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ANALYSIS OF WETLAND BIRD SURVEY (WEBS) DATA FOR THE WASH SSSI/NNR

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Summary

1. The Wash is a site of national and international importance for its wader and wildfowl populations, supporting a minimum estimate of approximately 373,000 individuals annually. It has been designated as a Special Protection Area (The Wash SPA) for 31 species of waterbird. Along with the neighbouring Norfolk coast, The Wash is also a Special Area of Conservation (The Wash and North Norfolk Coast SAC), and the SPA area is also a Ramsar Site and a SSSI. The Wash NNR falls within the SPA/Ramsar/SSSI area.

2. The Wetland Bird Survey (WeBS) is a long-running survey that records the number of all waterbird species on 18 different geographical count units (sectors) of The Wash SSSI (as well as many other sites nationally), five of which also fall within The Wash NNR, at monthly intervals. These data can be used to assess population trends in different parts of these regions.

3. This study aimed to assess population trends of waterbird species in different parts of the The Wash SSSI and The Wash NNR, in order to identify areas where species were declining contrary to, or in excess of, the trend for the estuary as a whole and, furthermore, to identify sectors that were changing in terms of the proportion of species they support relative to The Wash SSSI as a whole. The effect of grazing and inflows on WeBS counts was also evaluated, as was the correspondence between breeding bird counts and WeBS core counts. The relationship between winter roost areas and feeding grounds was also investigated.

4. Smoothed population trends were assessed for the 15-year period from 1993/94 (1994/95 for waders) to 2007/08, for 25 waterbirds designated as features of The Wash SPA/SSSI, on each count sector for which there were sufficient data. In addition, the importance of each sector in relation to the Wash SSSI as a whole over time was assessed for every species, by investigating whether the numbers of supported by each sector had increased or decreased significantly. Twenty-five year trends were also assessed for 26 species, and interpreted in the context of regional, national and international changes.

5. Numbers of most wader species, and shelduck, had declined across a wide geographical area, particularly in the southern part of The Wash.

6. Numbers of dabbling duck species had increased, particularly on the eastern (Norfolk) side of The Wash. However, these increases appeared to be levelling off in recent winters.

7. Declines in waterbird species numbers were more substantial and sustained on The Wash NNR than on The Wash SSSI. This is important as for the majority of species The Wash NNR supports a large proportion of individuals found on The Wash SSSI.

8. There was no relationship between WeBS counts and grazing regimes, inflows or breeding bird numbers. However, there was a significant positive relationship between the area of land grazed and the numbers of birds breeding at Frampton Marsh and Snettisham for redshank.

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1 Introduction

1.1 Background

The Wash is located on the east coast of England and is the largest estuarine system in the UK. It is fed by the rivers Witham, Welland, Nene and Great Ouse and as such, drains much of the East Midlands and East Anglia. The Wash comprises very extensive saltmarshes, major intertidal banks of sand and mud, shallow waters and deep channels. The eastern end of the site includes low chalk cliffs at Hunstanton. In addition, on the eastern side, the gravel pits at Snettisham are an important high tide roost for waders. The intertidal flats have a rich invertebrate fauna and colonising beds of glasswort *Salicornia spp*. which are important food sources for the large numbers of waterbirds dependent on this site. The sheltered nature of The Wash creates suitable breeding conditions for shellfish, principally mussel *Mytilus edulis*, cockle *Cardium edule* and shrimps. These are principal food sources for some species such as oystercatcher *Haematopus ostralegus*. To the north, the coastal habitats of The Wash are continuous with Gibraltar Point SPA, whilst to the east The Wash adjoins the North Norfolk Coast SPA (Stroud and others 2001).

The Wash is one of the largest protected sites in the country, exceeding 60,000 ha in area, and has exceptional wildlife importance. It is one of the primary estuaries for wintering waterbirds in the UK, currently supporting a minimum estimate of approximately 373,000 individuals annually (excluding introduced species) during the years of 2004/05 to 2008/09 (Calbrade and others 2010), including internationally important numbers of 16 species (Stroud and others 2001). This importance is recognised and protected through its designation within The Wash and North Norfolk Coast Special Area of Conservation (SAC) and as a Special Protection Area (SPA), Ramsar Site, National Nature Reserve (NNR) and Site of Special Scientific Interest (SSSI). The Wash NNR extends to some 8,777 ha within the much larger SPA, Ramsar Site and SSSI, which share a common boundary extending to over 62,000 ha.

The Wash NNR is the largest National Nature Reserve in England. The large expanses of mudflat and saltmarsh within the NNR support huge numbers of wintering and passage waterbirds. The saltmarsh is important for breeding waders and small passerines, and the outer trial bank is used by breeding seabirds. Common seals pup on the offshore banks in summer. A range of nationally scarce vascular plants and invertebrates have been recorded on the saltmarsh and parts of the seabank.

This work is required to contribute to the management plan's monitoring requirement, identify areas for proposing as refuges and to ascertain affects of grazing, management, and access on the NNR and further afield in The Wash. It will also inform investigation requirements triggered by the unfavourable declining condition assessment for the shelduck sub-feature of The Wash SPA, Ramsar Site and SSSI, and other species close to the Common Standards Monitoring Guidance thresholds for unfavourable declining status.

1.2 Objectives

From an initial list of 31 feature species of The Wash SPA (Stroud and others 2001), sufficient data were available from WeBS to assess the population trends of 24 species for The Wash SSSI and 18 for The Wash NNR. Trends for teal were also evaluated for both sites (see Table 1.1). Trends for all species were not available for every WeBS sector. The species for which trends were assessed are detailed in Table 1.1.

Table 1.1 Species for which trends and analyses were undertaken.

Species	SPA feature[1]	SSSI feature[2]	25yr trend produced	Sector level analysis (15yr)
Whooper swan *Cygnus cygnus*	✓	✓	✓	x[3]
Pink-footed goose *Anser brachyrhynchus*	✓	✓	x[4]	✓
Dark-bellied brent goose *Branta bernicla bernicla*	✓	✓	✓	✓
European white-fronted goose *Anser albifrons albifrons*	✓	✓	✓	x[3]
Shelduck *Tadorna tadorna*	✓	✓	✓	✓
Wigeon *Anas penelope*	✓	✓	✓	✓
Gadwall *Anas strepera*	x	✓	✓	✓
Teal *Anas crecca*	x	x	✓[5]	✓[5]
Mallard *Anas platyrhynchos*	✓	✓	✓	✓
Pintail *Anas acuta*	✓	✓	✓	✓
Common scoter *Melanitta nigra*	x	✓	✓	✓
Goldeneye *Bucephala clangula*	x	✓	✓	✓
Little grebe *Tachybaptus ruficollis*	✓	✓	✓[6]	✓
Cormorant *Phalacrocorax carbo*	✓	✓	✓[6]	x[3]
Oystercatcher *Haematopus ostralegus*	✓	✓	✓	✓
Avocet *Recurvirostra avosetta*	✓	✓	✓	✓
Ringed plover *Charadrius hiaticula*	✓	✓	✓	✓
Golden plover *Pluvialis apricaria*	✓	✓	✓	✓
Grey plover *Pluvialis squatarola*	✓	✓	✓	✓
Lapwing *Vanellus vanellus*	✓	✓	✓	✓
Knot *Calidris canutus*	✓	✓	✓	✓
Sanderling *Calidris alba*	✓	✓	✓	✓
Dunlin *Calidris alpina*	✓	✓	✓	✓
Black-tailed godwit *Limosa limosa*	✓	✓	✓	✓
Bar-tailed godwit *Limosa lapponica*	✓	✓	✓	✓
Whimbrel *Numenius phaeopus*	✓	✓	x[7]	x[7]
Curlew *Numenius arquata*	✓	✓	✓	✓
Redshank *Tringa totanus*	✓	✓	✓	✓
Turnstone *Arenaria interpres*	✓	✓	✓	✓
Little tern *Sternula albifrons*	✓	✓	x[8]	x[8]
Common tern *Sterna hirundo*	✓	✓	x[8]	x[8]
Marsh harrier *Circus aeruginosus*	✓	✓	x[9]	x[9]

[1] Stroud and others 2001.
[2] As received from Natural England.
[3] Species not assessed because its behaviour does not lend itself to monitoring by standard WeBS daytime counts (species typically forages in wider countryside during the day).
[4] Species not assessed because preferentially monitored by the WWT Goose Census at site level.
[5] Species included because it was requested (by virtue of being a quarry species) in a recent report to Natural England (Austin & Calbrade 2010).
[6] Species not counted in WeBS until 1987/88 (cormorant) and 1989/90 (little grebe).
[7] Species not assessed because only occurs on passage, so is not recorded by winter WeBS counts.
[8] Species not assessed because it is only present in any number during the breeding season and therefore not recorded by winter WeBS counts.
[9] Species not assessed because not a waterbird, and therefore not counted by WeBS.

2 Methodology

2.1 Waterbird data

WeBS is a long-running survey that monitors waterbird numbers on sites throughout the UK via monthly site visits, when numbers of all waterbird species are recorded (Calbrade and others 2010). On large sites, such as The Wash, where it is not feasible, or indeed desirable, to make a single count for the entire site, synchronous counts of smaller count sectors are undertaken (Figure 2.1.i). These sector counts are routinely summed to give the overall site total, and during this process the completeness of the overall count assessed. This is required because all sectors are not necessarily counted on all occasions. This is undertaken in a species specific manner because the absence of data from a given sector would not be expected to affect the overall total equally for all species. Furthermore, completeness is assessed on a month by month, year by year basis using algorithms that allow for both seasonal and long-term trends in site usage. Thus a consolidated count for a site composed of multiple sectors is considered complete when those sectors counted on the month in question would be expected to hold at least 75% of the site total for the species in question for the season and year in question. Whilst the division of large sites into sectors has evolved principally in response to the practicality of undertaking counts, the divisions between sectors typically follow distinctive features of the environment. Thus an analysis of waterbird trends on the individual sectors can inform in a biologically meaningful manner.

Over time, and particularly on larger sites a complex hierarchy of site structure can develop as sectors are subdivided by WeBS counters, however, importantly, existing sector boundaries are retained and incorporated into the new divisions to ensure that counts from divided sectors can be combined and numbers compared over long time series. Thus the hierarchical structure of The Wash (Figure 2.1.ii) has evolved through time as existing sectors have been subdivided. Where this subdivision has occurred in recent years, it is necessary to recombine the counts into the older division in order to generate long-term trends.

Eighteen constituent and extant WeBS sectors of The Wash SSSI were considered in this report (Figure 2.1.ii). Five of the WeBS sectors of The Wash SSSI were also considered as part of The Wash NNR. These were Ouse Mouth (34490), Terrington East (34491), Terrington West (35401), Gedney (35402) and Kirton (35407) (Figures 2.1.i and 2.1.ii). The boundaries of these sectors do not exactly correspond with those of The Wash NNR. Hence, sectors were only considered part of The Wash NNR if a substantial proportion of their area (approximately 50% or greater) fell within the NNR boundary or where knowledge of the site suggested that the majority of birds counted on a given sector could be expected in that part of the sector within the NNR. Snettisham (34486) and Welland (35405) were therefore not included in The Wash NNR, despite some overlap between these sites.

All analyses were undertaken using data that gave the highest spatial resolution possible, such that information was used at the subsector level when possible. As several years' worth of data has been collected for certain subsectors, for instance Frampton North (35419) and Frampton South (35420) (Figure 2.1.i), population trends were generated for these sites in the same way that they were at the sector level. These sites are also therefore shown on all figures in which WeBS sectors are depicted. In recent winters, information has been collected at a higher resolution spatial scale, but as this has only taken place since 2007/08,

insufficient data were available at this scale to generate the trends and figures in most of this report. However, the information on high tide counts shown in Figures 3.4.1, E.1 and F.1 is measured at the finest sub-sector level, while the analysis of the relationship between WeBS counts and breeding bird data (section 2.3) also incorporated WeBS data at this higher resolution.

Figure 2.1.i The Wash SSSI showing the WeBS count sectors and subsectors for which trends were obtained and analyses were performed in this report.

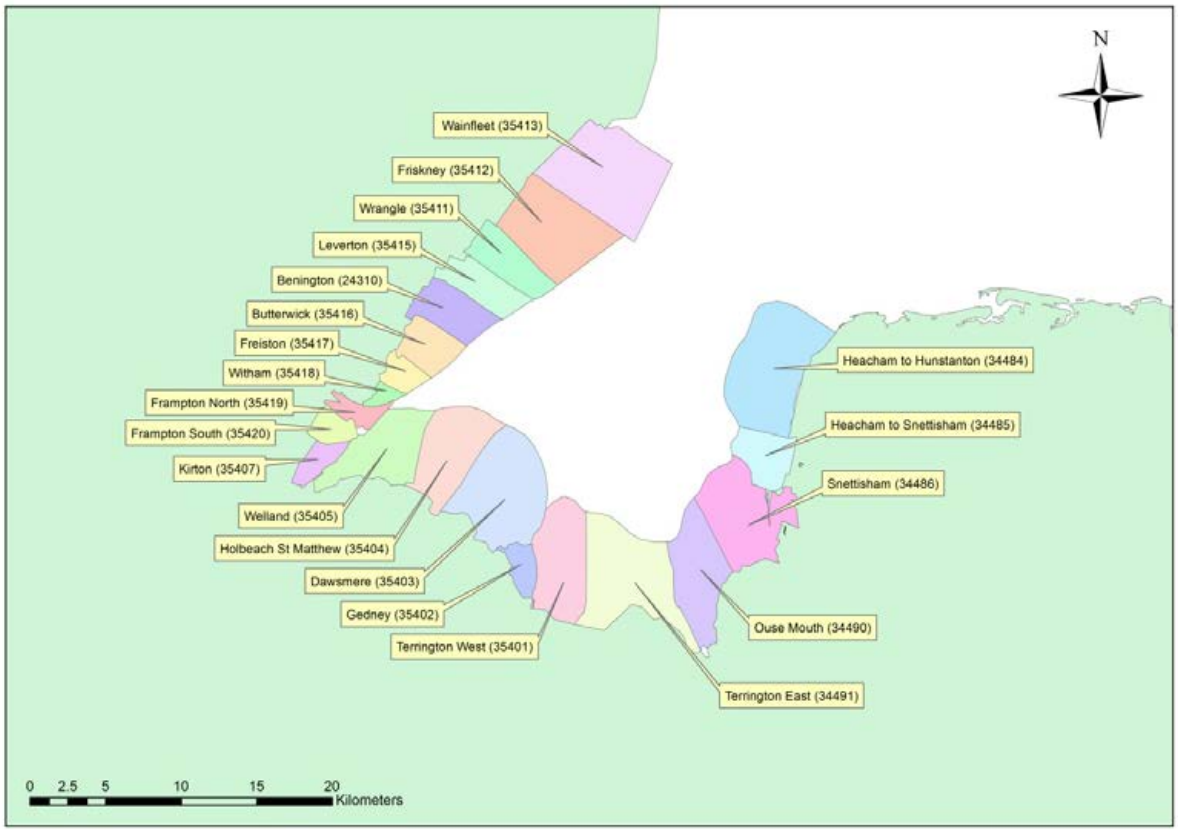
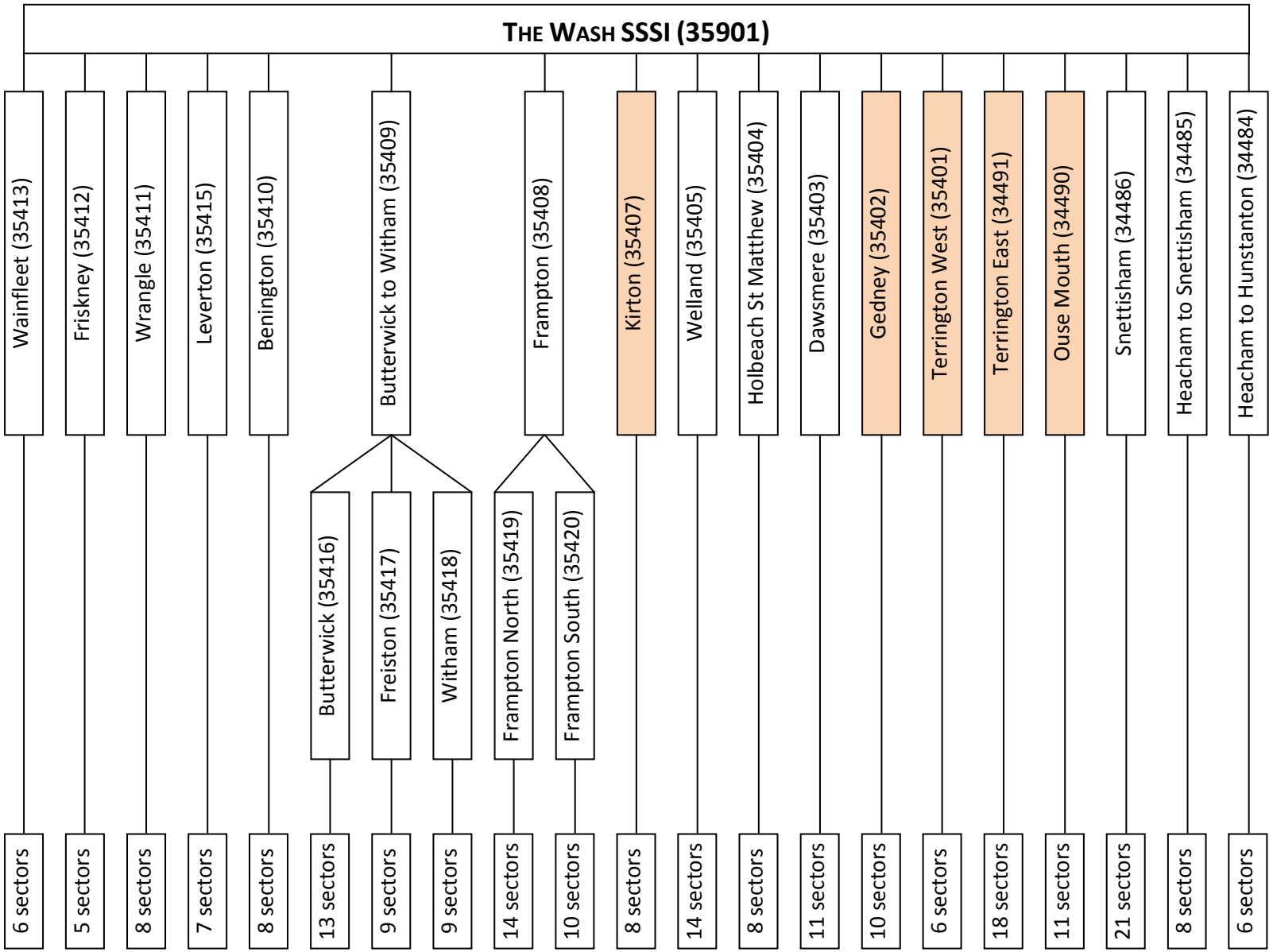


Figure 2.1.ii Structural hierarchy of WeBS count sectors on The Wash SSSI. Shaded sectors relate to those sectors used to characterise waterbird numbers on The Wash NNR. Time series extending back beyond 2007/08 are only available for those sectors named in this figure

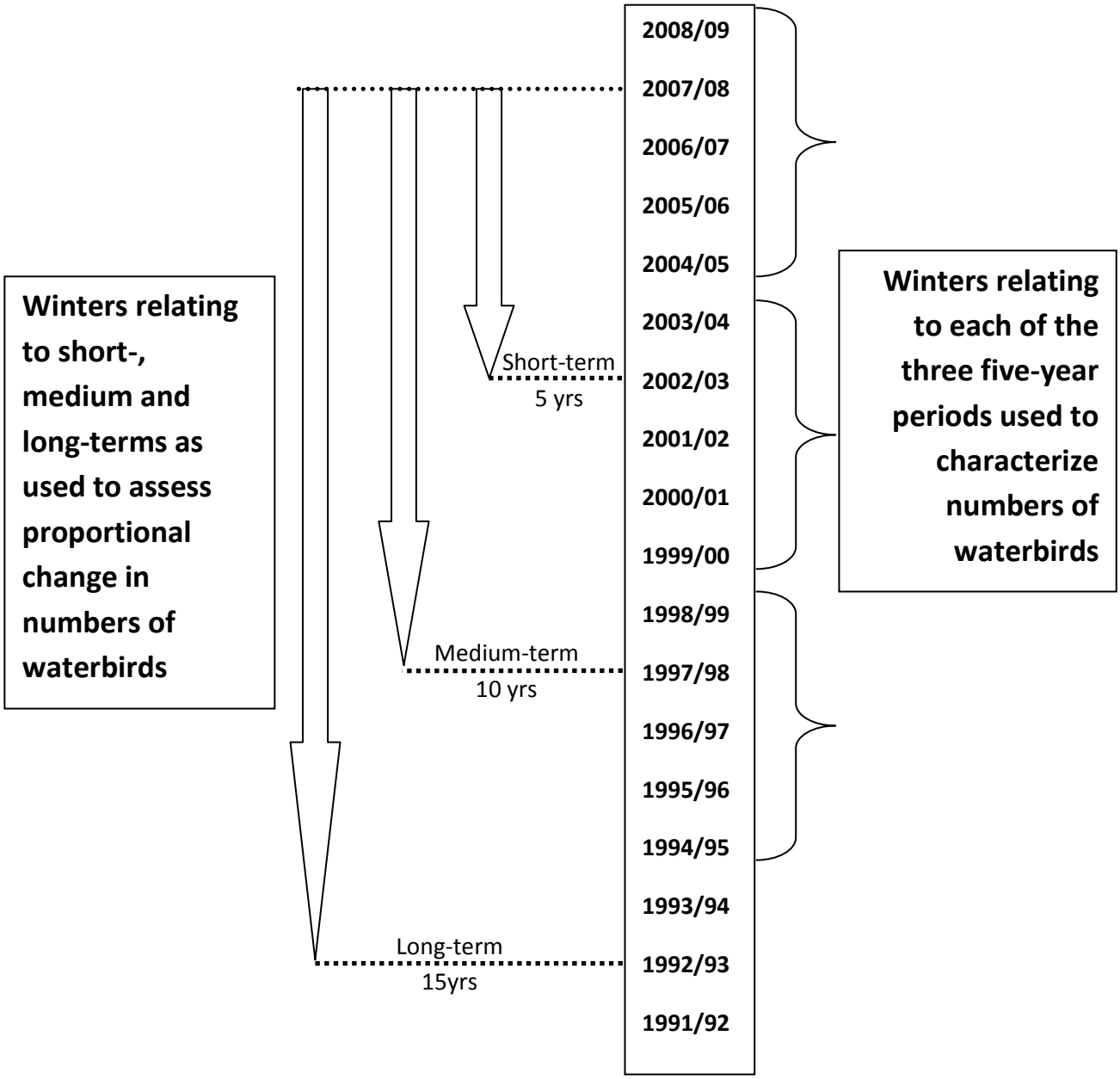


2.1.1 Smoothed waterbird trends and percentage change

The methodology used to produce smoothed site, regional and national trends as reported by WeBS Alerts (Thaxter and others 2010) can be usefully extended to generate trends on smaller areas of interest such as WeBS count sectors or appropriately grouped count sectors. It is, however, important to recognise that the numbers of birds underlying the observed trend on sectors are generally much lower than those underlying site trends reported by WeBS Alerts which are, by definition, are at least equal to the national qualifying threshold. Consequently, individual trends should not be 'over-interpreted'. For example, a 50% decline from 30 birds to 15 birds would give much less cause for concern than a 50% decline from 1000 to 500 birds the latter being much more likely to reflect a real and substantial loss of birds from an area than the former. While bearing this in mind, a consistent pattern of decline across multiple species, even when the numbers involved for some of them are comparatively low, is strongly indicative of adverse factors affecting the sector in question and the particular suite of species showing a decline in numbers can guide us in where to look for problems (for example, does the suite of species represent those known to be particularly sensitive to disturbance or those with similar ecological requirements).

Thus, using the latest available validated WeBS data (to winter 2008/09 inclusive), following Atkinson and others (2000, 2006), smoothed trends were calculated using Generalized Additive Models (GAMs) for the relevant species. The smoothing is to ensure that year-specific factors, such as poor conditions on the breeding grounds or particularly harsh weather on the wintering grounds, that are not related to changes in the quality of The Wash itself, do not contribute overly to the trend. Percentage change has been calculated for short- (5yr) medium- (10yr) and long-term (13yr for waders and 14yr for other species as dictated by data availability) (Figure 2.1.2.i). The percentage change is calculated with reference to the penultimate winter in the time series available so as to avoid referring to the end points of the smoothed trend (Figure 2.1.2.i). WeBS does not have the necessary data collated at the sector level to support analysis of longer time-series. By way of analogy with the WeBS Alerts system, declines of at least 25% but below 50% are flagged as medium-declines, and declines of 50% or greater are flagged as high-declines (we specifically do not use the terms medium- and high-Alerts because unlike the percentage change reported by WeBS Alerts, medium and high declines reported at the sector level do not constitute a formal WeBS Alert). The corresponding percentage change required to balance the numbers to their former level following a decline or increase are likewise termed medium- (at least 33% but below 100%) and high- (100% or greater) increases.

Figure 2.1.2.i Schematic of reference winters used for reported waterbird numbers and change.



2.1.2 Placing the smoothed waterbird indices into context

Once the smoothed sector indices have been produced the observed trends are placed in context of the site trends. The latest WeBS methodology (Banks & Austin 2004) as used to compare site trends with regional and national trends when reporting WeBS Alerts (Thaxter and others 2010) is extended here to compare counts sector trends with site trends. If waterbird numbers of a given species on a given count sector follow those of the species across the site as a whole then the proportion contribution of numbers on the site would remain constant. Any significant deviation from this gradient of zero would indicate that the waterbird populations on the relevant count sector are doing either better or less well than would be expected from the site trend. Consequently:

- where a decline on a sector reflects a decline across the site as a whole it is unlikely that the observed site trends is being driven by factors affecting that sector. If this is true of the majority of sectors, then this may indicate that the observed site decline in the species in question is due to factors external to the site and are thus not due to site management issues *per se*;

- where a decline on a sector is more substantial than that across the site as a whole, this may suggest that factors affecting that sector could be contributing to the overall decline;

- where a decline on a sector is less than the decline across the site as a whole, this suggests that relatively favourable conditions on that sector are helping buffer site declines;

- where an increase on a sector is less than that across the site as a whole, this suggests that the sector is already at carrying capacity for the species in question or, if historically it supported greater numbers, that the quality of the sector to that species has diminished;

- where an increase on a sector is greater than that across the whole site, this suggests that trends on that sector are driving the increase across the site or that the sector in question is relatively attractive compared to the site as a whole when increased numbers arrive at the site due to external factors.

The comparisons between sectors and site are derived from a logistic regression model with a binomial error term. The resulting plots depict the percentage contribution of the sector to the site as a whole and the associated confidence limits represent both variation in this proportion between months in a given year and the underlying sample size (for example, we would be more confident of our estimate that a sector contributed 10% of the site total if 100 birds out of 1000 on the site were counted there than we would be if this was 10 out of 100). This is based on the winter period as routinely used for all WeBS reporting (Nov-Mar for waders and Sep-Mar for other species). Only data from months where counts consolidated across the site as a whole had been assessed as complete were used - following standard WeBS protocol described above.

Having considered the trends on the sectors, each in the context of trends across the site as a whole, it is important to consider the site trends in the context of the region – here the Environment Agency (EA)'s Anglian Region (following standard WeBS Alerts reporting), as this can modify our interpretation of the pattern of change across sectors. This is especially important where there has been an increase or decline regionally. Consequently:

- where there has been an apparent re-distribution of a species within The Wash (that is, declines on some sectors appear to be balanced by increases on other sectors), but the proportional contribution of The Wash to increasing regional numbers is declining, then this implies that those sectors on The Wash with static or declining numbers are actually of concern because we would expect them to be increasing in parallel with the other sectors. Thus, in such cases, the apparent redistribution within The Wash is misleading and the species in question may be facing problems on those sectors not supporting an increase in numbers;

- where a species is in regional decline we would expect declines on at least some of the sectors of The Wash regardless of whether birds are being affected by adverse factors locally. Thus, we would expect those sectors of least suitable habitat to a given species to be the first to show a decline in numbers.

2.2 Effect of grazing and inflows on WeBS counts

Models were fitted to investigate whether grazing and inflows to The Wash affect waterbird numbers as measured by WeBS core counts. Data on grazing regimes at Terrington Marsh and North Wooton Marsh were obtained from Natural England for the years 2003 to 2007 inclusive (corresponding with the short-term timeframe used in other analysis, see Figure 2.1.2.i). These areas both fall within The Wash NNR as well as The Wash SSSI, and straddle the River Great

Ouse where it enters The Wash. Information from the EA detailed the inflow from this river to The Wash, which was calculated as the sum of flows (m^3/s) in the Ely Ouse at Denver and the Tail Sluice, the Bedford Ouse at Offord and the Middle Level at St Germans.

Grazing data were subdivided into grazing compartments, and encompassed information on the number of cattle put to pasture at each site and the height of sward (cm) obtained. For Terrington Marsh, grazing compartments all fell within WeBS sectors 34491, Terrington East, and 35401, Terrington West. WeBS core counts for these sectors were thus summed and the mean taken, for use as the response variable in our model. Species listed in Table 1.1 were included in the analyses, with the exception of gadwall, goldeneye, little grebe and ringed plover, which were omitted as numbers counted were negligible. Counts were considered for winter months only (November to March for waders, September to March for all other species). Inflows were extracted for corresponding months, while grazing data were considered for the preceding summer (which we consider to be the period most likely to influence winter bird populations).

Data were analysed using the statistical software R version 2.12.1 (R Core Development Team 2010), with the use of the additional package "MASS" (Venables & Ripley 2002). Generalized linear mixed effects models were employed with a Poisson error structure. The response variable was the mean WeBS count for each species over the winter months (rounded to the nearest integer). Fixed explanatory variables were the mean number of cattle present, median sward height, inflows into The Wash and year. Species identity was included as a random effect. Model selection proceeded by stepwise deletion.

The information available for Wooton Marsh was much less complete than that for Terrington Marsh, and the grazing compartments at Wooton Marsh did not correspond to WeBS sectors. It was therefore decided to exclude data from this region from the modelling process.

2.3 Comparison of breeding bird data and WeBS core counts

Analysis was undertaken to examine the possible relationships between breeding bird counts and WeBS core counts. Information on breeding bird numbers was obtained from the RSPB, and was therefore only available for a small part of The Wash, namely the RSPB reserves at Snettisham and at Frampton Marsh, both of which fall within The Wash SSSI, but not The Wash NNR. These sites are divided into grazing compartments, and breeding bird figures were available for each. Information on the level of grazing in each compartment was also available, with annual figures provided for cattle numbers and compartment area. Grazing compartments corresponded well to WeBS subsectors. In many cases, for example, Frampton subsectors 45465 and 45466, grazing compartments and WeBS subsectors were an exact match, while in others, a compartment was made up of several subsectors, for example, Snettisham subsectors 34943, 34944 and 34945. In all instances, the area (ha) was known. The mean WeBS core counts for the breeding season (April to June) were therefore calculated for the relevant subsectors/compartments. As WeBS core counts have only been available at a subsector level in recent years, and breeding bird species data were only available for a limited number of waterbird species, complete information could only be analysed for 2008 and 2009, and for four species (redshank, oystercatcher, shelduck and mallard).

Analysis was carried out with R version 2.12.1 (R Core Development Team 2010) in which generalized linear models with quasipoisson errors were fitted. Models were run separately for each species in order to avoid the issues of pseudoreplication and subsequent inflation of p-values that would have occurred due to paucity of data if all species had been analysed together. The response variable in each model was therefore taken as the breeding bird count for each species, and mean WeBS counts, the number of cattle present, the year and the area grazed were included as explanatory variables. Model selection proceeded by stepwise deletion of non-significant terms.

2.4 Comparison of low tide counts and WeBS core counts

WeBS core counts at the finest subsector level were plotted as dot density maps on GIS for the winter of 2008/09. Superimposed on this information, was a dot density map of birds counted at low tide in the winter of 2009/10 (data from Garbutt and others 2010). Low tide counts were carried out by four employees of the Centre for Ecology and Hydrology in Bangor, and the raw data were made available by Natural England.

3 Results

3.1 Sector plots

The trends of each species on each WeBS sector are given in Appendices A and B, together with plots comparing the count sector trends with the site trends for The Wash SSSI and, where applicable, The Wash NNR. This series of plots puts each sector into the context of trends on The Wash SSSI as a whole. Plots are grouped by sector and species presented in taxonomic order. This information is summarised below (Tables 3.1.i and 3.1.ii) and the underlying values representing percentage change to The Wash SSSI are available in the accompanying Excel™ Workbook (Analysis of WeBS sector data for The Wash.xls). Colour coding is used to represent declines or increases; species are listed in taxonomic order and sectors have been listed in geographical order. Caution is advisable in interpreting individual cells in these tables as, for example, a 50% decline (shown in red) could represent a decline from 10,000 to 5,000 birds or could be a decline from 20 to 10, and therefore the plots in the appendix should also be referred to. However, consistency between adjacent cells would suggest that either a group of species or a group of adjacent sectors have similar trends even when numbers of individuals involved are relatively low. Where this is the case, this may suggest that the trends represent real ecological changes.

This information is further summarised in map format, which better facilitates a geographic interpretation of the trends (Figures 3.1.i to 3.1.iv) (see also Appendices D – F).

The importance of individual sectors for given species can be determined by considering the five-year mean of peak counts (Tables 3.1.iii and 3.1.iv) and underlying values are available in the supporting material (Analysis of WeBS sector data for The Wash.xls), the importance of individual sectors to particular species clearly influencing one's level of concern regarding the characteristics of the trends.

Population trends have also been assessed for each species across The Wash SSSI as a whole over a 25yr period (or longest time period available), along with plots showing changes in the proportion of the east of England regional (EA Anglian Region) and Great Britain WeBS totals that are supported by The Wash SSSI, putting The Wash SSSI trends into a regional context (Appendix C).

Table 3.1.i Overview of population trends of wildfowl (and little grebe) within The Wash SSSI over the long- (1992/93 – 2007/08) the medium- (1997/98 – 2007/08) and the short- (2002/03 – 2007/08) terms. Cells are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Green – an increase in numbers of at least 33% but less than 100%; Dark Green – an increase in numbers of at least 100%. WeBS sectors of The Wash NNR are shown in bold.

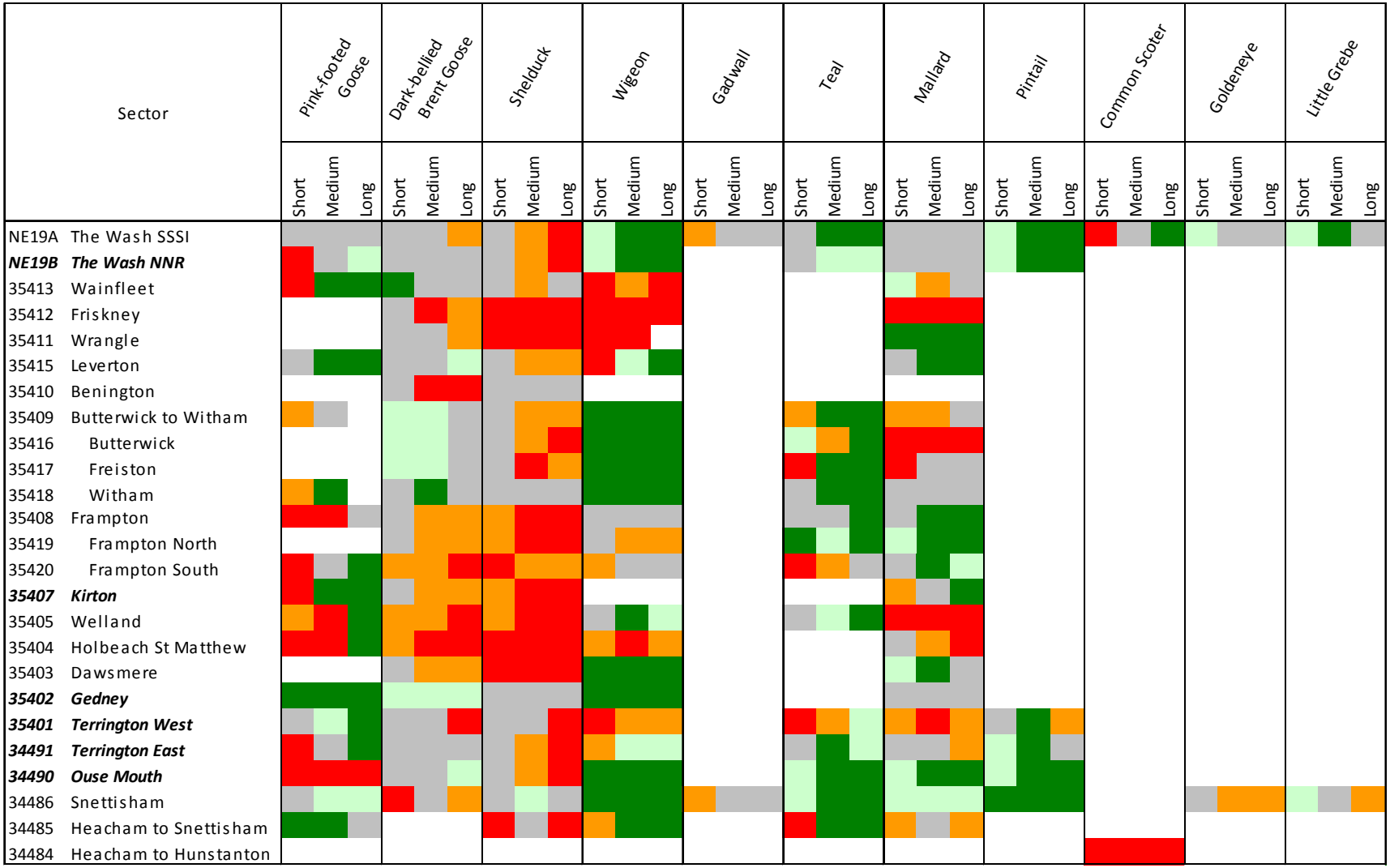


Table 3.1.ii Overview of population trends of waders within The Wash SSSI over the long- (1993/94 – 2007/08) the medium- (1997/98 – 2007/08) and the short- (2002/03 – 2007/08) terms. Cells are coloured to indicate trend status as follows: Red – a decline in numbers of at least 50%; Orange – a decline in numbers of at least 25% but less than 50%; Grey – a decline in numbers of less than 25% or an increase of less than 33%; Pale Green – an increase in numbers of at least 33% but less than 100%; Dark Green – an increase in numbers of at least 100%. WeBS sectors of The Wash NNR are shown in bold.

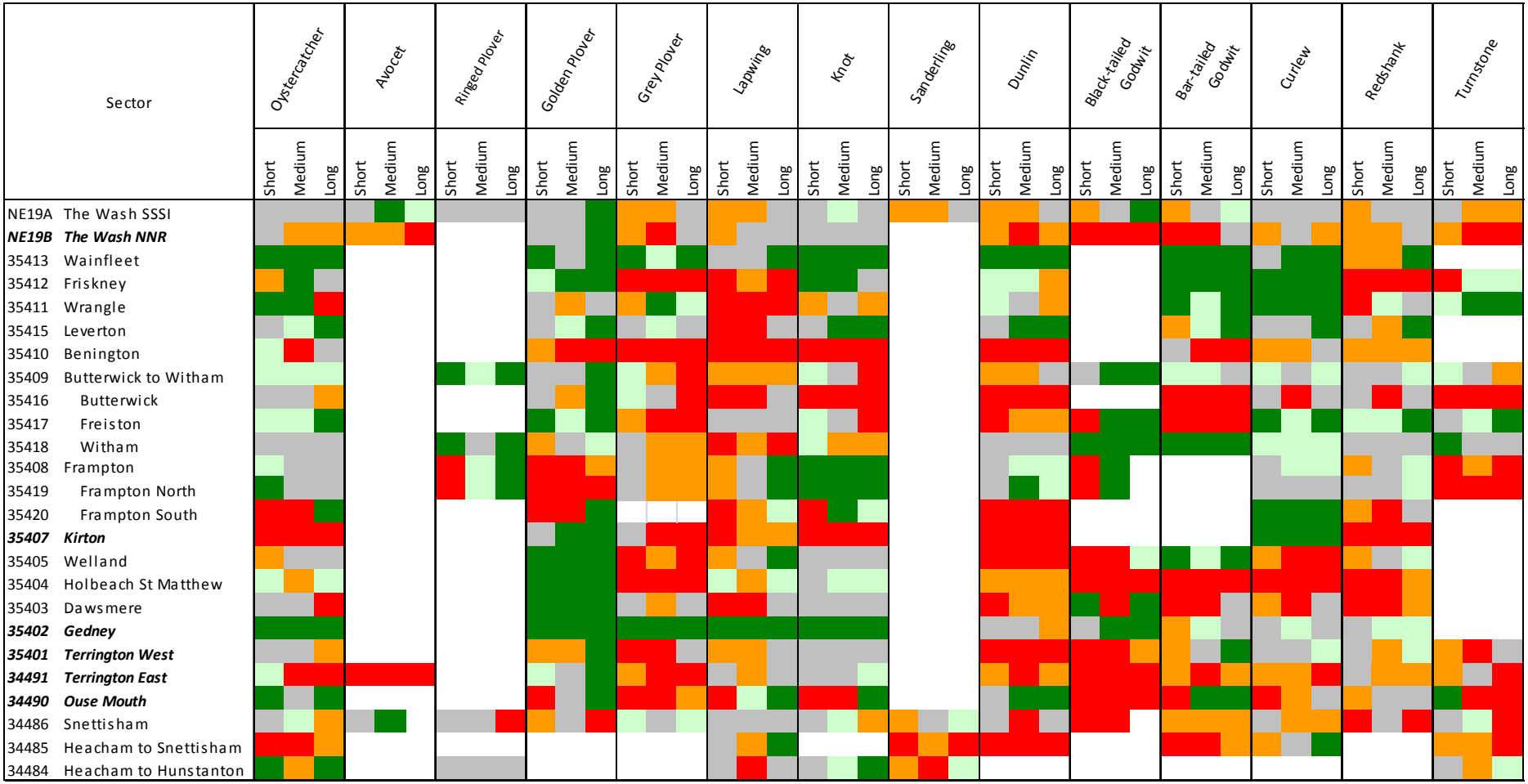


Table 3.1.iii The most important sectors for wildfowl (and little grebe) species in The Wash SSSI shown by colour: Dark Blue- sectors with a mean peak count over the last five winters (2004/05 – 2008/09) that is at least 20% of the total mean peak counts for The Wash SSSI over the same period; Light Blue – sites with a mean peak count over the last five winters that is between 10% and 20% of the total mean of peak count for The Wash SSSI over the same period; Dark Green – Sites with a peak count in the latest year (2008/09) that is at least 20% of the total peak count for The Wash SSSI in the latest year; Light Green – sites with a peak count in the latest year that is between 10% and 20% of the total peak count for The Wash SSSI in the latest year. WeBS sectors of The Wash NNR are shown in bold.

	Sector	Pink-footed Goose	Dark-bellied Brent Goose	Shelduck	Wigeon	Gadwall	Teal	Mallard	Pintail	Common Scoter	Goldeneye	Little Grebe
NE19A	The Wash SSSI											
NE19B	***The Wash NNR***											
35413	Wainfleet											
35412	Friskney											
35411	Wrangle											
35415	Leverton											
35410	Benington											
35409	Butterwick to Witham											
35416	Butterwick											
35417	Freiston											
35418	Witham											
35408	Frampton											
35419	Frampton North											
35420	Frampton South											
35407	***Kirton***											
35405	Welland											
35404	Holbeach St Matthew											
35403	Dawsmere											
35402	***Gedney***											
35401	***Terrington West***											
34491	***Terrington East***											
34490	***Ouse Mouth***											
34486	Snettisham											
34485	Heacham to Snettisham											
34484	Heacham to Hunstanton											

Table 3.1.iv The most important sectors for wader species in The Wash SSSI shown by colour: Dark Blue – sectors with a mean peak count over the last five winters (2004/05 – 2008/09) that is at least 20% of the total mean peak counts for The Wash SSSI over the same period; Light Blue – sites with a mean peak count over the last five winters that is between 10% and 20% of the total mean of peak count for The Wash SSSI over the same period; Dark Green – sites with a peak count in the latest year (2008/09) that is at least 20% of the total peak count for The Wash SSSI in the latest year; Light Green – sites with a peak count in the latest year that is between 10% and 20% of the total peak count for The Wash SSSI in the latest year. WeBS sectors of The Wash NNR are shown in bold.

Sector		Oystercatcher	Avocet	Ringed Plover	Golden Plover	Grey Plover	Lapwing	Knot	Sanderling	Dunlin	Black-tailed Godwit	Bar-tailed Godwit	Curlew	Redshank	Turnstone
NE19A	The Wash SSSI														
NE19B	***The Wash NNR***														
35413	Wainfleet														
35412	Friskney														
35411	Wrangle														
35415	Leverton														
35410	Benington														
35409	Butterwick to Witham														
35416	Butterwick														
35417	Freiston														
35418	Witham														
35408	Frampton														
35419	Frampton North														
35420	Frampton South														
35407	***Kirton***														
35405	Welland														
35404	Holbeach St Matthew														
35403	Dawsmere														
35402	***Gedney***														
35401	***Terrington West***														
34491	***Terrington East***														
34490	***Ouse Mouth***														
34486	Snettisham														
34485	Heacham to Snettisham														
34484	Heacham to Hunstanton														

Figure 3.1.i Distribution of wildfowl (and little grebe) across WeBS high tide count sectors over the 15 winters 1994/95 to 2008/09 divided into three 5yr periods. Dot density maps (1 dot = 20 birds) represent the five-year mean of peak counts for the periods 1994/95 – 1998/99, 1999/00 – 2003/04 and 2004/05 – 2008/09.

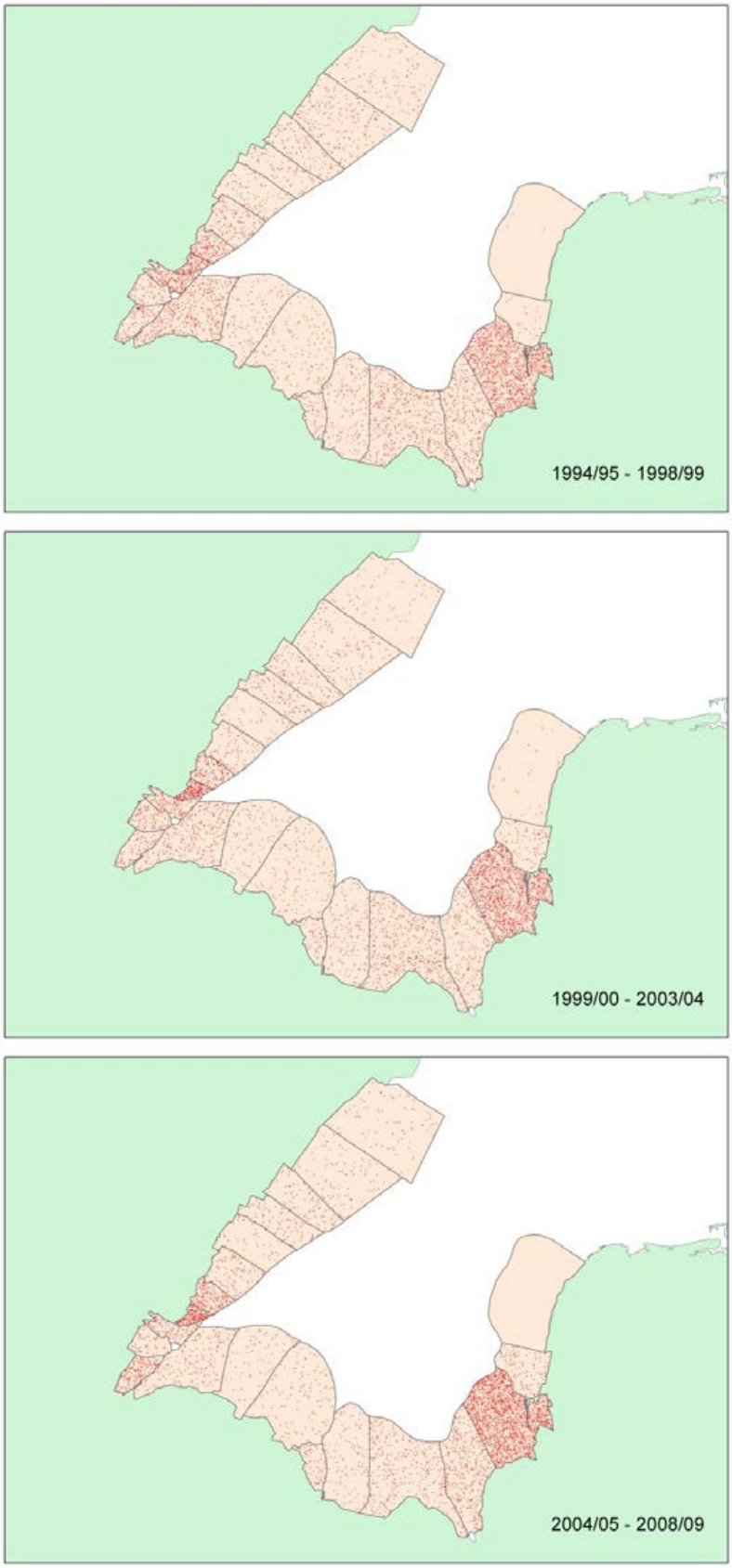


Figure 3.1.ii: Distribution of waders across WeBS high tide count sectors over the 15 winters 1994/95 to 2008/09 divided into three 5yr periods. Dot density maps (1 dot = 20 birds) represent the five-year mean of peak counts for the periods 1994/95 – 1998/99, 1999/00 – 2003/04 and 2004/05 – 2008/09.

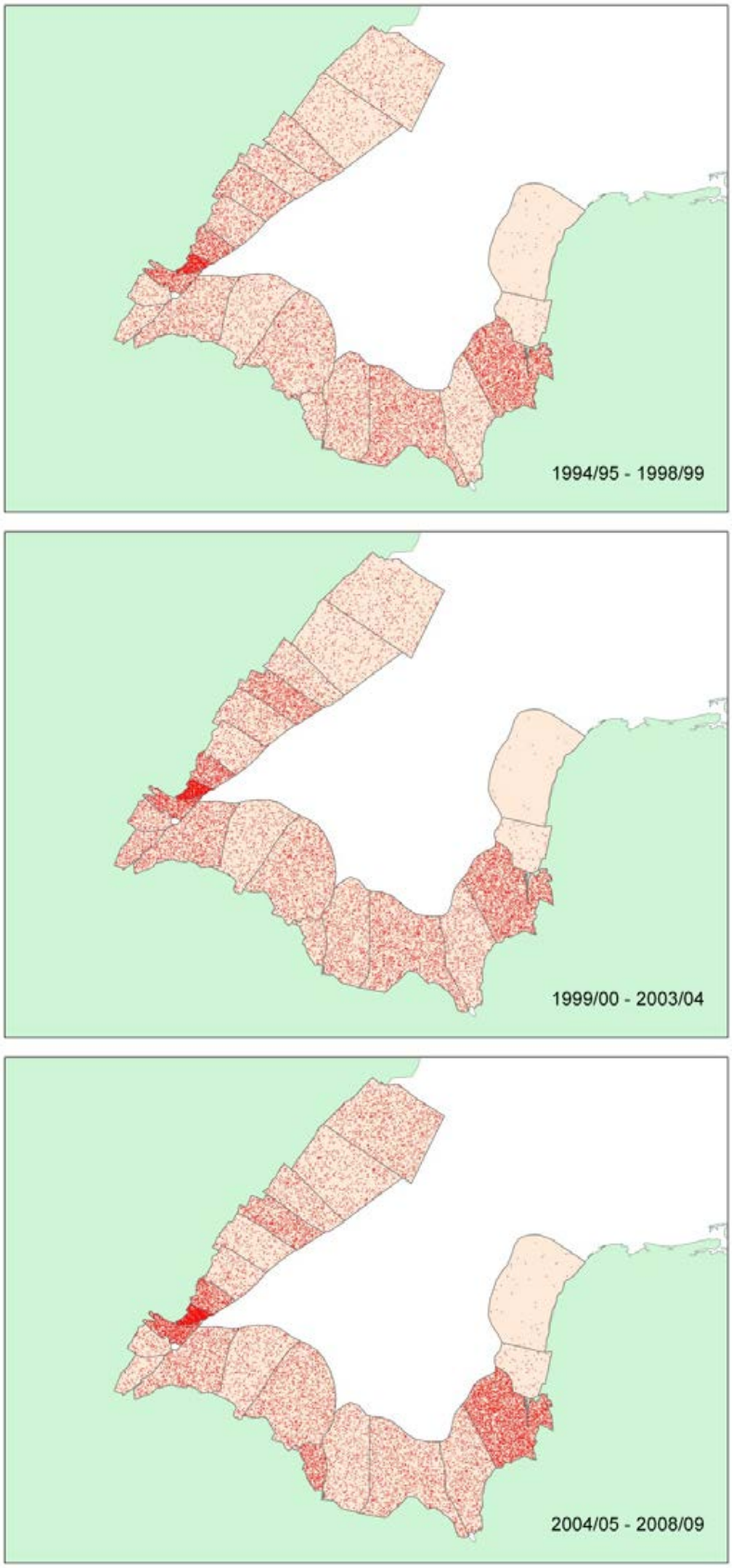


Figure 3.1.iii Population trends of waterbirds within The Wash SSSI over the long- (1992/93 – 2007/08) the medium- (1997/98 – 2007/08) and the short- (2002/03 – 2007/08) terms. The area of each pie chart relates to the number of species for which trends could be determined on the WeBS count sector in question and within each pie chart the proportions of those species that have undergone a high-decline (red), a medium-decline (orange), "no" change (grey), medium increase (pale green) and high increase (dark green).

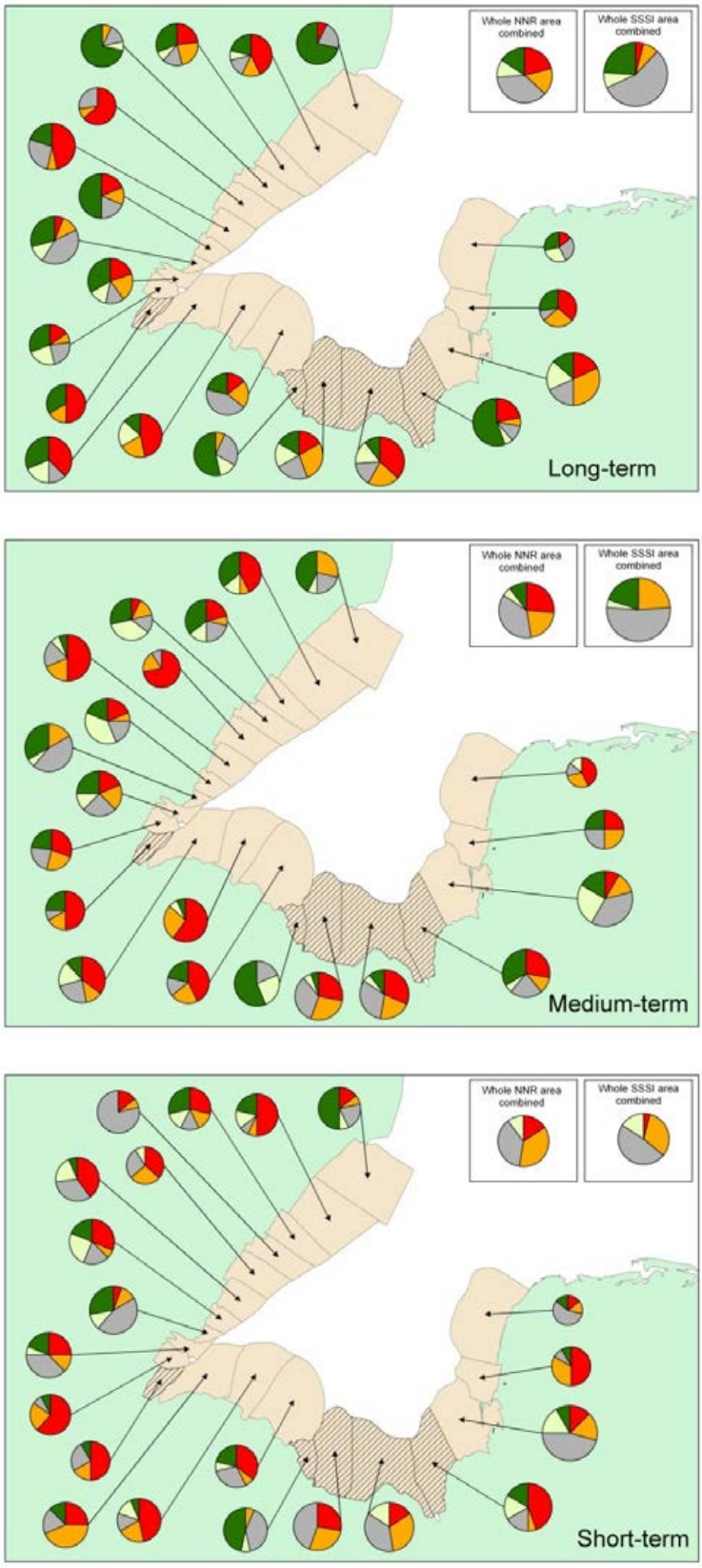
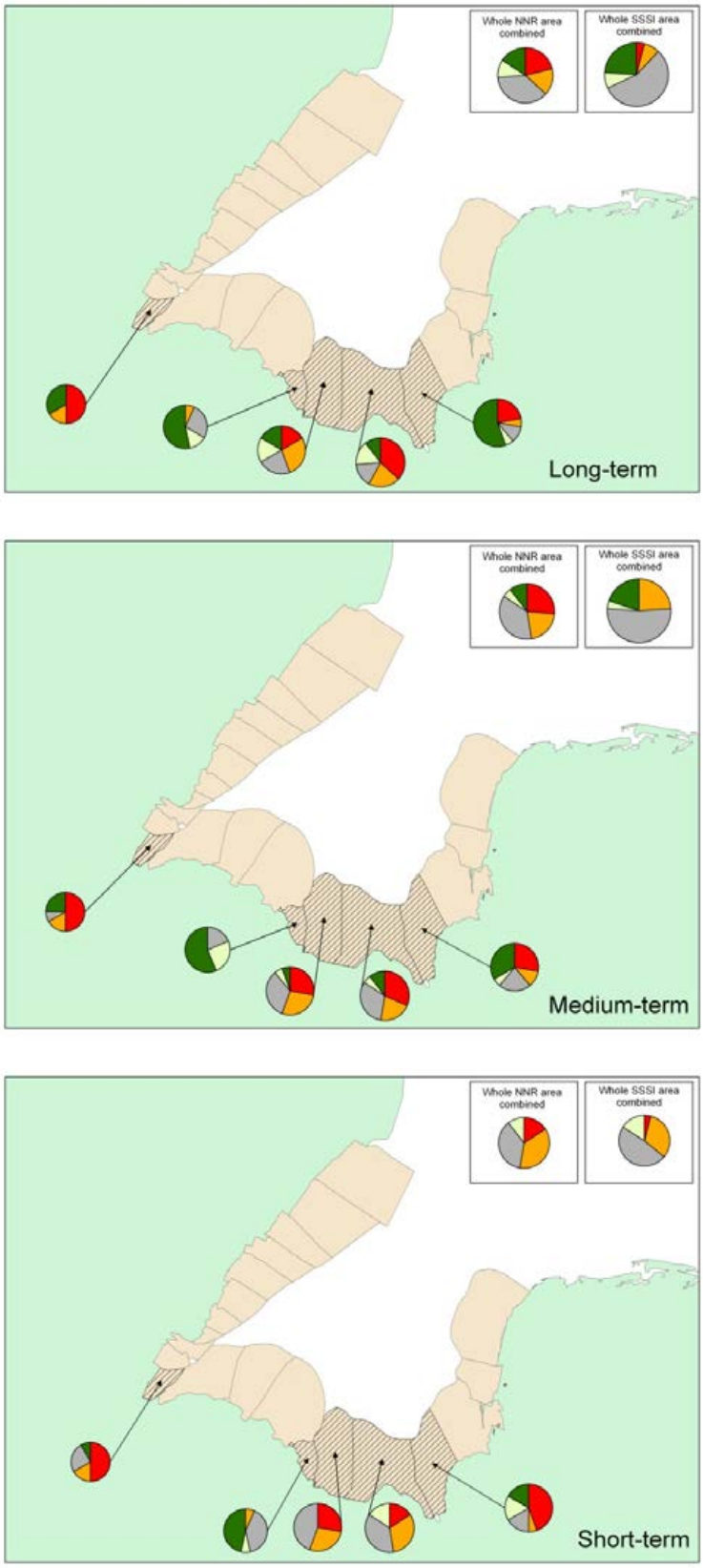


Figure 3.1.iv Population trends of waterbirds from Figure 3.1.iii presented for The Wash NNR alone.



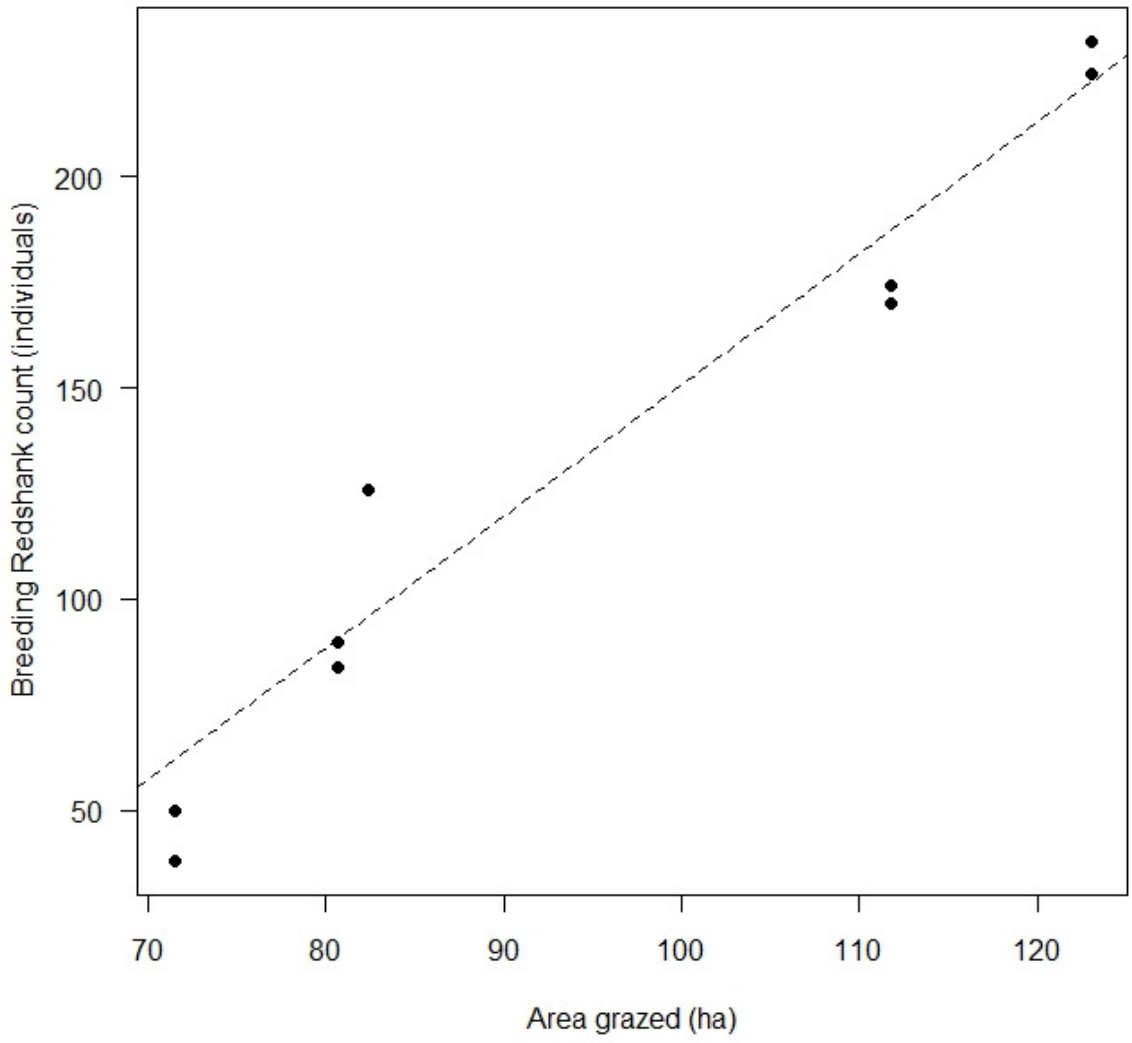
3.2 Effect of grazing and inflows on WeBS counts

None of the measured explanatory variables (water volume entering The Wash from the River Great Ouse, mean number of grazing cattle, median sward height, year) was found to have a significant effect on the number of birds counted by WeBS in Terrington East and Terrington West in the short-term (between 2003 and 2007).

3.3 Comparison of breeding bird data and WeBS core counts

None of the variables modelled (mean WeBS count, number of grazing cattle, area of land grazed, year) was found to have a significant effect on the number of breeding birds recorded at Frampton Marsh and Snettisham RSPB reserves for mallard, shelduck or oystercatcher. For redshank, however, there was a significant positive association (Figure 3.3.i) between the area of land grazed and the number of breeding birds observed ($t_1 = 6.64$, $p = 0.0002$).

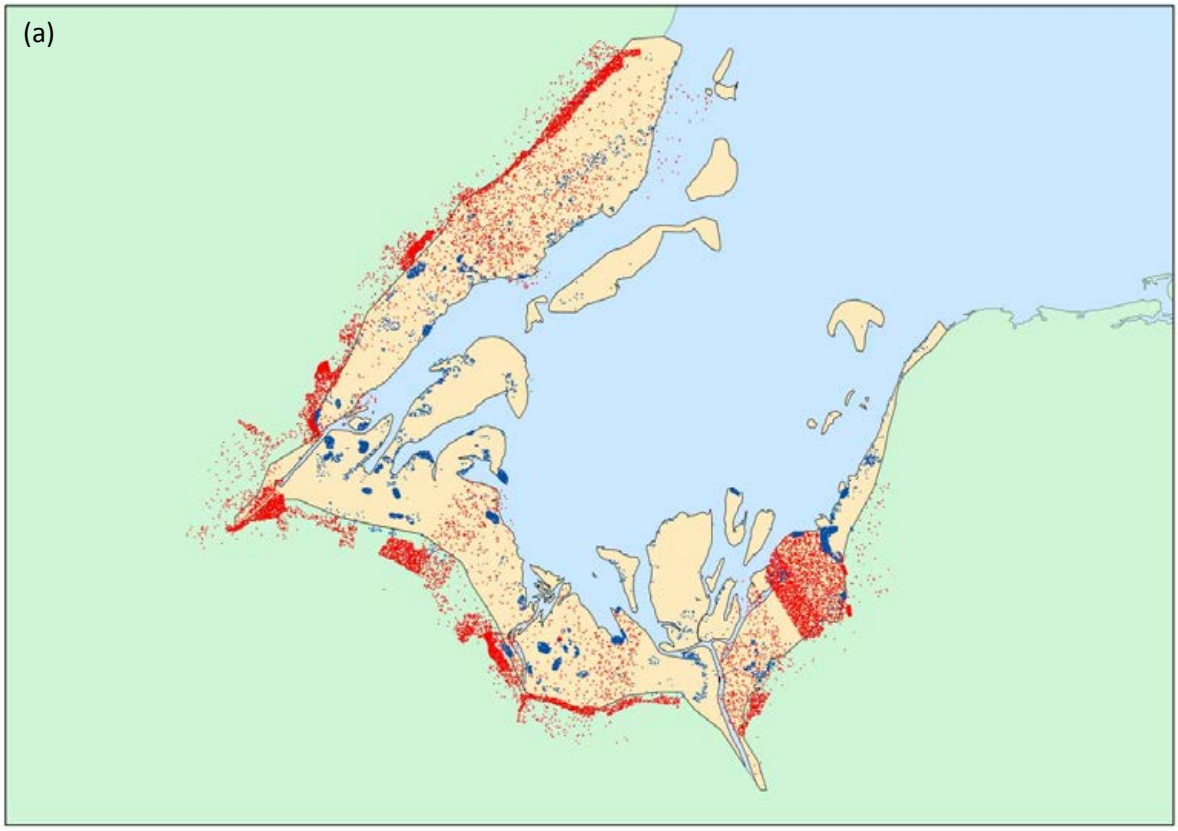
Figure 3.3.i A significant positive relationship was found between the number of breeding redshank and the area of land grazed by cattle for Frampton Marsh and Snettisham RSPB reserves within The Wash SSSI.

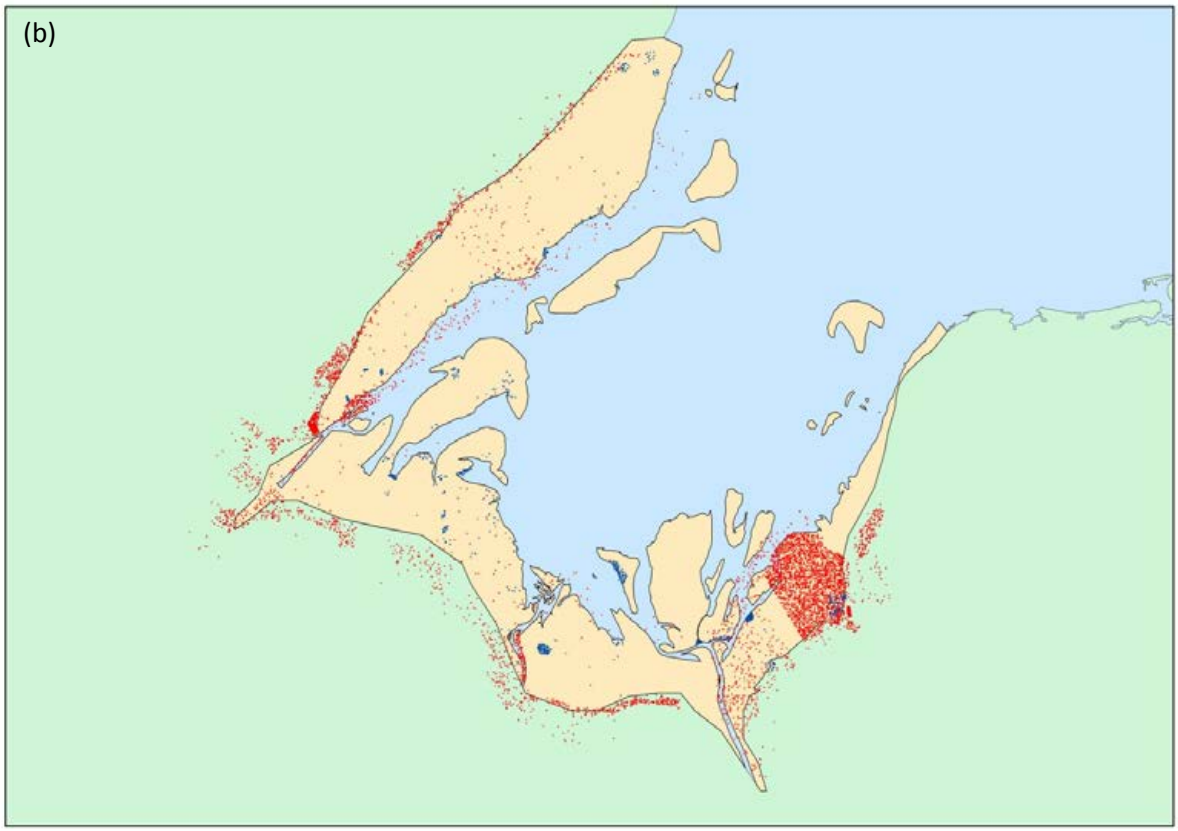


3.4 Comparison of low tide counts and WeBS core counts

Results are shown in Figure 3.4.i.

Figure 3.4.i Distribution of (a) waders (b) wildfowl and little grebe at high tide (red) and low tide (blue) for winters 2008/09 (high tide) and 2009/10 (low tide). 1 dot = 20 birds. Intertidal habitat shown in orange.





4 Discussion and conclusions

4.1 Species trends

4.1.1 Pink-footed goose *Anser brachyrhynchus*

While pink-footed goose numbers have remained relatively stable across The Wash SSSI, numbers in The Wash NNR have shown a greater degree of fluctuation. The long-term trend for The Wash NNR shows a moderate increase in numbers, but this is offset by a sharp decline in the short-term. It is worth noting, however, that this decline followed a spike in numbers in the mid-2000s, and that the absolute numbers of pink-footed goose on The Wash NNR are neither large, nor represent a marked proportion of those in The Wash SSSI as a whole. The WeBS sector accounting for the largest proportion of pink-footed goose in The Wash SSSI is Snettisham (34486), which has held between 70% and 90% of the overwintering population of this species throughout the 15 year period concerned. There was a moderate increase in pink-footed goose numbers for Snettisham over the long- and medium-terms. Some of the population fluctuations observed in various sectors between 1992/93 and 2007/08 might represent shifts in species distribution. For example, there was a fall in pink-footed goose numbers around the inflow of the River Great Ouse, with substantial decreases observed over the short-, medium- and long-term for Ouse Mouth (34490), and in the short-term for Terrington East (34491). These declines may reflect a westward shift in the within site distribution of The Wash SSSI, since numbers of pink-footed goose were seen to increase at Terrington West (35401) in the medium- (moderate increase) and long-terms (sharp increase), and at Gedney (35402) (sharp rise in numbers over all timescales). At the international scale, numbers of pink-footed goose in North-west Europe were increasing (Wetlands International 2006).

