BTO Research Report No. 660

The Wash Bird Decline Investigation 2014

Authors

Ian D. Woodward, Viola H. Ross-Smith, Rafael Pérez-Domínguez, Mark M. Rehfisch and Graham E. Austin

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EXECUTIVE SUMMARY

- Several studies have documented population declines in species of waterbird that winter on The Wash SPA and are protected as non-breeding features. With a few exceptions, the reasons for these declines are not clear cut.

- This project brought together findings from a wide range of studies to the identify drivers of population change on The Wash, where possible, for 15 species, and to make recommendations about measures that could be taken to halt or reverse these trends.

- The basis for this report was the collation of an extensive review of the literature to include information on the waterbird species themselves, information regarding their food resources, habitats, and anthropomorphic pressures that may influence their distribution on The Wash.

- Thus for each waterbird species we have collated information on population trends, general and local ecology (diet, habitat preferences, behaviour and sensitivity to disturbance), known reasons for both general and local declines, potential threats and detail of species distribution within The Wash.

- Although there is considerable information relating to The Wash as a whole, some of it going into great detail, there is a paucity of information reported in a systematic manner that would allow trends in different parts of the site to be compared and contrasted. Whilst some of the source information may make reference to particular areas within The Wash, without a systematic approach throughout the site it is not possible to put those particular examples into context.

- With the aim of highlighting potential drivers of change at the level at which waterbird numbers are routinely recorded, waterbird trends at the WeBS sector level were cross-tabulated against the information on potential drivers of change. As expected given the previous statement, the resulting cross-tabulation table contains many empty cells, not because the potential driver is not operating on that particular sector but because there is no direct evidence either way.

- There are clearly many anthropomorphic activities that have a long history on The Wash. These are likely to be responsible, at least in part, for present day number and distribution of waterbirds. However, data from fine-scale long-term monitoring of these activities are not readily identifiable, and in many cases probably do not exist. Consequently, clear signals of potential anthropomorphic drivers of change in waterbird abundance and distribution do not emerge from the literature review.

- Food availability clearly affects the abundance and trends in waterbirds, but other than for small number cases there is little direct evidence linking changes on food availability to waterbird abundance and none of these relationships can be shown for a finer spatial resolution than that of The Wash as a whole.

- Habitat change is implicated as affecting the abundance and trends of waterbirds. Again there appear to be no studies that have used systematically recorded long-term data on habitats to investigate this further.

- We recommend that the cross-tabulation matrix in this report would provide a useful basis for a more detailed, long-term data compilation. It is clear from this matrix where gaps in knowledge lie and as such this approach could be used to guide future monitoring and research.

- There is potentially a wealth of information that will not have been captured by this review. As an initial step to filling some of the knowledge gaps we have identified, we recommend that a questionnaire/interview based survey of stakeholders on The Wash be undertaken. As well as those involved professionally with managing the habitat, there are many other interested groups with a long history of activity on and around The Wash who may have valuable opinions to offer.

1. INTRODUCTION

1.1 Background and aims

The Wash, located on the east coast of England, 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, which are also important food sources for some waterbird species. 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 *et al.* 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, supporting a minimum estimate of approximately 359,000 individuals annually (excluding introduced species) during the years of 2008/09 to 2012/13 (Austin *et al*. 2014), including internationally important numbers of 16 species (Stroud *et al*. 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 (Figure 1).

As part of its programme of monitoring the condition of designated sites, Natural England is required to assess the size of bird populations on those sites where they are a feature of interest, compare current numbers with the population at the time of designation in order to identify changes, and put in place measures to address any decline that is considered to make the site's condition unfavourable. The Wash was classified as a SSSI in 1972 and as a SPA in 1988.

The monitoring and condition assessments of non-breeding waterbird features on SSSIs and SPAs are generally based upon data from the Wetland Bird Survey (WeBS). 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 (Austin *et al*. 2014). 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 areas, known as "WeBS sectors" are undertaken (Figure 1), the results of which are then summed to give the overall site total. Large WeBS sectors are further subdivided into smaller ones (Figure 2).

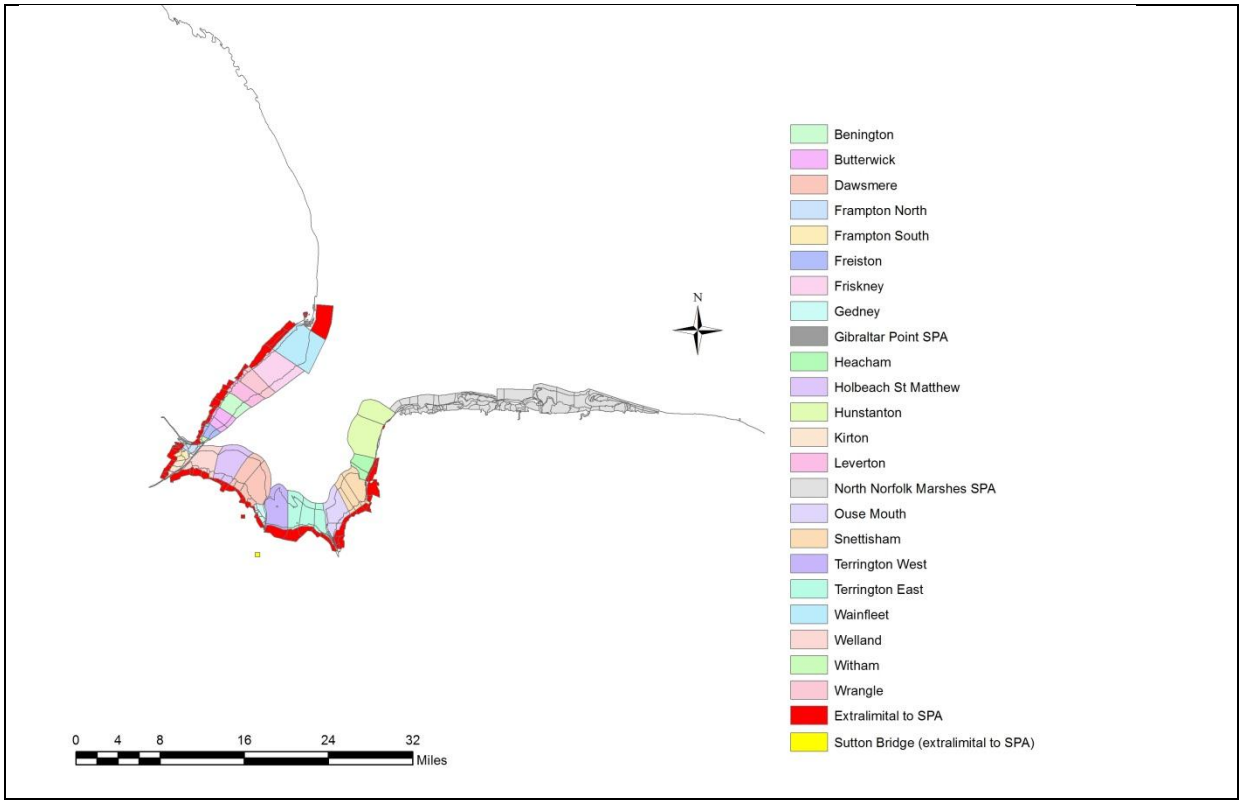


Figure 1. Map of The Wash, showing WeBS sectors and the extent of protected areas. Names relate to WeBS count areas referred to in this report. Sectors marked in grey belong to adjacent WeBS count sites. Sectors marked in red are those that lie outside the boundary of The Wash SPA but within the WeBS count site (except for Sutton Bridge, marked in yellow). These latter areas are included within the WeBS count site as they can support substantial wader high-tide roosts, particularly during periods of spring tides.

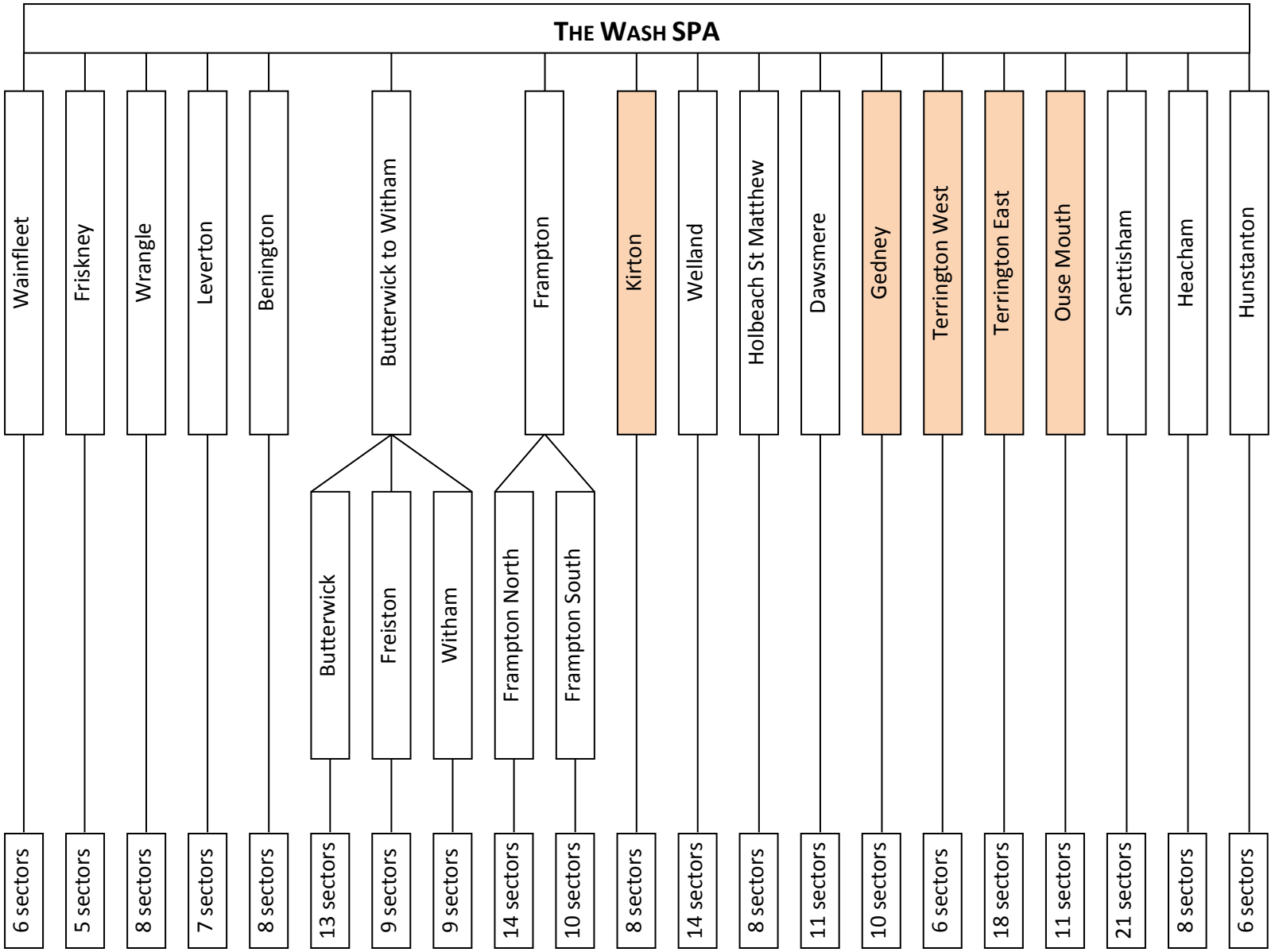


Figure 2. Structural hierarchy of WeBS count sectors on The Wash SPA. Shaded sectors are those that also make up The Wash NNR.

A recent analysis of WeBS data trends identified several species of concern which appear to be in decline and also, in some cases, have shifted in their distribution within the estuary (Ross-Smith *et al*. 2011). The reasons for the observed declines and changes in distribution for most of these species have not yet been clearly identified and measures to redress the issues cannot be formulated without a better understanding of the influences on population change. Reasons for these declines are many, varied and probably multifaceted, and likely to be linked to particular resource requirements of each of the bird species of concern, including food quality and quantity, location and availability of suitable roost sites, disturbance aspects, and feeding and roosting sites external to The Wash. Furthermore, additional factors that are considered important in the context of the whole estuarine system include changes in farming practice, commercial development, geo-morphological change, recreational disturbance, sea level rise and climate change. Many of these involve off-site impacts instead of, or as well as, on-site impacts.

The overall aim of the project is to capture both information sources and use them to answer the questions associated with changing bird populations on The Wash. The specific objectives of the project are:

- To produce a description of overwintering resource requirements for each of the species of concern (autecology) that relate to that species' use of the estuary, e.g. food type/abundance/quality, relationship between feeding and roost areas, sensitivity to disturbance, reliance on terrestrial habitats beyond the boundary of the SPA etc.
- To identify any gaps in existing knowledge which are a barrier to understanding why the declines are taking place.
- To recommend conservation measures and actions that could ameliorate the declining population trends.

1.2. Species of concern

This report is restricted to dealing with species for which there is evidence of decline either across The Wash as a whole or on WeBS count sectors important to a given species. Two principal sources of information have been used to derive this list these being the WeBS Alerts Report (Cook *et al*. 2013) and the WeBS sector-level analysis of Ross-Smith *et al*. (2011) (Table 1).

Table 1. List of species of concern on The Wash SPA and therefore considered in this review. Species that have triggered a WeBS Alert are automatically included, with other species considered for the reasons stated. The reference year for the WeBS Alerts is 2009/10. Red - HIGH ALERT (decline of >50% over period stated)
Orange - MEDIUM ALERT (decline of 25-50% over period stated)

Species	Reason(s) they are of concern				
	Short-term trend (5 years)	Medium-term trend (10 years)	Long-term trend (up to 25 years)	Trend since classification (1988)	Other
Dark-bellied Brent Goose *Branta bernicla bernicla*	0	-16	-2	-13	Moderate decline over 15 years to 2007/08. Evidence of redistribution (Ross-Smith *et al*. 2011).
Shelduck *Tadorna tadorna*	-12	-32	-60	-60	Declines in WeBS sectors supporting an important proportion of the SPA population (Ross-Smith *et al*. 2011).
Mallard *Anas platyrhynchos*	10	33	-41	-39	Evidence of redistribution (Ross-Smith *et al*. 2011).
Pintail *Anas acuta*	-32	167	-75	-93	
Oystercatcher *Haematopus ostralegus*	10	29	-33	-47	
Grey plover *Pluvialis squatarola*	34	24	78	16	Moderate declines over 5 and 10 years to 2007/08. Evidence of redistribution (Ross-Smith *et al*. 2011).
Lapwing *Vanellus vanellus*	-40	-58	1038	379	Evidence of redistribution (Ross-Smith *et al*. 2011).
Knot *Calidris canutus*	10	42	-10	-12	Evidence of redistribution (Ross-Smith *et al*. 2011).
Sanderling *Calidris alba*	10	26	10	-12	Moderate declines over 5 and 10 years to 2007/08 (Ross-Smith *et al*. 2011).
Dunlin *Calidris alpine*	-11	-25	-33	-46	
Black-tailed Godwit *Limosa limosa*	49	135	3033	2250	Moderate decline over 5 years to 2007/08 (Ross-Smith *et al*. 2011)
Bar-tailed Godwit *Limosa lapponica*	14	-2	61	44	Moderate decline over 5 years to 2007/08 (Ross-Smith *et al*. 2011)
Curlew *Numenius arquata*	53	21	43	34	Evidence of redistribution (Ross-Smith *et al*. 2011).
Redshank *Tringa totanus*	4	1	-15	-37	Moderate decline over 5 years to 2007/08 (Ross-Smith *et al*. 2011)
Turnstone *Arenaria interpres*	-11	-19	-61	-67	Evidence of redistribution (Ross-Smith *et al*. 2011).

2 METHODS

2.1 Literature search

A thorough literature search was carried out to inform the reasons behind the changing populations of the species concerned on The Wash SPA. This considered empirical scientific evidence, including various datasets, surveys, studies, and ecological literature. Expert opinion was also used when published information was lacking. Long-term data on bird number and distribution were available at the level of WeBS sectors, but unfortunately the same precision of information was not available for the majority of potential drivers of change, in particular the distribution and availability of these species' foods, which was only available at a broader spatial scale.

2.2 Assessment of the evidence and ecological knowledge

The quality of evidence available for inferring drivers of change on The Wash was assessed according to criteria based on its scientific credibility, age and geographical relevance. The same criteria were also used to assess the overall knowledge available. A ranking system was devised, with each piece of evidence allocated a score (Table 2). Peer-reviewed literature published this decade that included analysis of data from The Wash was considered to be the strongest form of evidence. Literature that gave suggestions and inferences rather than conclusions based on empirical data and subsequent analysis was given a lower score than studies that included data analysis. The score for each of the three categories was summed to give an overall value. Scores of 12 to 15 were considered to constitute "strong" evidence, while scores from eight to 11 to constitute "medium" evidence and scores of seven and below to constitute "weak" evidence. When a variety of sources of evidence were available on which to make a score (for example in the species accounts, section 2.1), the strongest evidence source available was chosen for the basis of that score for the following categories in the species accounts tables (section 2.1): "diet", "habitat", "sensitivity to disturbance", "threats".

Table 2. Scoring system for the assessment of evidence and knowledge.

Evidence type	Age of evidence	Geographical location	Score
Personal communication	Pre-1979	Rest of world	**1**
Grey literature – suggestion	1980-1989	Europe	**2**
Grey literature – empirical data	1990-1999	UK, outside eastern England	**3**
Peer review – suggestion	2000-2009	East of England	**4**
Peer review – empirical data	2010 onwards	The Wash	**5**

3. RESULTS

3.1 Waterbird accounts

The bird species accounts which follow are presented in tabular form organised into the following topic areas:

- ***Population estimates***: Here we give the number of individuals at the time of designation and the corresponding number using the latest WeBS count data.

- ***Trends***: Here we present the percentage change in numbers since classification and the WeBS short, medium- and long-term trends (5, 10 & 25 years) for The Wash as a whole taken from the WeBS Alerts Report (Cook *et al*. 2013); trends within The Wash, typically those identified by Ross-Smith *et al*. (2011) individual count sections and; how trend on The Wash relate to those in the broader context of the East of England (north Thames to the south Humber) and Great Britain (from Cook *et al*. 2013).

- ***Links:*** Here we list useful web links to a broad range of information on species ecology including information beyond that of immediate concern within this report.

- ***General Ecology***: Here we give general information on diet, habitat, behaviour and sensitivity to disturbance. This can be considered typical for the species in question and can be used to infer in information regarding birds on The Wash in the absence of site-specific information.

- ***Local Ecology***: Here we give any information of the species ecology with specific reference to The Wash or at least relatively local to The Wash.

- ***Origin***: Here we give any information regarding the breeding origins of birds frequenting The Wash outside of the breeding season.

- ***Reasons for decline***: Here we give any known reasons for decline on The Wash. Additionally we list factors that are known to affect numbers more widely.

- ***Threats***: Here we list threats that are known to affect the species elsewhere and therefore have the potential to impact numbers on The Wash should they become a local issue in the future.

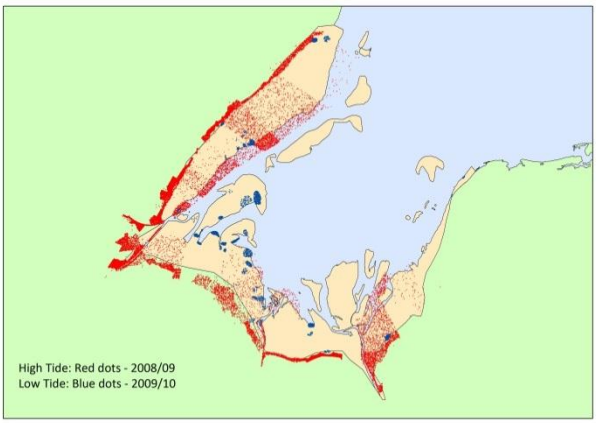
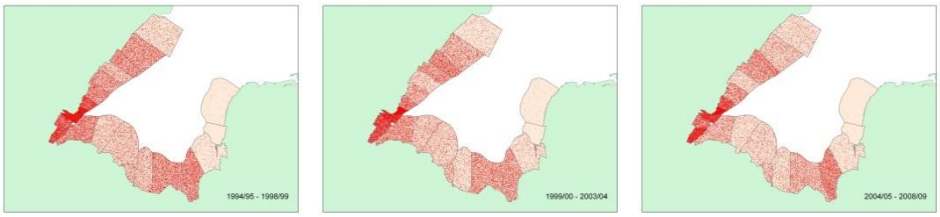
- ***Distribution***: Here we deal specifically with distribution of the species within The Wash. Sector-level distribution maps from Ross-Smith *et al*. (2011) are reproduced here with a brief statement drawing attention to the most important WeBS count sectors for each species. We first present distributions from both low tide (from the surveys of Yates *et al*. 2007) and high tide (from the WeBS Core Count Scheme) to indicate how the birds use the site. This is accompanied by depictions of the WeBS sector counts for each of the five-winter periods: 1994/95-1998/99; 1999/00-2003/04; 2004/05-2008/09. Note that there are two levels of precision relating to WeBS Core Counts. Firstly there are the reporting-level count sections referred to throughout this report and indeed throughout standard WeBS reporting and analyses. Secondly there are the finest level count sections that typically divide the reporting-level count sections parallel to the shoreline, against which counters actually record bird numbers. The latter, which are depicted on the combined low tide/high tide maps are essentially an aid to field recording rather than a meaningful description of bird distributions. This is because essentially the birds are responding to the rising tide as it

rapidly inundates the intertidal sediments and saltmarsh during the period over which WeBS counts are made (within an hour of high water during spring tides) and so does not relate to their use of the area for foraging and roosting although that said, one important aspect that can be deduced from counts mapped at the finest-level is the importance of the fields behind the sea wall as high-tide roosts for waders.

3.1.1 Dark-bellied Brent Goose (*Branta bernicla bernicla*)

Dark-bellied Brent Goose	
POPULATION ESTIMATES	At designation: **22,248** in winter (7.4% of the Western Siberian/western European population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **15,206** (Austin *et al*. 2014).
TRENDS	Site Trends: Change since classification: -13% Short-term trend: 0 Medium-term trend: -16% Long-term trend: -2% Sector trends: Moderate increases over 5 and 10 years to 2007/08 at Butterwick to Witham, which held ≥20% of The Wash SPA population between 2004/05 and 2008/09 (Ross-Smith *et al*. 2011). Broader context: UK/Region trends: The proportion of East of England Dark-bellied Brent Geese found on The Wash SPA has remained relatively stable, with The Wash trends mirroring the regional trends. The same is true for the population of Dark-bellied Brent Geese on The Wash SPA relative to Great Britain as a whole. 3.23
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=386 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob1680.htm
GENERAL ECOLOGY	DIET: Mainly herbivorous (del Hoyo *et al*. 1992 in Birdlife 2014), though it may take some animal matter (Johnsgard 1978 in Birdlife 2014). Preferred food is eelgrass *Zostera spp*. *Ulva lactuca* is also important, but many other estuarine plants are eaten including *Ruppia maritima*, *Spartina alterniflora*, *Salicornia* spp., and arrowgrass *Triglochin* spp. (Kear 2005a). Also feeds on *Lolium perenne*, especially inland near the coast (Vickery & Gill 1999 in Birdlife 2014). HABITAT: Over winter the Dark-bellied Brent Goose is found on estuaries, tidal mudflats, sandy shores, and shallow muddy bays (del Hoyo *et al*. 1992 in Birdlife 2014; Kear 2005a). It usually roosts on estuaries and feeds on plants below the high water mark (Kear 2005a). It has increasingly begun to use coastal grassland and winter cereal crops as feeding habitat (Kear 2005a).

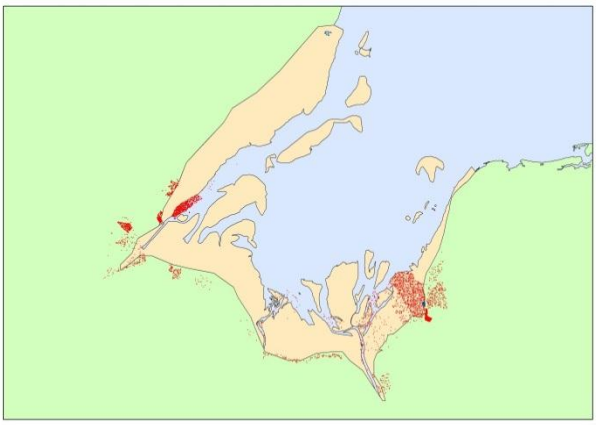
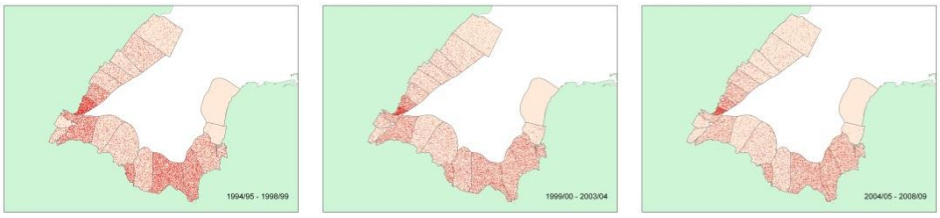
Dark-bellied Brent Goose	
	BEHAVIOUR: Gregarious, occurring in small to large flocks during winter, grazing on plants (Kear 2005a). A sequential pattern of habitat use may occur as birds deplete preferred saltmarsh species in turn before switching to inland food sources (WWT 2014). SENSITIVITY TO DISTURBANCE: This species is disturbed by vehicle movement in the UK, but relatively tolerant of human disturbances such as walkers nearby (Burton *et al*. 2002a). Displacement from preferred feeding habitats is therefore a possible impact for resident estuarine birds. On the Wadden Sea, pressure of recreational activity was found to limit numbers of Brent Geese using an area (Stock 1993). Tourists were the most frequent disturbing factor whilst the geese were found to be particularly sensitive to planes and helicopter activity. When disturbance was high, birds took refuge in undisturbed areas of saltmarsh.
LOCAL ECOLOGY	No site-specific references were found although a study on the adjacent North Norfolk Coast showed walkers to be the most frequent disturbance factor but that 'mechanised' activities (e.g. gunshots and aircraft) cause greatest energy expenditure (Riddington *et al*. 1996). Displacement from preferred feeding habitats is therefore a possible impact for resident estuarine birds and in areas of high disturbance they may be forced to feed at night. That study recommended the provision of large refuges from disturbance as a means to reducing these pressures and that those refuge areas should be close to roosts.
ORIGIN	Breeds on the Arctic coast of Russia (Birdlife 2014).
REASONS FOR DECLINE	There is no evidence of a decline for this species. SITE SPECIFIC: The site trend appears to be tracking the regional and British trends (stable in the long-term having previously declined). The proportion of regional and countrywide numbers on the site is stable, suggesting that conditions remain relatively favourable for this species (Cook *et al.* 2013).
THREATS	The return of a disease affecting the Dark-bellied Brent Goose's preferred food, eelgrass, may threaten this species in the future (Scott & Rose 1996 in Birdlife 2014). This disease is thought to have been responsible for reductions in Dark-bellied Brent Goose numbers in the 1930s (Kear 2005a). Persecution could also be a threat in areas where it has started to feed on arable crops (Birdlife 2014).

