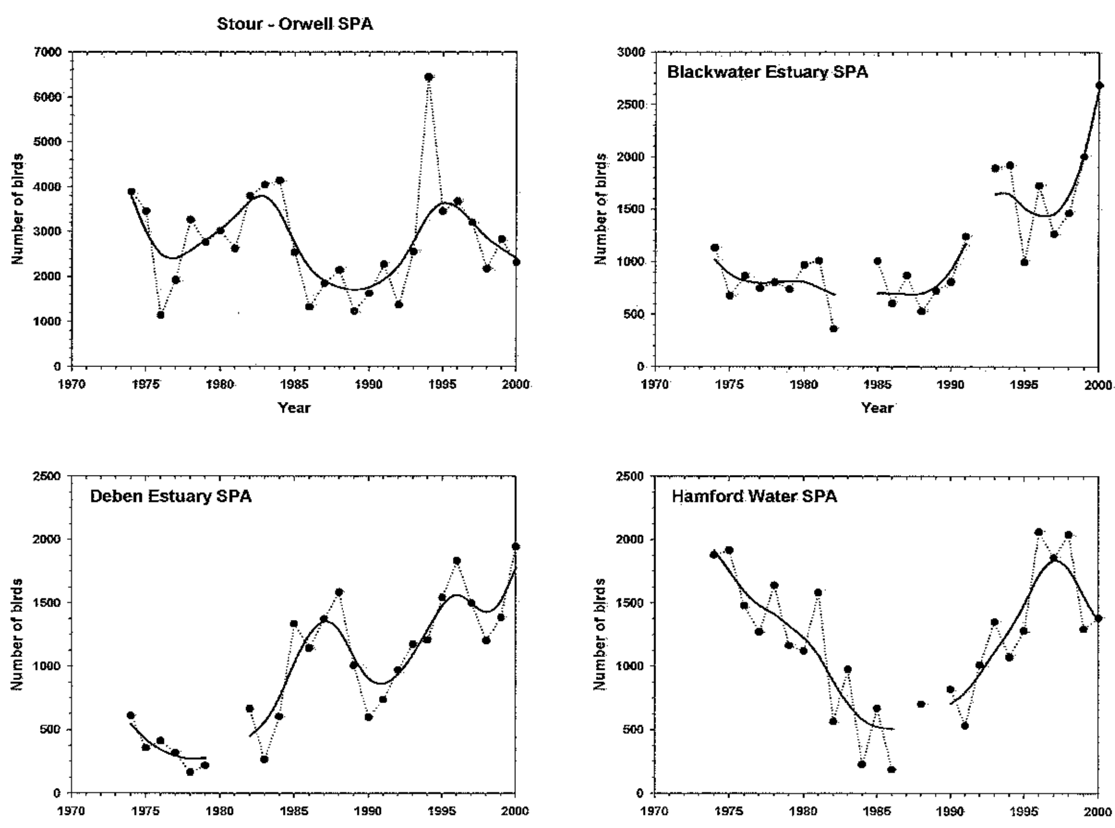


Figure 3.1.2 continued

3.2 Orwell Estuary: High Tide (Core) vs Low Tide (LTC) Alerts

The eight species of waterbird that have triggered whole Stour-Orwell SPA Alerts (using Core count data) are considered in this comparison of the numerical trends recorded by Low Tide Counts and Core counts (carried out at high tide) over five- and 10-year periods (Table 3.2.1 and Figure 3.2.1). The primary function of low tide counts is to record the feeding (mostly) distribution of waterbirds two hours either side of low tide, whereas the primary function of the Core counts that are predominantly carried out at high tide is to record the number of roosting (mostly) waterbirds on a site for monitoring purposes. For the species that are equally well counted by both count methods, differences in Alerts could indicate that birds feeding at the estuary may be choosing to roost elsewhere, and *vice versa*.

	5-year Alert						10-year Alert					
	LTC			Core			LTC			Core		
	Alert	%	nos	Alert	%	nos	Alert	%	nos	Alert	%	nos
Great Crested Grebe		-10	-7	--	-52	-18	+	58	23		-2	0
Cormorant		-9	-7	-	-28	-30	-	-34	-34		-23	-23
Shelduck	--	-59	-740	--	-62	-769	--	-57	-671	--	-53	-523
Pintail	--	-52	-152	--	-89	-157	--	-66	-271	--	-93	-280
Ringed Plover		-15	-29	--	-69	-117		-10	-18	--	-72	-131
Dunlin	--	-70	-7442	--	-70	-4857	--	-71	-7771	--	-70	-4788
Black-tailed Godwit	--	-53	-233	--	-72	-141	--	-60	-314	-	-47	-48
Redshank	-	-35	-909		-12	-146		-20	-414		28	238

-- High Alert (greater than 50% decline), - Medium Alert (25-100% decline), + 33-50% increase, ++ greater than 100% increase, otherwise population considered stable
"%" percentage change, "nos" numerical change

Table 3.2.1 The five-, 10- and 25-year Alerts, percentage change and modelled numerical change of waterbirds on the Orwell as measured by WeBS Core and LTC data. These results are based on data for the period 1990/91 to 2000/01, respectively. The species considered are those that have fired at least one Stour-Orwell SPA Alert using WeBS Core data up to 2000/01.

The changes in the numbers of four of the eight species of waterbird are very similar for both time periods and count methods (Table 3.2.1 and Figure 3.2.1). For example, the Shelduck five-year and 10-year changes recorded by LTCs and Core counts are –59% and –62%, and –57% and –53%, respectively, in each instance a High Alert. Five- and 10-year High Alerts are also triggered for Pintail and Dunlin by both count methods. Black-tailed Godwit just fails to fire a 10-year Core count High Alert but High Alerts are fired for the three other categories.

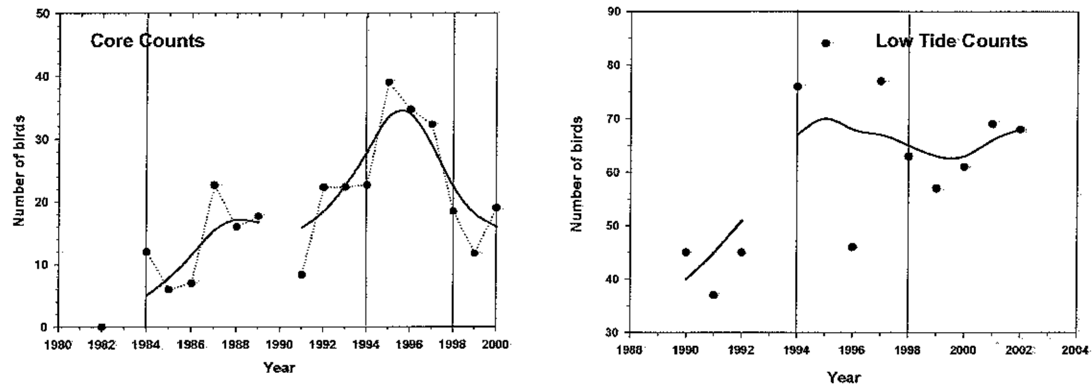
Both count methods record declines in the numbers of Cormorant for both time periods and they record broadly similar proportional declines (Table 3.2.1). As Cormorants feed by diving and as they are not associated with the intertidal zone they are not a LTC priority species, and thus more weight ought to be placed on the Core count results than those of the LTCs. Only a five-year LTC count Alert is fired for Redshank, but the Core count data also record a decline in Redshank numbers over the period.

The changes in Great Crested Grebes and Ringed Plover numbers recorded by Core and LTCs are dissimilar (Table 3.2.1). Both count methods record a decline in Great Crested Grebe numbers over five-years, but only the Core counts record a High Alert. Great Crested Grebes feed by diving and not being associated with the intertidal zone they are not a LTC priority species. More Great Crested Grebes are recorded during high tide counts than low tide counts (Musgrove 1998). Thus the Core count Alert is more relevant than the change in LTCs.

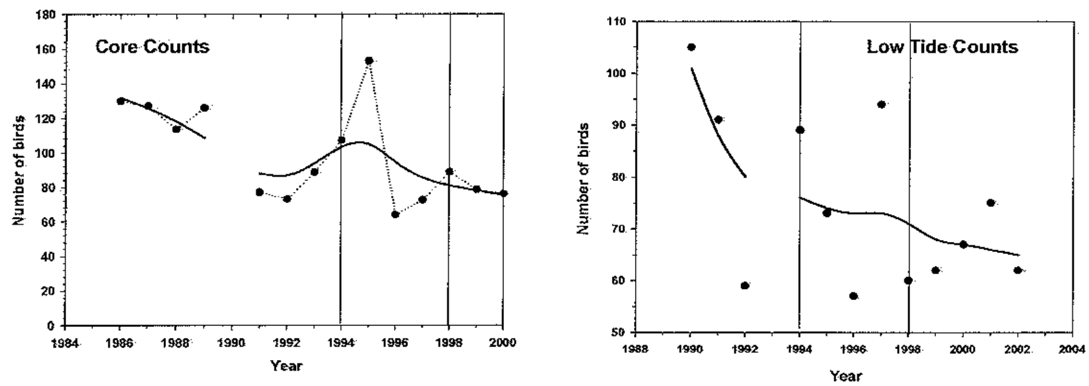
Both count methods over both time periods record declines in Ringed Plover numbers on the Orwell. The proportional declines recorded by the LTCs are much smaller than those recorded by the Core count method, to the extent that no Alerts are triggered using LTCs whereas High Alerts are triggered for both time periods by the Core counts. More birds are recorded by Core counts (*ca* 340 smoothed estimate) than by LTCs (*ca* 200 smoothed estimate) at the start of LTCs in the mid 1980s, but by the late 1990s the LTCs are recording more birds (*ca* 170 smoothed estimate) than the Core counts (*ca* 60 smoothed estimate) (Figure 3.2.1). This implies that roosting conditions may have changed and birds feeding at the site may be choosing to roost elsewhere.

In summary: no major differences were found in the Alerts triggered by the two count methods over the 5- and 10-year periods for six of the eight species considered. For these species the factors driving the declines are likely to be predominantly related to the deteriorating condition of the intertidal (as birds tend to select roosts that are near foraging sites rather than *vice versa*) rather than deterioration in roosting conditions. The difference recorded for Great Crested Grebe is probably due to LTCs not being designed to monitor such a diving species. The difference recorded for Ringed Plover could be due to the birds that feed at the site choosing to roost elsewhere.