4.1.2 Brent goose (dark-bellied) *Branta bernicla bernicla*

Overwintering numbers of dark-bellied brent goose have fallen gradually on The Wash SSSI, with a moderate decline recorded for the long-term. On The Wash NNR, however, which held a substantial proportion of this species on The Wash SSSI during all years, numbers were more stable. Declines were recorded in 10 of the 16 WeBS sectors making up The Wash SSSI for which there was sufficient data to generate trends. These declines were most substantial around the inflow of the River Welland, where they occurred over the long- and medium-terms for Dawsmere (35403), Kirton (35407), and Frampton (35408), and over all timeframes for Welland (35405) and Holbeach St Matthew (35404). There were, however, moderate increases in dark-bellied brent goose numbers in the short- and medium- terms at Butterwick to Witham (35409), which held a substantial proportion of the population of this species relative to The Wash SSSI as a whole, while on Gedney (35402) there were moderate increases over all timeframes. Relative to both the EA Anglian Region and Great Britain as a whole, The Wash SSSI has accounted for an approximately stable proportion of the population of overwintering dark-bellied brent goose, suggesting that declines in The Wash SSSI reflect the regional and national trends. Consistent with this, at the international level, the latest estimates for of dark-bellied brent goose in North-west Europe indicate a decline in numbers (Wetlands International 2006).

4.1.3 Shelduck *Tadorna tadorna*

Overwintering shelduck numbers on both The Wash SSSI and The Wash NNR declined steadily between the early-1990s and the early-2000s but have levelled off in recent winters. Consequently there has been a substantial decline in shelduck numbers over the long-term, and a moderate one over the medium-term. Declines between 1992/93 and 2007/08 were only absent in three sectors, Benington (35410), Gedney (35402) and Snettisham (34486), and of these, an increase was only seen in Snettisham (which held a substantial proportion of The Wash SSSI's shelduck population in recent years), with a moderate upturn in numbers in the medium-term. There were declines over all timescales in several sectors, including Dawsmere (35403), Holbeach St Matthew (35404), Frampton (35408), Kirton (35407) and Welland (35405), which are all located in the south-western area of The Wash SSSI. This is especially notable, as two of these sectors, Dawsmere and Welland, supported a large proportion of shelduck overwintering in The Wash SSSI. Shelduck numbers also declined substantially over all time periods in Wrangle (35411) and Friskney (35412), while similar trends were recorded in neighbouring sectors on the western, Lincolnshire, edge of The Wash. Other sectors reflected the overall trends for The Wash NNR and SSSI, with a stalling in the decline in shelduck numbers in recent years. These included Ouse Mouth (34490) and Terrington East (35401) straddling the River Great Ouse, which both accounted for a substantial proportion of shelduck overwintering on The Wash NNR and SSSI as a whole. Compared to the wider EA Anglian Region, and to Great Britain as a whole, the proportion of shelduck overwintering on The Wash SSSI has declined steadily, indicating that the site has become less important for this species, and that individuals might have moved to other areas. At the international scale, populations in North-west Europe were stable (Wetlands International 2006).

4.1.4 Wigeon *Anas penelope*

Although overwintering wigeon numbers have fluctuated, the overall trend has been for population growth on both The Wash SSSI and The Wash NNR, although in the short-term, this increase has been less marked. Wigeon populations have increased in several WeBS sectors, including Snettisham (34486), Ouse Mouth (34490), and Butterwick to Witham (35409), where there were substantial increases in numbers over every timescale. These sectors also supported a substantial proportion of wigeon overwintering on The Wash SSSI as a whole. There were also substantial increases in wigeon numbers in Gedney (35402) and Dawsmere (24303) over all time periods. Some of these increases may reflect a shift in distribution within The Wash SSSI. For example, Snettisham and Ouse Mouth have both increased in importance as a site for wigeon relative to The Wash SSSI as a whole in recent years, which has corresponded to a decrease in both relative importance and an absolute moderate fall in numbers in the short-term at the neighbouring sites of Heacham to Snettisham (34484) and Terrington East (34491). There were declines in wigeon numbers towards the north of the Lincolnshire side of The Wash, which were substantial over almost all timescales at Wainfleet (35413) and Friskney (35412), while there were short- and medium-term substantial declines at Wrangle (35411) and a short-term substantial decline at Leverton (35415), following a successively diminishing increase in numbers in the two time previous time periods. Some of the wigeon from these sites may have relocated in a southerly direction, as the relative importance of Butterwick to Witham as a site for wigeon on The Wash SSSI has increased while that of Wainfleet has diminished. The proportional of wigeon overwintering on The Wash SSSI relative to that found in the EA Anglian Region, and Great Britain as a whole, has remained relatively stable, in line with trends on the international scale, showing stability in North-west Europe (Wetlands International 2006).

4.1.5 Gadwall *Anas strepera*

Trends describing overwintering gadwall numbers in The Wash SSSI were only available for a single WeBS sector, Snettisham (34486), where there was a moderate decline in numbers in the short-term. This was also registered as the overall trend for The Wash SSSI. Peak counts were generated for other sectors, but the numbers involved were low, so any interpretation must proceed with care. Compared to the wider EA Anglian Region, and to Great Britain as a whole, the proportion of gadwall overwintering on The Wash SSSI has remained reasonably stable, while at the international level, numbers of gadwall in North-west Europe were increasing (Wetlands International 2006).

4.1.6 Teal *Anas crecca*

Numbers of teal overwintering on The Wash SSSI increased substantially and steadily between the early-1990s and the mid-2000s, since which time this species has gradually declined. The same trend is apparent for The Wash NNR, although the increase in the medium- and long-terms was less marked. Increases were recorded for all timescales in Snettisham (34486), a sector accounting for a substantial proportion of overwintering teal on The Wash SSSI, and Ouse Mouth (34490), although in both cases the increase fell from substantial to moderate in the short-term. There were increases in the long- and medium-terms at Terrington East (34491) and Welland (35405), before numbers stabilised in the short-term. In some sectors, changes in teal numbers might be a result of redistribution within the site. At Frampton (35408), for example, there was a sharp increase in numbers in the long-term, but a levelling off in the medium- and short-terms. However, at a higher resolution spatial scale, there was a moderate medium-term decline in teal numbers in Frampton South (35420), followed by a marked short-term decline. These declines coincided with moderate medium- and substantial short-term rises in teal numbers at Frampton North (24319). There is also some indication that the cessation of the overall increase in teal numbers on The Wash SSSI and The Wash NNR is because of recent local declines in particular sectors. At Heacham to Snettisham (34485), for example, there was a substantial increase in the medium- and long-terms, which was replaced by a substantial decline in the short-term. A similar pattern was seen at Terrington West (35401), where a moderate increase in the long-term was followed by a moderate decline in the medium-term and a substantial decline in the short-term, while at Butterwick to Witham (35409), the same long- and medium-term trends were seen, but the decline in the short-term was only moderate. At the subsector level, however, there was a substantial decline in teal Numbers at Freiston (35417) in the short-term, which is noteworthy because this site accounted for a substantial proportion of teal on The Wash SSSI in recent winters. All trends for teal on The Wash SSSI and The Wash NNR must be considered in light of the size of teal populations in this region, with have been relatively small, with a winter peak of 2099 individuals in The Wash SSSI in 2008/09. Therefore, caution should be exercised in interpreting reported trends. The proportion of teal held by The Wash SSSI relative to that found in the EA Anglian Region, and to Great Britain as a whole, has remained reasonably stable, however, suggesting that any increases seen on The Wash SSSI are in line with those occurring nationwide. Consistent with this, numbers of teal in North-west Europe have been increasing (Wetlands International 2006).

4.1.7 Mallard *Anas platyrhynchos*

Although there have been small fluctuations in overwintering mallard numbers on The Wash SSSI and The Wash NNR since the early-1990s, overall numbers at both sites have remained reasonably stable. At the WeBS sector level, however, there have been more substantial changes, which are likely to represent redistribution of individuals between

sectors. For example, there were increases in mallard numbers over all timeframes in Snettisham (34486) and Ouse Mouth (34490), which also gained in importance as sites for mallard relative to The Wash SSSI and The Wash NNR as a whole. However, there were declines and a concurrent loss in relative importance at the adjacent sectors of Heacham to Snettisham (34485), Terrington East (34491) and Terrington West (35401). A similar process might have occurred at Wrangle (35411), where there were substantial increases in mallard over all timeframes, while there were corresponding declines in neighbouring Friskney (35412). It is also possible that Frampton (35408), where increases in mallard numbers have been observed over all time periods in Frampton South (35420), and in the medium- and long-term in Frampton North (35419), is now preferred by mallard that were previously found on Butterwick to Witham (35409). In this sector, there were declines, especially in the subsector of Butterwick (35416), where a substantial decline occurred over all timeframes. Mallard numbers have also declined substantially over all time periods at Welland (35405) and in the medium- (moderate) and long-terms (substantial) at Holbeach St Matthew (35404), but these changes may have been offset by increases in the short- (moderate) and medium-terms (substantial) at Dawsmere (35403). It is worth noting that mallard numbers in The Wash SSSI are relatively low, with a five-winter mean of peak of approximately 2410 individuals between 2004/05 and 2008/09, and as such, all trends should be interpreted with caution. The proportion of overwintering mallard supported by The Wash SSSI relative to the wider EA Anglian Region, and to Great Britain, has remained quite stable. There has been some uncertainty about the direction of population trends at the international scale, with numbers in North-west Europe either stable or tending to decrease (Wetlands International 2006).

4.1.8 Pintail *Anas acuta*

Trends describing overwintering pintail numbers on The Wash SSSI could only be obtained for four WeBS sectors, three of which fall in The Wash NNR. Where pintail have been recorded, numbers are low, with a winter peak of 560 individuals in the 2008/09. Hence, results must be interpreted with care. However, overall, both there were increases in pintail numbers in both The Wash SSSI and The Wash NNR. These increases were substantial in the medium- and long-terms, and moderate in the short-term. The vast majority of pintail recorded were found around the south-east corner of The Wash. The trends for Snettisham (34486), Ouse Mouth (34490) and Terrington East (34491) were similar to those reported for The Wash SSSI and The Wash NNR as a whole, while pintail numbers at Terrington West (35401) fluctuated to a greater degree. Consistent with the trend towards increasing numbers on the site, comparison with the wider EA Anglia Region and Great Britain shows an increase in the relative importance of The Wash SSSI since the late-1990s. At the international scale, numbers of pintail in North-west Europe were stable (Wetlands International 2006).

4.1.9 Common scoter *Melanitta nigra*

Common scoter trends have only been produced for a single WeBS sector in The Wash SSSI, Heacham to Hunstanton (34484), which saw a substantial decline in numbers over the short-, medium- and long-terms. Overall, a substantial increase in common scoter numbers in the long-term was recorded in The Wash SSSI, followed by a substantial decline in the short-term. However, as overwintering numbers of this species were consistently small (with a winter peak count of only 150 individuals for The Wash SSSI in 2008/09), all trends must be interpreted with care. Comparison with the EA Anglian Region and Great Britain shows that The Wash SSSI accounted for a very small proportion of common scoter found in these areas. At the international scale, numbers in North-west Europe were stable (Wetlands International 2006).

4.1.10 Goldeneye *Bucephala clangula*

Trends for numbers of goldeneye overwintering on The Wash SSSI are only available for a single sector, that of Snettisham (34486). Here, moderate declines were recorded in the medium- and long-terms, which levelled off in the short-term. Overall The Wash SSSI saw a moderate increase in goldeneye in the short-term. However, the number of individual goldeneye observed was low, with a winter peak count of only 136 for The Wash SSSI in 2008/09, and consequently caution must be exercised in interpreting trends. The proportion of goldeneye supported by The Wash SSSI has remained low and stable relative to that in the EA Anglian Region and Great Britain since the early-1990s. At the international scale, numbers in North-west Europe were also stable (Wetlands International 2006).

4.1.11 Little grebe *Tachybaptus ruficollis*

Trends describing the number of little grebe overwintering on The Wash SSSI were only produced for a single WeBS sector, that of Snettisham (34486). In this sector, little grebe was found to moderately decline in the long-term, but to increase moderately in the short-term. In The Wash SSSI as a whole, little grebe increased substantially in the medium-term, and moderately in the short-term. It should be noted, however, that the number of little grebe concerned was consistently low, with a winter peak of only 56 birds counted for The Wash SSSI in 2008/09. As such, all population trends should be interpreted with care. Relative to the EA Anglian Region and Great Britain, The Wash SSSI supported a small and stable proportion of overwintering little grebe. At the international scale, little grebe numbers in North-west Europe were also stable (Wetlands International 2006).

4.1.12 Oystercatcher *Haematopus ostralegus*

Overall on The Wash SSSI, overwintering oystercatcher counts remained relatively stable, although in absolute terms there was a decline of approximately 6000 individuals between the early-1990s and the late-2000s. This gradual decline was also seen on The Wash NNR, and was sufficient to be classed as moderate for the long- and medium-terms. There was also a decline in the importance of The Wash NNR in terms of the proportion oystercatcher it supported relative to The Wash SSSI, although The Wash NNR still accounted for between 10% and 20% this species in recent winters. Oystercatcher numbers fluctuated substantially between WeBS sectors. For example, there were declines over all time periods at Kirton (35407) and Heacham to Snettisham (34485), while substantial increases were reported for Gedney (35402) and Wainfleet (35413) during the same timeframe. Within sectors, there have also been changes in oystercatcher numbers. For instance, there was a substantial decline in oystercatcher numbers at Wangle (35411) in the long-term, but a substantial increase in the medium- and short-terms, while at the subsector scale, the opposite pattern was seen at Frampton South (35420). These variations at different spatial scales make it difficult to assess the reasons underpinning trends in oystercatcher numbers in The Wash SSSI and The Wash NNR. At the wider regional scale, compared to EA Anglian Region and to Great Britain, there were fluctuations in the relative proportion of oystercatcher supported by The Wash SSSI. This site declined in relative importance in the early-1990s, indicating a movement of oystercatcher away from The Wash SSSI. There has, however, been a gradual increase in its relative importance of since this time. On the international level, numbers of oystercatcher in North-west Europe have fallen (Wetlands International 2006).

4.1.13 Avocet *Recurvirostra avosetta*

Overwintering avocet numbers on The Wash SSSI were very low throughout the time period concerned, with a winter peak count of 502 individuals 2008/09. As such, trends in avocet numbers are difficult to interpret. However, the overall trend showed a moderate increase in avocet numbers in the long-term and a substantial increase in the medium-term. This was reflected in a substantial medium-term increase at Snettisham (34486), which is an important sector for avocet, accounting for more than 20% of their numbers on The Wash SSSI in recent winters. Avocet numbers have fared less well in The Wash NNR, where a marked decrease was recorded in the long-term, and more moderate declines in the medium- and short-terms. At Terrington East (34491), which also held more than 20% of avocet on The Wash SSSI in recent years, numbers declined substantially over all timescales. Relative to the EA Anglian Region and to Great Britain, The Wash SSSI accounted for a small but stable proportion of overwintering avocet. At the international scale, numbers of avocet overwintering in North-west Europe have been increasing (Wetlands International 2006).

4.1.14 Golden plover *Pluvialis apricaria*

Numbers of Golden plover increased markedly in the long-term on both The Wash SSSI and The Wash NNR (which accounted for more than 20% of this species on The Wash SSSI in recent winters), but recent fluctuations have seen this population growth level off. Golden plover increased substantially over all timescales along the south-west shore of The Wash SSSI, with this trend observed at Gedney (35402), Dawsmere (35403), Holbeach St Matthew (35404) and Welland (35405). Indeed, Gedney, Dawsmere and Welland, have increased in importance as sites for golden plover relative to The Wash SSSI as a whole, with Welland holding between 10% and 20% of the population of this species in recent winters. Numbers of golden plover have also increased in the northern Lincolnshire part of The Wash SSSI, with substantial increases in the long- and medium-terms and a moderate increase in the short-term at Friskney (35412), while increases were also recorded at Wainfleet (35413) and Leverton (35415). Golden plover have declined at Frampton (35408), especially Frampton North (35419), which saw substantial declines over all time periods, and at Benington (35410), although there was a substantial increase in the long-term at the site holding the largest proportion of this species in recent years, Butterwick to Witham (35409). There is some indication that the long-term growth in golden plover numbers on The Wash SSSI corresponded to an increase in its importance relative to the EA Anglian Region and to Great Britain as a whole. At the international scale, however, numbers of golden plover in North-west Europe have been declining (Wetlands International 2006).

4.1.15 Grey plover *Pluvialis squatarola*

The numbers of grey plover overwintering on The Wash SSSI have declined moderately in the medium- and short-terms. A similar trend has been observed on The Wash NNR, which has accounted for more than 20% of grey plover on The Wash SSSI in recent winters, although the decline in the medium-term was substantial. This drop in numbers is reflected in several WeBS sectors, especially those around the inflow of the River Great Ouse, where moderate and substantial declines were seen over all timescales at Ouse Mouth (34490) and Terrington East (34491), while substantial declines also occurred in the short- and medium-terms at Terrington West (35401). There were also decreases in grey plover numbers around the River Welland inflow, with declines seen over all time periods in Holbeach St Matthew (35404) and Welland (35405). There were declines at Kirton (35407) and Frampton (35408) in the medium- and long-terms that levelled off in the short-term, while there were substantial declines over all timescales at Benington (35410) and Friskney

(35412). Some of the declines in the southern sectors of The Wash might reflect a redistribution of grey plover towards Gedney (35402), where there was a marked increase in golden plover during each time period. Gedney also increased in importance as a site for this species relative to both The Wash NNR and The Wash SSSI. Similarly, there might have been a shift of grey plover from Friskney to neighbouring Wainfleet (35413), where there was an increase (substantial in the short- and long-terms) over all time periods. The Wash SSSI has declined in importance as a site for grey plover relative to the EA Anglian Region and to Great Britain, indicating an emigration of this species. At the international scale, numbers of grey plover in North-west Europe have decreased (Wetlands International 2006).

4.1.16 Ringed plover *Charadrius hiaticula*

Numbers of ringed plover overwintering on The Wash SSSI have remained fairly stable over the period in question, although locally there has been more variation. Trends could only be obtained for three WeBS sectors in The Wash SSSI. Of these, increases were recorded on Butterwick to Witham (35409), and Frampton (35408), both of which accounted for more than 20% of ringed plover found on The Wash SSSI in recent winters. However, in case of Frampton, increases in the medium- and long-terms were replaced by a substantial decline in the short-term. No trend was generated for The Wash NNR, as counts for this species were consistently low in every sector. Indeed, with five-winter means of peak values of fewer than 300 individuals on The Wash SSSI over the entire period concerned, care must be exercised when evaluated those trends that have been produced. Relative to the EA Anglian Region and to Great Britain, The Wash SSSI held a small but stable proportion of overwintering ringed plover. Internationally, declines in this species were reported for North-west Europe (Wetlands International 2006).

4.1.17 Lapwing *Vanellus vanellus*

Numbers of overwintering lapwing have declined moderately in the medium- and short-terms on The Wash SSSI, and in the short-term on The Wash NNR. At the sector level there was quite a large degree of fluctuation, making trends difficult to interpret. However, lapwing numbers suffered sustained decreases in the northern Lincolnshire region of The Wash SSSI, with declines over all timeframes for Kirton (35407), Butterwick to Witham (35409), Benington (35410), Wrangle (35411) and Friskney (35412). In many of these cases, the decline was substantial. There were also substantial declines in the short- and medium-terms at Leverton (35415), while there was a moderate decline in the short-term at Frampton (35408). Lapwing numbers only increased consistently at Gedney (35402), where there were substantial increases over all timeframes, although the numbers recorded here were small. Gedney did, however, increase in importance as a site for lapwing relative to both The Wash SSSI and The Wash NNR in recent years, suggesting that this trend might reflect a movement of individuals to Gedney from other areas. Indeed, there were decreases in lapwing numbers in the medium- and short-terms in the neighbouring sectors of Terrington West (35401) and Dawsmere (35403), such that birds from these sites might have moved to Gedney. Relative to the EA Anglian Region and Great Britain, The Wash SSSI has decreased in importance as an area for overwintering lapwing, indicating movement of individuals away from The Wash. At the international scale, numbers of lapwing in North-west Europe have decreased (Wetlands International 2006).

4.1.18 Knot *Calidris canutus*

Although the number of knot overwintering on The Wash SSSI has fluctuated in recent years, overall there was a moderate increase recorded in the medium-term. Numbers on

The Wash NNR (which consistently accounted for a substantial proportion of this species on The Wash SSSI) have remained more stable over the same period, with no notable increases or decreases. Knot numbers rose on certain WeBS sectors, including Gedney (35402), where a substantial increase was observed over all timescales, coinciding with an increase in the importance of this sector relative to The Wash NNR and The Wash SSSI as a whole. A similar trend was recorded in Frampton (35408), as well as towards the northern Lincolnshire corner of The Wash SSSI, where substantial increases in numbers and relative sector importance were seen for the majority of time periods at Wainfleet (24313), Friskney (35412) and Leverton (35415). The overall stability in the overwintering knot numbers on The Wash SSSI and The Wash NNR suggests that such sector-level increases were offset by concurrent decreases in other sectors, and indeed, between Frampton and Leverton, declines, many of which were substantial, were recorded in Butterwick to Witham (35409) and Benington (35410). To the south of Frampton, there were also substantial declines in knot over all timeframes in Kirton (35407), where almost no members of this species have been observed since the mid-2000s. The Wash SSSI has decreased in importance as a site for overwintering knot relative to the EA Anglian Region since the early-1990s, but the proportion of knot relative to that found in Great Britain has remained more constant. On an international scale, the number of knot in North-west Europe has declined (Wetlands International 2006).

4.1.19 Sanderling *Calidris alba*

Trends for numbers of overwintering sanderling were only available for three WeBS sectors of The Wash SSSI; Snettisham (34486), Heacham to Snettisham (34485) and Heacham to Hunstanton (34484). Of these, all experienced declines in sanderling numbers in the short-term. Snettisham and Heacham to Hunstanton both accounted for a higher proportion of sanderling on The Wash SSSI than did Heacham to Snettisham, and there were some signs that these more important sectors were better suited to this species, as both saw moderate increases in the long-term, and their short-term declines were less marked that those at Heacham to Snettisham. Overall, numbers of overwintering sanderling on The Wash SSSI were subject to moderate declines in the medium- and short-terms. It should be noted, however, that sanderling numbers were consistently low on The Wash SSSI, with five-winter means of peaks of fewer than 450 individuals over the entire time period concerned, and therefore all trends should be interpreted with caution. Relative to the EA Anglian Region, and to Great Britain, there was some indication that The Wash SSSI had declined in importance as an overwintering site for sanderling. At the international level, there was uncertainty about trends in sanderling numbers in North-west Europe, but they were likely to be stable or increasing (Wetlands International 2006).

4.1.20 Dunlin *Calidris alpine*

Declines in overwintering dunlin numbers were apparent for 12 of the 16 WeBS sectors making up The Wash SSSI for which trends were available. This translated into moderate overall declines in dunlin on The Wash SSSI in the medium- and short-terms, and declines over all timeframes, including a substantial decline in the medium-term, for The Wash NNR (which held a substantial proportion of the dunlin found on The Wash SSSI). There were sustained increases in dunlin numbers in only one part of The Wash SSSI, which was the northern shore on the Lincolnshire side. Here, substantial increases were observed in every time period at Wainfleet (35413), which also increased in importance as a site relative to The Wash SSSI. A similar pattern was recorded at Leverton (35415), although no increases or decreases were apparent for the short-term, while dunlin numbers at Friskney (35412) and Wrangle (35411) increased moderately in the short-term. However, none of these sectors supported a substantial proportion of dunlin relative to the population in The Wash SSSI as a

whole. Increases in dunlin numbers in the short-term were not recorded in any other sectors. Indeed, most other sectors experienced moderate to substantial declines in almost every time period. These were particularly marked towards the south of The Wash, in the region between Terrington East (34491) and Kirton (35407), some sectors of which (Terrington East, Gedney, Dawsmere) accounted for a marked proportion of dunlin overwintering on The Wash SSSI in recent years. Relative to the EA Anglian Region and to Great Britain, The Wash SSSI has held a reasonably stable proportion of overwintering dunlin, indicating that the declines in dunlin seen on The Wash SSSI were mirrored at the regional and national levels. At the international scale, however, numbers of dunlin in North-west Europe stable (Wetlands International 2006).

4.1.21 Black-tailed godwit *Limosa limosa*

Trends describing overwintering black-tailed godwit numbers were only available for ten of the WeBS sectors comprising The Wash SSSI, of which declines during at least one time period were recorded in eight. Substantial declines in overwintering black-tailed godwit numbers were recorded over all timescales for The Wash NNR, which was reflected at the sector level in Ouse Mouth (34490), Terrington East (34491), and Terrington West (35401). There were also substantial declines over at least two time periods, including the short-term, at Snettisham (34486), Holbeach St Matthew (35404) and Welland (35405). The latter was an important sector in that it held a large proportion of this species relative to The Wash SSSI as a whole in recent winters. Despite such decreases, The Wash SSSI as a whole has shown a moderate increase in black-tailed godwit numbers the long-term, and only a moderate decline in the medium-term. However, these trends mask a decline in numbers in the most recent winters. The long-term increases are likely to be due to the few sectors in The Wash SSSI where black-tailed godwit numbers were increasing at this time, namely Gedney (35401), Dawsmere (35403), Welland (35405), and Butterwick to Witham (35409). Of these sites, however, only one (Dawsmere) has shown an increase in the short-term, which is likely to have influenced the overall trend for The Wash SSSI as this sector accounted for a substantial proportion of the region's black-tailed godwit in recent years. Stability or declines were recorded in all others sectors. It is worth noting, however, that black-tailed godwit numbers fluctuated quite considerably on The Wash SSSI during the winters concerned. Relative to the EA Anglian Region and to Great Britain, The Wash SSSI increased in importance as a site for black-tailed godwit between the mid-1990s and mid-2000s, but subsequently decreased again. On an international level, numbers of black-tailed godwit in North-west Europe have fallen (Wetlands International 2006).

4.1.22 Bar-tailed godwit *Limosa lapponica*

Numbers of overwintering bar-tailed godwit fluctuated across The Wash SSSI during the time period concerned, with a moderate increase in numbers recorded in the long-term, but a moderate decrease in the short-term. In The Wash NNR (which accounted for a marked proportion of The Wash SSSI's bar-tailed godwit numbers), the trend was more consistent, with a marked decline in the medium- and long-terms. Underlying the observed pattern in The Wash NNR were falls in bar-tailed godwit numbers in the short-, and in many cases the medium-terms, at Ouse Mouth (34490), Terrington East (34491), Terrington West (35401) and Gedney (35402). The more mixed picture for The Wash SSSI can be explained by similar declines at Dawsmere (35403), Holbeach St Matthew (35404), and Benington (35410), but offsetting increases at Welland (35405), Butterwick to Witham (35409), and especially the WeBS sectors in the northern Lincolnshire corner of The Wash SSSI, where substantial increases were seen over across nearly every time period at Wrangle (35411), Friskney (35412) and Wainfleet (35413). These sectors also held a large proportion of the total number of bar-tailed godwit found on The Wash SSSI. Relative to the EA Anglian

Region, The Wash SSSI has gradually declined in importance as a site for bar-tailed godwit since the early-1990s. However, it has increased in prominence relative to the population of this species found in Great Britain as a whole. This indicates some emigration of birds from The Wash SSSI to neighbouring areas, and a decline in bar-tailed godwit numbers nationally. At the international scale, numbers of bar-tailed godwit in North-west Europe were stable (Wetlands International 2006).

4.1.23 Curlew *Numenius arquata*

Overwintering curlew numbers remained reasonably stable over The Wash SSSI throughout the period concerned, although there were fluctuations at higher spatial resolutions. There were declines in curlew numbers in the short- and long-term in Wash NNR, which also diminished in importance as a site for this species relative to The Wash SSSI, although The Wash NNR still held more than 20% of this species on average during recent winters. Declines within The Wash NNR were particularly marked at Ouse Mouth (34490) and Terrington East (34491), although curlew populations were relatively stable at Terrington West (35401) and Gedney (35402), and increased substantially at Kirton (35407). It should be noted, however, that the number of curlew on The Wash NNR was small, with a winter count peak of 817 in 2008/09, making interpretation of trends difficult. Considering sectors in The Wash SSSI, there were decreases in curlew numbers on the southern side of The Wash, with moderate and substantial declines in at Dawsmere (35403), Holbeach St Matthew (35404) and Welland (35405). However, there were increases in numbers in northern part of The Wash on the Lincolnshire side, which also gained importance as an area for curlew relative to the region as a whole. This was especially true at Wrangle (35411) and Friskney (35412). There was also a substantial increase in curlew numbers at neighbouring Wainfleet (35413) and Leverton (35415) in the long-term, although these trends levelled off in the short-term for Wainfleet, and the short- and medium-term for Leverton. Relative to the EA Anglian Region and to Great Britain, The Wash SSSI accounted for a stable proportion of overwintering curlew. There have, however, been decreases in curlew numbers in North-west Europe (Wetlands International 2006).

4.1.24 Redshank *Tringa tetanus*

The overall picture of overwintering redshank numbers on The Wash SSSI is one of moderate decline. Declines were registered in 14 of the 16 WeBS sectors for which trends were obtained, and in no cases were increases reported for the short-term, although at the subsector level a moderate increase was seen at Freiston (35417) for this time period. Decreases were particularly marked at Dawsmere (35403) and Holbeach St Matthew (35403), where substantial declines were seen in the short- and medium-terms, along with a moderate decline in the long-term, as well as at Kirton (35406), where there was a substantial decline in redshank numbers over all timeframes. The latter was also observed at Friskney (35412). None of the sectors where substantial and sustained declines were reported supported a large proportion of redshank relative to The Wash SSSI as a whole, however. Indeed, the two most important sectors, Butterwick to Witham (35409) and Ouse Mouth (34490), held relatively stable numbers of redshank, although there was a moderate decline at Ouse Mouth in the short-term. These sector level patterns contributed to moderate declines in redshank numbers in the medium- and short-terms in The Wash NNR, and a moderate decline in the short-term in The Wash SSSI. Relative to the EA Anglian Region and to Great Britain, The Wash SSSI accounted for a reasonably stable proportion of overwintering redshank. Trends in redshank numbers at the international level were not clear, but this species appeared to be either stable or decreasing in North-west Europe (Wetlands International 2006).

4.1.25 Turnstone *Arenaria interpres*

There has been a general decrease in numbers of turnstone overwintering on The Wash SSSI, with moderate declines in the medium- and long-term, although numbers have levelled off in the short-term. In The Wash NNR, which represented a large proportion of turnstone on The Wash SSSI, there were substantial declines in turnstone numbers in the medium- and long-terms, and a moderate decline in the short-term. The turnstone declines in The Wash NNR are likely to be underpinned by moderate and substantial declines at Terrington West (35401), Terrington East (34491) and Ouse Mouth (34490), although the latter sector has seen a substantial increase in the short-term. In the wider Wash SSSI, there were declines in turnstone numbers over all timeframes at Heacham to Snettisham (34485) and Frampton (35408). These were partially offset by increases over all timeframes at Wrangle (35411), which was an important site in terms of the proportion of turnstone it held. It should be noted that numbers of turnstone recorded are small, with a winter peak count of 448 individuals in 2008/09. As such, trends must be interpreted with care. Since the mid-1990s, The Wash SSSI has declined in importance in terms of the proportion of turnstone it supports relative to the wider EA Anglian Region. Relative to Great Britain, however, the proportion of turnstone overwintering on The Wash SSSI has remained stable. These trends suggest a redistribution of turnstone from The Wash SSSI to neighbouring areas, but a national decline in line with that observed on The Wash SSSI. On an international scale, declines in turnstone were also seen in North-west Europe (Wetlands International 2006).

4.2 Broad patterns

4.2.1 Waders and shelduck

Shelduck and waders are discussed together because all these species feed on mudflat invertebrates, and are therefore likely to respond in similar ways to changes in the environment.

For many species in this group, the overall picture was one of decline in numbers of individuals overwintering on The Wash SSSI and The Wash NNR, reflecting international trends (Wetlands International 2006). This was especially true of The Wash NNR, where only two of the 13 species for which trends could be obtained did not decline over at least one time period. Considering that The Wash NNR holds a substantial proportion of waders and shelduck found on The Wash SSSI, such declines are a cause for concern. Declines, many of which were substantial, were recorded on The Wash NNR in every time period for avocet, dunlin, black-tailed godwit and turnstone. Of the species that did not decline, only one (golden plover) increased, with a substantial increase in numbers in the long-term, while the other (knot) remained stable. Overwintering numbers of waders and shelduck were slightly more stable on The Wash SSSI, with six of the 15 species concerned not declining in at least one time period. Again, however, only three of these species (avocet, golden plover and knot) showed any increases, and none increased in the short-term.

Shelduck numbers declined throughout The Wash SSSI. These were particularly substantial and sustained towards the south-west, around the inflow of the River Welland, but numbers also declined generally on the western, Lincolnshire side. Grey plover, lapwing, dunlin and redshank declined in the same areas, while dunlin numbers also declined consistently on the eastern and southern parts of The Wash, as did black-tailed godwit, bar-tailed godwit, curlew, redshank and turnstone. There was an indication that the northern part of the Lincolnshire side of The Wash SSSI had become a preferred area for many wader species, with the WeBS sectors in this region assuming importance for this group relative to The Wash SSSI as a whole, and a concomitant increase in numbers observed. This was

especially true for oystercatcher, golden plover, knot, dunlin, bar-tailed godwit and curlew, although lapwing and redshank, as well as shelduck, predominantly declined in this area.

4.2.2 Dabbling ducks

Although the overall trend suggests increases in dabbling duck numbers in The Wash SSSI and The Wash NNR, there is some indication that this is changing. For example, there were increases in numbers of wigeon and pintail over all time periods, but these were substantial in the long- and medium-term, but moderate in the short-term for both The Wash SSSI and The Wash NNR. Similarly, numbers of teal increased in the long- and medium-term (substantially in The Wash SSSI, moderately in The Wash NNR), but stabilised in the short-term. Mallard numbers remained largely stable over the whole period. Gadwall numbers, however, declined moderately in the short-term, although since only small numbers of this species were recorded on the site, it is difficult to interpret the trends produced. The eastern, Norfolk, bank of The Wash SSSI and The Wash NNR between Heacham and the River Great Ouse, showed particularly substantial and consistent increases in numbers of dabbling ducks, especially wigeon, teal, mallard and pintail at Snettisham (34486) and Ouse Mouth (34490). Several sectors in this region also held a large proportion of The Wash SSSI's dabbling duck population. There were few areas in which consistent declines in dabbling duck numbers were observed, although at Terrington West (35401), there were declines over at least one time period for wigeon, teal, mallard and pintail. However, the numbers of birds recorded in this sector were very small, and as such, trends must be interpreted with caution.

4.2.3 Other wildfowl and little grebe

There are too few data points available to make firm inferences about populations of diving ducks or little grebe on The Wash SSSI. The picture is more complete for geese, with numbers of dark-bellied brent goose showing a gradual decline, which translated to a moderate decline in numbers in the long-term for The Wash SSSI, and pink-footed goose populations remaining reasonably stable, although a small population peak in the early-2000s led to a decline being recorded for the short-term in The Wash NNR. However, pink-footed goose numbers on The Wash NNR were consistently low throughout the whole period, such that trends for this species in this site should be interpreted with caution. In many ways, dark-bellied brent goose population trends mirrored those of shelduck, as both species declined in the south-western part of The Wash SSSI, between Dawsmere (35403) and Frampton (354008). Like shelduck, dark-bellied brent goose also experienced declines in the northern part of The Wash SSSI on the Lincolnshire side, although in all cases, the declines in dark-bellied brent goose numbers were less sustained and substantial than those in shelduck numbers. Pink-footed goose numbers fluctuated more widely at the sector level than did dark-bellied brent goose numbers, although the stability recorded overall for The Wash SSSI suggests that these fluctuations reflected population movements, rather than increases or declines.

4.2.4 Summary

Of the 25 species for which trends were assessed for The Wash SSSI, declines in numbers over at least one time period were detected in 12, and increases in 11. However, the latter includes three species (common scoter, black-tailed godwit and bar-tailed godwit) in which increases in the long-term were replaced by declines in the short-term. In no cases did an increase succeed a decline. Declines in the short-term were found in nine species, whereas there were only short-term increases in four species (all dabbling ducks). Overall, therefore,

it appears that there is a trend towards a decrease in waterbird numbers on The Wash SSSI, particularly in recent winters.

Declines were recorded over at least one time period for 12 of the 19 species for which trends were obtained in The Wash NNR, while increases were only seen in five species (and in one of these cases, pink-footed goose, a long-term increase were succeeded by a short-term decline). Short-term declines were found in nine species, while short-term increases were only seen in two (wigeon and pintail). These trends therefore suggest that the overall pattern of waterbird decline on The Wash SSSI is also occurring, and indeed occurring more strongly, in The Wash NNR. This is concerning given that The Wash NNR supports a large proportion of waterbird numbers on The Wash SSSI for all but four species (Tables 3.1.iii and 3.1.iv).

Declines in wader and shelduck numbers were more substantial and sustained than those in wildfowl. Of the wildfowl, trends suggested an overall increase in dabbling duck numbers, although these increases appeared to be levelling off in recent winters. Although there were declines in some species, notably dark-bellied brent goose, shelduck, grey plover, lapwing and dunlin, throughout the WeBS sectors making up The Wash SSSI and The Wash NNR, trends for other species were confined to particular sectors. For example, there were consistent increases in dabbling duck numbers on the eastern (Norfolk) side of The Wash, while numbers of many wader species declined on the southern side of The Wash.

4.3 Effect of grazing and inflows on WeBS counts

Although the analysis we carried out did not find a significant effect of grazing or inflows in the region of the River Great Ouse on WeBS core counts, such effects cannot be ruled out. This is because the dataset used only encompassed information for five years, and only concerned the sites to the west of the River Great Ouse, as the data obtained from the opposite bank were too sparse to be included in the modelling process. Unlike the analysis discussed in section 4.4, the grazing compartments and WeBS sectors were incongruent, as the compartments were contained within the much larger WeBS sectors of Terrington East and Terrington West. However, the grazing compartments match WeBS sites at the subsector level far better, but analysis was not carried out at this spatial resolution because counts at the subsector level have only recently begun, and the years in which they were carried out did not coincide with the years in which grazing data were available. It is therefore possible that in future, once more data have been collected at the WeBS subsector scale, and further information on grazing is available, similar but more powerful analyses could be run.

4.4 Comparison of breeding bird data and WeBS core counts

The results of this analysis are largely inconclusive, which is not unexpected given the limited amount of data available. The entire dataset was comprised of only 34 breeding bird counts for four species, only one of which (redshank), was recorded at Snettisham RSPB reserve as well as at Frampton Marsh RSPB reserve. The significant positive relationship between the area of land grazed and breeding redshank numbers suggests that particular management regimes might be beneficial to this species. However, a larger dataset would

be required before any firm recommendations could be made. Ideally, information would also be available for a larger number of species, and on other factors that might influence breeding birds' nesting decisions, for example sward height.

4.5 Comparison of low tide counts and WeBS core counts

Figures 3.4.i (a) and 3.4.i (b) suggest that waders mostly stay in the same part of The Wash SSSI between at high- and low tides, and simply move with the tide-line, although on the eastern side, there is some indication that birds particularly congregate at Snettisham (34486). The pattern is similar for wildfowl and little grebe, with Snettisham also a favoured sector at high tide. Hence, waterbird flocks at low tide are closely associated with areas where the density of waterbirds is high at high tide.

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APPENDIX A

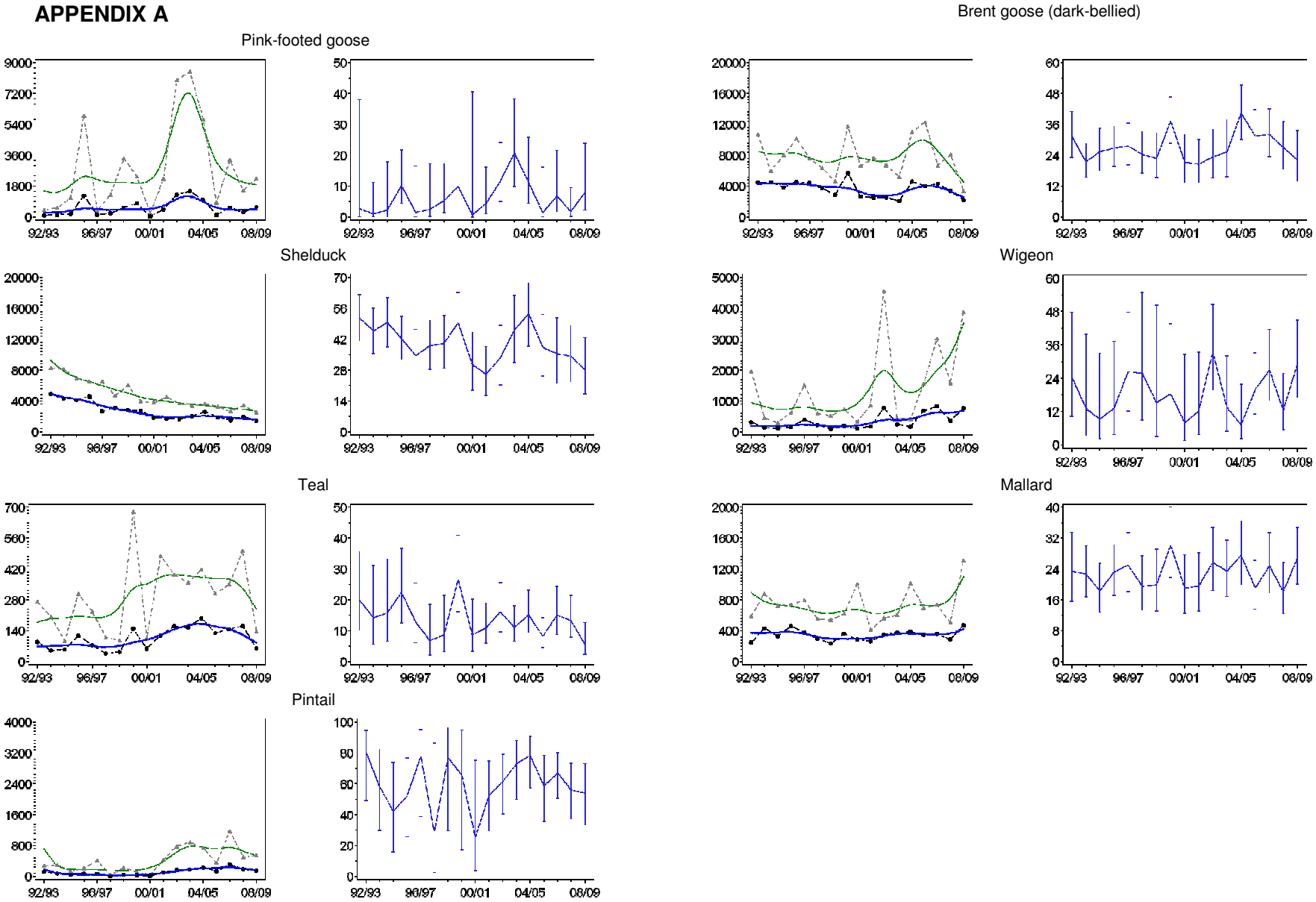
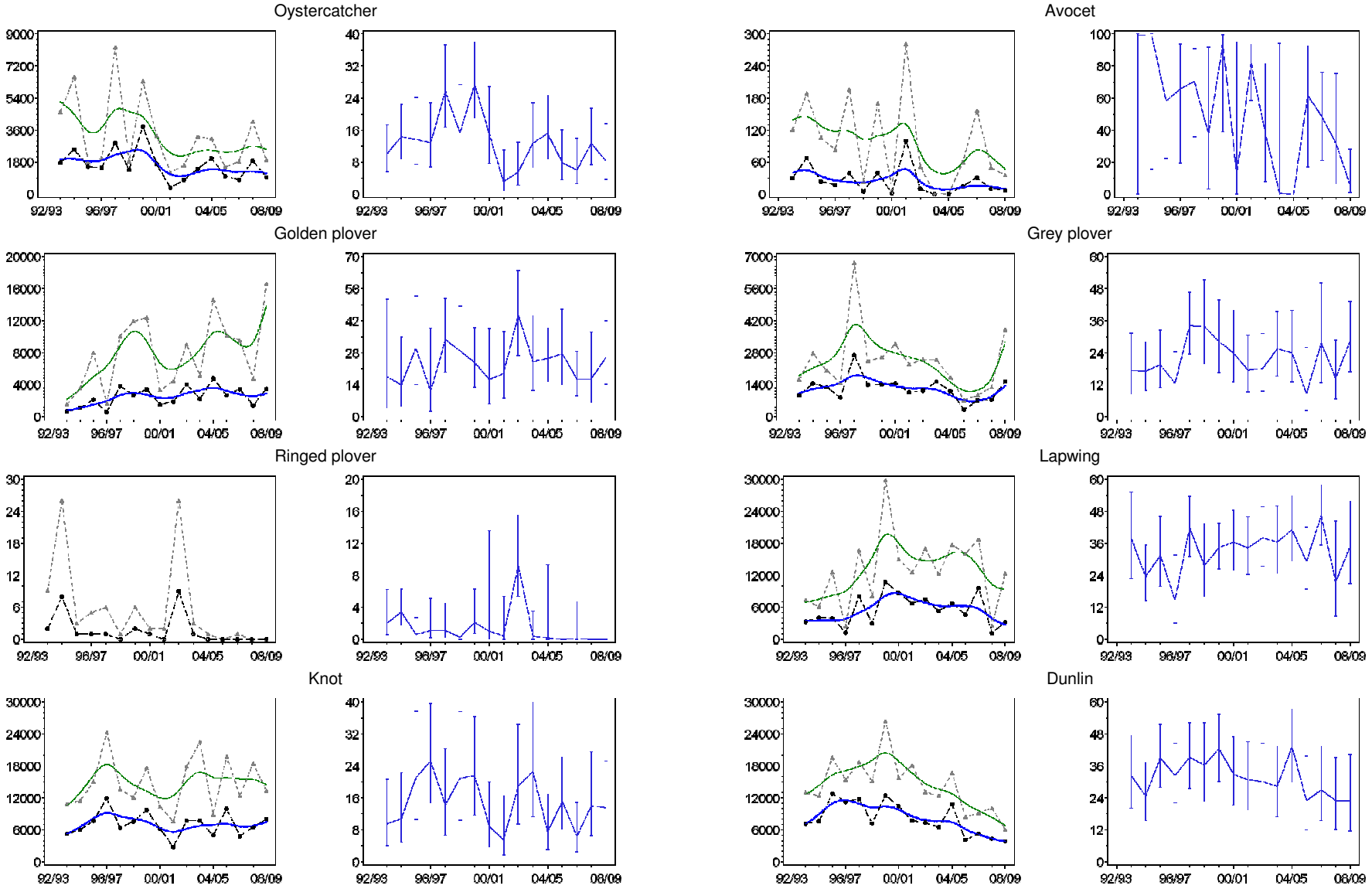


Figure A.NNR Population trends of each species in The Wash NNR (left-hand graphs), and the proportion of The Wash SSSI population found therein by winter (right-hand graphs).



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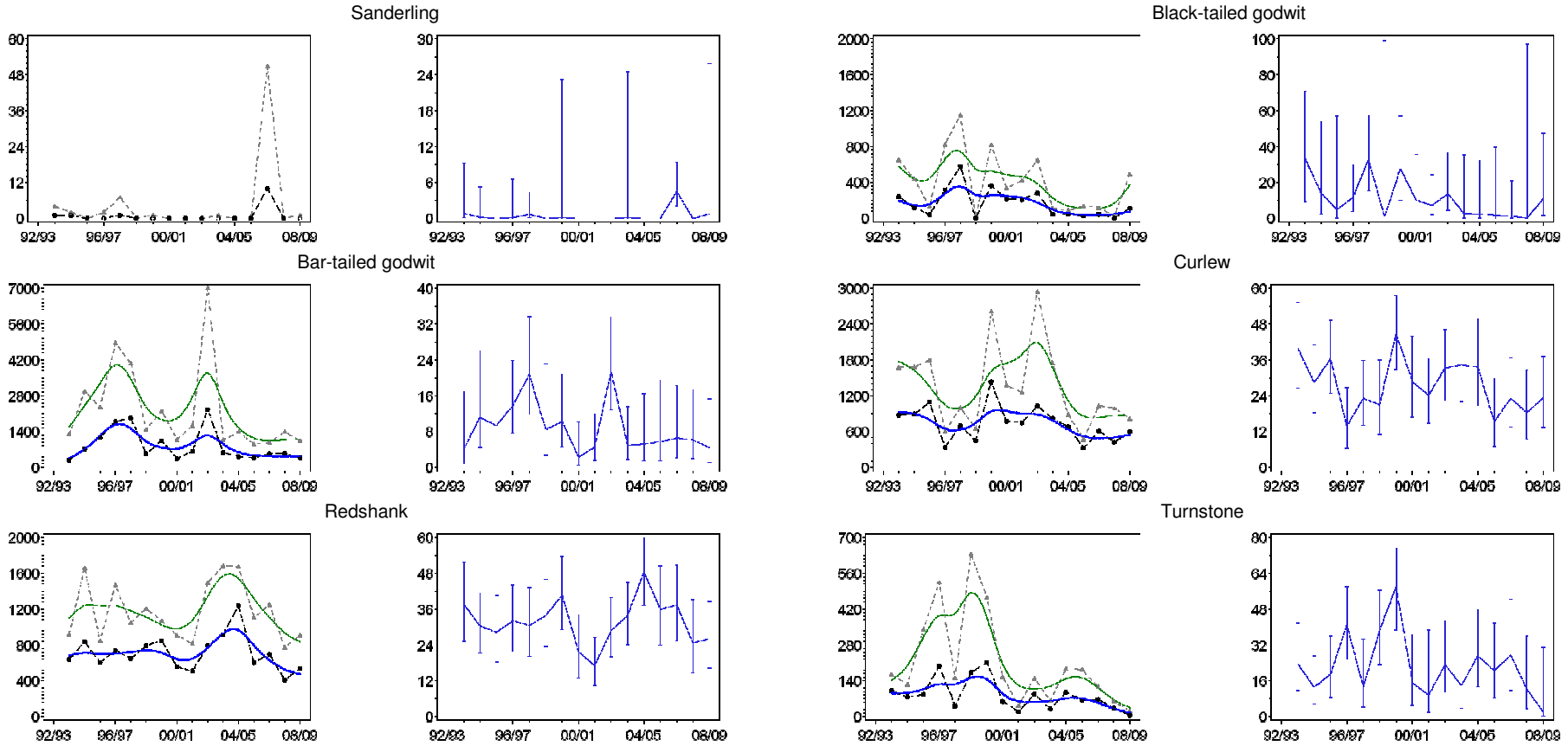

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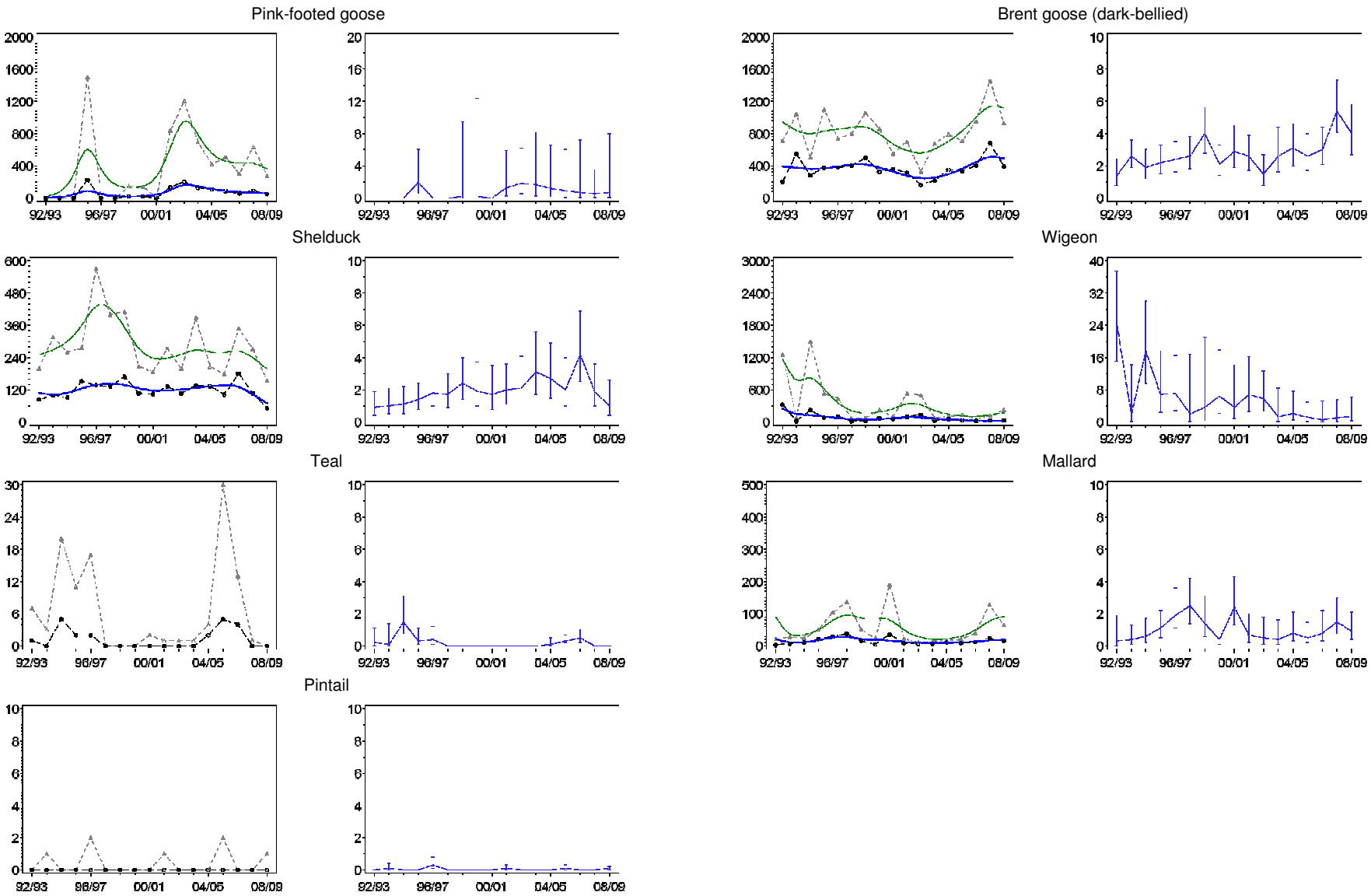
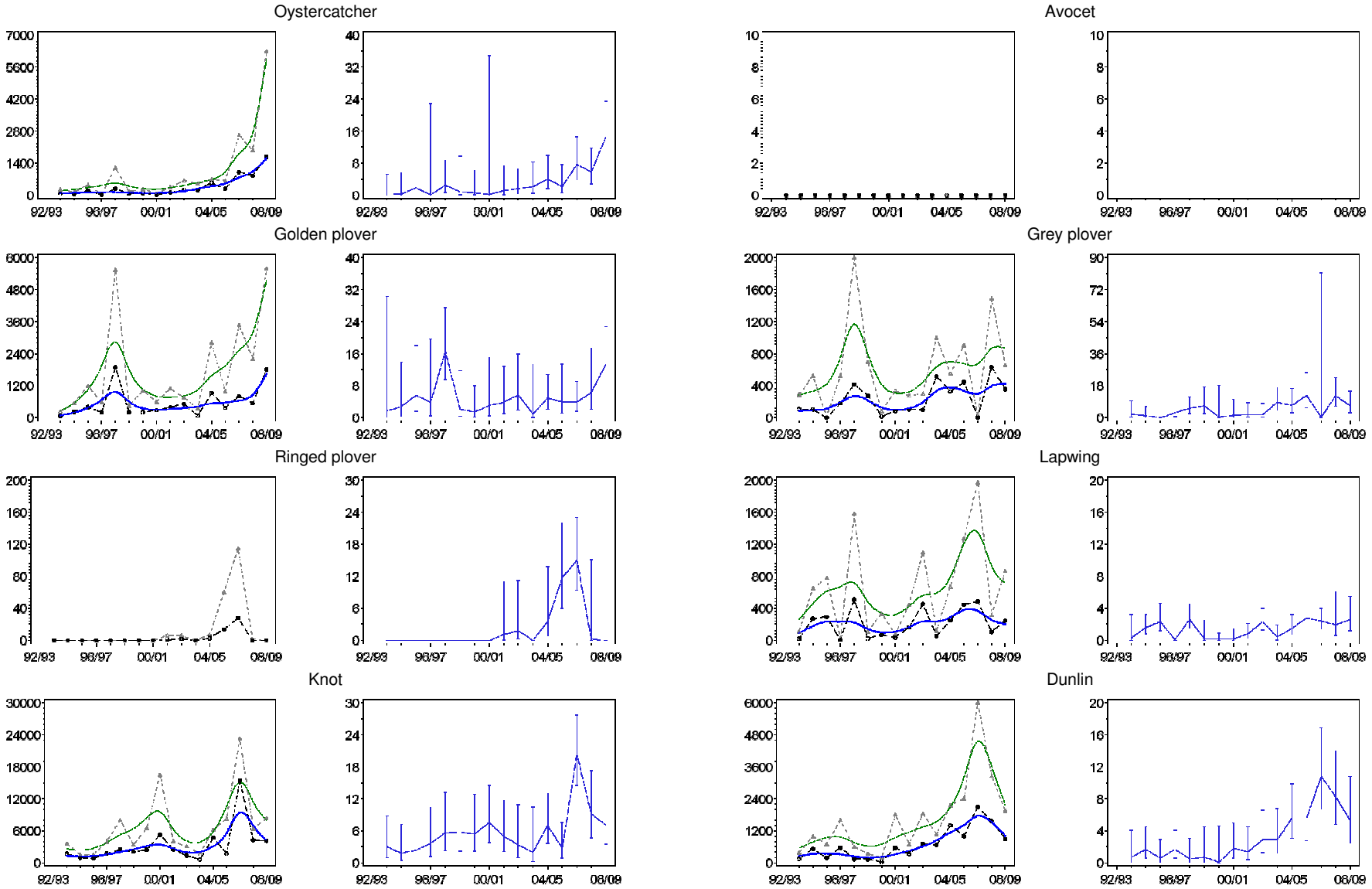


Figure A.35413 Population trends of each species in sector 35413 (Wainfleet) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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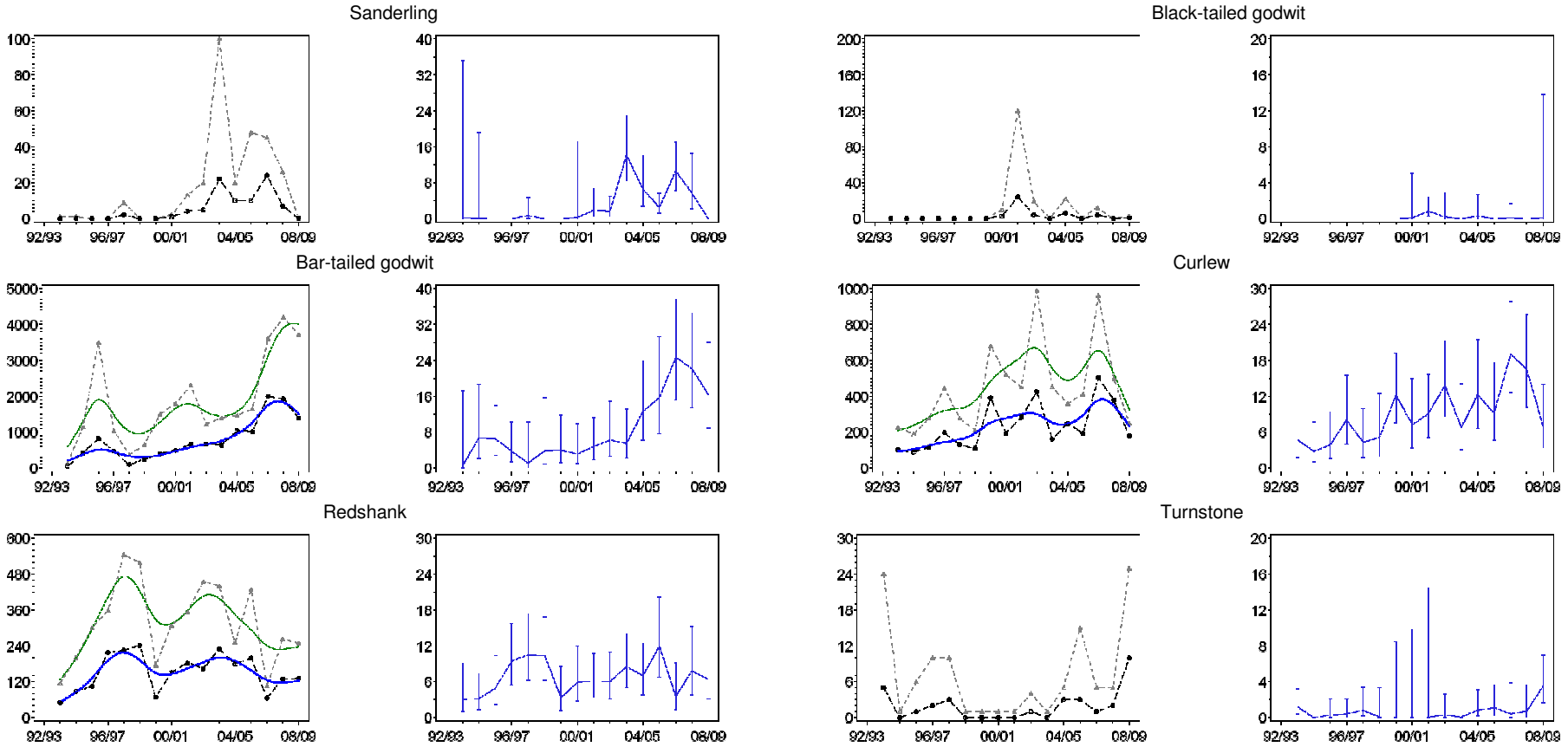


Figure A.35413 Continued

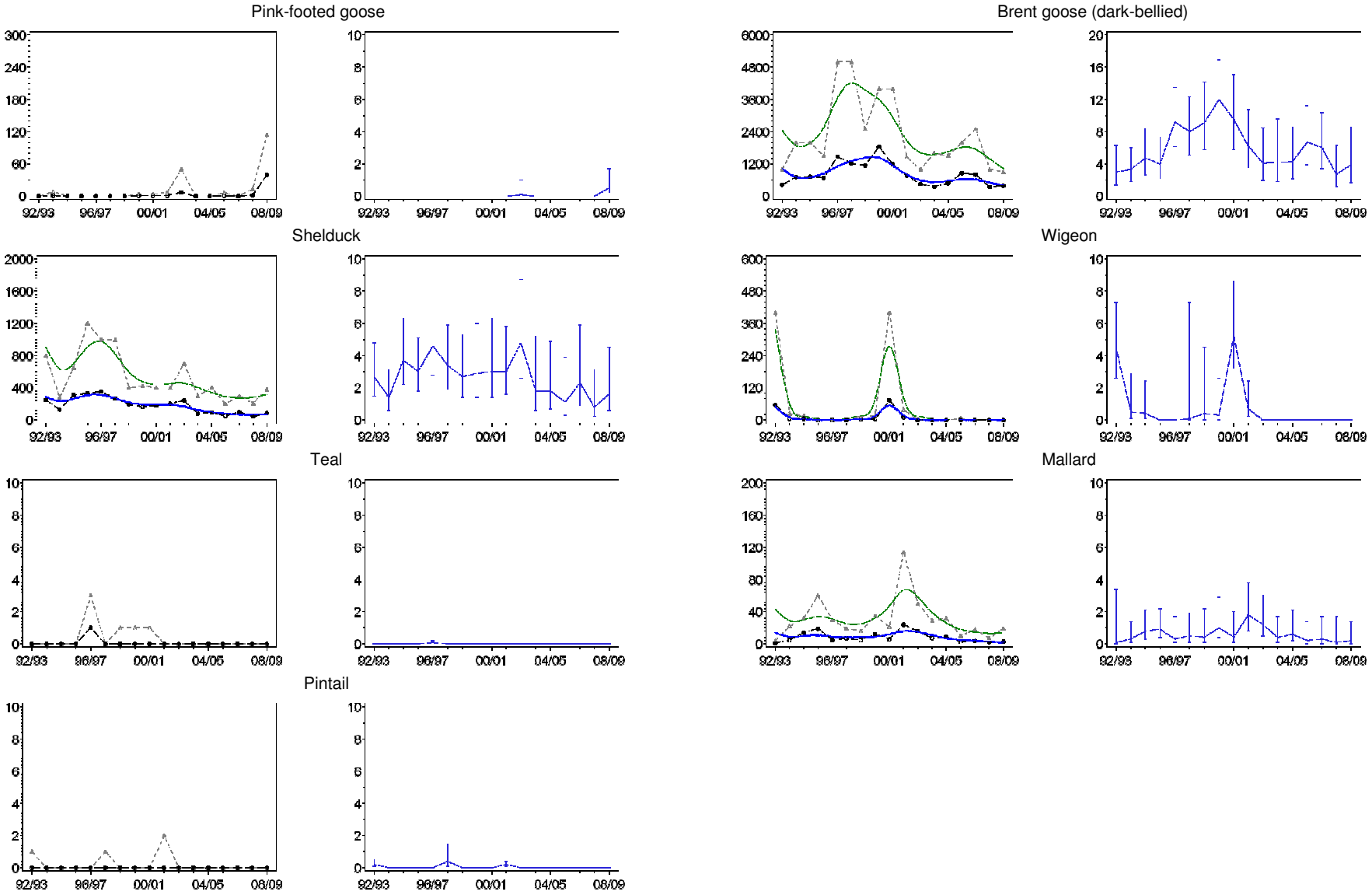
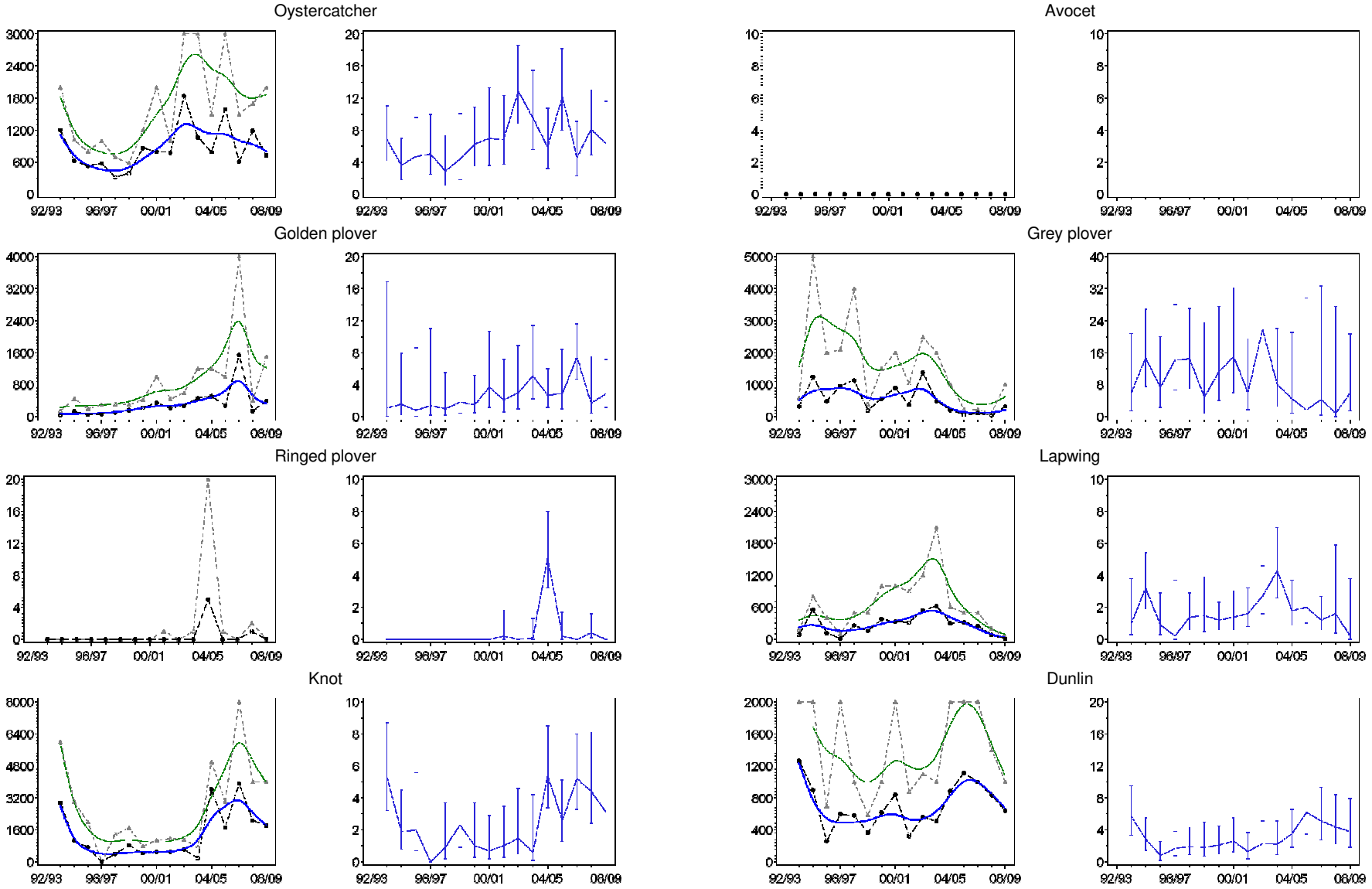


Figure A.35412 Population trends of each species in sector 35412 (Friskney) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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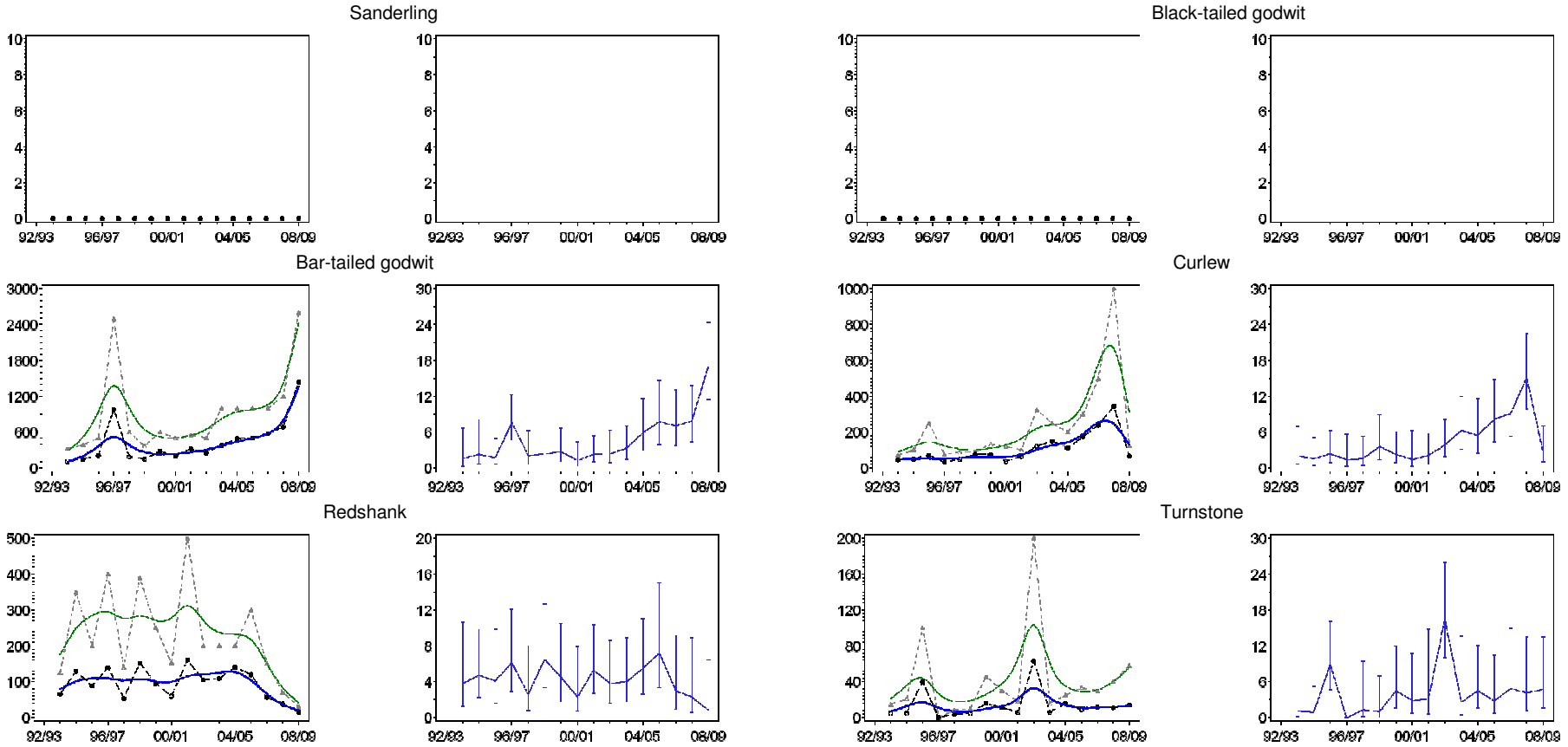