Dark-bellied Brent Goose	
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species is widespread across The Wash. The south and west coastlines support higher numbers than the west coastline, with especially high concentrations on the muddier sectors adjacent to and between the mouths of the River Great Ouse and the River Nene and sectors in the vicinity of the River Welland and The Haven. The within site distribution across The Wash has remained relatively stable since the mid-1990s although the relative importance of the sectors from Butterwick to Witham, which hold the highest concentrations of this species, have increased as small numbers have been lost from the site in general.

3.1.2 Shelduck (*Tadorna tadorna*)

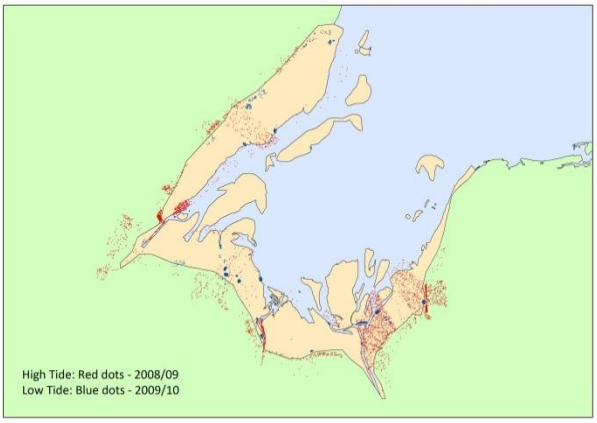
Shelduck	
POPULATION ESTIMATES	At designation: **15,981** wintering (5.3% of the north-western European population, 6 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **5,255** (Austin *et al*. 2014).
TRENDS	Change since classification: -60% Short-term trend: -12% Medium-term trend: -32% Long-term trend: -60% Sector trends: Moderate and substantial declines in WeBS sectors holding ≥10% (Dawsmere, Welland, Butterwick to Witham) and ≥20% (Ouse Mouth,

Shelduck	
	Terrington East) of The Wash SPA population between 2004/05 and 2008/09 (Ross-Smith *et al*. 2011). UK/Region trends: The proportion of East Anglian Shelduck found on The Wash SPA been declining since the 1990s, with numbers on The Wash declining at a steeper rate than the region as a whole. The same is true for the population of Shelduck on The Wash SPA relative to Great Britain as a whole. 3.80
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=402 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob1730.htm
GENERAL ECOLOGY	DIET: Various tiny invertebrates, with small molluscs predominant in north and west Europe, especially *Peringia* spp. (formerly *Hydrobia* spp.) (Kear 2005a). Shelduck feed on invertebrates of intertidal area. The species has been observed consuming Oligochaetes, small Polychaetes (e.g. *H. diversicolor* small size classes); *Carcinus maenas* (small size classes), *Corophium* spp., *P. ulvae*, *M. balthica* (small size classes), and *M. edulis*. HABITAT: Shelduck prefer saline habitats such as mudflats (del Hoyo *et al*. 1992 in Birdlife 2014) and muddy or sandy estuaries (Madge & Burn 1988 in Birdlife 2014). BEHAVIOUR: Feeds by digging, scything and dabbling in intertidal area, feeding during both day and night according to the tide times (Kear 2005a). SENSITIVITY TO DISTURBANCE: Burton *et al*. (2002a) found that counts were significantly lower on estuarine count sectors that were closer to footpaths.
LOCAL ECOLOGY	Numbers near the Great Ouse outfall were consistently higher in the late 1980s to early 1990s than during the period 1996-2006 (Yates *et al.* 2007).
ORIGIN	European breeding populations are largely sedentary, though they undertake short migrations to moulting sites in late summer (Birdlife 2014) when a large proportion of the British population aggregates on the Wadden Sea (Meltofte *et al*. 1994).
REASONS FOR DECLINE	SITE SPECIFIC: The site tend appears to be tracking the regional and British trends (declines in the medium/long term). However, the decline in the proportion of regional and countrywide numbers on this site suggests that site-specific factors may be affecting the site (Cook *et al*. 2013). The decline of Shelduck on The Wash may be linked to the fall in shellfish stocks in the 1980s and 1990s (Atkinson *et al*. 2010).

Shelduck	
THREATS	Reductions of feeding areas are among the direct pressures that affect overwintering Shelduck, e.g. this species is threatened by European tidal barrage schemes (Kear 2005a; Burton 2006). May be at risk from improvements to water quality which has been found to cause reductions in benthic invertebrate densities at sites close to sewage outfalls (Burton *et al*. 2002b).
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  The distribution of this species is closely associated with the muddier sectors of The Wash, especially those sectors adjacent to and between the mouths of the River Great Ouse and the River Nene and sectors in the vicinity of the River Welland and The Haven. The relative distribution within The Wash has remained stable since the mid-1990s, with the overall decline on the site as a whole affecting all sectors more or less equally.

3.1.3 Mallard (*Anas platyrhynchos*)

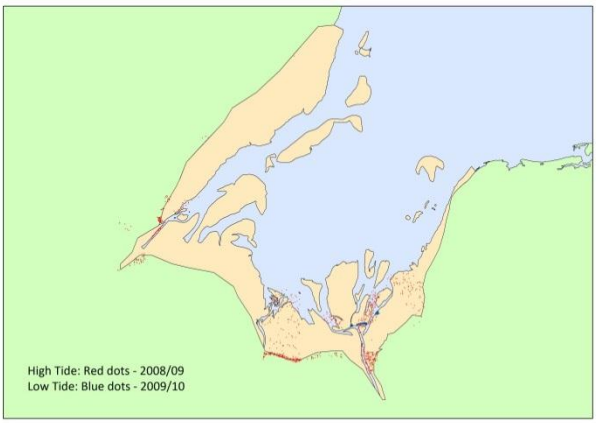
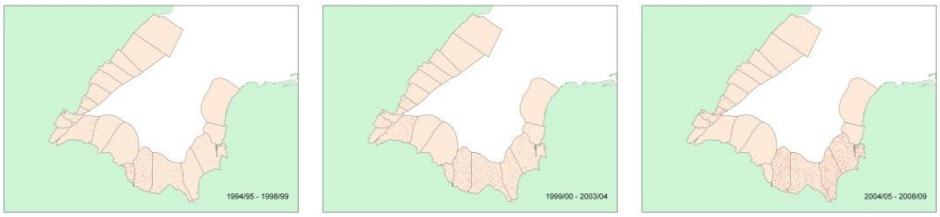
Mallard	
POPULATION ESTIMATES	At designation: Not listed (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **2,506** (Austin *et al*. 2014).
TRENDS	Change since classification: -39% Short-term trend: +10% Medium-term trend: +33% Long-term trend: -41% Sector trends: Moderate decline in Butterwick to Witham, but moderate increases at Ouse Mouth and Snettisham. Each of these sectors held ≥20% of The Wash SPA population between 2004/05 and 2008/09 (Ross-Smith *et al*. 2011).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=435 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob1860.htm
GENERAL ECOLOGY	DIET: Omnivorous, including both plants and animal matter (Kear 2005b). HABITAT: Inhabits all wetland types, though prefers sites with shallow water and cover. Will feed and roost on the sea and in brackish waters (Kear 2005b). BEHAVIOUR: Feeds predominantly by dabbling in shallows, or upending in slightly deeper water. May also feed ashore and occasionally graze. Usually feeds in morning or evening, but may also feed at night (Kear 2005b). SENSITIVITY TO DISTURBANCE: Often tolerant of humans (Kear 2005b).
LOCAL ECOLOGY	No site-specific references found.
ORIGIN	Many breeding populations are sedentary or only move in severe weather. However some populations are migratory and up to three-quarters of the birds wintering in the UK may be winter visitors from north-west Europe (Wernham *et al.* 2002).
REASONS FOR DECLINE	SITE SPECIFIC: The trend on site appears to be tracking the regional and British trends suggesting that the declines result from broad-scale population trends rather than site-specific reasons (Cook *et al*. 2013). Mallard, together with three other species were found to be decreasing at a disproportional rate on the South Lincs. Shooting Zone (overlapping Wrangle,

Mallard	
	Leverton, Bennington & Butterwick sections) with a shift in local distribution towards the north of the area (Austin & Calbrade 2010). Suggested reasons for the decline was increasingly rank vegetation due to decreased frequency of inundation as a result of saltmarsh accretion making the habitat less attractive to this species. The northward shift reflecting a higher rate of change in the north possibly coupled with increased disturbance in the south. OTHER: The decline in the wintering population in the UK is thought to be caused by a reduction in long distance movement by European-breeding Mallards, perhaps because of milder winters in mainland Europe (Sauter *et al*. 2010).
THREATS	Wetland habitat loss and degradation (Birdlife 2014)
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species is widely distributed across the site with highest densities on the sectors of Witham to Butterwick, although a shift in distribution since the mid-1990s had led to decline in that area. Generally, any increases elsewhere on the site, the most noteworthy being in the sectors immediately east and north of the River Great Ouse inflow have been insufficient to compensate for the aforementioned decline.

3.1.4 Pintail (*Anas acuta*)

Pintail	
POPULATION ESTIMATES	At designation: **923** wintering (1.5% of the north-western European population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **535** (Austin *et al*. 2014).
TRENDS	Change since classification: -93% Short-term trend: -32% Medium-term trend: +167% Long-term trend: -65% Sector trends: Trends are only available for four sectors due to extremely low numbers being recorded elsewhere. Trends for Snettisham, Ouse Mouth and Terrington East are similar to the trend for the SPA, whilst the trend for Terrington West fluctuated to a greater degree. All these sectors held ≥20% of The Wash SPA population between 2004/05 and 2008/09 (Ross-Smith *et al*. 2011). UK/Region trends: Numbers of Pintail in East Anglia have been decreasing in the short-term having previously peaked, while numbers in the UK have been decreasing in the short-term having been relatively stable. The high level of fluctuation in numbers of Pintails at The Wash SPA precludes a comparison of trends with the region and the UK (Cook *et al.* 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=457 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob1890.htm
GENERAL ECOLOGY	DIET: Omnivorous, mainly vegetable especially seeds, with invertebrates increasingly taken prior to spring migration (Kear 2005b). HABITAT: Productive wetlands with shallow water (freshwater, brackish and saline) (Kear 2005b). Roosts by day on open water (Birdlife 2014). BEHAVIOUR: Highly gregarious in winter (Birdlife 2014). Feeds nocturnally, roosting by day (Birdlife 2014). SENSITIVITY TO DISTURBANCE: No specific information found.
LOCAL ECOLOGY	The important areas for this species are the sectors around the Ouse Mouth (Ross-Smith *et al*. 2011).

Pintail	
ORIGIN	Pintail wintering in Britain & Ireland come from a widely dispersed area from Iceland to Russia (Wernham *et al.* 2002).
REASONS FOR DECLINE	SITE SPECIFIC: Site numbers have fluctuated throughout the period recorded by WeBS. There was a substantial peak in the 1980s and especially in 1987/88 and 1988/89 when counts were around ten times the number recorded during the 1970s, 1990s and 2000s (Cook *et al.* 2013). The high peak could suggest that conditions at The Wash SPA were temporarily particularly suitable for this species. The reasons for the decline are unknown though Pintail are thought to be 'nomadic' and similar large fluctuations in numbers have been reported elsewhere (Earll 2001).
THREATS	Habitat loss and overexploitation have been identified as threats in the action plan for Europe (Kear 2005b). The threat is exacerbated by a highly aggregated winter distribution at relatively few sites (Kear 2005b). May be at risk from improvements to water quality which has been found to cause reductions in benthic invertebrate densities at sites close to sewage outfalls (Burton *et al*. 2002b).

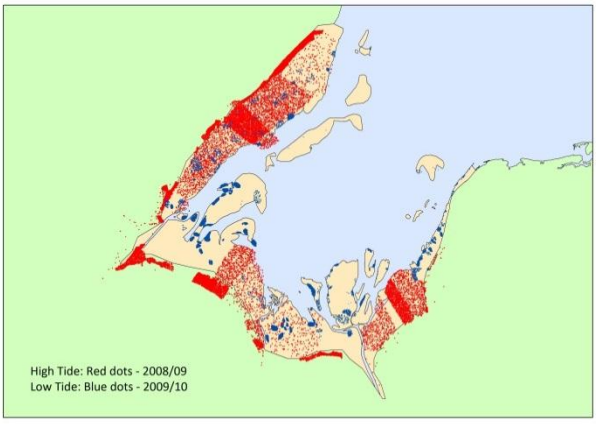
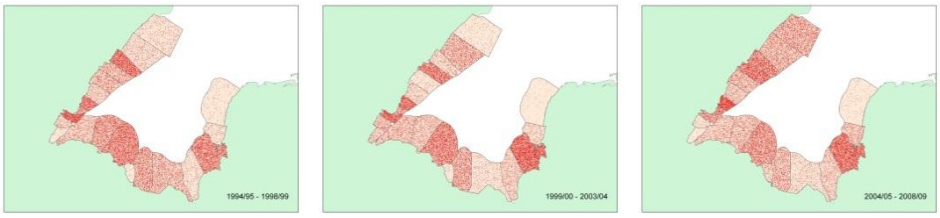
Pintail	
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species has a fairly restricted distribution within The Wash with most birds occurring on the muddier sections adjacent to the inflows of the River Nene and River Great Ouse. Numbers of this species on The Wash have fluctuated over time but the relative distribution across the site has remained essentially stable.

3.1.5. Oystercatcher (*Haematopus ostralegus*)

Oystercatcher	
POPULATION ESTIMATES	At designation: **25,651** wintering (2.9% of the European and northern/western African population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **20,635** (Austin *et al*. 2014).
TRENDS	Change since classification: -47% Short-term trend: +10% Medium-term trend: +29% Long-term trend: -33% Sector trends: Trends are relatively stable in WeBS sectors where a large proportion of the SPA population is held, e.g. Dawsmere, Snettisham (Ross-Smith *et al*. 2011). UK/Region trends: Between the early 1970s and the early 1990s, the proportion of East Anglian Oystercatcher population found on The Wash SPA fell, but has

Oystercatcher	
	since stabilised. The same is true for the population of Oystercatcher on The Wash SPA relative to Great Britain as a whole.
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3088 BTO FACTS: http://blx1.bto.org/birdfacts/results/bob4500.htm
GENERAL ECOLOGY	DIET: Shellfish from inter-tidal mudflats often predominate in the Oystercatcher diet, especially large Cockles and Mussels (Delany *et al*. 2009). However, the foods eaten vary according to the habitat (del Hoyo *et al*. 1996 in Birdlife 2014). This species has been observed to feed on Polychaetes (large size classes) - *Hediste* spp., *C. edule* (large size classes between 20-30 mm shell length), *M. edulis* (juvenile and large Mussels, generally of 15-50 mm shell length), and *Macoma balthica* (large size classes) (Horwood & Goss-Custard 1977; Goss-Custard *et al.* 1996). Oystercatchers may also consume ragworms *Nereis* spp. and lugworms *Arenicola* spp. on mudflats, and earthworms from wet fields (Hulscher 1996). Earthworms are sometimes taken at high tide when birds unable to find sufficient food, as mudflats are inundated (Caldow *et al*. 1999 in Delany *et al*. 2009). HABITAT: Over winter the Oystercatcher is a coastal bird, frequenting estuarine mudflats, saltmarshes and sandy and rocky shores (del Hoyo *et al*. 1996 in Birdlife 2014). It uses mixed wader roost sites when nearby feeding areas are covered by tides (e.g. Rehfisch *et al*. 1996). BEHAVIOUR: Individual Oystercatchers often specialise on one prey species for extended periods and from one winter to the next, and have different bill shapes and different techniques for opening shells. Birds can respond to environmental conditions by changing bill shape, though there is a time delay of 10-20 days before the bill changes to the optimum shape for a different prey species (Sutherland *et al*. 1996). Prey is detected by both sight and touch and birds can feed by day and night, with most of the winter studies listed in Hulscher (1996) showing *c*.2/3 of food intake occurring during the day. Many Oystercatchers are very site faithful, returning to the same wintering site and feeding on the same shellfish beds, though others roam over a wider area (Ens & Cayford 1996). Though they are not strictly territorial, dominance interactions create a dispersed feeding pattern (Colwell 2010). As a result, less dominant birds, including young birds, may be unable to feed on Mussel beds and may be forced to feed on other food items and on fields (Ens & Crayford 1996). SENSITIVITY TO DISTURBANCE: Several studies suggest that Oystercatcher is less sensitive to disturbance than other species, allowing a closer approach and showing habituation to recreational activity and construction work (e.g. various references in Cutts & Allen 1999; Davidson & Rothwell 1993; Cutts *et al*. 2009).

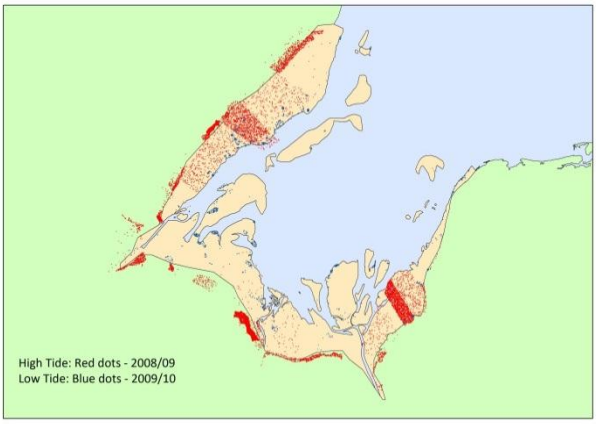
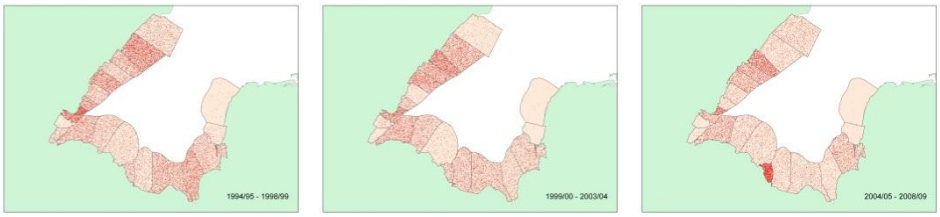
Oystercatcher	
LOCAL ECOLOGY	Goss-Custard *et al.* (1977, 1978 in Durell & Atkinson 2004) found that the majority of Oystercatchers on The Wash were Cockle feeders. Durell & Atkinson (2004) found that there were more female than male birds on The Wash, with females and younger birds more likely to be found in the southwest and adults and males in the east, and suggested that these findings could be explained by differences in diets and feeding methods (with males more likely to be Mussel-feeders). Birds wintering on The Wash tend to be relatively site faithful both within and between winters, with around 83% of re-trapped adults and 80% of re-trapped juveniles at roost sites occurring in the same section of The Wash (Rehfisch *et al.* 1996). This species will often use fields adjacent to the SPA to roost when high spring tides cover the saltmarsh (N.Clark *pers. comm*.). Catching of Oystercatcher (for ringing) on the south shore became less frequent in the late-2000s as a consequence of irregular use of Holbeach by this species, and because the Inner Bund was no longer being used as a roost site (WWRG 2010). A substantial decline was noted in the Heacham sector over the period 2002/03–2007/08, though a substantial increase was noted in the Hunstanton sector for the same period. Declines were reported in both sectors for the period 1997/08–2007/08 (Ross-Smith *et al*. 2011). Near the Great Ouse outflow, the number over the period 1996-2006, peaked in 2003, then declined (Yates *et al.* 2007). The peak occurred at the same time as peaks in polychaete worm and crustacean abundance, and three years later than the peak in bivalve abundance (Yates *et al*. 2007).
ORIGIN	Ringing recoveries suggest that the majority of the birds wintering on The Wash breed in Norway, with a small proportion coming from Iceland and the Faroe Islands (Atkinson *et al*. 2000; WWRG report 2011-12).
REASONS FOR DECLINE	SITE SPECIFIC: Site numbers have been stable in the medium term having declined in the late-1980s and early-1990s. The site trend appears to be tracking that of the region, though not the British trend. The declines in the proportion of British Oystercatcher found in the region suggest site-specific pressures may be affecting numbers (Cook *et al.* 2013). Several studies and models have linked Oystercatcher declines in The Wash directly to shellfish and Mussel farming (e.g. Atkinson *et al.* 2000, 2003, 2010; Stillman *et al.* 2004). Major losses occurred in three winters on The Wash (1991-2, 1994-5 and 1995-6) when mortality was at 5-13 times normal levels. They occurred at the same time as the collapse of the Mussel stock due to shellfishing, and coincided with years of low Cockle abundance (Atkinson *et al.* 2003, 2010). The link between declines in shellfish stocks and Oystercatchers has also been identified in the Dutch Wadden Sea (various references in Delany *et al*., 2009). The trend graph for The Wash (Cook *et al.* 2013) shows a clear drop in the mid-1990s at the time of the major kills, but has remained relatively stable since. As the species is long-lived and site

Oystercatcher	
	faithful, and does not start breeding until around four years old (Delany *et al.* 2009), any recovery may be relatively slow, particularly if the winter distribution is shifting as a result of climate change (see below). OTHER: Slight distribution shifts of seven wader species towards the north-east over the period 1981-2000, including Oystercatcher, was attributed to greater numbers wintering in north-east Europe as a result of climate change, though this may be caused by range expansion and changes in juvenile settlement rather than movements by individual birds (Maclean *et al.* 2008).
THREATS	The largest threat is deterioration of the habitat and/or shellfish beds to such an extent that the major benthic shellfish kills observed during the 1990s are repeated. Survival models have predicted that in order to maintain Oystercatcher populations, the volume of bivalves available in autumn needs to be 2.5-8 times the amount they will consume during the winter. This is because intraspecific competition increases when food supplies are low and sub-dominant birds are excluded from much of the food supply (Goss-Custard *et al.* 2004).
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al.* 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al.* 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species is widespread within the site as a whole although Snettisham, Dawsmere, Holbeach, Frieston and Wrangle stand out as supporting particularly high densities of birds. The maps suggest a shift in relative distribution since the mid-1990s with reduced densities being found in the Terrington Marsh area and increased densities along the more northerly sectors of the Lincolnshire coastline.

3.1.6. Grey Plover (*Pluvialis squatarola*)

Grey Plover	
POPULATION ESTIMATES	At designation: **9,708** wintering (5.8% of the Eastern Atlantic wintering population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **10,330** (Austin *et al*. 2014).
TRENDS	Change since classification: +16% Short-term trend: +34% Medium-term trend: +24% Long-term trend: +78% Sector trends: Trends in the WeBS sectors has been mixed, with declines noted around the inflow of the River Great Ouse (Ouse Mouth and Terrington East sectors) and River Welland (Holbeach St. Matthew and Welland), as well as in Terrington West, Benington and Friskney. There were increases at Gedney and Wainfleet (Ross-Smith *et al*. 2011). UK/Region trends: The proportion of the East Anglian wintering population using The Wash SPA is decreasing, suggesting that the site is becoming less important relative to others in the region (Ross-Smith *et al.* 2011; Cook *et al.* 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3114 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob4860.htm
GENERAL ECOLOGY	DIET: In winter, Grey Plover predominantly eat polychaete worms, molluscs and crustaceans (Del Hoyo *et al*. 1996 in Birdlife 2014). Leopold *et al.* (2004a, b in Atkinson *et al.* 2010) state that 87% of their diet is made up of polychaete worms. HABITAT: During the wintering period the Grey Plover is found on intertidal mudflats, sandflats and on beaches, bays and estuaries (Johnsgard 1981 in Birdlife 2014; del Hoyo *et al*. 1996 in Birdlife 2014), and joins mixed wader roosts close to its feeding areas (e.g. Rehfisch *et al*. 1996). BEHAVIOUR: The Grey Plover is site faithful, and defends feeding territories within and between winters (Delany *et al*. 2009). Feeds by sight and, like other plovers, its large eyes enable it to forage by night as well as day (Shrubb 2007). SENSITIVITY TO DISTURBANCE: Grey Plover was among the species noted to be sensitive to disturbance by walkers and dogs on the Dee (Kirby *et al*. 1993 in Cutts *et al.* 2009).