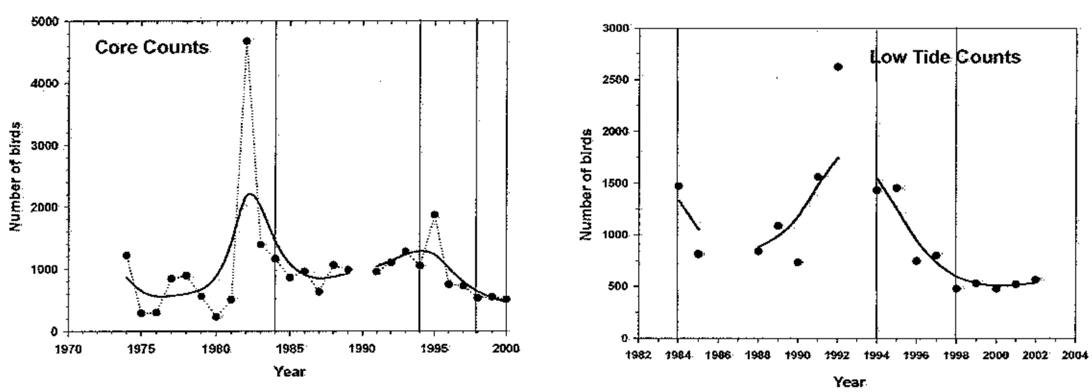
a. Great Crested Grebe



b. Cormorant



c. Shelduck



d. Pintail

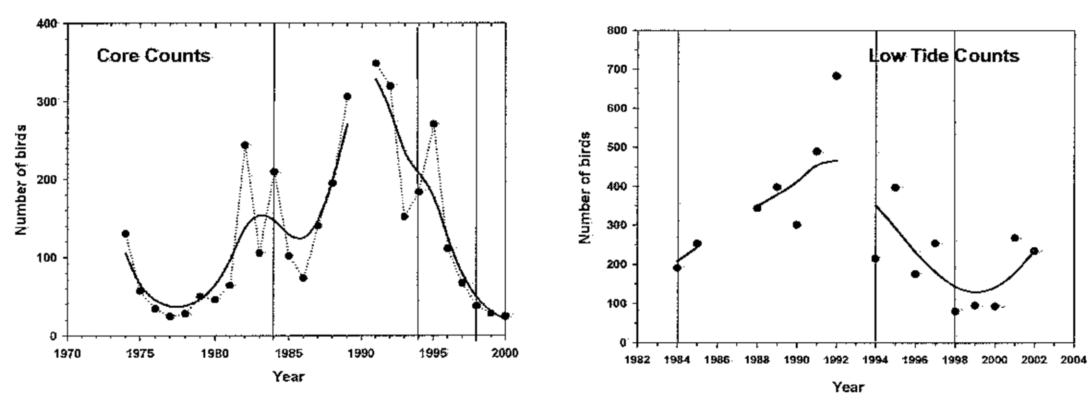
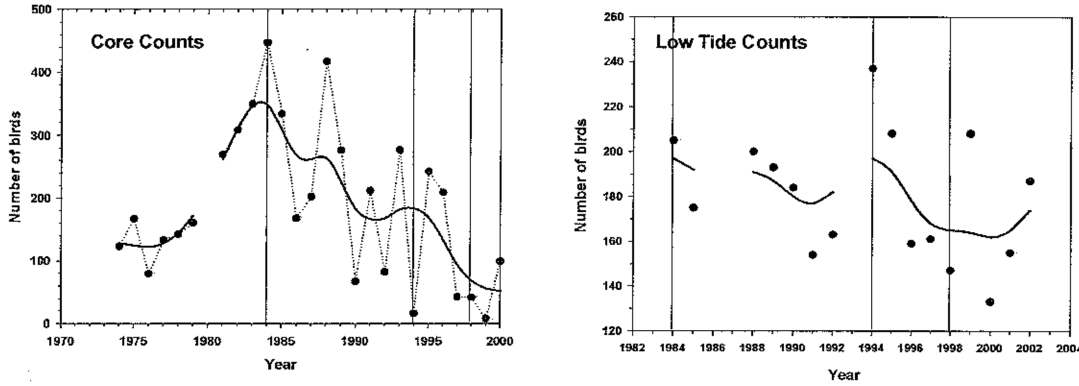
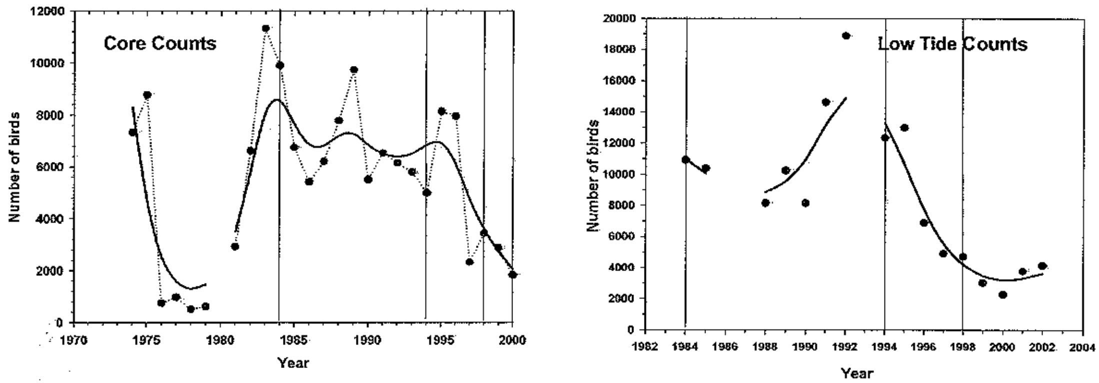


Figure 3.2.1 Trends in the numbers of birds at the Orwell Estuary, calculated using Core Counts (high tide) and Low Tide Counts. Species assessed are those considered to be declining at the Stour-Orwell SPA (based on Core Counts). Points are estimated average winter counts, the solid line represents the smoothed trend. Vertical lines depict the timing of the major dredging events.

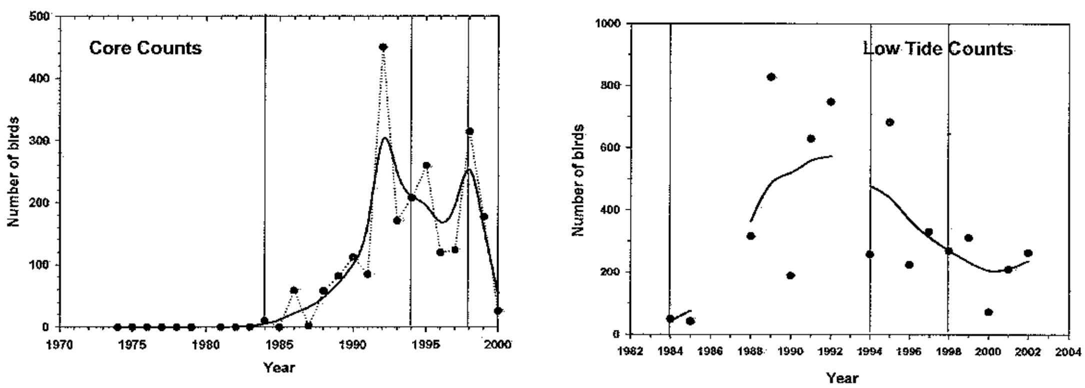
e. Ringed Plover



f. Dunlin



g. Black-tailed Godwit



h. Redshank

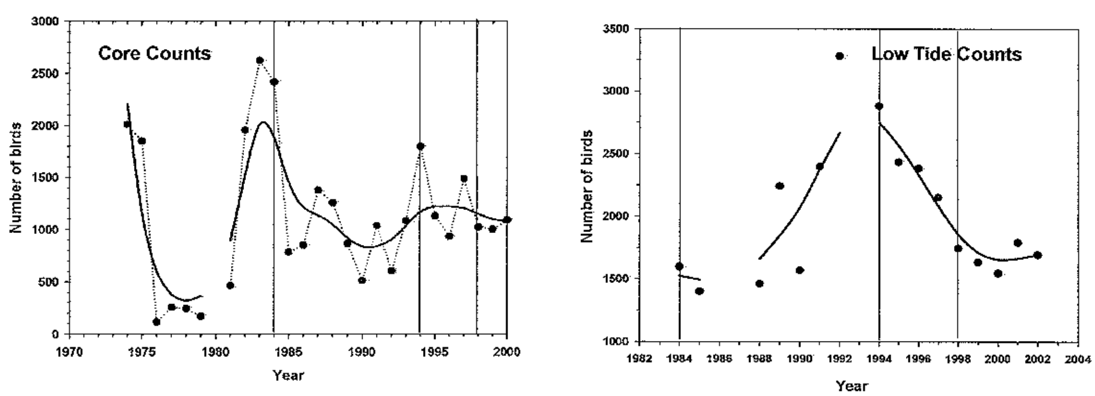


Figure 3.2.1 continued

3.3 Orwell Estuary: Waterbird Trends on LTC Count Units

The eight species that have triggered whole Stour-Orwell SPA Alerts are considered in this assessment based on LTCs of where waterbird numbers have changed on the Orwell intertidal over two five-year periods, 1995-96 to 2000-01 and 1990-91 to 1995-96 (Table 3.3.1, Figure 3.3.1-3.3.8). This temporal division has been used as it makes it easier to relate any changes in numbers to the timing of possible explanatory events.

1995-96 to 2000-01	A	F3	B1	F2	B2	F1	B3	E2	C1	E1	C2	D2	D3	C3	D4	D1
Great Crested Grebe	-7		=	+3	+4	+6		-4			-5					
Cormorant	+5		-4		-3	-2	-2	-3	-4		-3			+5	-6	
Shelduck	-100			=		=		-100					=			=
Pintail			=		=	=		-90		=			-20		+20	
Ringed Plover	=		-10	+20	=	-10	=	-20	-5	=	-10	+10	-10	+10	-5	=
Dunlin				-500		-1500		-500		-500			=		-500	-300
Black-tailed Godwit	-100		-100	+10	=	-20		-20								=
Redshank	-350		-200	-200	+200	=	+100	-200		=		=	-100		-100	-20
Σchanges	6	0	6	6	6	8	3	8	2	4	3	2	5	2	5	5
Σdeclining:increasing spp.	**4:1**	0	**4:0**	2:3	1:2	**4:1**	1:1	**8:0**	2:0	1:0	**3:0**	0:1	**3:0**	0:2	**4:1**	2:0
1990-91 to 1995-96	**A**	**F3**	**B1**	**F2**	**B2**	**F1**	**B3**	**E2**	**C1**	**E1**	**C2**	**D2**	**D3**	**C3**	**D4**	**D1**
Great Crested Grebe	+10		=	=	=	=		+3			+4					
Cormorant	-7		+4		+4	-2	=	=	+4		=			-20	+6	
Shelduck	+50			=		-100		=					=			=
Pintail			-20		-30	-40		=		=			+20		=	
Ringed Plover	-15		+5	-10	+10	+5	=	+30	-5	=	=	-10	=	=	=	=
Dunlin				=		-500		=		=			=		+500	-300
Black-tailed Godwit	=		+50	=	=	=		=								-10
Redshank	=		+100	+200	-20	+100	=	+200		=		=	=		+100	-30
Σchanges	6	0	6	6	6	8	3	8	2	4	3	2	5	2	5	5
Σdeclining:increasing spp.	2:2	0	1:4	1:1	2:2	4:2	0:0	0:3	1:1	0:0	0:1	1:0	1:0	1:0	0:3	**3:0**

Direction of trends: "-" a decline, "=" no clear change, "+" an increase.
Rounding off convention: ≤10 to nearest integer, 10≤x≤99 to nearest 10, ≥100 to nearest 100
Σchanges: number of species considered found commonly on the LTC sector
Σdeclining:increasing spp.: ratio of number of species declining to increasing on the LTC sector
(results in bold indicate LTC sectors where clearly more species are declining than are increasing)

Table 3.3.1 The size and direction of the change in estimated waterbird numbers on the Orwell LTC sectors over two five-year periods, 1995-96 to 2000-01 and 1990-91 to 1995-96. The species considered are those that have fired at least one Stour-Orwell SPA Alert over five or 10 years using WeBS Core data up to 2000-01. The direction of the trend is followed by an estimate of the size of the decline over the five-year period.

3.3.1 Distribution of species-specific declines

Great Crested Grebe numbers declined on sectors A, C2 and E2 between 1995-96 and 2000-01, otherwise it was broadly stable or increased on all other sectors (Table 3.3.1, Figure 3.3.1). Cormorant numbers declined over much of the Orwell (Figure 3.3.2). Numbers declined on sectors B1, B2, B3, C1, C2, D4, E2 and F1 between 1995-96 and 2000-01, and on A, F1 and C3 between 1990-91 and 1995-96.

Shelduck numbers declined on sectors A and E2 between 1995-96 and 2000-01, and on F1 between 1990-91 and 1995-96 (Table 3.3.1, Figure 3.3.3). Pintail numbers declined on sectors D3 and E2 (the largest observed decline) between 1995-96 and 2000-01, and on B1, B2 and F1 between 1990-91 and 1995-96 (Table 3.3.1, Figure 3.3.4).