Figure A.35412 Continued

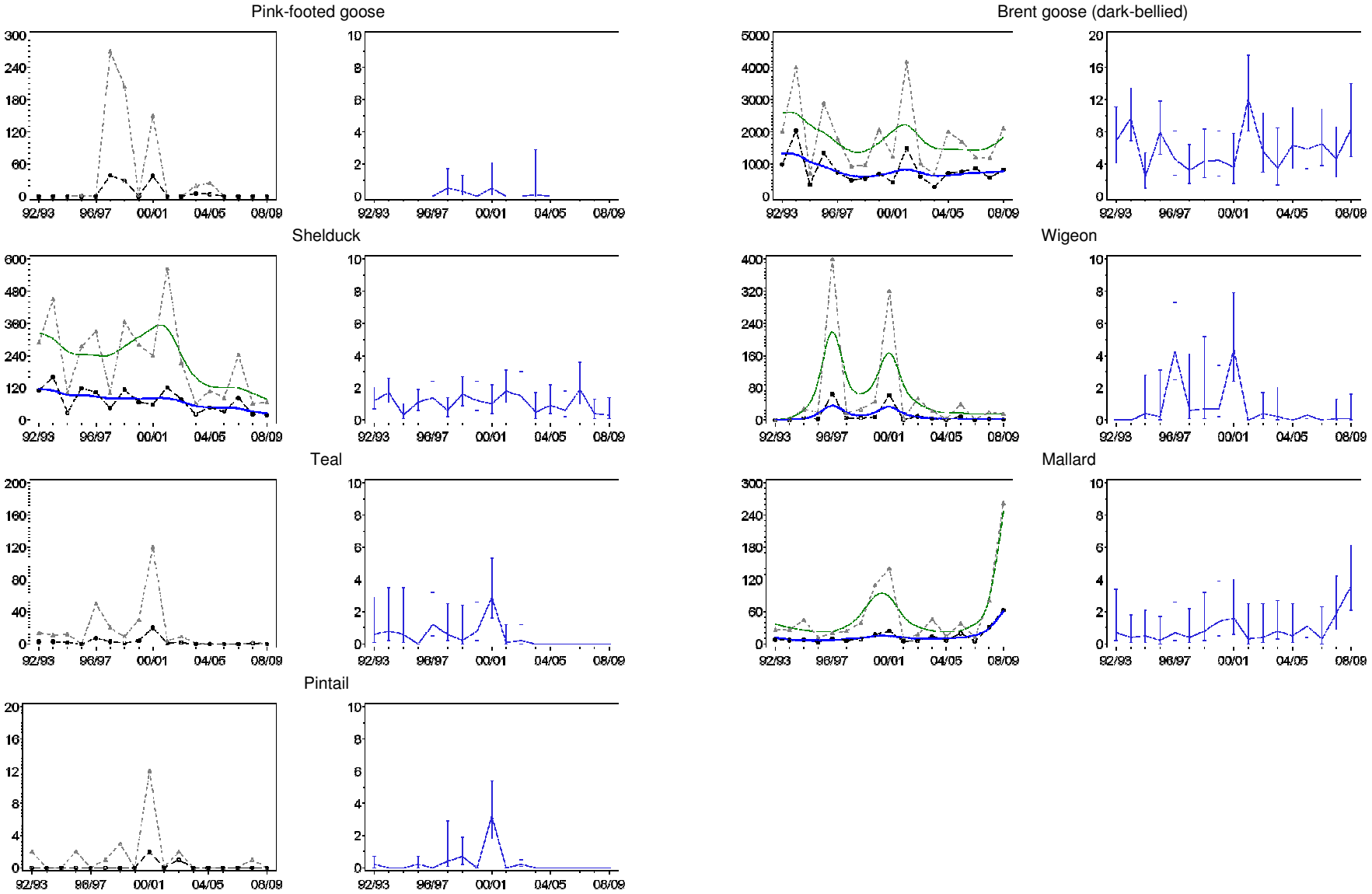


Figure A.35411 Population trends of each species in sector 35411 (Wrangle) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

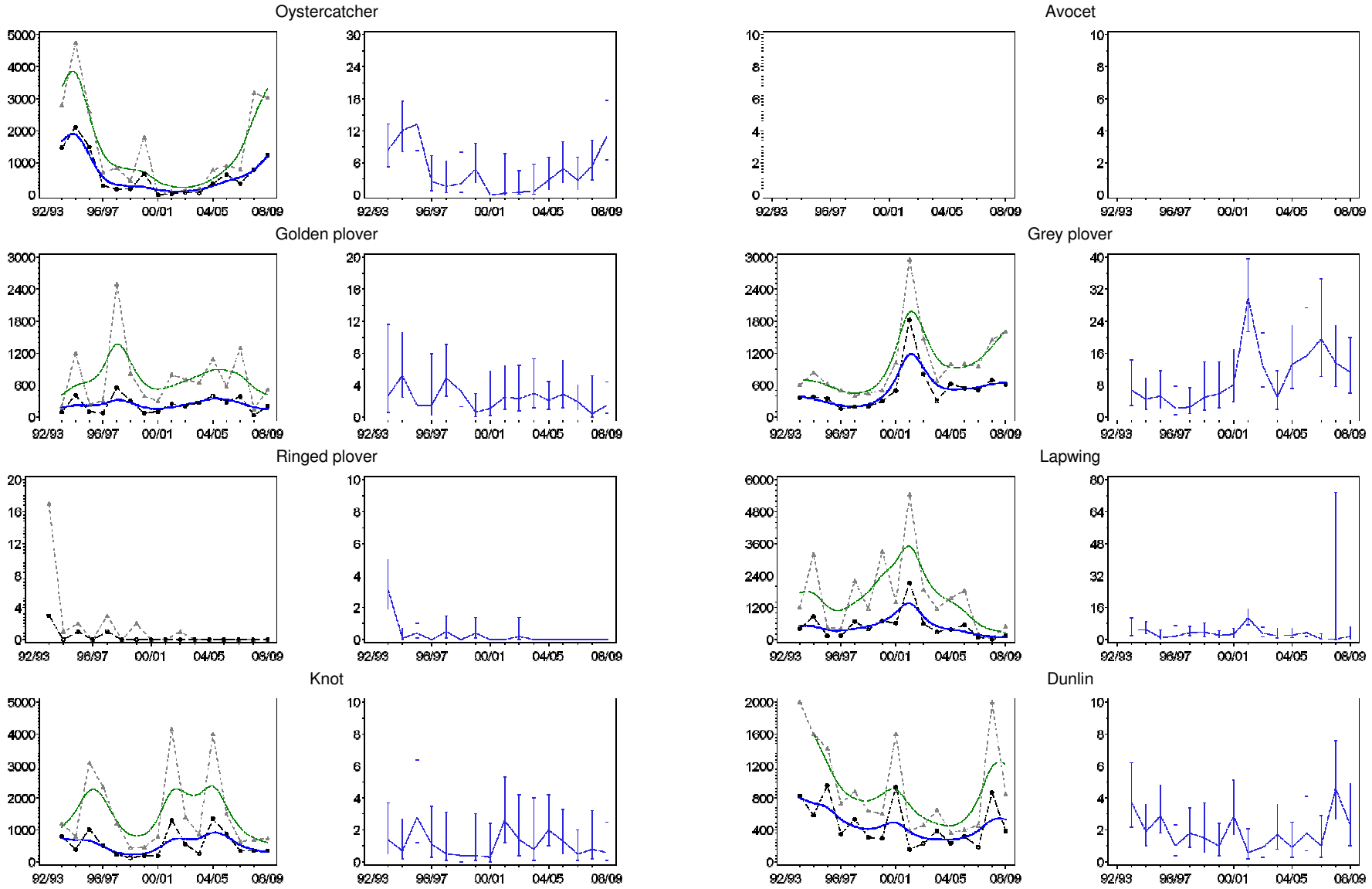


Figure A.35411 Continued

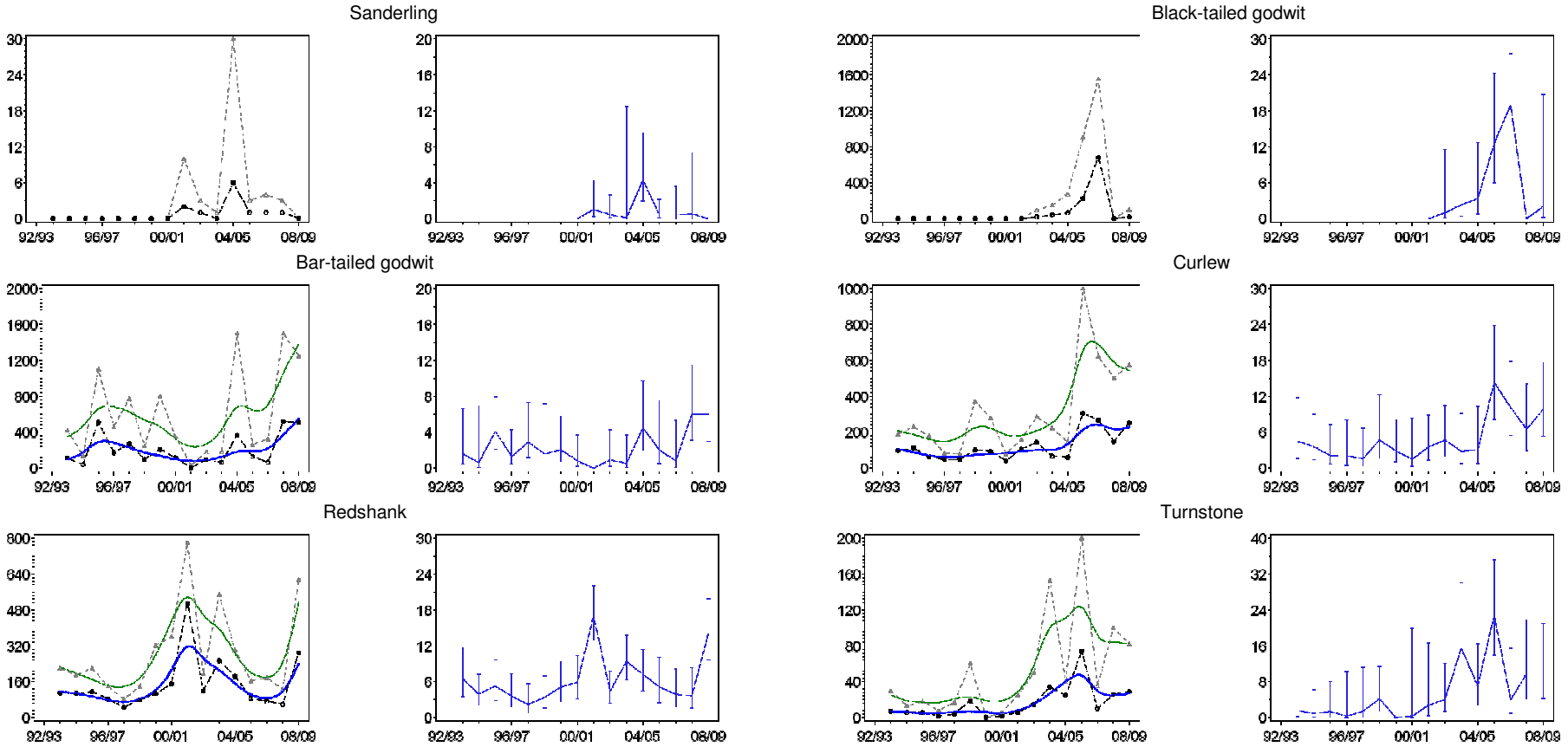


Figure A.35411 Continued

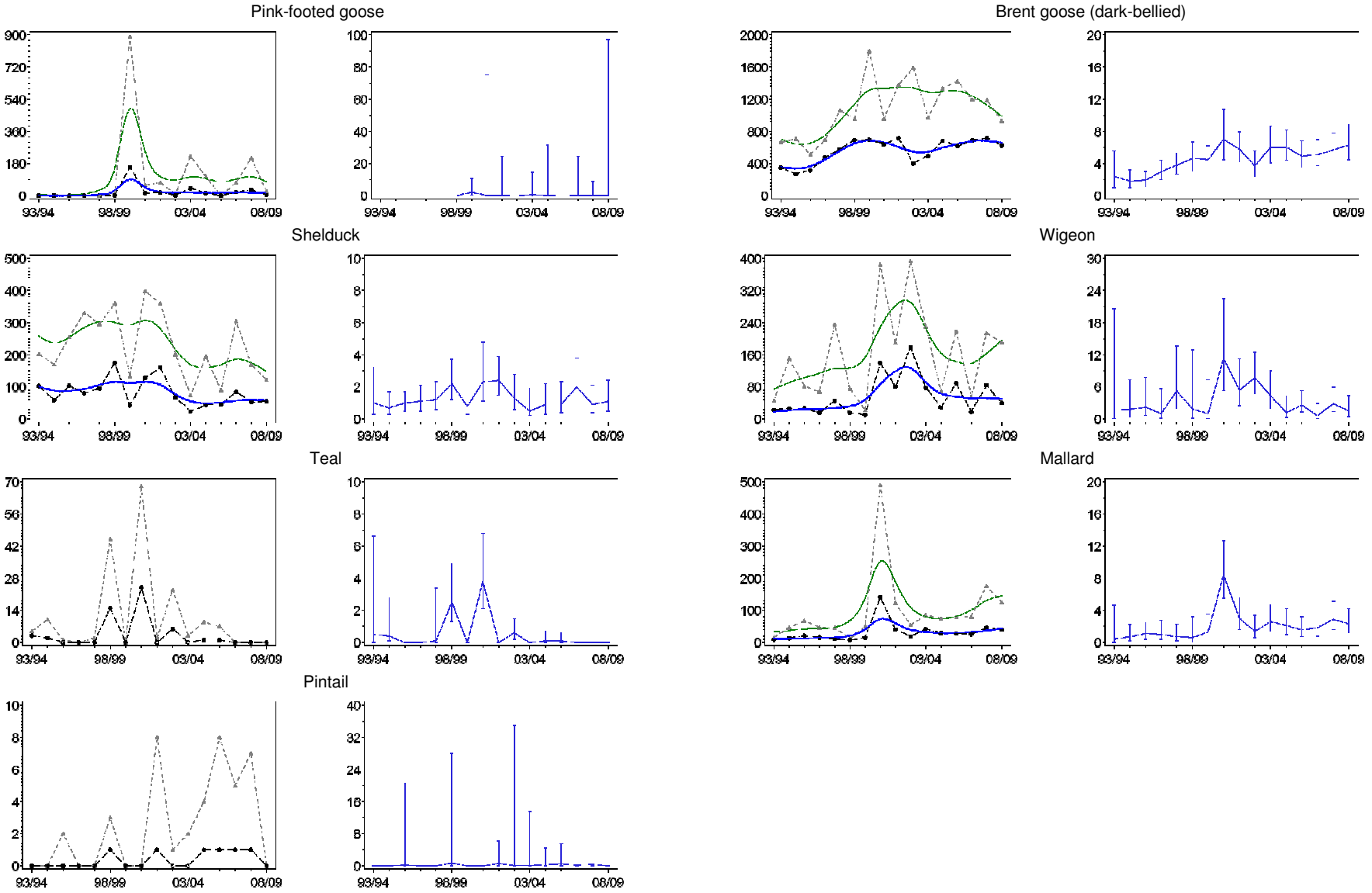
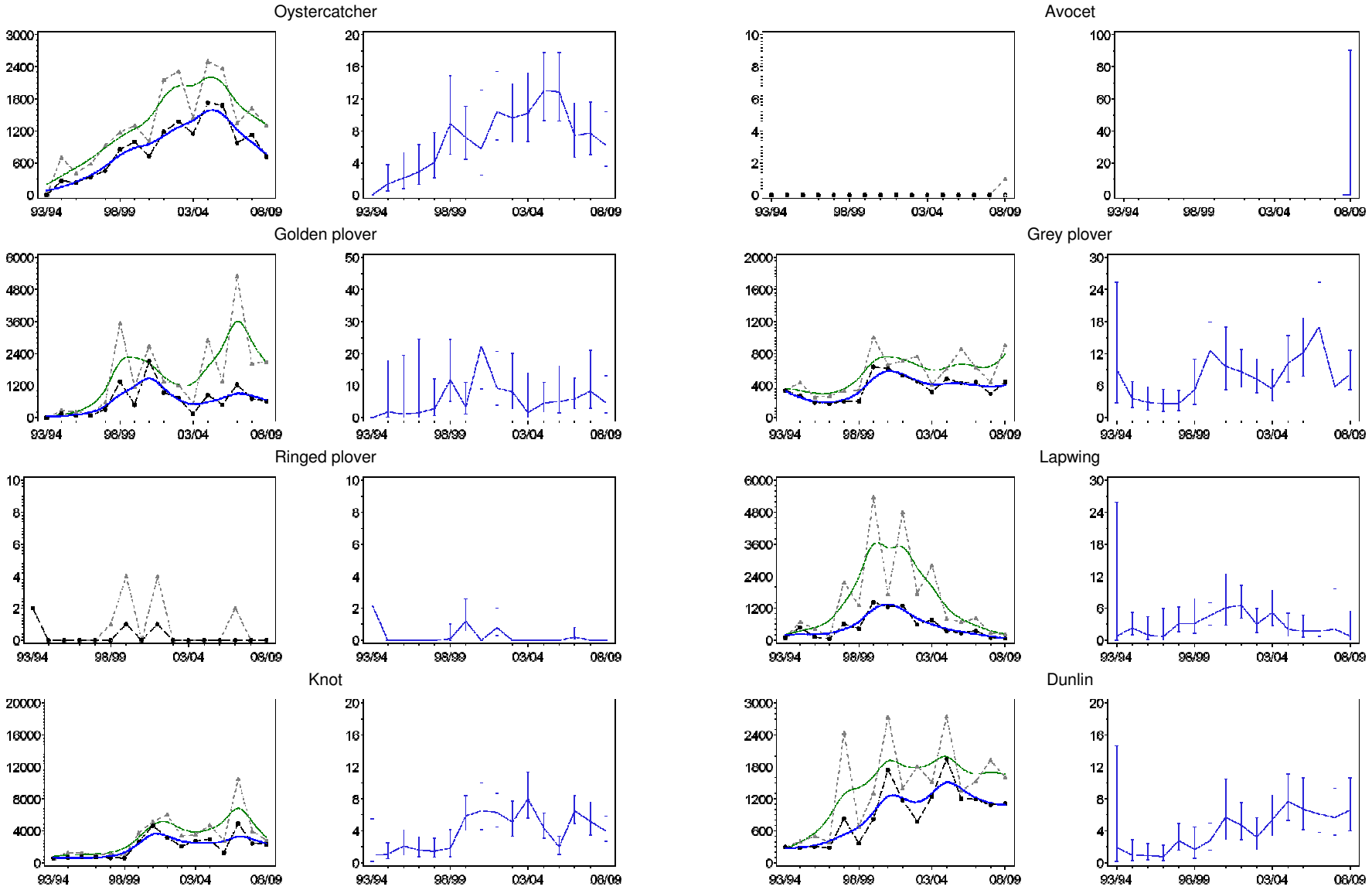


Figure A.35415 Population trends of each species in sector 35415 (Leverton) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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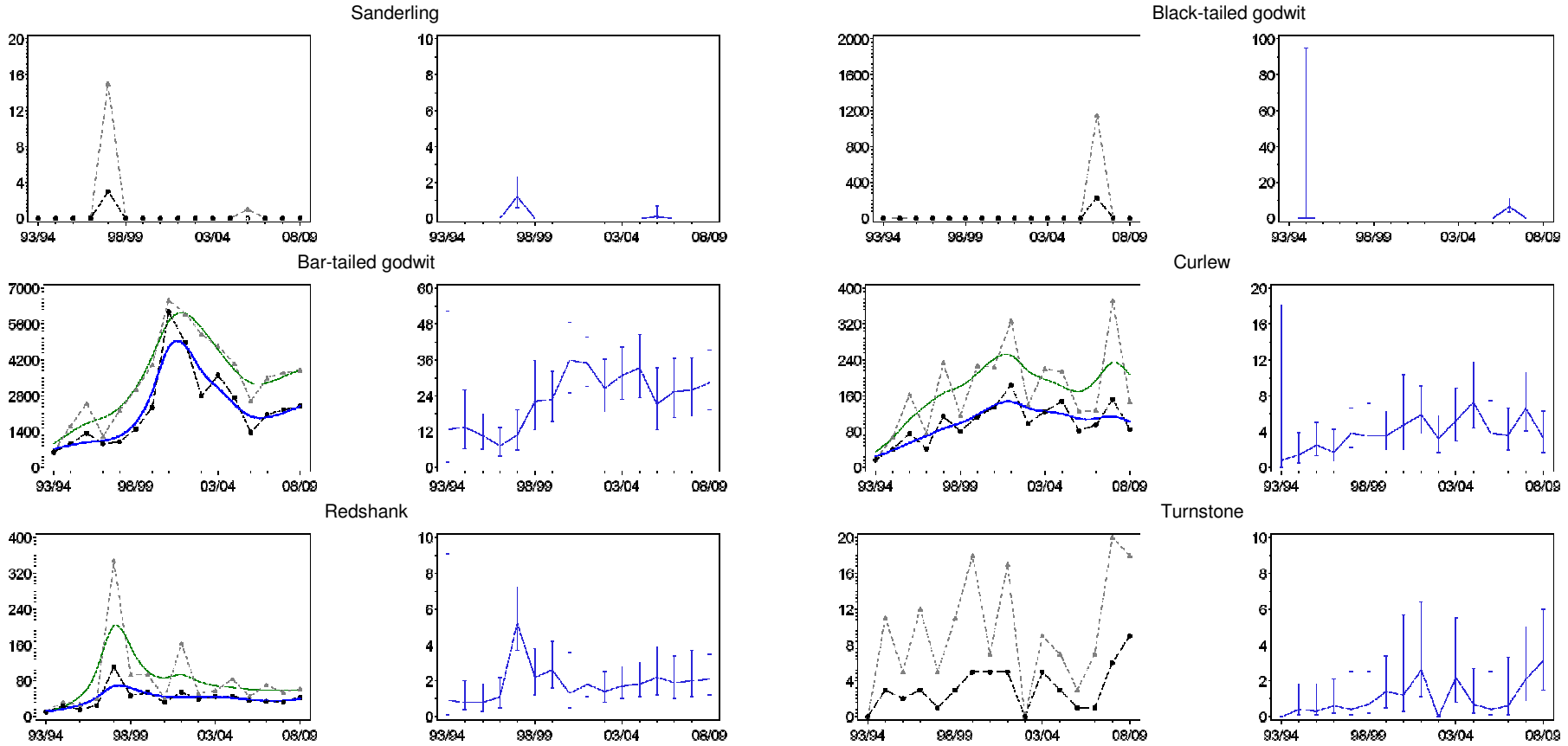

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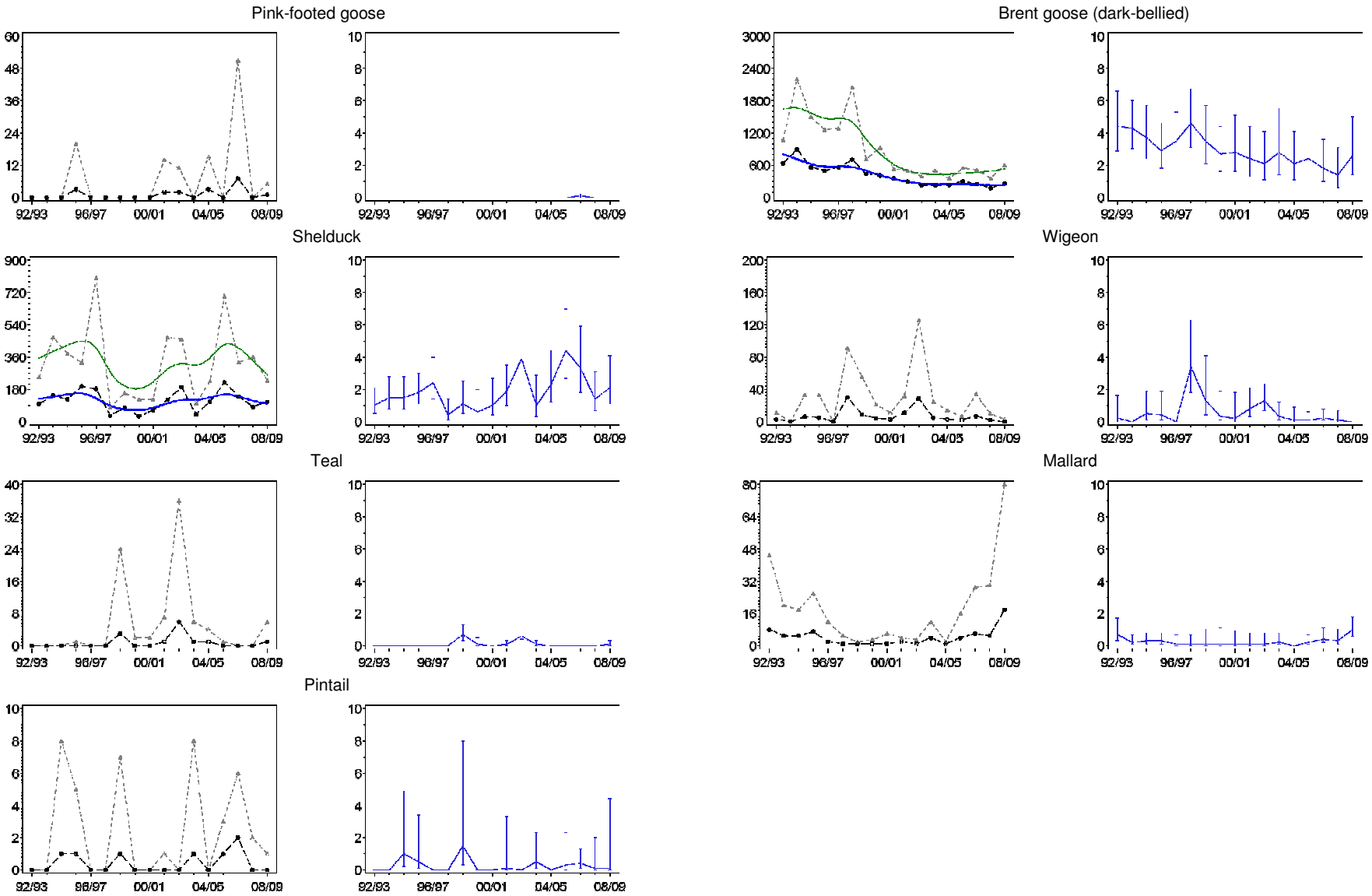
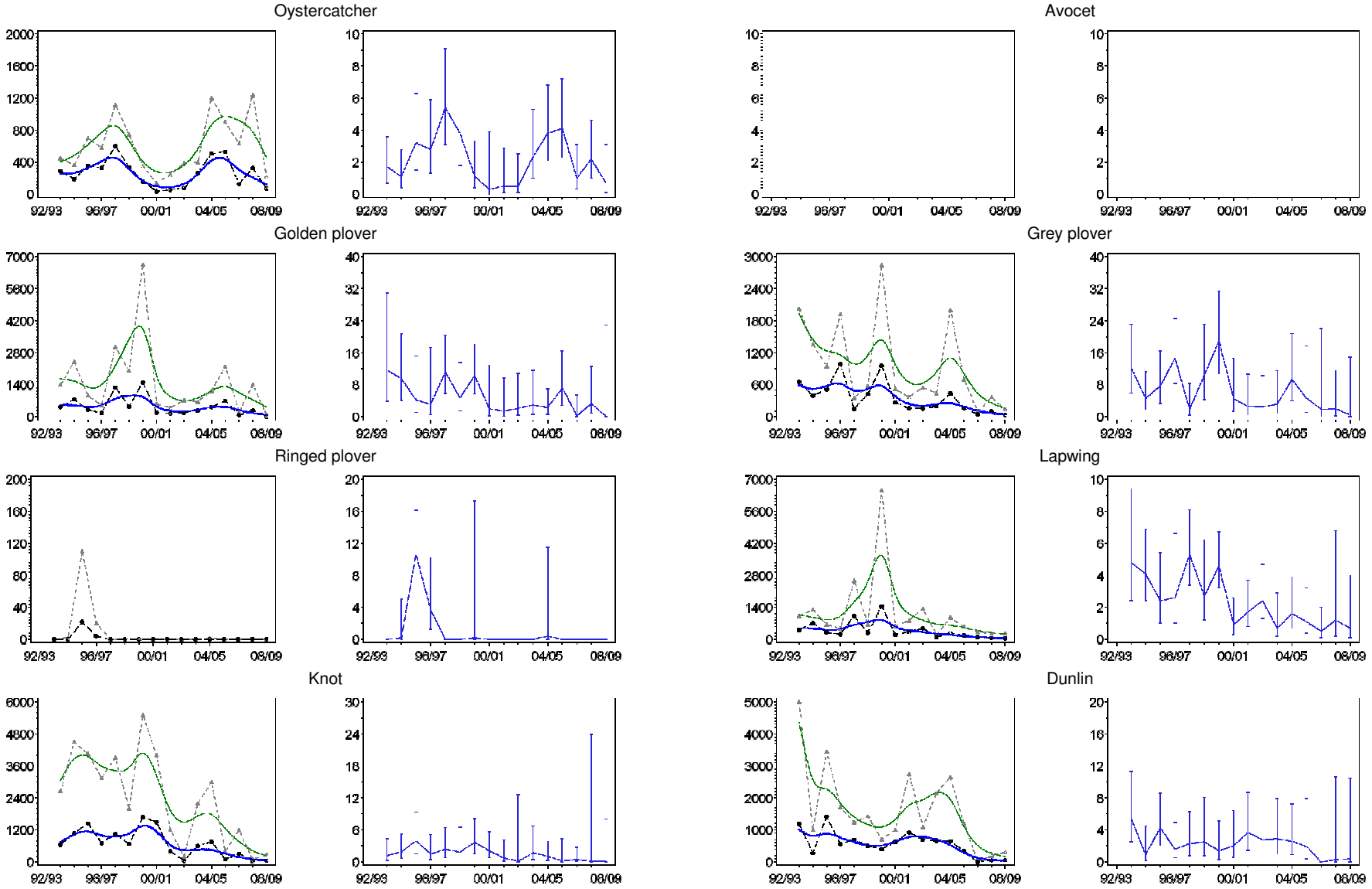


Figure A.35410 Population trends of each species in sector 35410 (Benington) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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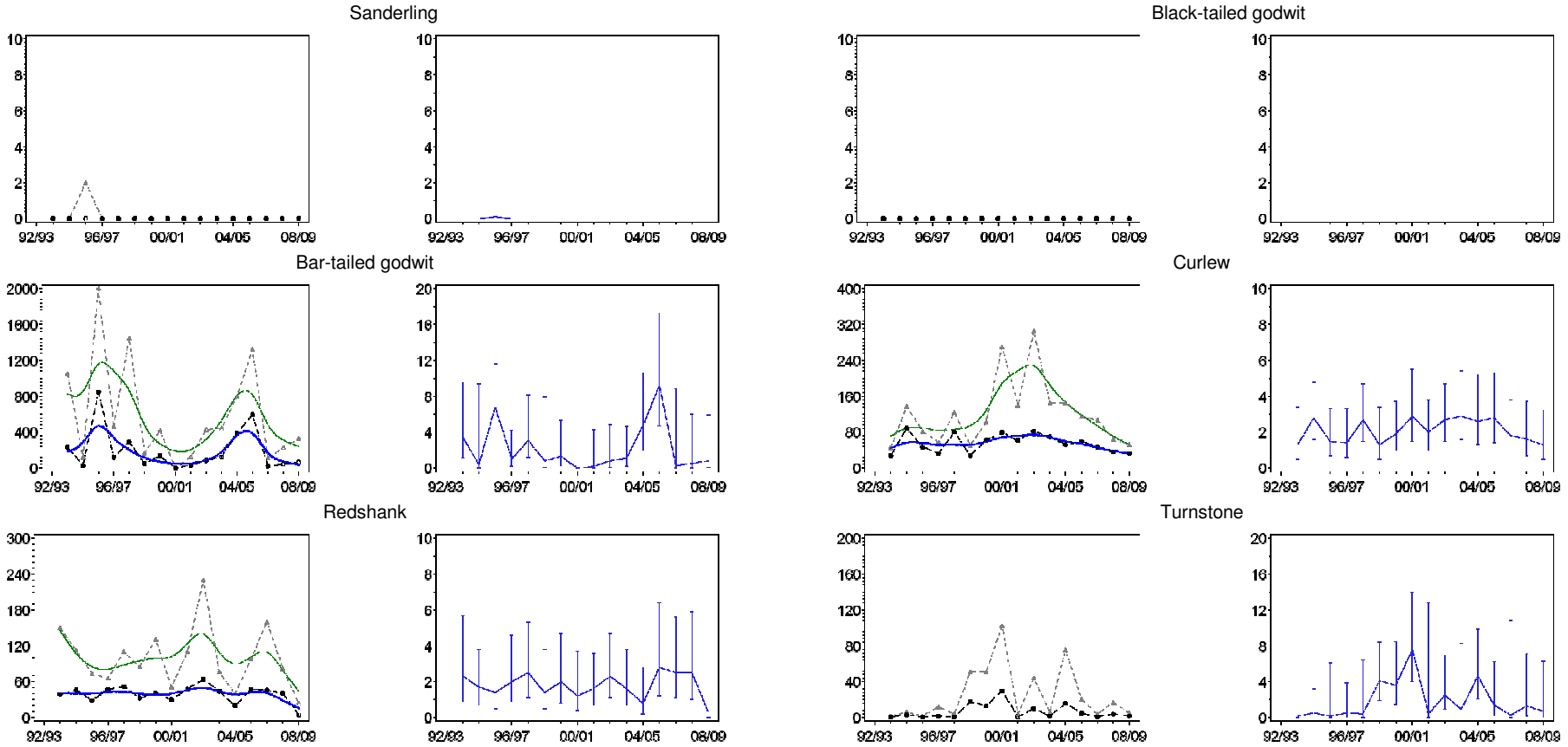

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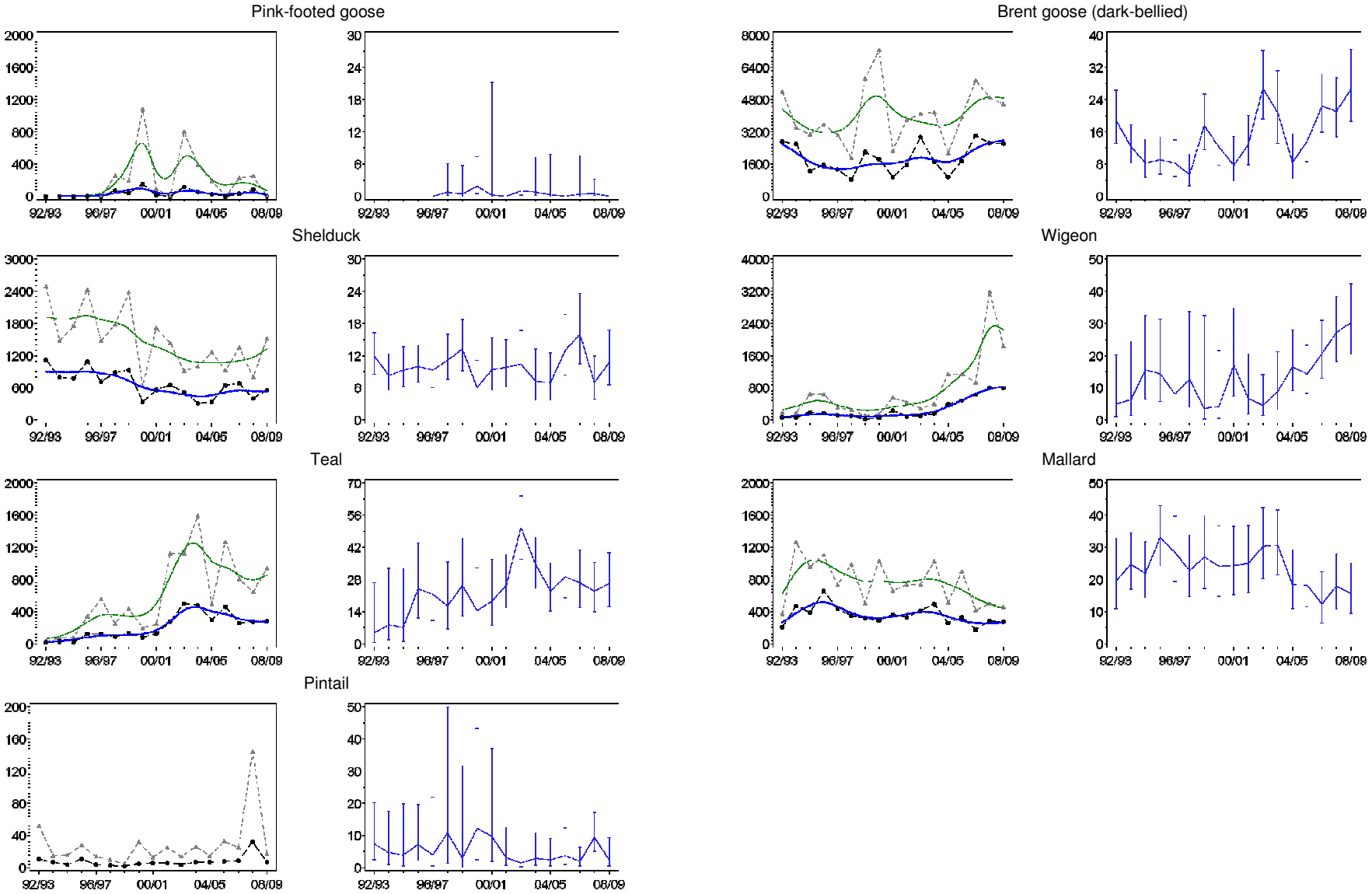
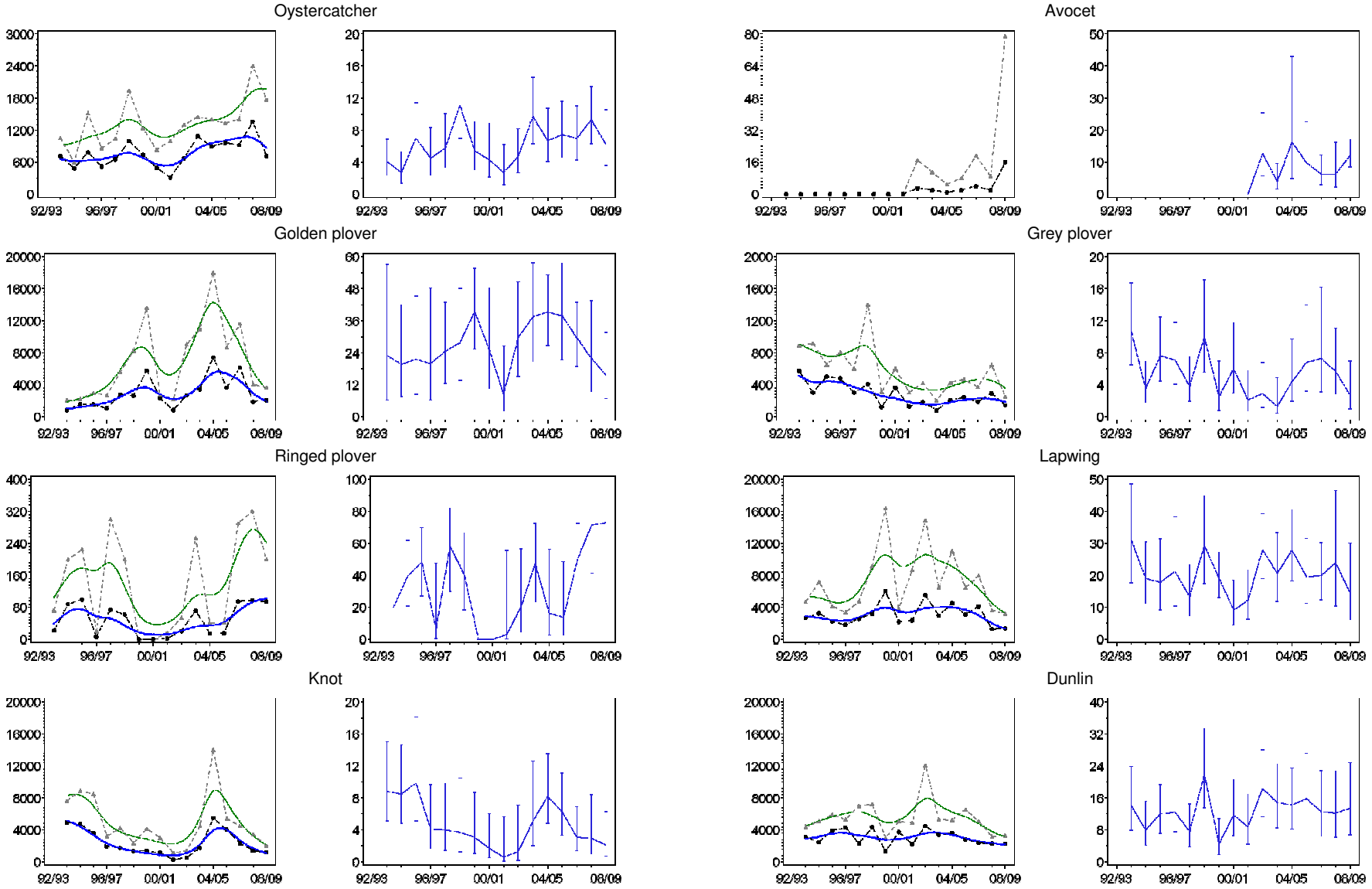


Figure A.35409 Population trends of each species in sector 35409 (Butterwick to Witham) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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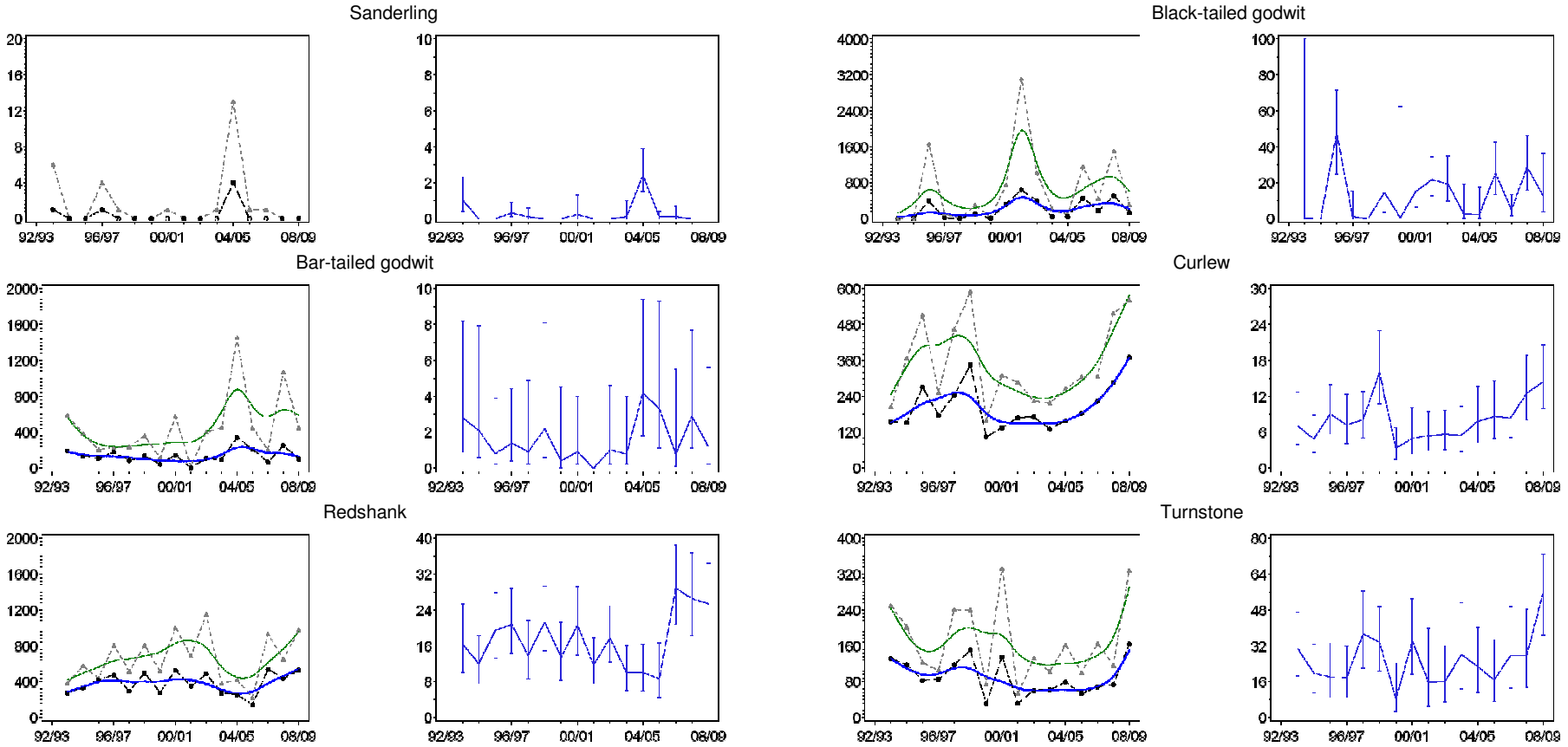

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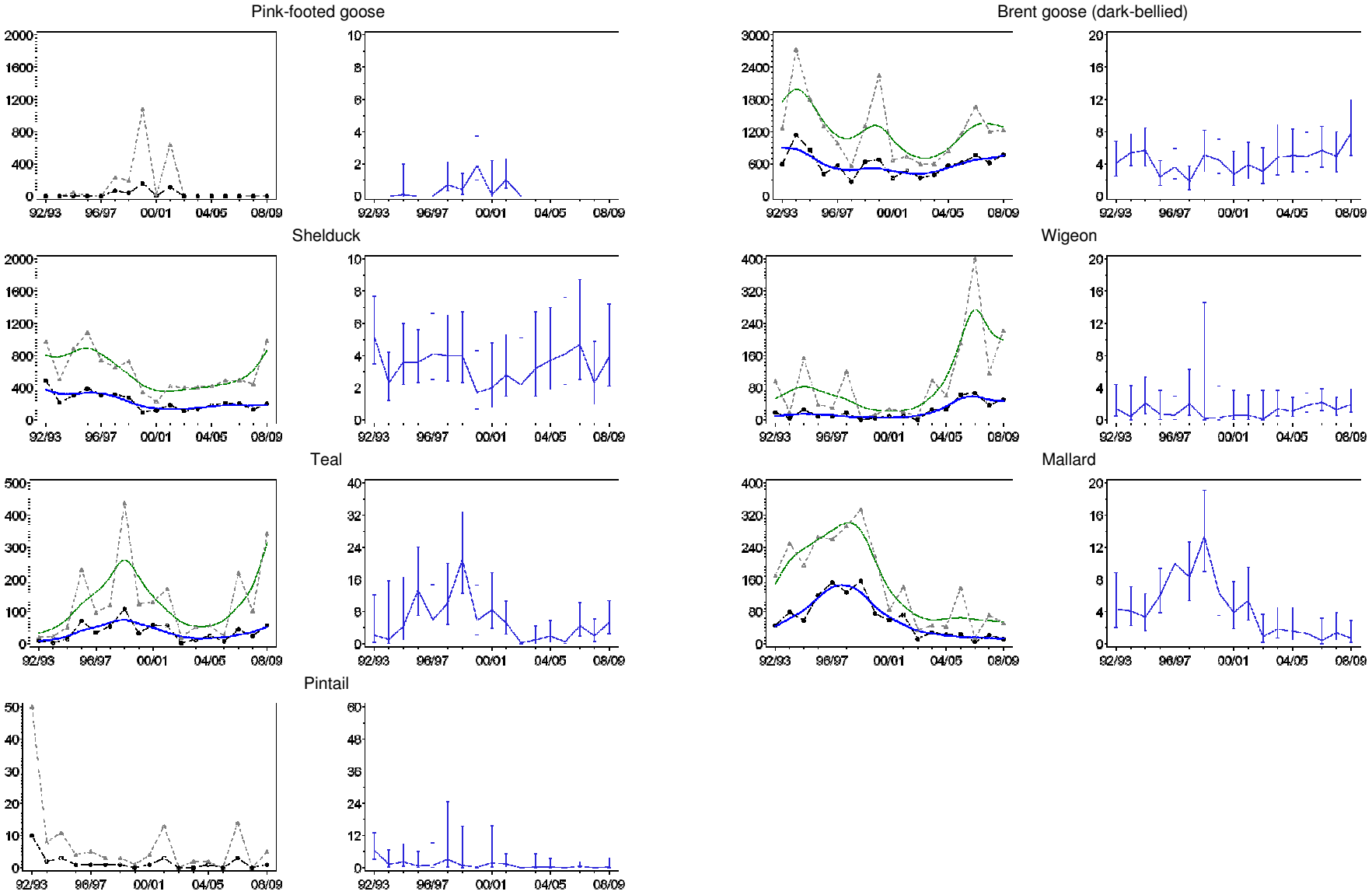


Figure A.35416 Population trends of each species in sector 35416 (Butterwick) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

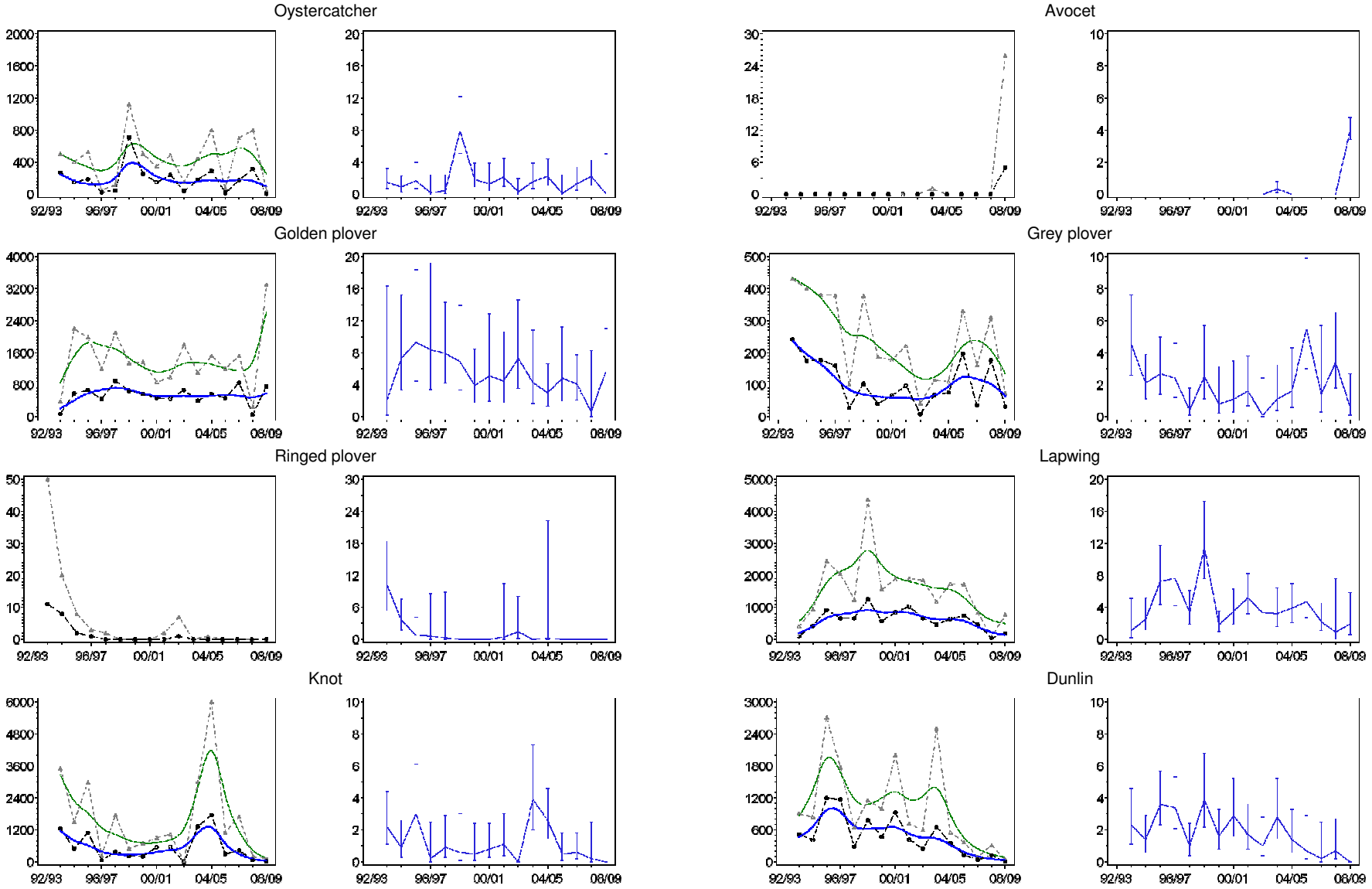
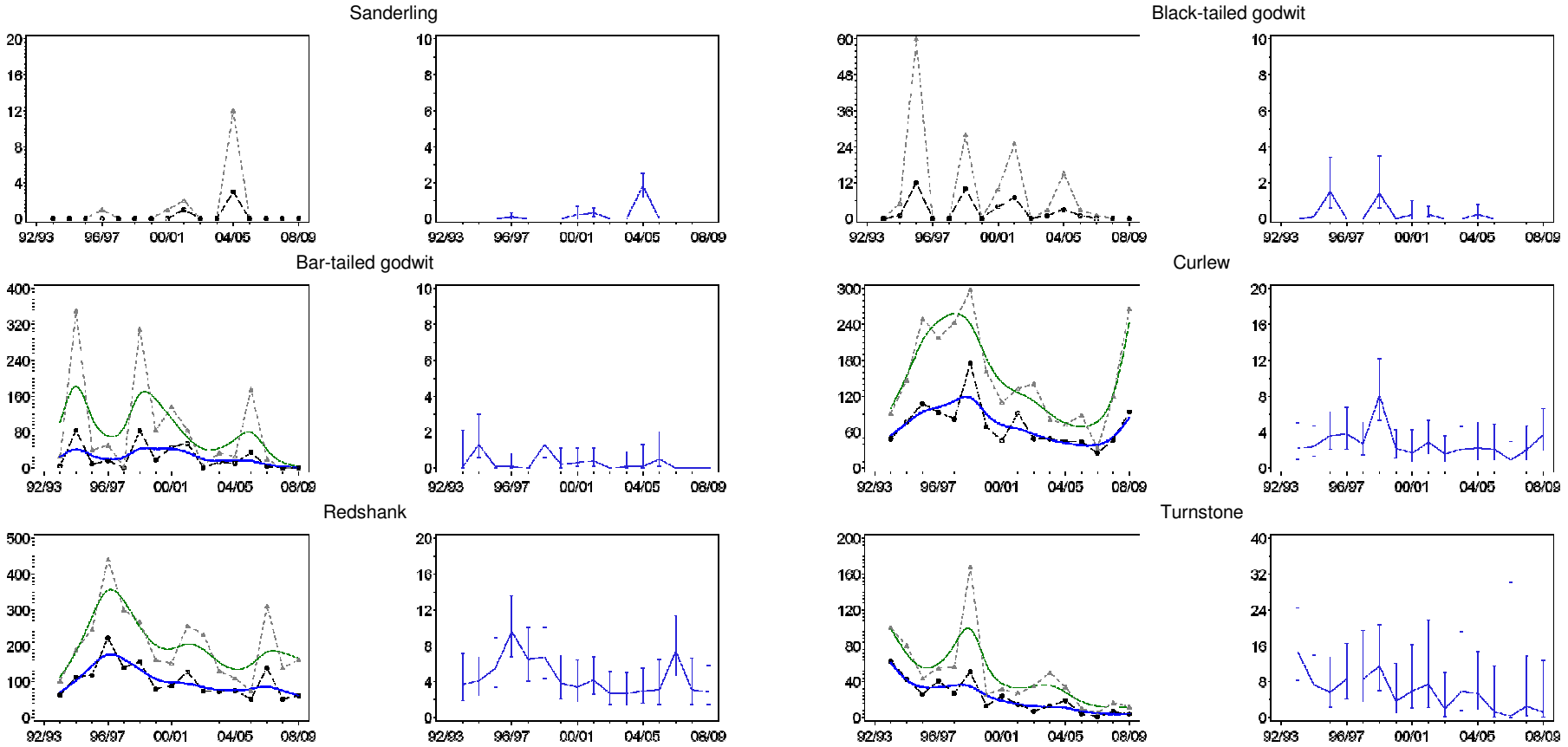


Figure A.35416 Continued



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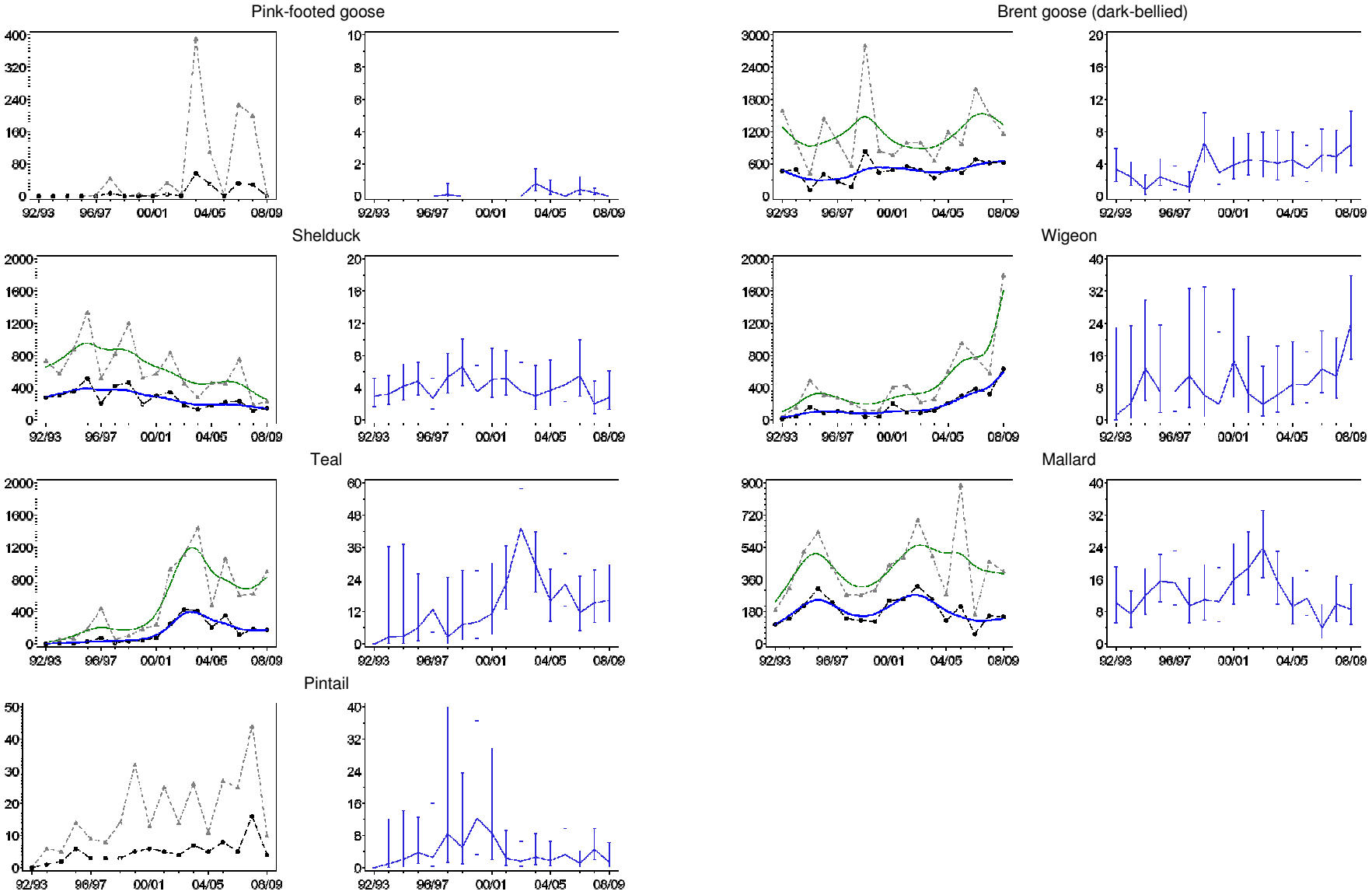


Figure A.35417 Population trends of each species in sector 35417 (Freiston) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

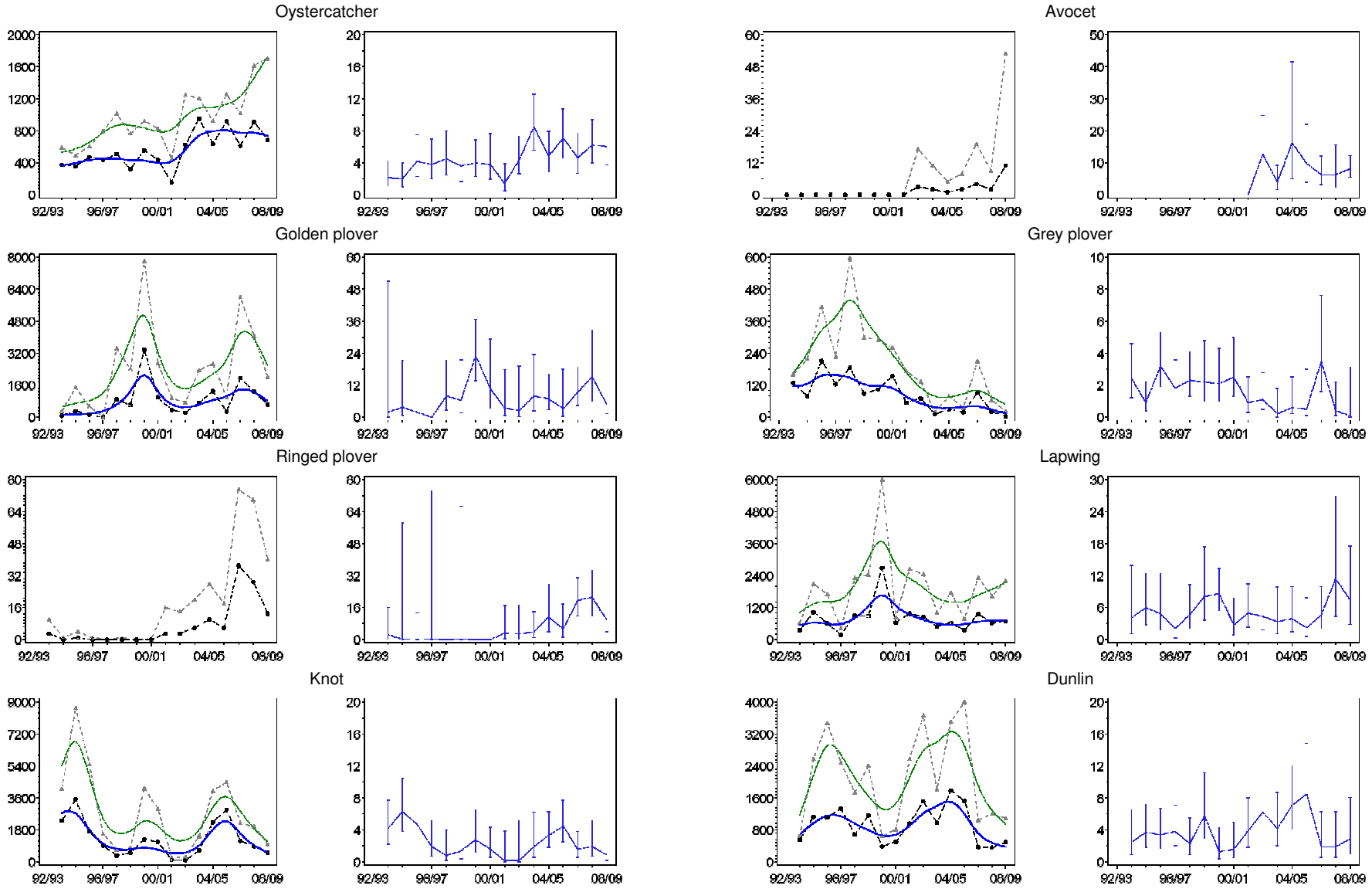
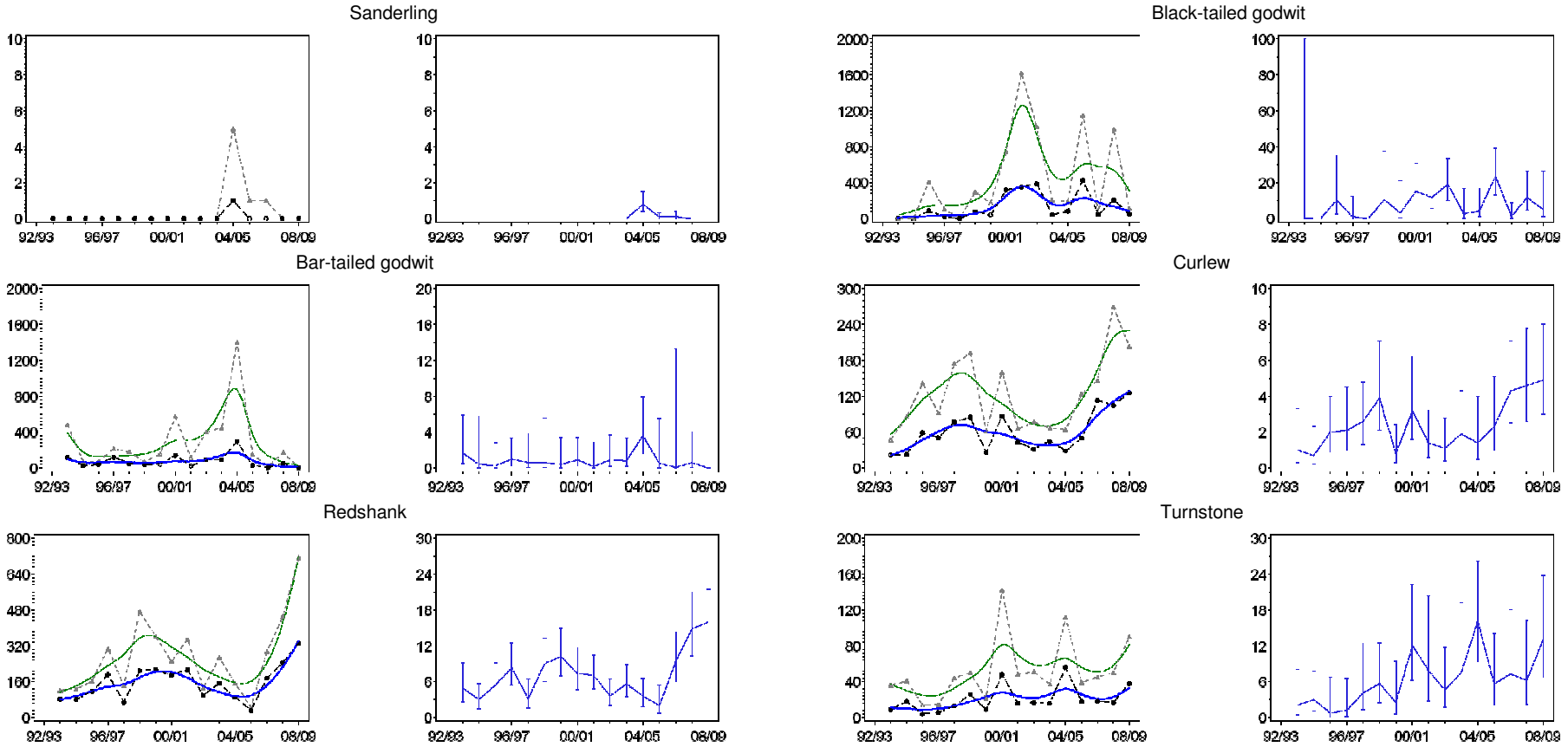


Figure A.35417 Continued



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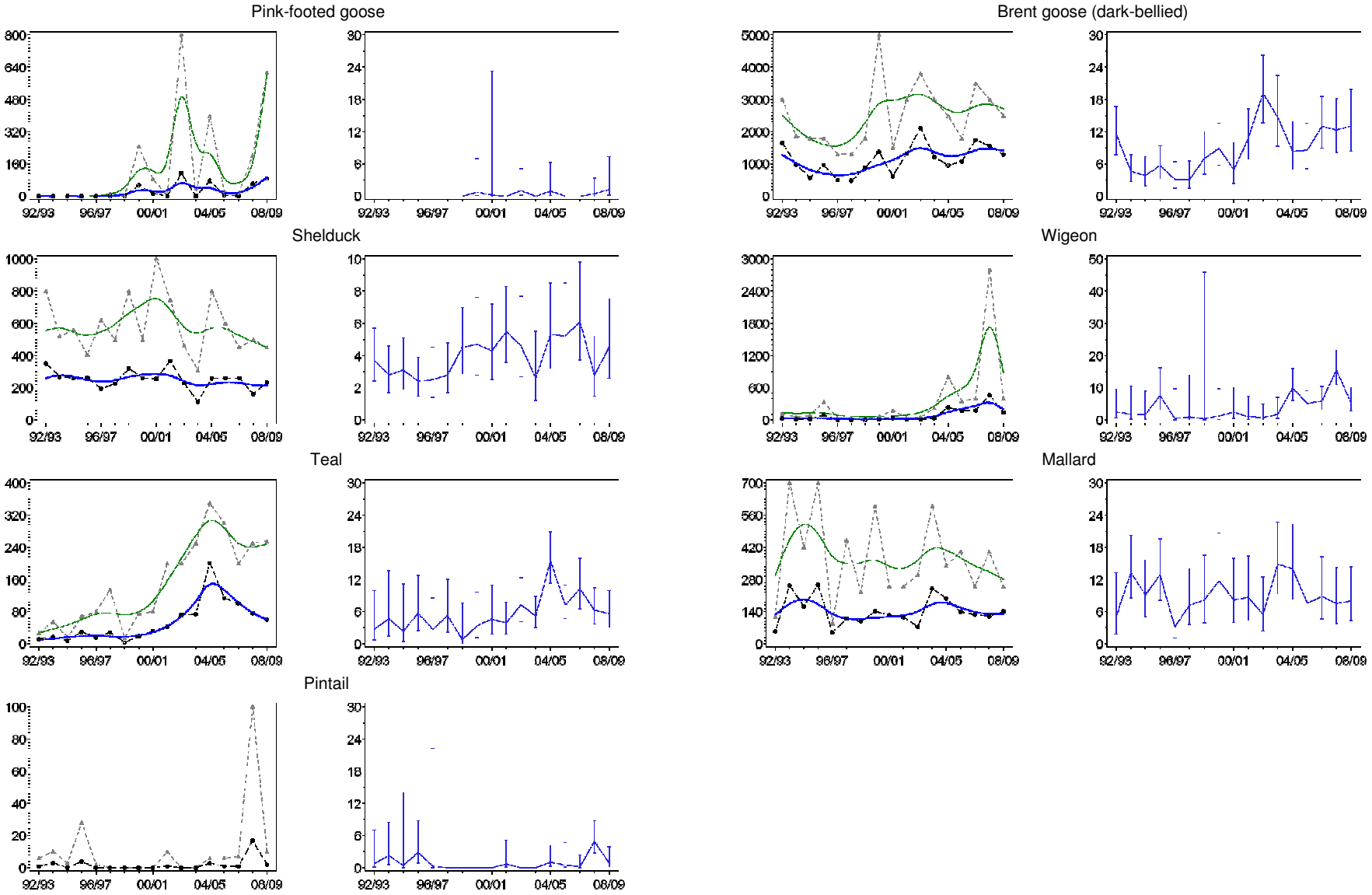
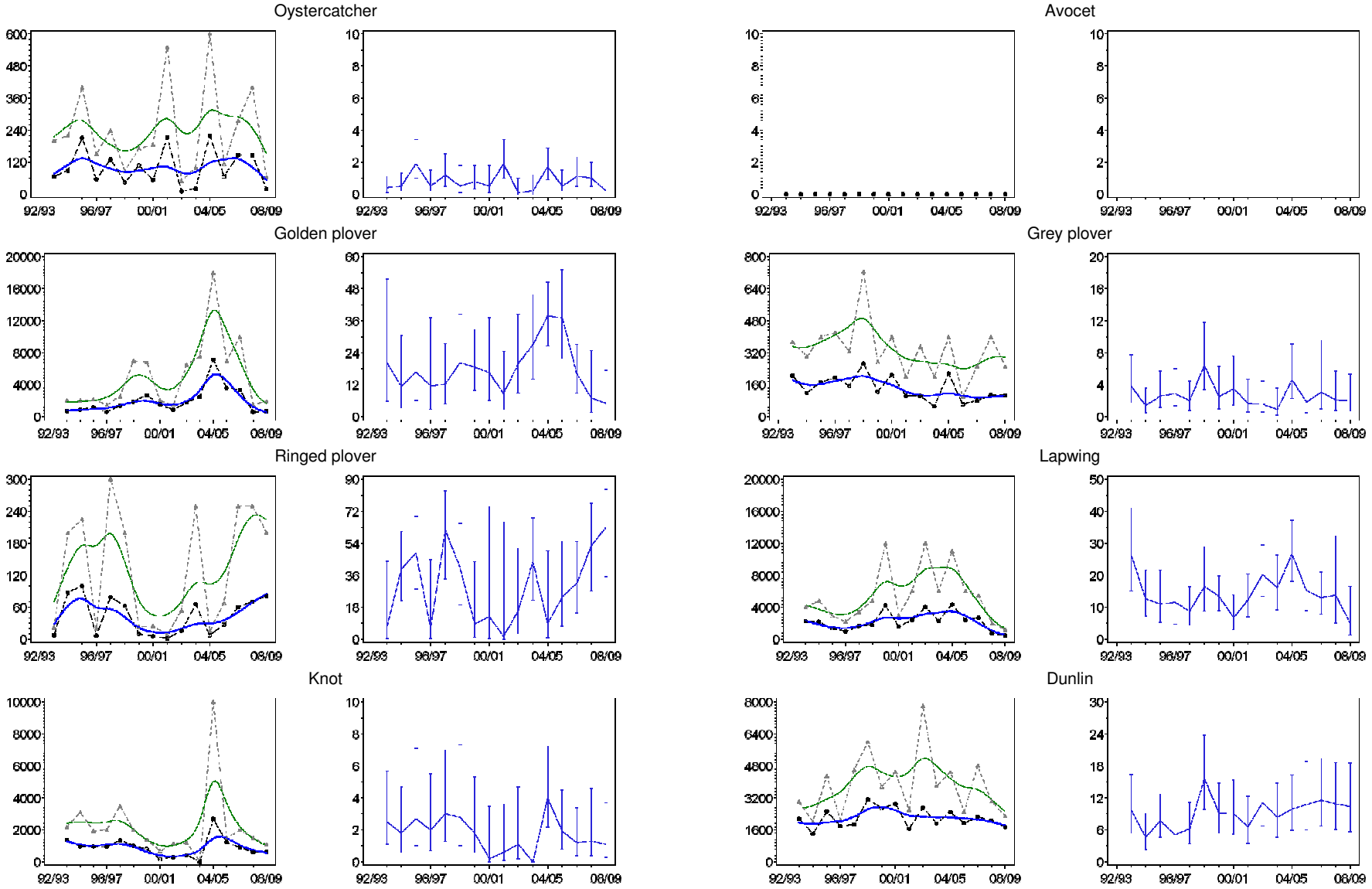