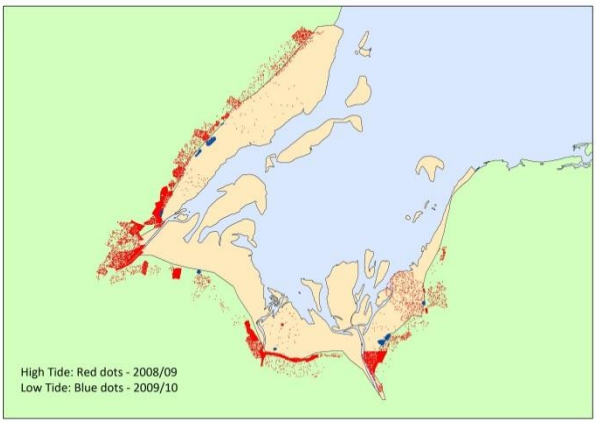
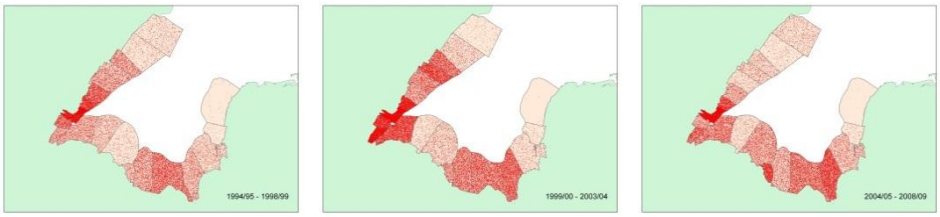
Grey Plover	
LOCAL ECOLOGY	Durell & Kelly (1990) found the main diet on The Wash to follow the typical pattern consisting of polychaete worms (*Nereis diversicolor*, *Arenicola marina*) and molluscs (*Macoma balthica*, *Cerastoderma edule*, *Peringia ulvia* (formerly *Hydrobia ulvae*)) The species is site faithful when roosting and is unlikely to move to a different part of The Wash. Some 96% of roost movements were within the same section of the SPA, both within and between years (Rehfisch *et al*. 1996). The species will often roost in fields adjacent to the SPA when the saltmarsh is covered by high spring tides, and some birds join the roost at Holme on the North Norfolk Coast (N. Clark *pers. comm*).
ORIGIN	UK wintering birds come from western Siberia (Delany *et al*. 2009), and three ringing recoveries suggest that Wash birds are from this area (WWRG 2012). There are important staging areas for European wintering birds in north-east European Russia in August, and in the Wadden Sea in spring (Delany *et al.* 2009). Some birds pass through The Wash on passage and winter further south (WWRG 2012).
REASONS FOR DECLINE	SITE SPECIFIC: There is no evidence of a decline for this species as WeBS Alerts have not been triggered and trends for The Wash SPA are positive over all time periods. However, the sector trends suggest that there has been some movement within the SPA, so conditions may have changed in certain sectors. Note that the baseline year for the sector trends (2007/08) is different from the baseline year for The Wash SPA trends (2008/09). Over-exploitation of shellfish during the late-1980s and early-1990s may have caused increases in worm-feeders like Grey Plover at the time, though the evidence is correlative (Atkinson *et al.* 2010). Numbers at The Wash did peak at this time; however, the proportion of the East Anglian wintering population at The Wash SPA was lower in most years during the 1990s than in the 1980s, with 1994/95 a notable exception (Cook *et al*. 2013). OTHER: Wintering numbers in the UK peaked in the 1990s and have since declined. This may reflect population declines, or redistribution of the population in response to climate change (Balmer *et al.* 2013). There is some evidence that the distribution of this species is shifting north-eastwards in response to climate change (Maclean *et al.* 2008), leading to an increase in numbers wintering in Europe rather than the UK. However, this shift may also lead to an increase on The Wash with more birds wintering in the east of Britain rather than the south-west (Austin & Rehfisch 2005).
THREATS	There are threats on the breeding grounds from the oil and gas industry, and on the wintering grounds from loss of intertidal habitat as a result of human activity, leading to a reduction in the availability of food (Delany *et al*. 2009).

Grey Plover	
	May be at risk from improvements to water quality which has been found to cause reductions in benthic invertebrate densities at sites close to sewage outfalls (Burton *et al*. 2002b).
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species is widespread within the site although scarce on the Holbeach and Hunstanton sectors. There has been a shift in relative distribution since the mid-1990s with a notable decline on the muddy sectors in the vicinity of the inflow of the River Great Ouse but a marked increase in density in the vicinity of the inflow of the River Nene at Gedney.

3.1.7 Lapwing (*Vanellus vanellus*)

Lapwing	
POPULATION ESTIMATES	At designation: Not listed (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **16,612** (Austin *et al*. 2014).
TRENDS	Change since classification: +379% Short-term trend: -40% Medium-term trend: -58% Long-term trend: +1,038% Sector trends: Lapwing numbers have sustained substantial declines over the 15 winters to 2007/08 in many sectors in the northern Lincolnshire region of The Wash SPA. Substantial increases over the same time period only occurred at Gedney, which increased in importance relative to The Wash SPA though numbers at this sector were relatively low (Ross-Smith *et al.* 2011). UK/Region trends: The proportion of East Anglian and UK wintering numbers The Wash SPA is increasing suggesting conditions remain relatively favourable for this species (Cook *et al.* 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3153 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob4930.htm
GENERAL ECOLOGY	DIET: Lapwing eat a very wide range of invertebrates including beetles and earthworms (Shrubb 2007; del Hoyo *et al*. 1996 in Birdlife 2014), spiders and snails (Del Hoyo *et al*. 1996 in Birdlife 2014), as well as seeds and other plant material (Urban *et al*. 1986 in Birdlife 2014). HABITAT: Feeds mainly on pasture, wet meadows and arable farmland in winter (Delany *et al*. 2009). Larger fields may be preferred, but evidence is contradictory and an open boundary may be more important (Shrubb 2007). Roosts in large open fields with ploughed soil or tussock grassland for concealment (Shrubb 2007). Also uses estuarine and saltmarsh habitats for roosting. Use of estuarine sites can become important in cold weather when other sites freeze, and flocks may move long distances at the onset of severe weathers (Delany *et al*. 2009). BEHAVIOUR: Lapwings feed by sight using a pause/travel approach (pausing to look for prey then walking a few steps and pausing again). They have large eyes and so can feed at night, especially during brighter nights. During mild weather and when there is a full moon, they tend to feed at night and roost by day. Feeding birds spread out more widely across fields when less prey is available, e.g. during frosty conditions (Shrubb 2007).

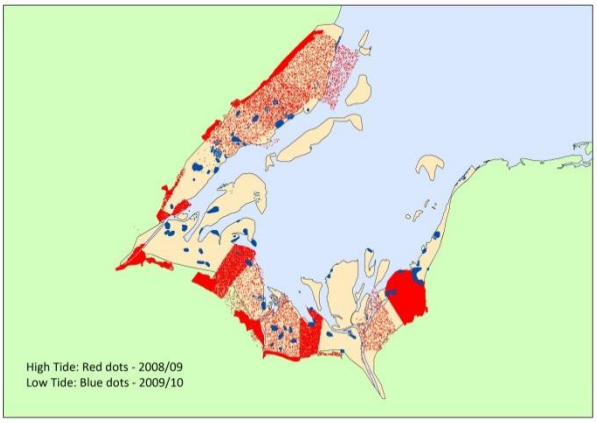
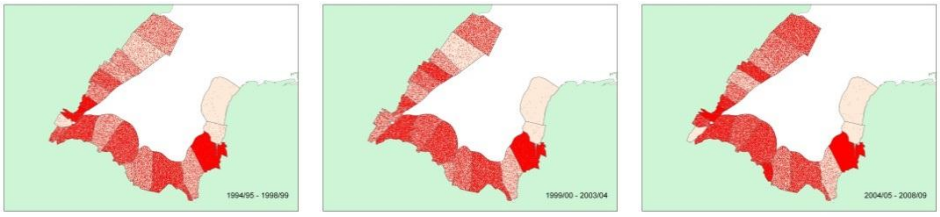
Lapwing	
	DISTURBANCE: Believed to be relatively tolerant to disturbance compared to other species (Cutts *et al*. 2009).
LOCAL ECOLOGY	No site-specific references found.
ORIGIN	The Lapwings breeding in the south-west of the range (which includes the UK) are resident or partial migrants apart from in severe weather (Delany *et al*., 2009). However, the majority of wintering birds in the UK are from elsewhere, with birds in the east thought to come from Scandinavia (Wernham *et al.* 2002).
REASONS FOR DECLINE	SITE SPECIFIC: The proportion of regional and UK birds using The Wash SPA is increasing suggesting that the reason for the short and medium-term decline is not site-specific (Cook *et al.* 2013). However, sector level declines across much of the North Lincolnshire region and increases at Gedney suggest that local conditions within The Wash SPA may have changed. However, this species regularly feeds in arable fields so the sector declines may also relate to changing conditions outside the SPA boundary. Lapwing, together with three other species were found to be decreasing at a disproportional rate on the South Lincs. Shooting Zone (overlapping Wrangle, Leverton, Bennington & Butterwick sections) with a shift in local distribution towards the north of the area (Austin & Calbrade, 2010). Suggested reasons for the decline was increasingly rank vegetation due to decreased frequency of inundation as a result of saltmarsh accretion making the habitat less attractive to this species. The northward shift reflecting a higher rate of change in the north possibly coupled with increased disturbance in the south. OTHER: Steep declines in Western Europe, including a decline of 42% in the UK breeding population over the period 1995-2012 (Harris *et al*. 2014), have been linked to agricultural intensification (Beintema *et al.* 1995 in Delany *et al.* 2009). A distributional shift in wintering Lapwing in the UK occurred between 1974/05 and 2002/03, leading to a marked increase in numbers wintering on the east coast and explaining the peak in numbers at this time on The Wash and within the East Anglia region (Gillings *et al*. 2006).
THREATS	The main threat is thought to be changes to breeding habitats, but stopover sites may also be affected by pollution and drainage (Birdlife 2014).

Lapwing	
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species is widespread across The Wash although there are distinctly higher densities associated with the muddier sectors adjacent to the inflows of The Haven and the River Welland and those between the inflows of the River Great Ouse and River Nene. Densities on the sandier sectors have been consistently low in comparison.

3.1.8 Knot (*Calidris canutus*)

Knot	
POPULATION ESTIMATES	At designation: **186,892** wintering (54.2% of the north-eastern Canada/Greenland/Iceland/north-western European population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **134,338** (Austin *et al*. 2014).
TRENDS	Change since classification: -12% Short-term trend: +10% Medium-term trend: +42% Long-term trend: -10% Sector trends: Over the period 1992/03–2007/08, increases in some WeBS sectors, e.g. Gedney and Frampton, were offset by declines in others including Butterwick to Witham, Benington and Kirton (Ross-Smith *et al*. 2011). UK/Region trends: The proportion of the wintering population in East Anglia using The Wash SPA is decreasing, suggesting the site is becoming less attractive relative to others in the region. (Cook *et al*. 2013). The proportion of numbers in the UK has remained more constant (Ross-Smith *et al.* 2011).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3041 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob4960.htm
GENERAL ECOLOGY	DIET: Mainly molluscs, including Tellins *Macoma balthica*, Mussels *Mytilus edulis*, Cockles *Cerastoderma edulis* and Mudsnails *Peringia ulvia* (formerly *Hydrobia ulvae*), the latter especially in early winter (Zwarts *et al*. 1992 & Piersma *et al*. 1998 in Delany *et al*. 2009). Atkinson *et al.* (2010), gives diet proportions after Leopold *et al*. (2004a, b), of 75% bivalves, 1% worms and 24% 'other'. Prey is eaten whole and crushed within the gizzard (Piersma 2006). Knot feeds on invertebrates of intertidal areas. The largest component of the knot's diet is Annelida (polychaete worms) (87%), with a lesser tendency to graze on Bivalves and other benthic organisms (6% and 7% respectively). Species reportedly consumed include small *Hediste* spp, *C. edule* (spat & small size classes up to 12.5 mm shell length), *P. ulvae*, *M. balthica* (medium size classes) (Zwarts & Blomert 1992). However, this directly contradicts the figures in Atkinson *et al*. (2010). HABITAT: The Knot is found solely on the coast during the non-breeding season and frequents tidal mudflats and sandflats, bays and lagoons among others (del Hoyo *et al*. 1996 in Birdlife 2014). Feed in dense flocks on extensive intertidal mudflats (Delany *et al.* 2009). Sometimes fly many kilometres to roost sites, along undisturbed shorelines (Piersma *et al*. 1993). Knots are apparently more reluctant than other wader species to roost inland.

Knot	
	BEHAVIOUR: Knots feed in very large flocks on open mudflats, catching food mainly by touch by making 'sewing movements' with their bill as they move forward (Piersma 1994), and may also detect prey by 'remote sense' (i.e. from vibrations rather than direct touch) (Piersma *et al.* 1994a). Flocks will move with the tide and cover may very extensive areas of mudflat, e.g. Knots covered most of the intertidal flats in the Dutch Wadden Sea in just a couple of tidal cycles (Piersma *et al*. 1994b). SENSITIVITY TO DISTURBANCE: Several studies indicate that this species is sensitive to disturbance, especially at roost sites (Kirby *et al.* 1993; Burton *et al.* 1996; Pfister *et al.* 1992).
LOCAL ECOLOGY	Knots may move right round The Wash over the course of a season rather than staying in one area (N. Clark *pers. comm*). This species will roost in fields adjacent to the SPA when roost sites are covered by high spring tides, but they will also fly some distance to roost including to sites outside The Wash SPA, such as Gibraltar Point and the North Norfolk Coast. Many birds fly to Holme to roost and some go as far as Titchwell (N. Clark *pers. comm*)
ORIGIN	Birds wintering in Britain are believed to be from the *islandica* race which breeds in Greenland and Arctic Canada. Around 65% of the *islandica* population are thought to be in Britain & Ireland in midwinter (Delany *et al.* 2009). Ringing recoveries confirm that most Knot seen on The Wash are *islandica*, with passage occurring via Norway and Iceland. Small numbers of the nominate race *canutus*, which breeds in Siberia, also occur on passage (WWRG 2012).
REASONS FOR DECLINE	SITE SPECIFIC: Numbers of Knot over-wintering on The Wash SPA have been stable in the short-term after declining in the early-1990s, and no WeBS Alerts have been triggered for this species. The trend on the site appears to match that of the region although not the British trend. The proportion of the East Anglian population using The Wash SPA is decreasing, suggesting the site is becoming less attractive in comparison to others in the region. (Cook *et al*. 2013). Declines in Knot numbers have been linked to the overexploitation of shellfish at both the Wadden Sea (Piersma 2006) and specifically on The Wash (Atkinson *et al.* 2010). Knots may also be sensitive to changing feeding conditions at a site. Quaintenne *et al.* (2011), suggested that Knots may be aware of potential food resources across western Europe, and may fly to a different area once or twice within the same winter (e.g. between The Wash and the Wadden Sea). OTHER: There is evidence that an easterly shift in the wintering distribution of

Knot	
	this species in Europe has occurred as a result of climate change (Maclean *et al.* 2008).
THREATS	Knots need to range over an extensive area of mudflats during the course of a winter, so as well as direct impacts such as shellfishing and habitat loss due to drainage and development (del Hoyo *et al*. 1986 in Birdlife 2014), they may be more vulnerable than other species to changes to the extent of mudflat as a result of natural processes and indirect anthropogenic effects such as climate change and sea level rise. Knots may also be susceptible to disturbance as walkers on beaches (Burton *et al*. 2002a in Birdlife 2014), recreational activities and over-flying aircraft can cause reductions to the extent of available foraging areas (del Hoyo *et al*. 1996 in Birdlife 2014).
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species is widespread across The Wash aside from the sandier and more disturbed sectors of Heacham and Hunstanton. As noted above there has been some re-distribution between sectors since the mid-1990s but this has not resulted in any major gaps in the distribution.

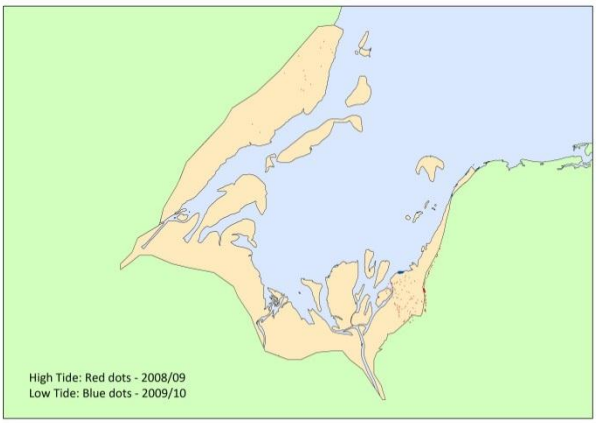
3.1.9 Sanderling (*Calidris alba*)

Sanderling	
POPULATION ESTIMATES	At designation: **355** wintering (0.3% of the eastern Atlantic/western and southern African wintering population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **3,417** (Austin *et al*. 2014).
TRENDS	Change since classification: -12% Short-term trend: +10% Medium-term trend: +26% Long-term trend: +10% Sector trends: The more important sectors for Sanderling in The Wash SPA are at Hunstanton, Heacham and Snettisham. Declines over the period 2002/03–2007/08 were noted in all sectors (Ross-Smith *et al*. 2011). However, a dip in count numbers occurred around this number. Counts were substantially higher in 2010/11, and hence the short term trend for the whole SPA, based on different years to the sector trends, shows a slight increase (Cook *et al.* 2013) UK/Region trends: The trend on The Wash SPA appears to be tracking that of East Anglia and the UK. The proportion of the regional population supported by this site is decreasing, suggesting the site is at carrying capacity (Cook *et al*. 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3042 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob4970.htm
GENERAL ECOLOGY	DIET: Mainly invertebrates, including molluscs, polychaete worms, crustaceans and insects (Del Hoyo *et al*., 1996 in Birdlife 2014). Atkinson *et al*. (2010), give diet proportions after Leopold *et al.* (2004a, b), of 60% worms, 1% molluscs and 39% 'other'. Feeds on invertebrates of intertidal area, predominantly, *H. diversicolor* (small size classes); *Talitrus saltator*; *C. edule* (small size classes), and *Peringia* spp have been observed as prey species of the Sanderling. HABITAT: Largely coastal over the wintering period and can be found on open, exposed sandy beaches, outer reaches of estuaries, rocky and muddy shores and mudflats (del Hoyo *et al*. 1996 in Birdlife 2014i). Uses roost sites with other wader species. BEHAVIOUR: Typically a bird of sandy beaches where it feeds along the shoreline. Gregarious, often occurring in large flocks and highly site faithful (Delany *et al*. 2009).

Sanderling	
	SENSITIVITY TO DISTURBANCE: Sensitive to disturbance from recreation on sandy beaches (Burger & Gochfeld 1991 in Colwell 2010; Birdlife 2014), particularly when large numbers of people and/or free running dogs are present (Thomas *et al*. 2003).
LOCAL ECOLOGY	A detailed study of colour ringed Sanderling has been undertaken on the eastern side of The Wash: Although some birds in The Wash do follow the tide, the main feeding areas in the eastern wash are on the outer sandbanks, often more than a kilometre from the tide's edge, with birds moving to different sandbanks as they become exposed. Shrimps *Crangon spp*. are a favoured food item. Razor clams *Ensis spp*. become important when wrecks occur along the North Norfolk coast, and birds from The Wash will move long distances to take advantage of this resource (e.g. 35 colour-ringed birds recorded at Titchwell in April 2008 represented 83% of those known to be alive at the time). Some birds have also been observed scavenging from Cockles eaten by Oystercatchers, and defending individual Oystercatchers as a resource against other Sanderling (Kelly 2008).
ORIGIN	Breeds in the Arctic, usually migrating via a number of stopover sites (Del Hoyo *et al.* 1996 in Birdlife 2014). UK birds are mainly from Siberia, with birds from Greenland thought to pass through on their way to Africa (Delany *et al*. 2009). However, ringing studies suggest that some Greenland birds may overwinter in the UK (Wernham *et al*. 2002; Reneerkens *et al.* 2009 in Balmer *et al*. 2013). Colour ringing has confirmed that some the Sanderling recorded on The Wash do breed in Canada or Greenland. There are also records from Africa and on spring passage in eastern Iceland (Kelly 2008).
REASONS FOR DECLINE	SITE SPECIFIC: No WeBS Alerts have been triggered for Sanderling and there is no evidence of a decline in numbers using The Wash SPA. Numbers of Sanderling over-wintering on The Wash SPA have remained relatively stable in the long term. However, the proportion of the regional population supported by this site is decreasing, suggesting the site is at carrying capacity. (Cook *et al*. 2013) OTHER: Increases have been reported in several European countries, not all of which can be attributed to better count coverage (Balmer *et al*. 2013)
THREATS	Sensitive to disturbance (see above). Also sensitive to the degradation of wetland habitats via environmental pollution and reduced river flows (Kelin & Qiang 2006 in Birdlife 2014), probably through indirect mechanisms associated to reductions of food resources or access/ displacement from feeding areas. May be more vulnerable on The Wash as numbers are relatively low and mostly confined to just a few sectors where conditions are most suitable.

Sanderling

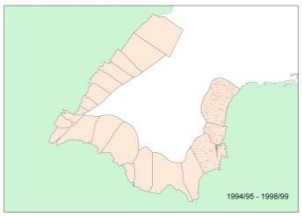
DISTRIBUTION WITHIN THE WASH



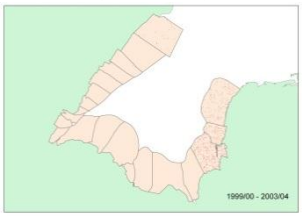
Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).

Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).

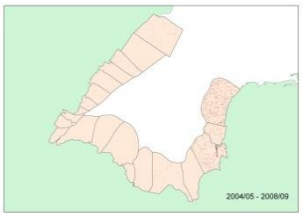
1994/95 to 1998/99



1999/00 to 2003/04



2004/05 to 2008/09

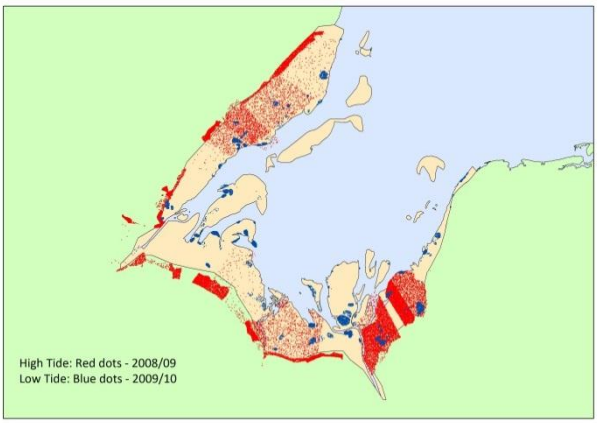
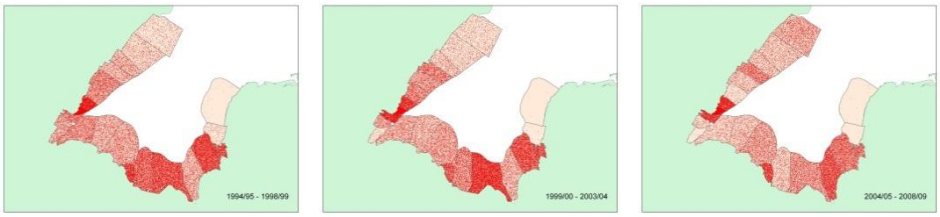


The small number of this species occurring on The Wash is largely confined to the east coastline and is associated with the sandier sectors from Snettisham north to Hunstanton.

3.1.10 Dunlin (*Calidris alpina*)

Dunlin	
POPULATION ESTIMATES	At designation: race *alpina* **35,620** wintering (2.6% of the northern Siberian/European/western African population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **24,467** (Austin *et al*. 2014).
TRENDS	Change since classification: -46% Short-term trend: -11% Medium-term trend: -25% Long-term trend: -33% Sector trends: Declines were noted in 12 of the 16 WeBS sectors where trends could be calculated. The only increases occurred on the northern shore of The Wash in Lincolnshire, including substantial increases at Wainfleet (Ross-Smith *et al*. 2011). UK/Region trends: The proportion Dunlin wintering in East Anglia using The Wash SPA remains stable despite declining numbers. The same is true of the proportion of UK birds (Cook *et al*. 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3056 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob5120.htm
GENERAL ECOLOGY	DIET: Omnivorous, mainly polychaete worms and small gastropods during winter (Birdlife 2014). Atkinson *et al.* (2010), gives diet proportions after Leopold *et al*. 2004a, b, of 70% worms, 14% bivalves and 16% 'other'. HABITAT: The Dunlin has a wintering preference for estuarine mudflats, but is also found on freshwater and brackish wetlands including muddy freshwater shores, tidal rivers and sandy coasts (Cramp & Simmons 1977 in Birdlife 2014; del Hoyo *et al*. 1996 in Birdlife 2014j). Dunlin join wader roosts near feeding areas and will use open fields during highest tides (Delany *et al*. 2009; Shepherd and Lank 2004 in Birdlife 2014). It prefers large open fields (Shepherd and Lank 2004 in Birdlife 2014). BEHAVIOUR: Feeds by touch and sight by day and night according to tides, remaining in large flocks during winter (various in Birdlife 2014). Site faithful to winter roost sites both within and between winters (Delany *et al.* 2009). SENSITIVITY TO DISTURBANCE: Mixed. Kirby *et al*. 1993 found that it was one of the more commonly disturbed species at roost sites on the Dee, though Davidson & Rothwell (1993) did not include it among the more nervous species. Burton *et al.* (2002a) noted that it was the last species to fly when disturbed by walkers, though counts were still significantly lower at sites close to footpaths.