Widespread declines in Ringed Plover numbers were recorded on sectors B1, C1, C2, D3, D4, E2 and F1 between 1995-96 and 2000-01, and on A, C1, D2 and F2 between 1990-91 and 1995-96 (Table 3.3.1, Figure 3.3.5). Dunlin numbers declined on sectors D1, D4, E1, E2, F1 (the largest observed decline) and F2 between 1995-96 and 2000-01, and on D1 and F1 between 1990-91 and 1995-96 (Table 3.3.1, Figure 3.3.6). Black-tailed Godwit numbers declined on sectors A, B1, E2 and F1 between 1995-96 and 2000-01, and also to a lesser extent on D1 between 1990-91 and 1995-96 (Table 3.3.1, Figure 3.3.7). Widespread declines in Redshank numbers were recorded on sectors A (the largest observed decline), B1, D1, D3, D4 and E2 between 1995-96 and 2000-01, and smaller declines were recorded on B2 and D1 between 1990-91 and 1995-96 (Table 3.3.1, Figure 3.3.8).

3.3.2 Sectors where several species are declining

Between 1990-91 and 1995-96 only one sector witnessed many more declines than increases in the numbers of the eight species assessed (Table 3.3.1, Figure 3.3.1-3.3.8). Three species, all waders that tend to be associated with muddy sediments (Dunlin, Black-tailed Godwit and Redshank), declined and no species increased on sector D1 at the mouth of the estuary.

Between 1995-96 and 2000-01, at least three more species declined than increased on sectors A, B1, C2, D3, D4, E2 and F1. All eight species declined over this period on E2. Three out of the four wader species declined on B1, D4 and F1. The decline witnessed between 1990-91 and 1995-96 in two of the three species of wader on D1 continued during this second five-year period. Apart from C3, that only holds good numbers of Cormorant and Ringed Plover, all sectors at the mouth of the Orwell have witnessed declines in the numbers of many of their species.

In summary: the number of Cormorant, Ringed Plover, Dunlin and Redshank making use of the Orwell at low tide declined over much of the estuary. Especially between 1995-96 and 2000-01, the sectors at the mouth of the Orwell near Felixstowe, those furthest inland near Ipswich and the Cliffe Quay outfall, and two sectors on the north bank of the Orwell between Felixstowe and Ipswich have recorded declines in several species.

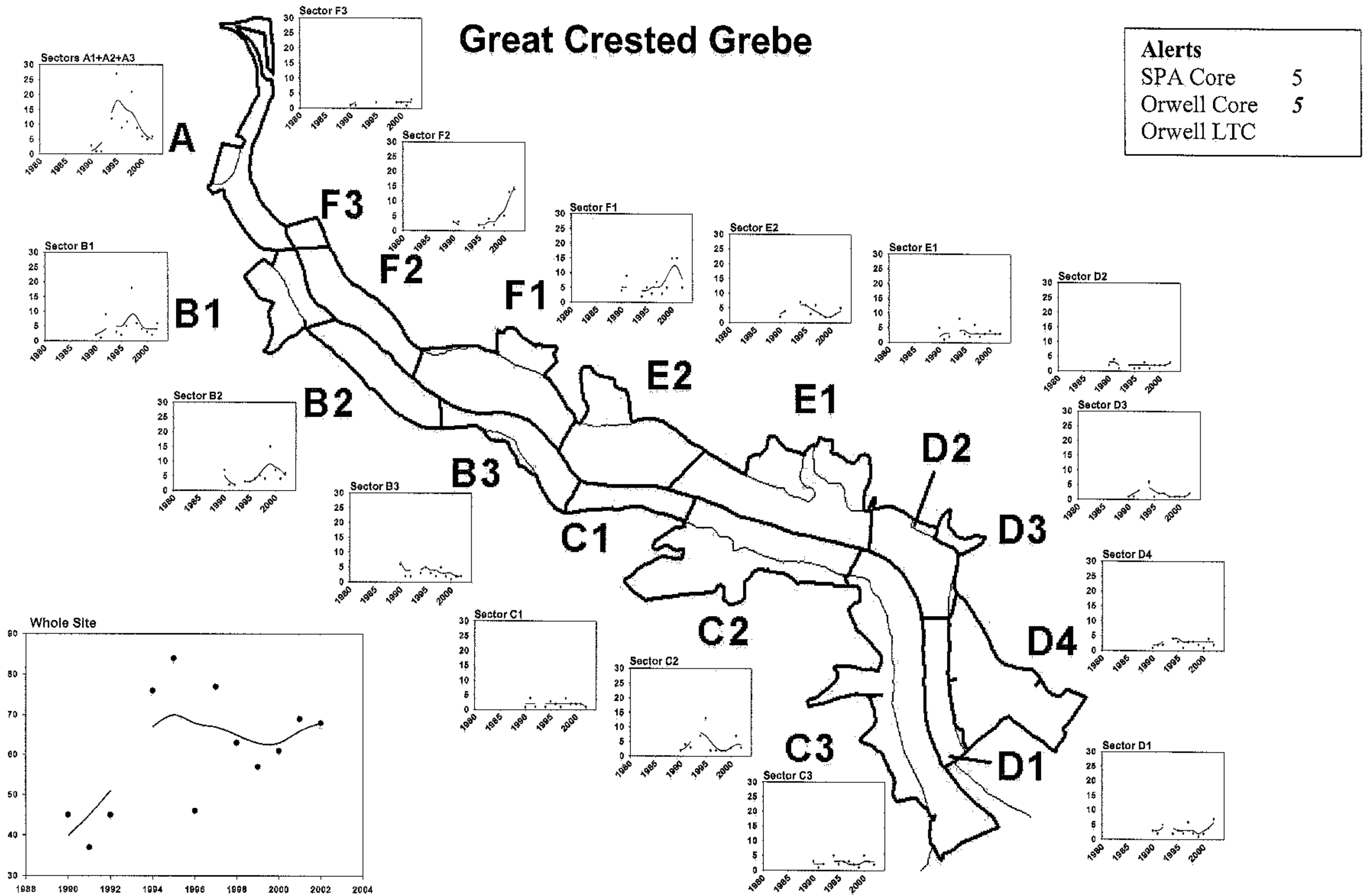


Figure 3.3.1 Changes in Great Crested Grebe numbers through time on individual sectors and the whole of the Orwell Estuary as recorded by LTC data. Any Alerts fired for the species are listed on the top rhs of the figure, with high Alerts in bold-italics. The five-year and 10-year Alerts are based on the change in numbers between 2000/01 and 1995/96 and 1990/91, respectively.

Cormorant

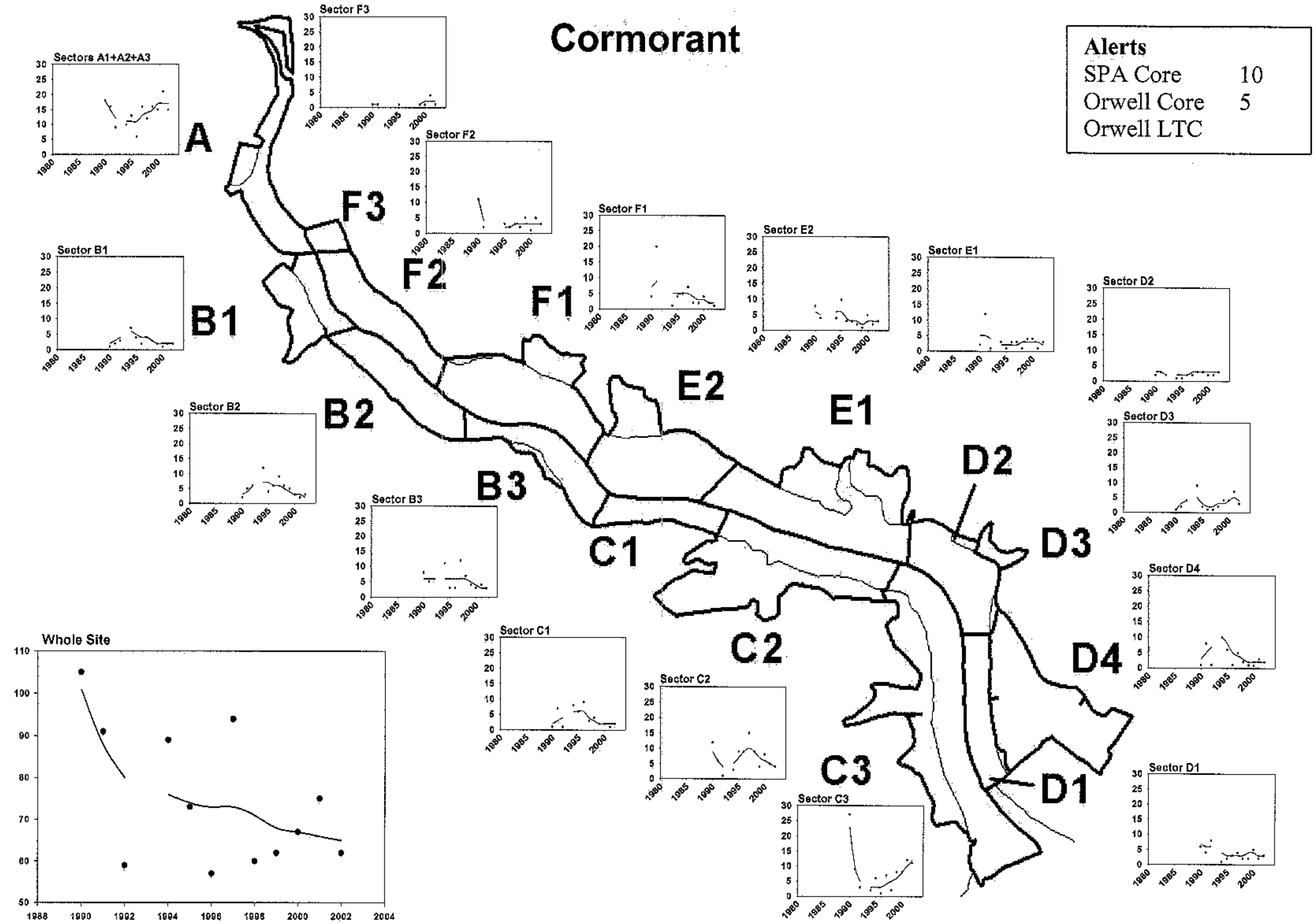


Figure 3.3.2 Changes in Cormorant numbers through time on individual sectors and the whole of the Orwell Estuary as recorded by LTC data. Any Alerts fired for the species are listed on the top rhs of the figure, with high Alerts in bold-italics. The five-year and 10-year Alerts are based on the change in numbers between 2000/01 and 1995/96 and 1990/91, respectively.