Figure A.35418 Population trends of each species in sector 35418 (Witham) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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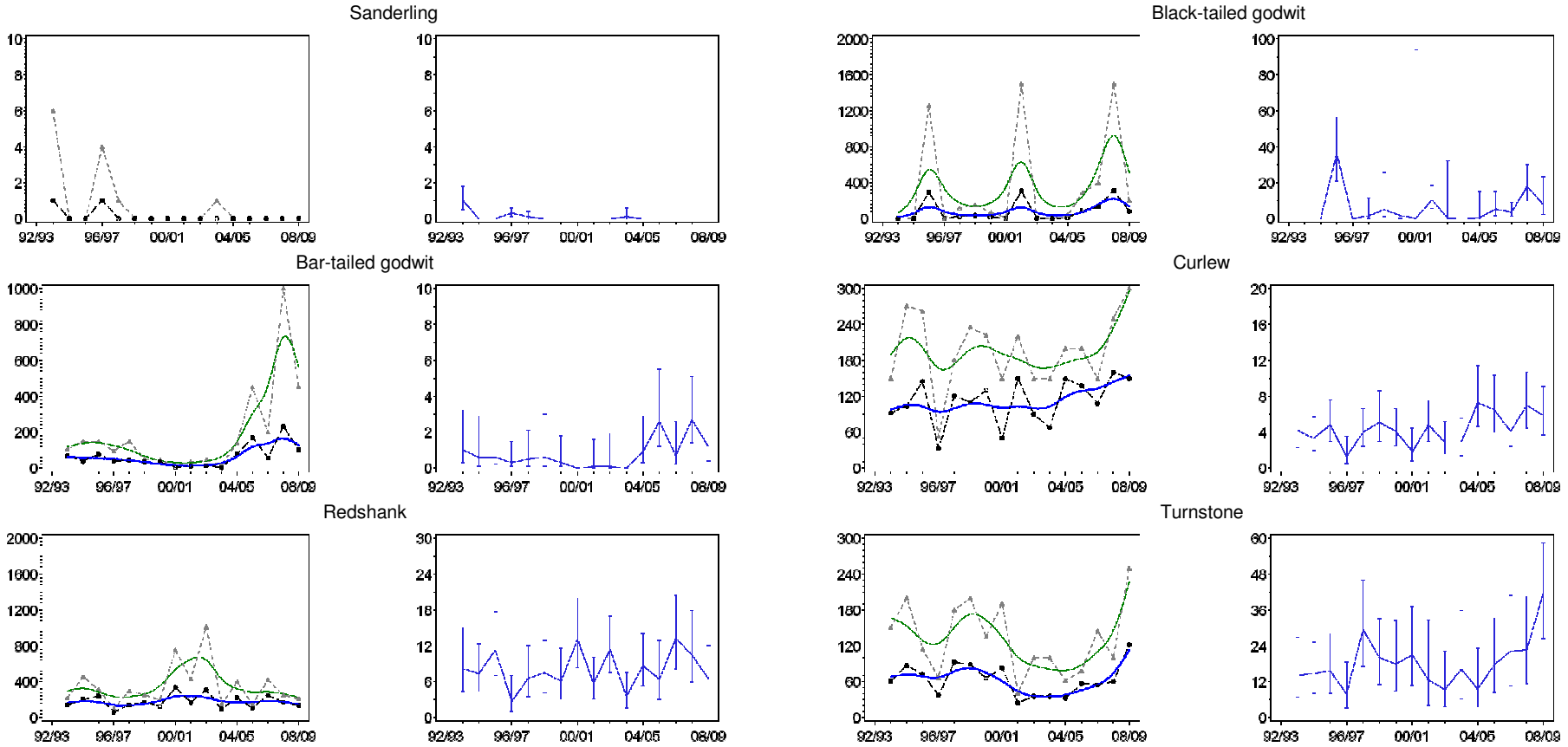

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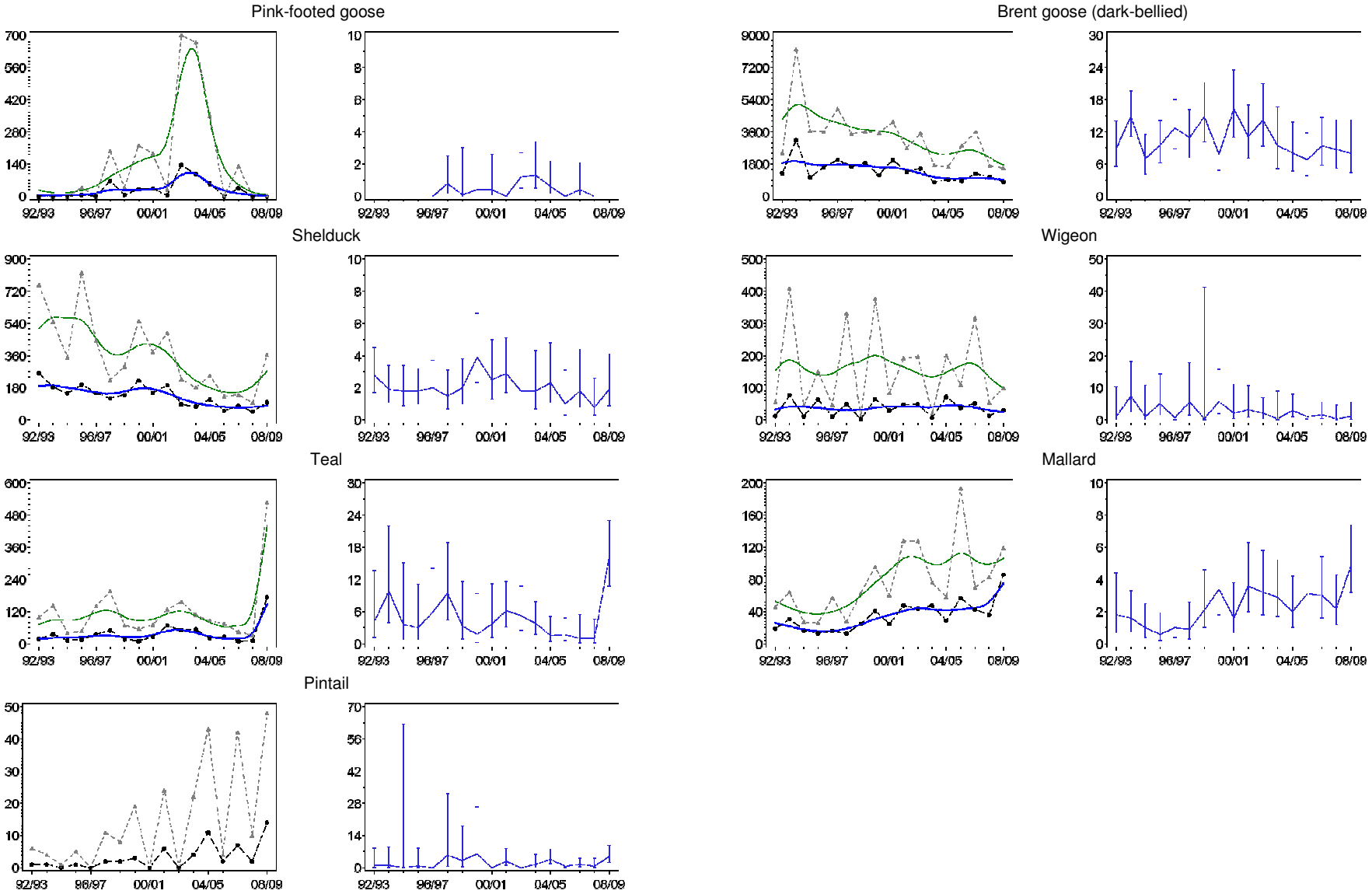
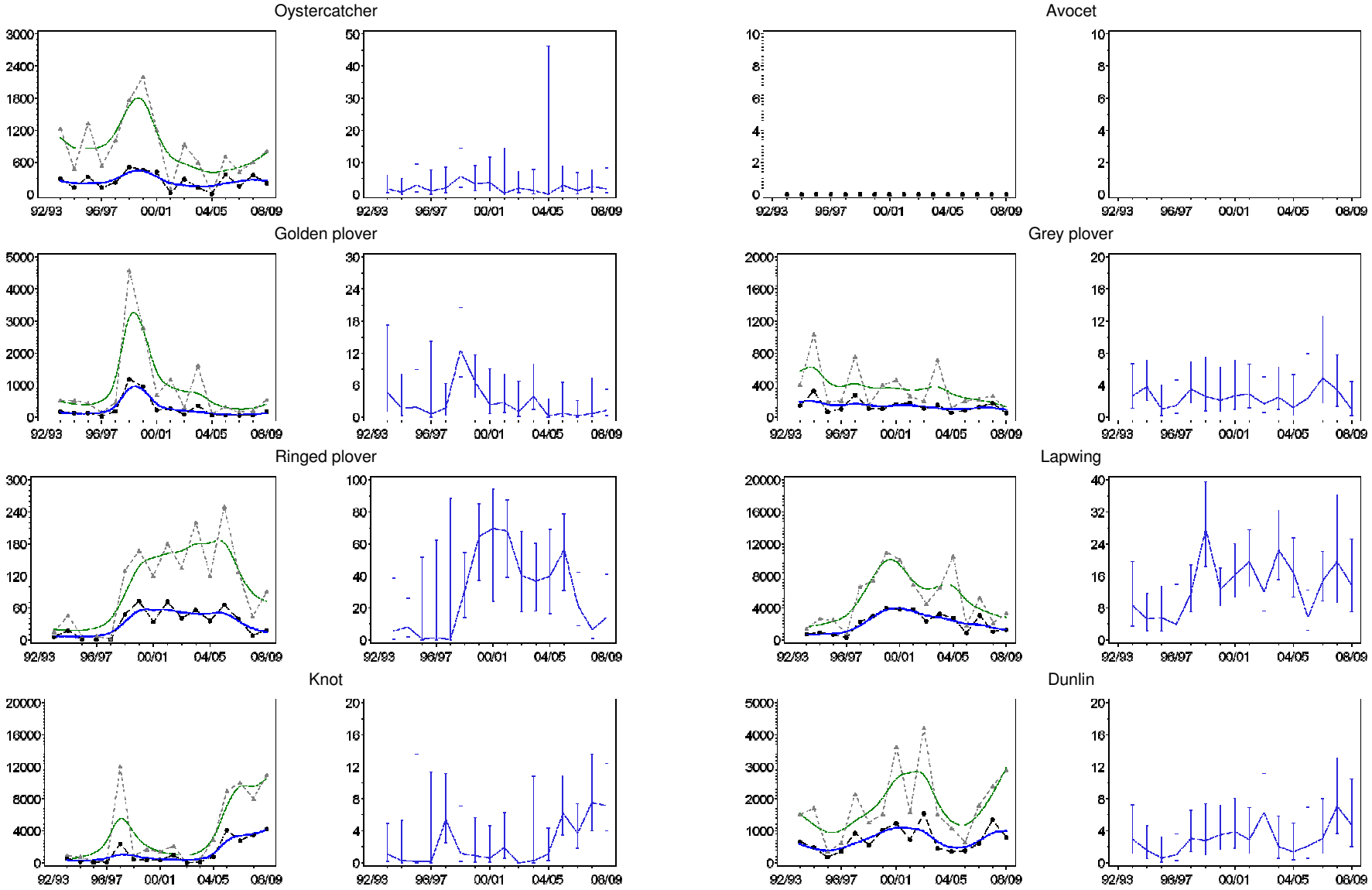


Figure A.35408 Population trends of each species in sector 35408 (Frampton) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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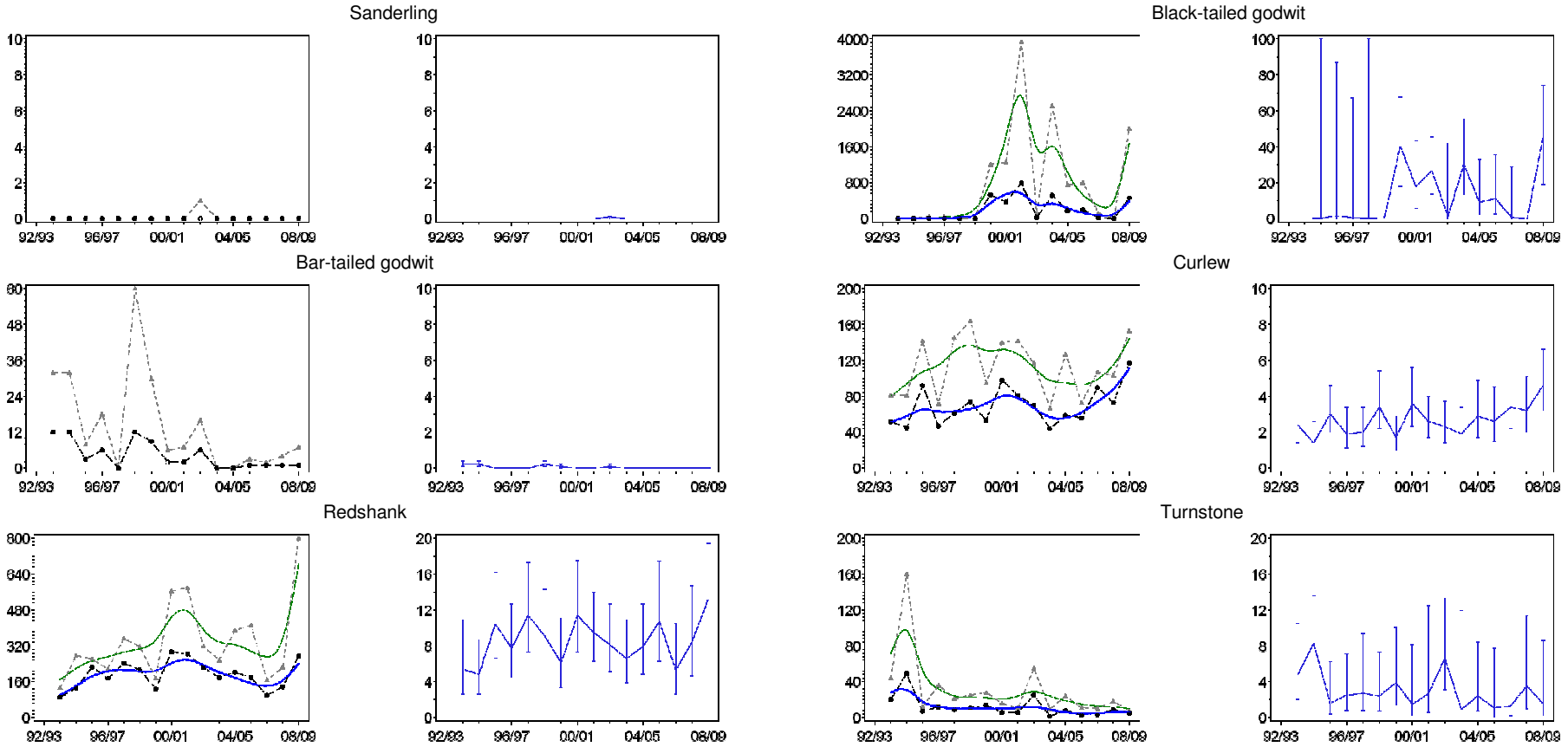

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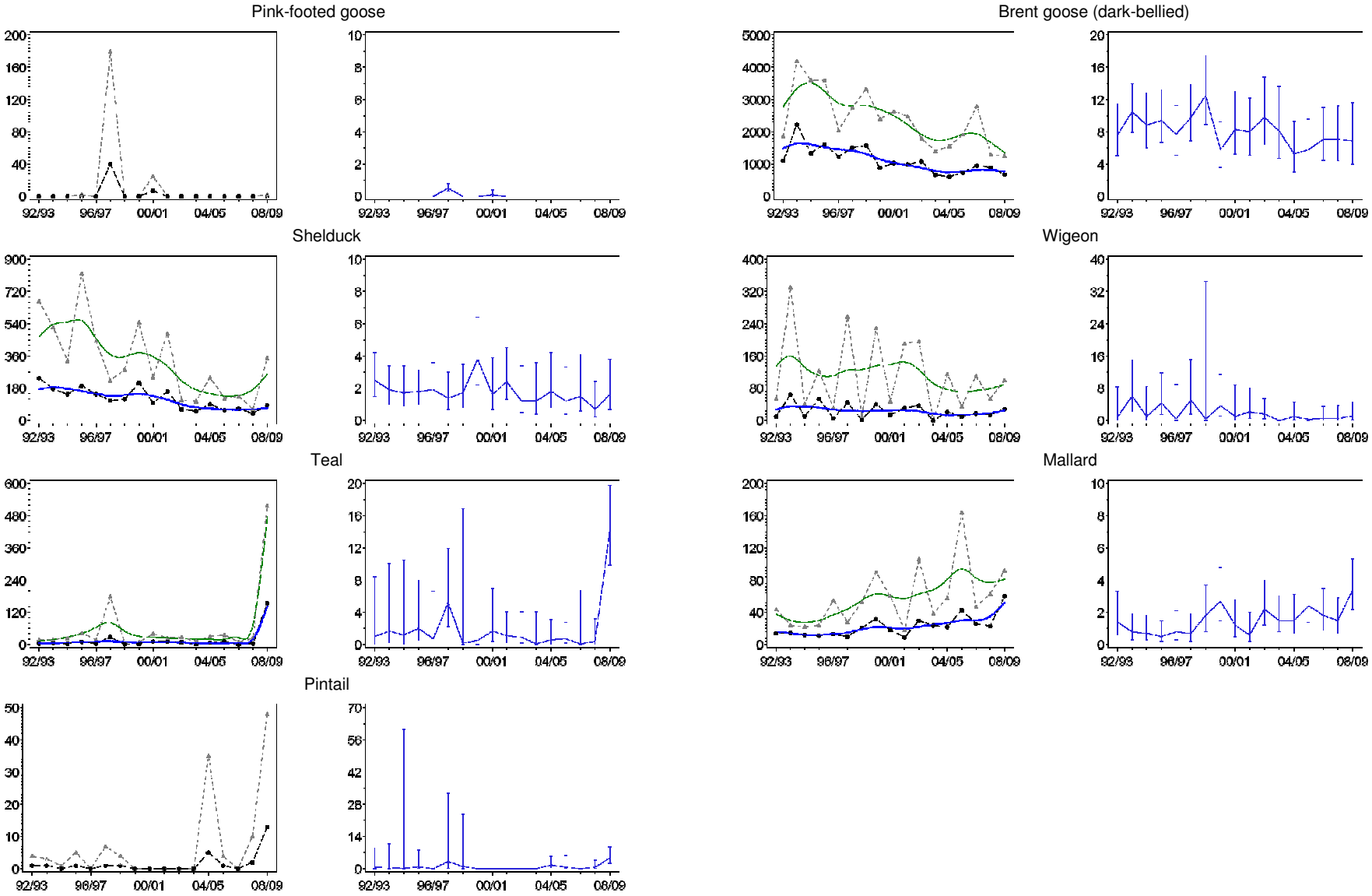


Figure A.35419 Population trends of each species in sector 35419 (Frampton North) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

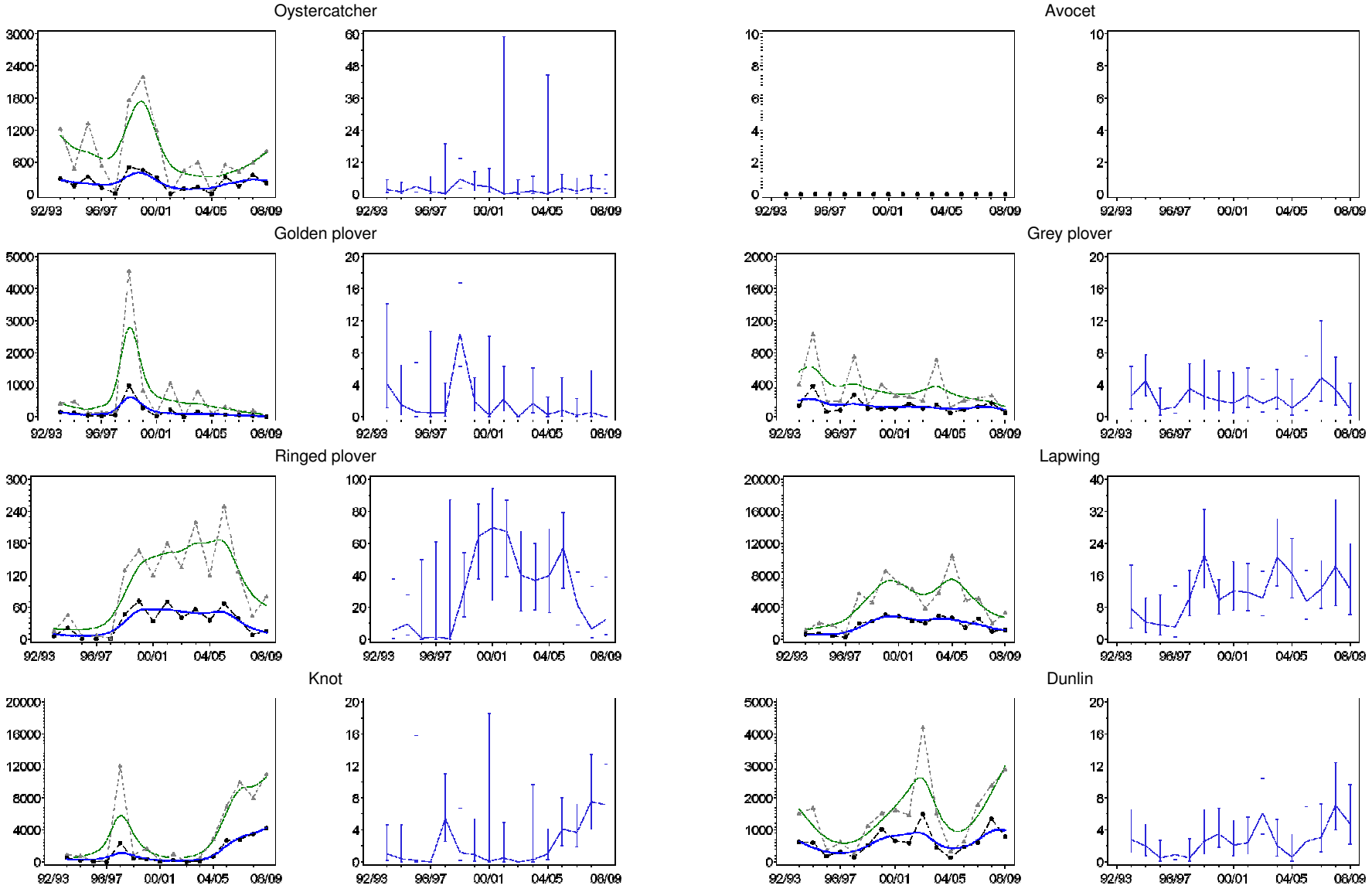
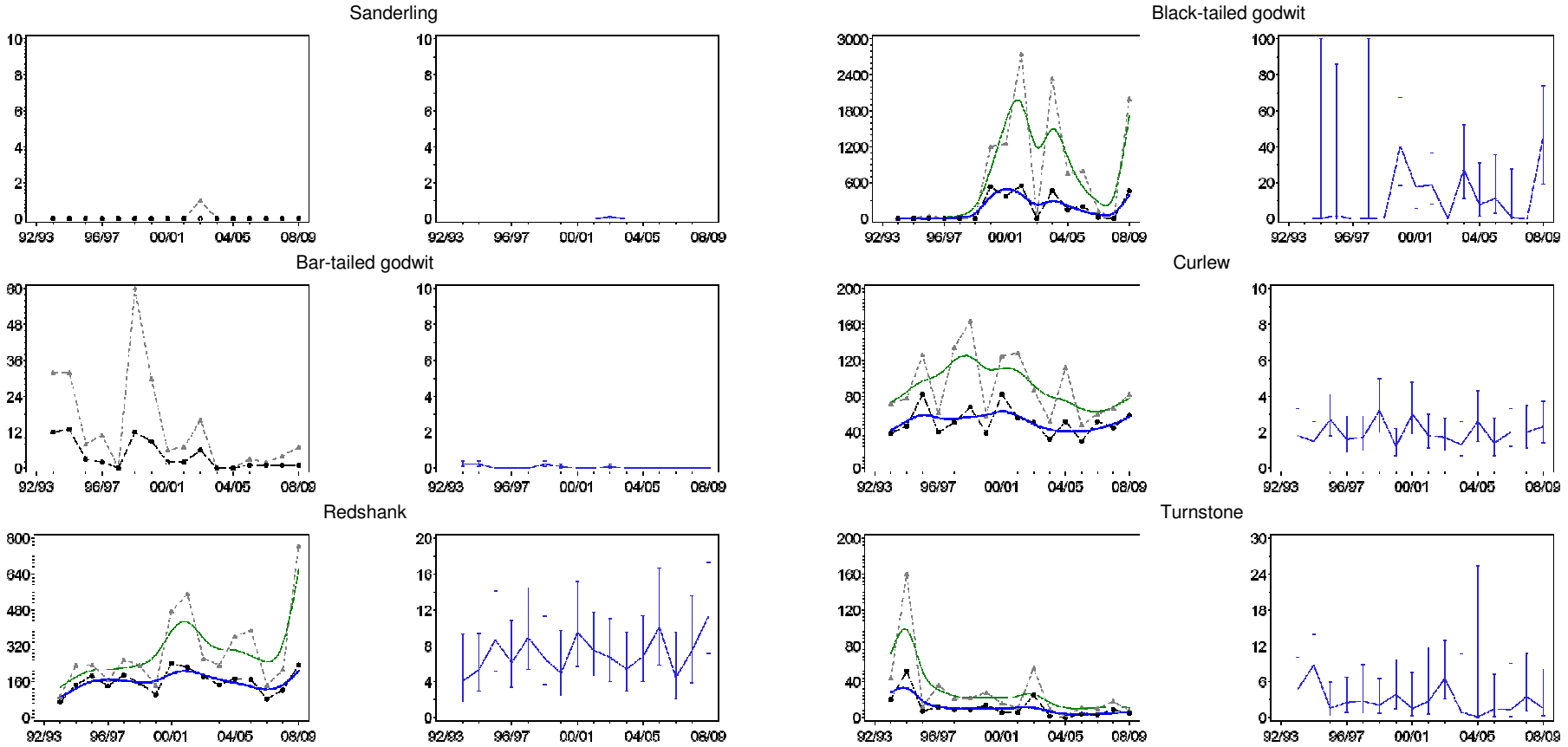


Figure A.35419 Continued



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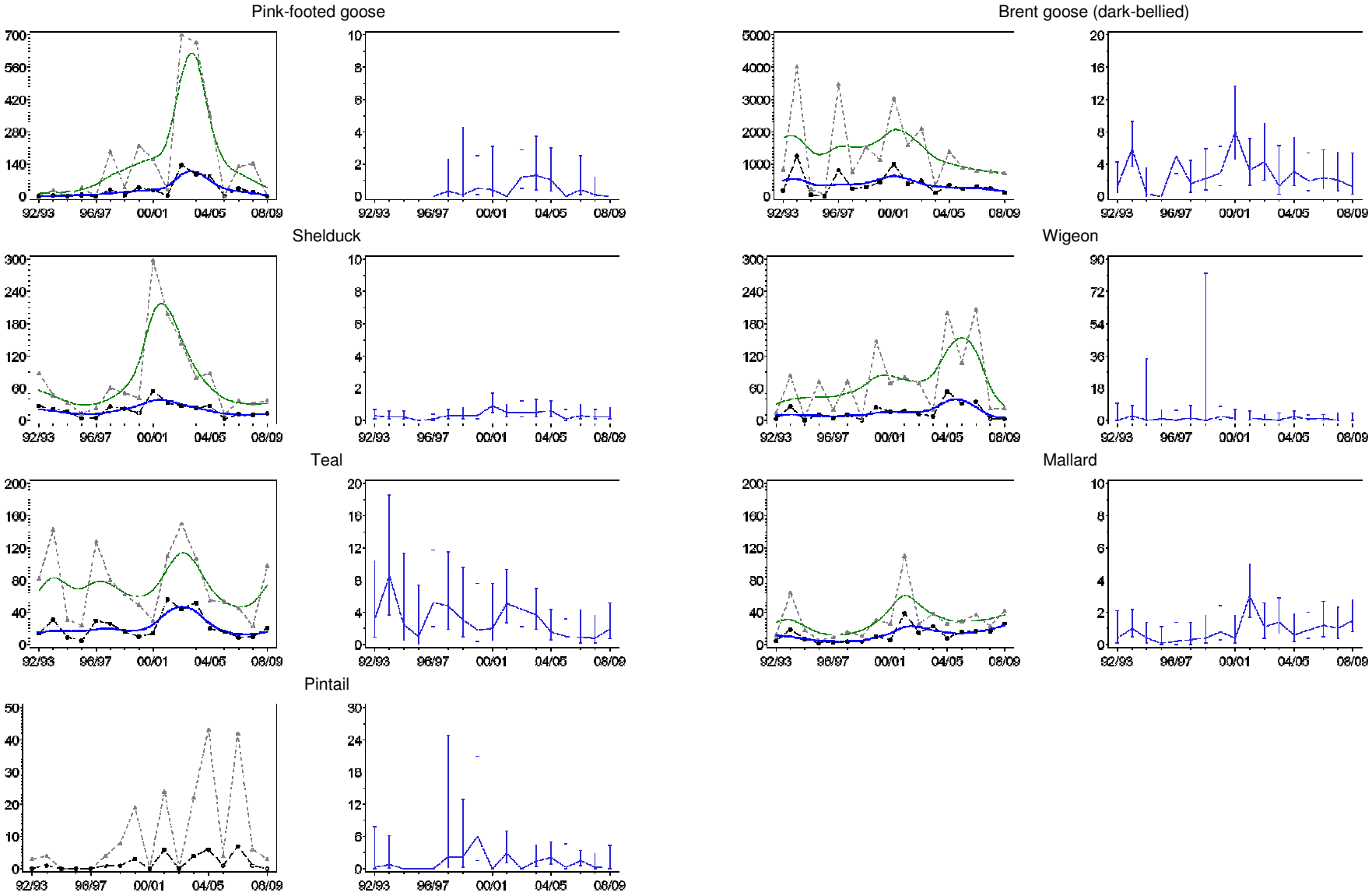
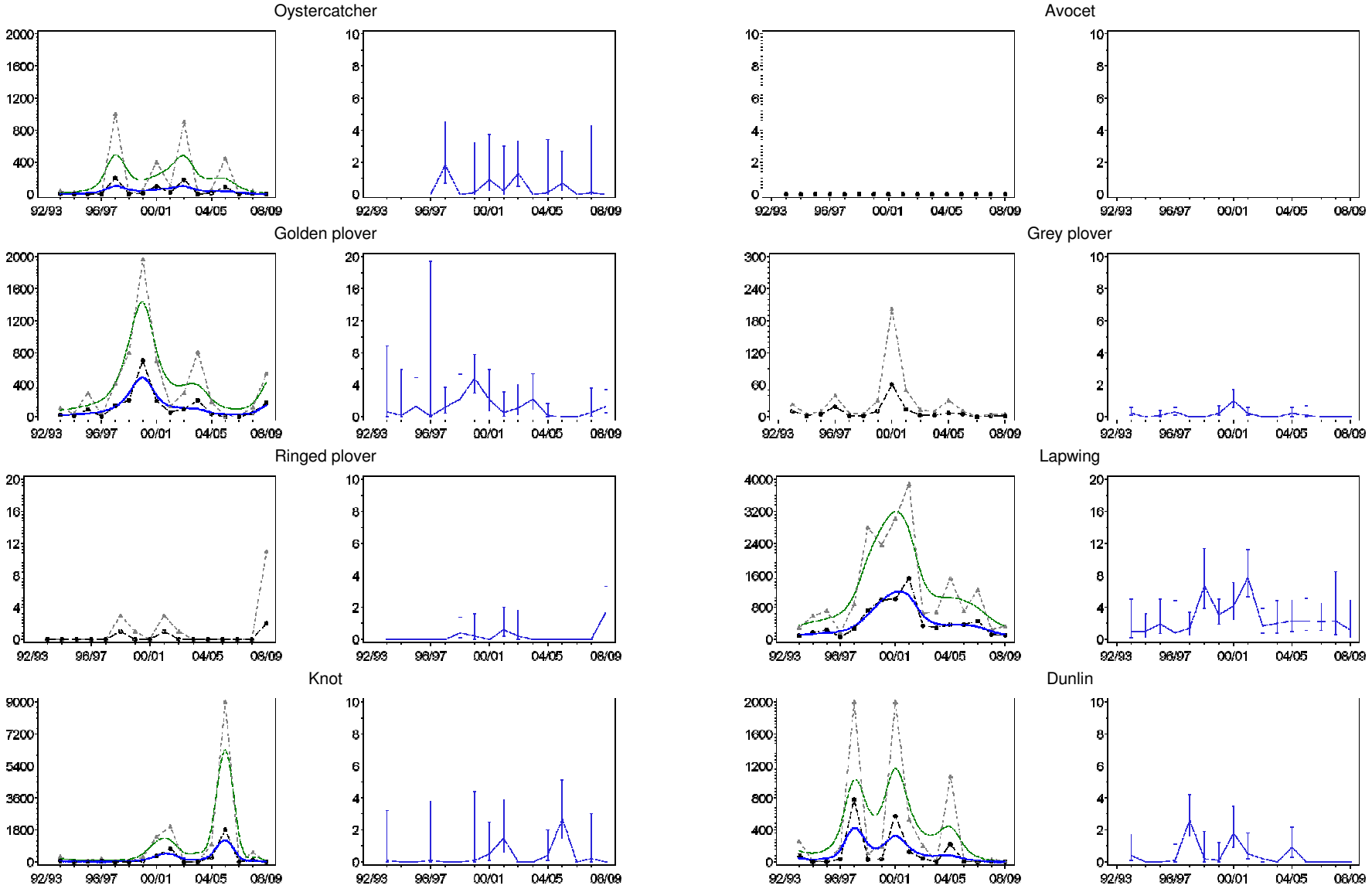


Figure A.35420 Population trends of each species in sector 35420 (Frampton South) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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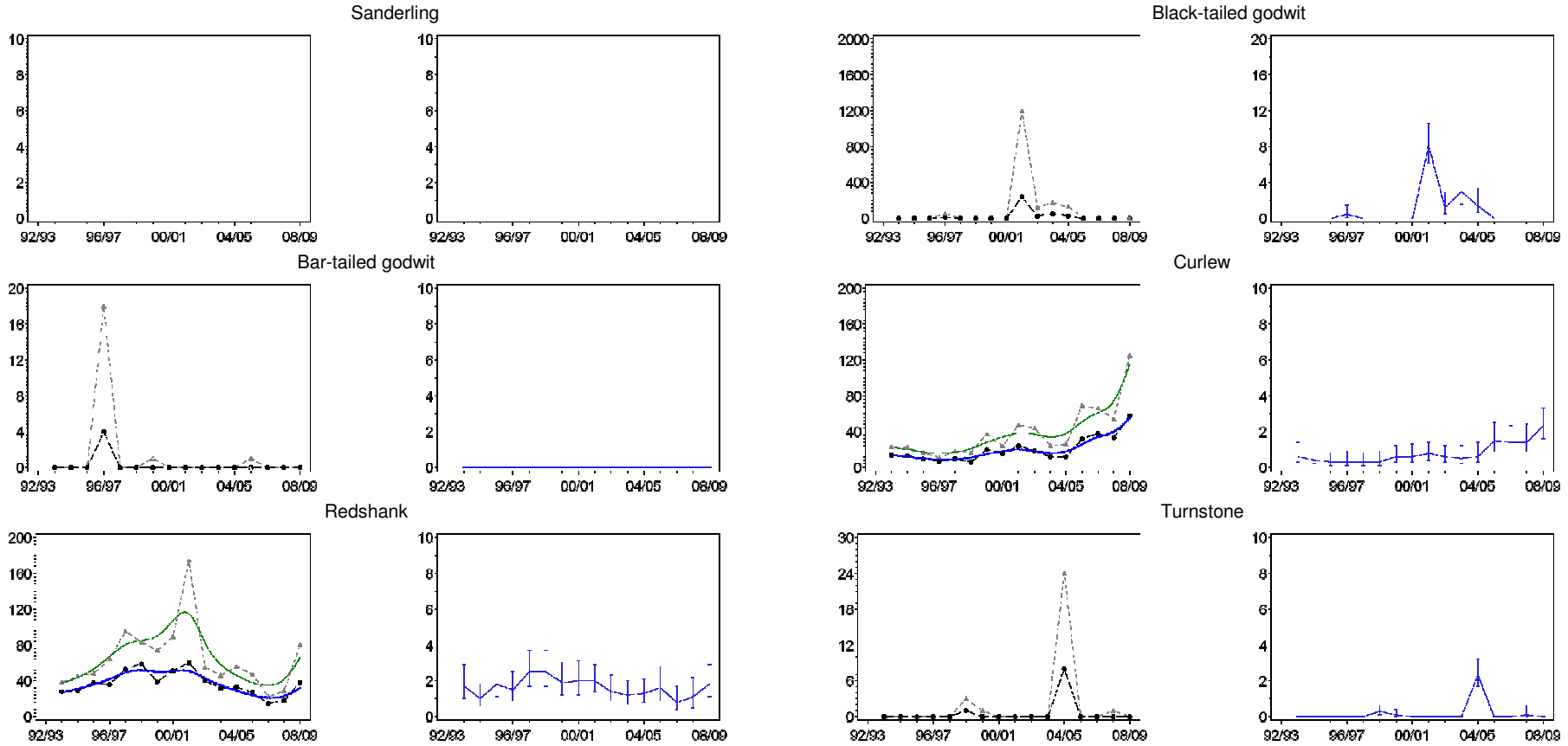

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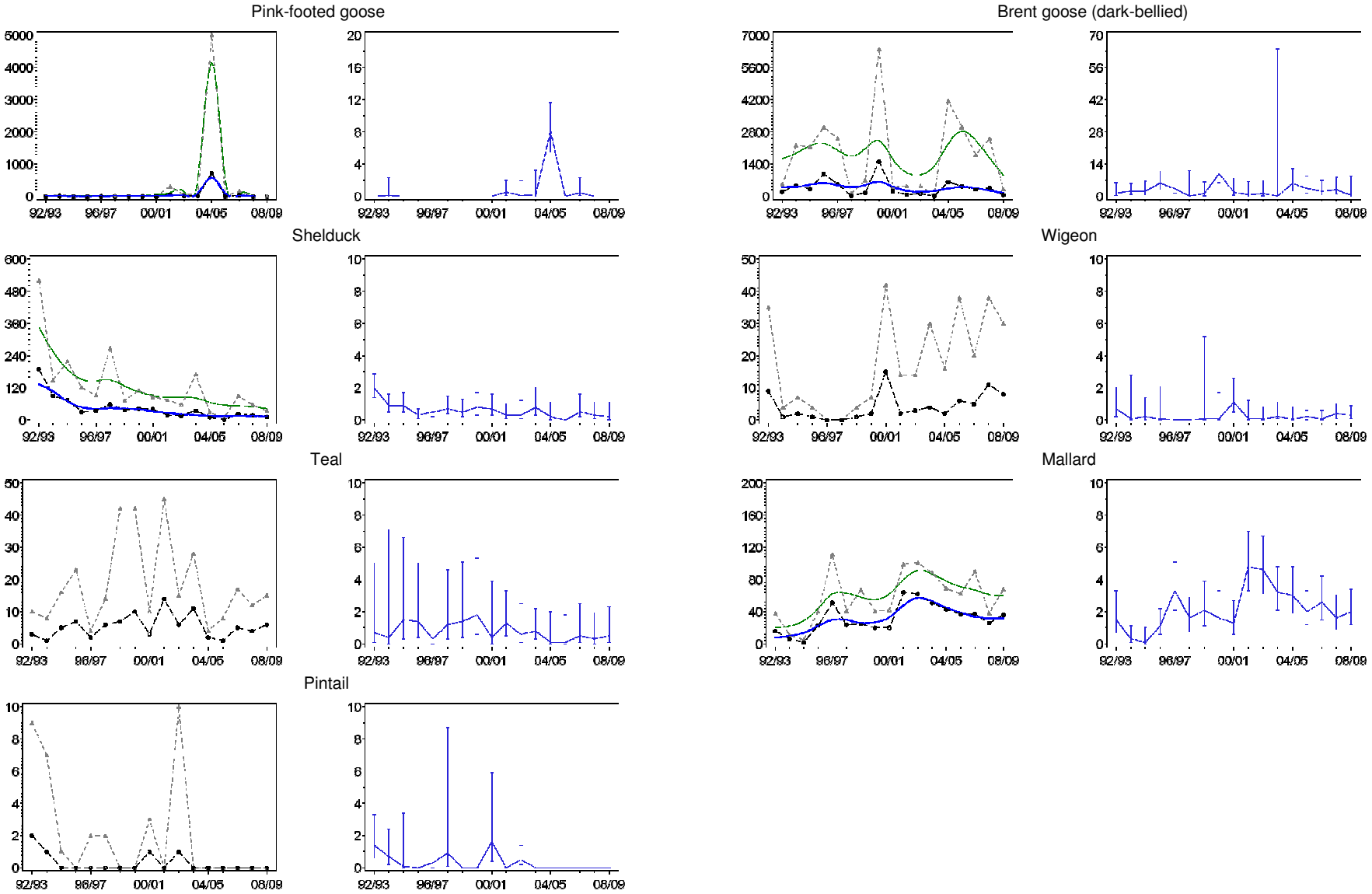
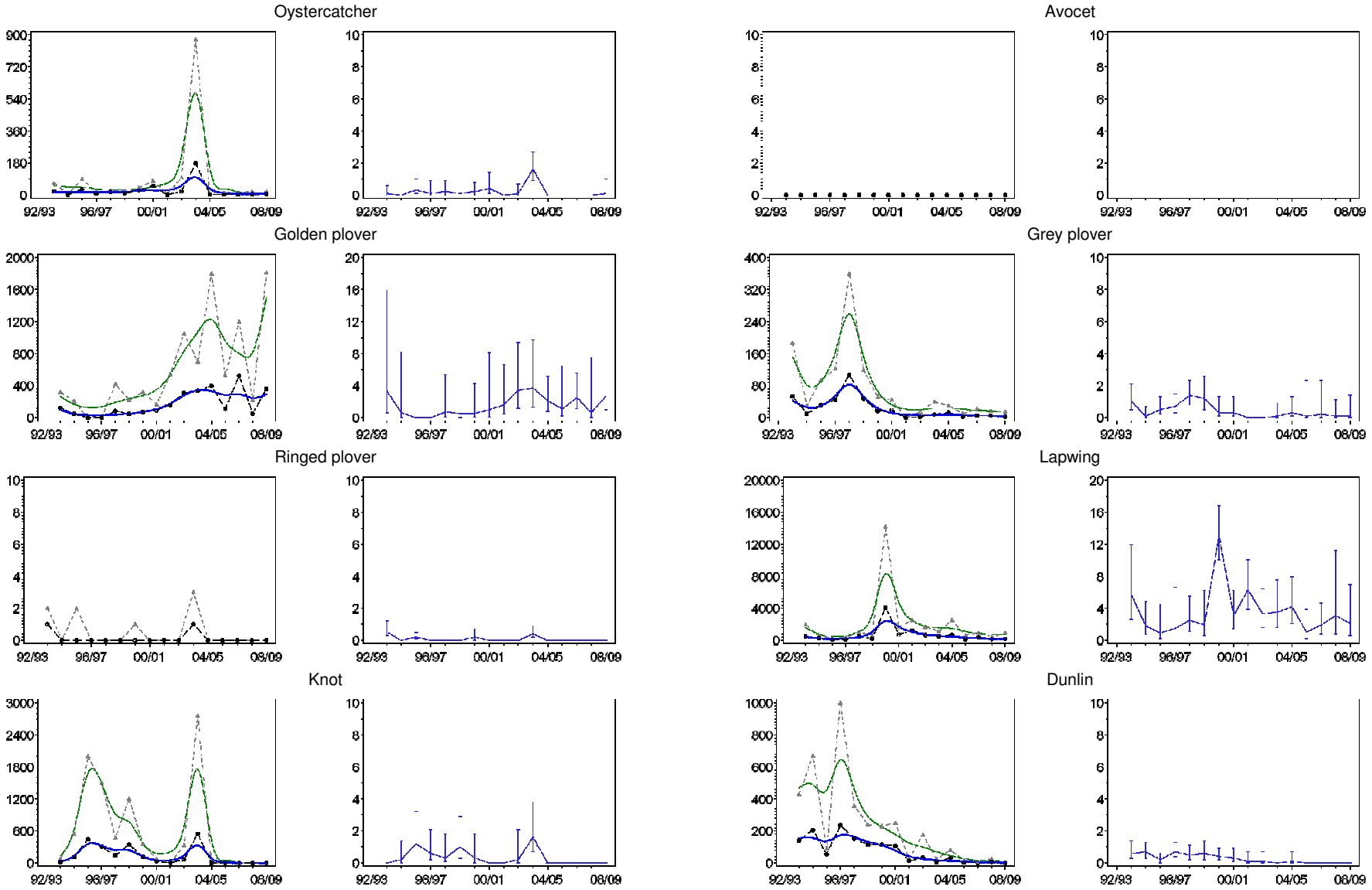


Figure A.35407 Population trends of each species in sector 35407 (Kirton) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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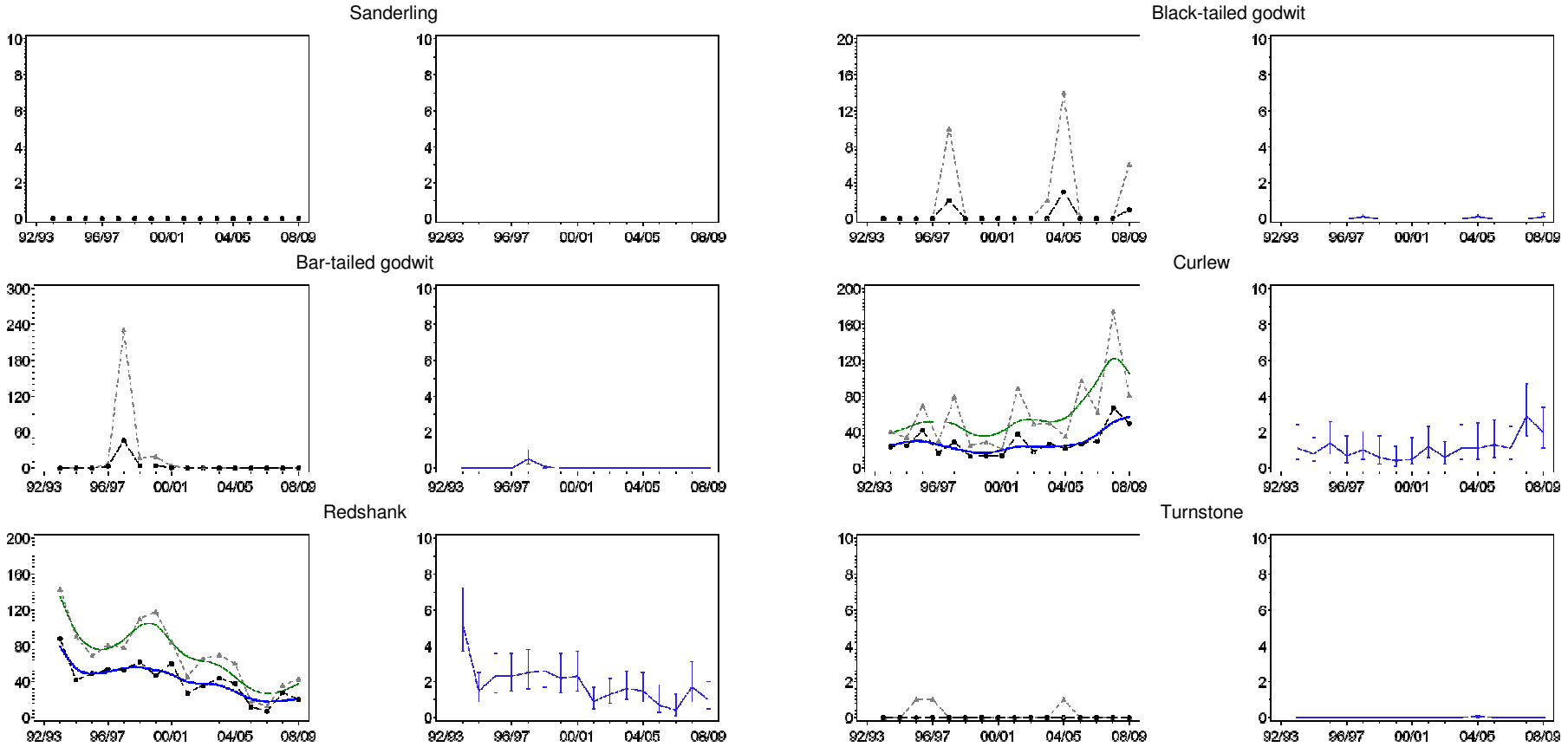

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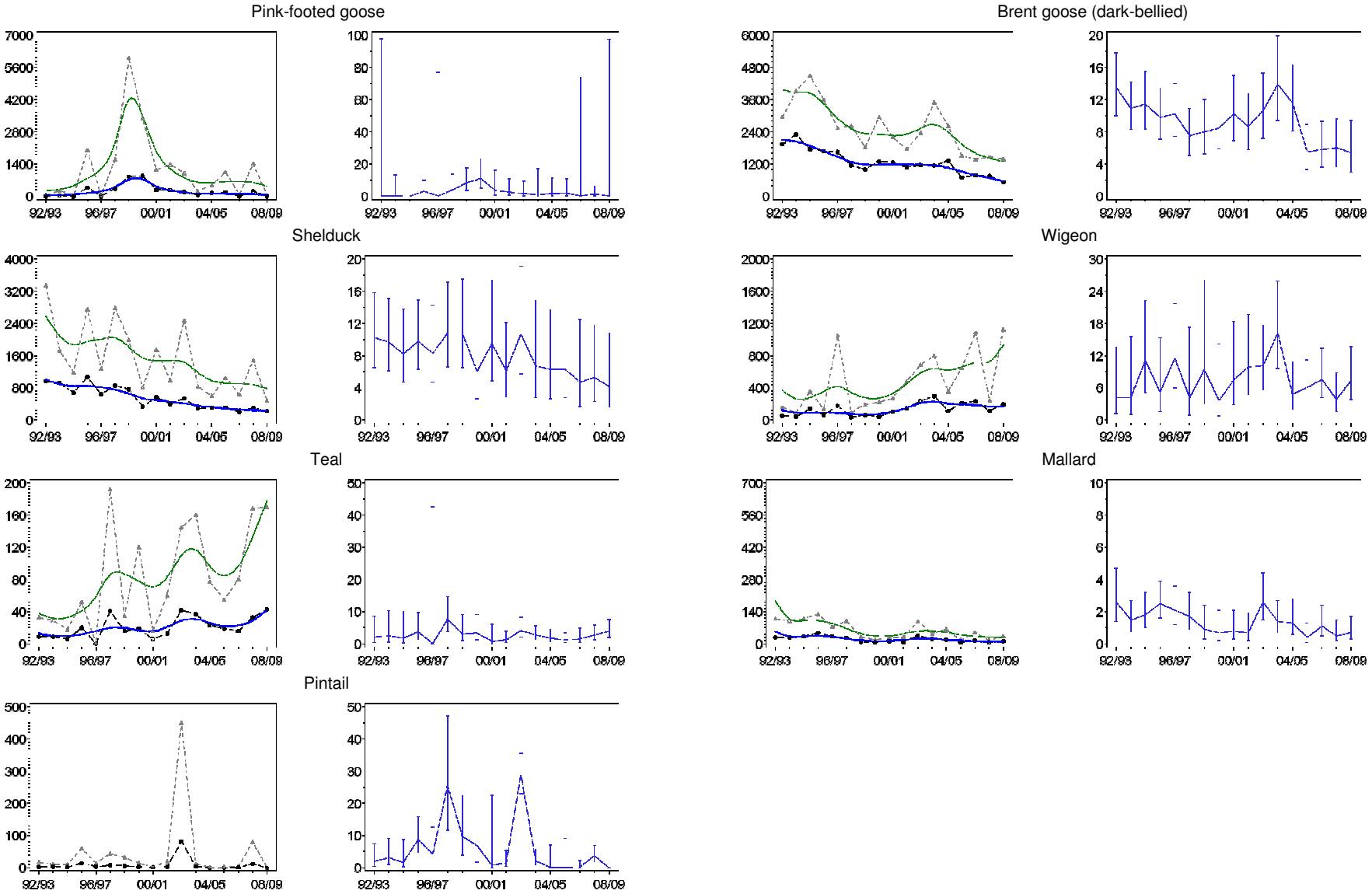
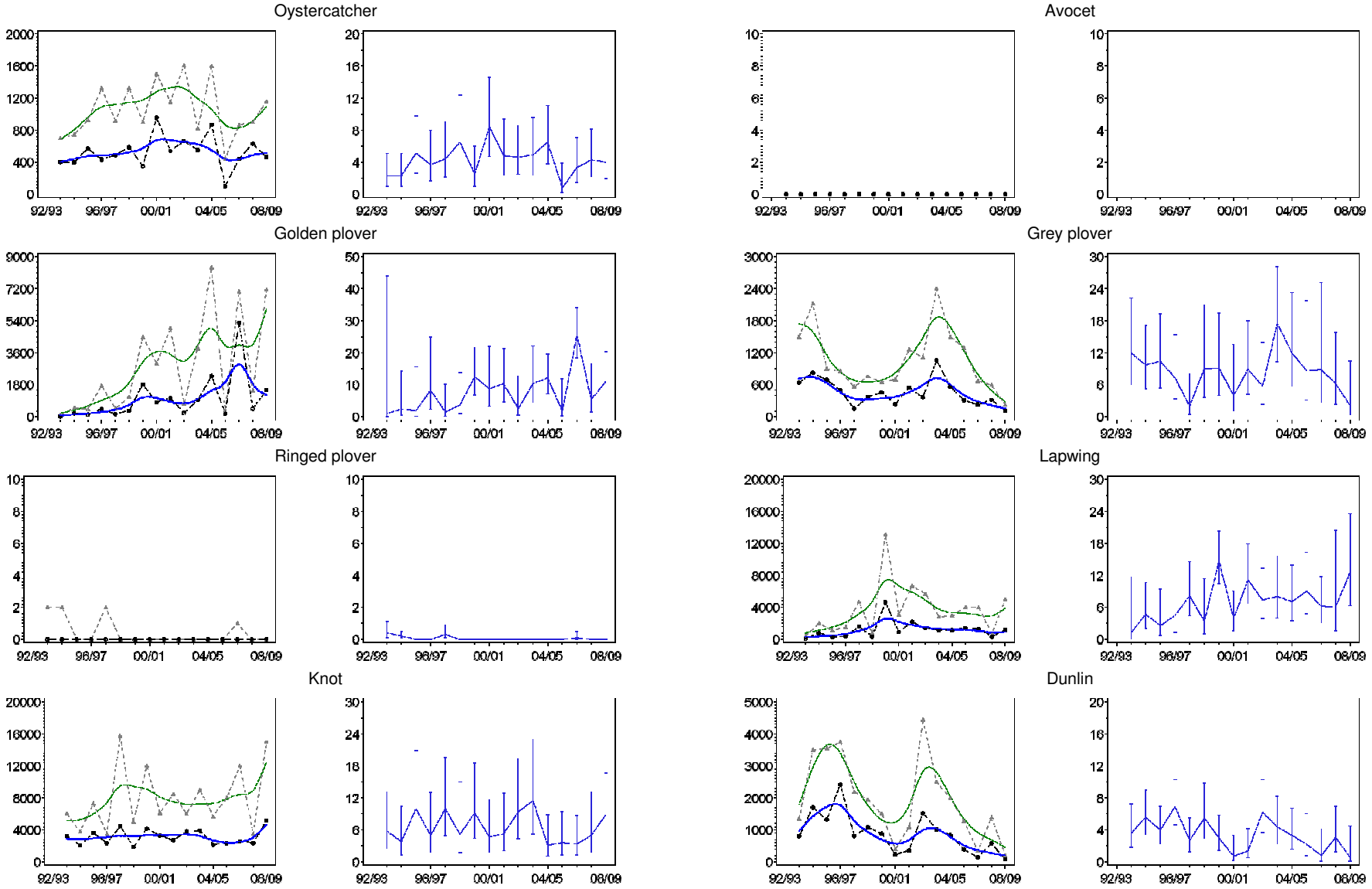


Figure A.35405 Population trends of each species in sector 35405 (Welland) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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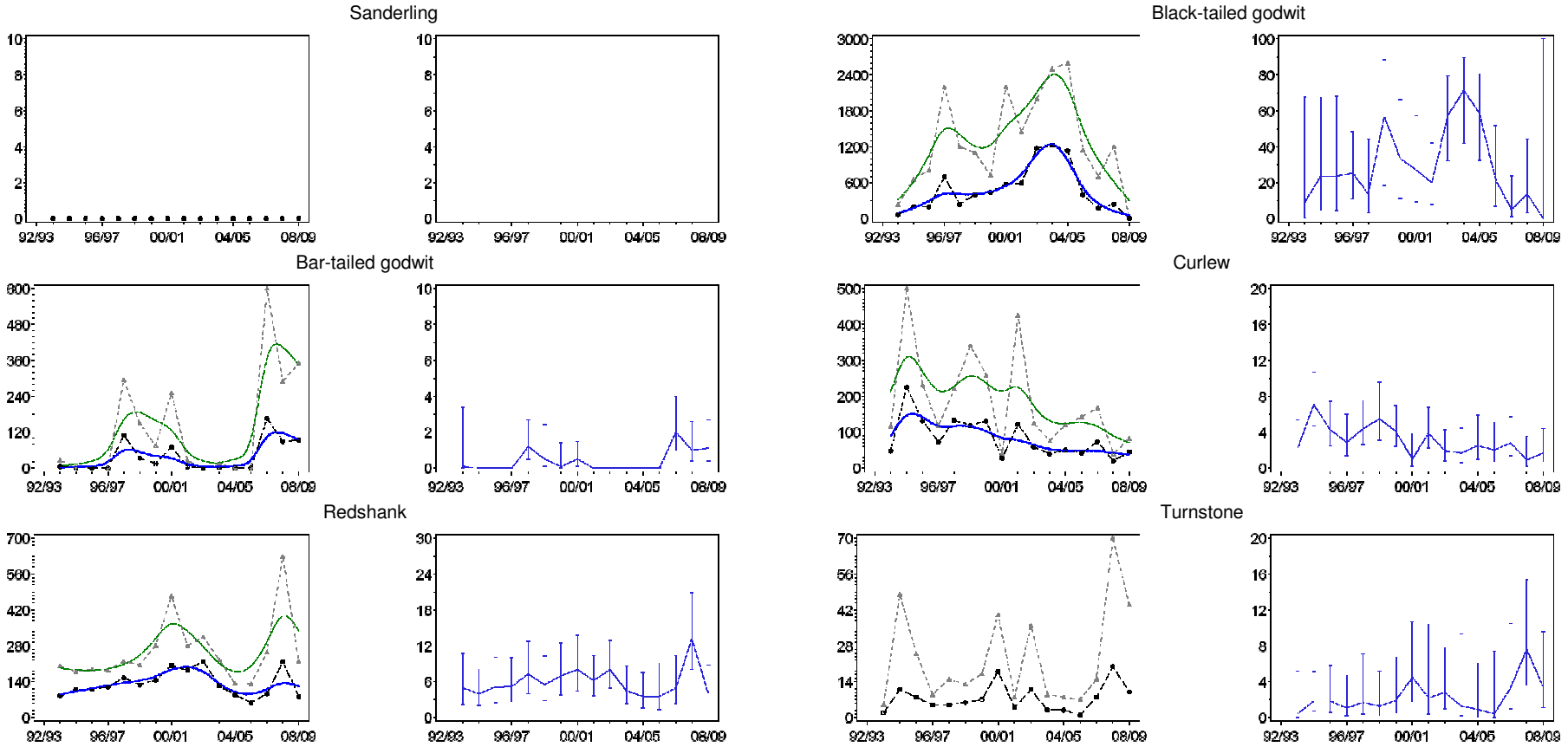

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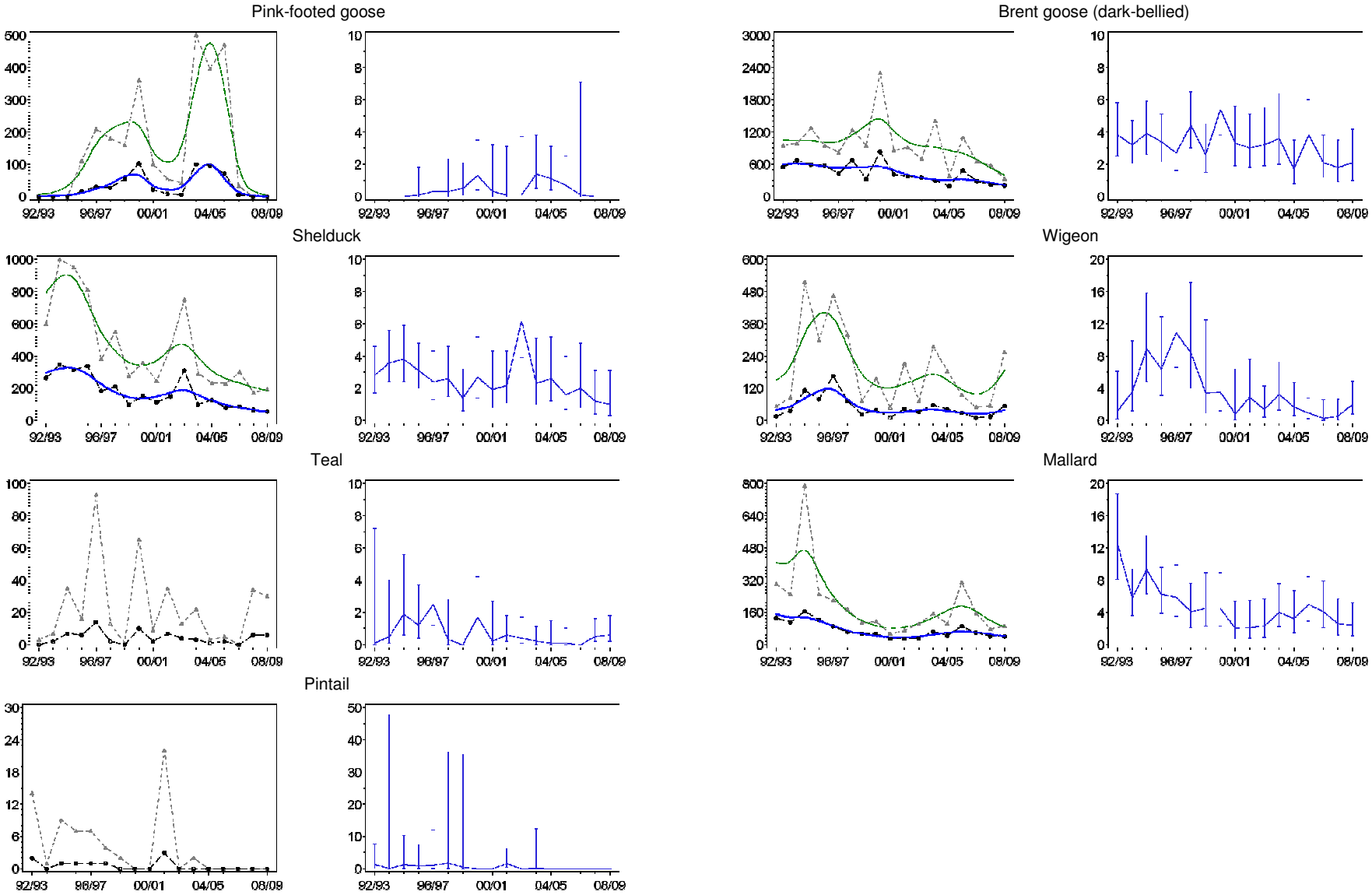
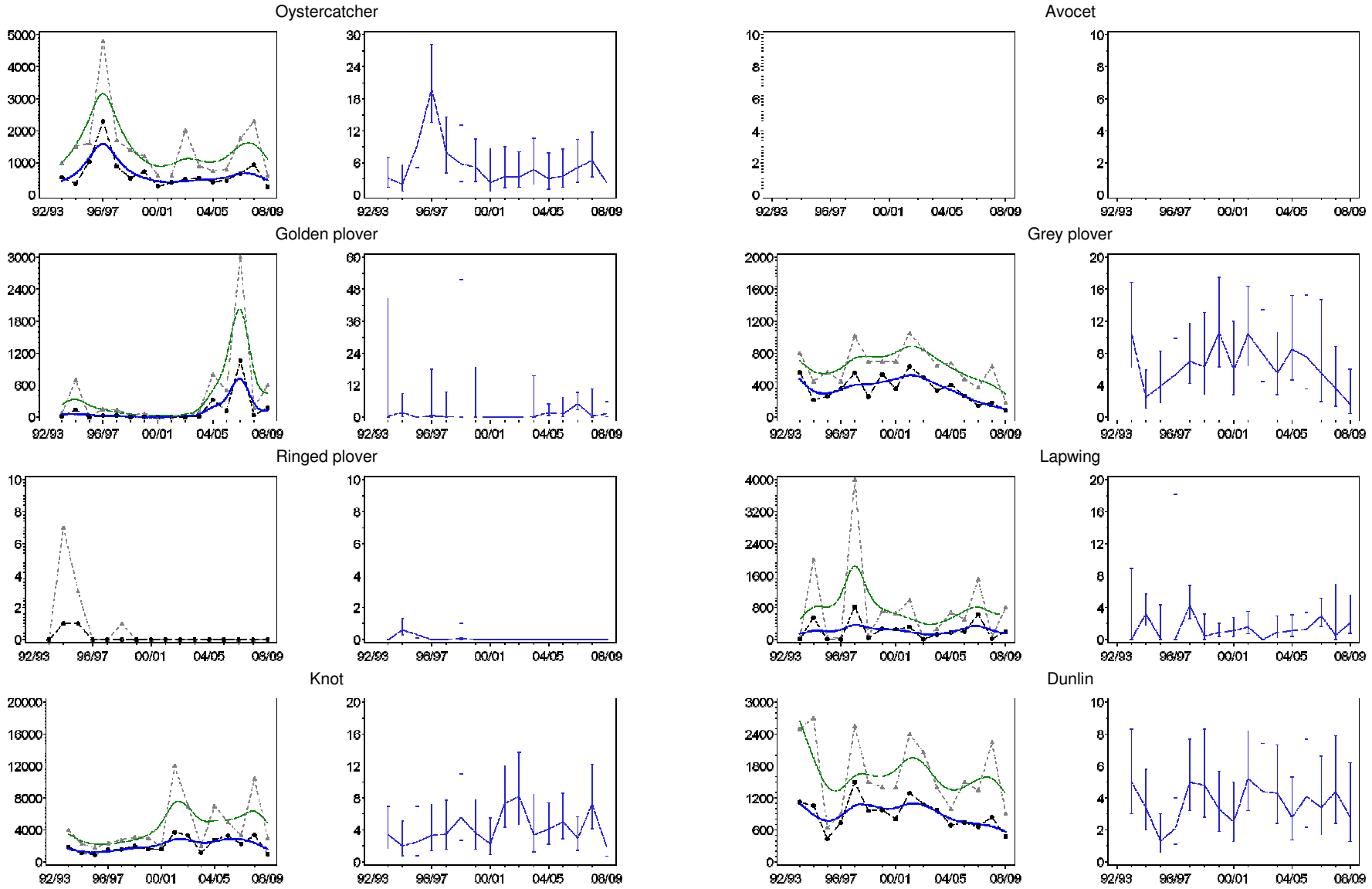


Figure A.35404 Population trends of each species in sector 35404 (Holbeach St Matthew) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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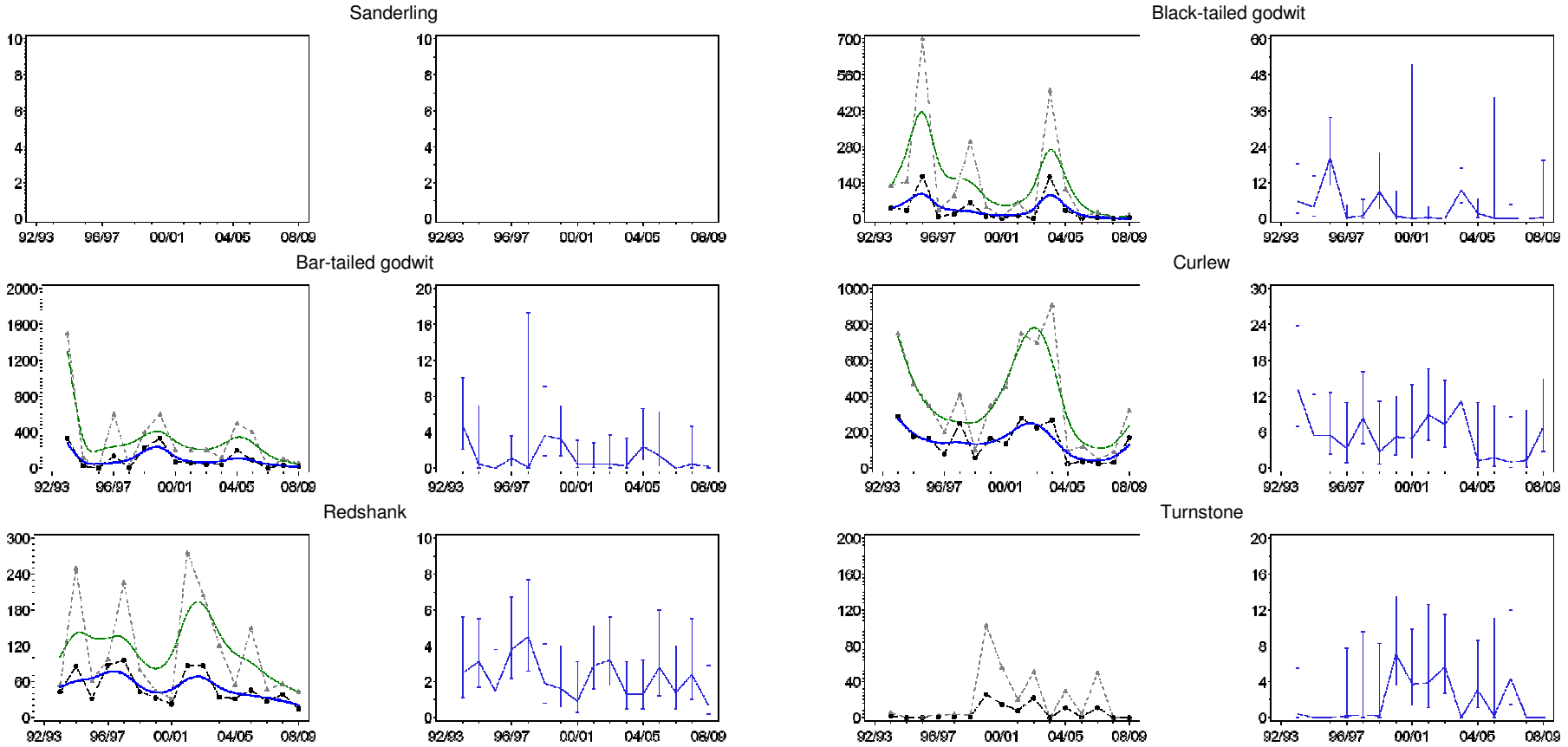

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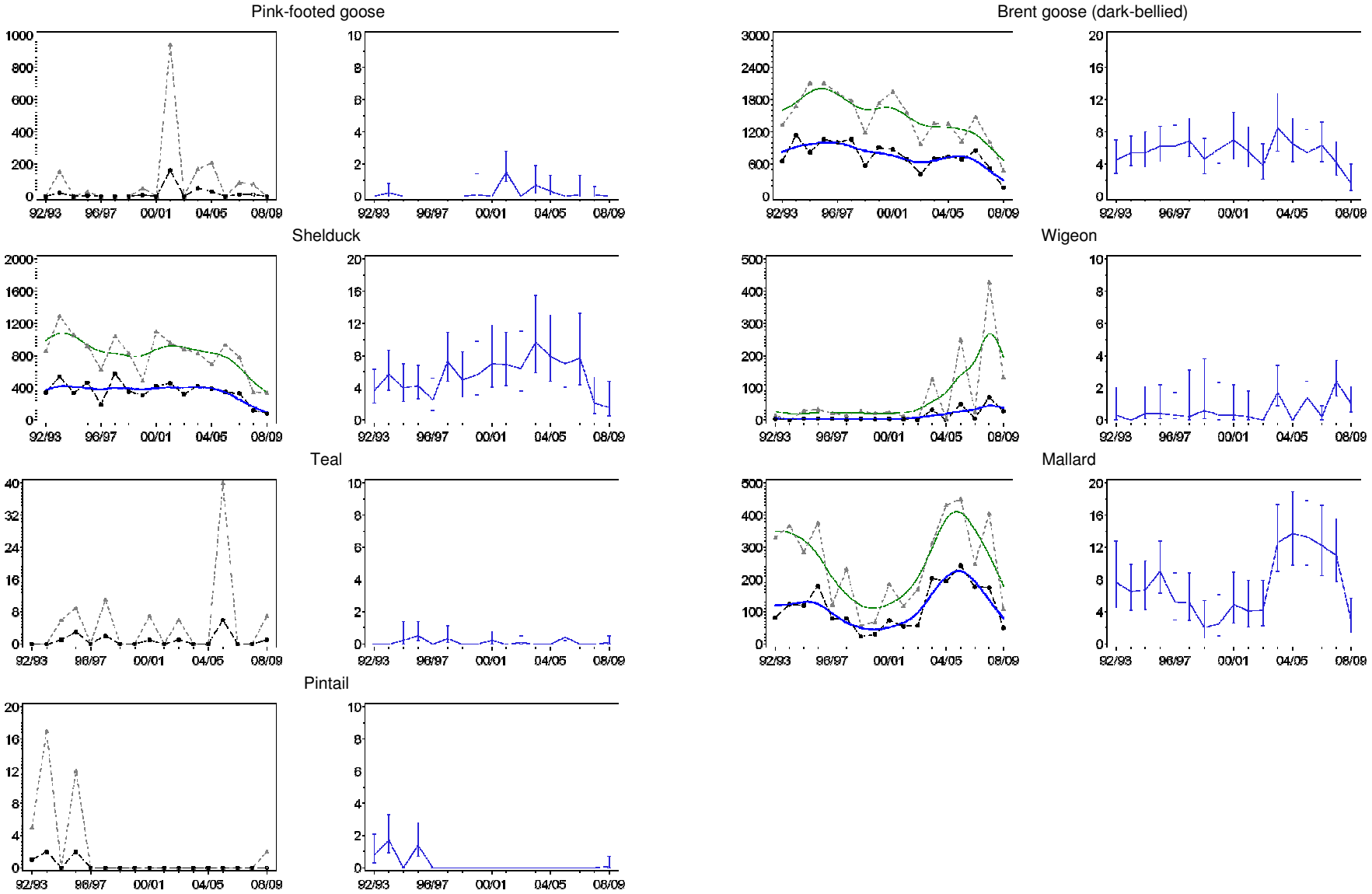
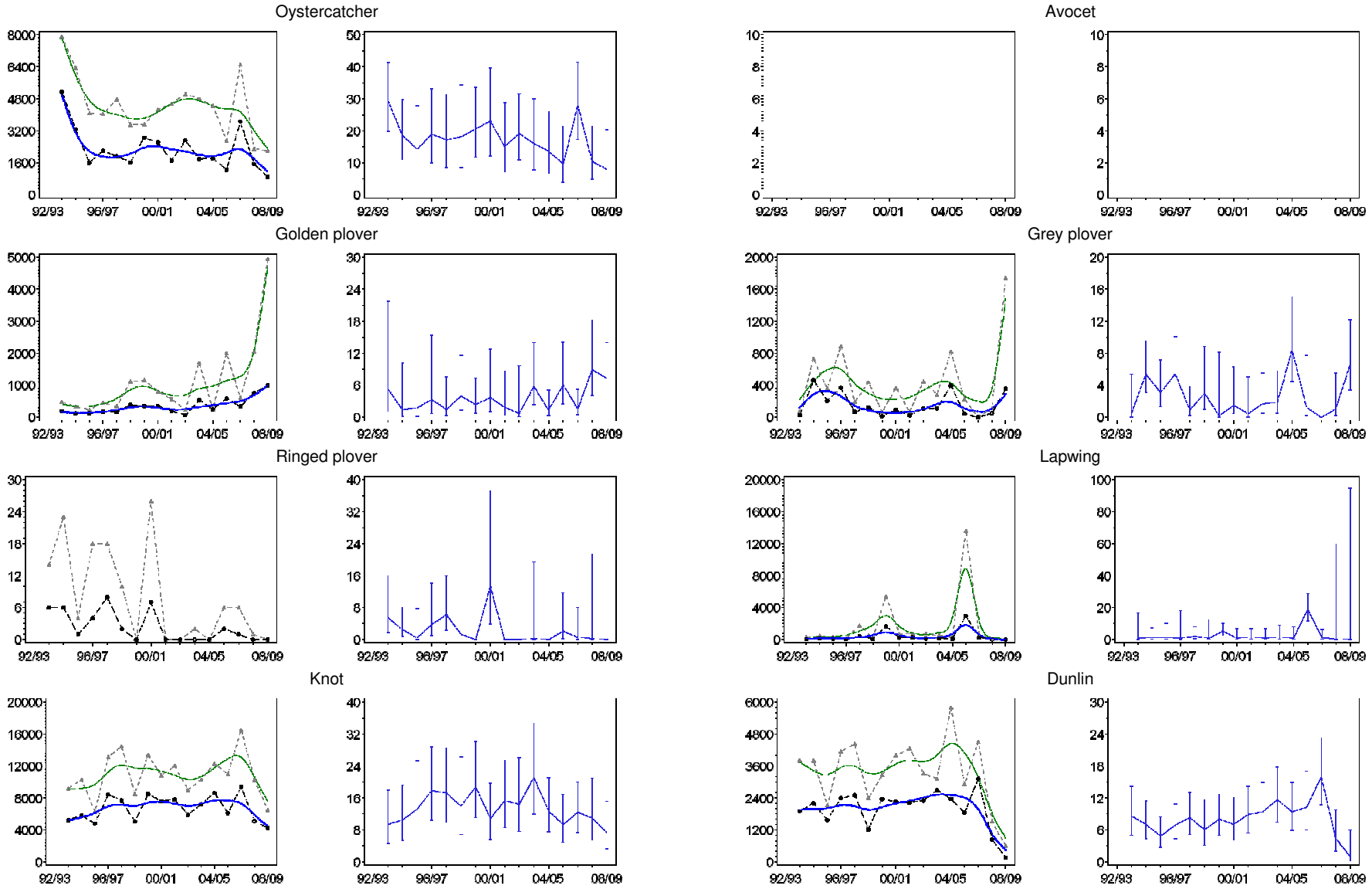


Figure A.35403 Population trends of each species in sector 35403 (Dawsmere) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).