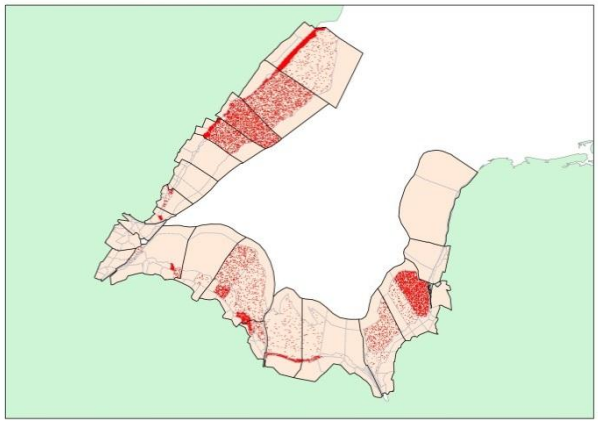
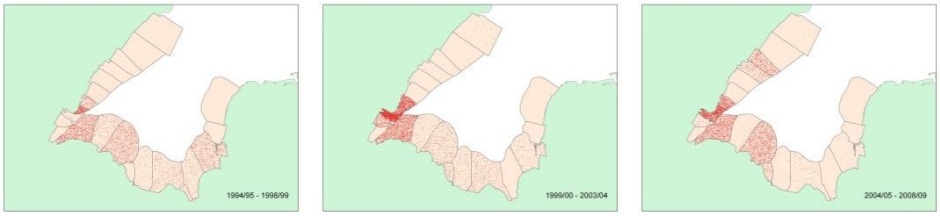
Dunlin	
LOCAL ECOLOGY	On The Wash diet was found to be typical consisting principally of oligochaete worms and to a lesser extent molluscs (*Peringia ulvia* (formerly *Hydrobia ulvae*), *Cerastoderma edule*, *Macoma balthica*) (Durell & Kelly 1990). Most Dunlin remain in the same area on The Wash during the course of the winter, with only around 8% of adults and 20% of juveniles moving to a roost on a different part of The Wash within the same winter (Rehfisch *et al.* 1996). This species will often roost in fields adjacent to the SPA when the saltmarsh is covered by high spring tides (N.Clark *pers. comm*.).
ORIGIN	Three subspecies of Dunlin are found in the UK. *Artica* (Greenland/Iceland) only occurs on passage (Wernham *et al*. 2002), and *schinzii* (UK/western Europe) winters mainly in Africa (Delany *et al*. 2009). The majority of British wintering birds are *alpina* from northern Fennoscandia and European Russia (Wernham *et al*. 2002). Large congregations of *alpina* gather in the Wadden Sea in spring prior to migration, though some birds also aggregate on The Wash (Wernham *et al.* 2002).
REASONS FOR DECLINE	SITE SPECIFIC: Numbers of Dunlin over-wintering on The Wash SPA have been decreasing in the medium-term having previously been relatively stable. The fact that the proportion of Dunlin wintering in East Anglia using The Wash SPA remains stable suggests that this decline is being caused by broad-scale shifts in distribution rather than site-specific reasons. (Cook *et al*. 2013). In British mudflats, the encroachment of the invasive grass *Spartina anglica* into mudflats and subsequent biotope changes has resulted in the reduction in size of feeding areas (del Hoyo *et al*. 1996 in Birdlife 2014). OTHER: There is evidence that a north-easterly shift in the wintering distribution of this species has occurred in Europe in response to climate change, with the 'weighted centroid' for the distribution shifting from near the south coast of Britain towards the east coast (Maclean *et al.* 2008). This shift may lead to some birds remaining in mainland Europe during winter rather than wintering in the UK (Maclean *et al*. 2008), but may also lead to increased numbers remaining on the east coast of Britain rather than wintering in the south-west (Austin & Rehfisch 2005).
THREATS	The Dunlin is restricted to a small number of estuaries during the wintering period and as such is highly vulnerable to habitat changes such as land claim or alien plant invasion (del Hoyo *et al*. 1996 in Birdlife 2014) and visual disturbance (Burton *et al*. 2002a). May be at risk from improvements to water quality which has been found to cause reductions in benthic invertebrate densities at sites close to sewage outfalls (Burton *et al*. 2002b).

Dunlin	
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species is widespread across The Wash but there is a clear association with the muddier sectors adjacent to the inflows of The Haven, the River Welland, the River Nene and the River Great Ouse. It is relatively scarce on the sandy sectors of Heacham and Hunstanton.

3.1.11 Black-tailed Godwit (*Limosa limosa*)

Black-tailed Godwit	
POPULATION ESTIMATES	At designation: race *islandica* **859** wintering (11.6% of the population in GB, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **9,382** (Austin *et al*. 2014).
TRENDS	Change since classification: +2,250% Short-term trend: +49% Medium-term trend: +135% Long-term trend:+3,033 % Sector trends: Substantial declines in Black-tailed Godwit numbers have occurred over the period 1992/03–2007/08 at The Wash NNR (Ouse Mouth; Terrington East and Terrington West), and in the short term (2002/03–2007/08) at Snettisham, Holbeach St. Matthew and Welland (Ross-Smith *et al.* 2011). However, numbers at The Wash SPA have fluctuated quite considerably in recent years and the baseline year for the sector trends occurred during a dip with numbers increasing again in 2009/10 and 2010/11 (Cook *et al.* 2013). UK/Region trends: The increasing proportion of East Anglian and UK numbers supported by The Wash SPA suggest the environmental conditions remain relatively favourable and that this site is becoming increasingly important for this species. (Cook *et al*. 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3003 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob5320.htm
GENERAL ECOLOGY	DIET: Black-tailed Godwit eat invertebrates, including beetles, annelid and polychaete worms, molluscs, ragworms, crustaceans and some plant material (Birdlife 2014). Major components include *Hediste* spp. (large size classes); *Mya arenaria*, *Scrobicularia plana*, *Macoma balthica (*large size classes), *Cerastoderma edule* have been observed as the largest components in the diet of the Black-tailed Godwit. HABITAT: Feeds on mudflats on the upper reaches of estuaries, muddy inland lakes, and sometimes on farmland and flooded grassland. Joins high tide roosts (Delany *et al.* 2009). BEHAVIOUR: Feeds by touch and sight (BTO 2014). Birds tend to be highly site faithful both within and between winters (Wernham *et al*. 2002). Very gregarious and occurring in flocks at both feeding and roosting sites (Delany *et al.* 2009). SENSITIVITY TO DISTURBANCE: One of the most tolerant species to walkers along footpaths at low tide, though numbers were still significantly lower at sites close to a footpath (Burton *et al*. 2002a).

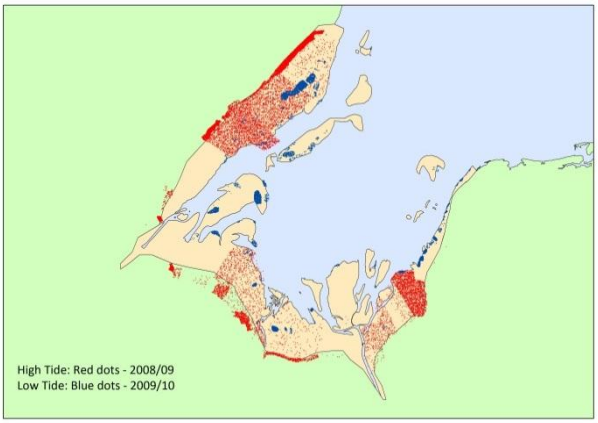
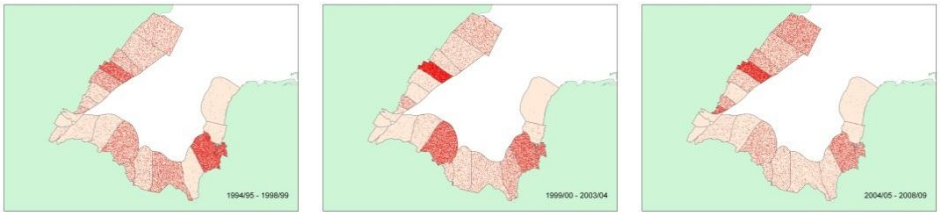
Black-tailed Godwit	
LOCAL ECOLOGY	Very mobile during winter (N. Clark, *pers. comm*). This species will often roost in fields adjacent to the SPA when the saltmarsh is covered by high spring tides (N.Clark *pers. comm*).
ORIGIN	Two subspecies occur in the UK. *Limosa* breeds in Europe/western Siberia (including very small numbers in the UK), occurring on passage but wintering mainly in Africa. Birds wintering in the UK are primarily of the subspecies *islandica* which breeds in Iceland (Wernham *et al.* 2002). Colour-ringing confirms the birds from The Wash are from Iceland. A large proportion pass through The Wash on passage, with some 30% of those present in autumn remaining in the east of England during the winter and others moving elsewhere (Ireland, southern England, western France, Iberia) (Gill 2006). During spring passage, some birds from The Wash may move inland to the Nene and Ouse Washes before migration, and some of the birds that passed through The Wash in autumn towards western France and Iberia head back to their breeding grounds via the Netherlands (Gill 2006).
REASONS FOR DECLINE	SITE SPECIFIC: There is no evidence of a decline in numbers of Black-tailed Godwit at The Wash SPA. The trend is increasing in the medium term and appears to be tracking the East Anglian and UK trends, though numbers at The Wash fluctuate from one winter to the next (Cook *et al.* 2013). However, differences in trends in some sectors in The Wash suggest that conditions for this species may have become poorer in some parts of The Wash SPA and further analysis may be required to identify possible reasons for these declines.
THREATS	Threats may include pollution and disturbance (Birdlife 2014). Subspecies *islandica* has a relatively restricted distribution and is dependent on a relatively restricted number of sites especially during passage (Wernham *et al*. 2002). May be at risk from improvements to water quality which has been found to cause reductions in benthic invertebrate densities at sites close to sewage outfalls (Burton *et al*. 2002b).

Black-tailed Godwit	
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species occurs throughout The Wash but by for the greatest concentrations are to be found across sectors toward the south and west, especially in those sectors adjacent to the inflows of The Haven and River Welland. Fluctuating numbers result in much 'noise' which hinders meaningful interpretation of changes in relative distribution across the site. The low tide surveys of Yates *et al*. (2007) contained no data for this species.

3.1.12 Bar-tailed Godwit (*Limosa lapponica*)

Bar-tailed Godwit	
POPULATION ESTIMATES	At designation: **11,250** wintering (21.4% of the GB population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **15,991** (Austin *et al*. 2014).
TRENDS	Change since classification: +44% Short-term trend: +14% Medium-term trend: -2% Long-term trend: +61% Sector trends: Moderate declines at Snettisham, but increases at Wainfleet, both of which held ≥20% of The Wash SPA population between 2004/05 and 2008/09 (Ross-Smith *et al*. 2011). Leverton, which also held ≥20% of the population, had a fluctuating trend, while increases on Friskney were offset by declines at Dawsmere, both of which supported ≥10% of the SPA population between 2004/05 and 2008/09 (Ross-Smith *et al*. 2011). UK/Region trends: The increasing long term trend for Bar-tailed Godwit on The Wash SPA is tracking the trend in East Anglia, though not the British trend which has remained stable. However, the proportion of the East Anglian wintering population using The Wash SPA is decreasing which suggests that The Wash SPA is at carrying capacity for this species (Cook *et al*. 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3005 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob5340.htm
ECOLOGY	DIET: Polychaete worms are the principal food source during winter. Atkinson *et al.* (2010) give the proportion of worms in the diet as 94%, based on Leopold (2004a, b). Duijns *et al*. (2013) stated 79% Ragworm *Hediste divesicolor* , 17% King ragworm *Alitta virens*. And 2% Lugworm *Arenaria marina*. The sexes are dimorphic and feed in different parts of the estuary. In one study, females fed at the tide's edge and ate 71% lug worms *Arenaria marina*, whereas the smaller subordinate males feed on mudflats and took only 18% *A. marina*. (Duijns & Piersma 2014). HABITAT: Overwintering birds are commonly found in intertidal areas along muddy coastlines and in wetlands (del Hoyo *et al*. 1996 in Birdlife 2014) especially those with tidal mudflats or sandbars (Johnsgard 1981 in Birdlife 2014). Birds around the North Sea prefer the outer parts of estuaries where substrates are usually sandy (Musgrove *et al*. 2003; Scheiffarth 2001 in Delany *et al.* 2009). Bar-tailed Godwits join mixed wader roosts at high tide. BEHAVIOUR: Highly gregarious in winter, forming large flocks (Delany *et al*. 2009). Many birds are site faithful, during subsequent winters, but small numbers do move sites both within and between winters (Wernham *et al.*

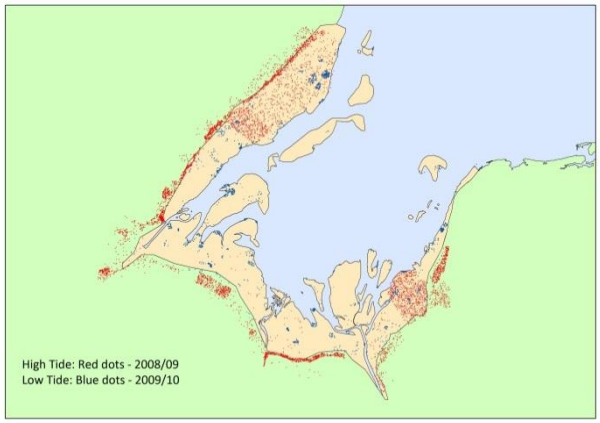
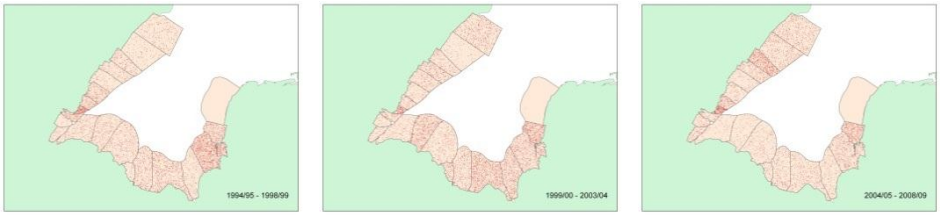
Bar-tailed Godwit	
	2002). SENSITIVITY TO DISTURBANCE: Relatively sensitive to disturbance compared to other wader species (e.g. Kirby *et al.* 1993; Davidson & Rothwell 1993).
LOCAL ECOLOGY	Individuals of this species appear to be relatively faithful in their roosting and foraging areas within The Wash. A colour marking study recently started on Norfolk coast of The Wash in 2010 and (as yet) no birds have been re-sighted to the north on the Lincolnshire coast although birds can be seen flying to roost along the North Norfolk coast at Holme (N. Clark, *pers comm*). The species will often roost in fields adjacent to the SPA when the saltmarsh is covered by high spring tides (N.Clark *pers. comm*).
ORIGIN	British wintering Bar-tailed Godwit come from the population breeding in northern Europe/ western Siberia (*lapponica* race). Some birds may migrate directly to Britain in autumn, but most birds stage in the Wadden Sea in March ahead of their return migration Delany *et al*. 2009). Some birds from more easterly breeding populations may pass through the UK on passage (Wernham *et al.* 2002). Ringing recoveries confirm that birds on The Wash are from the *lapponica* race, from Scandinavia and northern Europe, with small numbers of birds from further east passing through on passage in late August and early September (Atkinson 2010).
REASONS FOR DECLINE	SITE SPECIFIC: Numbers of Bar-tailed Godwit over-wintering on The Wash SPA have been increasing long term. The trend on the site appears to be tracking that of the region although not the British trend. The proportion of the regional population supported by this site is decreasing, suggesting the site is at carrying capacity. (Cook *et al.* 2013) OTHER: There is evidence that an easterly shift in the wintering distribution of this species has occurred in Europe in response to climate change (Maclean *et al.* 2008).
THREATS	The Bar-tailed Godwit is threatened by the degradation of foraging sites. This can be due to land claim, pollution or human disturbance (del Hoyo *et al*. 1996 in Birdlife 2014; Kelin & Qiang 2006 in Birdlife 2014). May be at risk from improvements to water quality which has been found to cause reductions in benthic invertebrate densities at sites close to sewage outfalls (Burton *et al*. 2002b).

Bar-tailed Godwit	
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species is widespread across The Wash although rather scarce on the eastern coastline north of Snettisham. However Snettisham itself together with in particular sectors from Leverton to Wainfleet on the west coastline and Dawsmere all support relatively high densities of this species. Elsewhere this species does not seem particularly faithful to any given sector which will hinder meaningful interpretation of trends therein relative to potential drivers of change.

3.1.13 Curlew (*Numenius arquata*)

Curlew	
POPULATION ESTIMATES	At designation: **3,835** wintering (1.1% of the European breeding population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **9,467** (Austin *et al*. 2014).
TRENDS	Change since classification: +34% Short-term trend: +53% Medium-term trend: +21% Long-term trend: +43% Sector trends: Declines have occurred at Ouse Mouth and Terrington East, and on the southern side of The Wash SPA, with increases occurring on the northern side of the site, especially at Wrangle and Friskney (Ross-Smith *et al*. 2011) UK/Region trends: The trend on the site does not appear to be tracking that of the either the region or the British trend. The proportion of the regional population supported by this site is decreasing, suggesting the site is at carrying capacity (Cook *et al*. 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3012 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob5410.htm
GENERAL ECOLOGY	DIET: The Curlew diet is very variable, including worms, crustaceans and molluscs (del Hoyo *et al*., 1996 in Birdlife 2014). Atkinson *et al.* (2010) listed proportions during winter as 46% bivalves, 35% worms and 19% other, based on Leopold (2004a, b). Specific dietary items include *Hediste diversicolor* (large size classes), *Lanice conchilega*; *Carcinus* spp.; *M. balthica* (large size classes) and *C. edule* (medium size classes) (West *et al*. 2006). HABITAT: Over winter, the Curlew is found on muddy coastlines, bays and estuaries that have tidal mudflats and sandflats, coastal marshes and muddy shores of coastal lagoons (del Hoyo *et al*. 1996 in Birdlife 2014; Snow & Perrins 1998 in Birdlife 2014; Johnsgard 1981 in Birdlife 2014), with some birds also using inland fields (Delany *et al*. 2009). Roosts at high tide among communal mixed wader flocks. BEHAVIOUR: Gregarious during winter, occurring in small to large flocks (Delany *et al*. 2009). Birds are thought to mostly be site faithful within and between winters (Wernham *et al.* 2002). Food is located primarily by touch (BTO 2014). SENSITIVITY TO DISTURBANCE: High. Numbers were significantly lower at sites close to footpaths and Curlew is the least tolerant species to the presence of walkers (Burton *et al*. 2002a).

Curlew	
LOCAL ECOLOGY	This species will often roost in fields adjacent to the SPA when the saltmarsh is covered by high spring tides (N.Clark *pers. comm*.).
ORIGIN	British-breeding Curlews mostly winter in the south-west and in Ireland, and the vast majority of Curlews on the east coast in winter are from further north and east (Wernham *et al*. 2002). Ringing recoveries suggest that the birds wintering on The Wash mostly originate from Sweden and Finland (Minton, 1978; WWRG 2014).
REASONS FOR DECLINE	SITE SPECIFIC: There is no evidence of a decline in Curlew numbers at The Wash SPA. Numbers are stable in the long term and no Alerts have been triggered. The proportion of the regional population supported by this site is decreasing, suggesting the site is at carrying capacity (Cook *et al*. 2013). The differing trends between sectors within The Wash SPA suggests that conditions in some sectors may have become relatively more attractive compared to others, though there is no strong evidence to state why this is the case. OTHER: There is evidence that this species is shifting its wintering distribution north-eastwards in response to climate change, with the 'weighted centroid' of the wintering distribution in western Europe moving 119 km to the northeast between 1981 and 2000 and out into the middle of the North Sea ($P<0.01$), indicating that a larger proportion of birds are wintering in mainland Europe rather than Britain (Maclean *et al.* 2008).
THREATS	The Curlew is threatened by disturbance on intertidal mudflats (del Hoyo *et al*. 1996 in Birdlife 2014), walkers (Burton *et al*. 2002a) and the flooding of mudflats and saltmarshes for tidal barrage construction (Burton 2006) probably through indirect mechanisms associated to reductions of food resources or access/ displacement from wintering grounds. May be at risk from improvements to water quality which has been found to cause reductions in benthic invertebrate densities at sites close to sewage outfalls (Burton *et al*. 2002b).

Curlew	
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species is widespread across The Wash with no particular sectors supporting disproportional densities. Whilst there have been some sector level increases or declines these have not resulted in a notable re-distribution within the site.

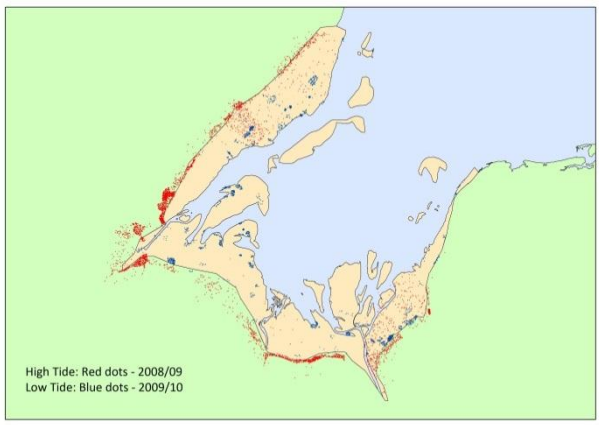
3.1.14 Redshank (*Tringa totanus*)

Redshank	
POPULATION ESTIMATES	At designation: **2,953** wintering (1.7% of the eastern Atlantic wintering population, 5 year peak mean 1991/2 to 1995/6) (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **7,242** (Austin *et al*. 2014).
TRENDS	Change since classification: -37% Short-term trend: +4% Medium-term trend: +1% Long-term trend: -15% Sector trends: Declines were noted in 14 of the 16 WeBS sectors for which trends were available, and were particularly marked at Dawsmere, Holbeach St. Matthew and Kirton (Ross-Smith *et al*. 2011). UK/Region trends: The trend on The Wash SPA appears to follow that of East Anglia and the UK. However, the proportion of the East Anglian Redshank population using this site is decreasing, suggesting that site-specific factors may be affecting Redshank (Cook *et al*. 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3017 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob5460.htm
GENERAL ECOLOGY	DIET: Redshank feed on invertebrates, including insects, spiders, annelid worms, molluscs and crustaceans (especially amphipods). Atkinson *et al.* (2010), gives diet proportions after Leopold *et al*. (2004a, b), of 46% worms, 7% bivalves and 47% 'other'. HABITAT: The Redshank stays in the coastal region over winter and can be found on rocky, muddy and sandy beaches, saltmarshes, tidal mudflats, saline and freshwater coastal lagoons (del Hoyo *et al*. 1996 in Birdlife 2014) and tidal estuaries (Johnsgard 1981 in Birdlife 2014), joining mixed wader roosts at high tide (Delany *et al*. 2009). BEHAVIOUR: Some adults are solitary and defend feeding territories in winter, others occur in flocks (Delany *et al*. 2009) UK Redshanks are usually site faithful in winter, though long distance movement sometimes occurs probably in response to cold weather (Wernham *et al.* 2002). SENSITIVITY TO DISTURBANCE: Flight distances of c.100 m were noted by Smit & Visser (1993). Susceptible to disturbance from construction and other activities as often feeds closer to shore than other waders (Cutts *et al.* 2009). Redshanks are particularly susceptible to disturbance in severe weather (e.g. Clark *et al*. 1993). As they take small prey in relation to their body size, they need to feed for longer periods during the tidal cycle than other species and therefore have less scope for extending feeding time when necessary to meet their energy requirements (Mitchell *et al.* 2000).

Redshank	
LOCAL ECOLOGY	This species has been shown to be particularly susceptible to severe weather events with high mortality reported for The Wash (Clark *et al*. 1993). This species will occasionally roost in fields adjacent to the SPA when the saltmarsh is covered by high spring tides (N.Clark *pers. comm*.).
ORIGIN	The taxonomy is controversial with different subspecies recognised by different authors. British birds are only partially migratory and may stay close to their breeding area, especially in the south of the UK (Cramp & Simmons 1983). They are joined in winter by large numbers from Iceland and a few birds from the continent (Wernham *et al.* 2002). Most ringing recoveries are from Iceland, confirming Icelandic breeders are present on The Wash, or from the coasts of France or the low countries which may represent onward movement of passage birds (WWRG 2012).
REASONS FOR DECLINE	SITE SPECIFIC: Numbers of Redshank over-wintering on The Wash SPA have remained relatively stable long-term. The only Alert triggered was for the trend since classification, and it should be noted that the year of designation coincided with an unusually high count of Redshank at this site. However, the declining proportion of the East Anglian birds using this site suggests that site-specific factors may be affecting Redshank (Cook *et al*. 2013). A severe weather event in 1990/91, two years after classification, caused high Redshank mortality and led to a population decline of 68% on The Wash (Clark *et al*. 1993). Numbers have not recovered to pre-classification levels. OTHER: Widespread declines in Britain and Europe have been attributed to agricultural intensification on the breeding grounds (Delany *et al*. 2009), with the British breeding population declining by 44% over the period 1995-2012 (Harris *et al*. 2014). There is evidence that a north-westerly shift in the wintering distribution of this species has occurred in Europe in response to climate change (Maclean *et al.* 2008).
THREATS	Wintering habitats have been threatened by agricultural intensification, wetland drainage and land claim (del Hoyo *et al*. 1996 in Birdlife 2014), the encroachment of *Spartina spp.* on mudflats (Evans 1986 in Birdlife 2014). In addition to habitat and /or food-mediated sensitivities it is vulnerable to severe cold in Western European wintering grounds (del Hoyo *et al*. 1996 in Birdlife 2014). May be at risk from improvements to water quality which has been found to cause reductions in benthic invertebrate densities at sites close to sewage outfalls (Burton *et al*. 2002b).

Redshank

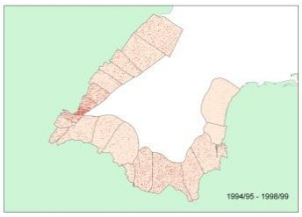
DISTRIBUTION WITHIN THE WASH



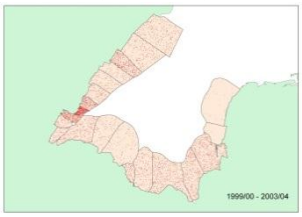
Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low tide (blue) (from Ross-Smith *et al*. 2011).

Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).