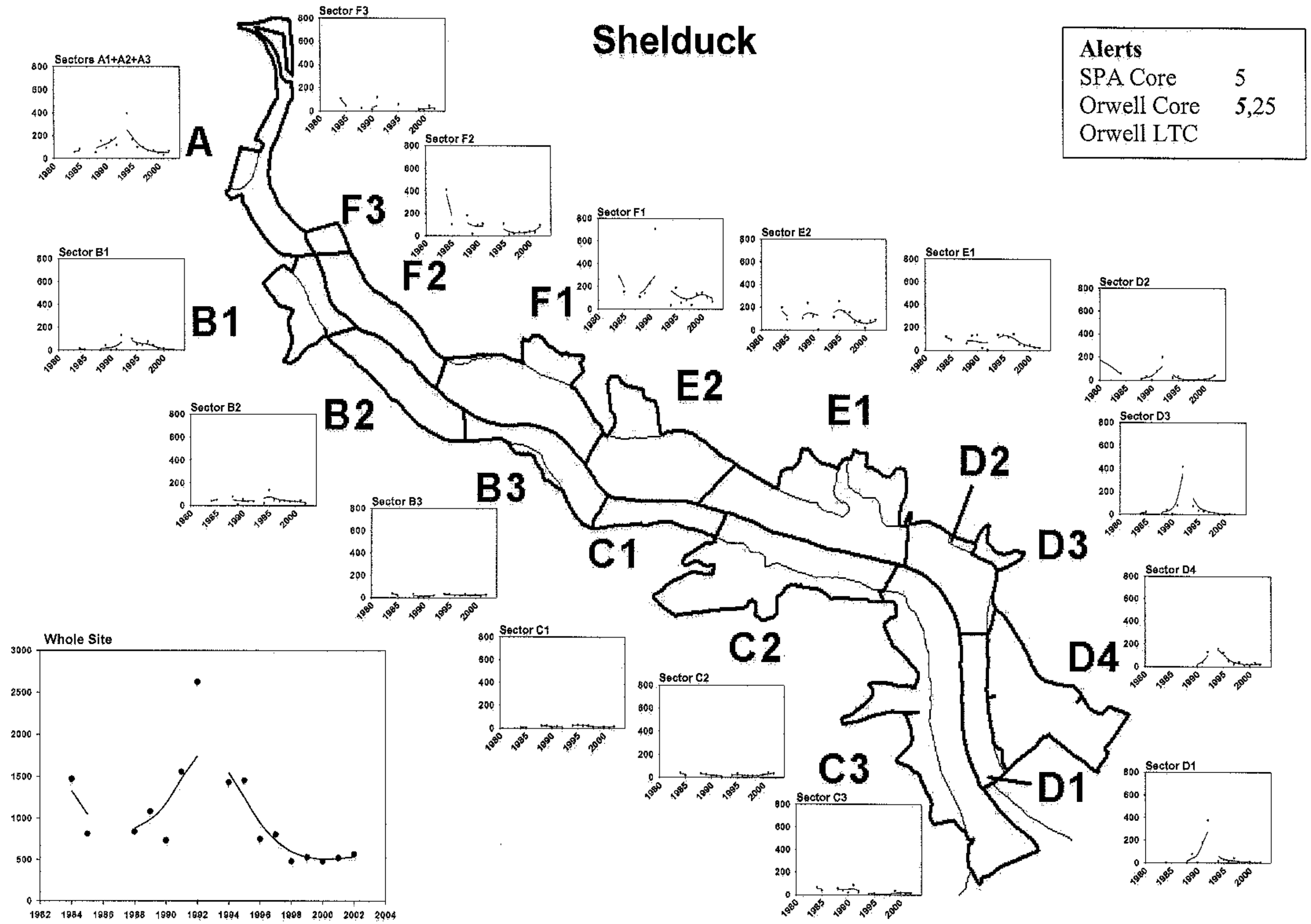


Figure 3.3.3 Changes in Shelduck numbers through time on individual sectors and the whole of the Orwell Estuary as recorded by LTC data. Any Alerts fired for the species are listed on the top rhs of the figure, with high Alerts in bold-italics. The five-year and 10-year Alerts are based on the change in numbers between 2000/01 and 1995/96 and 1990/91, respectively.

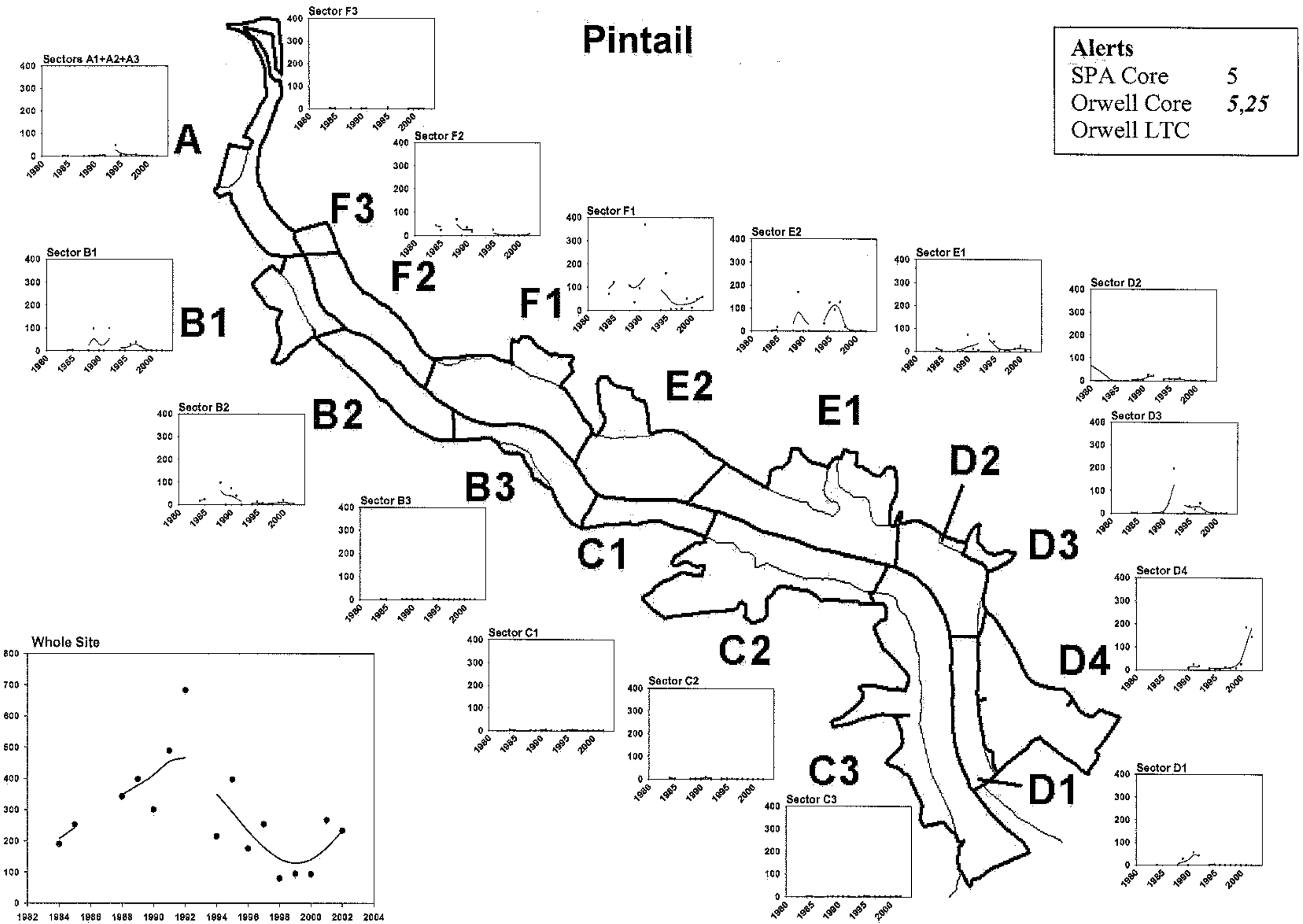


Figure 3.3.4 Changes in Pintail numbers through time on individual sectors and the whole of the Orwell Estuary as recorded by LTC data. Any Alerts fired for the species are listed on the top rhs of the figure, with high Alerts in bold-italics. The five-year and 10-year Alerts are based on the change in numbers between 2000/01 and 1995/96 and 1990/91, respectively.

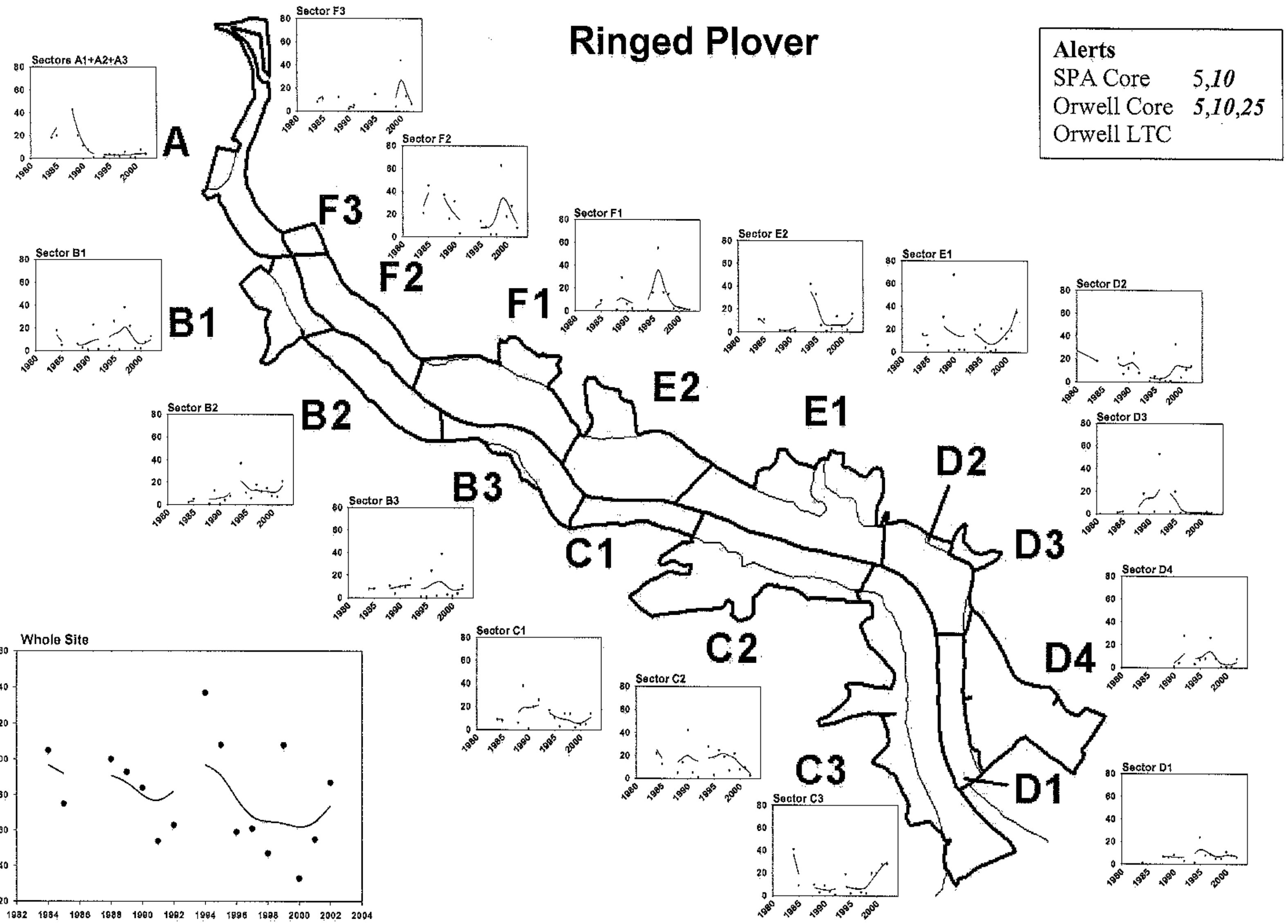


Figure 3.3.5 Changes in Ringed Plover numbers through time on individual sectors and the whole of the Orwell Estuary as recorded by LTC data. Any Alerts fired for the species are listed on the top rhs of the figure, with high Alerts in bold-italics. The five-year and 10-year Alerts are based on the change in numbers between 2000/01 and 1995/96 and 1990/91, respectively.