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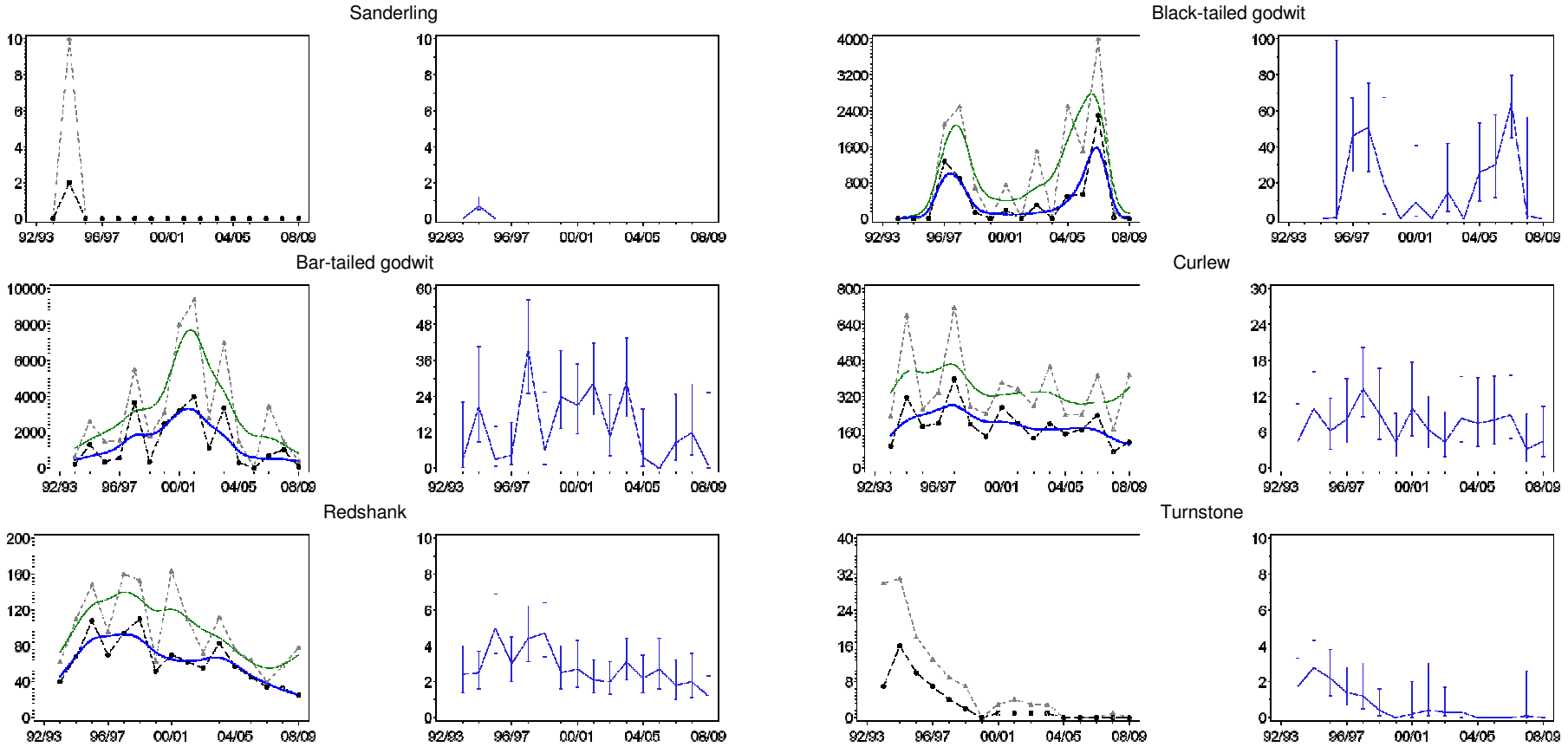

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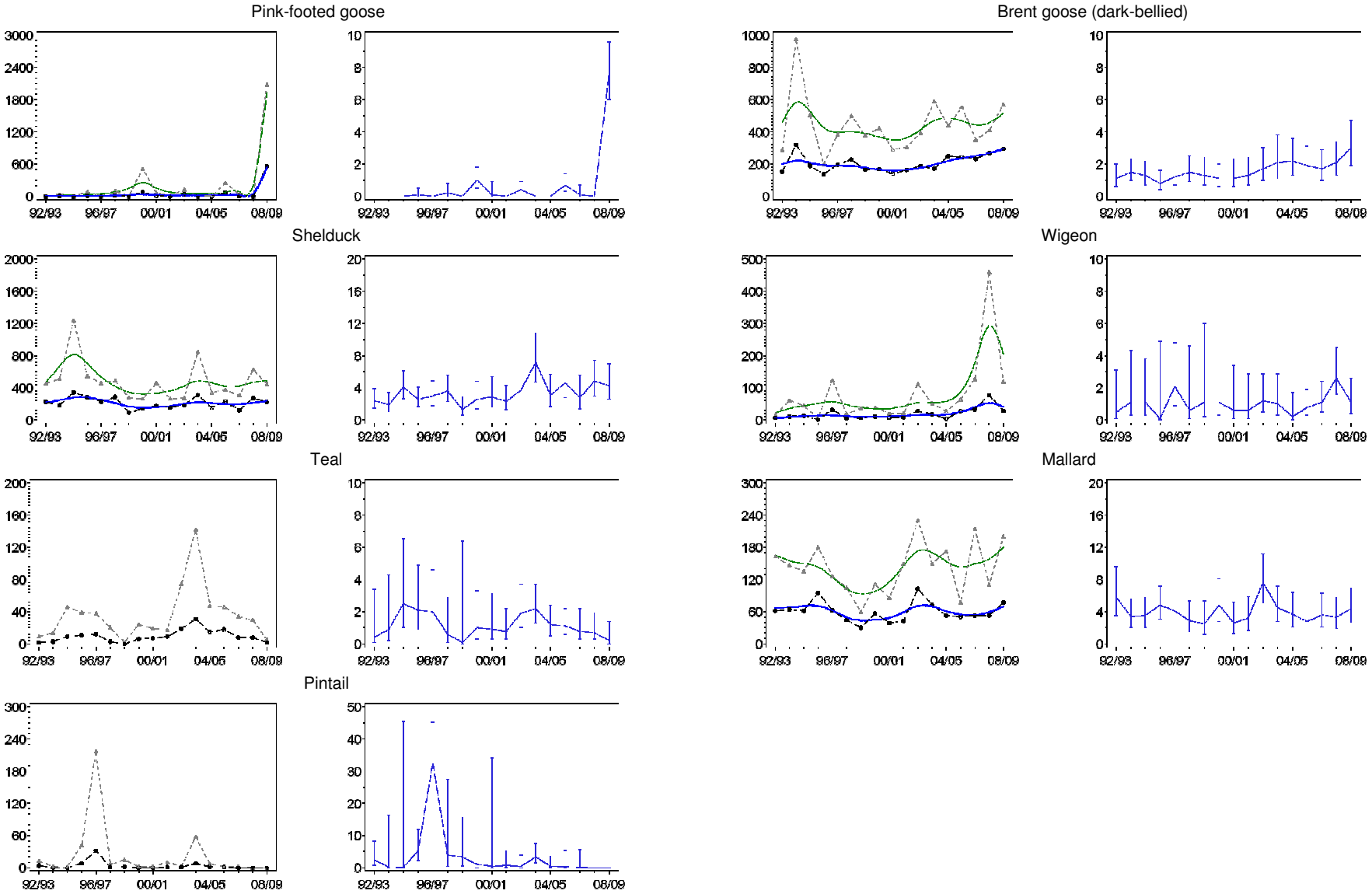


Figure A.35402 Population trends of each species in sector 35402 (Gedney) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

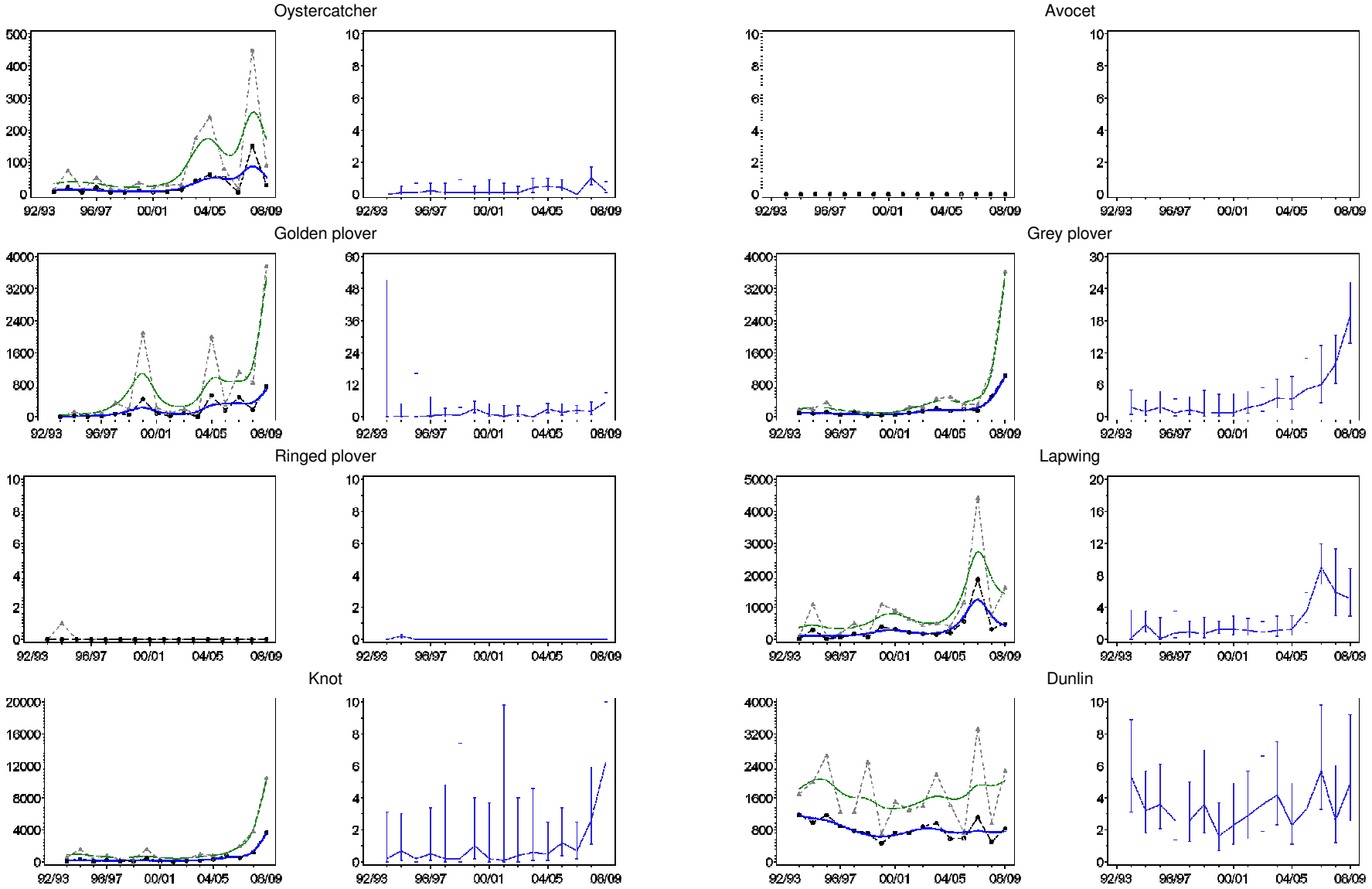


Figure A.35402 Continued

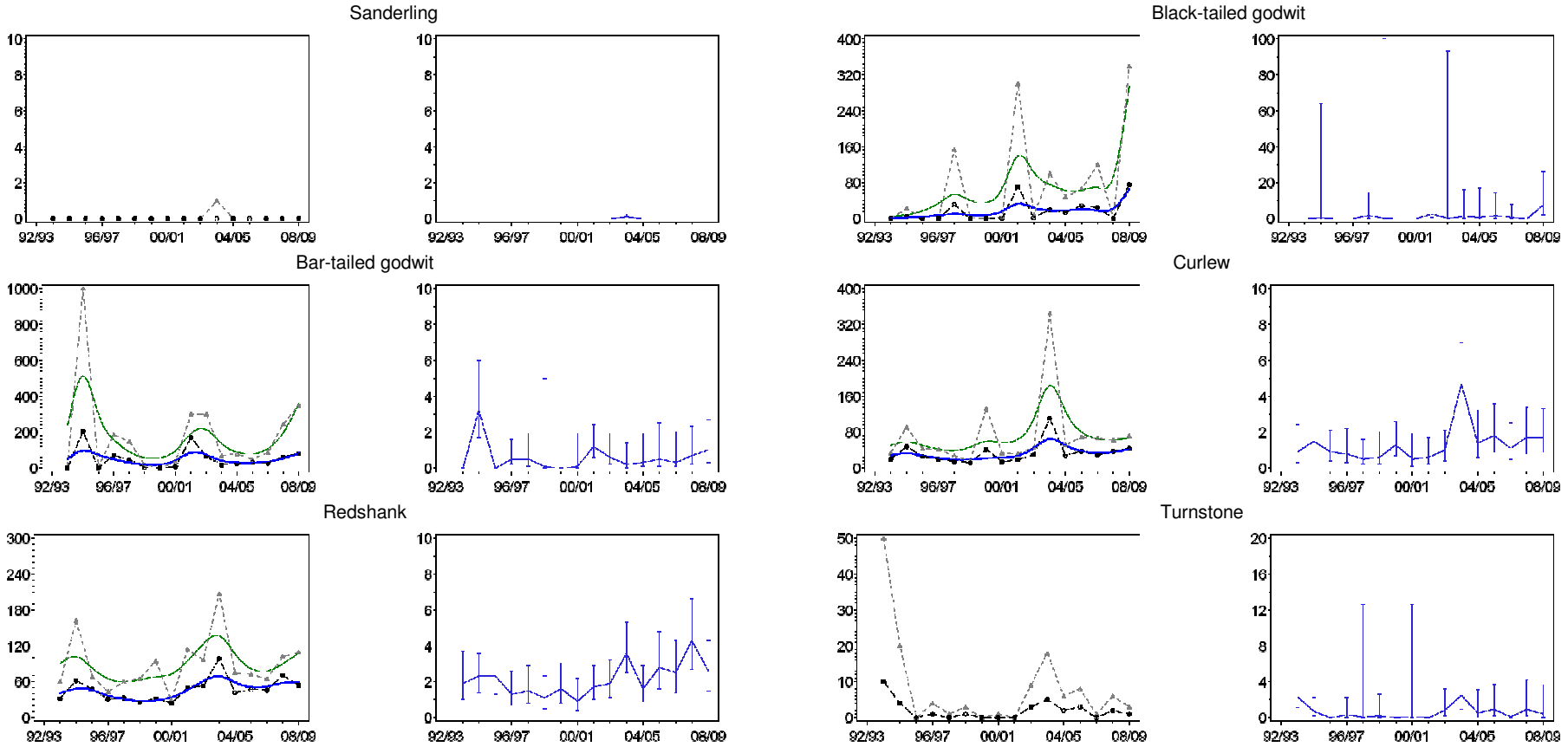


Figure A.35402 Continued

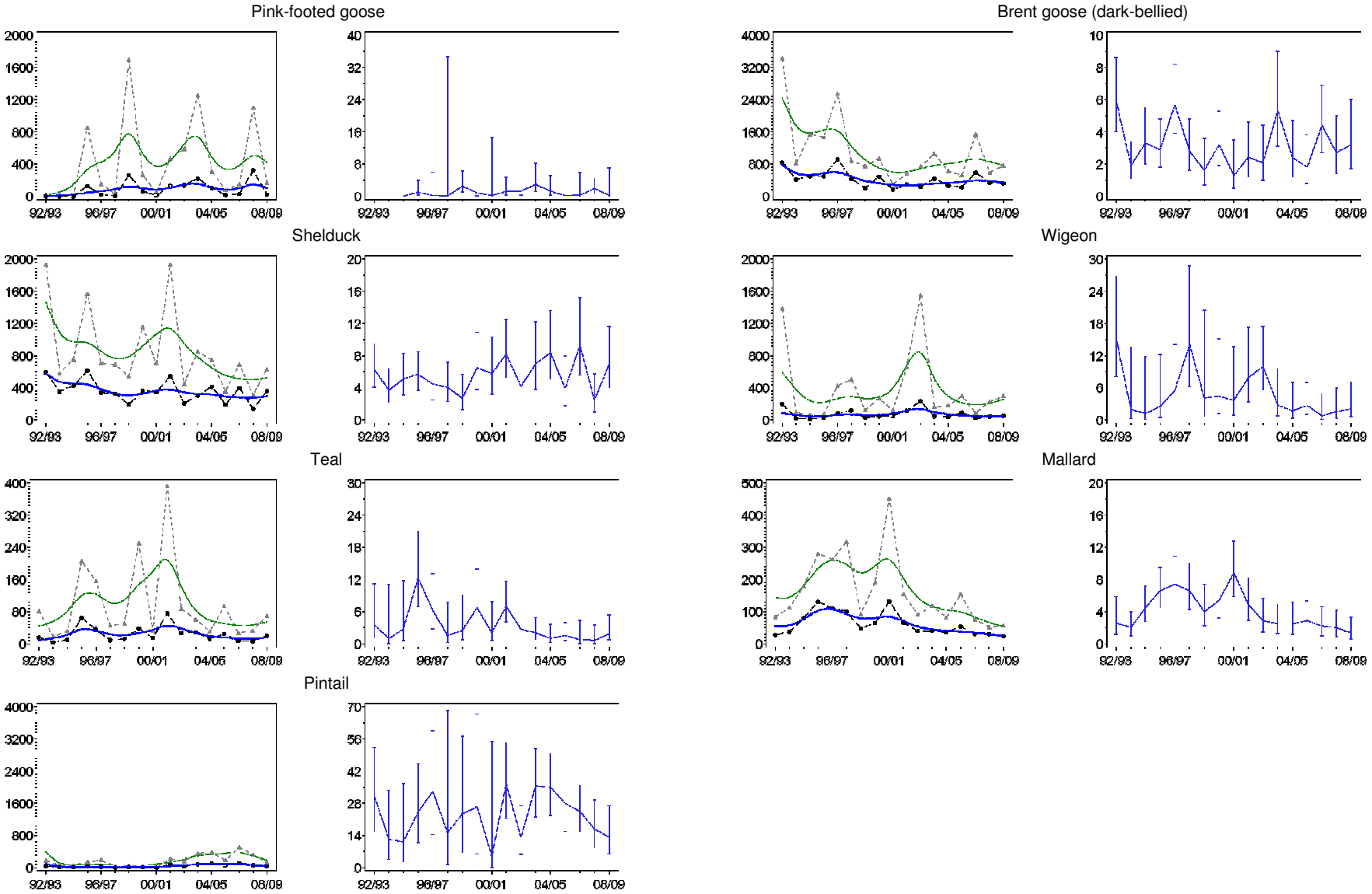


Figure A.35401 Population trends of each species in sector 35401 (Terrington West) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

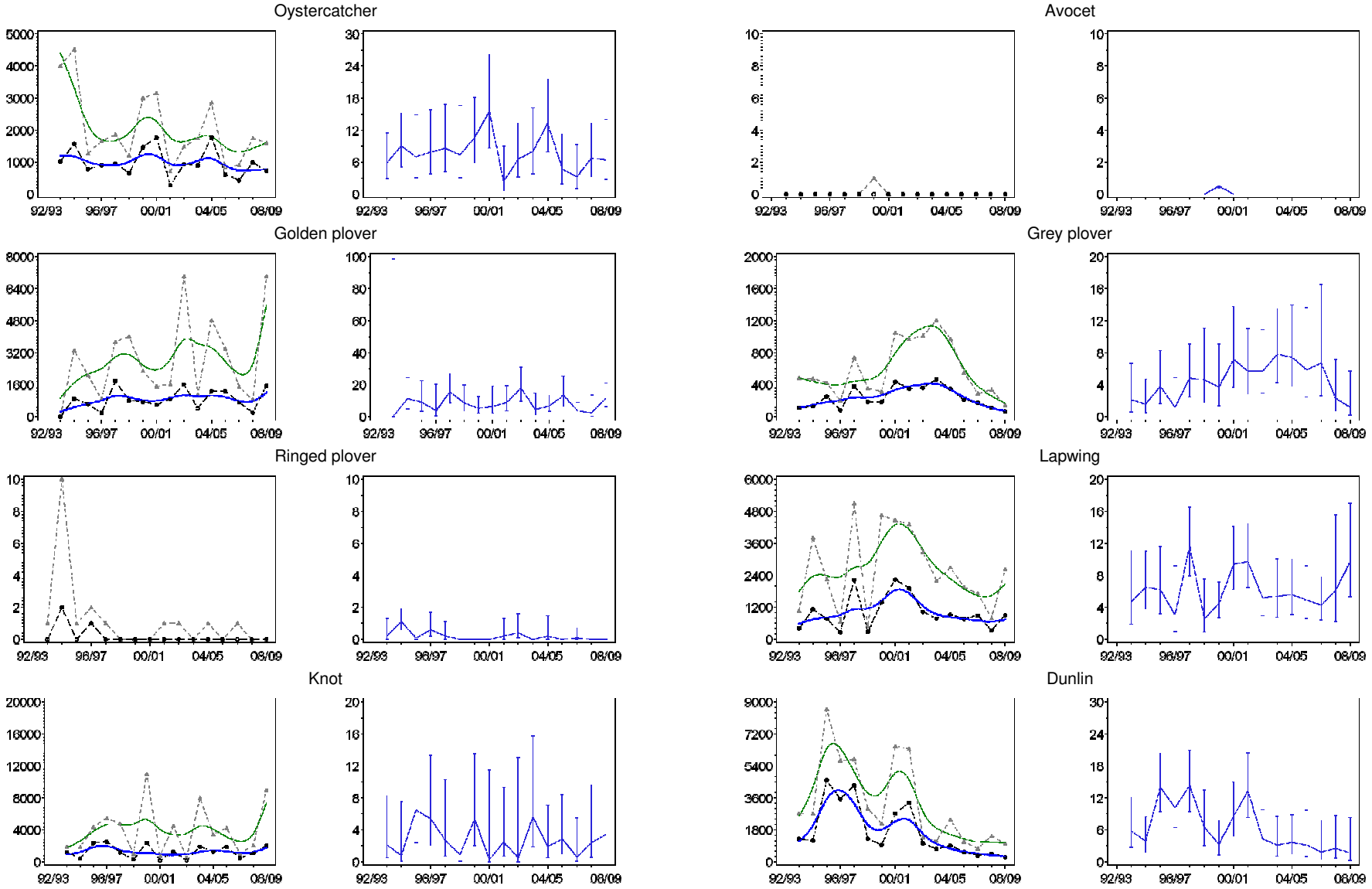


Figure A.35401 Continued

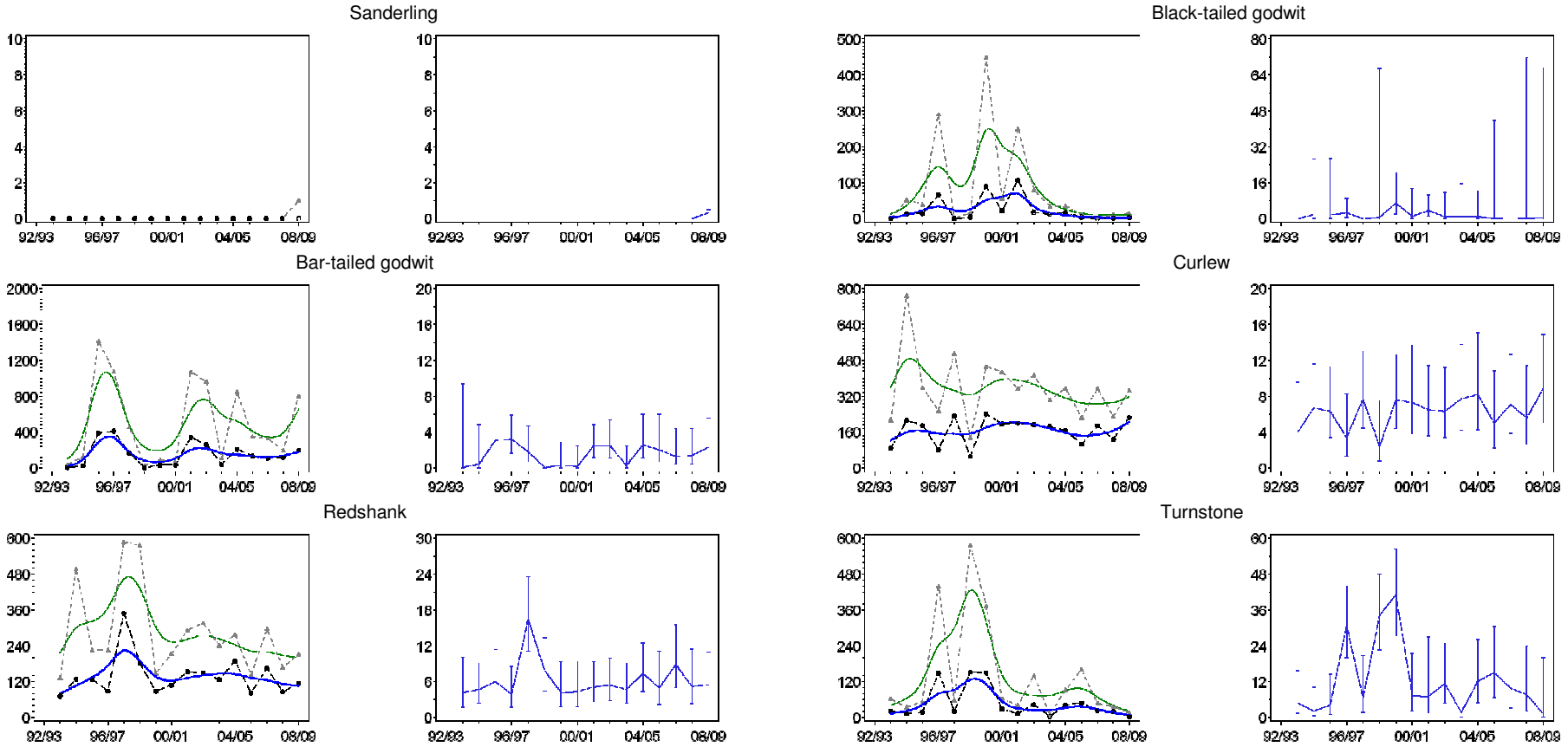


Figure A.35401 Continued

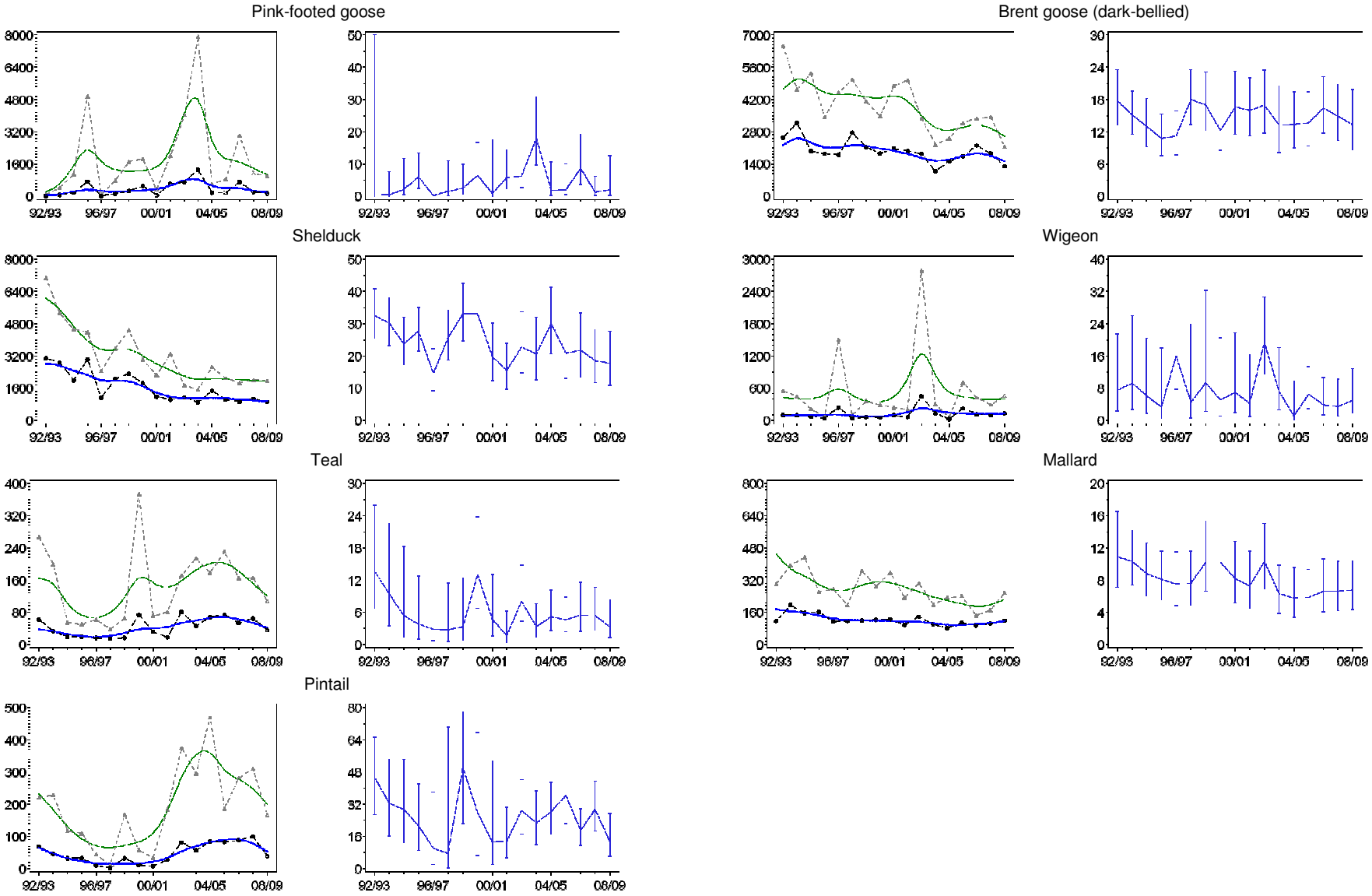


Figure A.34491 Population trends of each species in sector 34491 (Terrington East) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

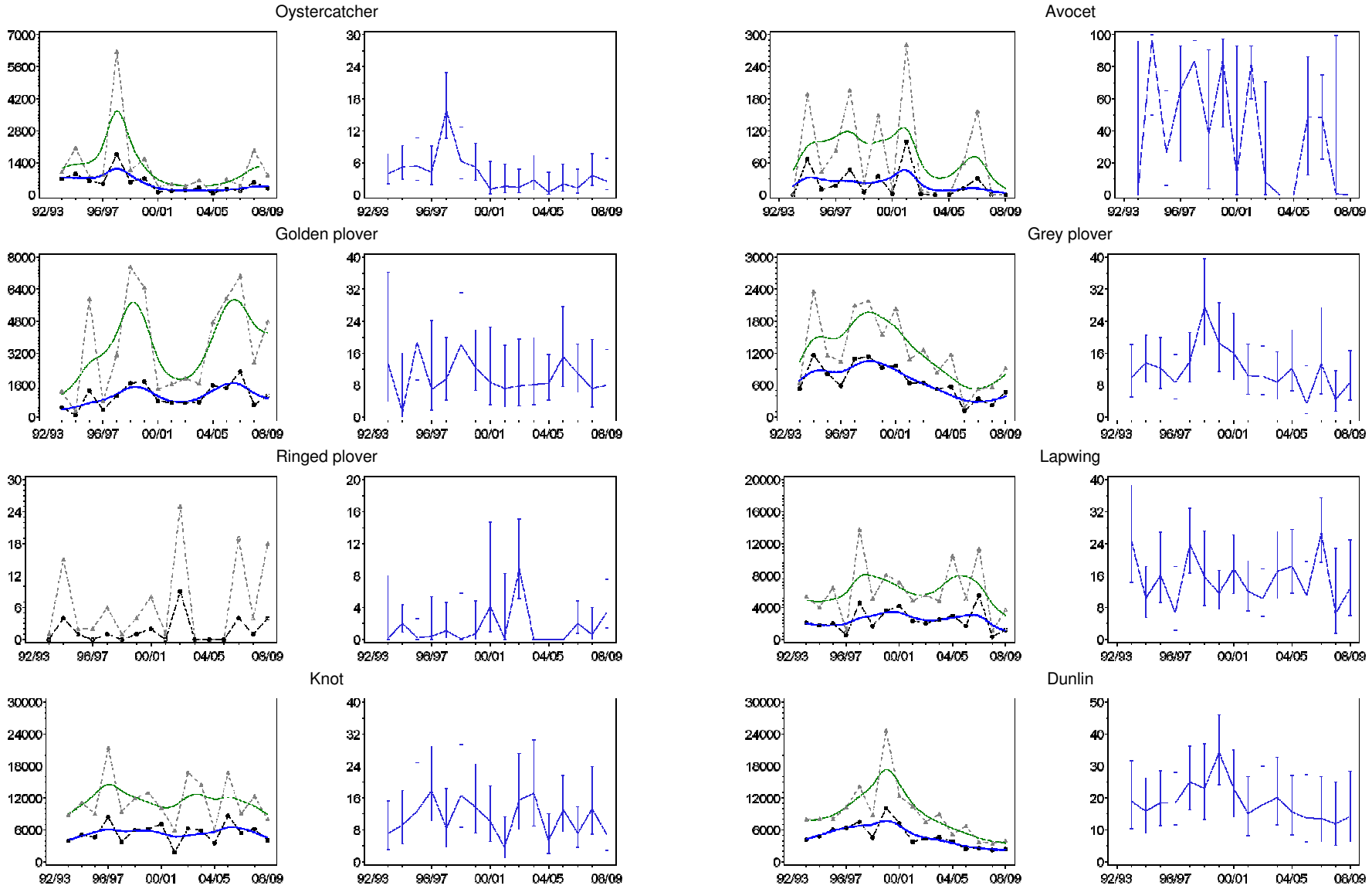


Figure A.34491 Continued

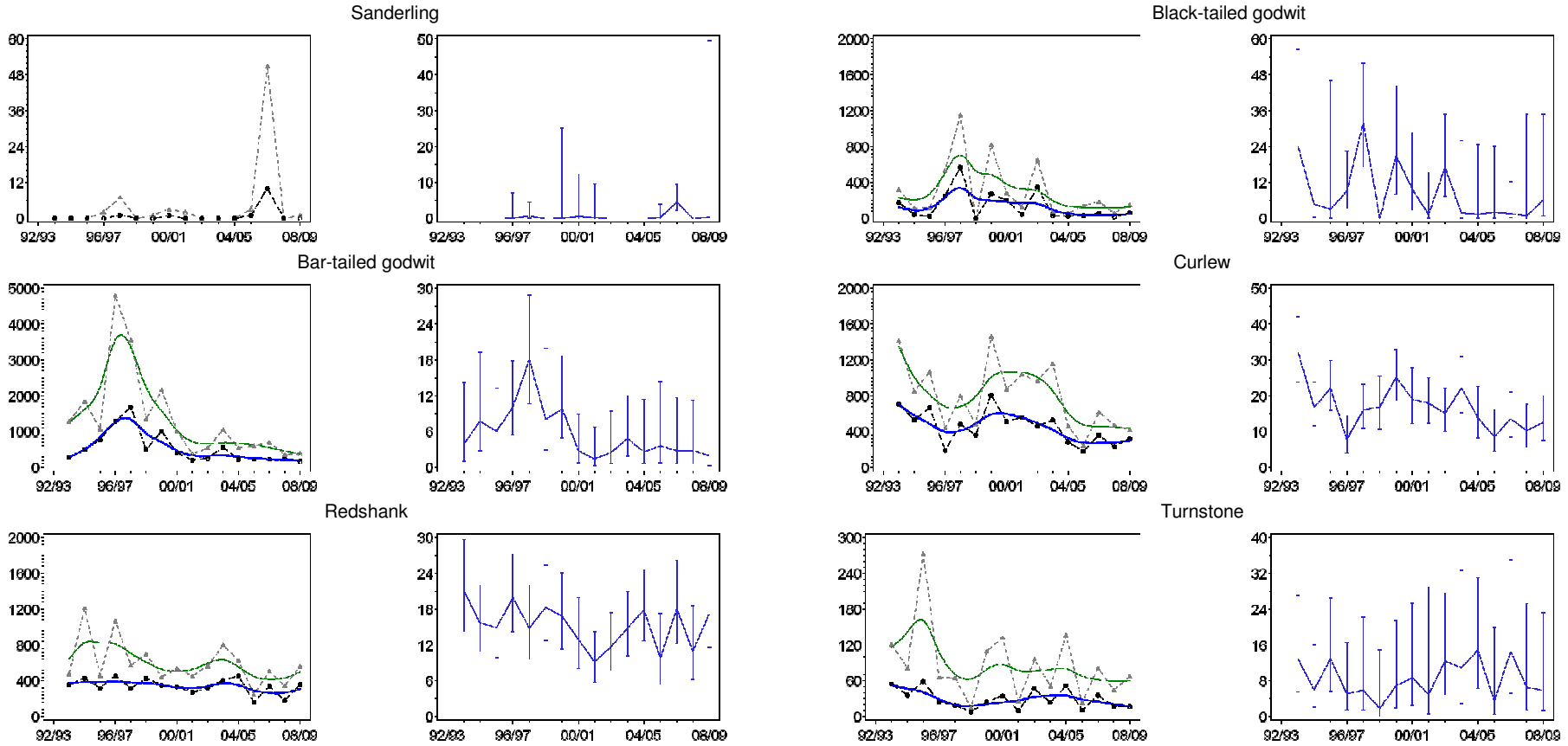


Figure A.34491 Continued

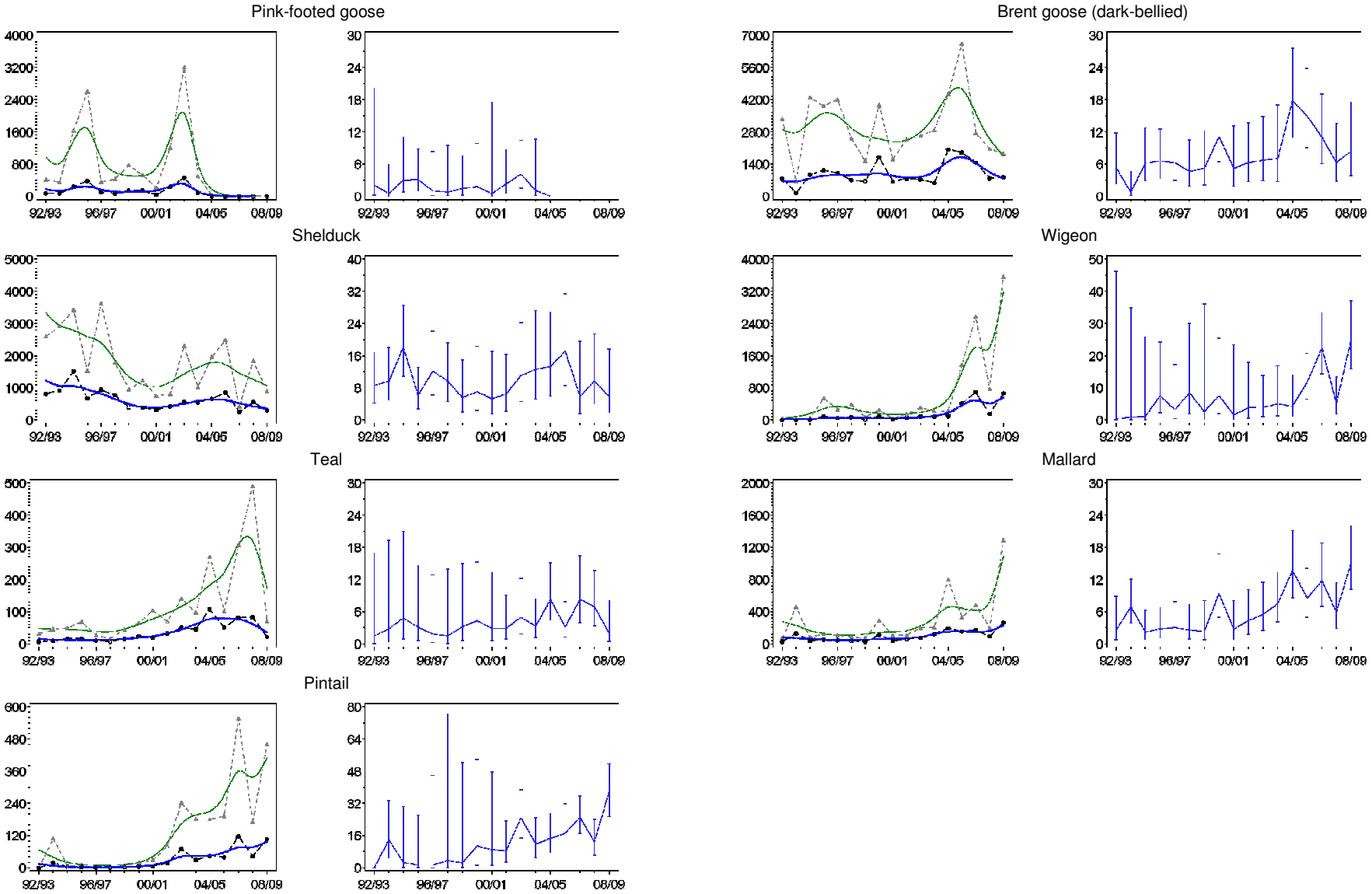


Figure A.34490 Population trends of each species in sector 34490 (Ouse Mouth) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

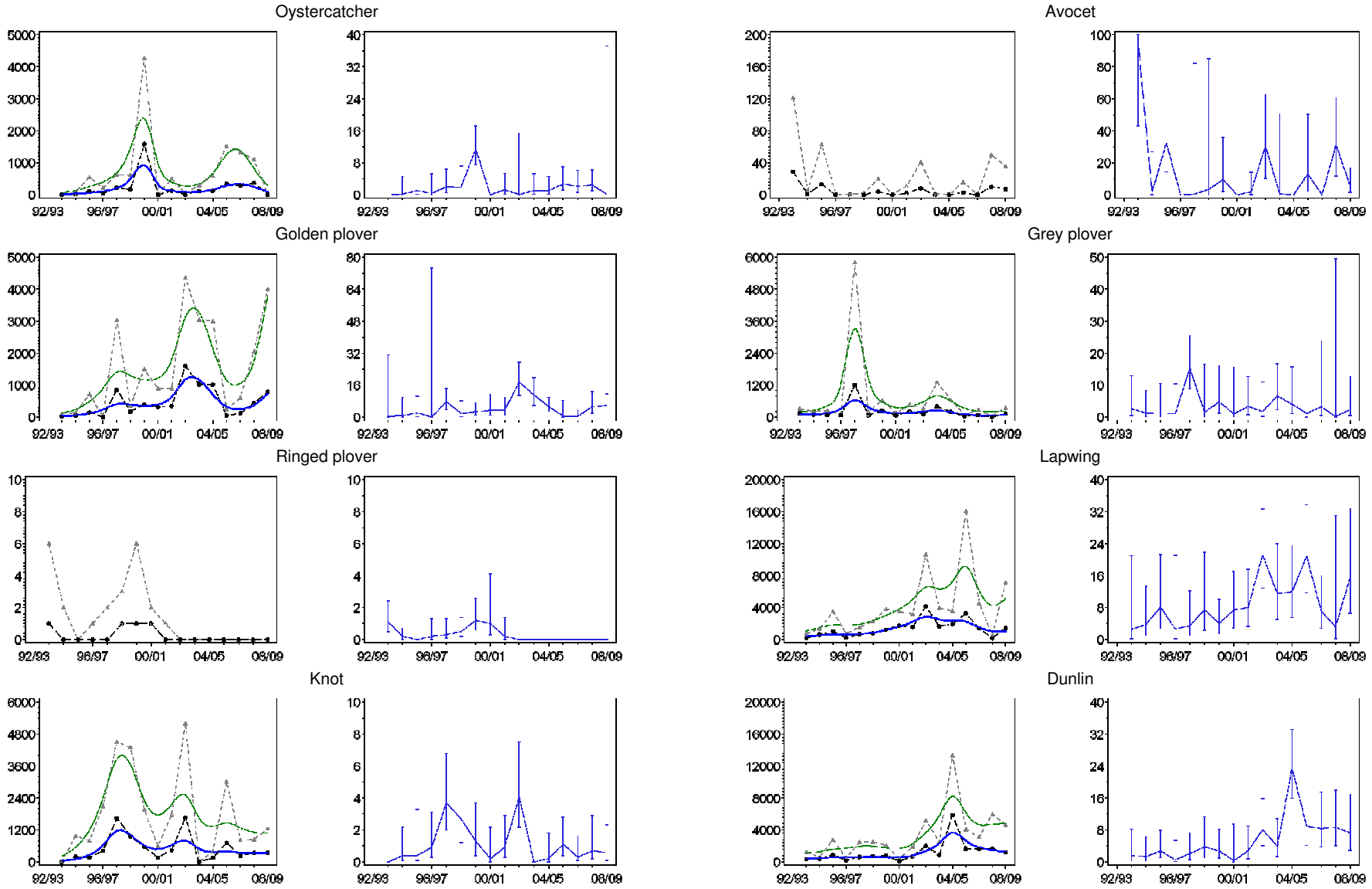


Figure A.34490 Continued

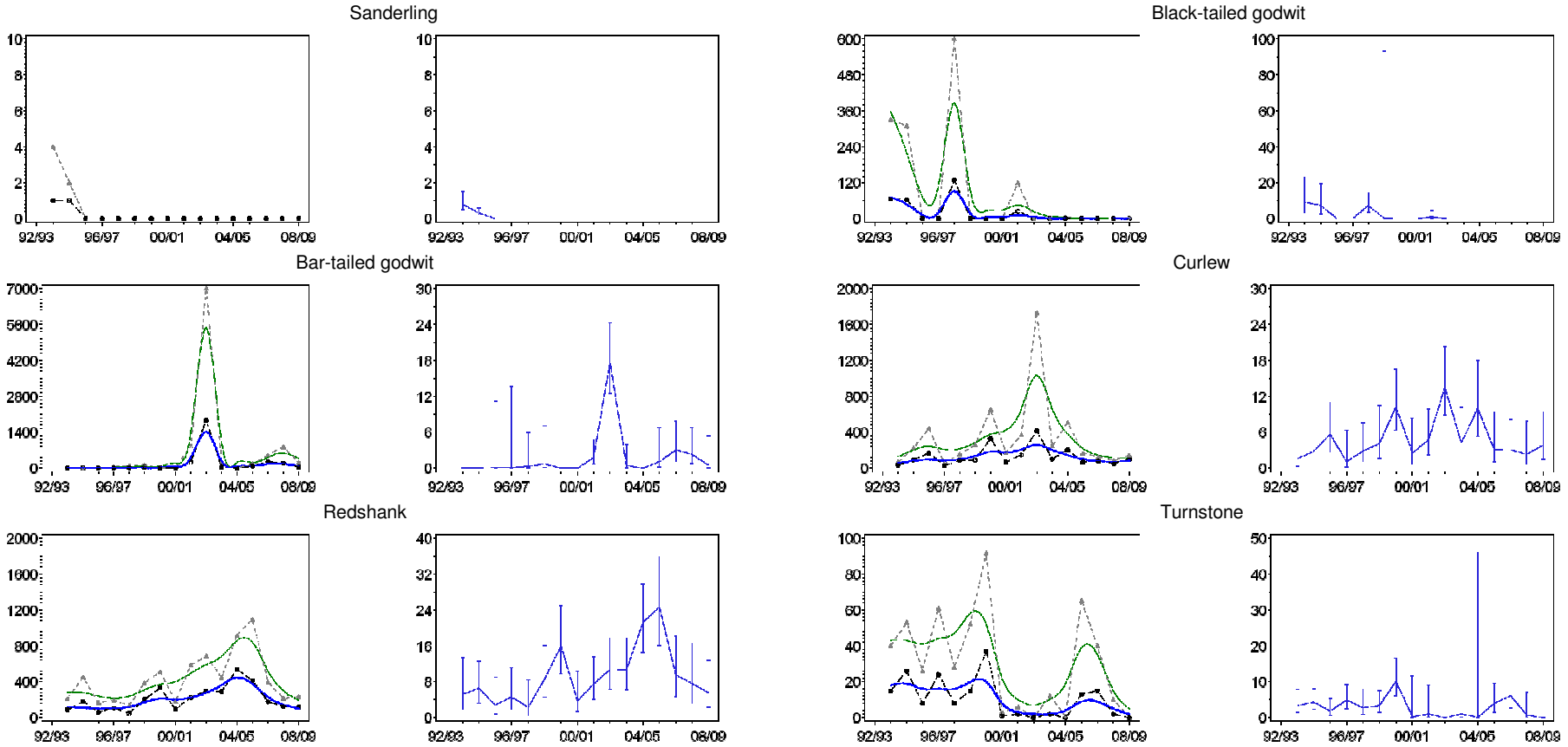


Figure A.34490 Continued

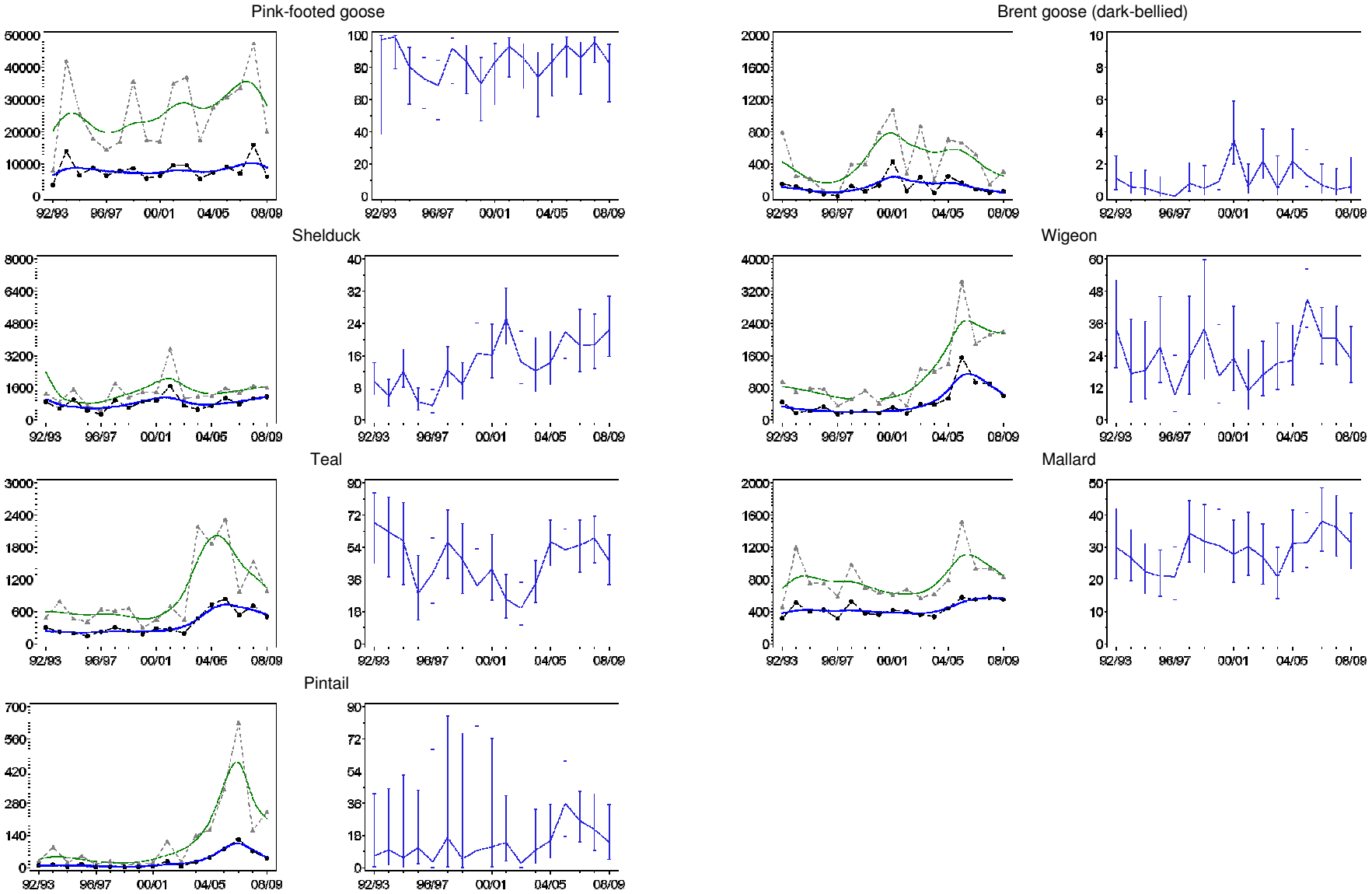


Figure A.34486 Population trends of each species in sector 34486 (Snettisham) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

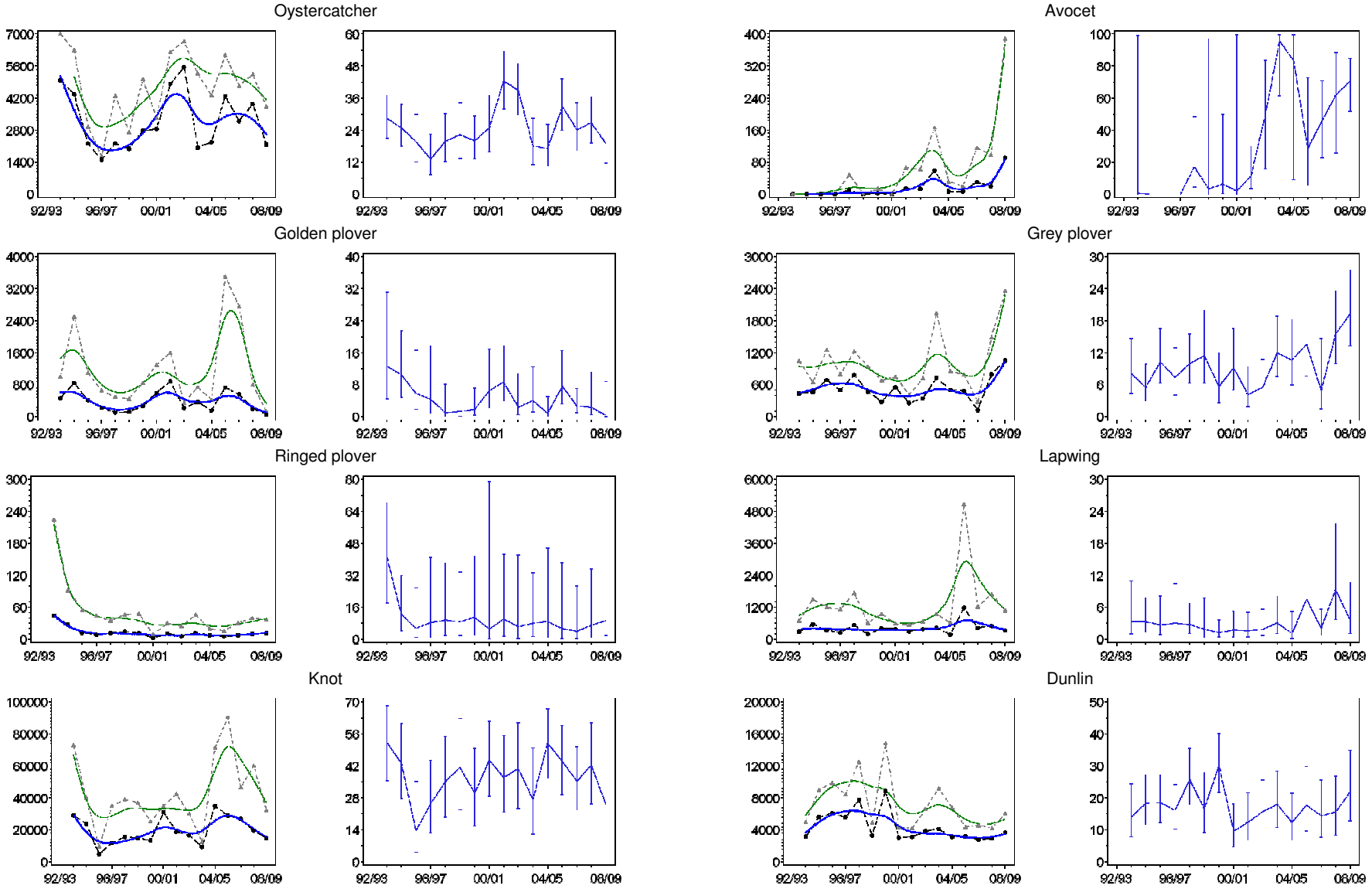


Figure A.34486 Continued

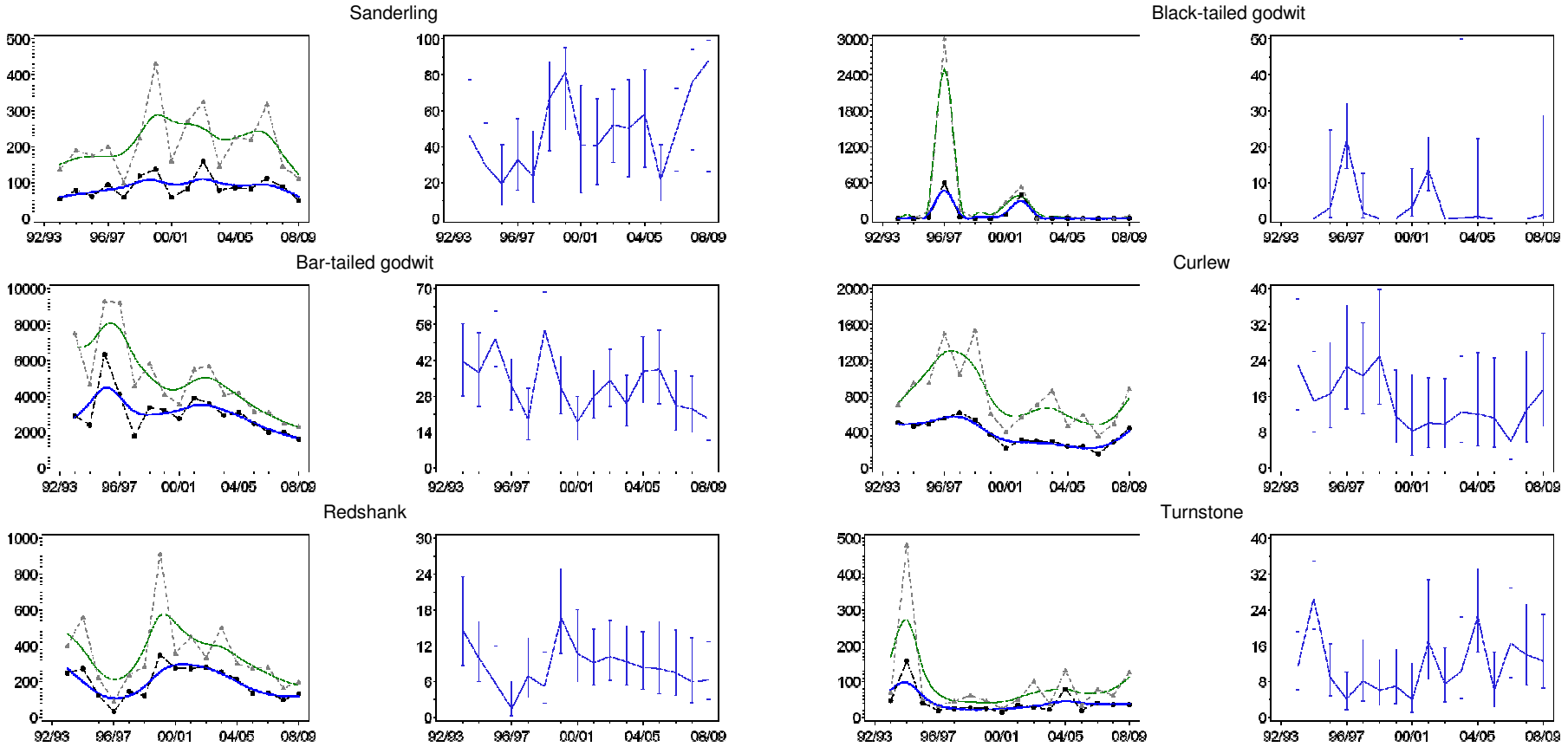


Figure A.34486 Continued

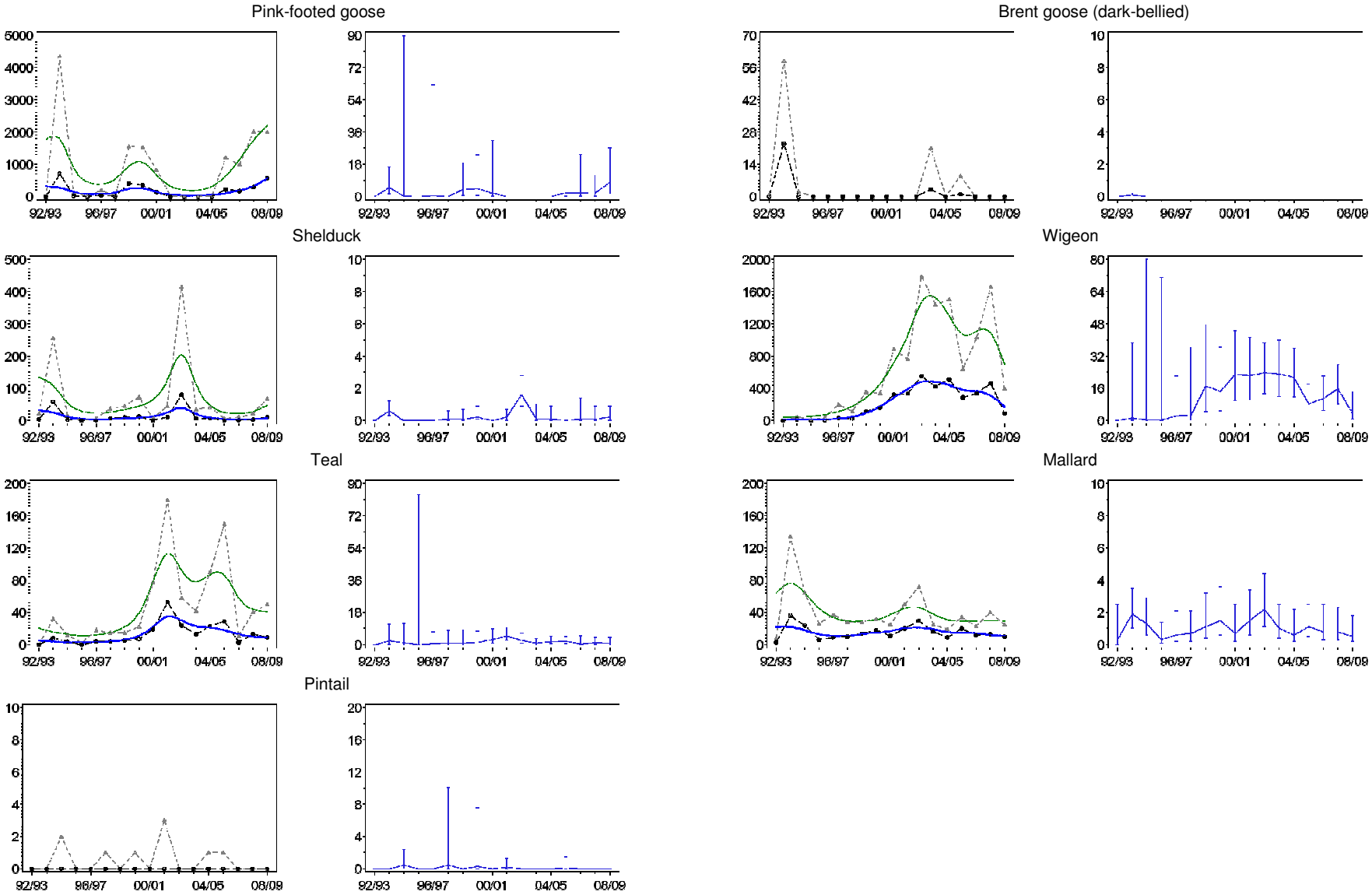


Figure A.34485 Population trends of each species in sector 34485 (Heacham to Snettisham) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