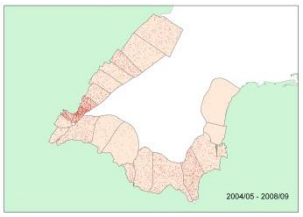
1994/95 to 1998/99



1999/00 to 2003/04



2004/05 to 2008/09

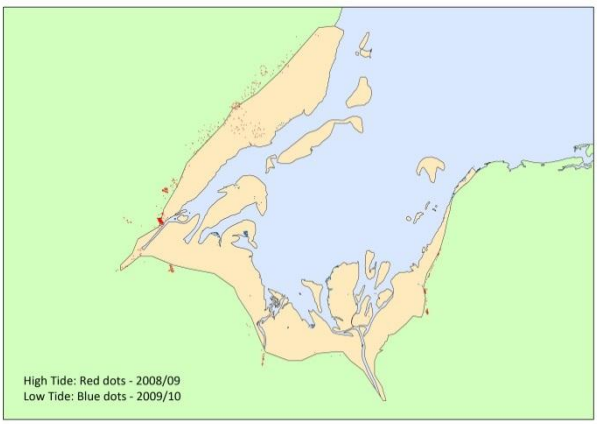
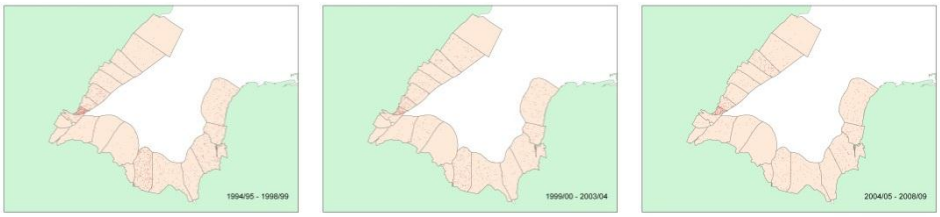


This species is widespread across The Wash with slightly higher densities being supported by sectors adjacent to the river mouths, in particular the inflows of The Haven and the River Welland. Although there has been no large decline in this species across the site as a whole, as stated above, declines are evident on virtually all sectors and accordingly the relative distribution within the site has remained more or less stable.

3.1.15 Turnstone (*Arenaria interpres*)

Turnstone	
POPULATION ESTIMATES	At designation: **717** wintering (JNCC 2014). WeBS 5-year peak mean as of winter 2012/13: **686** (Austin *et al*. 2014).
TRENDS	Change since classification: -67% Short-term trend: -11% Medium-term trend: -19% Long-term trend: -61% Sector trends: Substantial declines occurred on The Wash NNR over the period 1992/03-2007/08, at Terrington East, Terrington West and Ouse Mouth, though numbers increased at Ouse Mouth over the period 2002/03–2007/08. There were also declines at Heacham to Snettisham and Frampton, but increases at Wrangle (Ross-Smith *et al*. 2011). UK/Region trends: The trend on the site is similar to the British trend. However, the proportion of the East Anglian wintering population supported by The Wash SPA is decreasing. (Cook *et al.* 2013).
LINKS	BIRDLIFE: http://www.birdlife.org/datazone/speciesfactsheet.php?id=3034 BTO BIRDFACTS: http://blx1.bto.org/birdfacts/results/bob5610.htm
GENERAL ECOLOGY	DIET: Feeds on a range of food resources which include small terrestrial invertebrates and discarded human food and plant material. Small intertidal worms, crustaceans and molluscs, or even small fish are important for wintering birds (del Hoyo *et al*. 1996) Atkinson *et al*. (2010), giving proportions after Leopold *et al*. 2004a,b, indicate that the diet consists of 20% bivalves, 5% worms and 75% 'other'. The Turnstone has a lesser preference for bivalves (making up 7% of its overall diet) and feeds predominantly on intertidal Annelids (46%) and other invertebrate species. These include; *Carcinus* spp., *Gammarus* spp.; *Balanus* spp, *Mytilus edulis*, *Littorina* spp; and *Diptera* larvae. HABITAT: Turnstone are often found along rocky or stony shores, but also on mudflats or sandy shores where there are pebbles, shores, washed up seaweed (Delany *et al*. 2009), or beds of molluscs (del Hoyo *et al*. 1996 in Birdlife 2014). They usually occur in small groups, but may form larger flocks at roost sites (Delany *et al.* 2009). BEHAVIOUR: Turnstone locates food by sight, sometimes by turning over pebbles or other items, which has given the bird its common name in English (BTO 2014). It is highly site faithful, both within and between winters, often remaining in flocks with the same membership (Wernham *et al*. 2002).

Turnstone	
	SENSITIVITY TO DISTURBANCE: Not particularly nervous compared to other wader species (Davidson & Rothwell 1993), allowing a closer approach than other species (Cutts *et al*. 2009).
LOCAL ECOLOGY	High numbers of Turnstone frequented Sutton Bridge Docks during the 1990s, where they feed on foodstuffs including wheat and fishmeal split during the loading and unloading of ships, and also on nearby arable fields (Smart & Gill 2003). It is believed that the port became important due to the reduction in Mussel stocks in the 1990s, and numbers at the port diminished in the early 2000s (WWRG 2006). Peak numbers in the port occur later in the winter and vary between years, suggesting that the port may still be an important food resource in some years (Smart & Gill 2003). Colour-ringing has confirmed that some individuals using the port come from other sectors in The Wash (Smart 2006).
ORIGIN	An overwhelming majority of Turnstone wintering in the UK are from the Canada/Greenland population, and use Iceland as a stopover during migration. A small number come from Fennoscandia (Wernham *et al*. 2002). One Turnstone colour ringed on The Wash was seen on its breeding ground on Ellesmere Island, Arctic Canada (Smart 2006). Ringing recoveries come from Greenland, Canada, Iceland, Scandinavia and also Africa, indicating that some Wash birds stop *en route* to wintering grounds elsewhere (WWRG 2012).
REASONS FOR DECLINE	SITE SPECIFIC: Numbers of Turnstone over-wintering on The Wash SPA have been decreasing in the medium-term having previously peaked. The decreasing proportion of the East Anglian population wintering on The Wash suggests that site-specific pressures may be affecting this species. (Cook *et al.* 2013). Smart & Gill (2003) argued that the pattern of use of Sutton Docks indicated that the intertidal food supplies on The Wash were not able to support Turnstone throughout the winter. This would suggest insufficient food resources may explain the emigration of Turnstones to other sites in East Anglia. OTHER: Declines shown by the non-estuarine winter shorebird count are thought to have been caused by a northerly range shift brought about by climate change (Rehfisch *et al.* 2004). However, numbers in the East Anglian region are currently stable (Cook *et al*. 2013) suggesting they have not been substantially affected by this range shift.
THREATS	May be at risk from improvements to water quality which has been found to cause reductions in benthic invertebrate densities at sites close to sewage outfalls (Burton *et al*. 2002b).

Turnstone	
DISTRIBUTION WITHIN THE WASH	 **Left: WeBS sub-sector level distribution at high tide (red) and observed concentrations at low low tide (blue) (from Ross-Smith *et al*. 2011).** **Below: Sector-level distribution averaged over three consecutive five-year periods (from Ross-Smith *et al*. 2011).** **1994/95 to 1998/99** **1999/00 to 2003/04** **2004/05 to 2008/09**  This species only occurs in relatively small numbers on The Wash. The species is however widespread occurring on most sectors. The highest densities are found in the vicinity of the inflow of The Haven but because of the small size of this sector numbers there are nonetheless small. The dock at nearby Port Sutton Bridge on the River Nene is known to be an important extralimital resource for Turnstone otherwise supported by The Wash SPA.

3.2 Food availability trends

3.2.1 Intertidal bivalve fishery resource abundance and distribution

Regular stock assessments of commercial Mussel and Cockle beds in The Wash SPA provide robust evidence to assess changes in this food resource for overwintering bird features (mainly Knot & Oystercatcher) (Jessop *et al*. 2013; Dare *et al*. 2004). These surveys are designed to assist the management of the fishery and are understandably highly biased towards larger beds of commercial relevance. Cockle surveys are in general particularly informative as they have comprehensive area coverage and provide better estimates for areas of high and low Cockle densities. Less is known about the contribution of smaller or widely dispersed settlement areas where Mussel spat may establish ephemeral or low density aggregations. Anecdotal evidence indicates that new Mussel beds appear after strong settlement pulses, and intertidal macrobenthic surveys have identified Mussel biotopes outside established commercial Mussel beds. It is also general practice to source Mussel seed from high intertidal locations for lays (Jessop *et al*. 2013). Together this evidence suggests that under normal recruitment conditions, areas other than commercial beds also provide important feeding resources to birds. Therefore data from stock assessments should be taken with caution when assessing the potential resource available to birds especially for Mussels.

3.2.2 Mussels (*Mytilus edulis*)

In the last 30 or 40 years The Wash Mussel stock has experienced regular fluctuations in size. Peaks and troughs in Mussel numbers have been linked to recruitment success, and fishing pressure and/or die-off of entire year classes, respectively. In peak years, an area of about 15 km^2 would have been occupied by Mussel beds. Most recent data (2013) from the Eastern Inshore Fisheries and Conservation Authority (IFCA) estimates the total area at 4.2 km^2, this is more than a three-fold reduction in the total area covered by commercial Mussel beds. Currently the overall stock appears to be in poor condition and is mainly dominated by juvenile size classes (<45 mm length). This downward trend has been a dominant feature of the commercial stocks since a crash in 2010 (Jessop *et al*. 2010) and continues the previous declines that have occurred since the 1970s, when new and more efficient fishing methods resulted in increasing fishing pressure on Mussel and Cockle stocks (Dare *et al*. 2004).

The current total estimated biomass meets the Conservation Objective target for total Mussel biomass. However, it is dominated by juvenile Mussels and fails the Conservation Objective target for adult stock. Assuming that the commercial beds are a good reflection of the quality of the resource for overwintering birds (i.e. Oystercatcher), the resource appears to have declined from historical levels pre-1970 when Mussels constituted the main fishery in The Wash (Dare *et al*. 2004). There is a strong possibility that fishing mortality has played a significant role in the past (Dare *et al*. 2004). However, after the introduction of new management measures in 1990s (e.g. Wash Fishery Order 1992) other mechanisms, especially recruitment variability, may also have played a significant role (Jessop *et al*. 2013).

Indirect evidence and studies on the general ecology of Mussels indicate that in addition to recruitment failure and fishing mortality, other factors such as predation, parasites, and extreme weather events (temperature and storm-related bed damage) can affect rates of natural mortality. No definitive and direct evidence of the main mechanism(s) responsible for the declines within The Wash designated areas was found during the review. Likewise the proportional share of the stock required by overwintering birds, in particular Oystercatchers, is expected to be significant due to the specialised feeding habits of the species (Oystercatcher prey on juvenile and large Mussels (15-50 mm shell length) (Horwood & Goss-Custard 1977)). Predation mortality caused by Oystercatchers has been estimated in controlled experiments to be as high as 70% of the standing stock (Meire *et al*. 1994). Although the quantity and quality of the Mussel resource required to sustain the overwintering Oystercatcher population of The Wash will primarily be related to the population size

and feeding behaviour of Oystercatchers themselves, it is likely that in years following poor recruitment, Mussel biomass and / or bed area might have been a primary factor limiting bird populations (Stillman & Goss-Custard 2010; Atkinson *et al*. 2010). However, this conclusion should be considered preliminary until better, more complete and direct evidence is available.

3.2.3 Cockle (*Cerastoderma edule*)

The Wash Cockle stocks support very important and strictly regulated local fisheries. Commercial Cockle beds are more variable and dispersed than Mussel beds. The largest commercial stock ever recorded totalled 54,000 tonnes in 1967 (Dare *et al*. 2004). The modernisation of the commercial fleet and methods in the 1970s resulted in increases in extraction efficiency which culminated with the introduction of hydraulic suction dredges in 1986 (Jessop & Maxwell 2011). The pressure on the stocks resulted in widespread declines throughout most of the 1990s and prompted the introduction of daily vessel quotas, and the establishment of an annual Total Allowable Catch (TAC). Regular stock assessments conducted by the Eastern IFCA (and its predecessors) since 1993 indicate that the stocks have fluctuated between 10,000 and 35,000 tonnes with a periodicity of approximately four years. Upward trends appear to be driven by good recruitment of juvenile stocks and subsequent growth of strong year-class cohorts. Large declines (e.g. in 2008 and 2011) have been associated with large and widespread natural mortalities of predominantly adult (≥14 mm width) Cockles (Jessop *et al*. 2013). The evidence suggests that Cockle densities and the overall resource available to the overwintering bird population, are controlled by mechanisms operating early in life (typically predation after settlement) (Andresen *et al*. 2013) which would explain high spat settlement rates but low population numbers. Predation on spat and young Cockles combined with poor growth performance over their first and second year, and further mass mortality of adult Cockles, may explain the decline and size/age-composition of Cockle stocks occurring in The Wash (Dare *et al*. 2004).

The TAC allocated to the Cockle fishery is 33.3% of the fishable biomass. This figure assumes that the removal of one third of the estimated adult biomass does not have any impact on the conservation status of the site. While the connection between waterbirds declines and shellfish fishing has been made in the past (Atkinson *et al*. 2003; Atkinson *et al*. 2010), the evidence provided by stock assessments is generally inconclusive due to large variability, and different stock evaluation methods or incomplete records prior to 1993.

3.2.4 Intertidal macrofauna abundance

Intertidal mudflats and sandflats in The Wash support a varied infaunal invertebrate community. Although the significance of these communities for overwintering birds and other features of the estuary has been recognised for many years, quantitative information on these important communities is scarce and long-term datasets are lacking. The best direct evidence is relatively recent, and consists of intertidal invertebrate coring data for The Wash from 1986, 1998, 1999, 2008 and 2012 (Yates *et al*. 2002; Enviromuir 2009; APEM 2013). However, differences in sampling effort across sampling years, particularly the number and distribution of replicate cores, and biotope classification changes over the years (see next section) has complicated the identification of trends. To reduce possible bias APEM (2013) produced a global analysis on presence-absence transformed data. The study shows that some taxa have had relatively consistent densities across the past two decades while others have fluctuated considerably across surveys. There was a significant difference for eight of the 21 taxa considered to be of importance to wading birds (Table X1), including four of the six mollusc taxa (*M. edulis, C. edule, Macoma balthica*, and *Scrobicularia plana*). However, over recent years (1998-2012) the differences are generally non-significant suggesting that most of these changes were due to differences between densities recorded in 1986 and those recorded in 2012. In 2012, core sites were characterised by relatively high densities of a range of annelid species with one or two crustacean taxa and two or three mollusc species, sometimes in high densities (particularly *C. edule, M. balthica and Peringia ulvae*). Even although suffering an apparent decline in recent

years, the molluscs *C. edule, M. balthica* and *P. ulvae* have consistently accounted for most of the invertebrate biomass across years.

Polychaete and oligochaete densities were relatively low in 1986 and 1998 but have increased in 2012 (e.g. *Hediste diversicolor*, *Nephtyidae, Arenicola marina* casts, cirratulids and capitellids all show increases) (Table 2). This trend, however, was species dependent and some species have remained relatively consistent across the years (e.g. Phyllodocidae) or have slightly decreased in density in 2012 (e.g. *Spio* spp.). Common intertidal crustaceans such as *Bathyporeia* spp. and *C. volutator* have fluctuated from high to low abundance years without specific trends.

Densities of *M. edulis*, *C. edule* and *M. balthica* were greater in 1986 than each of the other years and were significantly higher than densities recorded in 2012. *S. plana*, although recorded at relative low densities in comparison to the other mollusc species, showed a reverse tend with numbers significantly greater in 2012 than in 1986. Overall, 1986 seems to have been a particularly good recruitment year for a range of invertebrates (Yates *et al.* 2002). In recent surveys abundance of all main species has fluctuated at levels lower than those originally recorded which is consistent with a general decline in the 1990s and relatively low densities up to 2012 (Table 3).

Table 3. Summary of comparisons of the mean densities of invertebrates across The Wash (numbers of individual m^{-2}). Ratios above 1 indicate an increase in 2012 (reference). *Corophium arenarium* was not found in the 2012 survey. The statistical significance was determined using PERMANOVA following fourth root transformation of mean density. Levels of significance are indicated as follows, ns=not significant *=p<0.05, **=p<0.01, ***p<0.001 and ****=p<0.0001. Taxa and ratios for which a significant difference was identified are highlighted in bold text.

Invertebrate family or species	**Ratio**	**Ratio**	**Ratio**	**Ratio**	**Overall significance across all years**
	2012:1986	2012:1998	2012:1999	2012:2008	
Annelida					
Oligochaeta	2.76	6.09	1.03	2.01	ns
Phyllodocidae	1.22	1.23	1.29	3.04	ns
Hediste diversicolor	1.58	**6.07***	1.12	4.37	ns
Nephtyidae	**2.27 ****	**0.67***	0.68	0.60	****
Scoloplos armiger	1.51	0.46	1.63	1.81	ns
Pygospio elegans	1.80	2.13	0.76	2.80	ns
Spio spp.	0.69	0.83	0.20	0.55	ns
Cirratulidae	1.03	0.41	0.24	0.52	ns
Capitellidae	4.36	2.59	3.69	6.86	ns
Arenicola marina [§]	1.30	NA	3.11	NA	ns
Crustacea					
Crangon crangon	**0.13****	0.46	**0.25***	**0.45***	**
Urothoe spp.	9.23	0.07	0.11	0.92	ns
Bathyporeia spp.	0.22	0.58	1.02	0.58	ns
Corophium arenarium	-	-	-	-	***
Corophium volutator	1.58	6.42	1.98	1.94	ns
Mollusca					
Retusa obtusa	1.75	1.07	6.30	1.94	ns

Invertebrate family or species	Ratio	Ratio	Ratio	Ratio	Overall significance across all years
	2012:1986	2012:1998	2012:1999	2012:2008	
Mytilus edulis	**0.29****	**0.52****	0.71	1.38	*
Cerastoderma edule	**0.30****	0.69	0.96	0.83	*
Macoma balthica	**0.18***	1.72	0.31	1.38	**
Scrobicularia plana	**14.22***	0.94	11.35	8.42	**
Peringia ulvae	0.95	0.76	1.12	1.32	ns

[§] Assessment based on number of casts

3.2.5 Intertidal macrofauna assemblages, biotope and sediment type

The more recent assessment (2012) used standardised intertidal coring survey and analysis methodologies, and included biotope and sediment composition descriptions as well as providing trend assessments (APEM 2013). Temporal and biotope analyses were also provided in 2008 (Enviromuir 2009). To allow comparisons APEM (2013) reassigned historical biotope codes to the most recent 2004 JNCC Marine Habitat Classification format (Connor *et al*. 2004). Due to the somewhat subjective nature of biotope definitions temporal trends must be considered with caution.

Multivariate community analyses indicated that assemblage differences were non-significant across and within years and the overall faunal groups have remained fairly constant. This result suggests that differences in the faunal communities of The Wash were driven largely by greater densities of *P. ulvae*, *P. elegans*, *M. balthica* and *C. edule*. Generally, faunal groups in sand, mud/sand and mud across all years indicated a consistent grouping of the mud/sand and mud sites which further suggest two distinct assemblage types only. Nevertheless, at the scale of The Wash the correlation between faunal groups present and sediment type or organic content of sediment across years was non-significant and this was supported by the biotope results which suggest a general consistency across years (1998, 1999, 2008 and 2012).

Most recent distribution of The Wash common MuSa.MacAre/MacAre[1] biotopes in the north west of The Wash were consistent with the biotope distribution recorded in 1998/1999. Within the south eastern section of The Wash there seems to have been a potential slight change from MuSa.MacAre/MacAre in 1998 and 1999 to MEst.Nhom.MacStr, MEst.HedMac and MuSa.Cer.Po. The biotope MuSa.Cer.Po. distribution across The Wash was relatively consistent but was less frequently recorded in 1998 and 1999 (APEM 2013).

Sediment texture is a very important parameter for intertidal macrofauna and is used as a biotope descriptor. There is a clear transition from sand/slightly gravelly sand to muddy sand on The Wash, moving from the western areas to the more southern areas. The percentage of sites exhibiting a change in sediment type across years has ranged from 24-35%, with 6-9% of these sites exhibiting an extreme change.

3.2.6 Relevance of changes in Intertidal macrofauna to bird numbers on The Wash

[1] For biotope description see Connor *et al*. 2004. LS.LSa.MuSa.MacAre: *Macoma balthica* and *Arenicola marina* in littoral muddy sand; MEst.Nhom.MacStr: *Nephtys hombergii, Macoma balthica* and *Streblospio shrubsolii* in mid estuarine mud shores; MEst.HedMac: *Hediste diversicolor* and *Macoma balthica* in mid estuarine mud shores; MuSa.Cer.Po: *Cerastoderma edule* and polychaetes in muddy sand shores

A shortlist of eleven SPA bird feature species was identified which feed on invertebrates within intertidal sediments (Table 4). A reduction in mollusc densities and increase in polychaete densities which appears to have occurred since 1986 could, based on the food preferences identified, lead to an increase in populations of species with greater reliance on annelids (e.g. Redshank, Curlew and Bar-tailed Godwit) and potentially result in a reduction in numbers of species that feed on molluscs (e.g. Oystercatcher, Shelduck and Knot). There is enough evidence to conclude that greater reductions in bivalve densities have occurred in the past, with densities indicating a decline in the 1990s.

Recent infaunal assemblage data (post-1999) suggest that The Wash has maintained its overall intertidal invertebrate assemblages and no evidence of any specific spatial or temporal community trend was noted. Although the general character of The Wash has not been changed the abundance of certain species has certainly fluctuated probably reflecting species-specific recruitment patterns and mortality events. It is of note, however, that the intertidal infauna and biotope evidence is fairly recent (1998-2012) and changes might have occurred earlier as suggested by other lines of evidence.

Table 4. Prey preferences of wading birds across the intertidal invertebrate assemblage recorded during The Wash benthic coring surveys. Food items which showed a significant temporal change are highlighted in bold text. Dark-Bellied Brent Goose, Mallard, Pintail and Lapwing are excluded from the table on the grounds that benthic invertebrates do not constitute a substantial proportion of their diets.

Invertebrate family or species	**Bar-Tailed Godwit**	**Black-Tailed Godwit**	**Dunlin**	**Grey Plover**	**Knot**	**Oystercatcher**	**Redshank**	**Sanderling**	**Shelduck**	**Curlew**	**Turnstone**
Annelida											
Oligochaeta			X						X		
Phyllodocidae	X	X	X			X	X		X		
Hediste diversicolor	X	X	X	X	X	X	X	X	X	X	X
Nephtyidae	X	X	X			X	X		X		X
Scoloplos armiger	X	X	X			X	X		X		X
Pygospio elegans	X	X	X			X	X		X		X
Spio martinensis	X	X	X			X	X		X		X
Cirratulidae	X	X	X			X	X		X		
Capitellidae	X	X	X			X	X		X		
Arenicola marina (casts)				X		X					
Crustacea											
Crangon crangon	X						X			X	
Urothoe poseidonis											
Bathyporeia spp.											
Corophium arenarium	X						X		X	X	X
Corophium volutator	X						X		X	X	X
Mollusca											
Retusa obtusa											
Mytilus edulis						X			X		X
Cerastoderma edule		X	X	X	X	X		X		X	
Macoma balthica	X	X	X	X	X	X	X		X	X	
Scrobicularia plana		X									
Peringia ulvae			X	X	X		X	X	X		

3.3 Disturbance

Many species of estuarine bird are known to be susceptible by disturbance. Disturbance can be defined as any event that disrupts behaviour of bird communities or individual birds, and can vary in magnitude, frequency, predictability, space or duration (Cayford 1993). Disturbance can be natural (e.g. disturbance caused by predators). However, this section focuses on anthropogenic disturbance.

3.3.1 Activities causing disturbance

Disturbance may occur to both feeding and roosting waterbirds, and may be caused by a wide variety of recreational activities and other human activities. A large number of studies have identified activities causing disturbance. Burton *et al.* (2002a) listed some sixteen reports covering disturbance from walkers, dogs and bikes, roads and railways, construction work, water-based activities (sailing, water-skiing, jet-skis, motorboats and windsurfing), and the noise from aircraft and hunting.

Walking and dog-walking (including bird-watching) are among the most common and widespread activities carried out on British estuaries (Davidson & Rothwell 1993), and therefore are likely to cause the majority of potential disturbance events. Although most individual instances of disturbance from these activities may be relatively minor, the combined effect from a large number of disturbance events may be more detrimental (see discussion below). Foraging birds are often spread out over a large area of mudflat, whereas at roost they are usually gathered in large flocks close to the high water mark where more recreational activity takes place. Hence, roost sites are often more vulnerable to disturbance than feeding sites, although water based activities can cause major disturbance to feeding birds (Davidson & Rothwell 1993). Free running dogs can also result in substantial disturbance at both roost sites and feeding sites (Thomas *et al*. 2003 in Cutts *et al*. 2009).

Construction work on or adjacent to an estuary will also cause noise and visual disturbance. Major construction work can reduce densities, or exclude birds from some intertidal areas, during the construction phase (and sometimes after construction). At Cardiff Bay, construction work significantly reduced the densities of a number of species on the adjacent mudflat – Teal, Oystercatcher, Curlew and Redshank (Burton *et al*. 2002a).

On the Humber estuary, the effects of disturbance during construction work at Salt End were studied by the Institute of Estuarine and Coastal Studies: The amount of disturbance to feeding waders varied according to the level and type of construction activity. They found that the highest levels of disturbance occurred when plant or personnel were on the mudflat itself, with high to moderate levels of disturbance occurring when personnel were on the seaward toe and face, or intermittently present on the crest. The presence of other parties (i.e. non-construction workers) on the seawall also caused high to moderate disturbance, as did irregular piling noise above 70 dB levels. More regular piling noise, or irregular noise at lower levels, was accepted by the birds (Cutts *et al*. 2009).

Other activities that have been observed causing disturbance include bait-digging (Townshend & O'Connor 1993), wildfowling (Hirons & Thomas 1993), military activity (Cutts *et al*. 2009) and horse-riding, angling and bathing/general beach use (Davidson & Rothwell 1993).