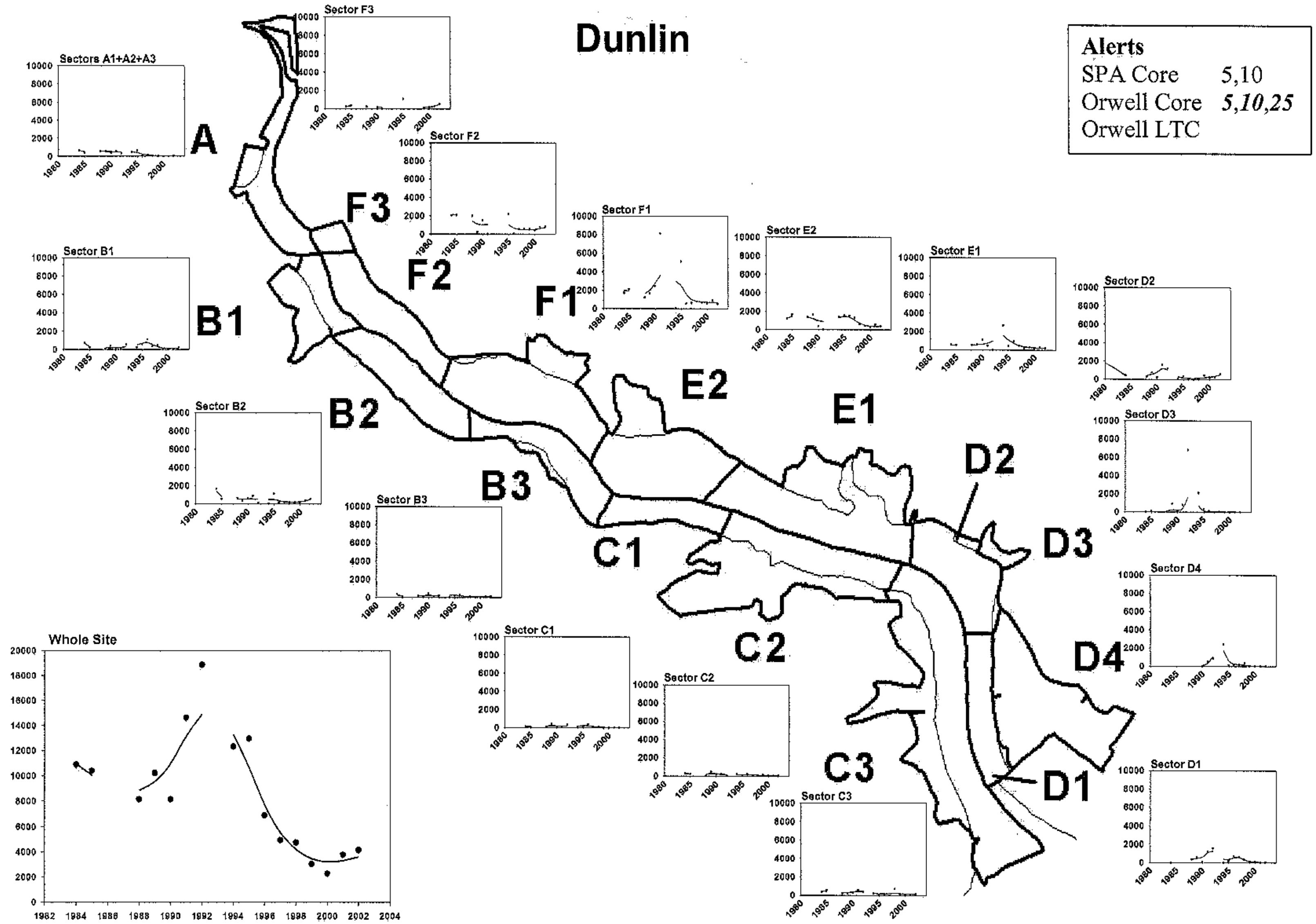


Figure 3.3.6 Changes in Dunlin numbers through time on individual sectors and the whole of the Orwell Estuary as recorded by LTC data. Any Alerts fired for the species are listed on the top rhs of the figure, with high Alerts in bold-italics. The five-year and 10-year Alerts are based on the change in numbers between 2000/01 and 1995/96 and 1990/91, respectively.

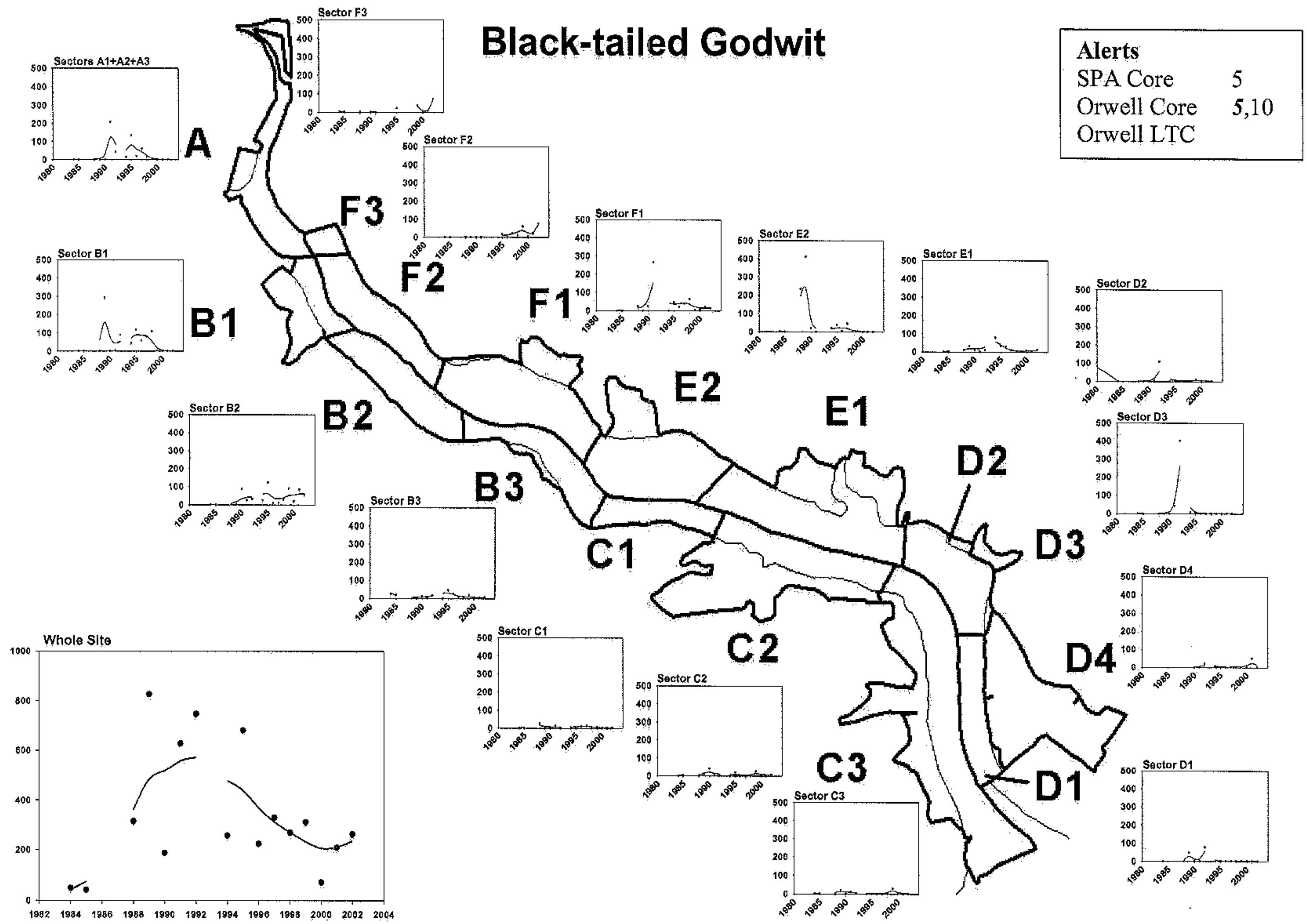


Figure 3.3.7 Changes in Black-tailed Godwit numbers through time on individual sectors and the whole of the Orwell Estuary as recorded by LTC data. Any Alerts fired for the species are listed on the top rhs of the figure, with high Alerts in bold-italics. The five-year and 10-year Alerts are based on the change in numbers between 2000/01 and 1995/96 and 1990/91, respectively.

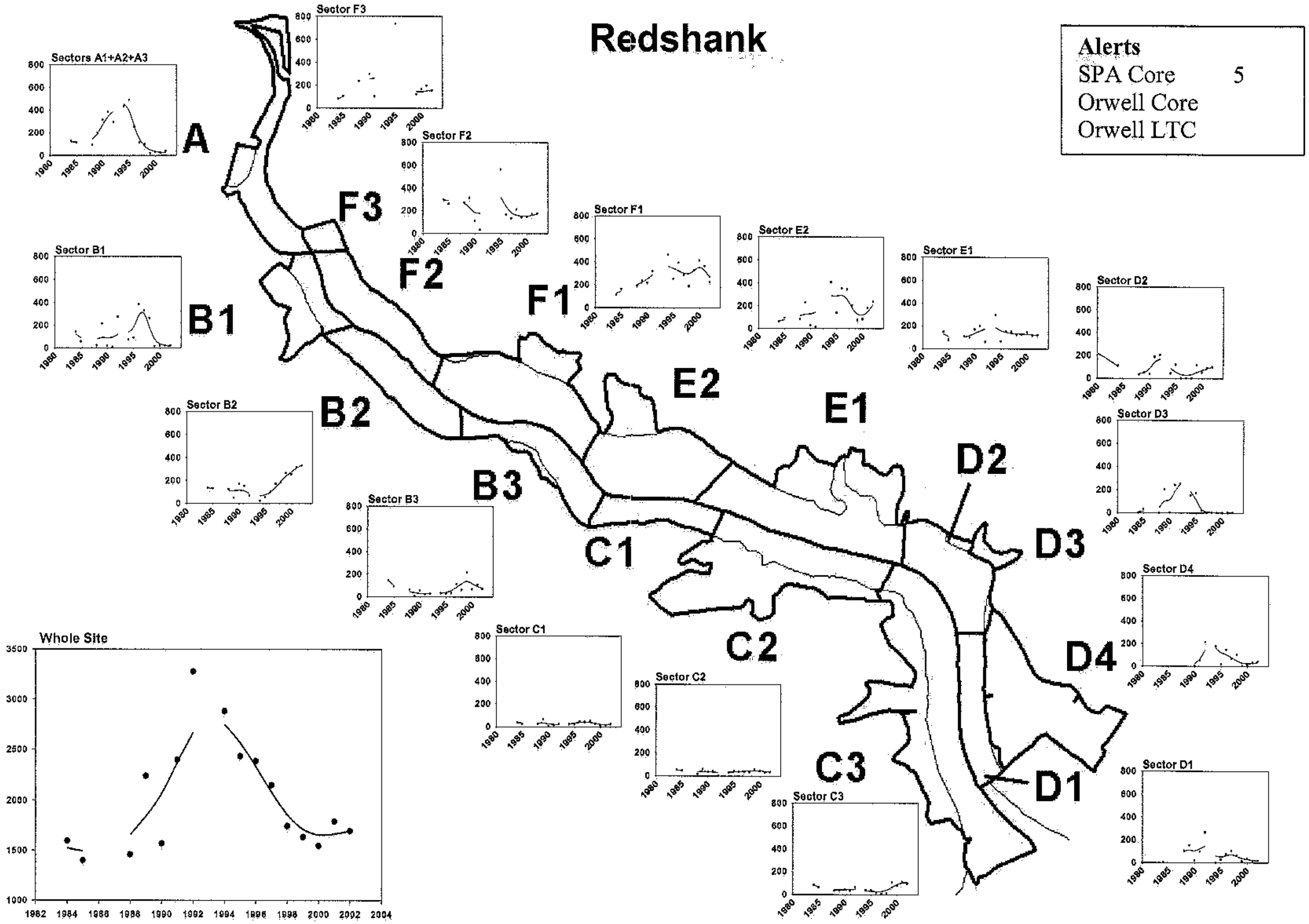


Figure 3.3.8 Changes in Redshank numbers through time on individual sectors and the whole of the Orwell Estuary as recorded by LTC data. Any Alerts fired for the species are listed on the top rhs of the figure, with high Alerts in bold-italics. The five-year and 10-year Alerts are based on the change in numbers between 2000/01 and 1995/96 and 1990/91, respectively.