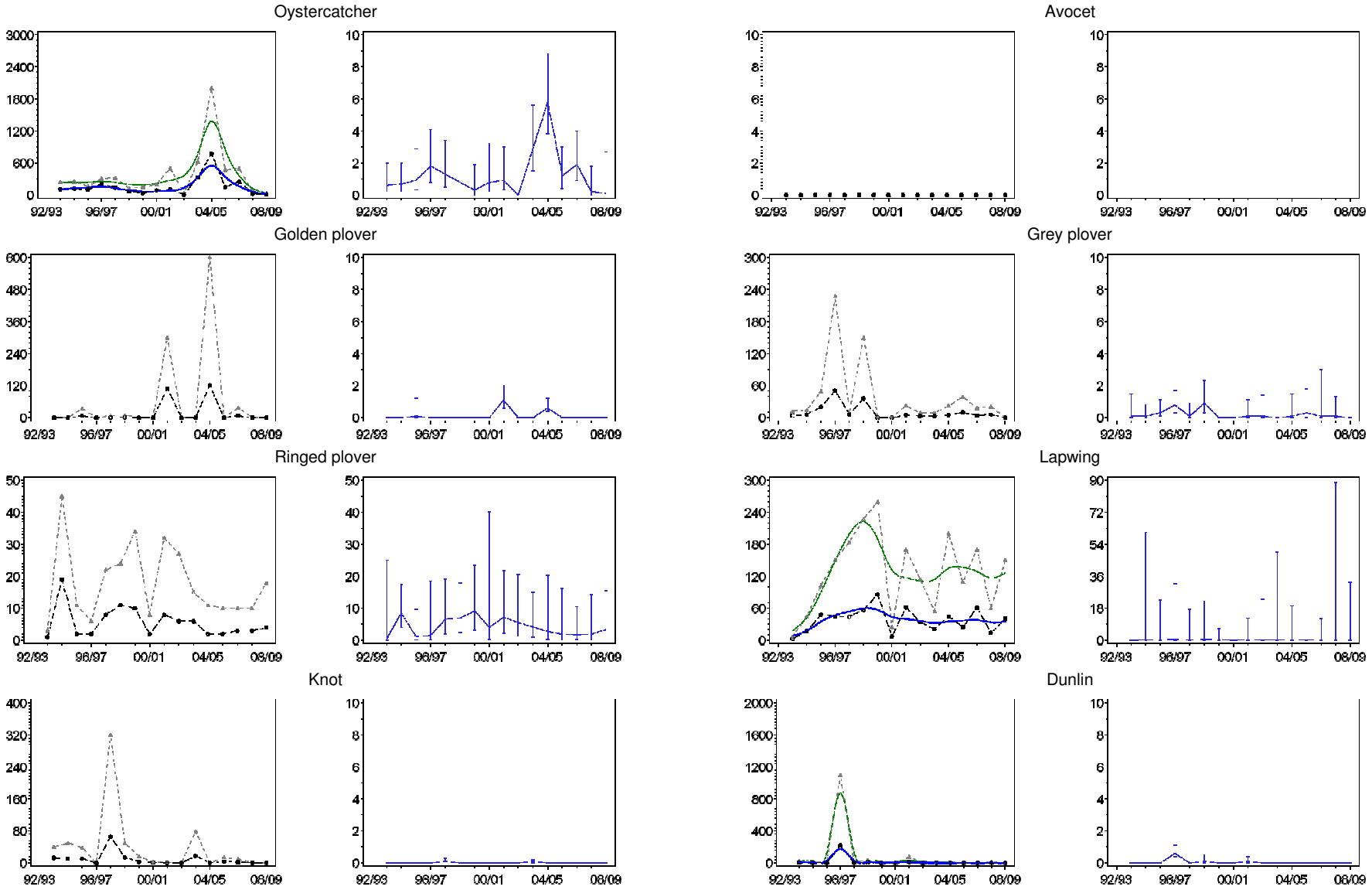


Figure A.34485 Continued

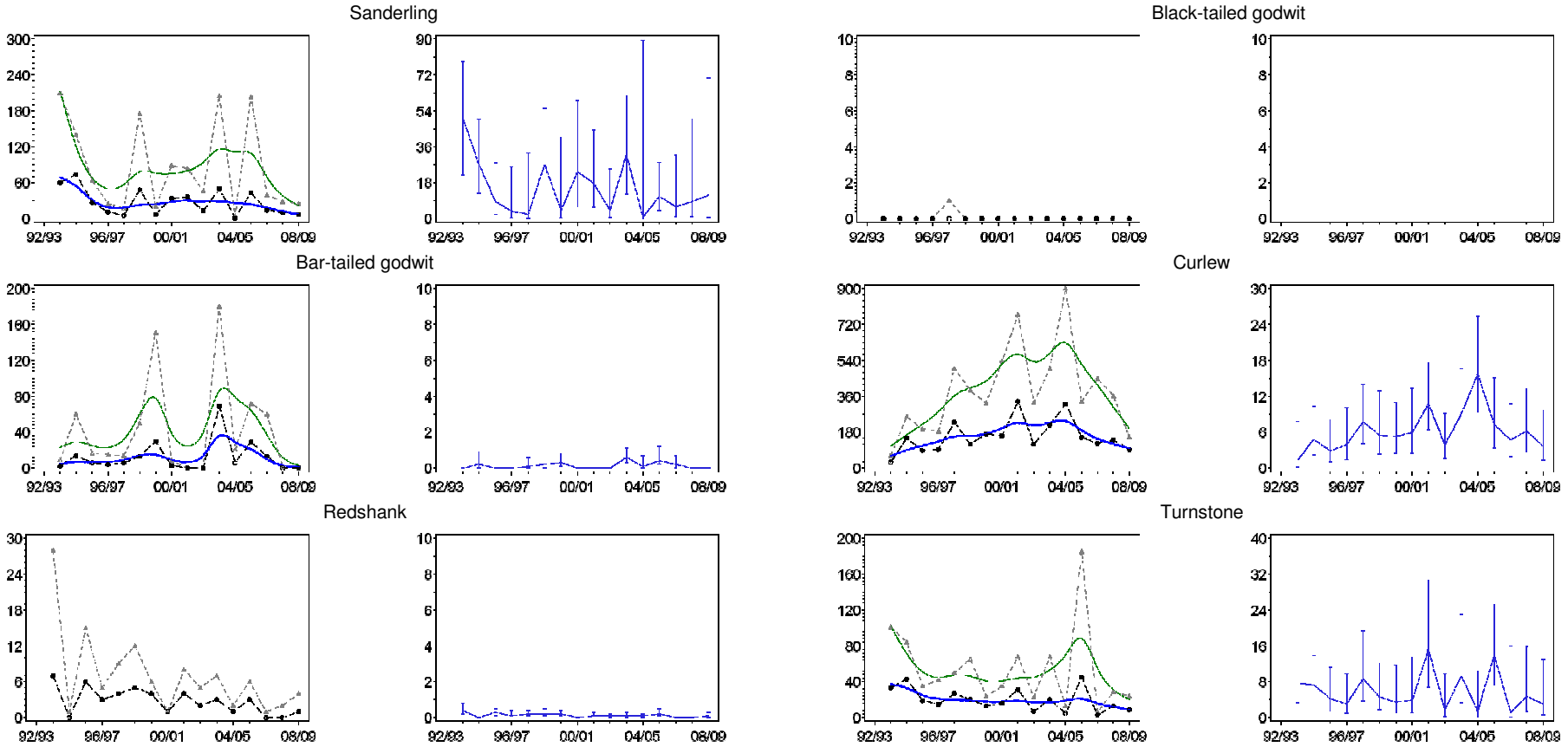


Figure A.34485 Continued

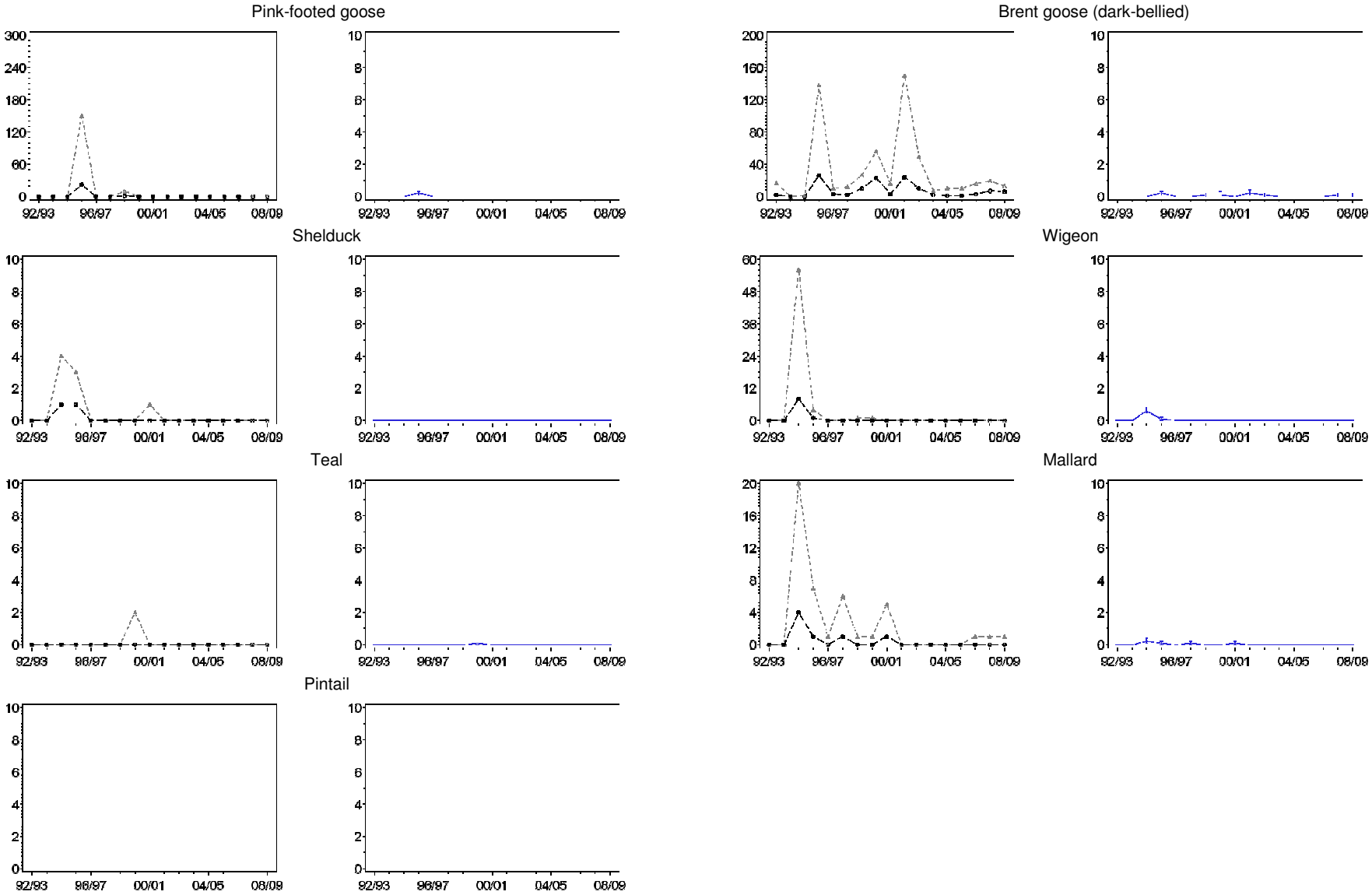


Figure A.34484 Population trends of each species in sector 34484 (Heacham to Hunstanton) (left-hand graphs), and the proportion of The Wash SSSI population found in this sector by winter (right-hand graphs).

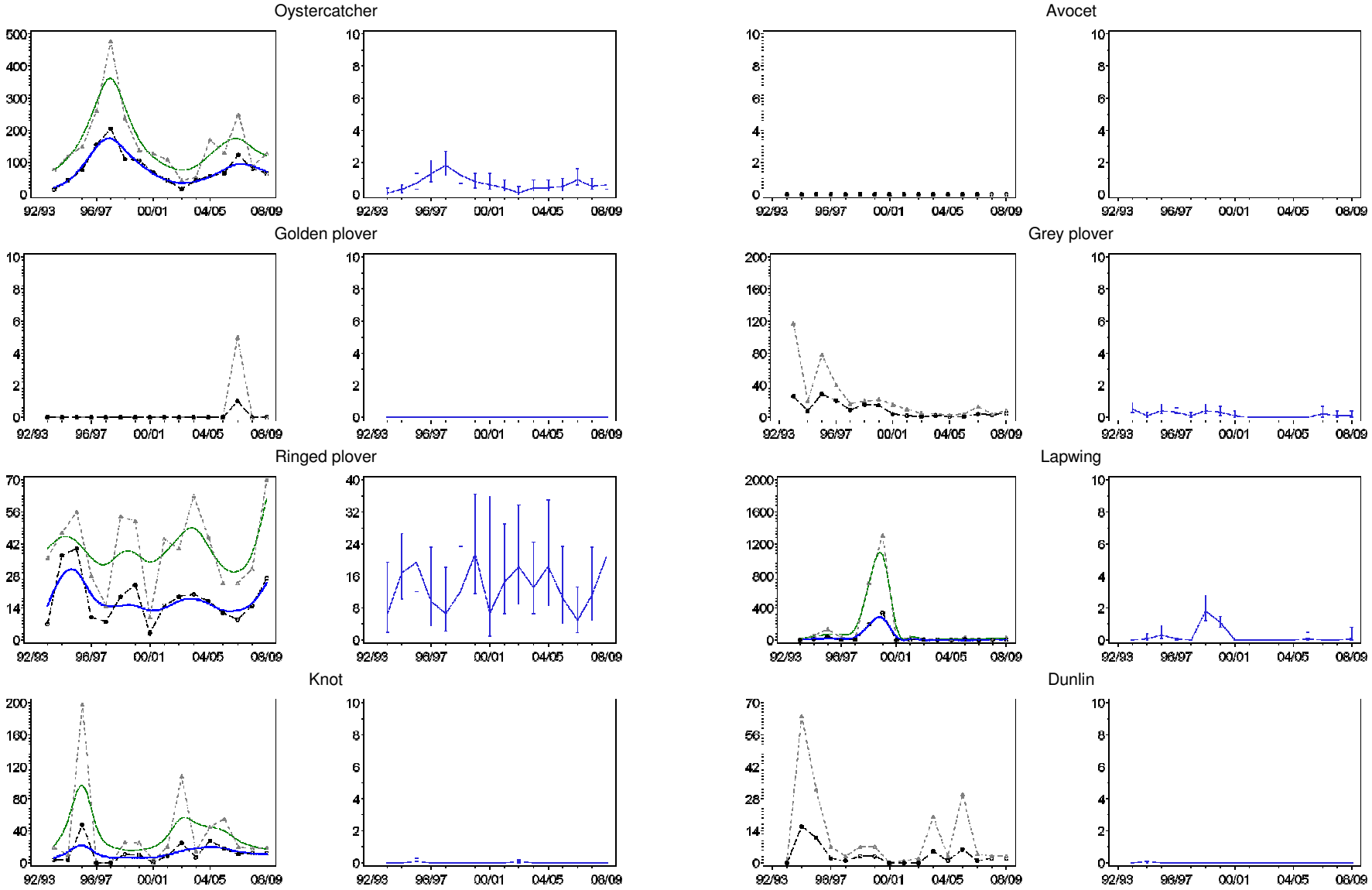


Figure A.34484 Continued

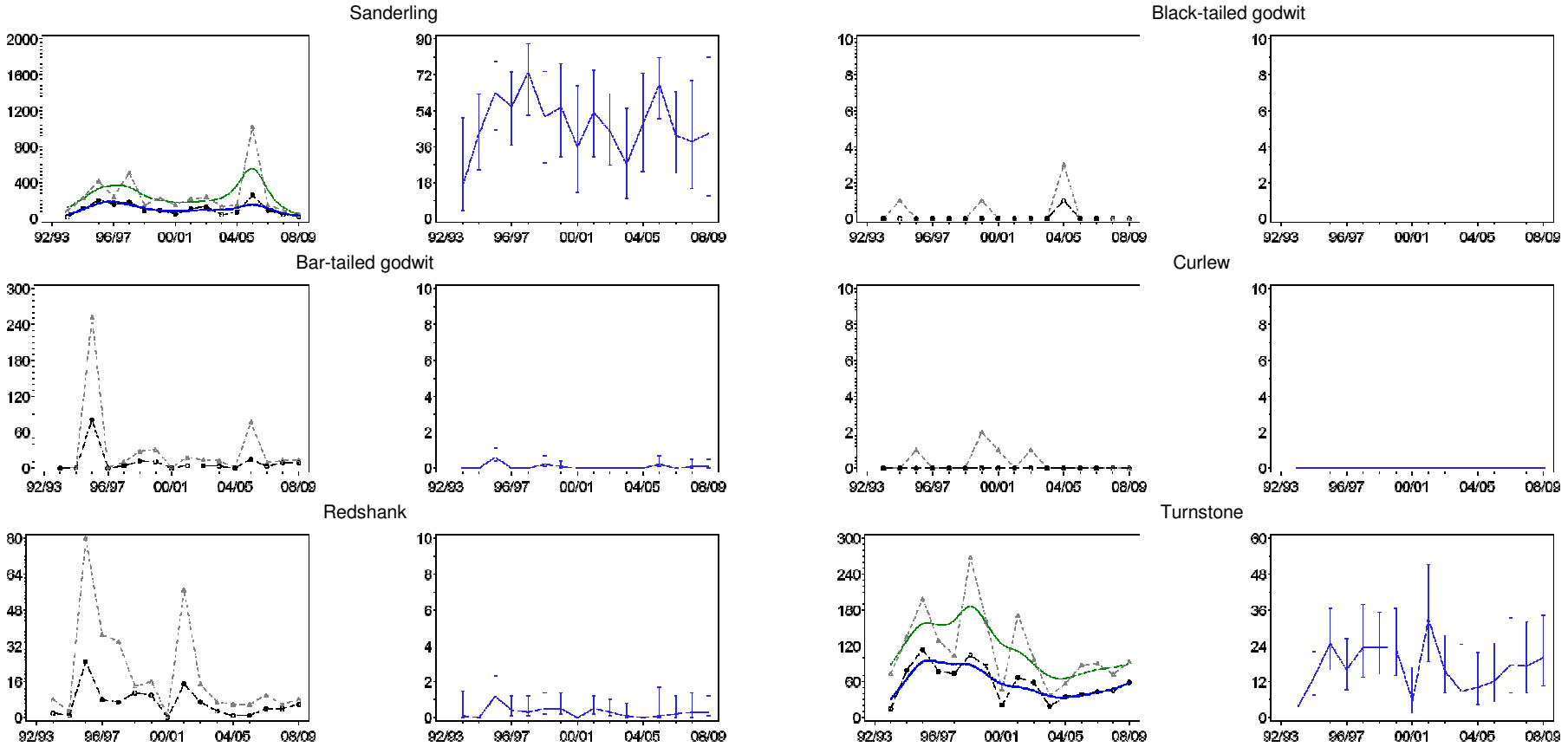


Figure A.34484 Continued

APPENDIX B

Figure B.35407 Population trends of each species in sector 35407 (Kirton) (left), and the proportion of total numbers recorded on The Wash NNR (centre) and The Wash SSSI (right) in this sector by year.

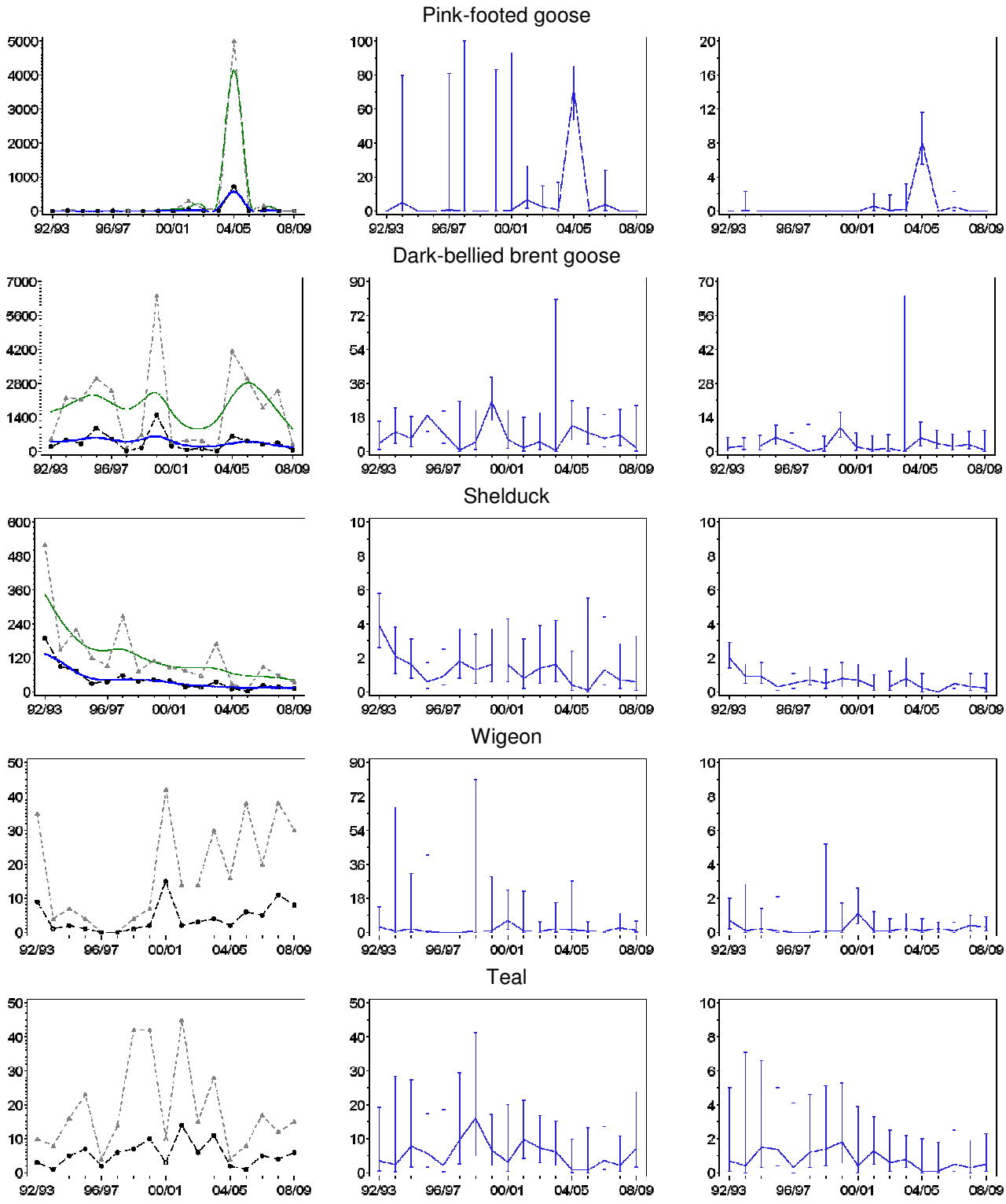


Figure B.35407 (continued).

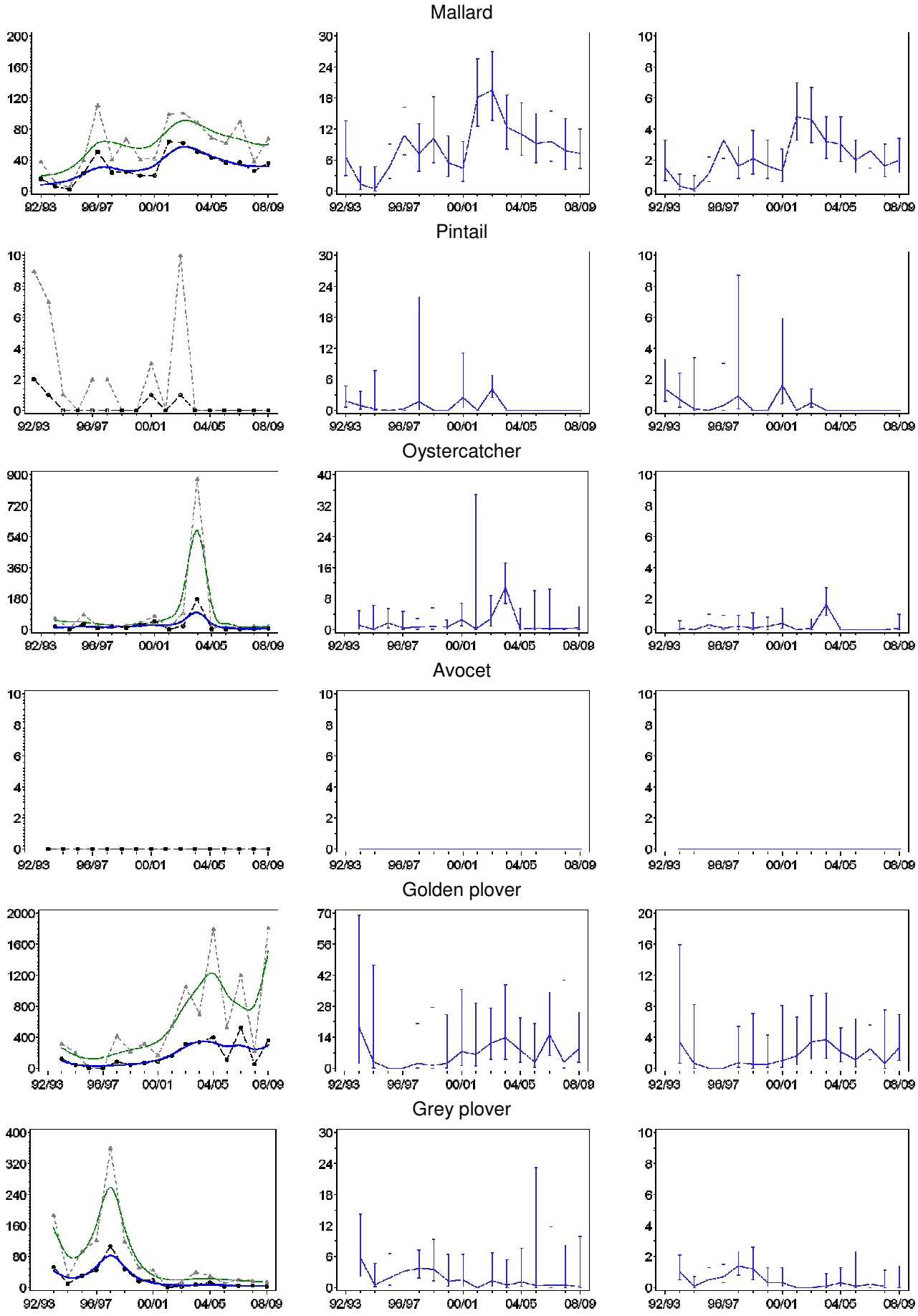


Figure B.35407 (continued).

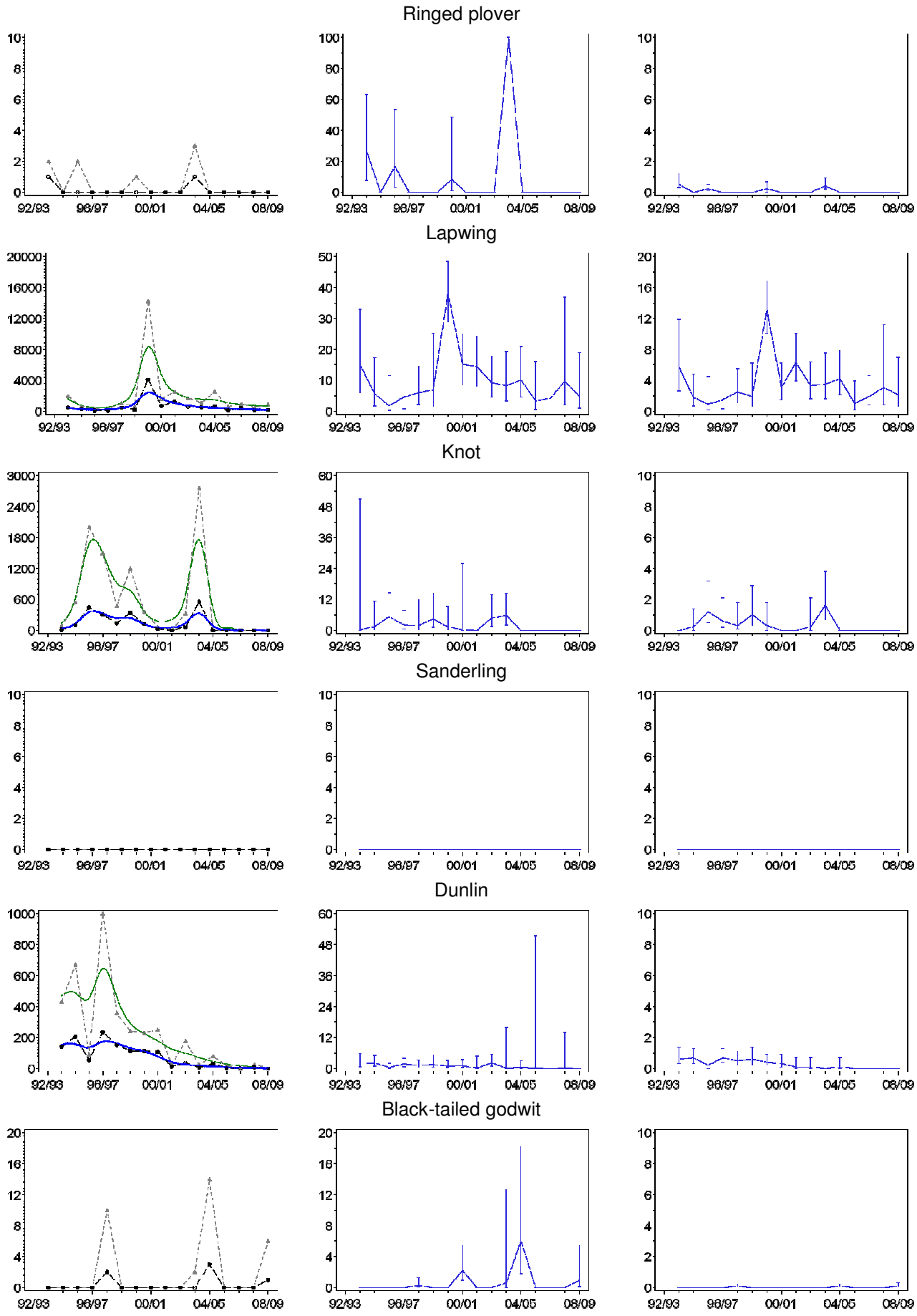


Figure B.35407 (continued).

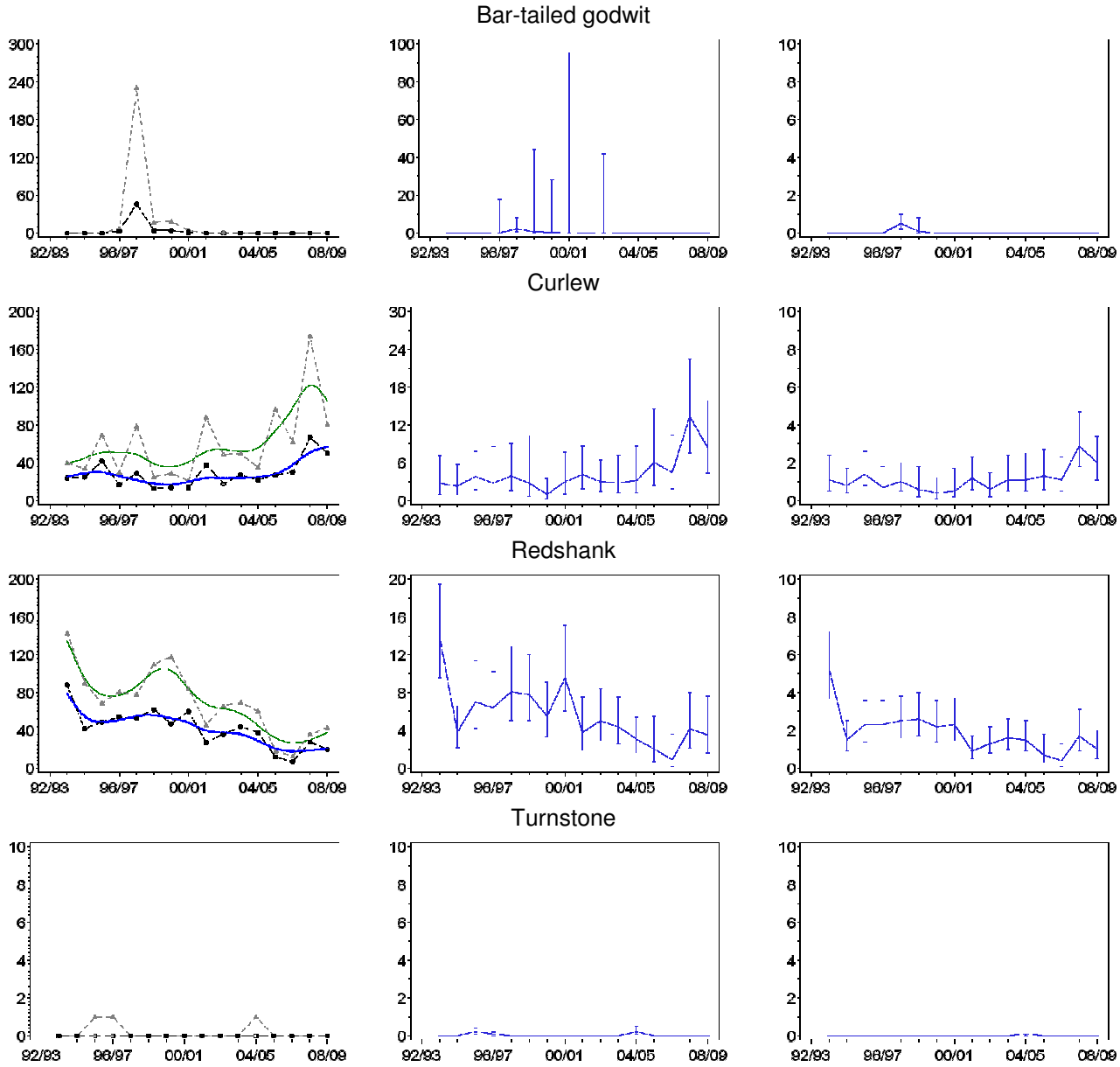


Figure B.35402 Population trends of each species in sector 35402 (Gedney) (left), and the proportion of total numbers recorded on The Wash NNR (centre) and The Wash SSSI (right) in this sector by year.

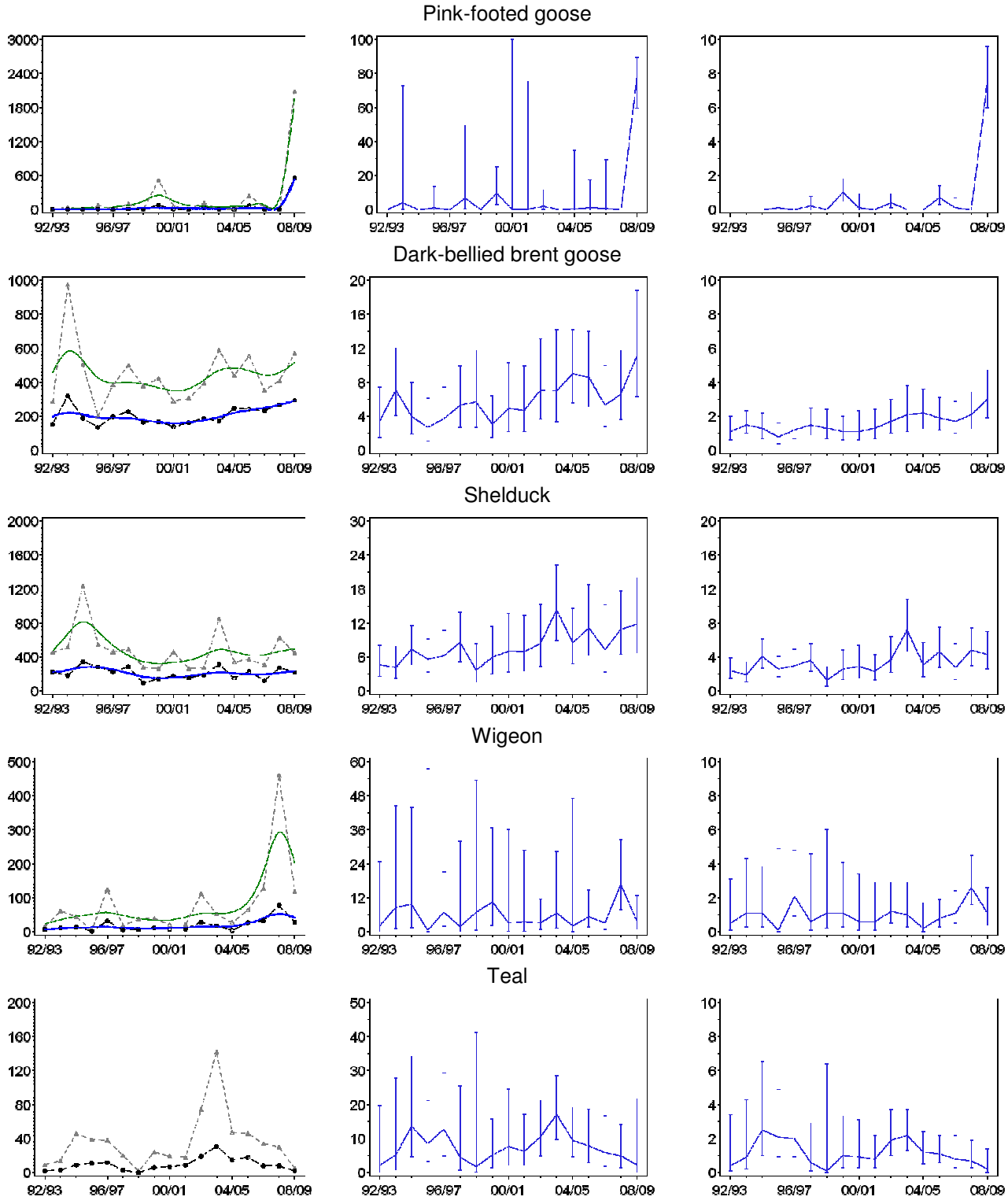


Figure B.35402 (continued).

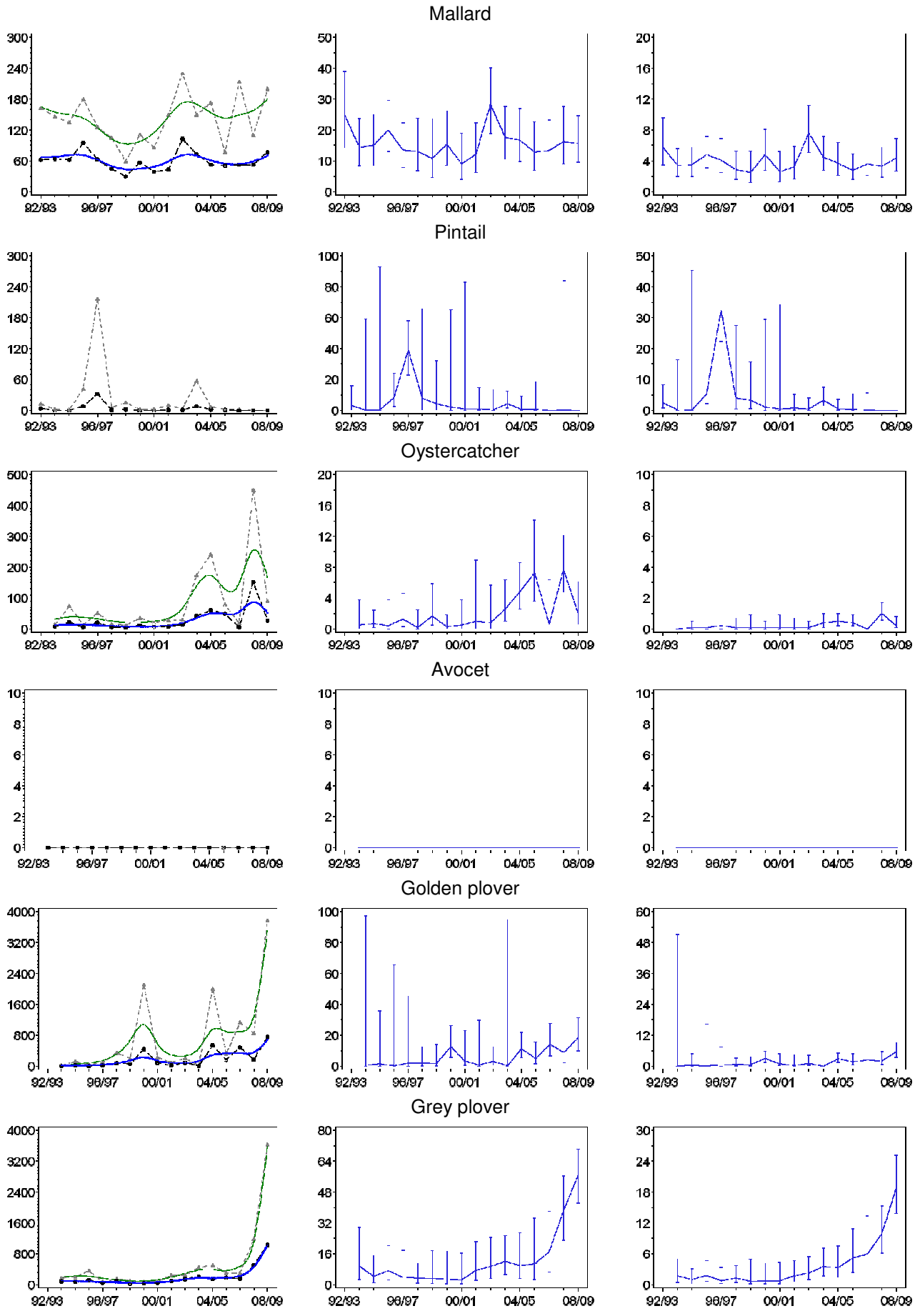


Figure B.35402 (continued).

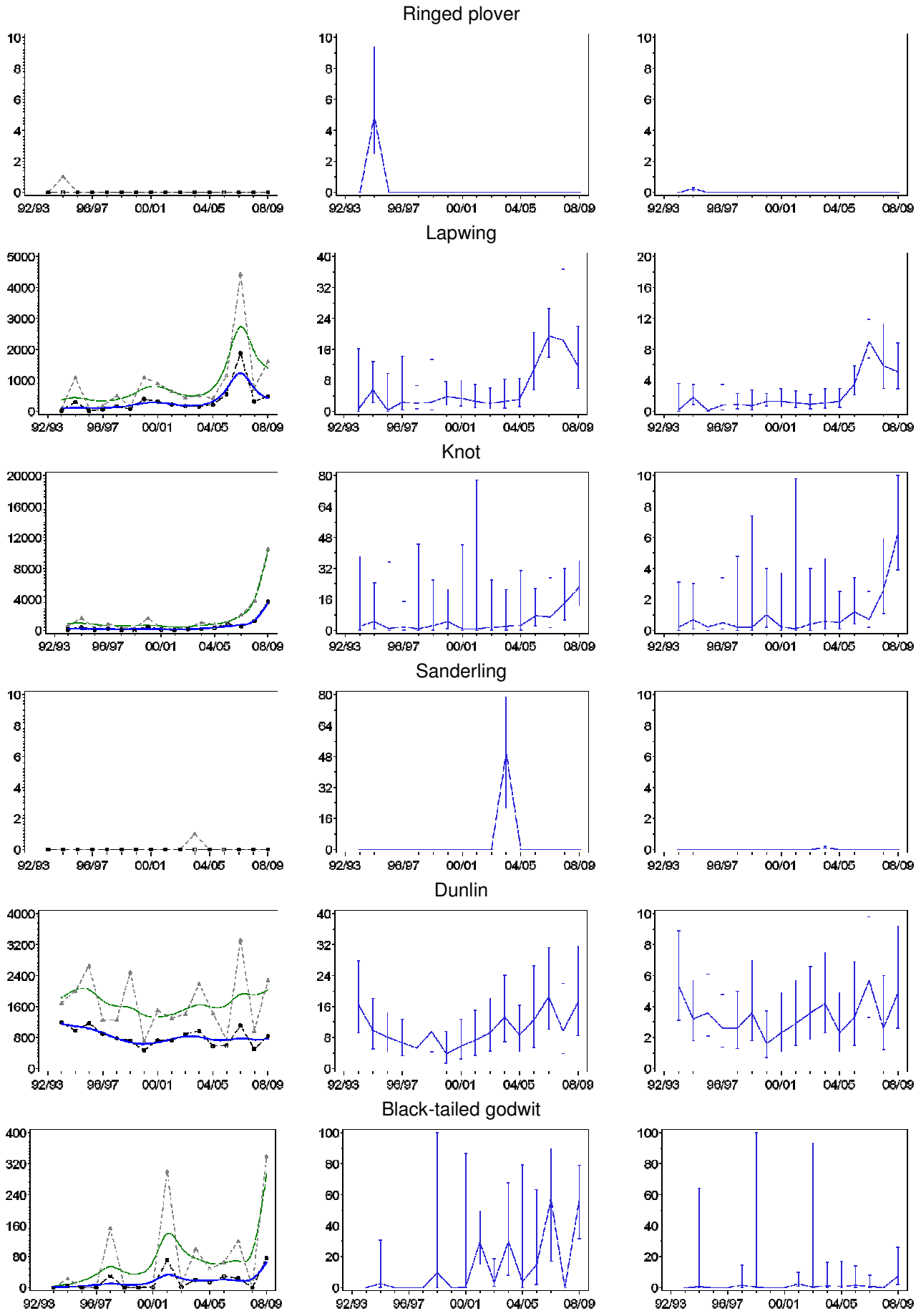


Figure B.35402 (continued).

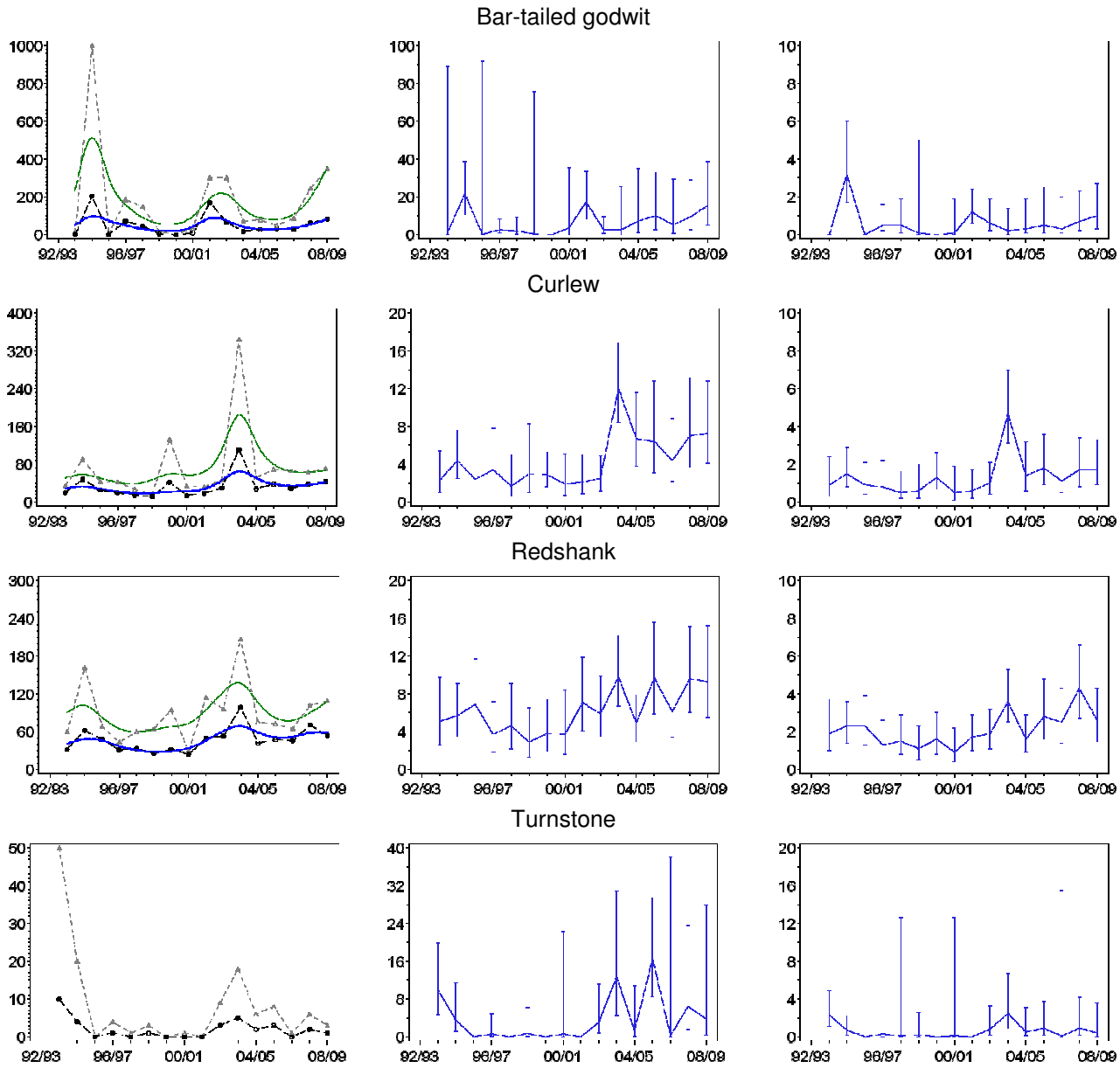


Figure B.35401 Population trends of each species in sector 35401 (Terrington West) (left), and the proportion of total numbers recorded on The Wash NNR (centre) and The Wash SSSI (right) in this sector by year.

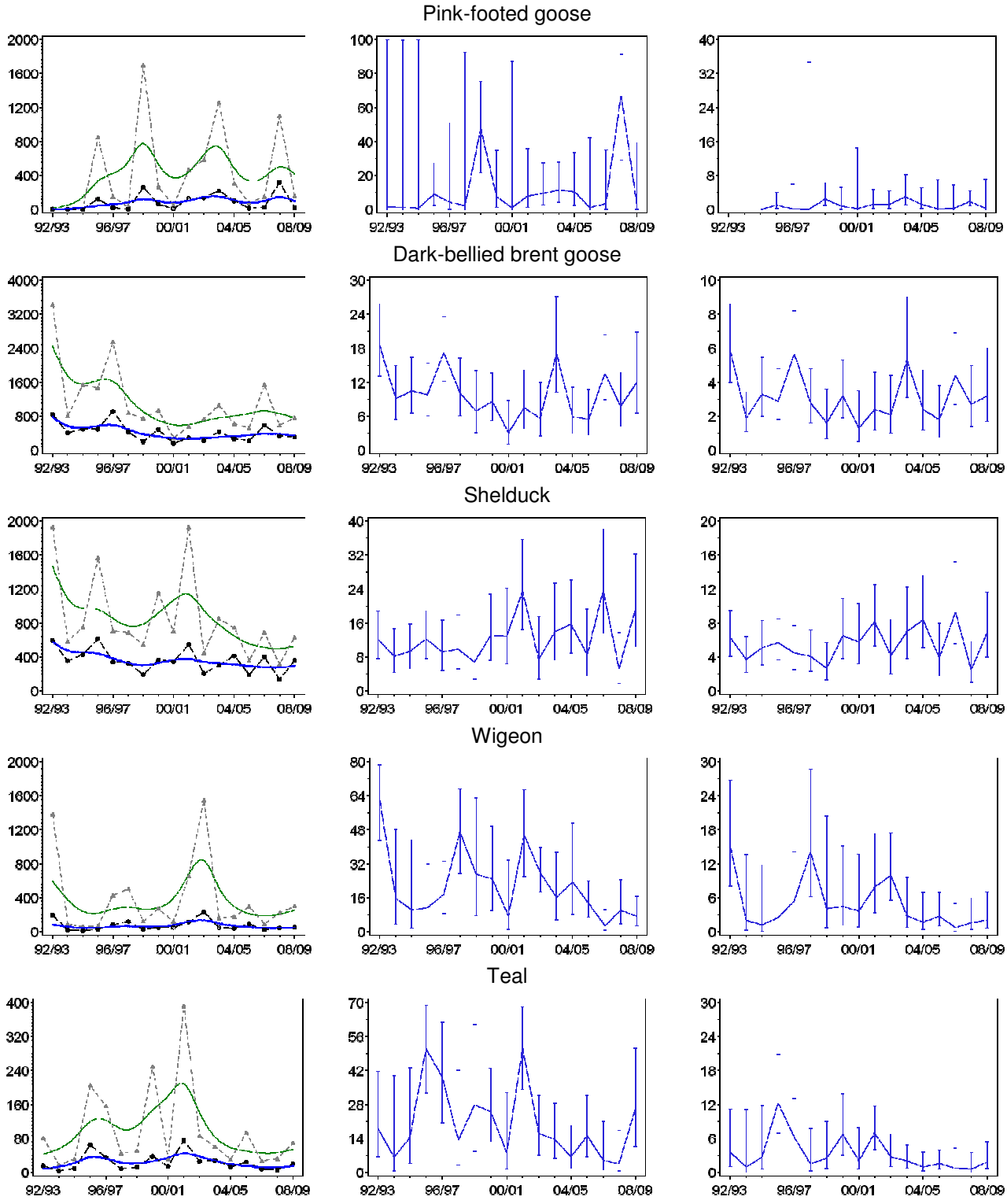


Figure B.35401 (continued).

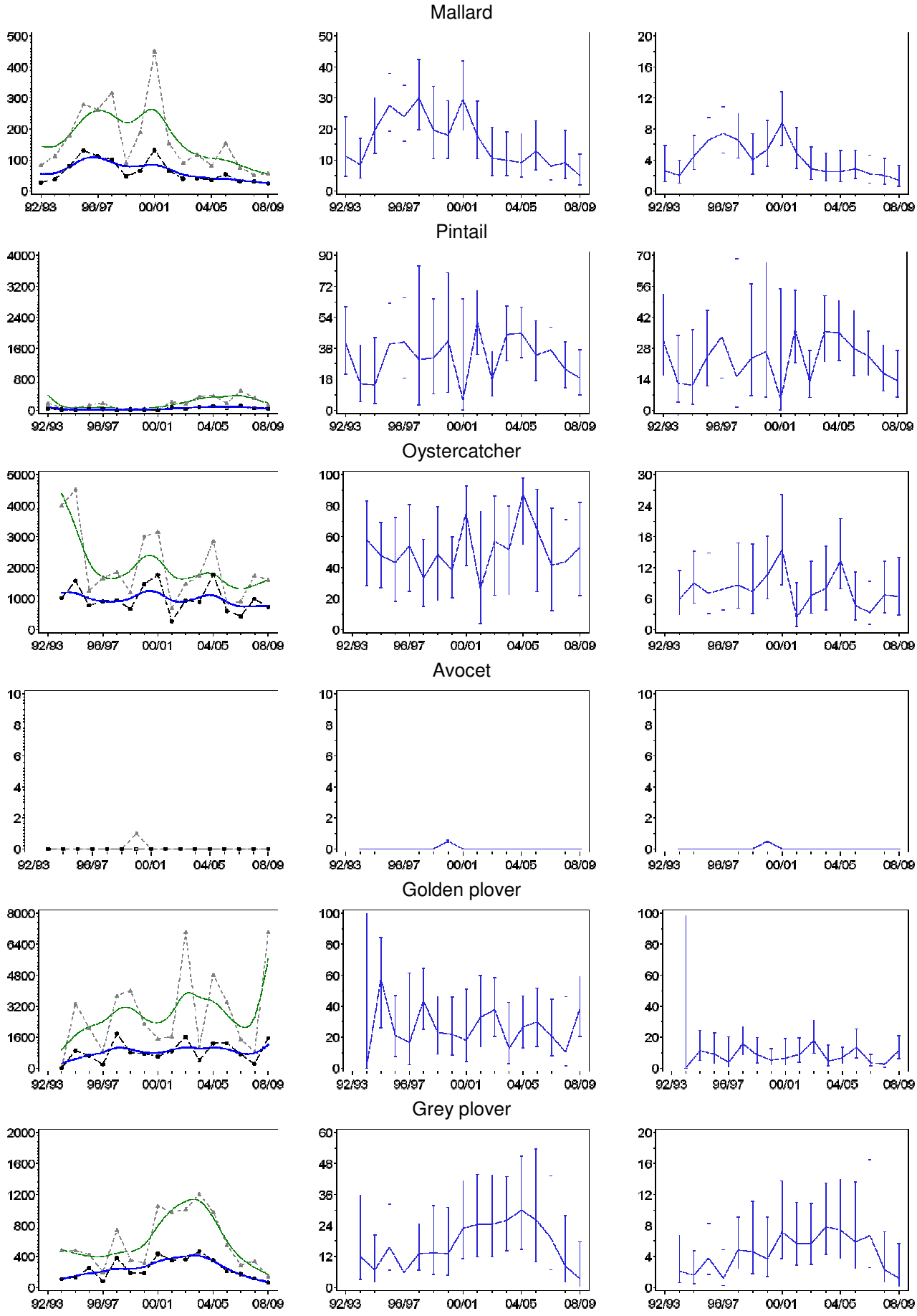


Figure B.35401 (continued).

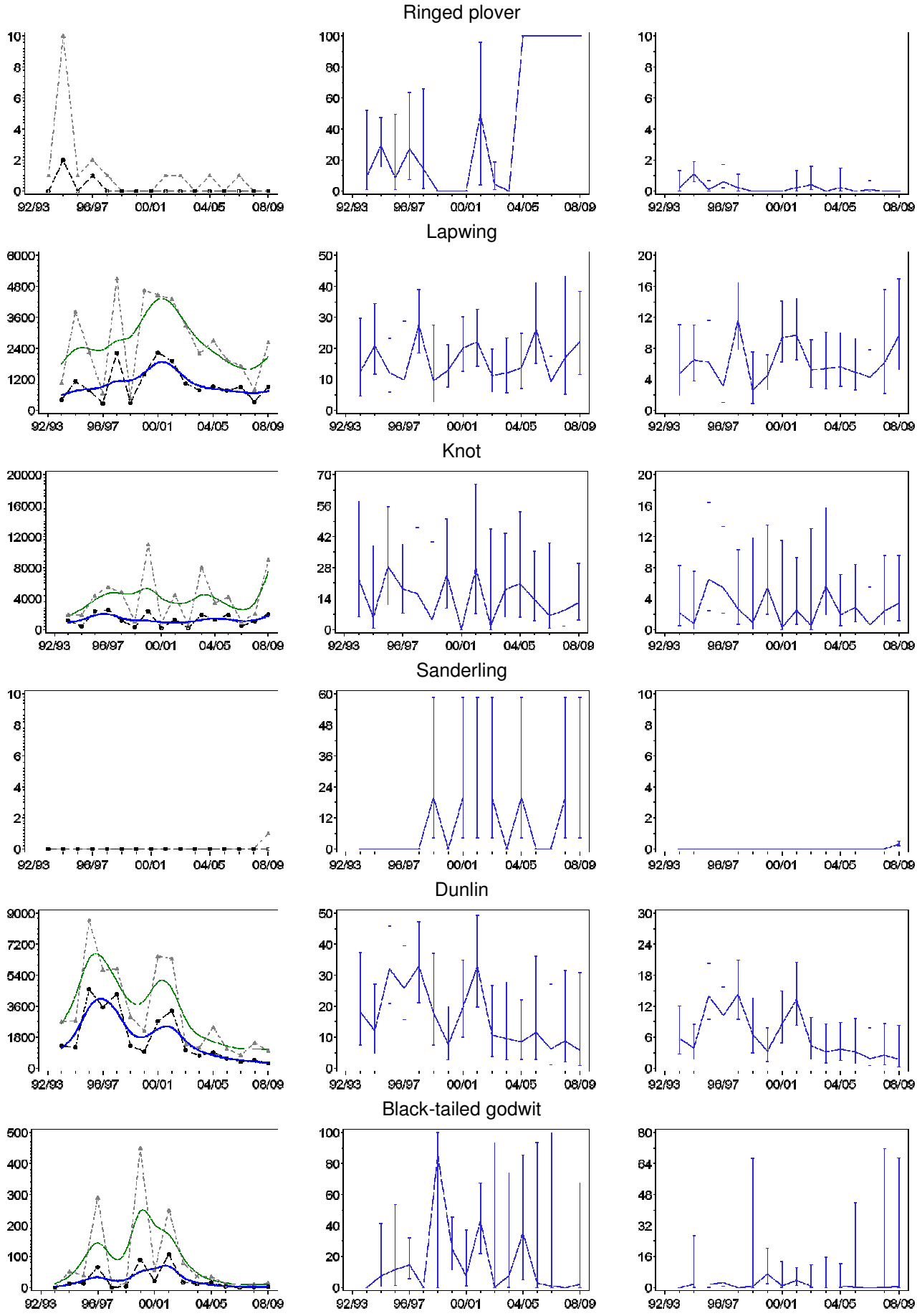


Figure B.35401 (continued).

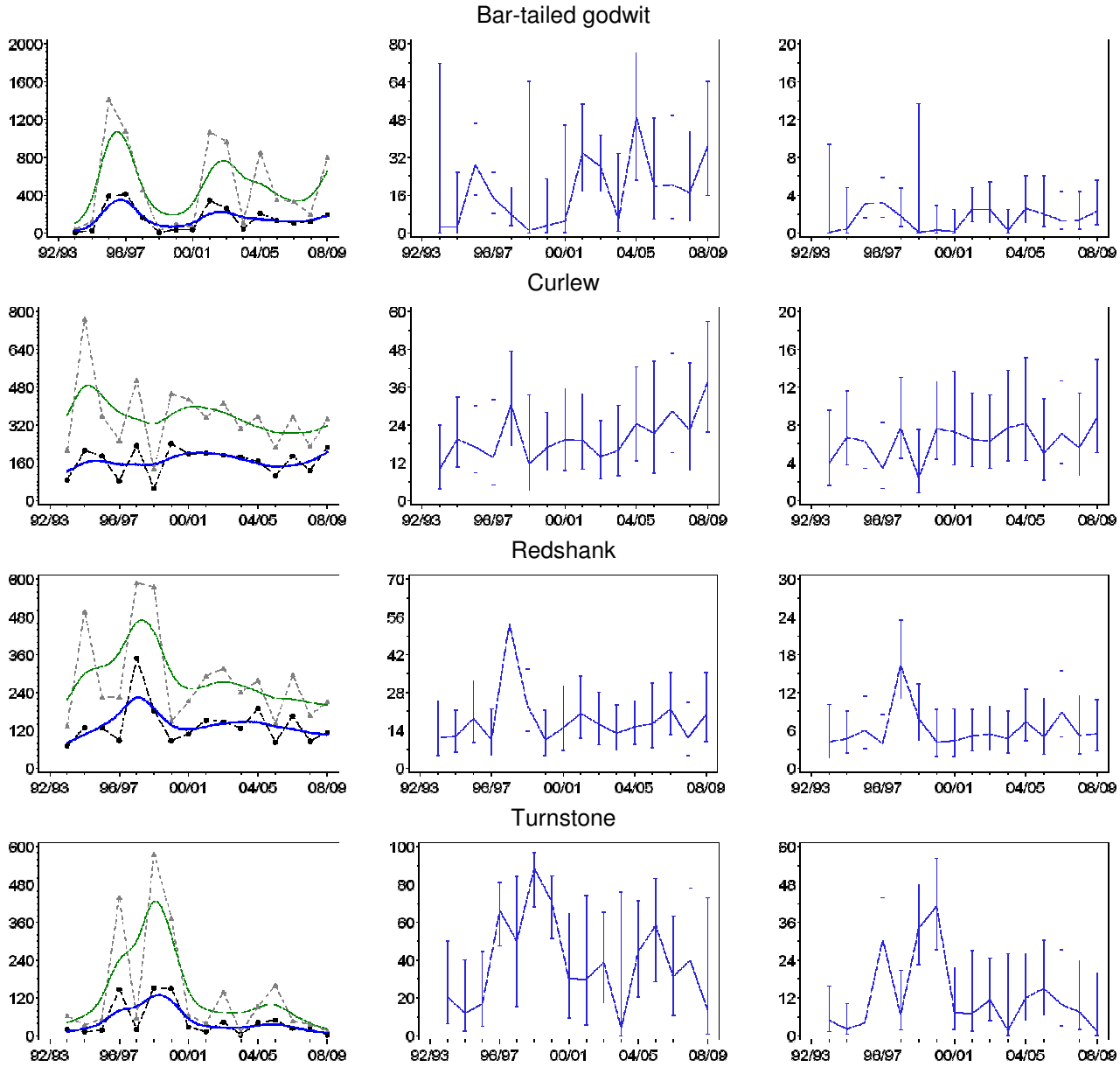


Figure B.34491 Population trends of each species in sector 34491 (Terrington East) (left), and the proportion of total numbers recorded on The Wash NNR (centre) and The Wash SSSI (right) in this sector by year.

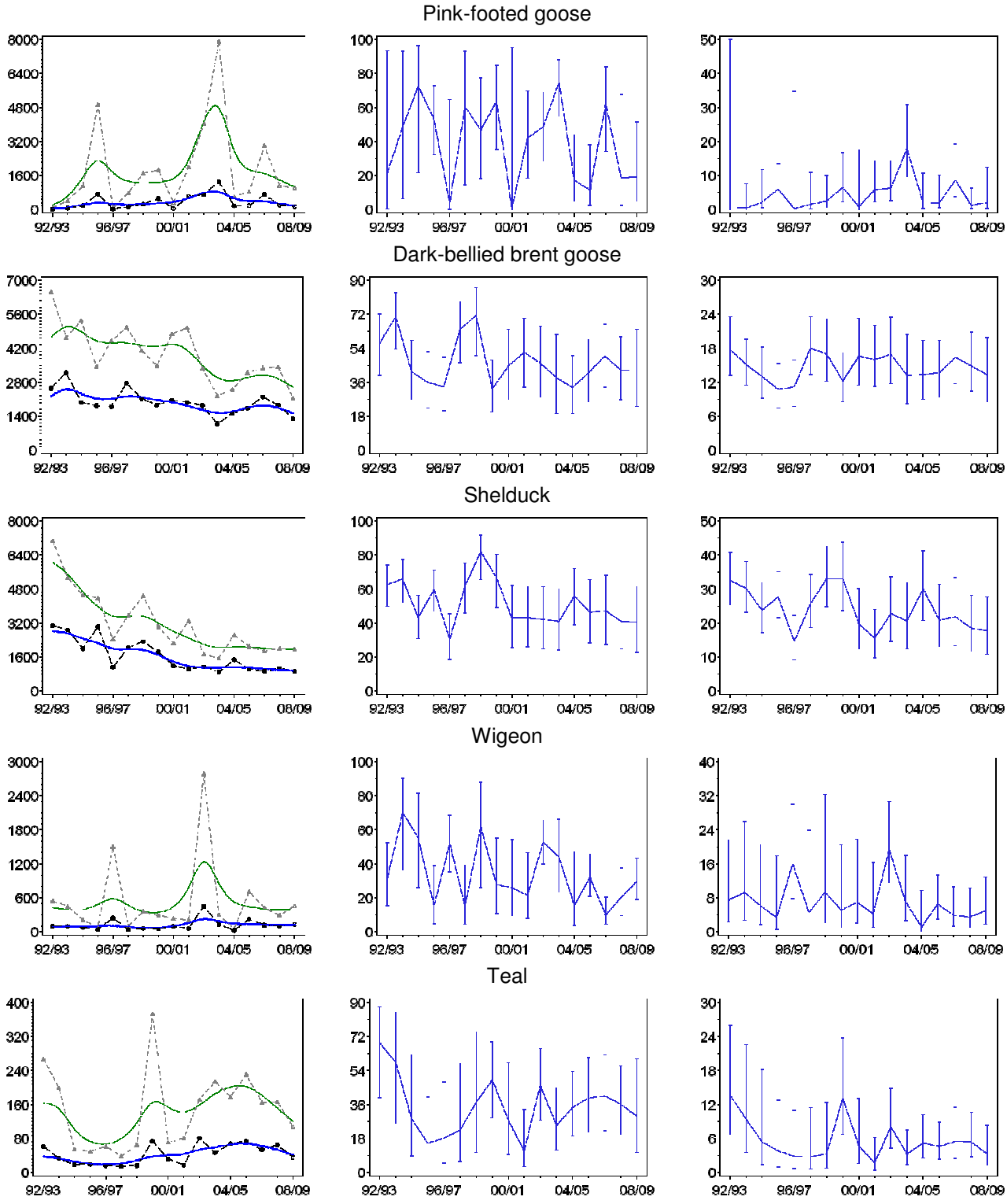


Figure B.34491 (continued).

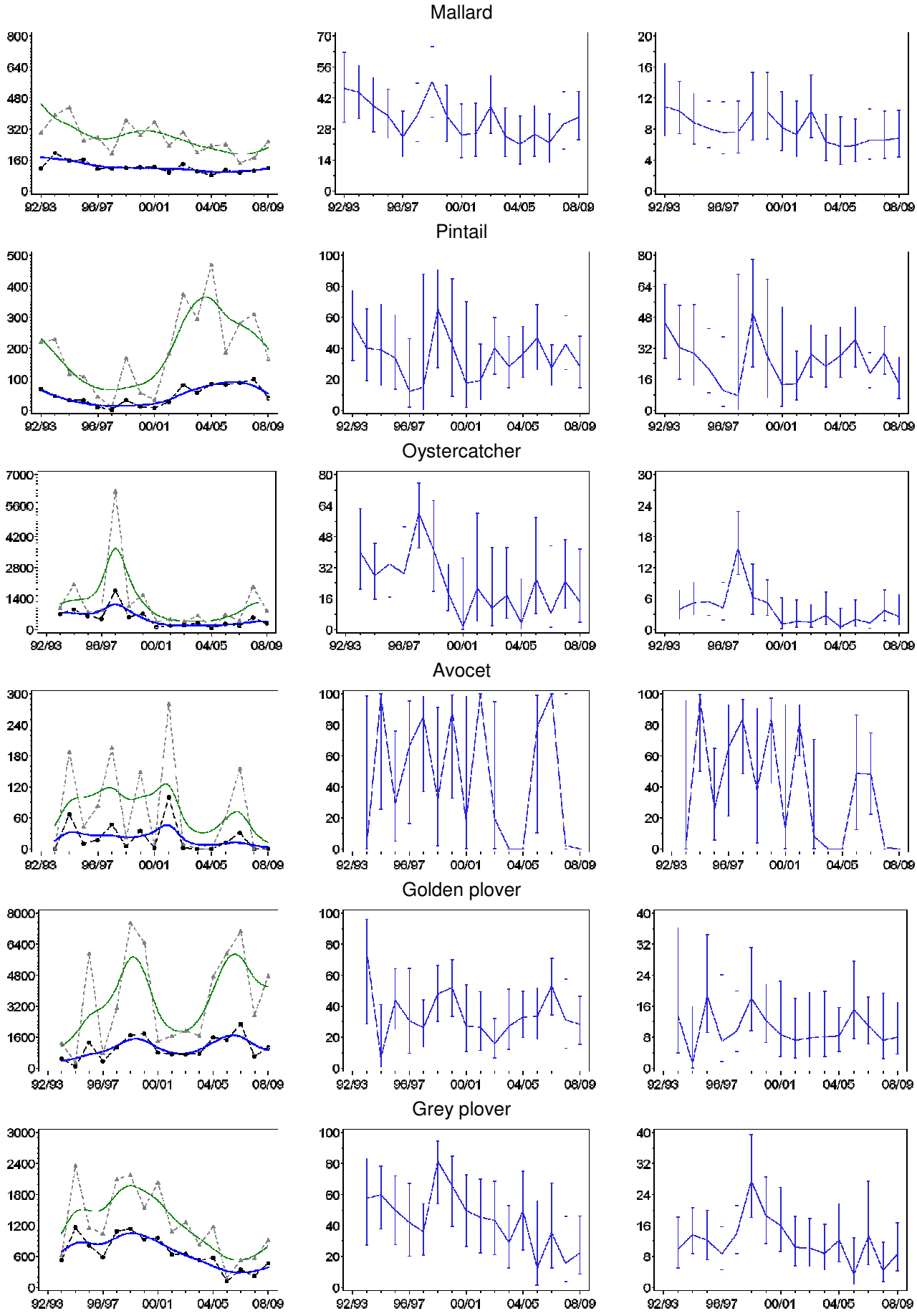


Figure B.34491 (continued).