Aircraft may have particularly strong effects on waterbirds, especially slow flying aircraft (Davidson & Rothwell 1993). In the Wadden Sea, Knot were strongly affected by the presence of both jet fighters and light aircraft. On days when aircraft were present, Knot were rarely present in large numbers and were more likely to take flight at greater distances with the approach of human observers, or for no apparent reason (Koolhas *et al*. 1993). However, observations by Smit & Visser (1985, in Smit & Visser 1993) showed that foraging birds showed little or no response.

Other studies have shown variable levels of response to aircraft which may depend in part on the altitude of the plane and also on differing levels of habituation (Smit & Visser 1993). Another study on the Wadden

Sea found that military jets had a relatively mild effect on roosting birds in spite of the associated high sound levels, and that helicopters caused more disturbance and caused birds to take flight at greater distances than military jets (Visser 1986 in Smit & Visser 1993). Heinen (1986 in Smit & Visser 1993) also found that helicopters were the most disturbing aircraft type at a shorebird roost (causing disturbance in 100% of potentially situations), followed by jets (84%), small civil aircraft (56%) and motor gliders (50%).

3.3.2 Impacts of Disturbance

Whilst it is clear from the literature that birds on estuaries may be prone to disturbance, it is more difficult to assess the actual impact that disturbance may have on individual birds or at a site or population level (Davidson & Rothwell 1993; Hill *et al.* 1997 in Burton *et al*. 2002a).

Where disturbance is only temporary, it may not have an impact on the survival of species using the site. This will depend on how much foraging time is lost and how much extra energy expenditure occurs because of the disturbance, and whether individual birds can compensate (Davidson & Rothwell 1993). For example, Riddington *et al*. (1996) found that Brent Geese on the North Norfolk Coast would need to feed for up to an hour at night in midwinter to balance their energy budget as a result of disturbance.

Where alternative habitat is available, or birds can quickly return after a disturbance, most birds will be able to overcome the effect of disturbance by increasing food intake rates (Swennen *et al.* 1989 in Davidson & Rothwell 1993), and/or extending the length of time that they feed (Davidson & Rothwell 1993). However, their ability to extend feeding times may be limited. Many estuarine birds can only feed during low tide when mudflats are uncovered, and this limiting factor becomes more important in cold weather when birds need to feed for longer to meet their energy requirements. Some species need to feed for longer than others to meet their energy requirements and so are more susceptible to the effects of disturbance during cold weather. The Redshank is particularly susceptible to disturbance in severe weather as it feeds on very small prey relative to its size (Clark *et al*. 1993; Mitchell *et al*. 2000).

In some cases birds leave the immediate area of the disturbance. This will not necessarily have a significant effect on the overall numbers of birds using the site, if suitable habitat is available elsewhere for the duration of the disturbance. However, sustained disturbance may result in the effective long term loss of an area of feeding habitat (Cayford 1993).

Regular disturbance may therefore cause a reduction in the number of birds that an area can support. Burton *et al.* (2002a) used generalized linear models to test whether the number of birds using different count sectors on six English estuaries varied according to a number of factors, including the proximity of the sector to the nearest footpath access point. Six of the nine species considered were found in significantly lower numbers where a footpath was close to the count sector (Shelduck, Knot, Dunlin, Black-tailed Godwit, Curlew and Redshank). Count numbers were also reduced by the proximity of railway lines (Brent Goose, Shelduck and Grey Plover) and roads (Ringed Plover, Grey Plover and Curlew). This suggests that disturbance can reduce the number of birds using sectors within the site.

The impact of disturbance may also be related to the carrying capacity of a site, i.e. the maximum number of birds an area can support. Where an area is close to its carrying capacity, the availability of prey may become a limiting factor, leading to a need to increase feeding time and to more competition between individuals, and hence the potential for disturbance to have more impact (Cayford 1993). Goss-Custard & Moser (1988 in Cayford 1993) demonstrated that feeding habitat was a major limiting factor for Dunlin in the UK, and that a decline between 1983-86 was linked to availability of such habitat (although in that instance, the loss of foraging area was attributed to the spread of cord-grass *Spartina*, rather than by disturbance).

Many species also vary in how they respond to instances of disturbance. For example, some Sanderling will allow approaches to within 30 metres, whereas Curlew will take flight at much greater distances (Cutts *et al*. 2009). Some studies have attempted to quantify which species are more prone to disturbance relative to

other species, or which species are more sensitive to disturbance, or flight distances for different species when disturbed. Often, smaller species are less prone to disturbance than larger species but there are some exceptions, e.g. Oystercatcher is less prone to disturbance than Redshank (Table 5).

Table 5 Relative responses to disturbance from several studies as examples of differing reactions between species.

Species	Cutts *et al*. 2009	Burton *et al*. 2002a	Davidson & Rothwell 1993	Kirby *et al*. 1993	Van der Meer 1985 in Smit & Visser 1993	Koepff & Dietrich 1986 in Smith & Visser 1993[#]
	Level of species sensitivity in Assessment for the Humber estuary (winter)	Level of tolerance when approached		Level of response to disturbance at roost**	Mean distances at which birds took flight when approached by people walking across tidal flat	Approximate mean distances at which roosting waders took flight when approached by kayaks/wind-surfers
Brent Goose			"more nervous"		105 m	
Shelduck	Moderate to Low				148 m	200m/380 m
Wigeon	Moderate					
Teal	Moderate					
Oystercatcher	Moderate to Low		"less nervous"	Medium	85 m	50m/140 m
Ringed Plover	Moderate			Low	121 m	
Grey Plover	Moderate			High	124 m	
Golden Plover	High					
Lapwing	Moderate to Low					
Knot	High			High		275m/210 m

Species	Cutts *et al*. 2009	Burton *et al*. 2002a	Davidson & Rothwell 1993	Kirby *et al*. 1993	Van der Meer 1985 in Smit & Visser 1993	Koepff & Dietrich 1986 in Smith & Visser 1993[#]
	Level of species sensitivity in Assessment for the Humber estuary (winter)	Level of tolerance when approached		Level of response to disturbance at roost**	Mean distances at which birds took flight when approached by people walking across tidal flat	Approximate mean distances at which roosting waders took flight when approached by kayaks/wind-surfers
Sanderling	Moderate			Low		
Dunlin	Moderate	"most tolerant"	"less nervous"	High	71 m	
Black-tailed Godwit	High*	"most tolerant"				
Bar-tailed Godwit	Moderate		"more nervous"	High	107 m	200m/240 m
Curlew	Moderate	"least tolerant"	"more nervous"	Medium	211 m	230m/400 m
Redshank	High	"most tolerant"	"more nervous"	Low		190m/280 m
Turnstone	High*		"less nervous"		47 m	

*Black-tailed Godwit was defined as Highly sensitive in Cutts *et al*. 2009 due to its status as a Red-listed species rather than due to a known sensitivity to disturbance, and Turnstone due to having specific habitat requirements and a limited range on the Humber estuary.

**For Kirby *et al*. (1993): HIGH – species most likely to leave estuary when disturbed; MEDIUM – most likely to move to other roosts within the estuary but outside the study area; LOW – more likely to stay at the same roost or move to another roost within the study area.

#Distances are approximate as source report is in graphical form and exact distances are not stated

The impact of low-level disturbance may be lower if it occurs regularly and is predictable (e.g. walkers staying on footpaths). In such cases, birds may show habituation to disturbance and allow a closer approach than birds are not habituated. However, some birds may not become habituated to disturbance (Smit & Visser 1993). A comprehensive literature review of disturbance is provided in Cutts *et al.* 2009.

In a sensitivity analysis for the Humber estuary, Cutts *et al.* (2009) attempted to assess the severity of activities in relation to their effect on birds on the estuary (Table 6).

Table 6 Activities in order of severity of disturbance to waterbirds on the Humber (based on Cutts *et al*. 2009):

Response level	Activity
HIGH	Jets (particularly low flying) Subsonic transport aircraft Free running dogs within 100 m
HIGH TO MODERATE	Irregular construction noises above 70 dB Other construction activities (personnel on site)
MODERATE	Shooting (wildfowling and military) Recreational activity (walking, running, dogs) within 100m Boat disturbance within 100 m Regular construction noise 50-70 dB
LOW	Recreational activity (walking, running, dogs) outside 100 m Noise below 50 dB

3.3.3 Potential disturbance activities on The Wash

In a review of recreational disturbance at European marine sites, The Wash was not highlighted as one of the sites at high risk (Natural England 2010a). A wide range of recreational and other activities take place on The Wash. Natural England (2010b) carried out a review of the risks from ongoing activities within European marine sites, including The Wash SPA.

This review categorised only one activity as high risk. This was the ongoing activity at le Strange estate fisheries in the south-east of The Wash. The activity on this fishery comprises suction dredging for Cockles and hand picking of Mussels at Hunstanton, under a lease granted in 1984. Only very limited controls were put in place on the activities carried out under the lease when it was granted. Natural England have assessed this site as being in unfavourable – declining condition, but are unable to take any enforcement action to prevent the damage to the SSSI, and are considering options such as entering into a voluntary agreement with the leaseholder (Natural England 2010b).

Until recently the Mussel beds were included within the "Hunstanton (le Strange) Several Order". Several Orders may grant exclusive fishing or management rights within a designated area, and allow legal ownership of certain named shellfish species in a private shellfishery. The Hunstanton Several Order this has now expired, and a recent application for a new Several Order has also expired. Natural England is keen that Mussel beds on the Estate are also managed sustainably (Natural England 2010b)

The other activities considered under the review were all assessed as posing a medium, low or no risk in the Natural England report (2010b) report. The following activities were considered to relate to the bird feature for The Wash SSSI.

MEDIUM RISK ACTIVITIES

- Recreation – Boating
- Recreation – dog walking
- Recreation – microlites/paragliders
- Recreation – bait digging
- Military – helicopter activity

LOW RISK ACTIVITIES

- Commercial vessels – shipping
- Recreation – wildfowling
- Recreation – angling
- Military – practice firing
- Military – low flying aircraft

In addition to these activities, a number of other activities that could potentially cause disturbance to bird populations occur around The Wash (Table 7), and have been described in the Ramsar Wetlands Information Sheet (JNCC 2008), the Management Plans for The Wash (WEMP 1996; Kennedy & Holmes 2004) and/or the Biodiversity Action Plan (Hartwell 2011).

Table 7 Summary of some of the activities occurring around The Wash that could potentially disturb bird populations

Activity	Description
Walkers, dogs	Walking along the sea bank occurs along two-thirds of The Wash SPA (JNCC 2008). The Peter Scott walk between the Rivers Nene and Great Ouse is particularly popular (WEMP 1996; JNCC 2008). Other well used sites are Boston Haven to Cut End, on the River Witham, the Plummers at Freiston and Shep Whites at Holbeach (WEMP 1996). Methods to discourage uncontrolled dogs are employed in particularly sensitive areas (Kennedy & Holmes 2004).
Bird watching	Bird watching occurs around the SPA (Kennedy & Holmes 2004).
Motorbikes	Motorbiking was noted as a particularly intrusive activity in the early 1990s on the saltmarshes at Wrangle, Frampton Marsh and Duck Points (WEMP 1996). However, it was not noted as a problem in Kennedy & Holmes (2004).
Wildfowling	Wildfowling is widespread around The Wash. Wildfowling clubs hold shooting rights on The Wash and are also licenced to shoot on the military ranges when it is safe to do so (Kennedy & Holmes 2004). The South Lincs. Shooting Zone covers four WeBS sectors (Wrangle, Leverton, Benington and Butterwick) (Austin & Calbrade 2010). Birds are apparently more likely to go inland to roost in July, August and September, but seem less likely to do so with the onset of the shooting season. However, there is no indication that wildfowling on The Wash presents a problem (N. Clark *pers. comm*)
Beach activities	Traditional beach activities occur between Snettisham and Hunstanton, where there are two bathing waters recognised under the EC Bathing Waters Directive (at Old Hunstanton and Heacham North (WEMP 1996; JNCC 2008)).

Activity	Description
Commercial ports	There are four commercial ports operating on The Wash, located at Boston, Sutton Bridge, Wisbech and King's Lynn. In recent years the numbers of recreational craft have been increasing in relation to commercial traffic (Kennedy & Holmes 2004)
Pleasure craft	A number of pleasure craft operate out of moorings along the tributary rivers or at the main dock sites, including Wisbech (WEMP 1996; Kennedy & Holmes 2004), King's Lynn (JNCC 2008) and Boston (JNCC 2008). Although there is little recreational sailing in the main body of The Wash (due to adverse tidal conditions) areas within the mouths of the tributary estuaries and the area between Hunstanton and Snettisham are popular (WEMP 1996). Boats are inclined to moor near or in the channel between Long and Roger Sands until the tide permits passage. Parties occasionally land on Roger Sands during low tide (WEMP 1996)
Windsurfing/Water-skiing/Power boats	In recent years windsurfing has become increasingly popular at Hunstanton with people travelling considerable distances to participate (WEMP 1996). The two main centres for power boats and water skiing are at Hunstanton and Heacham, the former being of national importance and hosting major championships (WEMP 1996). On a smaller scale, water skiing also takes place from the Nene Outfall Lighthouse (Guy's Head) and below Fosdyke Bridge (WEMP 1996).
Military aircraft	Two RAF ranges located on The Wash are of national significance. These are at Holbeach (Holbeach and Dawsmere WeBS sectors) and Wainfleet (Wainfleet, Friskney and a small part of Wrangle WeBS sectors) and have training for both helicopters and fixed wing aircraft (Kennedy & Homes 2004).
Light aircraft	The coastal area around The Wash is popular with recreational flyers as one of the few places in Britain where they can fly around without radio contact. Small, slow flying single engine aircraft are only able to fly around The Wash at weekends and public holidays when the RAF weapons ranges are inactive. Low flying aircraft and microlites, which are particularly disturbing to roosting waterfowl, are regularly noted over the Nature Reserves at Gibraltar Point and Snettisham. Parascending has also occurred above The Wash based at Hunstanton (WEMP 1996)
Seal watching	Commercial pleasure cruisers sail from Hunstanton taking trippers out into The Wash to view the seals and cliffs (WEMP 1996).
Bait-digging	Occurs in more remote parts of the embayment and estuaries (Kennedy & Holmes 2004)
Construction	Construction activity around The Wash is relatively limited. Offshore wind farm development will not be allowed within 8 km of the Lincolnshire coast and 13 km of the North Norfolk coast (Kennedy & Holmes 2004). However, associated infrastructure such as cabling has been allowed through The Wash subject to close regulation by the relevant nature conservation authorities (Hartwell 2011; Centrica 2011).

Although the descriptions in the management plans detailed the locations of some of the activities, the literature review did not identify any specific papers or reports that assessed the relative levels of

disturbance at a precision that would allow them to be related to specific WeBS sectors around The Wash. The Norfolk Coast Partnership Visitor Management Strategy (NCP 2014) categorises areas of the North Norfolk coast into different zones according to visitor pressure levels. The only areas included from within The Wash SPA are the Ouse WeBS sector, categorised as Orange (second highest level – 'ensure visitor use does not increase') and the southern portion of the Snettisham WeBS sector, with the area around the roost site on the lagoons categorised in the highest Red level ('overcome existing damage and problems associated with visitor activity').

In conclusion, most bird species may be able to tolerate low levels of disturbance on a daily basis. An accurate assessment of the relative levels and types of disturbance in different sectors would be necessary to inform whether specific disturbance activities may have caused declines in particular species, or cause a redistribution of particular species around The Wash.

3.4 Habitat change

The Wash SPA contains a number of important habitat features including saltmarsh, intertidal mudflats, sandy beaches, open marine water and sublittoral habitats, coastal lagoons and grazing marshes. Coastal sand dunes also occur in the Gibraltar Point SPA adjacent to The Wash. The main habitats of interest to the majority of the bird species considered in this report are intertidal mudflats and saltmarsh and coastal lagoons. Inland habitats, including grazing marshes and agricultural land, are also important to species such as Lapwing and Curlew and more generally at high tide roosts during spring tides.

3.4.1 Intertidal mudflats

Intertidal mudflats have an upper layer containing oxygen rich sediment and a black, anoxic layer beneath (Hartwell 2011). Mudflats have low species diversity but are home to an abundance of organisms living in the sediment, which in turn provide food to large numbers of waterbirds, both during passage and over winter (BRIG 2010 in Hartwell 2011).

The Wash has the second largest area of intertidal mudflats in Britain, the area of which was estimated at 9000ha from a map by Hartwell (2011), though with Gibraltar Point SPA included in the area covered by the estimation. However, when the conservation objectives and definitions of favourable condition were defined for The Wash (Natural England 2008) no baseline measure for the extent of intertidal mudflats was included, as monitoring did not extend to the low tide mark.

The Wash acts as a sediment sink, with sediment being drawn in from the North Sea outside The Wash, particularly from the north from the Lincolnshire coast and as far away as the Humber estuary (Pye 1995). The rate of accretion has declined since Roman times but is still occurring, with recent patterns of accretion and erosion apparently controlled by movements in the position of deep water channels and variations in the storm wave frequency and direction (Pye 1995).

The Wash is still recovering from the effects of land claim, which is impacting the extent of intertidal mudflats in several locations, including the coast between Witham and Gibraltar Point SPA, where the salt marsh is moving seaward following accretion which in conjunction with a fixed low water mark means that intertidal mud is decreasing (Pethick 2002 in Natural England 2008). This is happening elsewhere on The Wash as most of the saltmarshes on The Wash are still accreting both vertically and laterally (Pye 1995). There has also been a seaward movement of both the high and low tide marks along the western shore of The Wash, accompanied by a seaward extension of the saltmarsh (Pye 1995), and Hartwell (2011) also noted that loss of intertidal mudflat was especially occurring on the western side of The Wash. Seaward movement of the low water mark between the Rivers Welland and Nene may have been caused by the landward advance of eroding offshore banks (Posford Duvivier 1997 in Natural England 2008).

The intertidal mudflats are further threatened by sea level rise caused by climate change which is predicted to increase the frequency of storm events and to cause 'coastal squeeze' (the loss of intertidal habitats where sea defences are fixed and the habitats cannot retreat naturally) (IPCC 2007 in Hartwell 2011).

3.4.1.1 Sewage inputs

Biological monitoring of the intertidal mudflats and their benthic communities have concluded that the environmental condition of The Wash is good or very good (Bailey 2004). In particular, there have been substantial improvements in the quality of the water that enters The Wash from discharge sources. This has occurred as a result of improvements to sewage treatment following implementation of the Water Framework Directive. The main sources of sewage discharge into The Wash came from the four major rivers entering The Wash, with water quality from the Nene and the Great Ouse being particularly poor, and from an outfall at Hunstanton. Discharge from Hunstanton stopped in 1990, with the Great Ouse changing from Class B to Class A in 1998, and the Nene from class D to class A between 1995 and 2002 (Bailey 2004).
However, it is worth noting that in some cases sewage outfalls have been shown to be beneficial to birds on estuaries and coastal waters. The extra nutrient loading and organic content in sediments as a result of discharges increases the abundance, diversity and biomass of invertebrates in areas of increasing distance from outflow points. Some species are able to tolerate high levels of organic and nutrient loading close to the source of the discharge, while others benefit from more moderate enrichment occurring over a wider area, including *Corophium*, *Eteone longa*, *Macoma balthica*, *Scolelepsis fuliginosa* and *Mytilus edulis* (Burton *et al*. 2002b). Bird species which feed on benthic invertebrates may therefore be at risk from improvements to water quality. These include Brent Goose, Shelduck, Pintail, Oystercatcher, Grey Plover, Lapwing, Knot, Dunlin, Black-tailed Godwit, Bar-tailed Godwit, Curlew, Redshank and Turnstone (Burton *et al.* 2002b).

3.4.1.2 The Great Ouse Outflow

At the Great Ouse outflow, annual monitoring of sediments, invertebrates and shorebirds occurred in 1986 and then annually between 1996 and 2006. The main aim of this monitoring was to assess changes in relation to the distance from the outfall and the variations in river flow (Yates *et al.* 2007). During the course of the study, sediments were sandiest in 1998 and muddiest in 2000. Three sampling sites on the mudflats (out of 45) had to be abandoned due to encroachment of saltmarsh.
Worm densities were at their lowest in 1996 and then increased annually until 2003, but have since declined and by 2006 were nearly as low as in 1996. Crustacean density was very variable, but was also high in 2003, and low in 1996 and 2000. Bivalve density was highest in 2000 when there was a large spatfall of many species notably Cockle and *Macoma balthica*, but densities have remained relatively low since then (Yates *et al*. 2007).

Most species were at their lowest level in 1996, when worm and crustacean densities were low, and the trend described for Redshank appears to match the trend for worm densities, peaking in 2003 when both worm densities were at their highest, and crustacean densities were also high. A similar pattern was observed for Curlew. Oystercatcher also increased to a peak in 2003 but then declined by 2006 to its lowest level since 1991. Bar-tailed Godwit stands out from the other species as its peak was highest in 1996, when most other species were at their lowest densities and also when their main food source (worms) was at its lowest density (Yates *et al*. 2007).

3.4.2 Saltmarsh

Coastal saltmarshes in the UK cover the upper, vegetated portions of intertidal mudflats, and different parts of the marsh may develop slightly different plant communities depending on how often they are covered by the tide. Species at the lowest level can survive regular immersion by tides, while species on the upper marsh can only withstand occasional inundation (Hartwell 2011).

Saltmarsh habitat is important for waterfowl. It provides a high tide refuge for birds using adjacent mudflats. In winter, grazed saltmarshes are also used as feeding grounds by duck and geese (Hartwell 2011).

Since the 1980s, the saltmarsh of The Wash has been and is accreting seawards at the expense of intertidal mudflats (Pye 1995; Hartwell 2011). Currently, there is saltmarsh coverage, to varying degrees, all the way round The Wash to approximately Snettisham in Norfolk on the eastern side of The Wash (Hartwell 2011), where the beaches become sandy. The saltmarsh around Frampton marsh and Kirton marsh is some of the oldest in The Wash. The marsh north of Boston and the River Witham, are relatively less established in terms of age and zonation. (Hartwell 2011).

Currently, saltmarsh accretion is outpacing the rate at which the sea level is rising. The accretion is occurring across the whole of The Wash, with the most significant increase occurring on the south-western side, particularly between the Rivers Welland and Nene (Environment Agency 2010 in Hartwell 2011).

Maps showing the extent of the saltmarsh in different areas around The Wash, broken down into different plant communities, were included in Hill (1988). Hill estimated the extent of saltmarsh within The Wash to be 4,158ha. It was estimated at 4,265 ha from aerial photographs taken in 2000 (Natural England 2008), and at 4,886ha from a NVC survey carried out in 2001/2 (Hemphill *et al*. 2003 in Natural England 2008). The discrepancy between the latter two estimates was thought to result from the difficulty in assessing the boundary of the saltmarsh from aerial photographs, highlighted the difficulty in measuring changes to this habitat (Natural England 2008).

Although the overall extent of saltmarsh around The Wash SPA has increased, habitat changes within the saltmarsh may have made it less attractive to some species in certain areas. A study of the South Lincs. Shooting Zone highlighted declines of Lapwing and Golden Plover within the zone, and a redistribution in waterfowl numbers of several other species from the southern end of the zone towards the northern end. The increase in vegetation length within the zone was identified as one of two possible causes for these changes, alongside increased disturbance (Austin & Calbrade 2010).

Threats to the saltmarsh include a reduction in grazing on the marshes (Hartwell 2011). Coastal and floodplain grazing was formerly abundant in Lincolnshire (Simpkin 2006), but has been abandoned in most areas around The Wash (Hartwell 2011). Sea level rise may also have an effect on the salt marsh through coastal squeeze (IPCC 2007 in Hartwell 2011), though Pye (1995) found that vertical accretion of the salt marsh on The Wash was keeping up with sea level rise.

Coastal grazing has been introduced at the RSPB reserves at Frampton and Freiston on the western side of The Wash (Ausden *et al*. 2005; Simpkin 2006).

3.4.3 Managed Realignment

In recent years, managed realignment has been increasingly used as a method of flood defence management, and also to provide compensation for intertidal habitats lost as a result of development, and is expected to continue to be used as an important management tool in the future (e.g. Thomas, K.). Managed realignment involves moving back the flood defences in order to allow an area to be inundated by the tide. Over time, this area will develop into intertidal mudflats, salt marsh or other habitats.

A substantial amount of academic work has been undertaken to try to understand the processes that cause the different types of habitat to be created following realignment, and to assess whether these will provide equivalent habitat to natural sites (e.g. Mossman *et al*. 2012).

On The Wash, the outer bank at Freiston Shore was breached in 2002, and since the 80ha behind the outer bank has been developing into a healthy saltmarsh community. A saline lagoon has also been created at this site (Hartwell 2011).

A monitoring programme was completed in 2008, and judged the managed realignment at Freiston to have been a success. The site biodiversity was close to matching that of surrounding marshland, and provided habitat for a variety of wildfowl and waders including Brent Goose and Redshank (Environment Agency 2008). A number of papers have judged Freiston to have been a success (e.g. Bradley & Allcorn 2006; Friess *et al*. 2008)

Managed realignment is one of the four options for flood defence listed in The Wash Management Plan, provided suitable sites can be identified that do not affect grade 1 agricultural land (Kennedy & Holmes 2004).

3.4.4 Sandy Beaches

Occur from Hunstanton to the south sandy beaches backed into a natural shingle ridge turn into mudflat the further seaward they become (Environment Agency 2010 in Hartwell 2011). This habitat is particularly important for Sanderling.

This habitat suffers a high amount of pressure from recreational activities including traditional beach activities, sailing, windsurfing, water skiing and power boating (WEMP 1996), as well as walkers, dogs and bird watching (N. Clark, *pers. comm*).

3.4.5 Lagoons

Saline lagoons are partially separated from the adjacent sea, but with some influx of sea water occurring. They retain saline water at low tide and may develop as brackish, full saline or hyper-saline water bodies (BRIG 2010 in Hartwell 2011). They provide feeding and roosting habitat for waders and wildfowl.