3.4 Main Events Potentially Impacting on Bird Numbers at the Stour-Orwell SPA

The following is a summary of the most likely natural or man-made events that have occurred at the Orwell Estuary, which may have impacted directly or indirectly on bird numbers. Additional events which are less likely to have had a major impact on bird numbers are listed in Table 3.4.1.

Habitat loss

1985	Felixstowe Docks Trinity Terminal I. Loss of part of Fagbury Flats and consequent deterioration of the sediments (Evans 1997).
1988/89	Felixstowe Docks Trinity Terminal II. Loss of 19 ha of the remaining 34 ha of Fagbury Flats to land claim and consequent change in the nature of the sediment from muddy to sandy due to overspill from development being spread on the remaining intertidal area (Evans 1997).
1995	Extension of Felixstowe Docks claiming a further 13 ha of intertidal area (Evans 1997, Posford Duvivier Environment 2000).
early 1980s -	Continuing development of the west bank of the upper reaches of the Orwell Estuary at Ipswich (Mick Wright pers. comm.).
1973-1997	46% (46 ha) nett loss in saltmarsh area on the Orwell Estuary (Burd 1992, Cooper *et al.* 2000). This compares to 59% (157 ha) nett loss in saltmarsh area on the Stour Estuary.

Dredging

1984 1994 1999/2000	Capital dredging of sediment from the Harwich Haven approach channel. Affects the hydrodynamic character of the estuary, generally leading to a more ebb-dominant system, where a nett loss of sediment occurs in the estuary. A result of the effects of dredging is the accretion of sediments at the head of the estuary, with erosion at the lower reaches of the estuary (HR Wallingford 1997, 2001, Posford Duvivier Environment 1998).

Maintenace dredging of the estuary channel maintains a navigable route for large vessels to the port at Ipswich. If there has been an increase in the frequency and size of the vessels travelling this route, the associated increase in shipwash (wave action caused by the ships) could have increased the rate of erosion of the softer sediments and saltmarsh.

Organic input

1995	Secondary treatment imposed upon Cliff Quay outfall, one of the main discharges of untreated sewage material into the estuary. This resulted in a substantial decrease in the Biochemical Oxygen Demand (BOD) of the discharge, which suggests that less organic material entered the estuary after treatment. This potentially causes a reduction in the amount of food both directly and indirectly available to waterbirds (Anglian Water 1987, Burton *et al.* 2003).

Water abstraction

Ground and surface water abstraction have increased over the last 30 years as local farming and industrial practices have changed. This would have had a deleterious effect of freshwater flows in the estuary, which are known to attract higher densities of some species of waterbird (Ravenscroft *et al.* 1997, Environment Agency 2001).

Disturbance

Recreational disturbance has undoubtedly increased around the estuary over the last 30 years. At a local level, the Orwell Country Park has attracted more visitors to the estuary during the last 15 years and increasingly frequent events such as match fishing could prevent birds from roosting in favoured areas (Mick Wright pers. comm.).

Severe weather

The Orwell, particularly near the mouth of the estuary, acts as a cold weather refuge for waterbirds from other local estuaries.

1984/85	There was evidence that birds moved to feed on the Orwell Estuary during February 1985 as mudflats froze on adjacent estuaries and from the continental coast (Davidson & Clark 1985). High mortality was observed on the Stour Estuary.
1985/86	The Stour Estuary again experienced high mortality of waders (Clark & Davidson 1986).
1991	More than 1000 dead birds were found along the tide-line of the Orwell Estuary whereas very few were found dead on the Stour Estuary. Many more birds may have perished that were not located (Mick Wright unpublished report).

Impact	Location	Sectors affected	60 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00
Habitat loss	Fagbury Flats	D0	
	Ipswich West Bank[1]	A	last 20 years
	Levington Marina[1]	D1 D2	subsequent extensions
	Shotley Marina[1]	C3	
	Wolverstone Marina[1]	B3	
	Foxes marina[1]	A B1	
	Orwell Bridge[1]	A B1 F3	
	Bourne Park[1]	A	
Saltmarsh erosion		C1 C2 C3 E1 D2	
Spartina invasion[1]		mainly north shore	over last 20 years
Dredging	Approach channel	ALL	
	Harbour maintenance	ALL	0.05 M cu. m 0.15 M cu.m 0.3 M cu. m 1.7 M cu. m 2.6 M cu. m
	Estuary channel	ALL	Approx. 0.1 M cu. m per yer
Erosion[1]		B1 B2	over last 20 years
Shore recharge[1]	Trimley	D1 D2	
	Shotley	C3	
Substrate change[1]		ALL	over last 15 years
Organic input	Cliff Quay cut off	F3 (also F2 B1 B2)	
Water abstraction		ALL	Probably increased over last 30 years
Land management	Drainage ditches	F1	
Disturbance[1]	General recreation	mainly north shore	over last 30 years
	Orwell CP	F1 F2	over last 15 years
	Match fishing at Freston	B2	More frequent in recent years
Bait digging[2]		B1 C3 D2 E1 E2 F1	More so in last 5 years
Pollution[1]	Oil at Ipswich	A	
	Oil at Fagbury	D1	
Severe weather		ALL	
New site nearby[1]	Trimley/50 acre retreat	ALL	

Table 3.4.1 Events at the Orwell Estuary which could potentially have impacted on bird numbers.

Additional sources: 1. Mick Wright (pers. comm.) and questionnaires; 2. Babbs & Ravenscroft (1998). Other sources in text, section 3.4.

4. DISCUSSION

A large number of the possible impacts that have occurred on the Stour-Orwell estuary over the last 30 years could either individually or in combination help explain the unusually high number of declining species on this SPA in comparison to other SPAs in Britain (Section 3.4, Table 3.4.1). However, without very detailed site studies, it is not possible to determine with a high degree of confidence the factors that could be leading to the observed declines in waterbird numbers, but it is possible to identify the factors that are most likely to be leading to the changes. Such factors would have to be of sufficient magnitude and scale to cause declines in waterbird numbers over much of the estuary. It is important to emphasise that detailed site studies would be necessary to confirm that these factors are related to the declines.

Dredging events

Even though no LTC data exist for the 1993/94 winter, making it impossible to determine if some of the declines that appear to start in 1994/95 may have started in the 1993/94 winter preceding the 1994 dredge, the timing of one factor, the major dredging events of the approach channel (rather than maintenance dredging), coincides with the timing of the declines in the numbers of waterbirds recorded on the Orwell at low tide (Figure 3.2.1). Based on the smoothed existing count data, all six of the species well monitored by LTCs, Shelduck, Pintail, Ringed Plover, Dunlin, Black-tailed Godwit and Redshank show evidence of fairly rapid declines in the 1994/95 winter immediately following the 1994 dredge, or in the 1995/96 winter. This relationship is also apparent for Great Crested Grebe and Cormorant. The possible effect of the 1998 dredge is less clear, partly as a consequence of the fact that many species were already in decline prior to it. The declines in numbers of Shelduck, Pintail, Ringed Plover, Dunlin, Black-tailed Godwit and Redshank either level off or in some instances possibly increase slightly in the years following this latter dredge. In some instances this levelling off occurs at much-reduced numbers to those observed prior to the 1994 dredge.

The smoothed Core counts (counts of mainly roosting birds made at high tide) of the Orwell do not show as clear a relationship for all species between the timing of the dredging events and declining waterbird numbers as the LTCs. The smoothed Core counts on the Stour Estuary also do not show any consistent match between the timing of declines and the timing of the dredging events. A decline in Shelduck numbers on the Orwell Estuary was already occurring prior to the 1984 dredge. Following the 1994 dredge, numbers increased in winter 1995/96, but decreased considerably after that winter. Numbers stabilised following the 1998 dredge, remaining low compared to the previous 15 years. The timing of these fluctuations is similar to those on the Stour Estuary, but unlike on the Orwell Estuary, Shelduck numbers have essentially remained high. Pintail numbers on the Orwell Estuary showed a slight decline following the 1984 dredge, but increased significantly in the late 1980s and early 1990s. The start of the declines following a peak in the early 1990s can't be matched to the two dredging events in 1994 and 1998. Pintail numbers on the Stour Estuary have gradually increased since the mid 1980s. The pattern of change in Ringed Plover numbers on the Orwell matches the timing of the dredging events fairly well. Ringed Plover numbers start declining shortly after the 1984 dredge, a decline that appears to be accentuated by 1994 and 1998 dredges. On the Stour Estuary, Ringed Plover numbers continued to increase throughout the 1980s, but showed a decline in the latter half of the 1990s following the 1994 dredge. There is evidence of a slight increase following the latest dredging in 1998. Dunlin numbers on the Orwell show a slight decline shortly after the 1984 dredge, but level off in the late 1980s and early 1990s. Dunlin numbers then show a small decline in the winter following the 1994 dredge before recovering, and then decline again over the two winters following the 1998 dredge. In contrast, numbers on the Stour Estuary have fluctuated slightly, but remained high. Black-tailed Godwit numbers increased rapidly on the Orwell Estuary during the period following the 1984 dredge to reach a peak in 1992/93, during which time the national population size of the species has doubled (Pollitt *et al.* 2003). Their numbers show a declining trend following the 1994 dredge, but this decline had clearly started earlier. A very rapid decline from over 200 Black-tailed Godwit to some 20 follows the 1998 dredge. On the Stour Estuary, Black-tailed Godwit numbers also increased throughout the 1980s, reaching a peak in winter

1995/96. A decline followed this, which continued after the 1998 dredge. Redshank numbers decreased considerably on the Orwell Estuary in either or both of the winters following the 1984 and 1994 dredging events, although the overall trend since the mid 1980s has been stable. On the Stour, numbers declined following the 1984 dredge, then recovered during the late 1980s and early 1990s. Another decline occurred following the 1994 dredge. On both estuaries, there were no significant changes in numbers following the 1998 dredge. The timing of the declines in the numbers of Great Crested Grebe and Cormorant do not match the dredging events on either estuary.

Thus, in summary, the timings of the Ringed Plover, Dunlin and Redshank declines on the Orwell Estuary, as measured by Core counts, match the timing of the dredging events fairly well; the timings of the Shelduck, Pintail, Black-tailed Godwit, Great Crested Grebe and Cormorant declines do not provide a good match with those of the dredging events. On the Stour Estuary, only Redshank shows a match between the timing of the declines and the dredging events.

Thus, there is correlative evidence that dredging may have contributed to the observed waterbird declines on the Orwell and therefore on the Stour-Orwell SPA as a whole. This is shown more clearly by trends in LTCs, which describe the distribution and numbers of mostly feeding birds, than trends in Core counts, which monitor the population of a site through counts of mostly roosting birds at high tide. In the long-term, dredging has an impact on the hydrodynamics of the estuary which affects the extent and nature of the intertidal and subtidal sediments (HR Wallingford 1997, 2001, Posford Duvivier Environment 1998). Measured erosion and accretion rates have been determined based on comparisons of surveys undertaken on the Stour Estuary from 1965 to 1997. Between 1965 and 1982, it is thought that overall, accretion of sediments was occurring on the Stour Estuary, but after 1982, erosion of the sediments occurred. It was predicted that the effects of the 1994 and 1998 dredges would increase the rate of erosion on the estuary. It was further detailed that upper parts of the estuary would remain relatively stable, while the rate of erosion would increase towards the mouth of the estuary. It is likely that erosion would have most effect on the softer, muddy sediments and would therefore impact mainly on those species that prefer a muddy substrate. For example, Black-tailed Godwit have moved closer to the head of the Stour Estuary, away from the areas near the mouth, probably because the softer mud has been eroded away to leave a much harder substrate. Observational evidence of estuary wide morphological change could not be found for the Orwell Estuary, although it was suggested that due to the differing orientation and shape of the Orwell, there would be less variability in the erosion rates through the estuary. Anecdotal evidence suggests, however, that erosion is occurring around the mouth of the estuary, but that most of the estuary is currently accreting. It should be noted that the 'background state' during the last 20 years was predicted to be one of erosion overall, and that the dredging is predicted to have increased the rate of this erosion. It was also predicted that a reduction in tidal range would occur as a result of the dredging at the mouth of the estuaries. This would result in a reduced time over which the mudflats would be exposed to feeding birds.