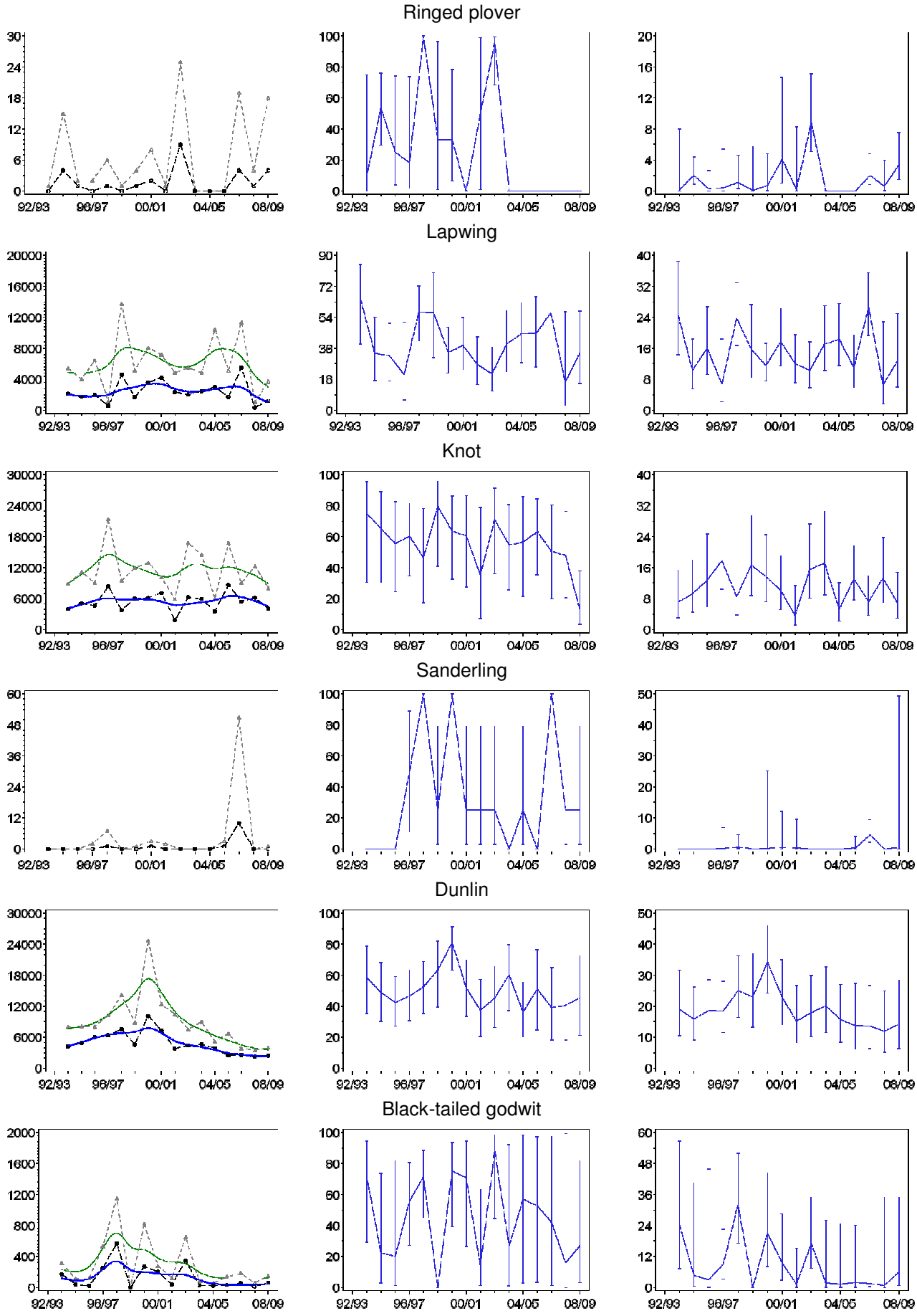


Figure B.34491 (continued).

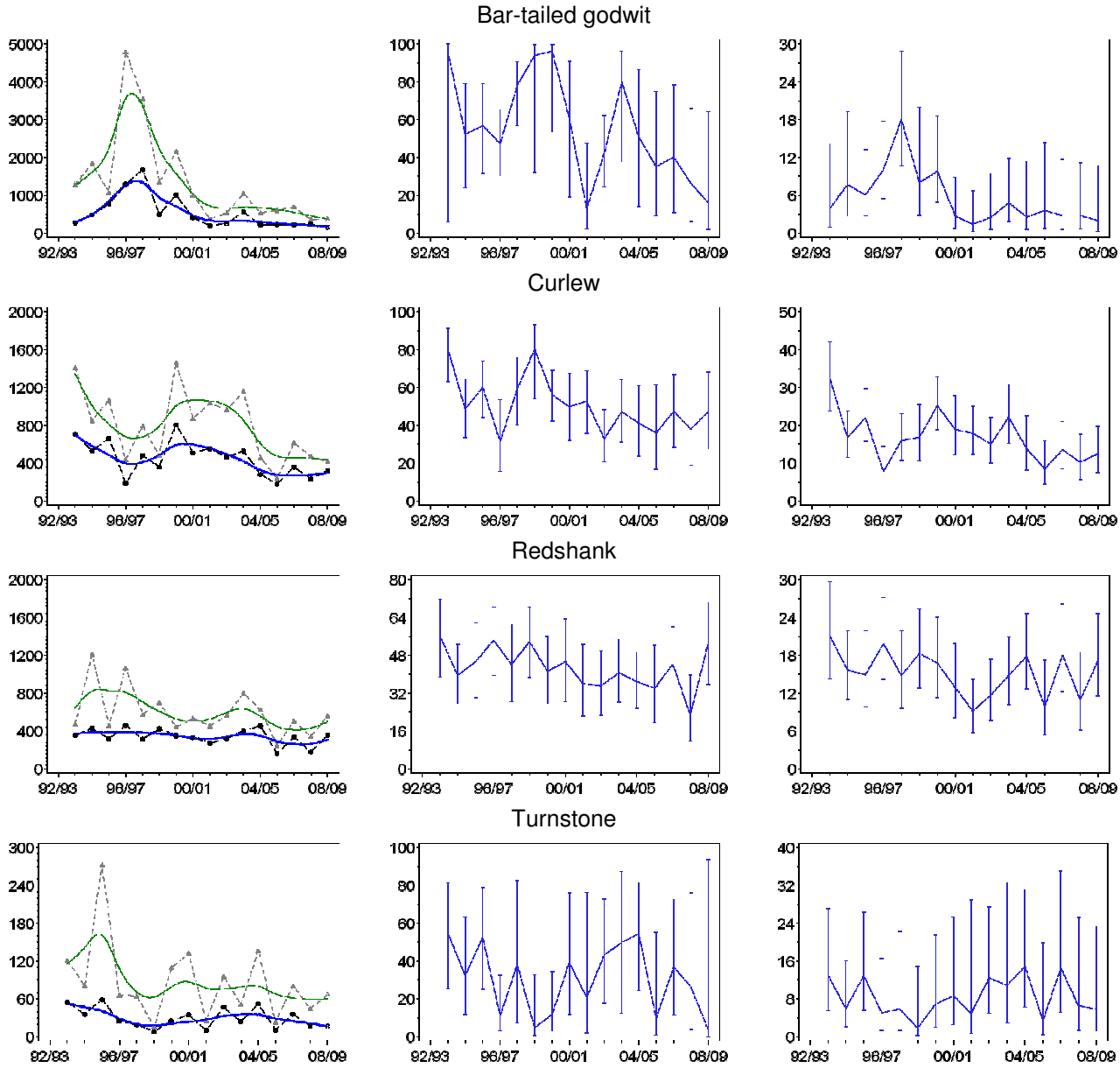


Figure B.34490 Population trends of each species in sector 34490 (Ouse Mouth) (left), and the proportion of total numbers recorded on The Wash NNR (centre) and The Wash SSSI (right) in this sector by year.

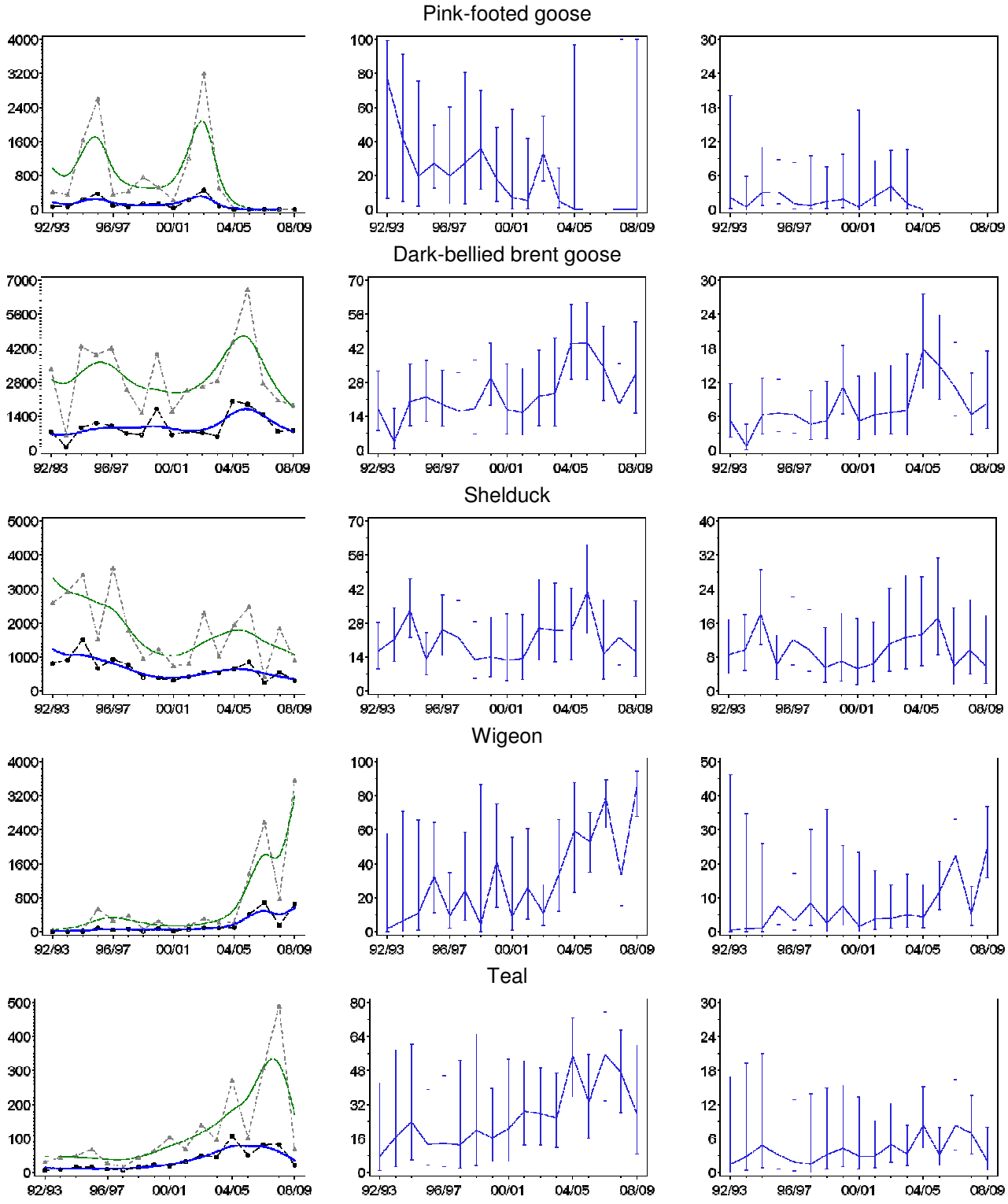


Figure B.34490 (continued).

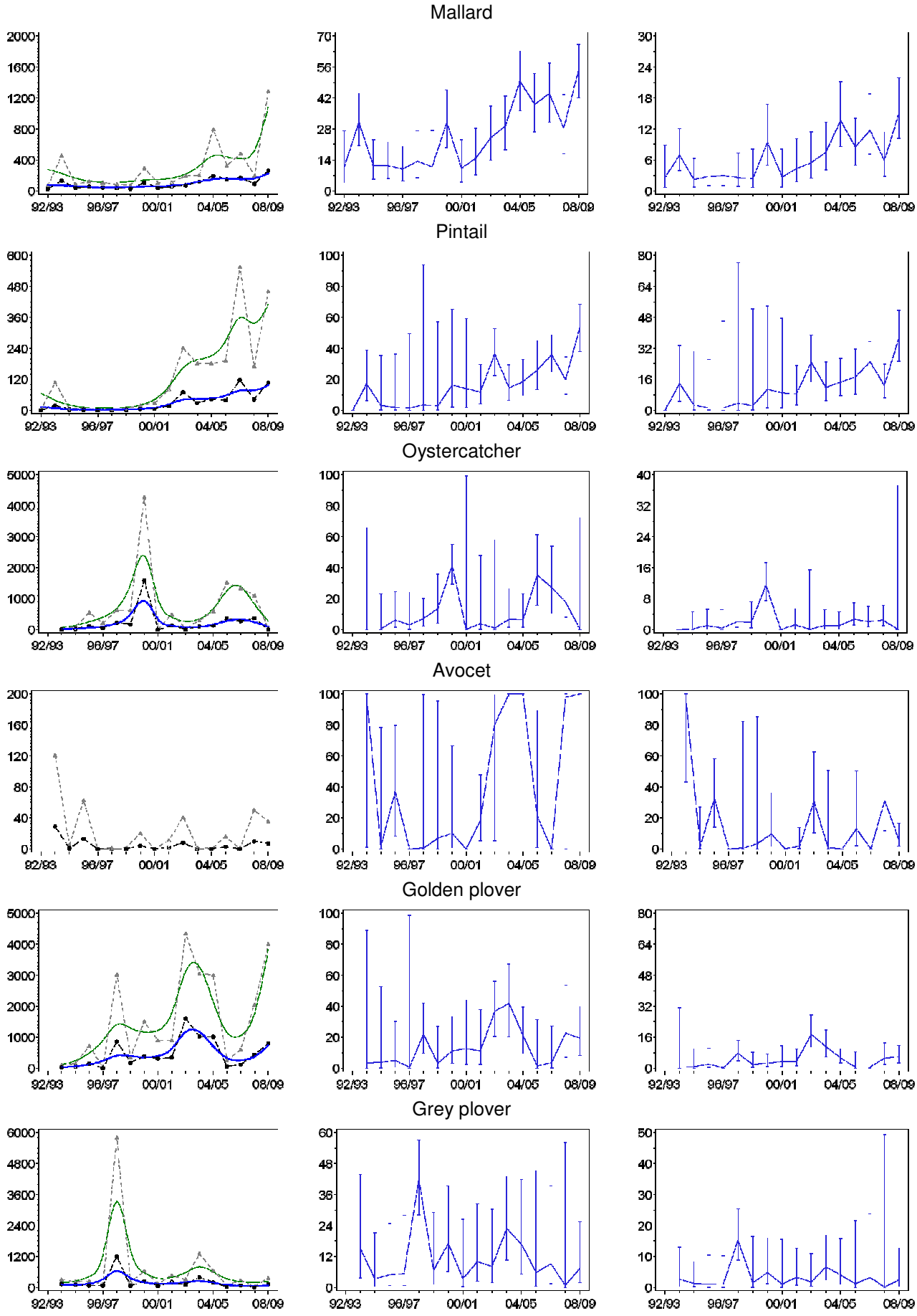


Figure B.34490 (continued).

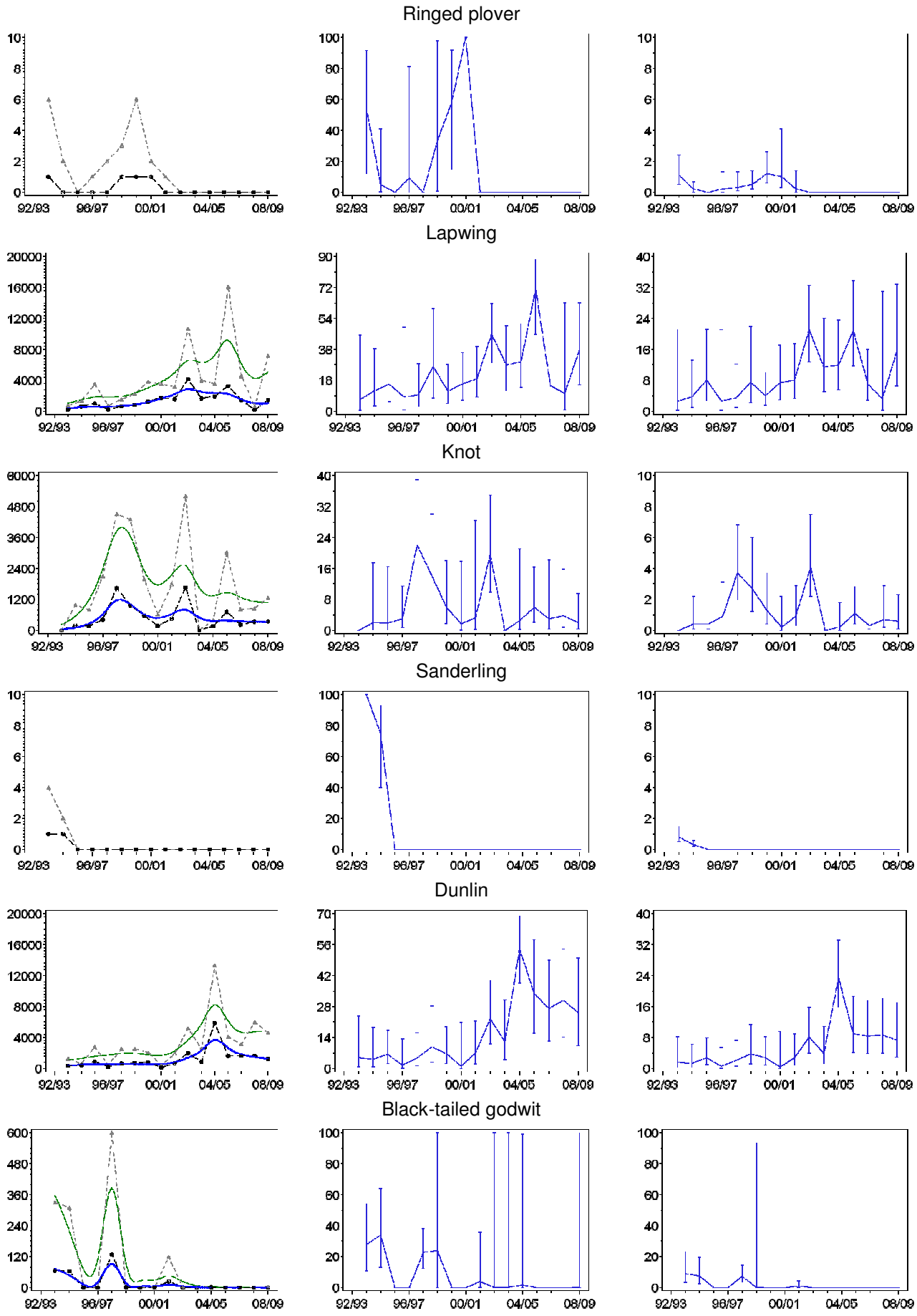
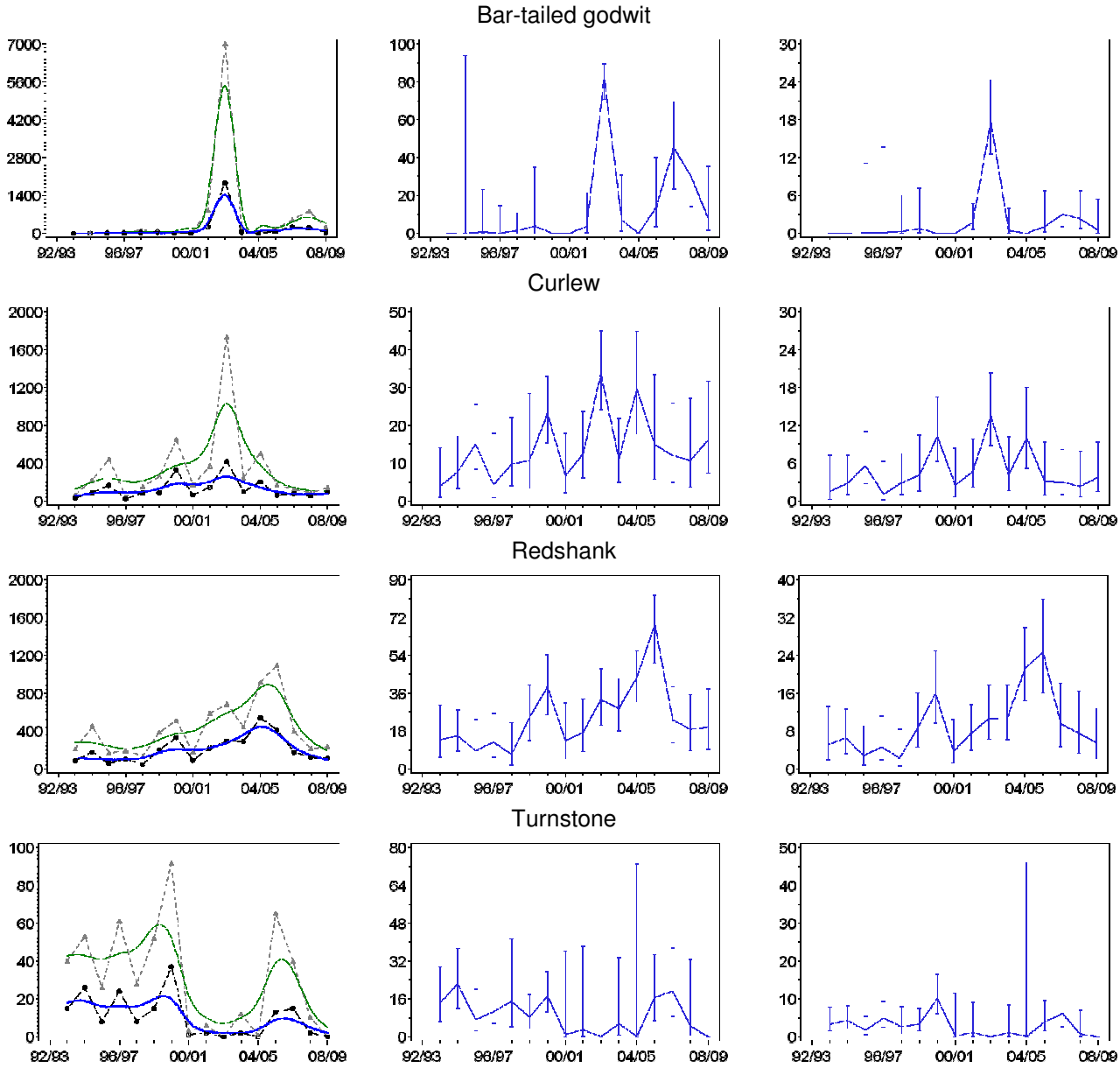


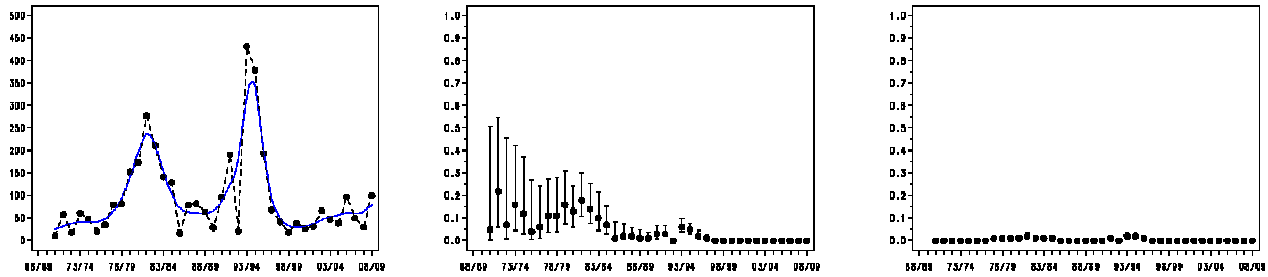
Figure B.34490 (continued).



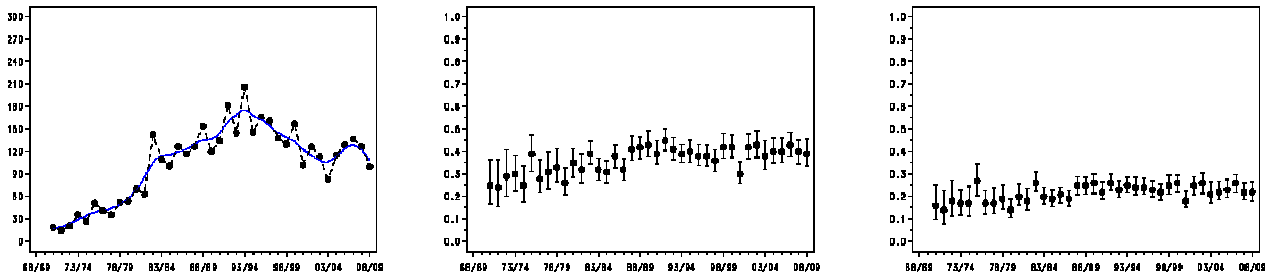
APPENDIX C

Figure C.1 Twenty-five year population trends for feature species of The Wash SPA/SSSI (left), and relative to the Environment Agency Anglian Region (centre) and Great Britain (right) by year.

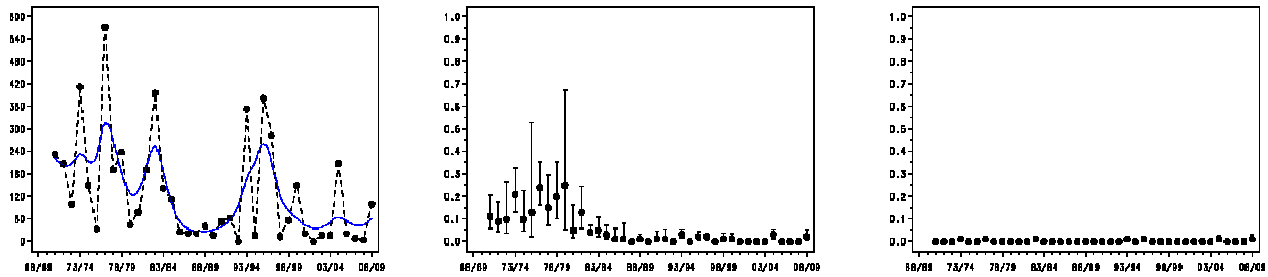
Whooper swan



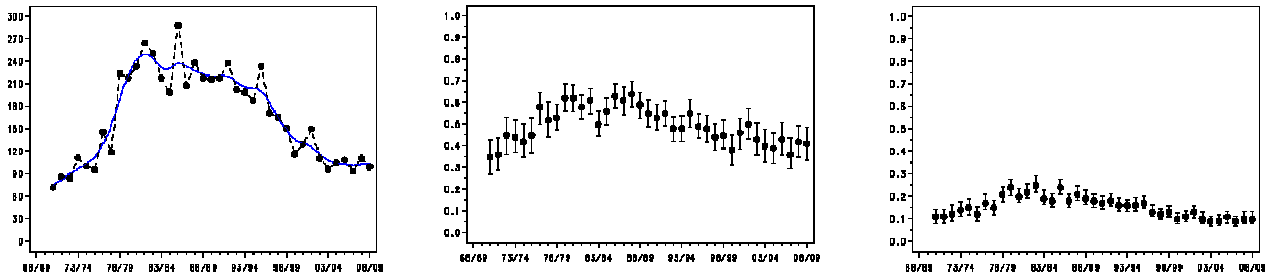
Dark-bellied brent goose



European white-fronted goose



Shelduck



Wigeon

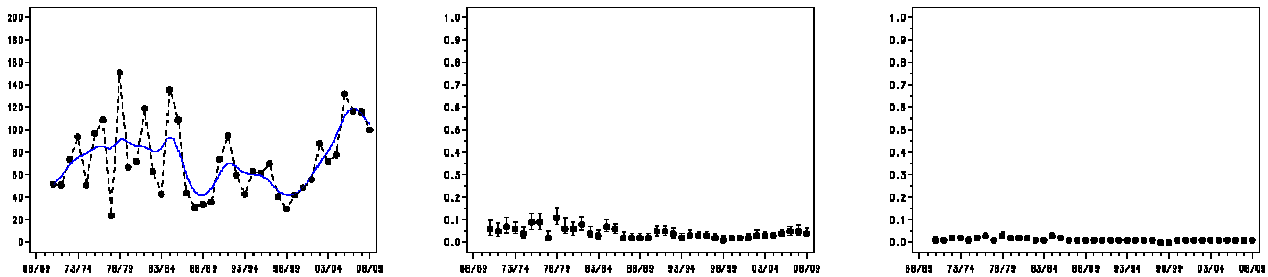
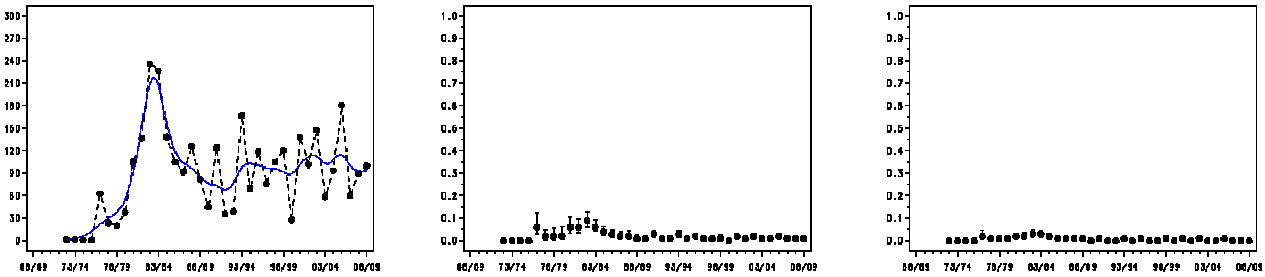
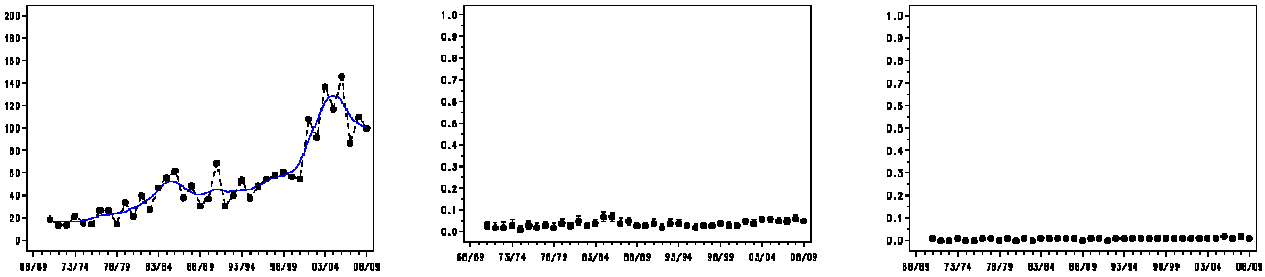


Figure C.1 (continued).

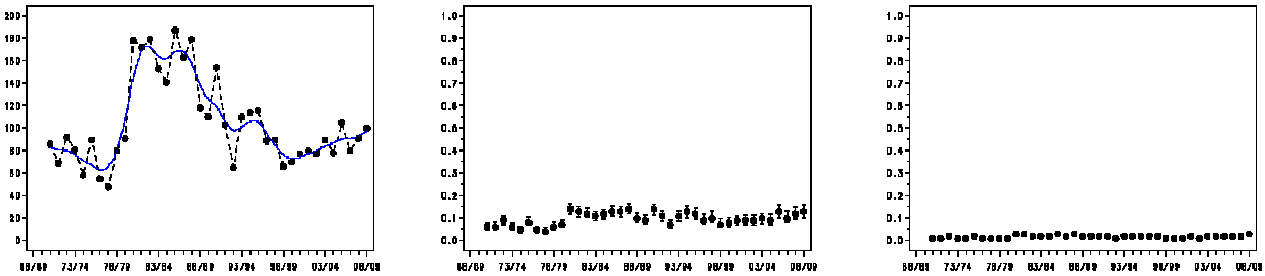
Gadwall



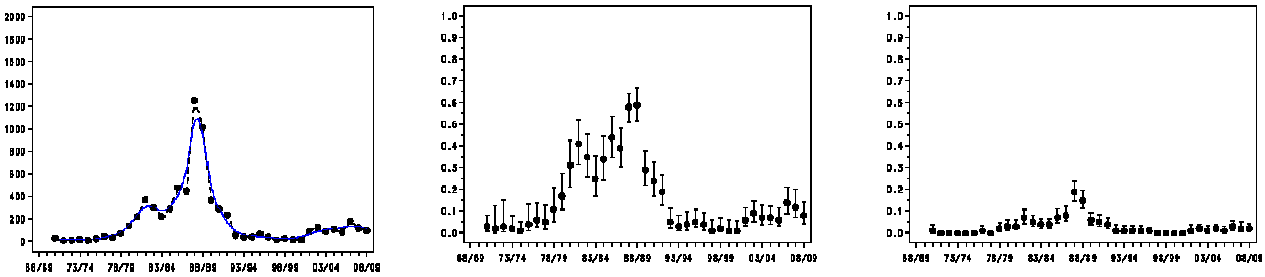
Teal



Mallard



Pintail



Common scoter

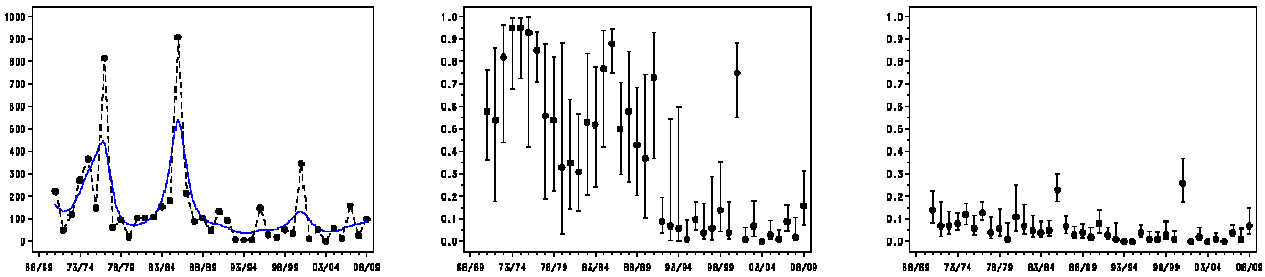
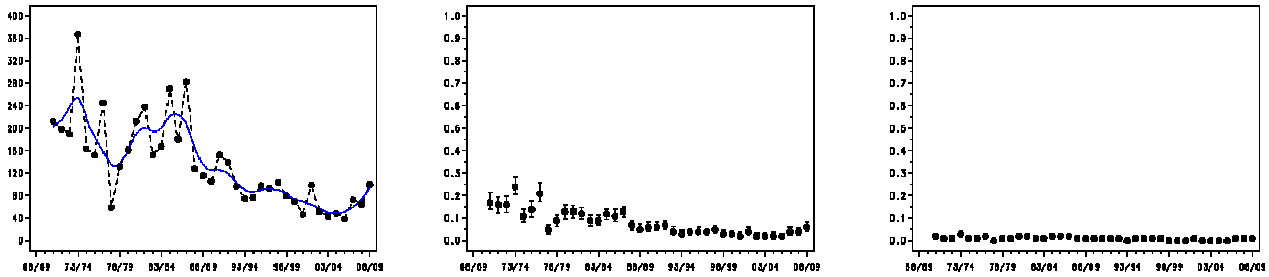
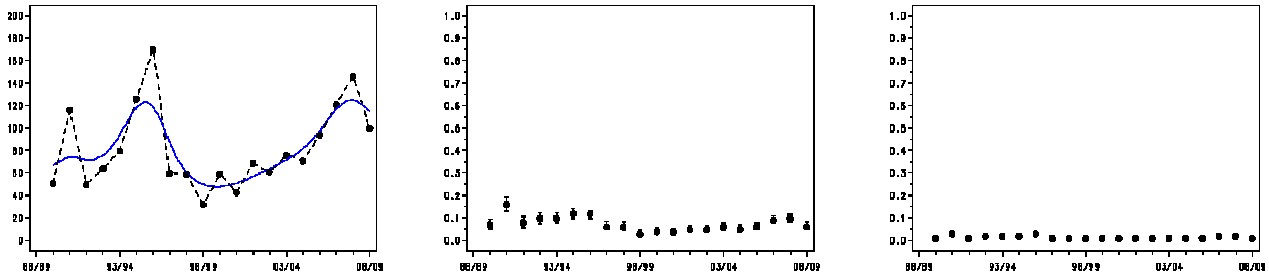


Figure C.1 (continued).

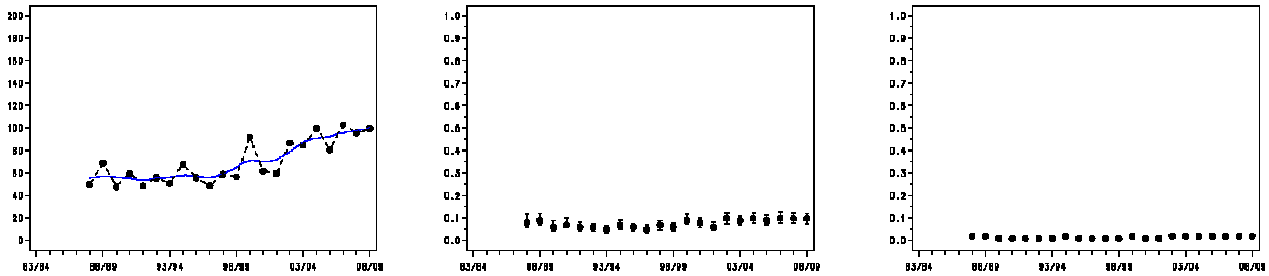
Goldeneye



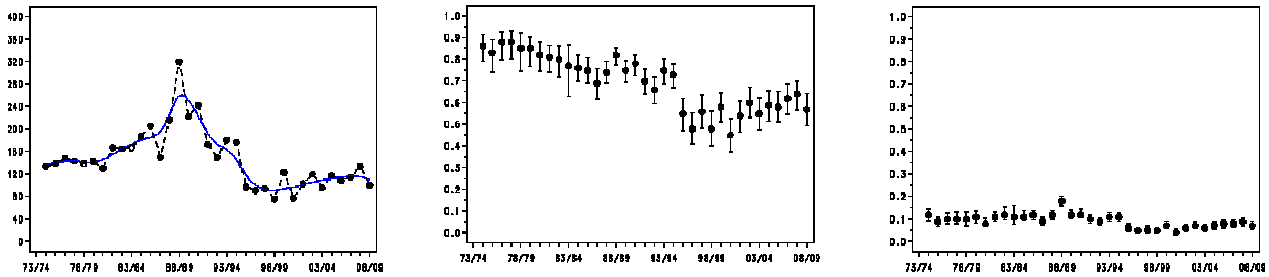
Little grebe



Cormorant



Oystercatcher



Avocet

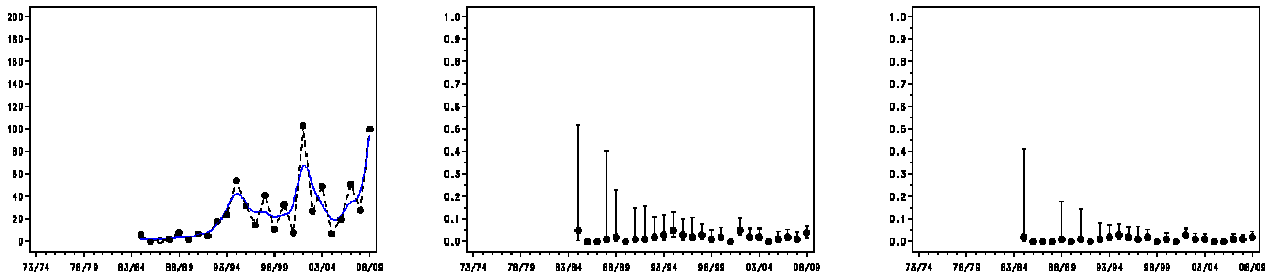
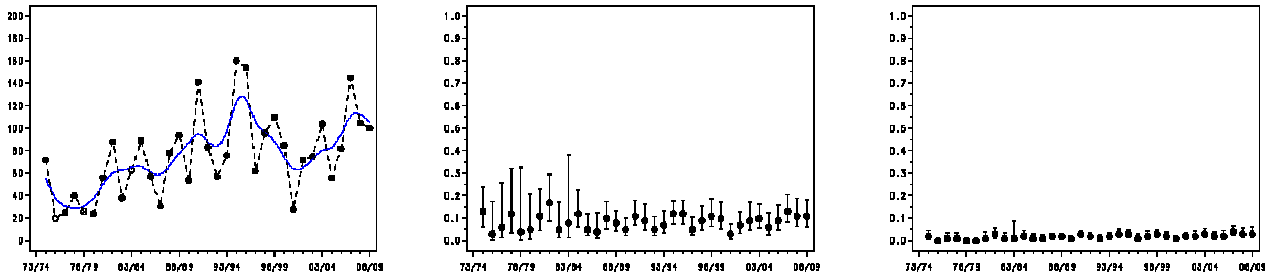
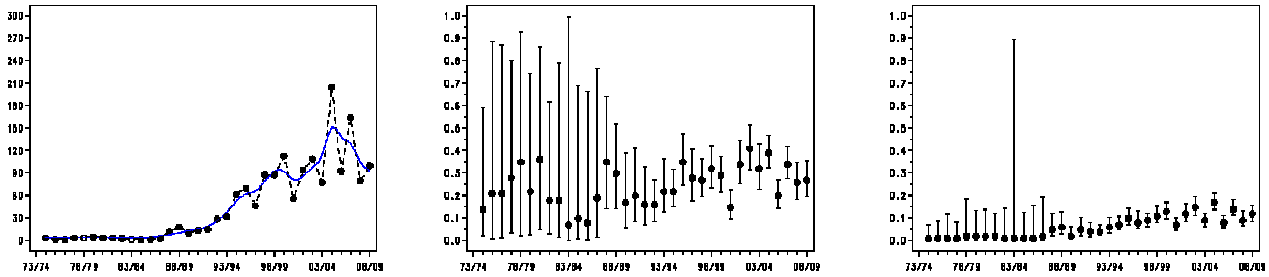


Figure C.1 (continued).

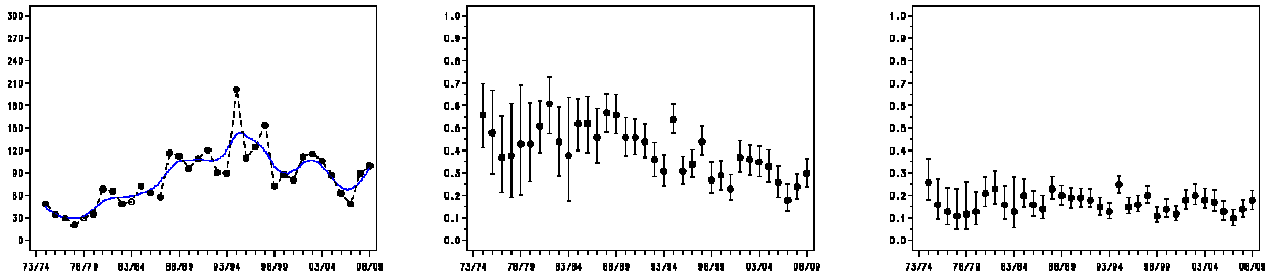
Ringed plover



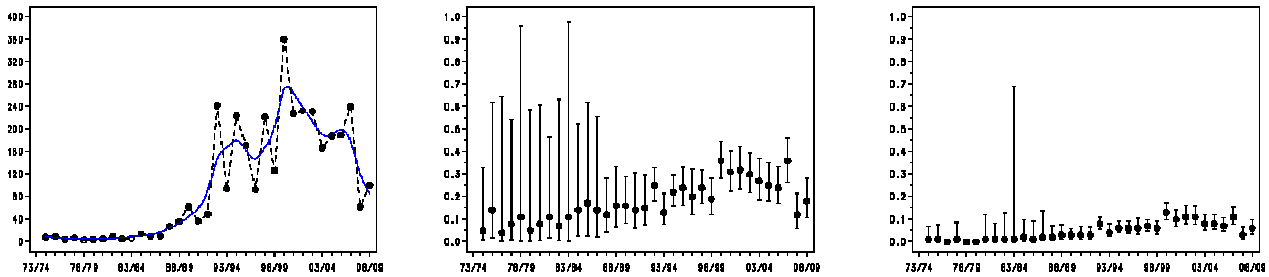
Golden plover



Grey plover



Lapwing



Knot

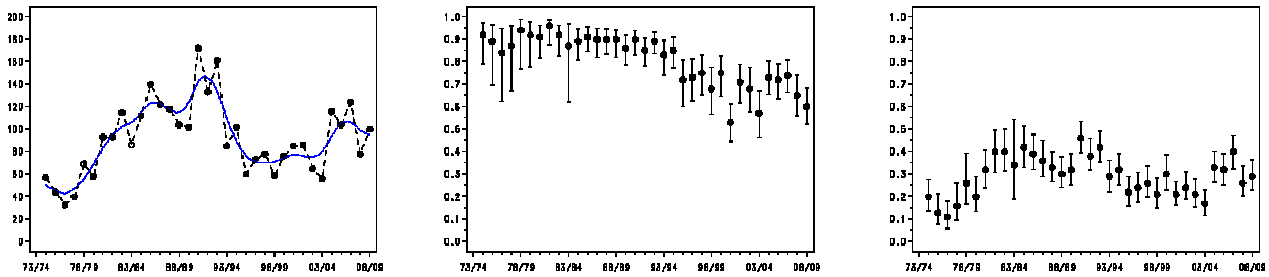
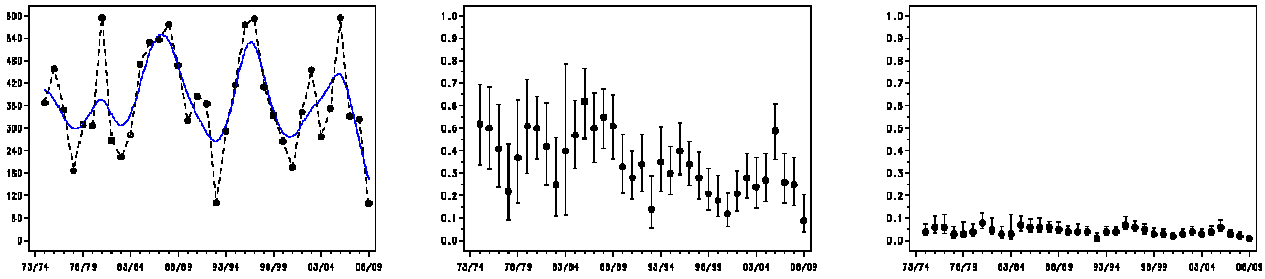
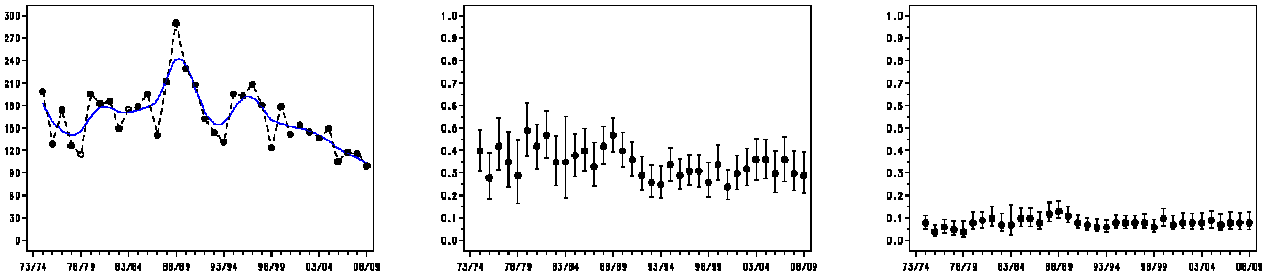


Figure C.1 (continued).

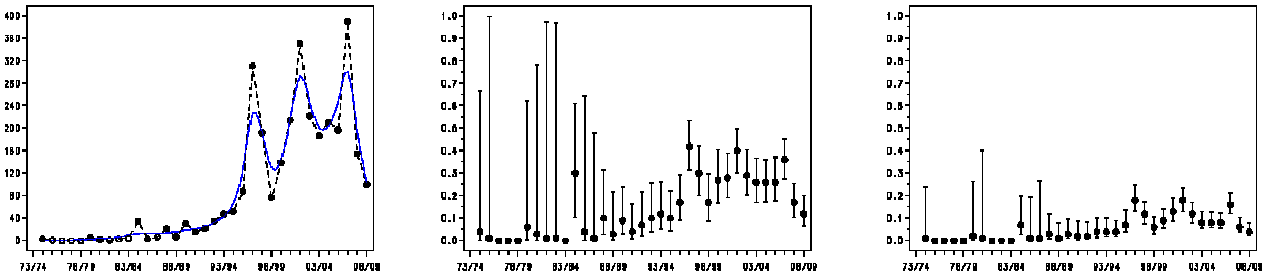
Sanderling



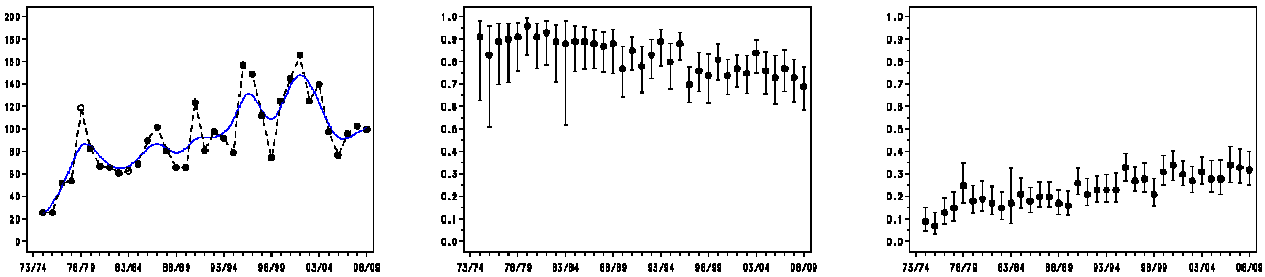
Dunlin



Black-tailed godwit



Bar-tailed godwit



Curlew

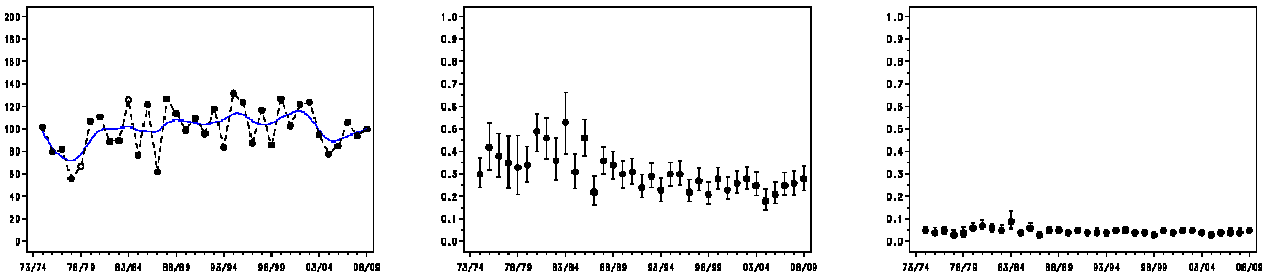
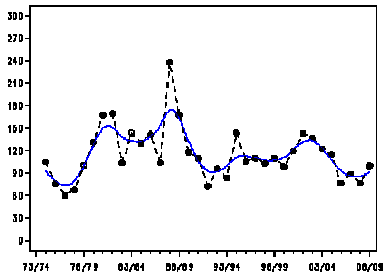
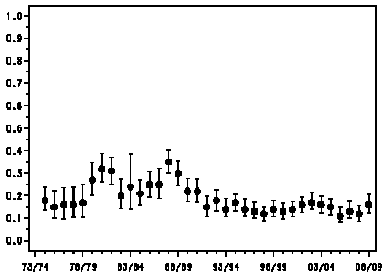
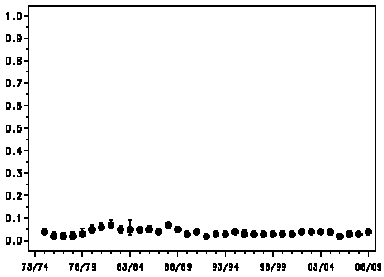


Figure C.1 (continued).

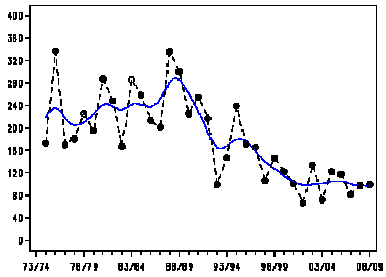
Redshank

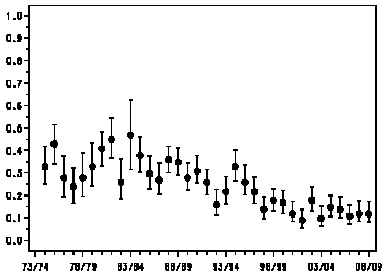


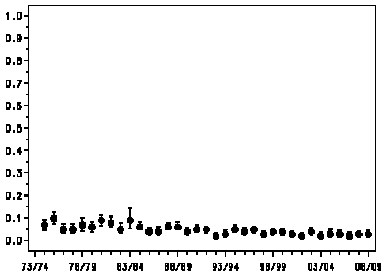




Turnstone

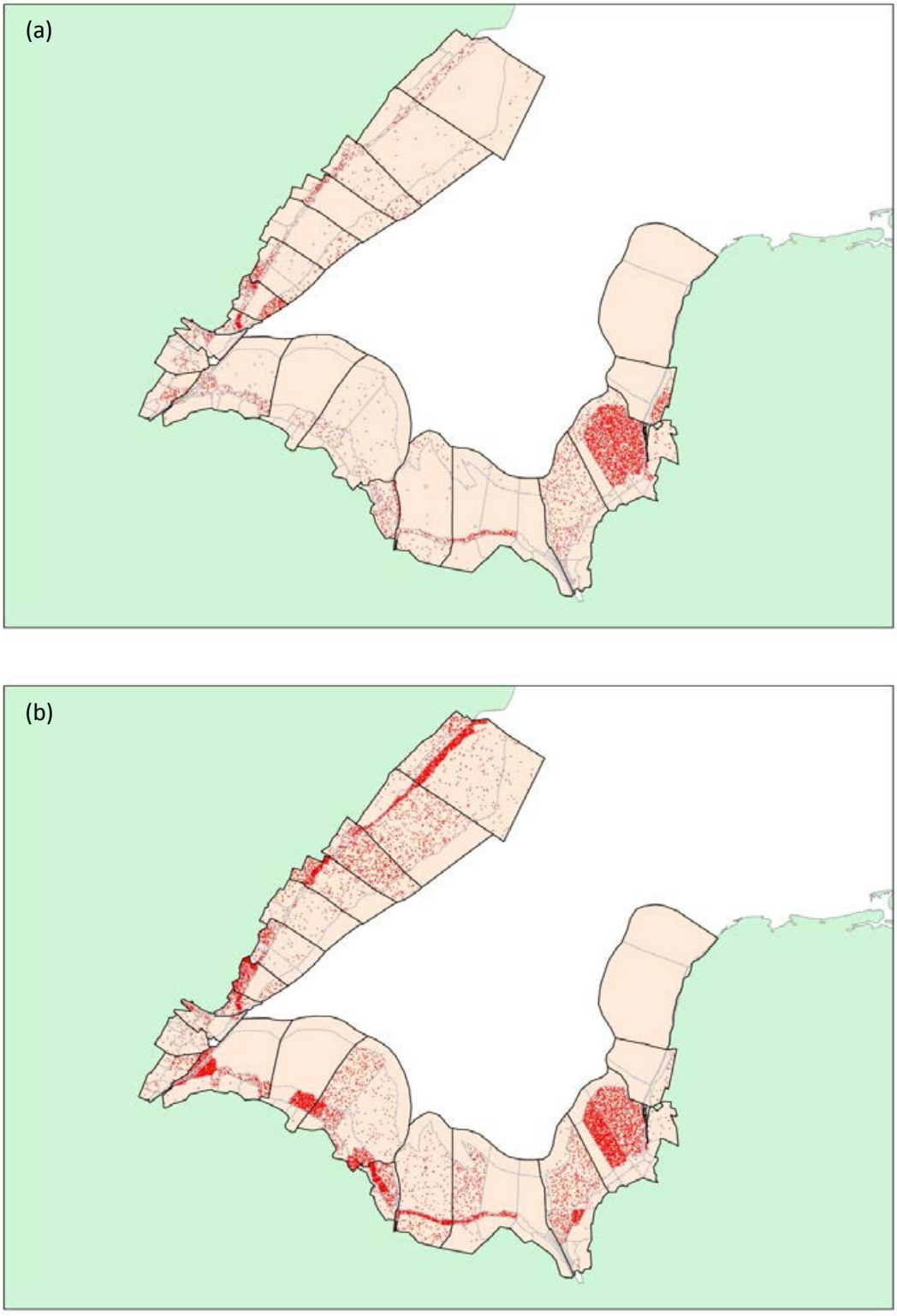






APPENDIX D

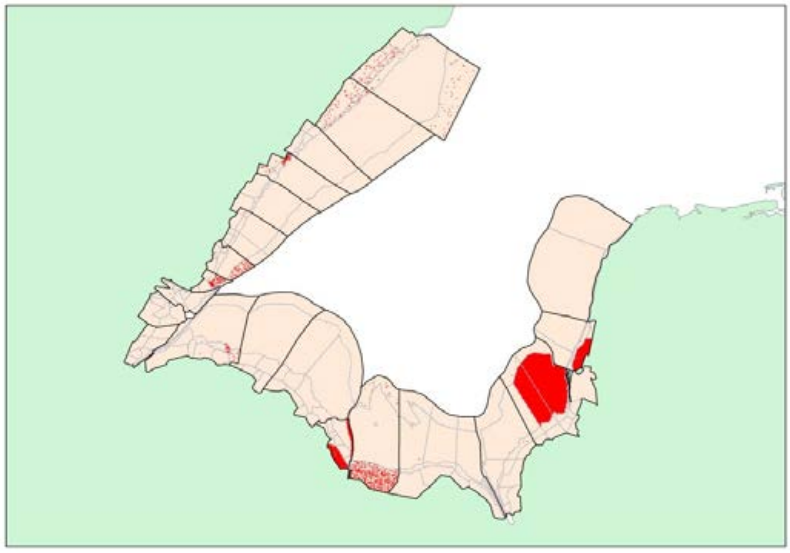
Figure D.1 Distribution of (a) wildfowl and little grebe (b) waders across WeBS high tide count sectors averaged over recent winters for which finer resolution data are available as compared with previous. Dot density maps (1 dot=20 bird) represent the mean of peak counts from winters 2007/08 & 2008/09.



APPENDIX E

Figure E.1 Distribution of waterbirds by species across WeBS high tide count sectors for which fine resolution data are available. Dot density maps (1 dot=1 bird) represent the mean of peak counts from winters 2007/08 & 2008/09.

i) Pink-footed goose



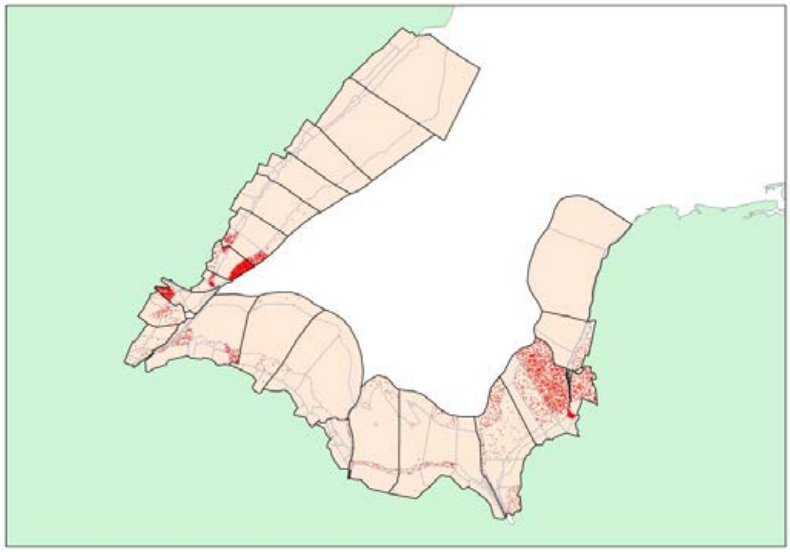
ii) Dark-bellied brent goose

iii) Shelduck

Figure E.1 (Continued)

iv) Wigeon

v) Teal



vi) Mallard

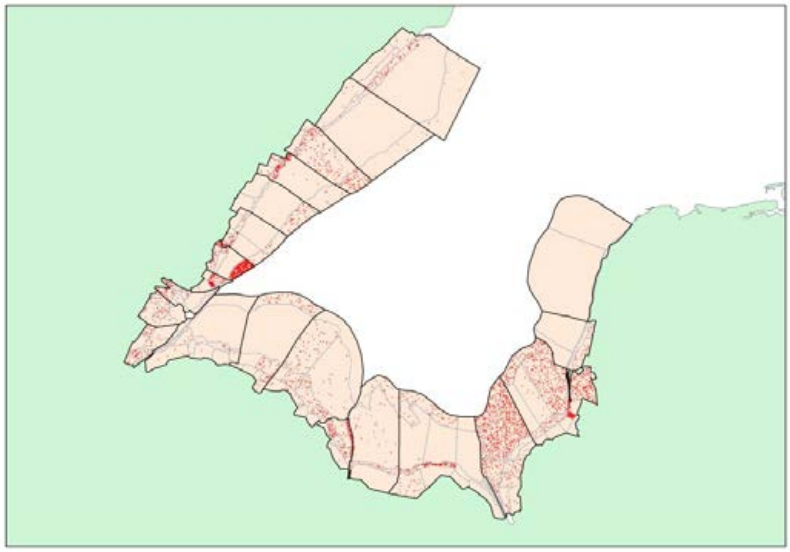
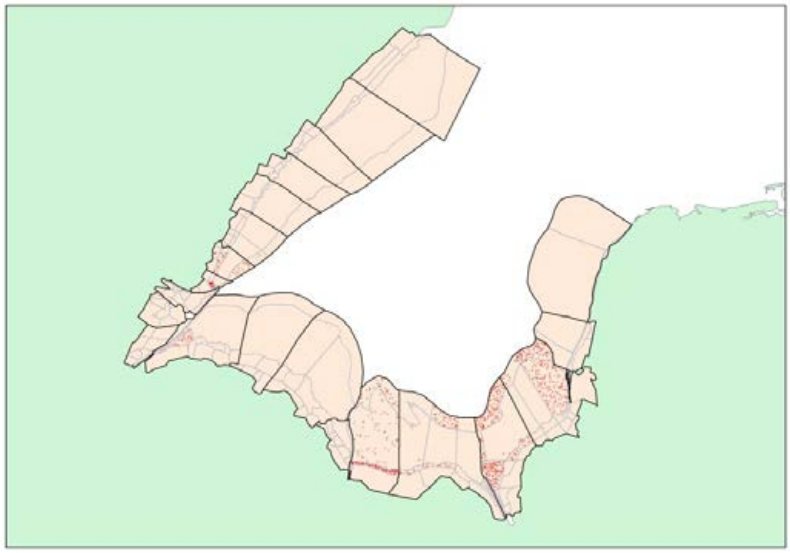
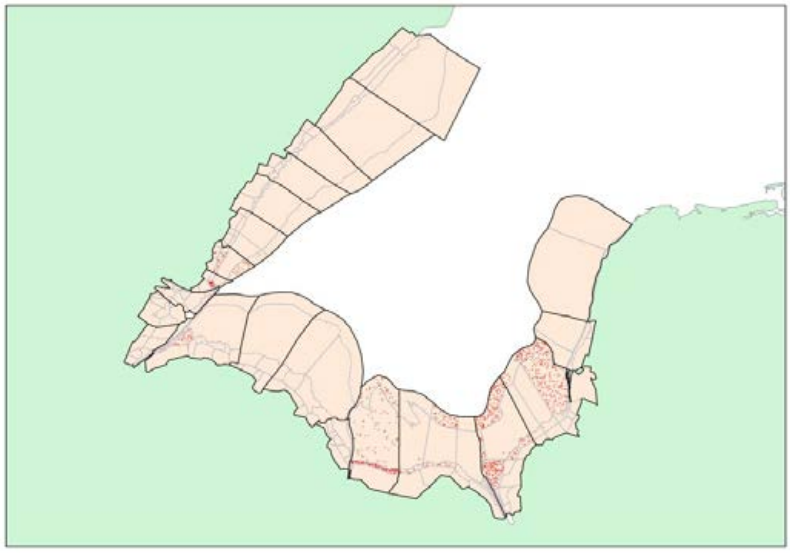


Figure E.1 (Continued)

vii) Pintail



viii) Oystercatcher



ix) Avocet

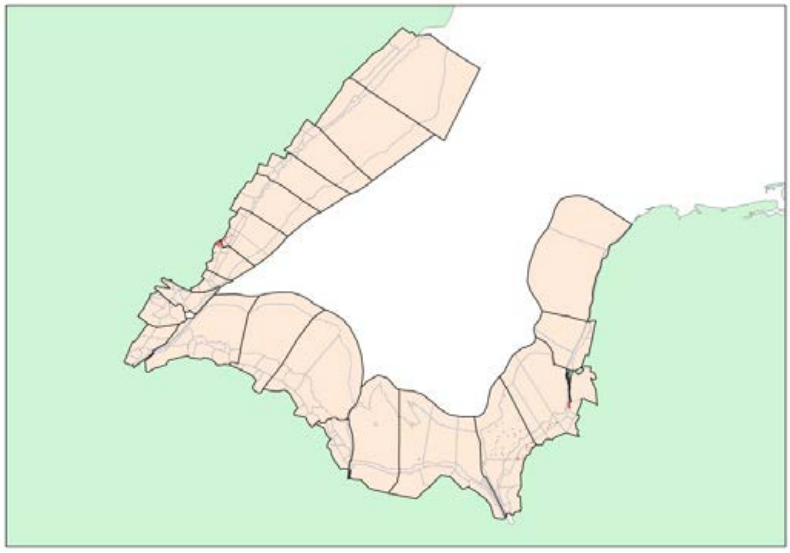
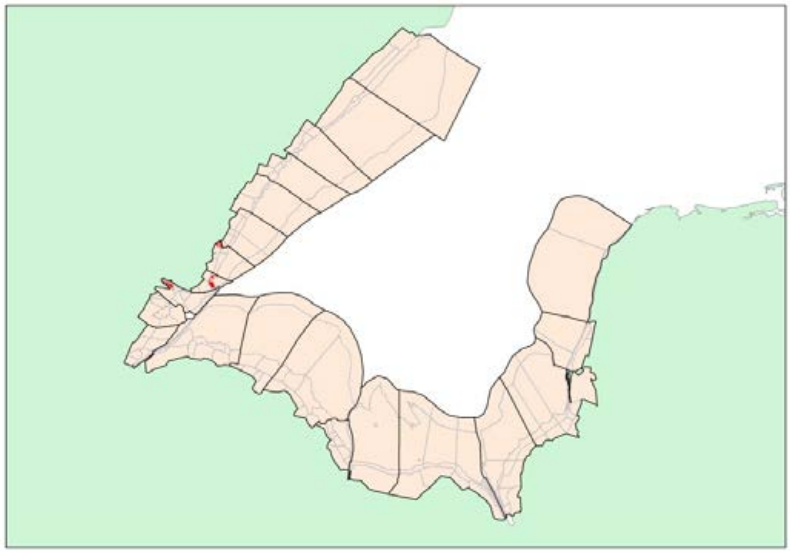


Figure E.1 (Continued)

x) Ringed plover



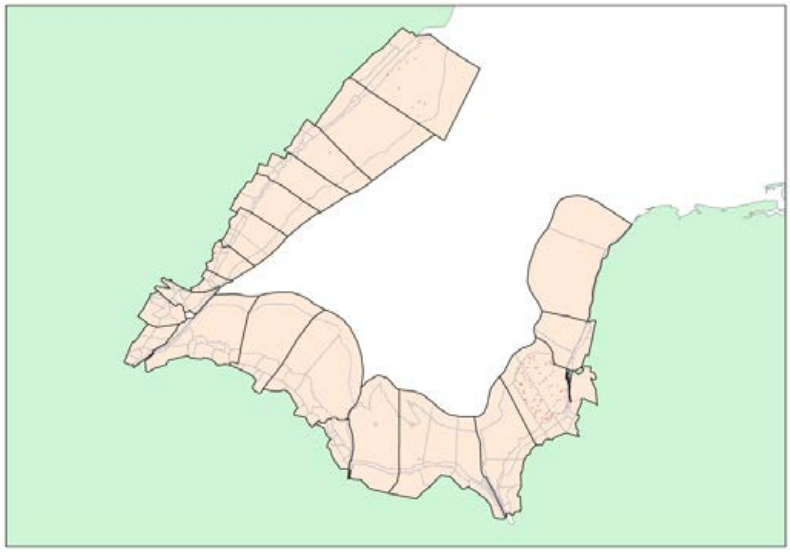
xi) Grey plover

xii) Lapwing

Figure E.1 (Continued)

xiii) Knot

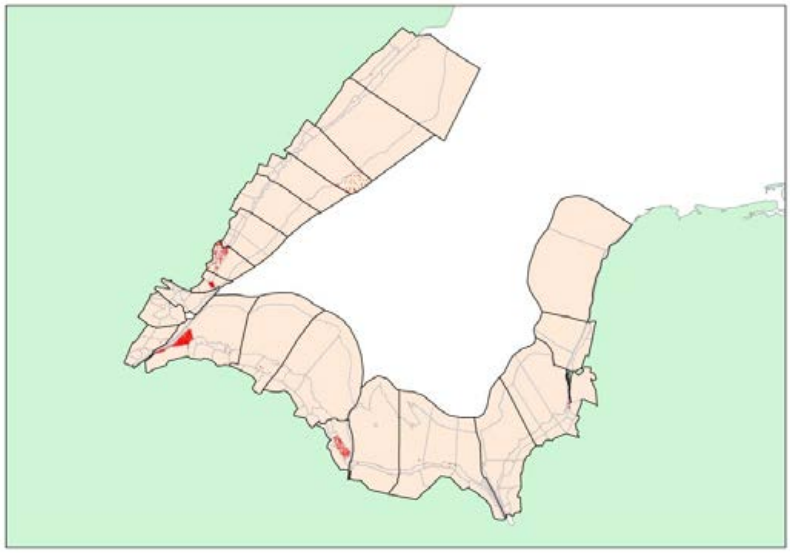
xi) Sanderling



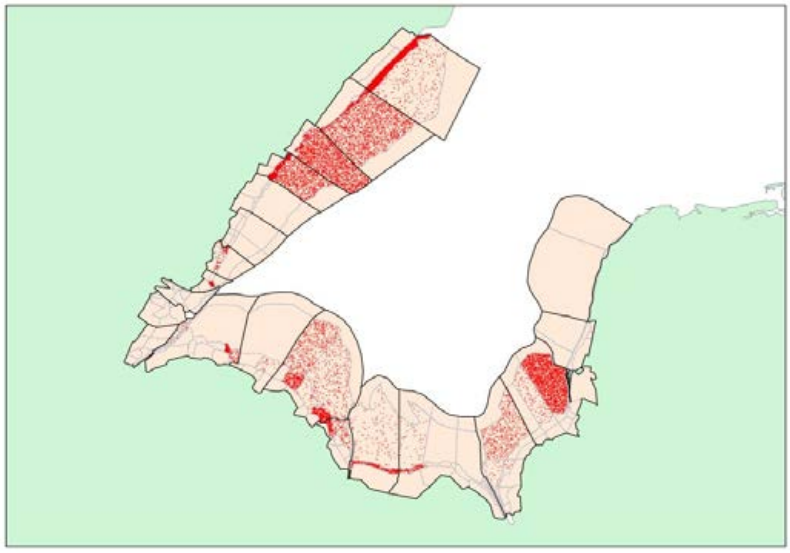
xvi) Dunlin

Figure E.1 (Continued)

xvii) Black-tailed godwit



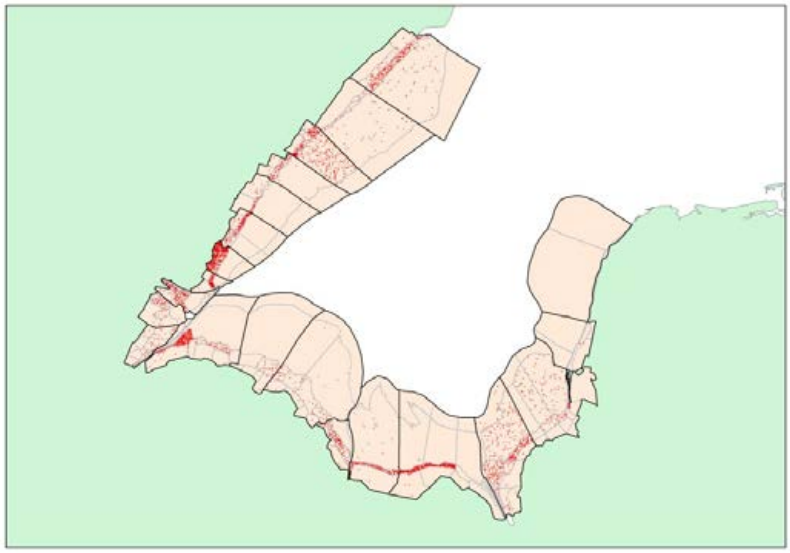
xviii) Bar-tailed godwit



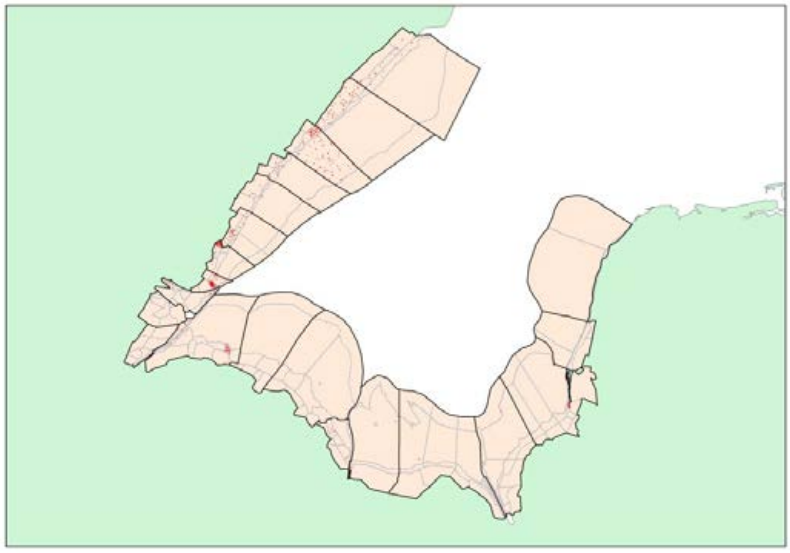
xix) Curlew

Figure E.1 (Continued)

xx) Redshank



xxi) Turnstone



APPENDIX F

Figure F.1 Distribution of waterbirds by species across WeBS high tide count sectors over the 15 winters 1994/95 to 2008/09 divided into three 5yr periods. Dot density maps (1 dot=1 bird) represent the five-year mean of peak counts for the periods 1994/95 – 1998/99, 1999/00 – 2003/04 and 2004/05 – 2008/09.