This type of habitat is uncommon on The Wash and their area was measured at just 17.38ha in c.2000 using OS Mastermap data in GIS (Natural England 2008).

There are four saline lagoons at Snettisham on the eastern shore of The Wash. Three lie within the boundary of The Wash SPA. The gravel pits at Snettisham are an important high-tide roost for waders, and also provide foraging habitat (Hartwell 2011). Managed realignment at Freiston Shore in 2002 formed an additional 12 ha of saline lagoon habitat (Hartwell 2011).

Additional saline lagoon habitat occurs at Moulton Marsh, a Lincolnshire Wildlife Trust (LWT) Nature Reserve, that lies just outside the boundary of The Wash SPA on the western side of The Wash. (Hartwell 2011). There are concerns over unregulated development on the shingle ridge, which may affect this site (Hartwell 2011).

3.4.6 Coastal and Floodplain Grazing Marsh

Threats to grazing marsh include agricultural intensification, decline in traditional livestock farming, lack of traditional management, pollution from agricultural run-off and sea-level rise (Hartwell 2011). Loss of grazing marsh in the UK has apparently been significant in recent years (Simpkin 2006 in Hartwell 2011) but no mention is made of changes to extent around The Wash and a target is set in the BAP to obtain baseline data for The Wash.

3.4.7 Inland Habitats

Outside The Wash SPA boundary, the habitat is predominantly made up of open agricultural land with a network of rivers, dykes and drains (Hartwell 2011).

This habitat is particularly important for Lapwing, which often feeds in grassland and arable fields both in winter and during the breeding season (e.g. Gillings *et al*. 2006). Fields adjacent to estuaries also provide important feeding habitat for Curlew over winter (Townshend 1981).

The agricultural field immediately adjacent to the estuary are extremely important as many species will roost in these fields when the highest spring tides cover their normal roost sites on the adjacent saltmarsh. Oystercatcher, Grey Plover, Knot, Dunlin, Curlew, Black-tailed Godwit, Bar-tailed Godwit are among the species that will often use the fields to roost, Redshank less so and Sanderling and Turnstone only exceptionally (N. Clark, *pers. comm.*)

An important habitat resource that is outside the SPA is the docks at Port Sutton Bridge. This is of particular importance to Turnstone which feed on spilt grain from the loading operations. A study by Smart & Gill (2003) found that Turnstones tended to use the docks during mid to late winter, and that numbers were variable from year to year. They suggested that this pattern of use indicated that the docks were an important food source for Turnstone when resources were low on the estuary itself. Turnstone numbers at the docks are included in the WeBS totals for The Wash and contribute to the SPA total.

3.5 Sector-level cross-tabulation of waterbird and environmental information

As a means to identifying possible drivers of change not directly obtained from the literature, here we cross-tabulate bird trends at the WeBS sector level (from Ross-Smith *et al*. (2011)) with issues which, although documented in the literature, have not been directly associated with changes in bird numbers at specific locations within The Wash (Table 8).

Table 8 (pages 79-84): Sector-level cross-tabulation of waterbird trends and potential drivers of change. For convenience of presentation, the information for the table has been split between the sectors of the west side of The Wash (12 sectors - Wainfleet to Welland) and those of the south and east sides (9 sectors - Holbeach St Matthew to Hunstanton sectors). There is a column for an overview of The Wash as a whole and columns for each of the sections (the overview is repeated with each group of sectors as often sector-level detail is not available for other than the bird trends). The table is arranged into topic sections for Changes to habitat extent; Changes to habitat quality; Food availability/quality/abundance; Disturbance/recreational activities and; Other land and water uses. Within each of these main sections, there is a more detailed breakdown of sub-topics. Where page breaks interrupt the flow of the table the header information regarding bird trends is repeated.

	The Wash SPA Trends	WeBS Sector trends: short-; medium- &; long-terms											
		Wainfleet	Friskney	Wrangle	Leverton	Benigtom	Butterwick	Freiston	Witham	Frampton North	Frampton South	Kirton	Welland
Dark-bellied Brent Goose	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Shelduck	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Mallard	S M L	S M L	S M L	S M L	S M L		S M L	S M L	S M L	S M L	S M L	S M L	S M L
Pintail	S M L												
Oystercatcher	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Grey Plover	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L		S M L	S M L
Lapwing	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Knot	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Sanderling	S M L												
Dunlin	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Black-tailed Godwit	S M L							S M L	S M L	S M			S M L
Bar-tailed Godwit	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L				S M L
Curlew	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Redshank	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Turnstone	S M L		S M L	S M L			S M L	S M L	S M L	S M L			

		Wainfleet	Friskney	Wrangle	Leverton	Benigtom	Butterwick	Freiston	Witham	Frampton North	Frampton South	Kirton	Welland
CHANGES TO HABITAT EXTENT													
Saltmarsh	Increasing almost everywhere especially between Nene and Ouse							Increase due to managed realignme					
Tidal mudflats	Decreasing everywhere	←	←	Decreasing			→	→					
Saline lagoons								New lagoon					
CHANGES TO HABITAT QUALITY													
Saltmarsh	Increased length of vegetation noted in "some" sectors - may be more widespread			Vegetation length has increased									
Tidal mudflats (Loss of sewage and nutrient input)	Probably declining in all sectors, e.g. due to sewage treatment in respect of Water Framework Directive								Close to Witham and Welland outflows				
FOOD AVAILABILITY/QUALITY/ABUNDANCE													
Polychaete Worms	The Wash has maintained its intertidal invertebrate assemblages. However, the abundance of certain species has certainly flutuated												
Crustaceans													
Bivalves (especially cockles and mussels)	A threefold reduction in the area covered by mussel beds has occurred in the last 30 or 40												
Grass/vegetative	No information available												

Table 8 (cont.)

	The Wash SPA Trends	WeBS Sector trends: short-; medium- &; long-terms											
		Wainfleet	Friskney	Wrangle	Leverton	Benington	Butterwick	Freiston	Witham	Frampton North	Frampton South	Kirton	Welland
Dark-bellied Brent Goose	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Shelduck	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Mallard	S M L	S M L	S M L	S M L	S M L		S M L	S M L	S M L	S M L	S M L	S M L	S M L
Pintail	S M L												
Oystercatcher	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Grey Plover	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L		S M L	S M L
Lapwing	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Knot	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Sanderling	S M L												
Dunlin	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Black-tailed Godwit	S M L							S M L	S M L	S M			S M L
Bar-tailed Godwit	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L				S M L
Curlew	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Redshank	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Turnstone	S M L		S M L	S M L			S M L	S M L	S M L	S M L			
DISTURBANCE/RECREATIONAL ACTIVITY													
Walking	Occurs across 2/3 of sea banks. Walks publicised in some areas							← High →					
Dogs	Probably widespread - no specific information found												
Birdwatching/Nature	Widespread							High					
Motorbiking	Noted in WEMP 1996, though attempts were being made to			High (1996)						High (1996)			
Wildfowling	Widespread around The Wash			← South Lincs Shooting Zone →									
Beach activities	Occurs on the sandy beaches in the south-east of The Wash												
Pleasure craft	Mainly around river mouths and between Hunstanton and								← High →				
Windsurfing/Water-skiing/Power boats	Mainly at Heacham and Hunstanton												
Low flying light aircraft	Recreational light aircraft can fly all round the Wash but only at												
Angling	No specific information												
Seal watching	Boat trips run from Hunstanton												
Bait digging	No specific information												

Table 8 (cont.)

	The Wash SPA Trends	WeBS Sector trends: short-; medium- &; long-terms											
		Wainfleet	Friskney	Wrangle	Leverton	Beningtom	Butterwick	Freiston	Witham	Frampton North	Frampton South	Kirton	Welland
Dark-bellied Brent Goose	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Shelduck	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Mallard	S M L	S M L	S M L	S M L	S M L		S M L	S M L	S M L	S M L	S M L	S M L	S M L
Pintail	S M L												
Oystercatcher	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Grey Plover	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L		S M L	S M L
Lapwing	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Knot	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Sanderling	S M L												
Dunlin	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Black-tailed Godwit	S M L							S M L	S M L	S M			S M L
Bar-tailed Godwit	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L				S M L
Curlew	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Redshank	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L	S M L
Turnstone	S M L		S M L	S M L			S M L	S M L	S M L	S M L			
Other land and water uses (excluding recreation)													
Fishing													
Marine/saltwater aquaculture	No specific information												
Gathering of shellfish	Subsantial impact in Hunstanton area (though not specific which sector fishery is in)												
Grazing	Much reduced since historic times, though recently re-introduced at Freiston and Frampton							Introduced in 2000s		Introduced 2002			
Harbour/port activity	Several ports are located around The Wash								Port at Boston close to these sectors				
Flood control	No specific information												
Military activities	Two RAF ranges are located around The Wash	Wainfleet range covers these sectors (only a very tiny part of Wrangle along the western edge of the sector)											
Construction	Cabling put in place from offshore wind farm to R.Ouse in summer 2011 (though too late to affect sector results)												

Table 8 (cont.)

	The Wash SPA Trends			WeBS Sector trends: (bird trends are for short-; medium- &; long-terms)																														
				Holbeach St Matthew			Dawsmere			Gedney			Terrington West			Terrington East			Ouse			Snettisham			Heacham			Hunstanton								
Dark-bellied Brent Goose	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L										
Shelduck	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L								
Mallard	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L								
Pintail	S	M	L										S	M	L	S	M	L	S	M	L	S	M	L										
Oystercatcher	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L		
Grey Plover	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L											
Lapwing	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L					
Knot	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L				S	M	L					
Sanderling	S	M	L																			S	M	L	S	M	L	S	M	L					
Dunlin	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L								
Black-tailed Godwit	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L											
Bar-tailed Godwit	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L								
Curlew	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L								
Redshank	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L											
Turnstone	S	M	L										S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L					
CHANGES TO HABITAT EXTENT																																			
Saltmarsh	Increasing almost everywhere especially between Nene and Ouse												Largest increases																						
Tidal mudflats	Decreasing everywhere especially in												Largest losses?																						
Saline lagoons													Losses?																						
CHANGES TO HABITAT QUALITY																																			
Saltmarsh	Increased length of vegetation noted in "some" sectors - may be more widespread																																		
Tidal mudflats (Loss of sewage and nutrient input)	Probably declining in all sectors, e.g. due to sewage treatment in respect of Water Framework Directive						Close to Nene outflow which was especially poor prior to 2002									Close to Great Ouse Outflow which was especially poor prior to 1998																				
FOOD AVAILABILITY/QUALITY/ABUNDANCE																																			
Polychaete Worms	The Wash has maintained its intertidal invertebrate assemblages. However, the abundance of certain species has certainly flutuated															1996-2006: Lowest in 1996, increased until 2003 then declined																				
Crustaceans																1996-2006: Very variable, - high in 2003, low in 1996 and 2000.																				
Bivalves (especially cockles and mussels)	A threefold reduction in the area covered by mussel beds has occurred in the last 30 or 40 years. A "crash"															1996-2006: Highest in 2000 but relatively low since then																				
Grass/vegetative	No information available																																		

Table 8 (cont.)

Table 8 (cont.)

	The Wash SPA Trends			WeBS Sector trends: short-; medium- &; long-terms																												
				Holbeach St Matthew			Dawsmere			Gedney			Terrington West			Terrington East			Ouse			Snettisham			Heacham			Hunstanton					
Dark-bellied Brent Goose	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L								
Shelduck	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L					
Mallard	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L					
Pintail	S	M	L										S	M	L	S	M	L	S	M	L	S	M	L								
Oystercatcher	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Grey Plover	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L								
Lapwing	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L		
Knot	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L				S	M	L		
Sanderling	S	M	L																			S	M	L	S	M	L	S	M	L		
Dunlin	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L					
Black-tailed Godwit	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L								
Bar-tailed Godwit	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L					
Curlew	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L					
Redshank	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L								
Turnstone	S	M	L										S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L		
DISTURBANCE/RECREATIONAL ACTIVITY																																
Walking	Occurs across 2/3 of sea banks. Walks publicised in some areas			High									High (Peter Scott walk)																			
Dogs	Probably widespread - no specific information found																															
Birdwatching/Nature	Widespread																					High										
Motorbiking	Noted in WEMP 1996, although attempts were being made to stop it																															
Wildfowling	Widespread around The Wash																															
Beach activities	Occurs on the sandy beaches in the south-east of The Wash																					←			High			→				
Pleasure craft	Mainly around river mouths and between Hunstanton and Snettisham			High												←			←			High			→			→				
Windsurfing/Water-skiing/Power boats	Mainly at Heacham and Hunstanton															Occurs?									High			High				
Low flying light aircraft	Recreational light aircraft can fly all round the Wash but only at weekends when the RAF base is inactive (WEMP 1996). High impact																					High impact						High impact				
Angling	No specific information																															
Seal watching	Boat trips run from Hunstanton																											Boat trips				
Bait digging	No specific information																															

Table 8 (cont.)

	The Wash SPA Trends	WeBS Sector trends: short-; medium- &; long-terms																											
		Holbeach St Matthew			Dawsmere			Gedney			Terrington West			Terrington East			Ouse			Snettisham			Heacham			Hunstanton		
Dark-bellied Brent Goose	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L							
Shelduck	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L				
Mallard	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L				
Pintail	S M L	S	M	L							S	M	L	S	M	L	S	M	L	S	M	L							
Oystercatcher	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L
Grey Plover	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L							
Lapwing	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	
Knot	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L				S	M	L	
Sanderling	S M L																			S	M	L	S	M	L	S	M	L	
Dunlin	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L				
Black-tailed Godwit	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L							
Bar-tailed Godwit	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L				
Curlew	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L				
Redshank	S M L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L							
Turnstone	S M L										S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	S	M	L	
Other land and water uses (excluding recreation)																													
Fishing																													
Marine/saltwater aquaculture	No specific information																												
Gathering of shellfish	Subsantial impact in Hunstanton area (though not specific which sector fishery is in)																									High?			
Grazing	Much reduced since historic times, though recently re-introduced at Freiston and Frampton																												
Harbour/port activity	Several ports are located around The Wash							Sutton Bridge port close to these sectors						Kings Lynn and Wisbech ports close to these sectors															
Flood control	No specific information																												
Military activities	Two RAF ranges are located around The Wash	Holbeach range covers these sectors																											
Construction	Cabling put in place from offshore wind farm to R.Ouse in summer 2011 (though too late to affect sector results)																												

4. DISCUSSION AND RECOMMENDATIONS

4.1 Species overviews

Bird species overviews are presented below in tabular form organised as follows:

- ***Status***: A statement of whether or not there are any current issues associated with the species in question on The Wash.

- ***Inferred drivers of change on The Wash***: Here we list those issues identified directly from the literature review or deduced through our consideration of trends and species traits in relation to known issues affecting The Wash or specific parts of The Wash.

- ***Quality of Evidence***: Here we assess the quality of evidence that underpins our suggestions for drivers of change on The Wash

- ***Potential future issues on The Wash***: Here, based on species traits and their know sensitivities to particular issues in a broader context, we shortlist issues that could be of concern in the future should there be any change from the *status quo* and speculate on whether these issues are likely to have low, medium or high impact based.

- ***Quality of knowledge***: Here we assess the quality of the knowledge leading to the identification of potential future issues have been based.

- ***Gaps in knowledge***: Here we list important knowledge gaps that were they to be addressed would lead to increased confidence in our assessments regarding potential drivers of change.

- ***Recommendations***: Here we make recommendations to address issues identified above.

4.1.1 Dark-bellied Brent Goose (*Branta bernicla bernicla*)

Dark-bellied Brent Goose	
STATUS	No current concern: Stable trend. However, sector level declines at Holbeach St. Matthew, Snettisham and in the western corner of The Wash near the River Welland, and sector level increases along the northern side of The Wash.
INFERRED DRIVERS OF CHANGE ON THE WASH	Reasons for re-distribution are unknown. Disturbance and habitat change are both possible causes.
QUALITY OF EVIDENCE	Re-distribution: ***weak*** (speculative)
POTENTIAL FUTURE ISSUES ON THE WASH	Any future increase in aircraft activity (high impact). Any future increase in recreational activity (low impact). Any future loss of food resources, due to habitat loss or "eelgrass disease" (medium to high impact). Any future loss of undisturbed "refuge" areas (medium impact).
QUALITY OF KNOWLEDGE	Diet: ***medium*** (8) Kear 2005a; Habitat: ***medium*** (8) Kear 2005a; Disturbance: ***strong*** (12) Riddington *et al*. 1996; Threats: ***medium*** (8) Kear 2005a
GAPS IN KNOWLEDGE	Lack of specific information for The Wash. In particular: Extent and availability of food resources. Disturbance studies with special attention to quiet "refuge" areas.
RECOMMENDATIONS	No immediate measures required. Continue current monitoring. It would be judicious to initiate further work to fill knowledge gaps to provide robust baseline information should issues arise in the future.

4.1.2 Shelduck (*Tadorna tadorna*)

Shelduck	
STATUS	High Alert: Long-term declining population (including in key WeBS sectors), species redistribution throughout The Wash.
INFERRED DRIVERS OF CHANGE ON THE WASH	Decline in shellfish stocks. Documented habitat (mudflat) loss a likely factor but little direct evidence.
QUALITY OF EVIDENCE	Food declines: ***strong*** (15) Atkinson *et al*. 2010; Habitat loss: ***weak*** (speculative).
POTENTIAL FUTURE ISSUES ON THE WASH	Further changes to shellfish stocks (high impact). Further changes to habitat extent and quality (medium impact). Disturbance (low to medium impact).
QUALITY OF KNOWLEDGE	Diet: ***strong*** (15) Atkinson *et al*. 2010; Habitat: ***strong*** (13) Natural England 2010b; Disturbance: ***strong*** (12) Burton *et al*. 2002a; Threats: ***strong*** (13) Natural England 2010b.
GAPS IN KNOWLEDGE	Declines and redistribution around The Wash are not well understood.
RECOMMENDATIONS	Prevent and reverse mudflat loss, especially around the Welland and Ouse outfalls which support a large proportion of the Shelduck population. Tightly regulate shellfish stocks to prevent declines.

4.1.3 Mallard (*Anas platyrhynchos*)

Mallard	
STATUS	Long-term population decline, species redistribution throughout The Wash.
INFERRED DRIVERS OF CHANGE ON THE WASH	The evidence suggests that the declines on The Wash probably result mainly from broad scale population changes rather than site-specific pressures, e.g. changes to wintering distribution in Europe. However, disturbance/mortality/habitat loss in the South Lincs. Shooting Zone was found to have caused local declines.
QUALITY OF EVIDENCE	Broad-scale redistribution: ***strong*** (12) Sauter et al. 2010; Disturbance/Habitat loss: ***strong*** (13) Austin & Calbrade 2010.
POTENTIAL FUTURE ISSUES ON THE WASH	Further habitat loss, decline in food availability (medium impact). Further changes to European wintering distribution (high impact).
QUALITY OF KNOWLEDGE	Diet: ***medium*** (8) Kear 2005a; Habitat: ***strong*** (13) Austin & Calbrade 2010. Disturbance: ***strong*** (13) Austin & Calbrade 2010; Threats: ***medium*** (9) Birdlife 2014
GAPS IN KNOWLEDGE	Little information on diet and habitat use on The Wash. Declines and redistribution around The Wash are not well understood.
RECOMMENDATIONS	Management of the areas around Welland and Ouse outfalls that are important for Mallard could be optimized to protect this species' food sources and habitats.

4.1.4 Pintail (*Anas acuta*)

Pintail	
STATUS	High Alert: Long-term decline (though medium term increase).
INFERRED DRIVERS OF CHANGE ON THE WASH	Unknown. The reported decline may simply relate to normal fluctuations which occur in this species, with numbers happening to peak at the time of designation. It is possible that the decline may also relate to improvements in water quality near the Ouse and Nene outfalls.
QUALITY OF EVIDENCE	***Weak*** (speculative)
POTENTIAL FUTURE ISSUES ON THE WASH	Habitat loss, decline in food availability.
QUALITY OF KNOWLEDGE	Diet: ***medium*** (9) Kear 2005b; Habitat: ***medium*** (8) Kear 2005a; Disturbance: **N/A**; Threats: ***medium*** (8) Kear 2005a.
GAPS IN KNOWLEDGE	Little information on diet and habitat use on The Wash. Sensitivity to disturbance is not known.
RECOMMENDATIONS	Management of the areas near the Ouse and Nene outfalls that are important for Pintail and could be optimized to protect this species' food sources and habitats.

4.1.5 Oystercatcher (*Haematopus ostralegus*)

Oystercatcher	
STATUS	Medium Alert: Long-term population decline. Sector level trends variable.
INFERRED DRIVERS OF CHANGE ON THE WASH	Declines in shellfish stocks.
QUALITY OF EVIDENCE	Shellfish declines: ***strong*** (15) Atkinson *et al*. 2010.
POTENTIAL FUTURE ISSUES ON THE WASH	Further declines in shellfish stocks on The Wash (high impact). Changes to habitat extent and quality on The Wash (medium impact). Disturbance on The Wash (low impact). Changes to wintering distribution within Europe (medium impact).
QUALITY OF KNOWLEDGE	Diet: ***strong*** (15) Atkinson *et al*. 2010; Habitat: ***strong*** (12) Rehfisch *et al*. 1996; Disturbance: ***medium*** (10) Cutts *et al*. 2009; Threats: ***strong*** (15) Atkinson *et al*. 2010.
GAPS IN KNOWLEDGE	Oystercatchers have been well studied on The Wash. A repeat of the analysis found in Atkinson *et al*. 2010 with updated data would help plug recent knowledge gaps.
RECOMMENDATIONS	Strict protection and management of habitat and shellfish resources on WeBS sectors identified as holding a large proportion of the population in Ross-Smith *et al*. (2011).

4.1.6 Grey Plover (*Pluvialis squatarola*)

Grey Plover	
STATUS	No current concern: Population is not declining and has increased in the long-term. However, sector level trends are variable.
INFERRED DRIVERS OF CHANGE ON THE WASH	Over-exploitation of shellfish may contribute to Grey Plover population increase by increasing the abundance of food resources (worms). Reasons for sector level changes are unknown.
QUALITY OF EVIDENCE	Increased food abundance: ***strong*** (15) Atkinson *et al*. 2010.
POTENTIAL FUTURE ISSUES ON THE WASH	Sensitive to disturbance by walkers and dogs (medium impact). Habitat loss (especially because this species is very faithful to key roosts) (medium to high impact). Range shifts within Europe due to climate change (low impact). Loss of farmland habitat just outside the SPA which is used as roost site at high tides (medium impact)
QUALITY OF KNOWLEDGE	Diet: ***strong*** (15) Atkinson *et al*. 2010. Habitat: ***strong*** (12) Rehfisch *et al*. 1996; Disturbance: ***medium*** (10) Kirby *et al*. 1993; Threats: ***medium*** (8) Delany *et al*. 2009.
GAPS IN KNOWLEDGE	Lack of recent site-specific information.
RECOMMENDATIONS	No urgent conservation recommendations: this species' population is not small nor declining. Research into factors such as habitat use and disturbance around the Wash would be useful to help identify reasons for differing trends at sector levels.

4.1.7 Lapwing (*Vanellus vanellus*)

Lapwing	
STATUS	High Alert: Medium and short-term population declines, especially on the Lincolnshire side of The Wash. However, substantial increases have occurred in the long-term.
INFERRED DRIVERS OF CHANGE ON THE WASH	The declines on The Wash SPA are likely to have been caused by non-site specific reasons. Steep declines in breeding success have occurred in Western Europe as a result of agricultural intensification. Substantial increases in Lapwing numbers in Eastern England were linked to distributional change in the UK between 1974/5 and 2002/3, so any more recent changes may have led to declines on The Wash (though this has not been investigated). However, disturbance/mortality/habitat loss in the South Lincs. Shooting Zone has also been identified as a reason for declines in this area.
QUALITY OF EVIDENCE	Breeding declines: ***medium*** e.g. (11) Harris et al. 2014; recent distribution changes: ***weak*** (speculative). Disturbance/habitat loss in South Lincs. Shooting Zone: ***strong*** (13) Austin & Calbrade 2010.
POTENTIAL FUTURE ISSUES ON THE WASH	Agricultural intensification during the breeding season contributing to general declines for this species (high impact). Changes to wintering habitat including fields outside the SPA boundary (medium to high impact)
QUALITY OF KNOWLEDGE	Diet: ***medium*** (10) Shrubb 2007; Habitat: ***strong*** (13) Austin & Calbrade 2010. Disturbance: ***strong*** (13) Austin & Calbrade 2010; Threats: ***strong*** (12) Harris *et al*. 2014
GAPS IN KNOWLEDGE	Declines on the Lincolnshire side of The Wash should be explored, with studies of habitat use (inside and outside the SPA) and diet. General lack of site specific information on feeding and habitat use for The Wash. Little information on susceptibility to disturbance for this species.
RECOMMENDATIONS	Strict protection and management of feeding areas and roosting habitat in important WeBS sectors (both inside and outside the SPA boundary), and on the Lincolnshire side of The Wash where declines have occurred.