The loss of intertidal areas through erosion, particularly of the finer, muddy sediments, coupled with a reduction in the time these areas are exposed, would decrease the availability of food to foraging birds, which could therefore impact upon their populations. Dredging may thus be at least in part responsible for some of the Alerts fired for the Stour-Orwell SPA. Changes in the sediments that have occurred on the Orwell as a result of dredging need to be determined and related to waterbird, and especially wader, foraging preferences that are well known. Declines in muddiness for example, would be expected to lead to declines in Dunlin, Black-tailed Godwit and Redshank numbers; increases in the proportion of larger sediments would be expected to be potentially advantageous for such species as Oystercatcher and to a lesser extent, Knot and Grey Plover (Austin *et al.* 1996, Holloway *et al.* 1996, Rehfisch *et al.* 1997, 2000,Yates *et al.* 1993). Oystercatcher, Knot and Grey Plover numbers have all increased since 1984 on the Orwell Estuary at low tide, especially so since 1993 (Ravenscroft 2001). The increase and gradual shift of the Oystercatcher population upriver over the last 10 years and especially the last four (along the north shore) has been quite remarkable (Ravenscroft 2000-2003) and this could be related to changing sediment.

It is important to note that this discussion suggests an immediate effect of dredging on the sediment type, leading to an immediate decline in waterbird numbers and it may seem unlikely that a change of sufficient magnitude to affect waterbird populations would occur so quickly. However, it is possible that numbers were already depressed in the years following the dredges, due to fluctuations in the bird populations driven by factors outside the estuaries. The immediate effects of the dredging are limited to an increase in turbidity, leading to a short-term settlement of material on the lower intertidal areas.

Several other factors could in themselves or in combination with dredging be leading to the observed decreases in waterbirds.

Disturbance As roosts tend to be near or beyond the high tide mark, roosting birds tend to be disturbed more than feeding birds by land-based disturbance such as walkers, dogs, cyclists, *etc.* As birds tend to roost near their feeding grounds (Symonds *et al.* 1984, Symonds & Langslow 1986, Warnock & Takekawa 1996, Rehfisch et al. 1996, in press) the greater number of birds recorded on the Orwell at low tide (Figure 3.2.1), when they are mostly foraging, rather than at high tide, when they are roosting, is an indication that disturbance levels on the Orwell may be high. This is as would be expected for an estuary adjacent to two towns, especially as it is narrow and much human disturbance tends to come from land. Indicators of human presence such as footpaths, roads and car parks lead to lower densities of foraging waterbirds (Burton *et al.* 2002a) and even reduces their breeding success (Liley 2000) and being above the high tide mark they would be expected to affect waterbird roosts more. Birds feeding on the Orwell Estuary may be choosing to roost at other sites, where they may or may not be counted by WeBS core counts. Core counts (roost counts at high tide) of Ringed Plover, for example, have increased at the nearby sites over the last 10 years. It is possible that some of these increases could be attributable to movement of birds from the Orwell Estuary to roost at high tide.

Waterbirds can habituate to disturbance as long as it is regular and not extreme (Davidson & Rothwell 1993). Thus although disturbance can't be discounted as a major cause of the observed waterbird declines it is unlikely that what is probably a gradual increase in disturbance over the last 30 years would in itself explain the many recent five-year Alerts that have been fired on the Orwell Estuary alone and on the Stour-Orwell SPA as a whole, especially as Curlew, a species that is particularly adverse to disturbance (Smit & Visser 1993), is not one of the species for which an Alert has been fired.

Water quality and organic inputs Prior to 1995, the outfall at Cliff Quay discharged untreated sewage directly into the Orwell Estuary. However, following the completion of a new treatment works that year (the year after the main dredging operations), the outfall now discharges waste water that has received secondary treatment (Table 3.4.1). Burton *et al.* (2002b, 2003) suggested that the Biochemical Oxygen Demand (BOD) concentration in the estuary - a measure of the organic and nutrient loading – fell from 1.31 to 1.04 mg/l following the improvements to treatment. The improvement in the quality of the discharge from this outfall in LTC sector A (*eg* Figure 3.3.1) would be expected to have led to a decline in the organic enrichment of its immediate vicinity and perhaps beyond and this could have led to a decline in invertebrates (Pearson & Rosenberg 1978, Burton *et al.* 2002b, 2003). The decline in invertebrates would lead to fewer waders and other waterbirds that feed on invertebrates being supported in the area. It might also affect fish such as Flounders that feed on the invertebrates, and this in turn could affect the number of piscivorous birds such as Great Crested Grebe and Cormorant present in the area. The material emanating from the outfall pipe can itself be fed upon directly by some ducks (and gulls) and therefore its disappearance could also lead to a decline in these species.

For at least some of the eight relevant species of waterbird there is as good a match or even a better match between the timing of the decline in their numbers and the change to the discharge from the Cliff Quay outfall than with the 1994 dredging event (Figure 3.2.1). The timing of the declines recorded for Great Crested Grebe (Core and LTCs), Cormorant (Core counts), Shelduck (Core and LTCs), Pintail (Core and LTCs) and Black-tailed Godwit (Core counts) match the change to the discharge well. In total, the sectors A and B1 that are near the Cliff Quay outfall (*eg* Figure 3.3.1) recorded declines in six species of waterbird. Five of these - Great Crested Grebe, Cormorant, Shelduck, Black-tailed Godwit and Redshank declined at least in part following the outfall closure. Sector F3, however, which is adjacent to the outfall and where the greatest impact on Redshank might be expected, appeared to be less affected than Sectors A and B1. Work carried out by the BTO has shown that the proportion of species showing declines following improvements to waste water treatment tends to be greatest at the sites where there has been the greatest change in BOD concentration (Burton *et al.* 2003).

It is thus possible that the change to the discharge from the Cliff Quay sewage outfall will have led to or contributed to the local decline in some waterbird species on the Orwell. It is very unlikely that it is the sole cause of the decline as some species (*eg* Pintail, Ringed Plover and Redshank) started declining on the Orwell well before any known change to the organic inputs into the estuary.

There is evidence that other water quality issues such as the decline in small freshwater inputs into the SPA may also affect waterbirds. Enhanced densities of species such as Shelduck, Redshank and Dunlin (of those triggering Alerts) occur in and around small freshwater flows over the mudflats of the Orwell (Ravenscroft & Beardall 2003). Increasing abstraction of freshwater and historical reduction of discharges in these flows may have impacted on numbers of birds feeding in some sections, especially those along the mid-estuary such as F1, F2, B1 and B2, where flows are most concentrated and abstraction is more pronounced. The freshwater input of the River Gipping has also diminished by 50% through time (Merle Leeds pers. comm.) and this almost certainly will have affected the invertebrate and plant communities on the Orwell and consequently affected its waterbirds.

Habitat loss

	1984/85	1985/86
Great Crested Grebe	0	0
Cormorant	0	3
Shelduck	34	45
Wigeon	0	0
Pintail	0	0
Ringed Plover	50	9
Dunlin	803	621
Black-tailed Godwit	7	1
Redshank	139	92

Table 4.1 Mean winter low tide counts of birds at Fagbury Flats (sector D0) before the development of the Trinity Terminal in 1988/89. Species considered are those that have triggered an Alert (based on Core counts) at the Stour-Orwell SPA.

The effective loss of Fagbury Flats as a major feeding area for waterbirds occurred in 1985, one year after the first major dredge in 1984. In most instances the decline in waterbird numbers is more closely related to the timing of the dredge than the loss of Fagbury Flats (Figure 3.2.1). However, the change in the numbers of Shelduck, Ringed Plover, Dunlin and Redshank, the four most commonly recorded of the declining species that fed on Fagbury Flats, recorded between 1984/85 and 1985/86 helps explain at least some of the observed declines in these species on the Orwell (Table 4.1, Figure 3.2.1). Fagbury Flats was also an important roosting area for these species, particularly Ringed Plover, and the loss of this area must have affected the numbers recorded on the Orwell Estuary by WeBS Core counts. The cumulative loss of habitat through landclaim on the Orwell is therefore likely to have contributed to the observed decline in waterbirds (Dolman & Sutherland 1995, Goss-Custard *et al.* 1995, 1997, Sutherland & Dolman 1994).

Conclusion and Recommendations

There is correlative evidence that dredging may have contributed to the observed declines in waterbird numbers on the Orwell and thus on the Stour-Orwell SPA as a whole. The timing of the declines as described by LTCs on the Orwell match fairly well with the timing of the capital dredging of the approach channel. However, there is no evidence that birds on the Stour have been affected in the same way.

Recreational disturbance has increased around the SPA over the last 30 years and may have impacted on waterbird numbers. However, it is unlikely that what is probably a gradual increase in disturbance during this period would in itself explain the many recent five-year Alerts that have been fired on the Orwell Estuary alone and on the Stour-Orwell SPA as a whole

The change in the treatment of discharges from the Cliff Quay outfall may also have been a major contributor to the declines in waterbirds on the SPA, as will have the major decreases in the freshwater inputs into the estuary. The BTO is currently involved in work for English Nature assessing the effects of reductions in organic and nutrient loading on bird numbers in estuaries. If this work is continued, it may be possible to better determine the impact that this has had on the waterbirds of this and other SPAs.

Finally the loss to landclaim of Fagbury Flats and other parts of the Orwell and the Stour will also have contributed to site deterioration and to fewer birds making use of the Orwell and the Stour-Orwell SPA.

If there is a relationship between dredging and waterbirds, it could be demonstrated by analysis of ringing data collected on the Stour and Orwell estuaries. If sufficient birds have been ringed on the Stour-Orwell SPA then it may be possible to estimate survival rates of the birds trapped. This will involve collation of the data, assessment as to the kind of survival models that could be built and running of the models. In an ideal scenario, it would be possible to estimate annual survival rates (*eg* as in the Wash shellfish and wader study, Atkinson *et al.* 2003) but it is likely that the data are not sufficient for this and it may be only possible to estimate survival pre- and post-dredging events. If sufficient data are available, it may be possible to estimate recruitment based on the adult/juvenile ratio in the catches. If so, then it would be possible to construct a population trajectory and determine whether there are any correlations between dredging and population change. The relationship between the change in sediments (as a consequence of dredging events) and waterbird numbers on the various LTC sectors could also help determine whether or not dredging is the cause of the declines. Finally, it should be possible to compare population trends of waterbirds on other sites where dredging occurs to similar sites where it does not occur. The null hypothesis would be that no differences in population trends are noted between the two sets of sites. If this is disproved, then dredging or the activities associated with it are likely to help explain the changes in waterbird numbers.

Acknowledgements

This research would not have been possible without the funding of Harwich Haven Authority facilitated by Posford Haskoning Ltd. Particular thanks to Tony Stones and Sian John for their input.

The Wetland Bird Survey is a joint partnership between the British Trust for Ornithology, The Wildfowl and Wetlands Trust, the Royal Society for the Protection of Birds and the Joint Nature Conservation Committee (the latter on behalf of English Nature, Scottish Natural Heritage, the Countryside Council for Wales and the Environment and Heritage Service in Northern Ireland). Many thanks to the thousands of volunteers who make the scheme possible.

Suffolk Wildlife Trust have funded and conducted the LTCs on the Orwell since 1984, and we are grateful for their permission to access this data. Counts in 1984/85 were part funded by the Felixstowe Dock and Railway Company, in 1996/97 and 1997/98 by English Nature and the Environment Agency, and those from 1999 onwards have been funded by Harwich Haven Authority as part of the monitoring package for the SPA.

We gratefully acknowledge the contributions of the following people who provided information and discussion regarding impacts on the SPA: Mick Wright and his team of WeBS counters on the Orwell Estuary, Rick Vonk and his team of WeBS counters on the Stour Estuary, Merle Leeds (Environment Agency), Matt Simpson (Posford Haskoning Ltd) and Dick Allen (HHA).