i) Pink-footed goose

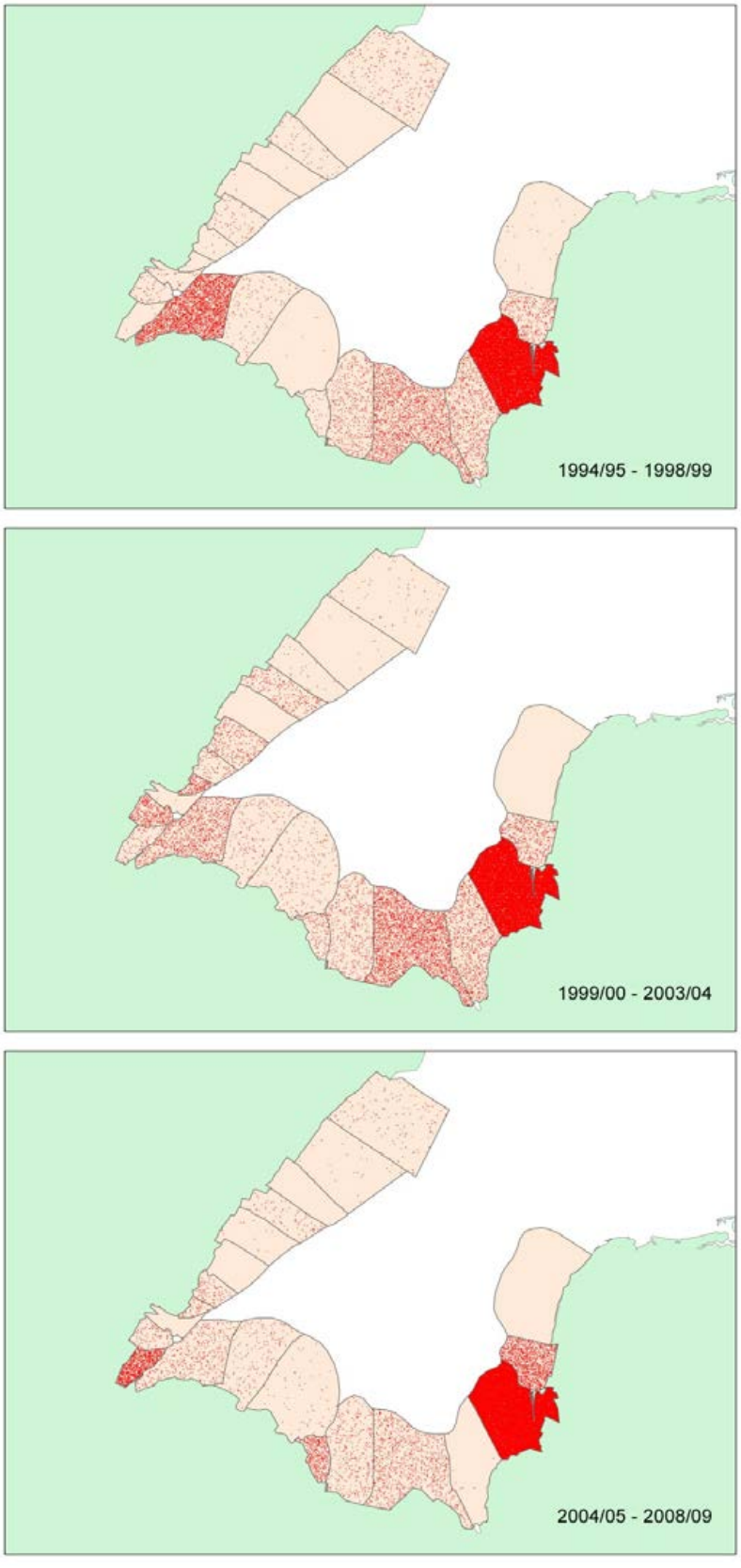


Figure F.1 (Continued)

ii) Dark-bellied brent goose

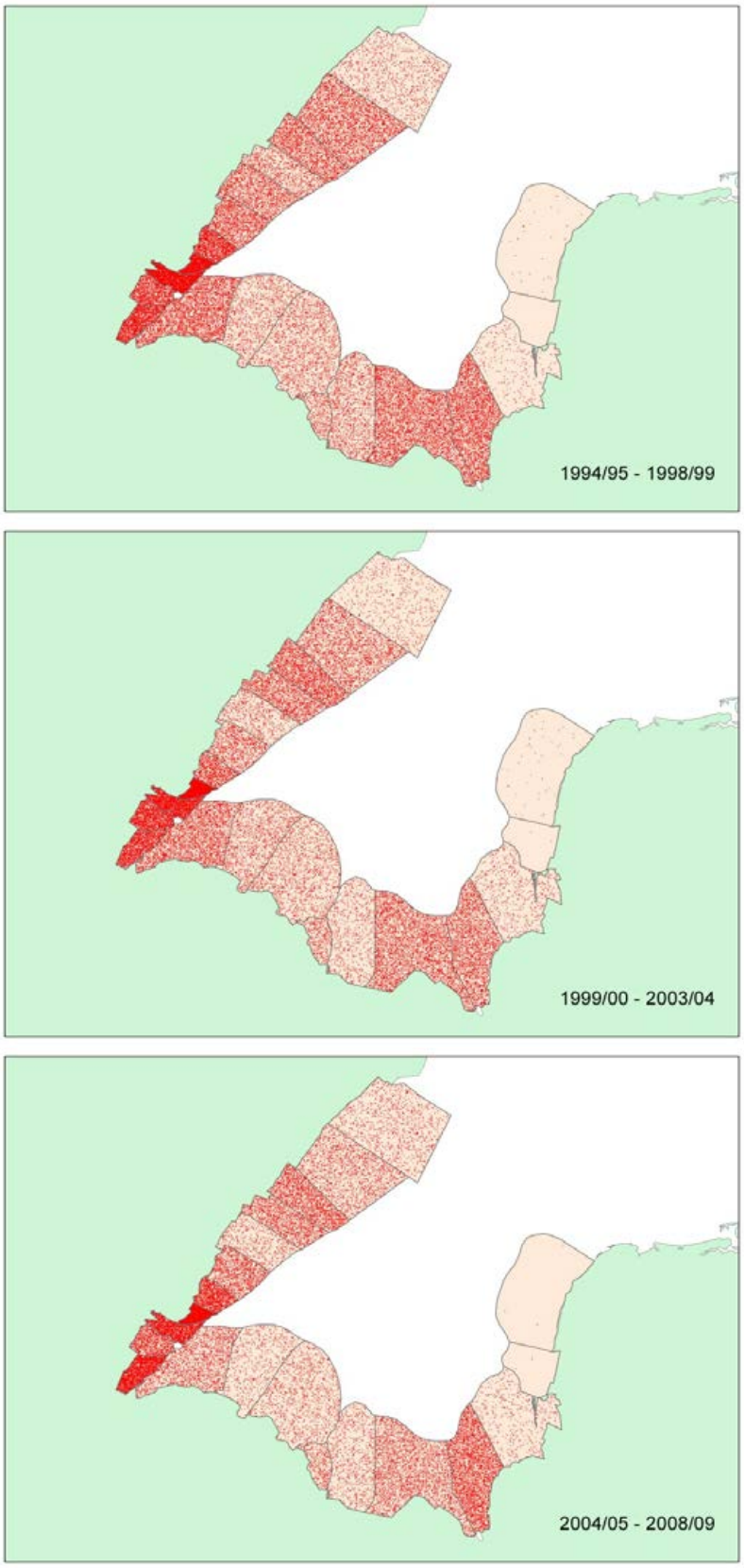


Figure F.1 (Continued)

iii) Shelduck

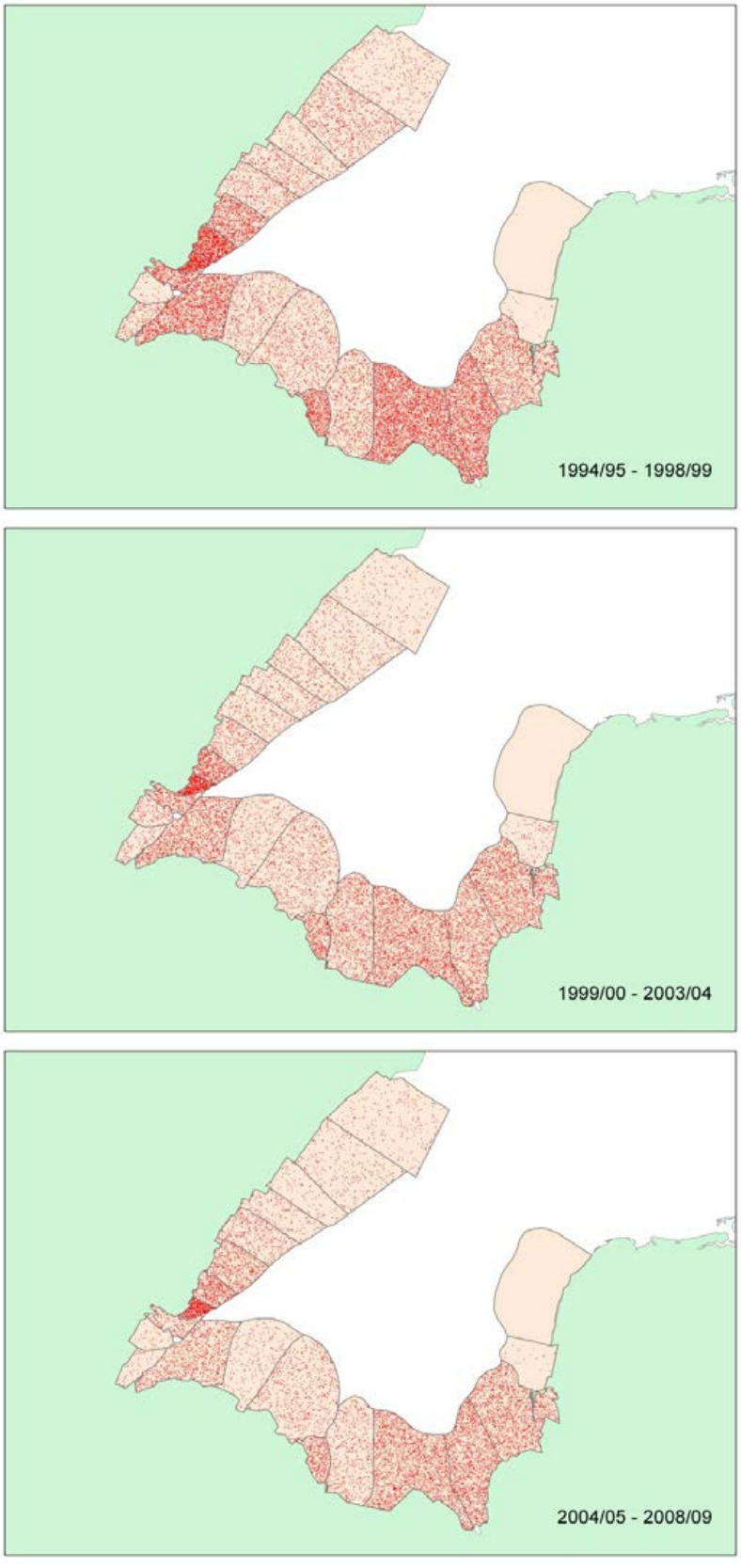


Figure F.1 (Continued)

iv) Wigeon

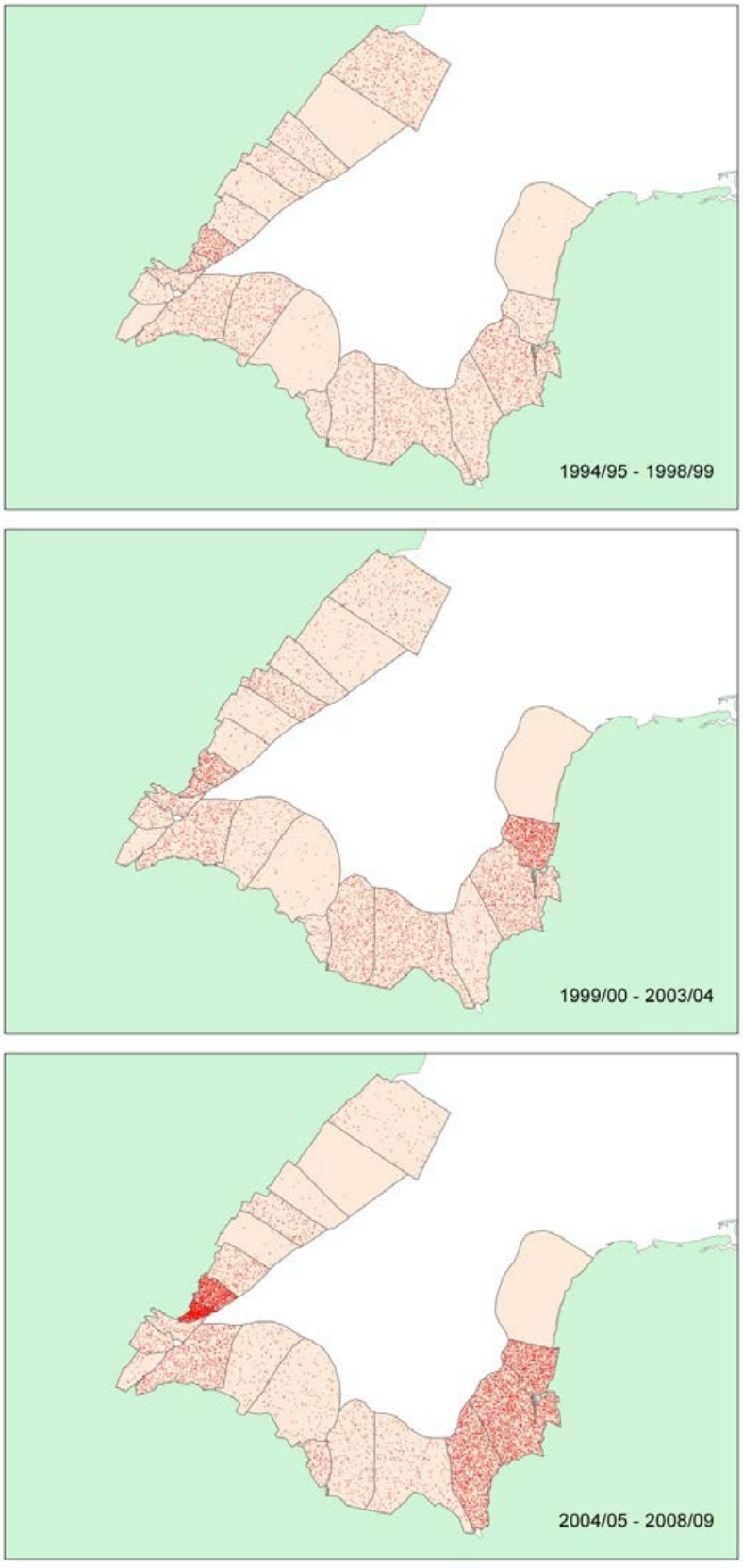


Figure F.1 (Continued)

v) Teal

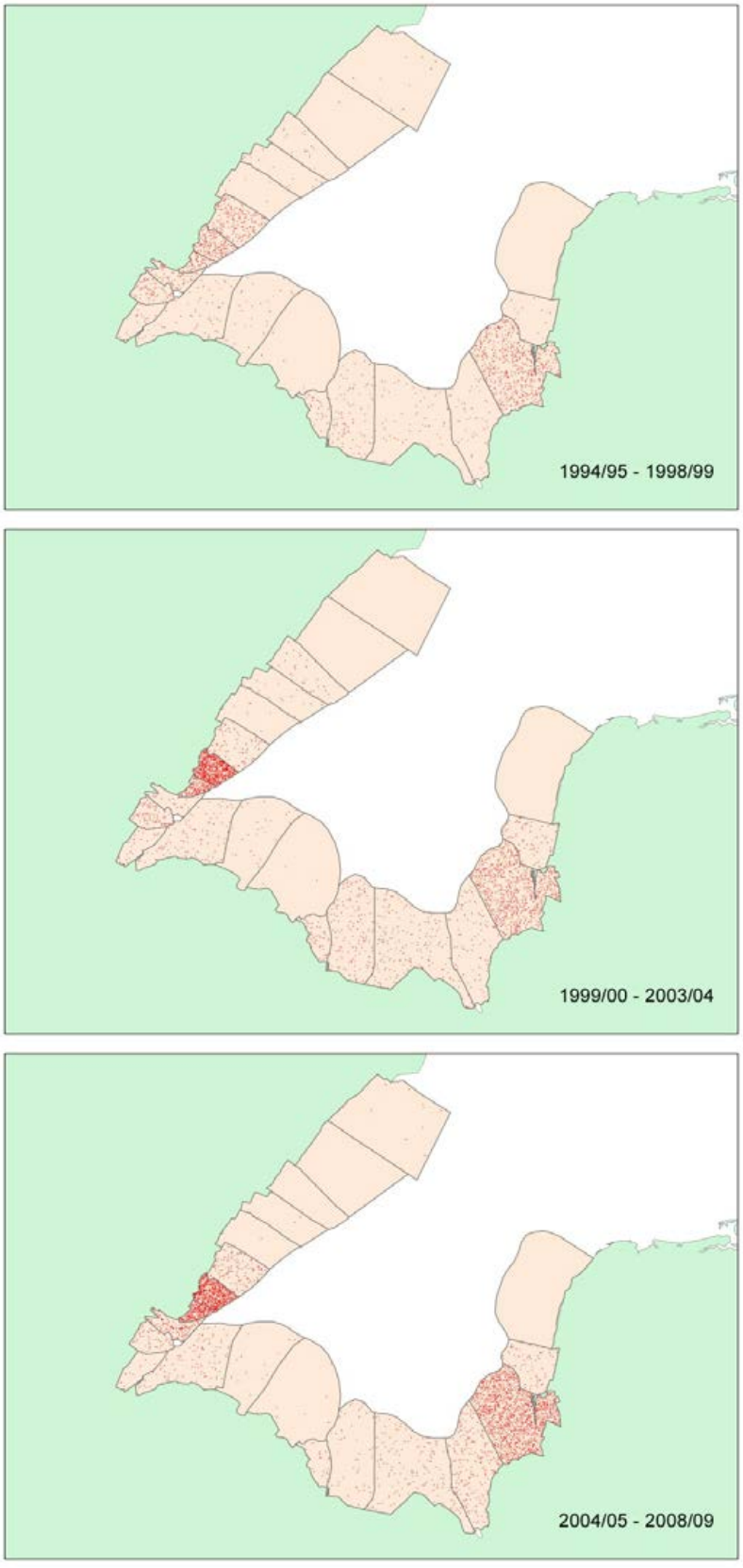


Figure F.1 (Continued)

vi) Mallard

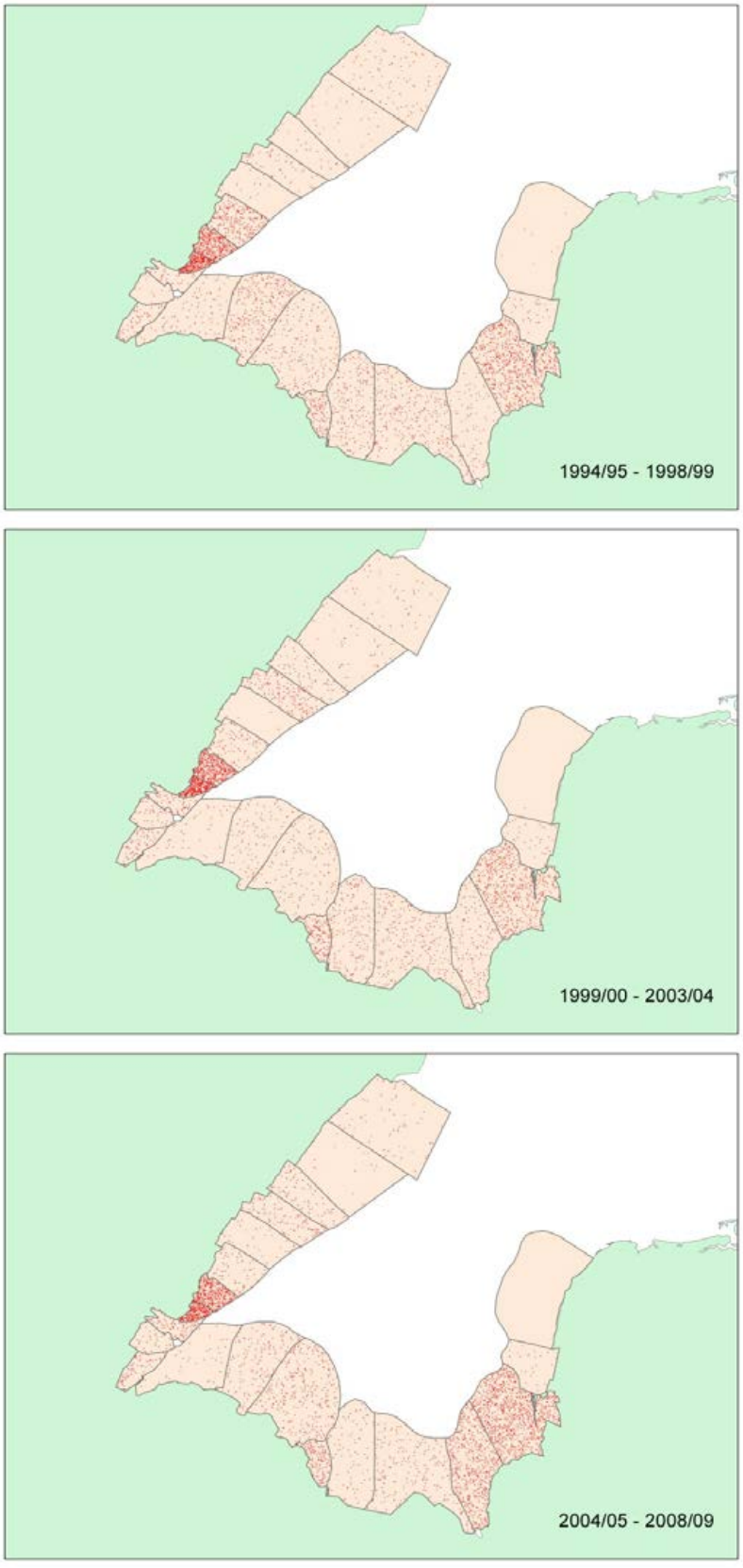


Figure F.1 (Continued)

vii) Pintail

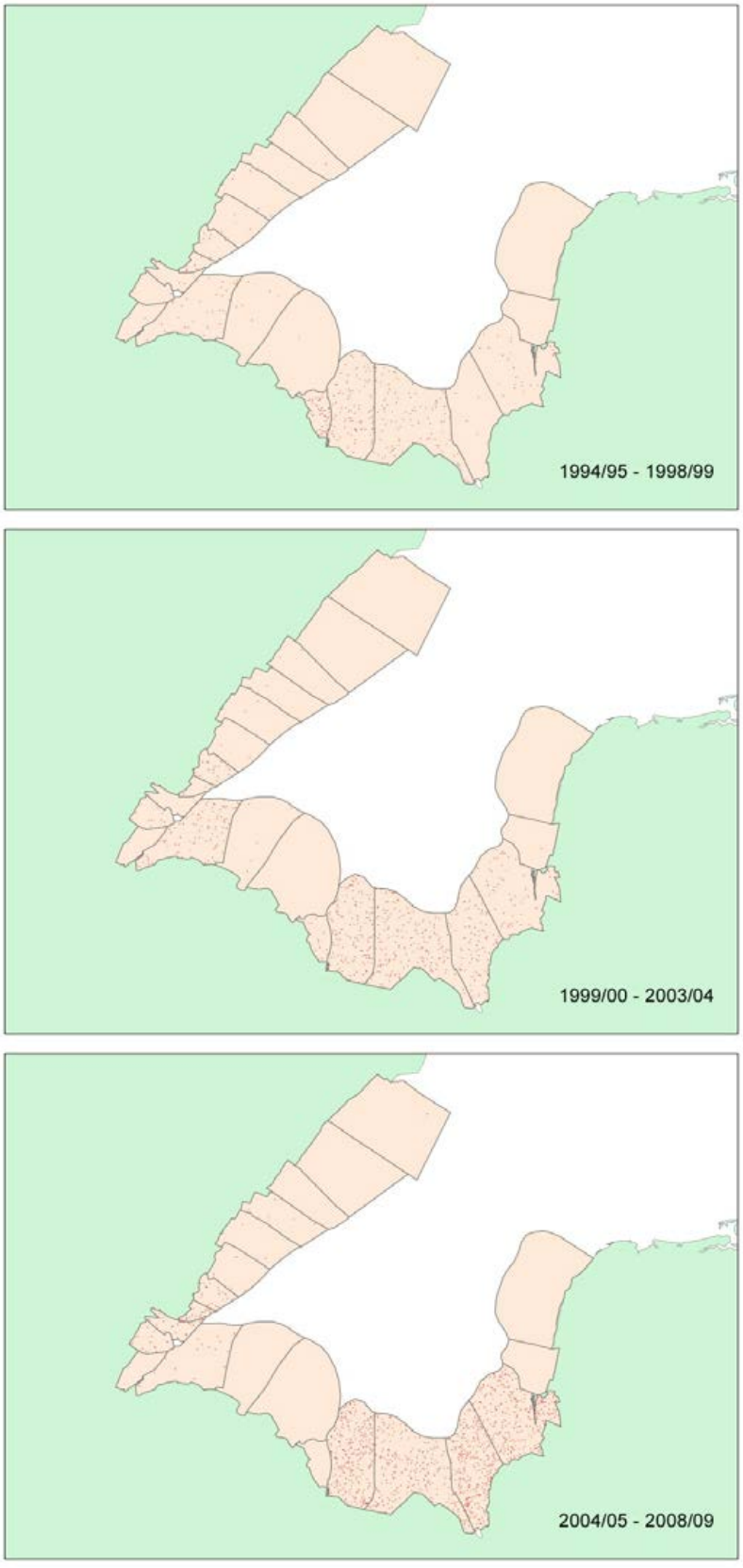


Figure F.1 (Continued)

viii) Oystercatcher

Figure F.1 (Continued)

ix) Avocet

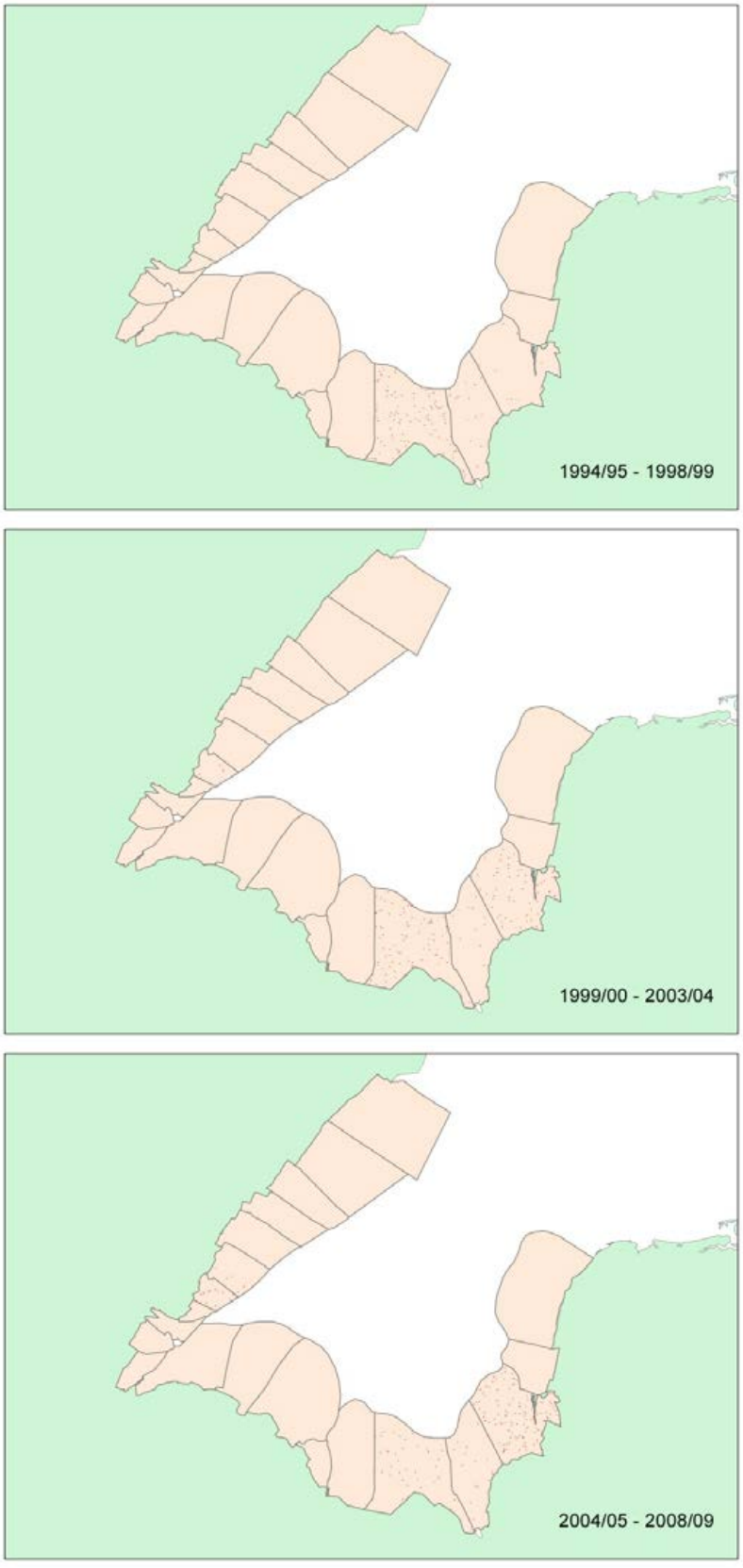


Figure F.1 (Continued)

x) Ringed plover

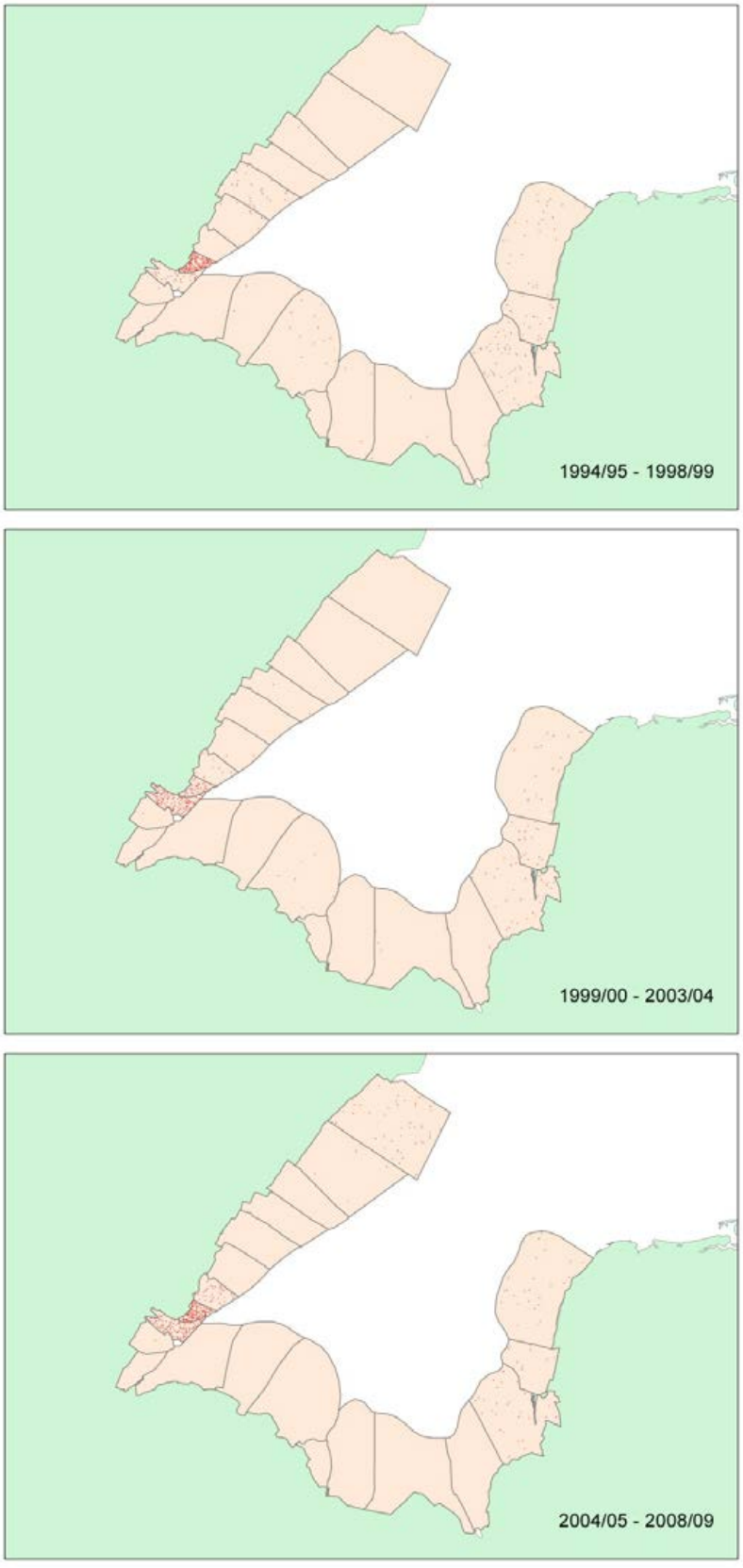


Figure F.1 (Continued)

xi) Golden plover

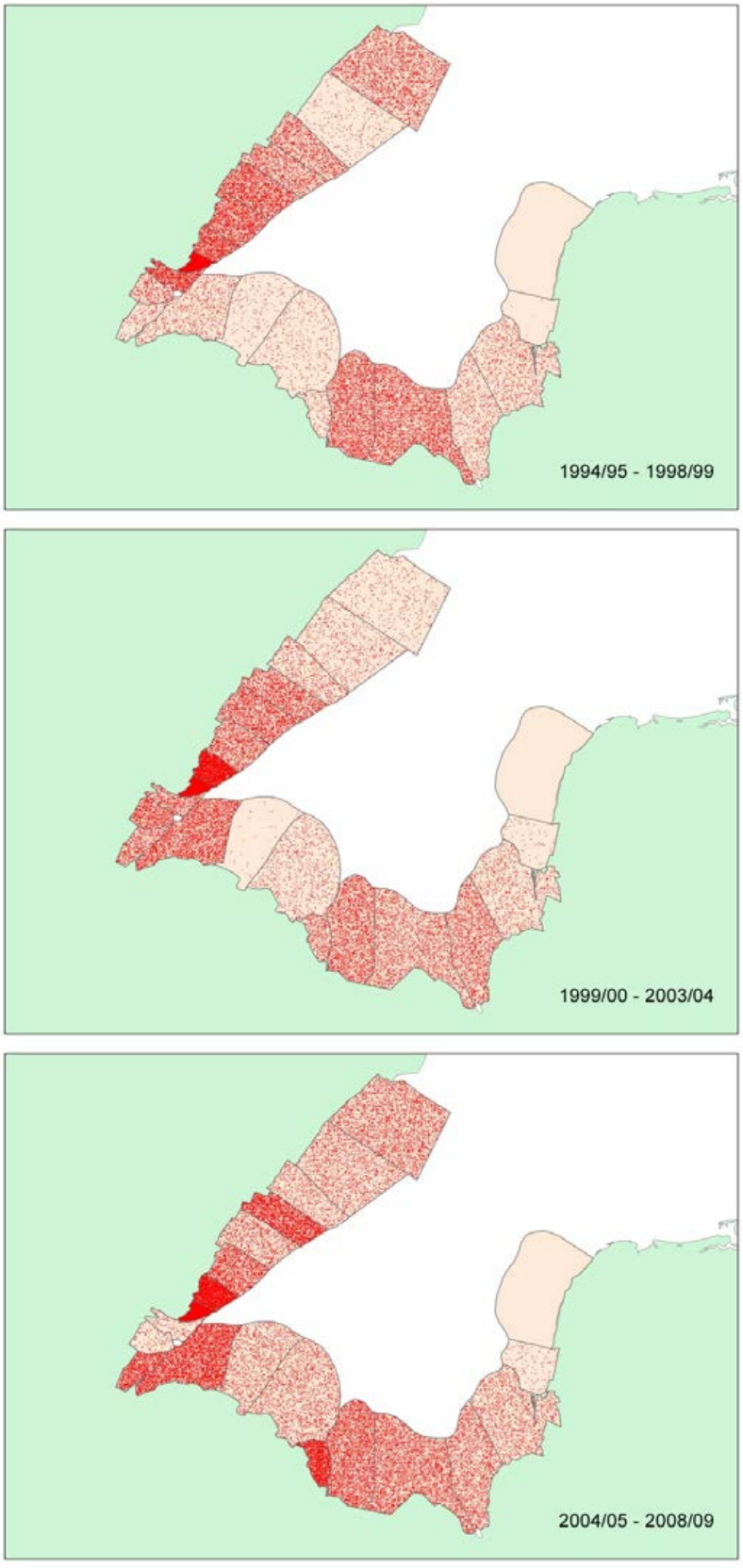


Figure F.1 (Continued)

xii) Grey plover

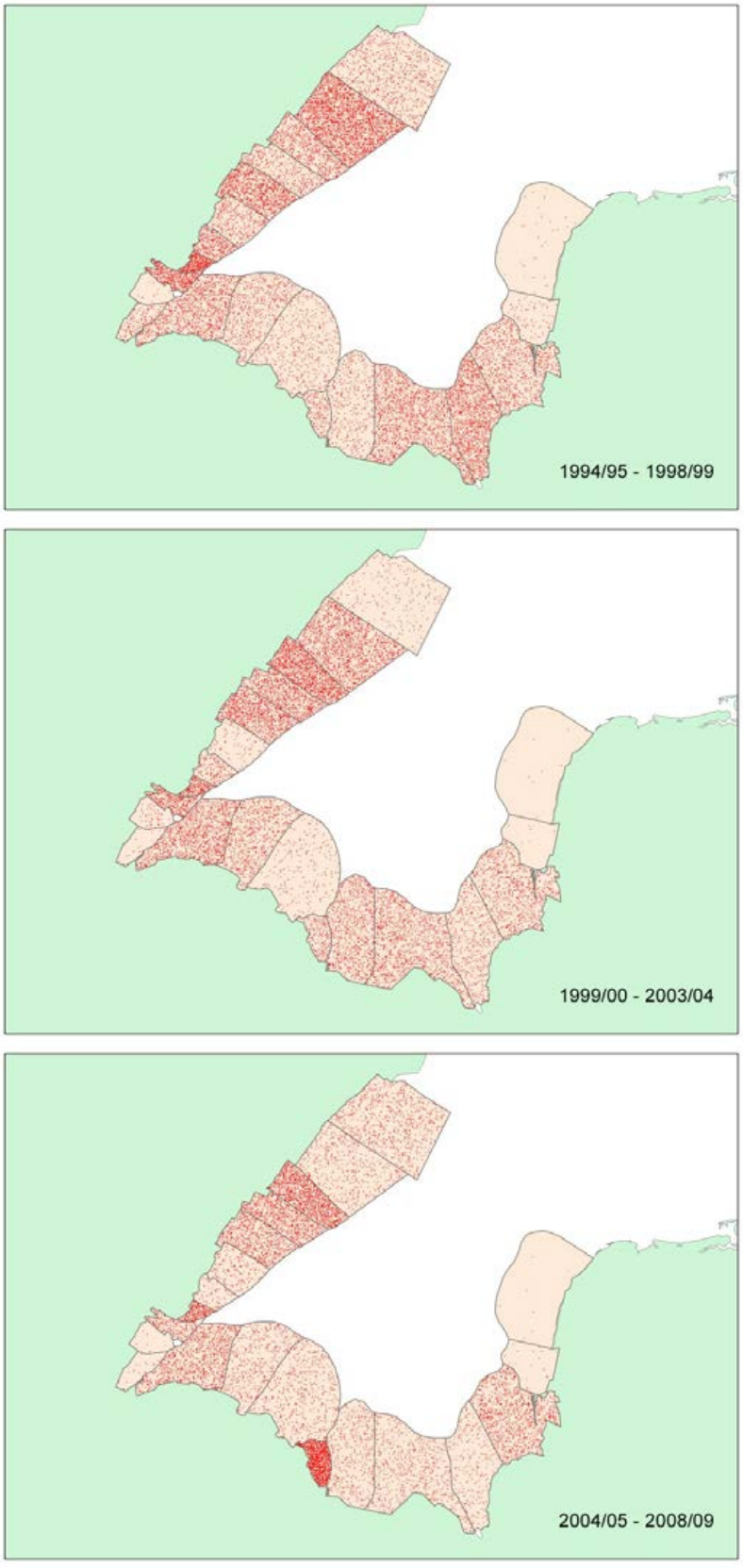


Figure F.1 (Continued)

xiii) Lapwing

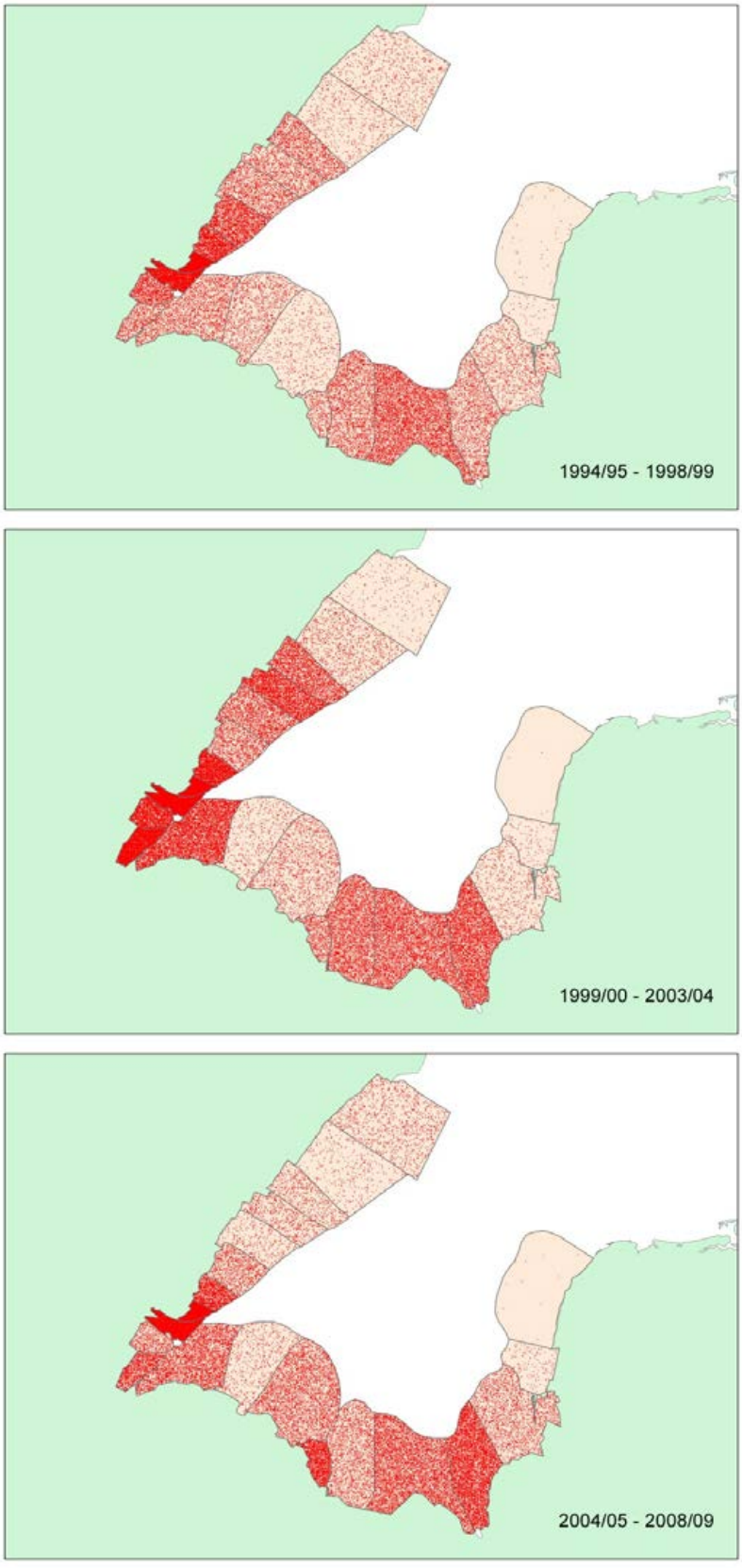


Figure F.1 (Continued)

xiv) Knot

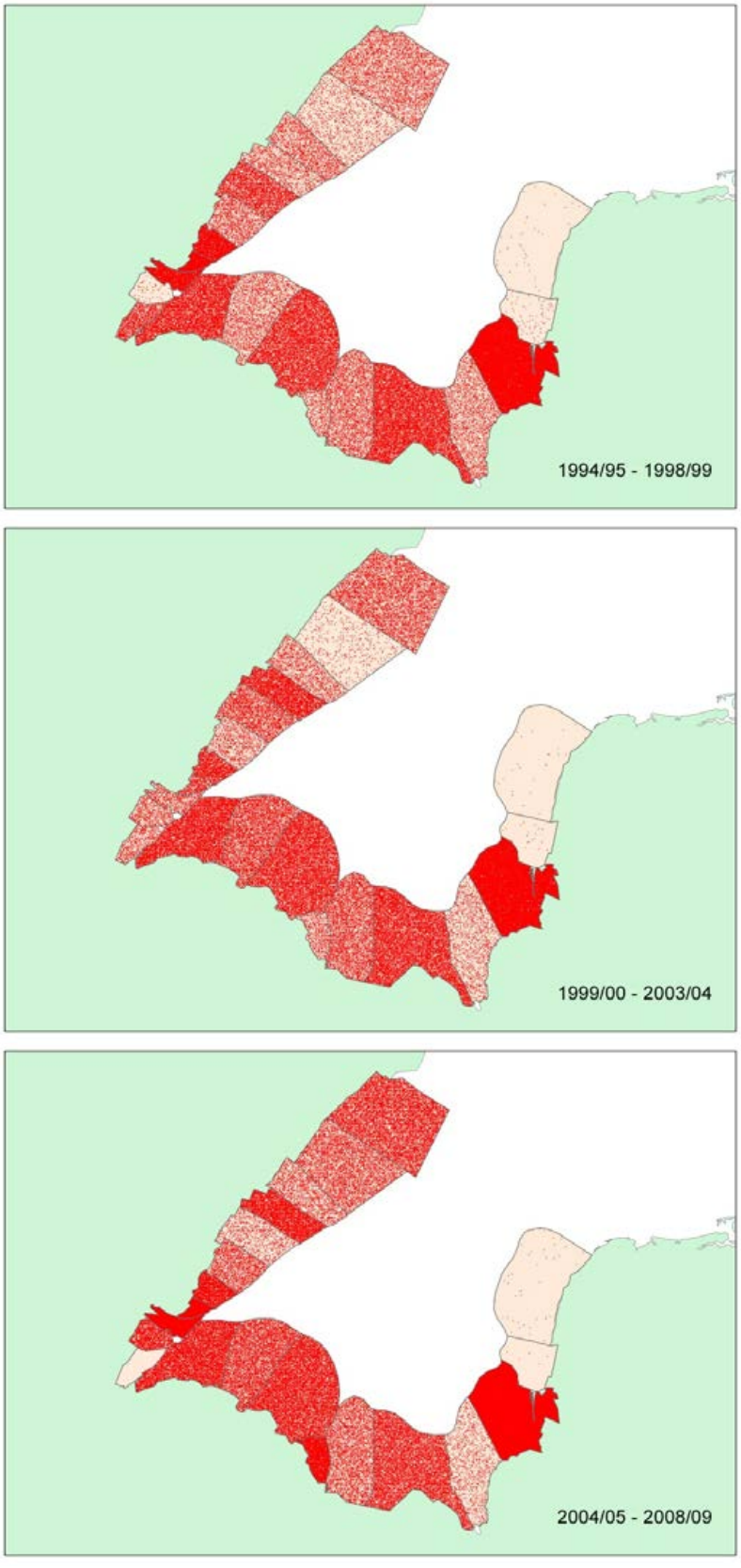


Figure F.1 (Continued)

xii) Sanderling

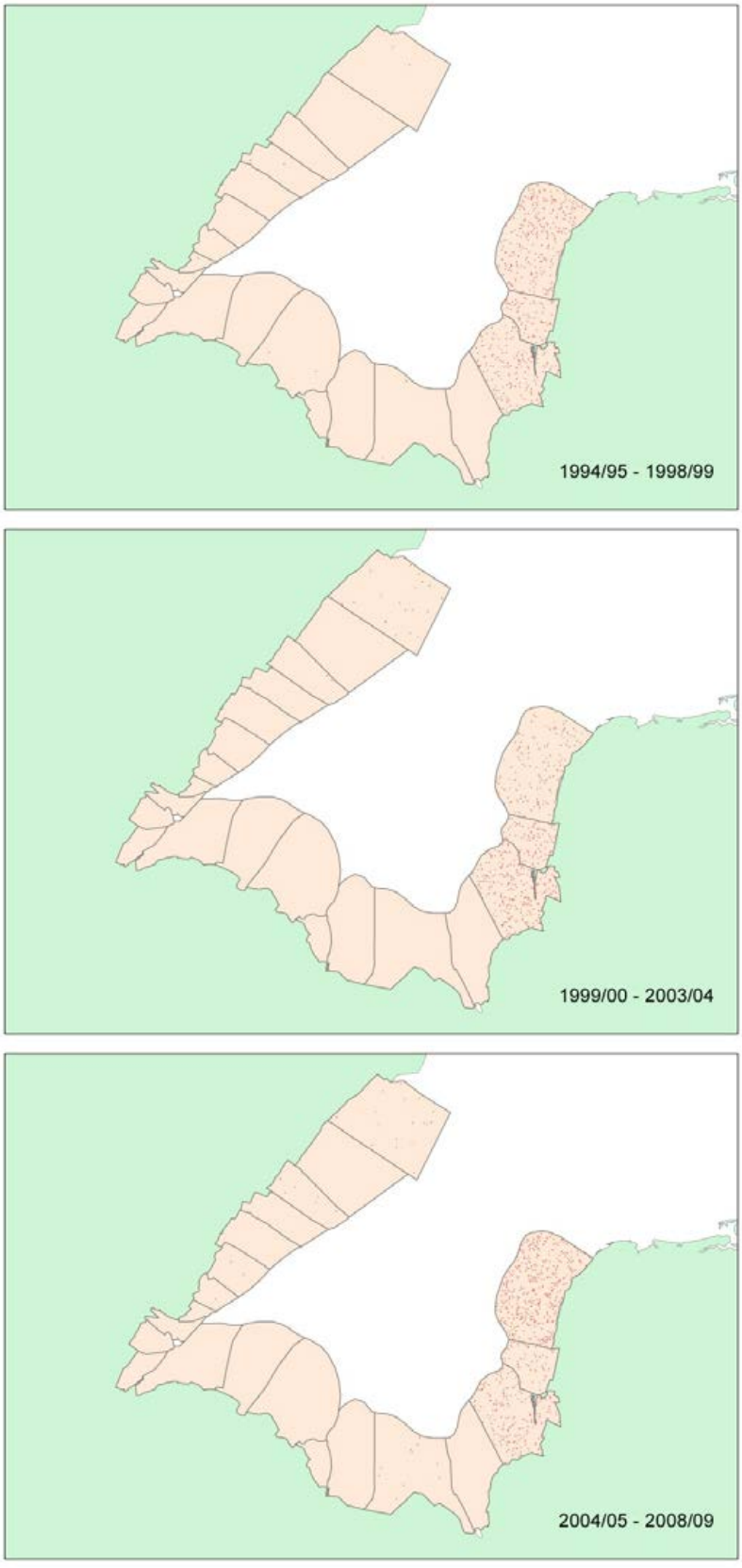


Figure F.1 (Continued)

xix) Dunlin

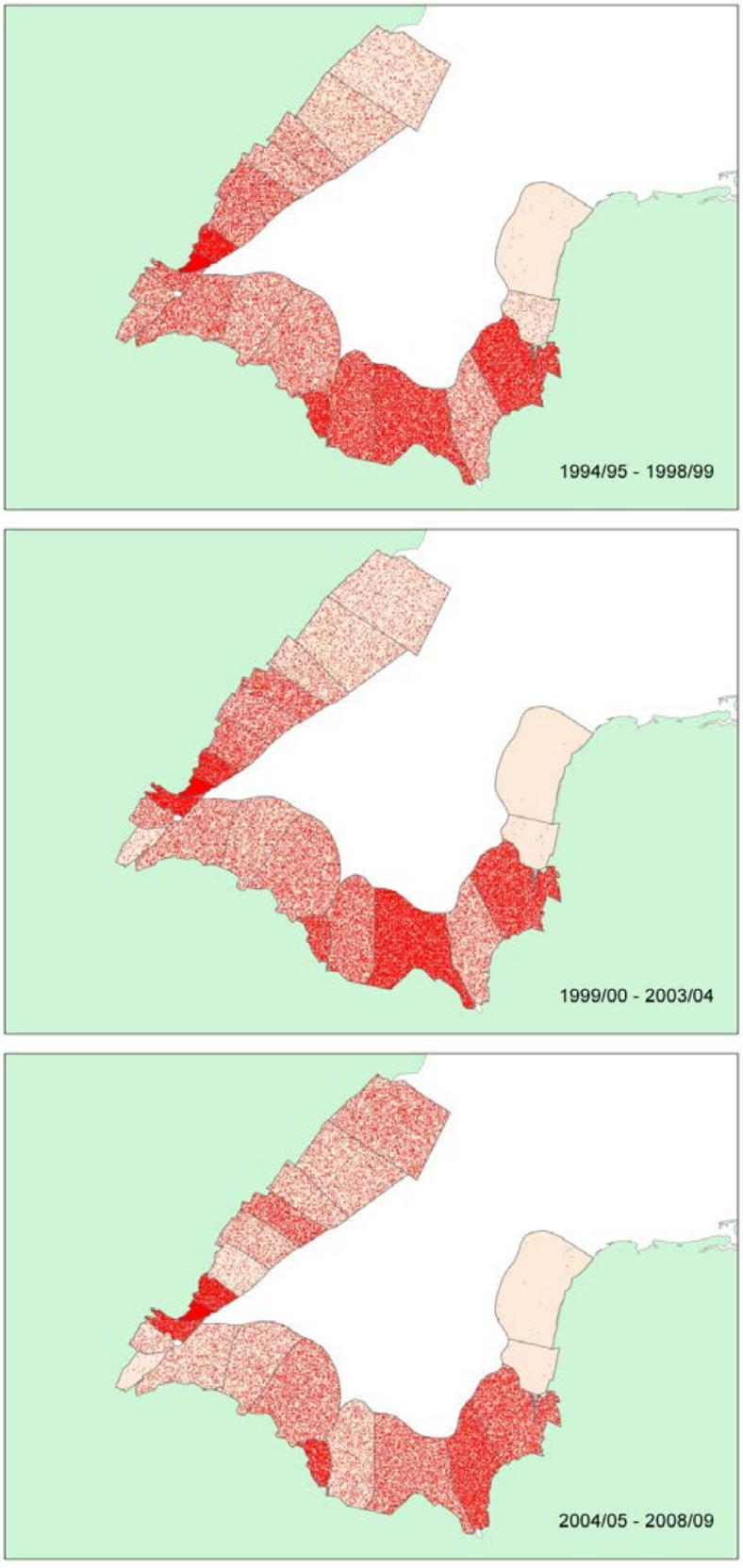


Figure F.1 (Continued)

xx) Black-tailed godwit

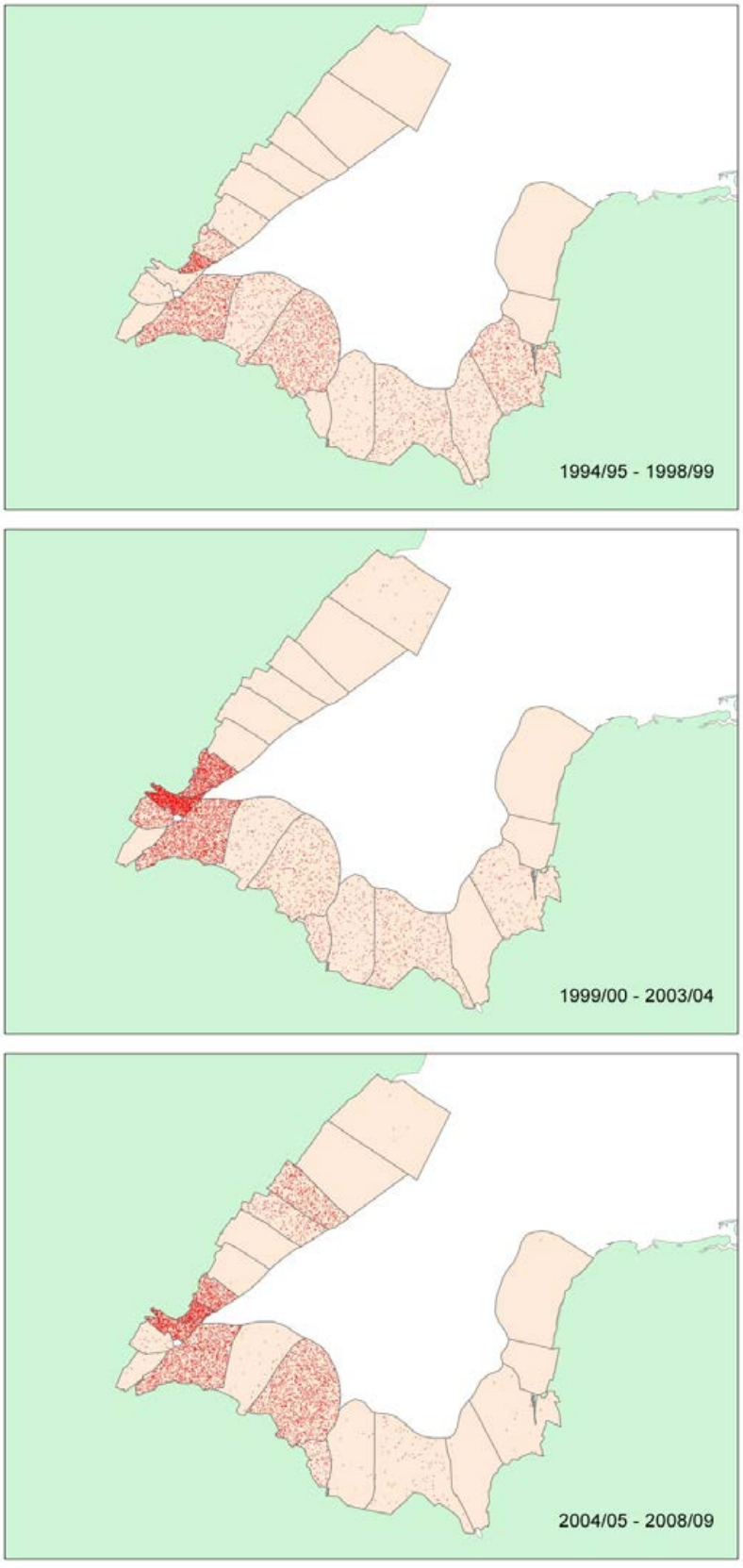


Figure F.1 (Continued)

xxi) Bar-tailed godwit

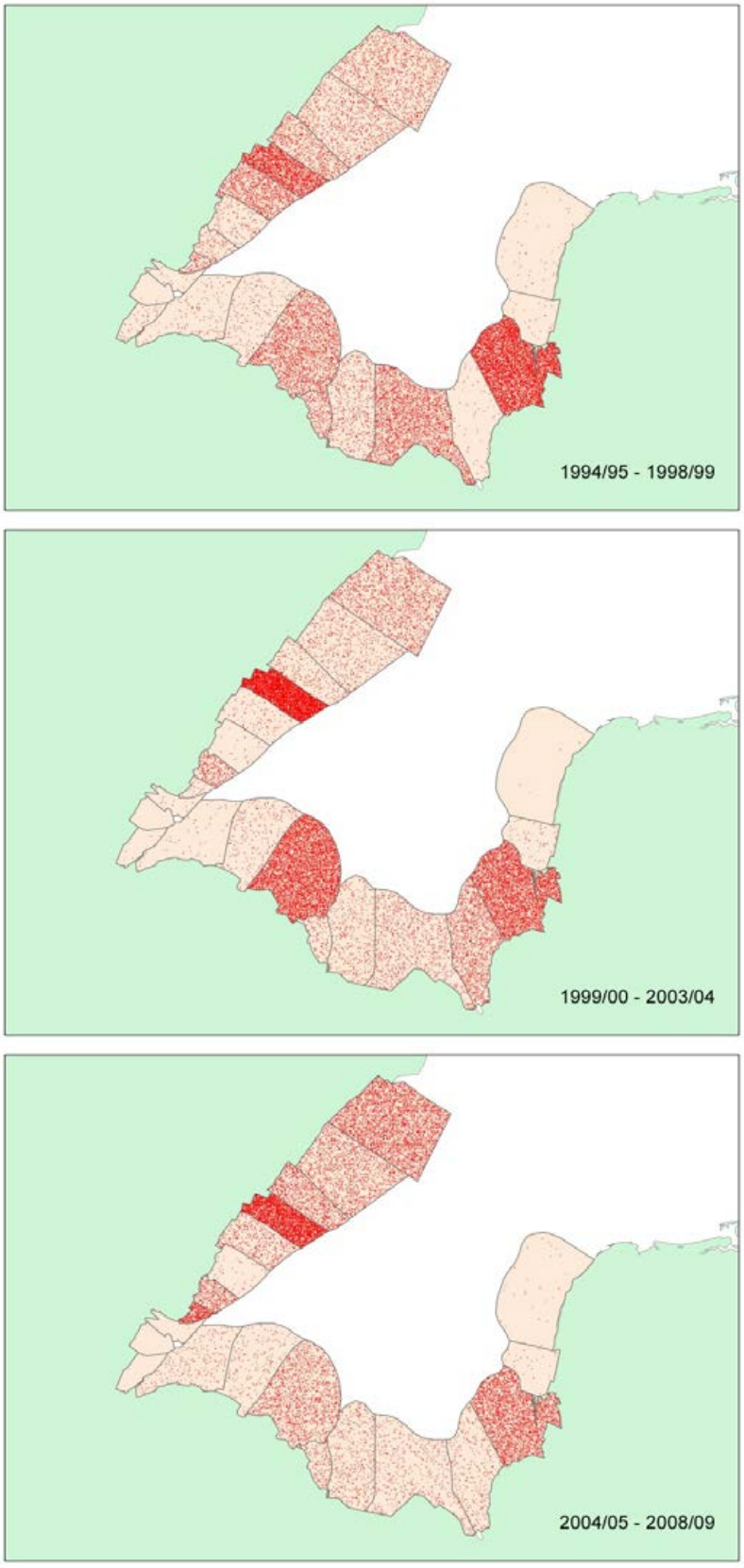


Figure F.1 (Continued)

xix) Curlew

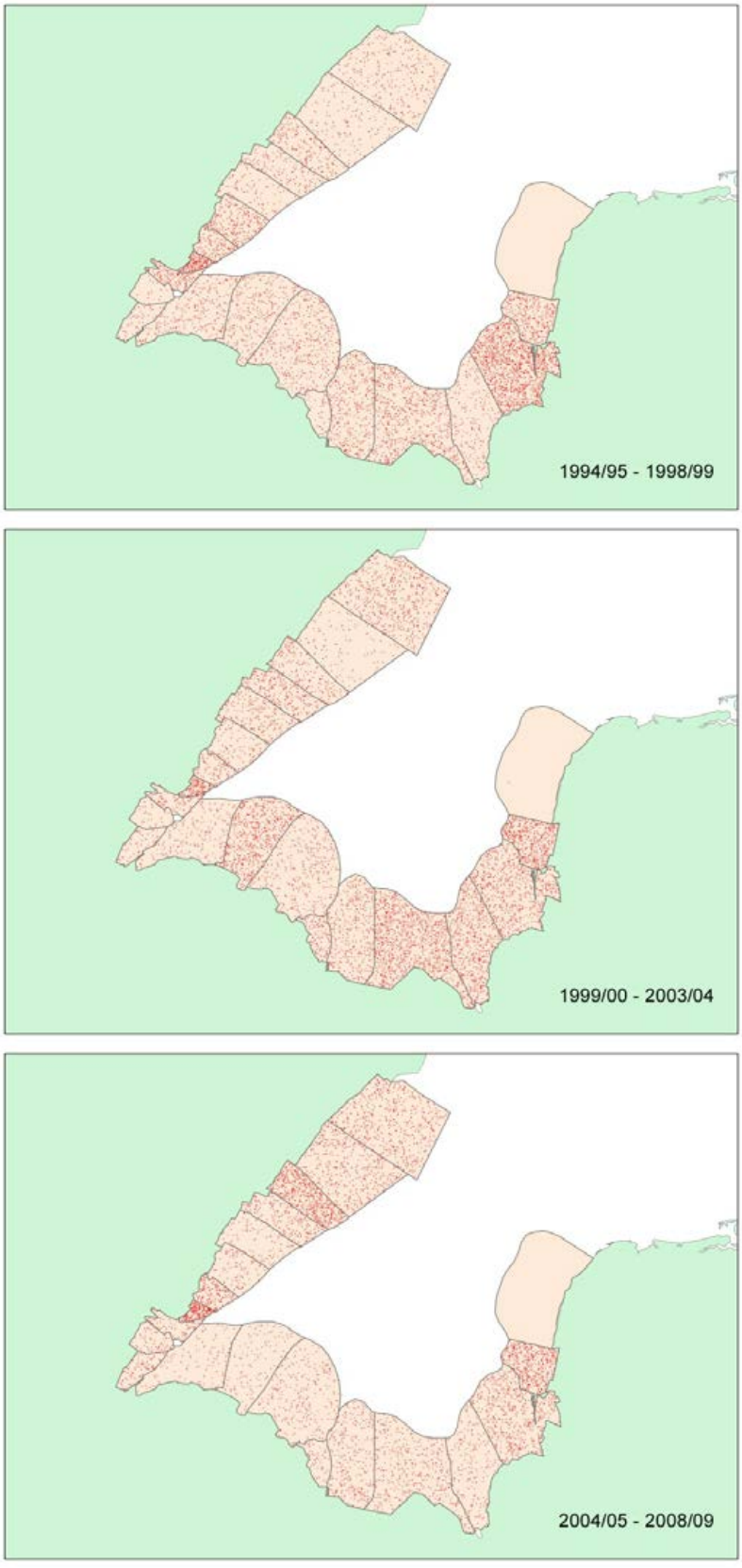


Figure F.1 (Continued)

xxii) Redshank

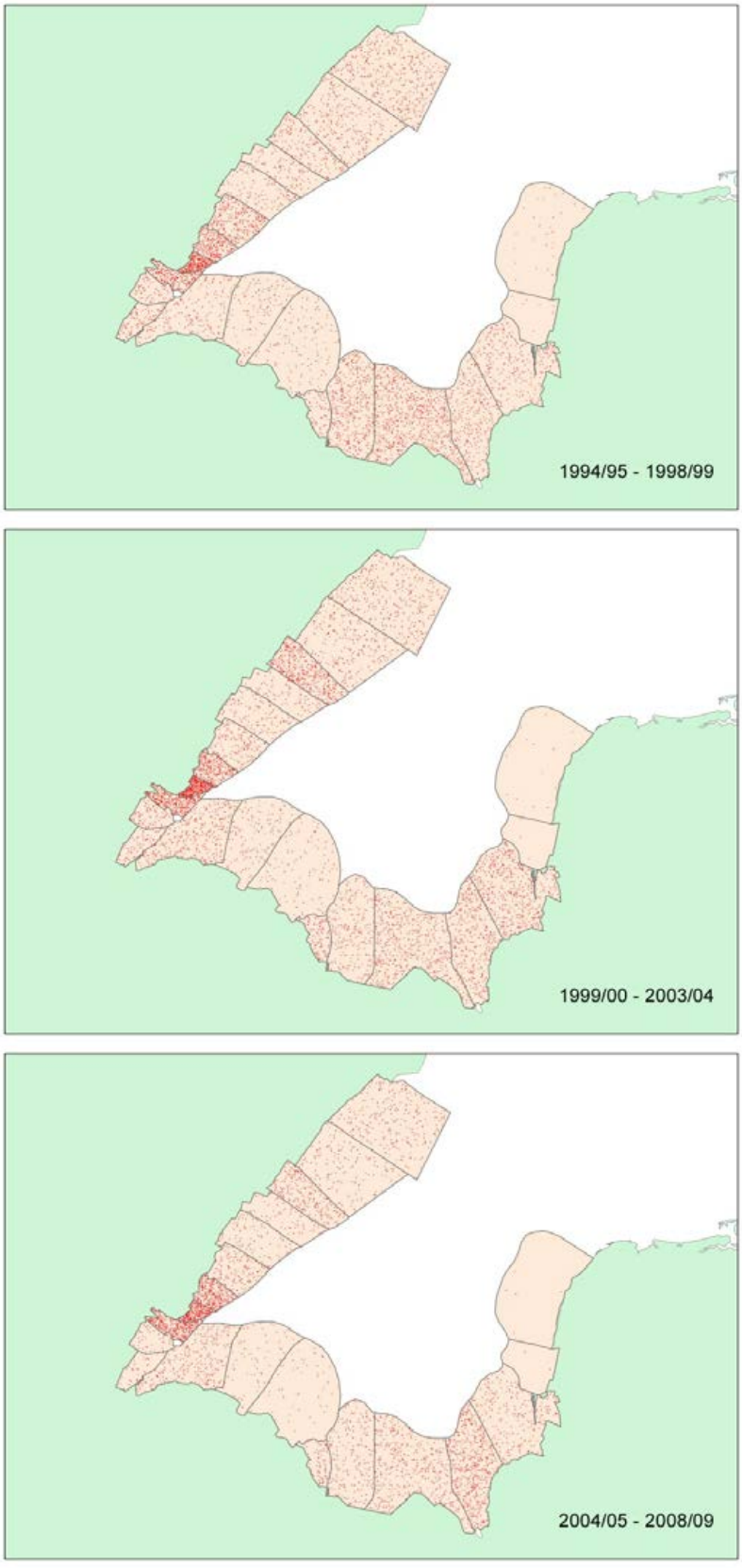


Figure F.1 (Continued)

xxiii) Turnstone