Thanks also to colleagues at the BTO for their discussion and to Heidi Mellan and Nicki Read for their assistance in finalising the report.

References

Anglian Water (1987) *Orwell Estuary Model.* R & D Project No. 220.

Armitage, M.J.S., Burton, N.H.K., Atkinson, P.W., Austin, G.E., Clark, N.A., Mellan, H.J. & Rehfisch, M.M. (2002b) *Reviewing the Impact of Agency Permissions and Activities on Bird Populations in Special Protection Areas: Level 1 Interpretation.* BTO Research Report 296 to EA. BTO, Thetford.

Armitage, M.J.S. & Rehfisch, M.M. (2002a) *Assessing Waterbird Population trends on the Stour and Orwell Estuaries SPA.* BTO Research Report 297 to Posford Haskoning Ltd. BTO, Thetford

Atkinson, P.W., Clark, N.A., Clark, J.A., Bell, M.C., Dare, P.J. & Ireland, P.L. (2003) Changes in commercially fished shellfish stocks and shorebird populations in the Wash, England. *Biological Conservation,* **114**, 127-141.

Atkinson, P.W. & Rehfisch, M.M. (2000) Development of a national and regional alert system for waterbirds using generalized additive models. In: *National and site-based alert systems for UK birds.* (Eds) Gregory, R.D., Rehfisch, M.M., Underhill, L.G., Field, R.H., Atkinson, P.W. Freeman, S.N., Siriwardena, G.M. & Baillie, S.R. BTO Research Report No. 226. British Trust for Ornithology, Thetford, UK.

Austin, G., Rehfisch, M.M., Holloway, S.J., Clark, N.A., Balmer, D.E., Yates, M.G., Clarke, R.T., Swetnam, R.D., Eastwood, J.A., Durell, S.E.A. le V. dit, West, J.R. & Goss-Custard, J.D. (1996) *Estuary, sediments and shorebirds III. Predicting waterfowl densities on intertidal areas.* BTO Research Report No. 160. A report by the British Trust for Ornithology under contract to ETSU (ETSU Project T/04/00207/REP). 179pp.

Babbs, S. & Ravenscroft, N. (1998) *Bait Digging on the Stour and Orwell Estuaries.* Report to English Nature. Contract No. NB/T/404/97-98.

Burd, F. (1992) *Erosion and vegetation change on the saltmarshes of Essex and north Kent between 1973 and 1988.* Nature Conservancy Council, Research and Survey in nature conservation, Report No. 42.

Burton, N.H.K., Armitage, M.J.S., Musgrove, A.J. & Rehfisch, M.M. (2002a) Impacts of man-made landscape features on the numbers of estuarine waterbirds at low tide. *Environmental Management,* **30**, 857-864.

Burton, N.H.K., Paipai, E., Armitage, M.J.S., Maskell, J.M., Jones, E.T., Struve, J., Hutchings, C.J. & Rehfisch, M.M. (2002b) *Effects of reductions in organic and nutrient loading on bird populations in estuaries and coastal waters of England and Wales. Phase 1 report.* BTO Research Report 267 to EN, CCW and EA. BTO, Thetford, UK.

Burton, N.H.K., Jones, T.E., Austin, G.E., Watts, G.A., Rehfisch, M.M. & Hutchings, C.J. (2003) *Effects of Reductions in Organic and Nutrient Loading on Bird Populations in Estuaries and Coastal Waters of England and Wales. Phase 2 Report.* BTO Research Report 326 (Draft) to EN, CCW and EA. BTO, Thetford.

Clark, N.A. & Davidson, N.C. (1986) WSG project on the effects of severe weather on waders: 6th progress report. *Wader Study Group Bulletin,* **46**, 7-8.

Cooper, N., Skrzypczak, T. & Burd, F. (2000) *Erosion of the saltmarshes of Essex between 1988 and 1998.* Report to the Environment Agency by Coastal Geomorphology Partnership, Dept. of Marine Sciences and Coastal Management, University of Newcastle.

Davidson, N.C. & Clark, N.A. (1985) The effects of severe weather in January and February 1985 on waders in Britain. WSG project on the effects of severe weather on waders: 5th progress report. *Wader Study Group Bulletin*, **46**, 10-16.

Davidson, N.C. & Rothwell, P.I. (1993) Disturbance to waterfowl on estuaries. *Wader Study Group Bulletin*, **68 Special Issue**. RSPB, Sandy.

Dolman, P.M. & Sutherland, W.J. (1995) The response of bird populations to habitat loss. *Ibis*, **137 suppl.**, S38-S46.

Environment Agency (2001) *Hydroecological Review of Selected European Sites within the Agency's Anglian Region.* DRAFT report by Entec UK Limited.

Evans, P.R. (1997) *Effects of Habitat Loss and Change on Waterbirds.* (Eds) Goss-Custard, J.D., Rufino, R. & Luis, A. The Stationary Office, London, UK.

Goss-Custard J.D., Caldow R.W.G., Clarke R.T., Durell S.E.A. le V dit, Urfi A.J. & West A.D. (1995) Consequences of habitat loss and change to populations of wintering migratory birds: predicting the local and global effects from studies of individuals. *Ibis*, **137 suppl.**, S56-66.

Goss-Custard J.D. & West A.D. (1997) The concept of carrying capacity and shorebirds. In: *Predicting and detecting the effect of habitat loss and change on wetland bird populations.* (Eds) Goss-Custard, J.D., Rufino, R. and Luis, A., pp. 52-62. ITE Symposium no. 30. Wetlands International Publication No. 42. HMSO, London.

Holloway, S.J., Rehfisch, M.M., Clark, N.A., Balmer, D.E., Austin, G., Yates, M.G., Clarke, R.T., Swetnam, R.D., Eastwood, J.A., Durell, S.E.A. le V. dit, Goss-Custard, J.D. & West, J.R. (1996) *Estuary, sediments and shorebirds II. Shorebird usage of intertidal areas.* BTO Research Report No. 156. A report by the British Trust for Ornithology under contract to ETSU (ETSU Project T/04/00206/REP). 270pp.

HR Wallingford (2001) *Harwich Harbour Strategic Studies: Review of present and historic maintenance dredging records.* Report to Harwich Haven Authority, no EX 4446.

HR Wallingford (1997) *Harwich Harbour Strategic Studies: Summary of Studies.* Report to Harwich Haven Authority, no EX 3604.

Liley, D. (2000) *Predicting the consequences of human disturbance, predation and sea level rise for Ringed Plover populations.* Ph.D. thesis, University of East Anglia.

Musgrove, A.J. (1998) *Validation of WeBS methodology – the relationship between waterfowl counts carried out at high and low tide.* A report by the British Trust for Ornithology to the WeBS partners. British Trust for Ornithology, Thetford, UK.

Musgrove, A.J., Clark, N.A., Gill, J. & Ravenscroft, N.O.M. (2001) *A Review of Wildfowling on the Stour Estuary.* BTO Research Report **248** to EN. BTO, Thetford.

Pearson, T.H. & Rosenberg, R. (1978) Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanographic Marine Biology Annual Review*, **16**, 229-311.

Pollitt, M.S., Hall, C., Holloway, S., Hearn, R., Marshall, P., Musgrove, A.J., Robinson, J. & Cranswick, P.A. (2003) *The Wetland Bird Survey 2000-2001: Wildfowl and Wader Counts.* BTO/WWT/RSPB/JNCC, Slimbridge.

Posford Duvivier Environment (1998) *Harwich Haven Approach Channel Deepening. Appropriate Assessment.* Report to Harwich Haven Authority.

Posford Duvivier Environment (2000) *Port of Felixstowe Harbour Revision Order. Trinity III Terminal (Phase 2) Extension. Environmental Statement.* Report to Harwich Haven Authority.

Ravenscroft, N.O.M. (2000) *Ornithological monitoring of the Stour and Orwell Estuaries SPA. Winter 1999/2000.* Report to Harwich Haven Authority.
Ravenscroft, N.O.M. (2001) *Ornithological monitoring of the Stour and Orwell Estuaries SPA. Winter 2000/2001.* Report to Harwich Haven Authority.

Ravenscroft, N.O.M. (2002) *Ornithological monitoring of the Stour and Orwell Estuaries SPA. Winter/2001/2002.* Report to Harwich Haven Authority.

Ravenscroft, N.O.M. (2003) *Ornithological monitoring of the Stour and Orwell Estuaries SPA. Winter2002/2003.* Report to Harwich Haven Authority.

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.

Ravenscroft, N.O.M., Beardall, C.H., Cottle, R., Willett, P. & Wright, M.T. (1998) *The Distribution of Wintering Waterfowl Around Freshwater Flows Over the Mudflats of the Orwell Estuary, England.* A Report to the Environment Agency and English Nature.

Rehfisch M., Austin G.E, Clark N.A., Clarke R.T., Holloway S.J., Yates M.G., Durell, S.E.A. le V. dit, Eastwood J.A., Goss-Custard J.D., Swetnam R.D., & West, J.R. (2000) Predicting densities of wintering Redshank *Tringa totanus* from estuary characteristics: a method for assessing the likely impact of habitat change. *Acta orn.*, **35**, 25-32.

Rehfisch, M.M., Clark, N.A., Langston, R.H.W. & Greenwood, J.J.D. (1996) A guide to the provision of refuges for waders: an analysis of thirty years of ringing data from the Wash, England. *Journal of Applied Ecology*, 33, 673-687.

Rehfisch, M.M., Holloway, S.J., Yates, M.G., Clarke, R.T., Austin, G., Clark, N.A., Durell, S.E.A. le V. dit, Eastwood, J.A., Goss-Custard, J.D., Swetnam, R.D. & West, J.R. (1997) Predicting the effect of habitat change on waterfowl communities: a novel empirical approach. In: *Predicting habitat loss*, (Eds) Goss-Custard, J., Rufino, R. & Luis, A., pp 116-126. The Stationery Office, London.

Rehfisch, M.M., Insley, H. & Swann, B. (In press) Fidelity of overwintering shorebirds to roosts on the Moray Basin, Scotland: implications for predicting impacts of habitat loss. *Ardea.*

Smit, C.J. & Visser, J.M. (1993) Effects of disturbance on shorebirds: a summary of existing knowledge from the Dutch Wadden Sea and Delta area. *Wader Study Group Bulletin*, **68**, 6-19.

Sutherland, W.J. & Dolman, P.M. (1994) Combining behaviour and population dynamics with applications for predicting consequences of habitat loss. *Proc. Roy. Soc. Lond. Series B*, **255**, 133-138.

Symonds, F.L. & Langslow, D.R. (1986) The distribution and local movements of shorebirds within the Moray Firth. *Proceedings of the Royal Society Edinburgh*, **91B**, 143-168.

Symonds, F.L.D., Langslow, D.R. & Pienkowski, M.W. (1984) Movements of wintering shorebirds within the Firth of Forth: species differences in usage of an intertidal complex. *Biological Conservation*, **28**, 187-215.

Underhill, L.G. & Prŷs-Jones, R. (1994) Index numbers for waterbird populations. I. Review and methodology. *Journal of Applied Ecology*, **31**, 463-480

Warnock, S.E. & Takekawa, J.Y. (1996) Wintering site fidelity and movement patterns of Western Sandpipers *Calidris mauri* in the San Francisco Bay estuary. *Ibis*, **138**, 160-167.

Yates, M.G., Goss-Custard, J.D., McGrorty, S., Lakhani, K.H., Durell, S.E.A. le V. dit, Clarke, R.T., Rispin, W.E., Moy, I., Yates, T., Plant, R.A. & Frost, A.E. (1993) Sediment characteristics, invertebrate densities and shorebird densities on the inner banks of the Wash. *Journal of Applied Ecology*, **30**, 599-614.