4.1.8 Knot (*Calidris canutus*)

Knot	
STATUS	No current concern. Medium term increase; otherwise stable. However, some indications of redistribution especially on the northern side of the Wash, where decreases have occurred in most sectors west of Benington and increases in most sectors east of Leverton.
INFERRED DRIVERS OF CHANGE ON THE WASH	Over-exploitation of shellfish was identified as a driver of Knot numbers on the Wash in the early 1990s, but current trends suggest this not had a long-term impact on numbers. Reasons for sector specific changes are unknown. Possible reasons include habitat loss and changes to habitat quality (e.g. increased grass length in some areas), as well as disturbance. This species is particularly susceptible to disturbance, especially from aircraft, and when at roost.
QUALITY OF EVIDENCE	Over-exploitation of shellfish: ***strong*** (15) Atkinson *et al*. 2010. Sector level changes: ***weak*** (speculative).
POTENTIAL FUTURE ISSUES ON THE WASH	Further habitat loss, especially since Knot need extensive areas of mudflats to feed (high impact). Susceptible to disturbance by walkers, aircraft and recreational activities especially at roost sites (high impact). Sensitive to overexploitation of shellfish (low to medium impact). Loss of farmland habitat just outside the SPA which is used as roost site at high tides (medium impact) Range shifts due to climate change (Medium impact).
QUALITY OF KNOWLEDGE	Diet: ***strong*** (15) Atkinson *et al*. 2010; Habitat: ***strong*** (11) N. Clark (pers. comm); Disturbance: ***strong*** (12) Burton *et al*. 2002a; Threats: ***strong*** (12) Burton *et al*. 2002a.
GAPS IN KNOWLEDGE	Lack of site-specific information on habitat use and disturbance.
RECOMMENDATIONS	Protect large areas of mudflat from further losses, regulate shellfish stocks, minimize disturbance close to large roosts. Protect farmland adjacent to SPA. Investigate reasons for redistribution at sector level.

4.1.9 Sanderling (*Calidris alba*)

Sanderling	
STATUS	No current concern. No overall change to numbers on The Wash SPA. Declines in all important sectors were noted in the sector trends. However, sector level trends were calculated at a time when site numbers dipped temporarily so this is not thought to be a major concern.
INFERRED DRIVERS OF CHANGE ON THE WASH	None
QUALITY OF EVIDENCE	N/A
POTENTIAL FUTURE ISSUES ON THE WASH	Disturbance by walkers and recreational activities, as the most important sectors are among the most disturbed (high impact). Protection of habitat outside the SPA especially the North Norfolk Coast (low to medium impact) (Numbers on The Wash are low so a small decline could represent a loss of a large proportion of the population)
QUALITY OF KNOWLEDGE	Diet: ***medium*** (11) Leopold *et al* 2004a, b; Habitat: ***strong*** (12) Kelly 2008; Disturbance: ***medium*** (11) Thomas *et al*. 2003; Threats: ***medium*** (11) Thomas *et al*. 2003.
GAPS IN KNOWLEDGE	Lack of up to date, site-specific information on susceptibility to disturbance and habitat use.
RECOMMENDATIONS	Identify and manage areas within and outside The Wash favoured by the small Sanderling population.

4.1.10 Dunlin (*Calidris alpina*)

Dunlin	
STATUS	Medium Alert: Long term declines across most of The Wash SPA. The only notable sector level increases were on the northern side of The Wash especially at Wainfleet.
INFERRED DRIVERS OF CHANGE ON THE WASH	The evidence suggests that the declines on The Wash probably result mainly from broad scale population changes rather than site-specific pressures, e.g. range shifts as a result of climate change, or breeding population declines. Habitat loss and encroachment by invasive grass may be a driver behind changes at the sector level. Site fidelity within The Wash leaves individuals vulnerable to changes in their favoured areas. However, other sector level drivers such as disturbance cannot be ruled out.
QUALITY OF EVIDENCE	Broad-scale changes: ***medium*** (11) Maclean *et al.* 2008; habitat loss: ***weak*** (speculative)
POTENTIAL FUTURE ISSUES ON THE WASH	Further broad-scale changes to wintering populations (High impact). Further losses to intertidal habitat (Medium to high impact). Disturbance to feeding areas (Low impact) Disturbance at roosting sites or loss of roosting sites including fields outside the SPA boundary (Medium impact).
QUALITY OF KNOWLEDGE	Diet: ***medium*** (11) Leopold *et al* 2004a, b; Habitat: ***medium*** (8) del Hoyo *et al*. 1996; Disturbance: ***strong*** (12) Burton *et al*. 2002a; Threats: ***strong*** (12) Burton *et al*. 2002a.
GAPS IN KNOWLEDGE	Lack of up to date, site-specific information on diet, habitat use, disturbance and threats.
RECOMMENDATIONS	Prevent further habitat loss in areas favoured by Dunlin and reduce disturbance nearby.

4.1.11 Black-tailed Godwit (*Limosa limosa*)

Black-tailed Godwit	
STATUS	No current concern. Substantial increases have occurred on The Wash SPA. Some declines were noted in sector level trends but these are not thought to be a major concern as wintering numbers are very variable and sector level trends were calculated at a time when site numbers dipped.
INFERRED DRIVERS OF CHANGE ON THE WASH	None
QUALITY OF EVIDENCE	N/A
POTENTIAL FUTURE ISSUES ON THE WASH	Slightly susceptible to disturbance by walkers (low impact). Any significant changes in habitat extent or quality may affect this species (medium impact).
QUALITY OF KNOWLEDGE	Diet: ***medium*** (9) Birdlife 2014; Habitat: ***medium*** (8) Delany *et al*. 2009; Disturbance: ***strong*** (12) Burton *et al*. 2002a; Threats: ***medium*** (9) Birdlife 2014.
GAPS IN KNOWLEDGE	Lack of up to date, site-specific information on diet, habitat use, disturbance and threats.
RECOMMENDATIONS	No urgent conservation recommendations: this species' population is not small nor declining. Further research to investigate why numbers fluctuate at a site level, and whether any drivers of the changes at sector level can be identified.

4.1.12 Bar-tailed Godwit (*Limosa lapponica*)

Bar-tailed Godwit	
STATUS	No current concern. Increasing trend for The Wash SPA. However, declines noted on the southern and south-eastern side of The Wash, and in the South Lincs. Shooting Zone, with increases between Wainfleet and Wrangle.
INFERRED DRIVERS OF CHANGE ON THE WASH	Reason for sector level changes unknown: Some declines have occurred in areas of high disturbance and some in areas where saltmarsh habitat has changed.
QUALITY OF EVIDENCE	Sector level changes: ***weak*** (speculative).
POTENTIAL FUTURE ISSUES ON THE WASH	Habitat loss due to changes to extent and quality of saltmarsh (medium impact) Increases in disturbance activity around The Wash SPA (medium impact) Range shifts due to climate change (medium impact) Loss of farmland habitat just outside the SPA which is used as roost sites (medium Impact).
QUALITY OF KNOWLEDGE	Diet: ***medium*** (11) Leopold *et al*. 2004a, b; Habitat: ***medium*** (9) Musgrove *et al*. 2003; Disturbance: ***medium*** (10) Kirby *et al*. 1993; Threats: ***medium*** (8) del Hoyo *et al*. 1996.
GAPS IN KNOWLEDGE	Lack of up to date, site-specific information on diet, habitat use, disturbance and threats.
RECOMMENDATIONS	No urgent conservation recommendations: this species' population is not small nor declining. Research into factors such as habitat use and disturbance around the Wash and reasons for differing trends at sector levels. Protection of habitat outside the SPA boundary.

4.1.13 Curlew (*Numenius arquata*)

Curlew	
STATUS	No current concern. Increasing trend for The Wash SPA. However, declines noted in Ouse Mouth, Terrington East and on the southern side of The Wash, with increases on the northern side.
INFERRED DRIVERS OF CHANGE ON THE WASH	Sector level changes may be linked to disturbance as this species is highly sensitive and declines have occurred in sectors thought to be subject to higher disturbance.
QUALITY OF EVIDENCE	Sector level changes: ***weak*** (speculative)
POTENTIAL FUTURE ISSUES ON THE WASH	Increases in disturbance activities around The Wash SPA (high impact). Range shifts due to climate change (low to medium impact). Changes to farmland habitat just outside the SPA which is used by Curlew for supplementary feeding and roosting (medium impact).
QUALITY OF KNOWLEDGE	Diet: ***medium*** (11) Leopold *et al*. 2004a, b; Habitat: ***medium*** (8) Delany *et al*. 2009; Disturbance: ***strong*** (12) Burton *et al*. 2002a; Threats: ***strong*** (12) Burton *et al*. 2002a.
GAPS IN KNOWLEDGE	Lack of up to date, site-specific information on diet, habitat use, disturbance and threats.
RECOMMENDATIONS	No urgent conservation recommendations: this species' population is not small nor declining. Research into habitat use by Curlew around the Wash and reasons for differing trends at sector levels. Protection of habitat outside the SPA boundary.

4.1.14 Redshank (*Tringa totanus*)

Redshank	
STATUS	Medium Alert: Decline since classification. Otherwise stable. However, declines in many WeBS sectors especially Dawsmere, Holbeach St. Matthew and Kirton.
INFERRED DRIVERS OF CHANGE ON THE WASH	A severe weather event, in 1990/91, just after classification caused high Redshank mortality on the site. Substantial declines to breeding populations have occurred in Britain and Europe. Reasons for sector specific changes are unknown. Redshank is highly sensitive to disturbance but declines have declined in many sectors including sectors not known to be subject to high disturbance.
QUALITY OF EVIDENCE	Severe weather: ***strong*** (13) Clark et al. 1993; Breeding declines: ***medium*** (11) Harris et al. 2014, (9) Delany et al. 2009; sector level changes: ***weak*** (speculative).
POTENTIAL FUTURE ISSUES ON THE WASH	Further long-term breeding declines (medium to high impact). Sensitive to disturbance and severe weather (high impact). Future habitat loss (medium impact). Future range shifts within Europe due to climate change (medium impact).
QUALITY OF KNOWLEDGE	Diet: ***medium*** (11) Leopold *et* a*l*. 2004a, b; Habitat: ***medium*** (8) Delany *et al*. 2009; Disturbance: ***medium*** (11) Mitchell *et al*. 2000; Threats: ***medium*** (8) del Hoyo *et al*. 1996.
GAPS IN KNOWLEDGE	Lack of up to date, site-specific information on diet, habitat use, disturbance and threats.
RECOMMENDATIONS	Minimize disturbance, particularly in cold weather.

4.1.15 Turnstone (*Arenaria interpres*)

Turnstone	
STATUS	High alert: Long-term decline. Variable trends at sector level: declines along Norfolk Coast and at The Wash NNR. Small, declining population concentrated on a small number of sites
INFERRED DRIVERS OF CHANGE ON THE WASH	Insufficient food resources within SPA especially in mid to late winter, leading to reliance on sites outside the SPA such as Sutton Docks. Sector level declines may be explained by the above driver, but other sector specific drivers may exist, e.g. disturbance is high is the sectors with declines (though this species is among the most tolerant).
QUALITY OF EVIDENCE	Insufficient food resources: ***strong*** (13) Smart & Gill 2003; Sector level changes: ***weak*** (speculative)
POTENTIAL FUTURE ISSUES ON THE WASH	Further changes to food resources (high impact). Disturbance (low impact). Future northerly range shifts due to climate change (low to medium impact)
QUALITY OF KNOWLEDGE	Diet: ***strong*** (14) Smart & Gill 2003; Habitat: ***strong*** (14) Smart & Gill 2003; Disturbance: ***medium*** (10) Cutts *et al*. 2009; Threats: N/A
GAPS IN KNOWLEDGE	Lack of up to date, site-specific information on diet, habitat use, disturbance and threats.
RECOMMENDATIONS	Identify and safeguard food resources used by Turnstone within The Wash SPA, manage habitat in preferred areas of The Wash for this species. Ensure sites outside the SPA boundary are protected (i.e. dock at Sutton Bridge Port).

4.2 Conclusions

The species conclusions above (4.1.1 – 4.1.15) aim to relate trends in waterbird numbers across and within The Wash SPA to activities and environmental changes that are candidates for drivers of population change. Some of these, such as global environmental change, might be impossible to mitigate at the local level, but nonetheless help account in part for observed changes. However, it may be possible to address other causes of change through appropriate site management.

Much of the information on potential drivers of change from the literature is at a much broader scale than the information from which WeBS sector-level waterbird trends are derived. Often such information describes the situation across The Wash as a whole and at best refers to one or two more precise locations, but certainly without a systematic treatment at a within site-level. This has impeded attempts to link

particular activities, habitat changes *etc*. to sector-level trends in waterbird numbers, and in turn reduces the confidence with which we can conclude that particular activities (even if known to affect waterbird numbers in general) are those driving observed changes on The Wash. So, for example, although we may know that there has been a change in prey abundance or composition near the mouth of the River Great Ouse, without knowing whether there have been similar changes, no changes, or different changes elsewhere, we cannot relate sector-level trends in bird numbers in that area to changes in prey in the same area, because changes elsewhere may be drawing birds away or forcing them towards those particular sectors.

Taking together the conclusions for individual species from above, some general statements can be made. The sector-level trends suggest changes have occurred to make some sectors more attractive than others for a range of species. There have been increases on Gedney in particular for most species. There are also several species where decreases have occurred on the Norfolk coast and between the Nene and the Great Ouse, whereas increases have generally occurred around the Welland and the North Lincolnshire coast (with the possible exception of the South Lincs. Shooting Zone). Disturbance takes place on many of the sectors showing general decreases, and habitat change has occurred in the South Lincs. Shooting Zone. However, we do not have enough knowledge about conditions on any of the sectors to have any confidence about what factors are causing these changes. For example, disturbance has not been measured, so we do not really know if it is lower at Gedney or along the northern side of The Wash, and we do not have sector level information about changes to habitat extent/quality or food resources. Similarly, we suspect that changes in saltmarsh accretion and grazing pressure may be affecting saltmarsh vegetation but there is a lack of systematic information for either of these underlying factors. In the case of grazing pressure, this is quite surprising as grazing would be a means of managing saltmarsh vegetation.

Whilst it is unquestionable that the habitats within the boundary of the SPA itself are of prime importance to waterbirds on The Wash, habitats outside the boundary are also of high importance to these same birds. The agricultural land behind the sea wall is essential in that it supports high tide roosts for the majority of waders, especially during spring tides. The nearby docks at Port Sutton Bridge are also vitally important to the Turnstone associated with the SPA.

It must not be forgotten that some of the waterbird declines of concern on The Wash may be, at least in part, due to broad-scale change such as population declines or re-distribution as a response to global change and as such unlikely to be reverse by site management. This may well be the case for Mallard, Lapwing, Dunlin and possibly Pintail and Redshank. However, although some trends may appear to be following broader scale changes, it is possible that this is coincidental and local drivers of change are important in some cases. Where waterbird numbers on the site are driven by external changes, less suitable areas within The Wash would be expected to be the first to lose birds. Consequently, numbers will decline on those areas even if pressures on them or across the site as a whole were unchanging. However, if local pressures are driving loss of numbers in particular areas, we would expect a relationship between changes in numbers and changes in those pressures. It therefore follows that information on habitat change, food resources and disturbance, are required at a resolution that can be matched to sector-level trends in waterbird numbers, in order to fully understand the reasons behind the waterbird declines that have been identified.

Thus most of the gaps in knowledge for individual species relate to a lack of detailed information on habitat, disturbance and food resources at a resolution approaching that of the waterbird count data. There is clearly a wealth of local knowledge and expertise that could further contribute to our understanding of issues on The Wash. However, much of this does not feature in the literature, peer reviewed or otherwise. The address this, a questionnaire / interview based survey to collate local knowledge and canvass expert and stakeholder opinion is recommended, as this approach has the potential to fill in many of the knowledge gaps that are apparent from our literature review and from the paucity of populated cells in the cross-tabulation of sector-level waterbird trends with potential drivers of change (Table 8). Aside from site managers and other professional stakeholders, all of whom would have useful knowledge to contribute, the site plays host an active wildfowling presence. The Wash Wader Ringing

Group is also active throughout the year and conducts specialist studies alongside long-term bird ringing and re-sighting, and The Wash is monitored by the WeBS counters. Members of all these groups include those with a long association with the site and a genuine "feel" for what has changed and how this has affected the waterbirds at the finer scale.

References

Andresen, H., Dorresteijn, I. & van der Meer, J. 2013. Growth and size-dependent loss of newly settled bivalves in two distant regions of the Wadden Sea. *Marine Ecology Progress Series* **472**, 141-154.

APEM. 2013. *The Wash and North Norfolk Coast SAC: Intertidal mud and sand flats assessment*. APEM Scientific Report 412317.

Atkinson, P.W., Clark, J.A. & Clark, N.A. 2000. *The effects of changes in shellfish stocks and winter weather on shorebird populations: the results of a 30-year study on The Wash, England*. BTO Research Report No. 238, BTO, Thetford.

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

Atkinson, P.W. 2010. The origins, moult, movements and changes in numbers of Bar-tailed Godwits *Limosa lapponica* on The Wash, England. *Bird Study* **43**, 60-72.

Atkinson P.W., Maclean I.M.D. & Clark N.A. 2010. Impacts of shellfisheries and nutrient inputs on waterbird communities in The Wash, England. *Journal of Applied Ecology* **47**, 191–199.

Ausden, M., Badley, J. & James, L. 2005. The effect of introducing cattle grazing to saltmarsh on densities of breeding Redshank Tringa totanus at Frampton Marsh RSPB reserve, Lincolnshire, England. Conservation Evidence **2**: 57–59.

Austin, G.E., Calbrade, N.A., Mellan, H.J., Musgrove, A.J., Hearn, R.D., Stroud, D.A., Wotton, S.R. & Holt, C.A. 2014. *Waterbirds in the UK 2012/13: The Wetland Bird Survey*. BTO/RSPB/JNCC, Thetford. http://www.bto.org/volunteer-surveys/webs/publications/webs-annual-report

Austin, G.E. & Calbrade, N.A. 2010. *Within-Site Waterbird Trends Relative to Whole-Site and Regional Population Trends: The South Lincs. Shooting Zone on The Wash SPA*. BTO Research Report No. 548, BTO, Thetford.

Austin, G.E & Rehfisch, M.M. 2005. Shifting nonbreeding distributions of migratory fauna in relation to climate change. Global Change Biology **11**: 31-38.

Bailey, M. 2004. *An overview of environmental quality in The Wash and its tributary estuaries*. Ecomaris Ltd, Lincoln on behalf of the Environment Agency.

Balmer, D.E., Gillings, S., Caffrey, B.J., Swann, R.L., Downie, I.S. & Fuller, R.J. 2013. *Bird Atlas 2007-11: the breeding and wintering birds of Britain and Ireland*. BTO Books, Thetford.

Beintema, A., Moedt, O. & Ellinger, D. 1995 Ecologische Atlas van de Nederlandse Weidevogels. Schuyt and Co, Haarlem.

BirdLife International. 2014. IUCN Red List for birds. Downloaded from http://www.birdlife.org on 30/09/2014.

Black & Veatch Ltd. 2008. *The implications of coastal change on Natura 2000 features of the lagoons at Easington*. Report to Environment Agency.

Bradley, J. & Allcorn, R.I. 2006. Changes in bird use following the Managed Realignment at Freiston Shore RSPB Reserve, Lincolnshire, England. *Conservation Evidence* **3**: 102-105.

BRIG. 2010. *UK Biodiversity Action Plan; Priority Habitat Descriptions 2008* (updated 2010) (ed. Ant Mattock). Online reference in Hartwell (2011) (link unavailable).

BTO. 2014. *BTO BirdFacts*. http://www.bto.org/about-birds/birdfacts (accessed on 30/09/2014).

Burger, J. & Gochfeld, M. 1991. Human activity influence and diurnal and nocturnal foraging of Sanderlings (Calidris alba). *Condor* **93**: 259-265.

Burton, N.H.K. 2006. *The impact of the Cardiff Bay barrage on wintering waterbirds*. In: Boere, G., Galbraith, C., Stroud, D. (ed.), Waterbirds around the world, pp. 805. The Stationary Office, Edinburgh, UK.

Burton, N.H.K., Evans, P.R., Robinson, M.A. 1996. Effects on shorebird numbers of disturbance, the loss of a roost site and its replacement by an artificial island at Hartlepool, Cleveland. *Biological Conservation* **77**, 193-201.

Burton, N.H.K., Rehfisch, M.M. & Clark, N.A. 2002a. Impacts of disturbance from construction work on the densities and feeding behavior of waterbirds using the intertidal mudflats of Cardiff Bay, UK. *Environmental Management* **30**, 865-871.

Burton, N.H.K., Paipai, E., Armitage, M.J.S, Maskell, J.M., Jones, E.T., Struve, J., Hutchings, C.J., Rehfisch, M.M. 2002b. *Effects of reductions in organic and nutrient loading on bird populations in estuaries and coastal waters of England and Wales Phase 1 Report March 2002*. BTO Research Report No. 267, BTO, Thetford.

Caldow, R.W.G., Goss-Custard, J.D., Stillman, R.A., Durell, S.E.A.le V. dit, Swinfen, R. & Bregnballe, T. 1999. Individual variation in competitive ability of interference-prone foragers: the relative importance of foraging efficiency and susceptibility to interference, *J. Anim. Ecol.*

Cayford, J.T. 1993. Wader disturbance: a theoretical overview. Wader Study Group Bulletin **68**, 3-5.

Centrica 2011. *Lincs. Offshore Windfarm Saltmarsh Cable Crossing*. Information Sheet.

Clark, J.A., Baillie, S.R., Clark, N.A., Langston, R.H.W. 1993. *Estuary wader capacity following severe weather mortality*. BTO Research Report No. 103, BTO, Thetford.

Cramp, S. & Simmons, K.E.L. 1977. *Handbook of the birds of Europe, the Middle East and Africa. The birds of the western Palearctic, vol. I: ostriches to ducks*. Oxford University Press, Oxford.

Colwell, M.A. 2010. *Shorebird Ecology, Conservation and Management*. University of California Press. Berkeley/Los Angeles/London.

Connor, David W., Allen, James H., Golding, Neil., Howell, Kerry L., Lieberknecht, Louise M., Northen, Kate O., and Reker Johnny B. (2004) *The Marine Habitat Classification for Britain and Ireland* Version 04.05. JNCC, Peterborough ISBN 1 861 07561 8 (internet version) www.jncc.gov.uk/MarineHabitatClassification

Cook, A.S.C.P., Barimore, C., Holt, C.A., Read, W.J. & Austin, G.E. 2013. *Wetland Bird Survey Alerts 2009/2010: Changes in numbers of wintering waterbirds in the Constituent Countries of the United Kingdom, Special Protection Areas (SPAs) and Sites of Special Scientific Interest (SSSIs)*. BTO Research Report No. 641, BTO, Thetford. http://www.bto.org/volunteer-surveys/webs/publications/webs-annual-report (accessed 3 October 2014).

Cramp, S. & Simmons, K.E.L. (eds). 1983. *Handbook of the Birds of Europe, the Middle East and North Africa. Vol. III: Waders to Gulls*. Oxford University Press.

Cutts, N. & Allen, J. 1999. *Avifaunal Disturbance Assessment: Flood Defence Work, Saltend*. Report to Environment Agency, by Institute of Estuarine and Coastal Studies, University of Hull.

Cutts, N., Phelps, A & Burdon, D. 2009. *Construction and Waterfowl: Defining sensitivity, Response, Impacts and Guidance*. Institute of Estuarine and Coastal Studies, University of Hull.

Dare, P.J., Bell, M.C., Walker, P. & Bannister, R.C.A. 2004. *Historical and current status of Cockle and Mussel stocks in The Wash*. CEFAS Lowestoft, 85pp.

Davidson, N.C. & Rothwell, P.I. 1993. Human disturbance to waterfowl on estuaries: conservation and coastal management implications of current knowledge. Wader Study Group Bulletin **68**, 97-106.

Delany, S., Scott, D., Dodman, T. & Stroud, D. (eds) 2009. *An atlas of wader populations in Africa and Western Eurasia*. Wetlands International. Wageningen, The Netherlands.

Del Hoyo, J., Elliot, A. & Sargatal, J. 1992. *Handbook of the Birds of the World, vol. 1: Ostrich to Ducks*. Lynx Edicions, Barcelona, Spain.

Del Hoyo, J., Elliott, A. & Sargatal, J. 1996. *Handbook of the Birds of the World, vol. 3: Hoatzin to Auks*. Lynx Edicions, Barcelona, Spain.

Duijns, S., Hidayati, N.A. & Piersma, T. 2013. Bar-tailed Godwits *Limosa l. lapponica* eat polychaete worms wherever they winter in Europe. *Bird Study* **60**, 509-517.

Duijns, S. & Piersma, T. 2014. Interference competition in a sexually dimorphic shorebird: prey behaviour explains intraspecific competition. *Animal Behaviour* **92**, 195-201.

Durell, S.E.A. le V. Dit, & Kelly C.P. 1990. Diets of Dunlin *Calidris alpina* and Grey Plover *Pluvialis squatarola* on The Wash as determined by dropping analysis. *Bird Study* **37**, 44-47.

Durell, S.E.A.L.D. & Atkinson, P.W. 2004. Differential distribution of Oystercatchers *Haematopus ostralegus* overwintering on The Wash, east England. *Bird study* **51**, 76-82.

Earll, R.C. (ed.) 2001. *Shellfish and birds populations in The Wash. Population declines in the 1990s. Wash Forum, 2001*. Review of the Research and Proceedings of The Wash Forum Conference.

Ens, B.J. & Cayford, J.T. 1996. '*Feeding with other Oystercatchers*' in Goss-Custard, J.D. (ed.) The Oystercatcher. From Individuals to Populations. Oxford. Oxford University Press, 77-104.

Environment Agency. 2008. *Freiston Shore managed realignment site. Information sheet no. 1 (April 2008).* Environment Agency Shoreline Management Group. Peterborough.

Environment Agency. 2010. *The Wash Shoreline Management Plan*: Hunstanton to Gibraltar Point. http://www.eacg.org.uk/smp4.asp

Enviromuir. 2009. *Wash intertidal report*. Report for Natural England.

Evans, P.R. 1986. Use of the herbicide 'Dalapon' for control of spartina encroaching on intertidal mudflats: beneficial effects on shorebirds. *Colonial Waterbirds* **9**,: 171-175.

Freiss, D., Möller, I. & Spencer, T. 2008. Case Study: *Managed Realignment and the Re-establishment of Saltmarsh Habitat, Freiston Shore, Lincolnshire, United Kingdom*. in *The Role of Environmental Management and Eco-Engineering in Disaster risk Reduction and Climate Change Adaptation*. ProAct Network.

Gill, J.A. 2006. *Movements and migration of colour-ringed Black-tailed Godwits* in Wash Wader Ringing Group 2004-2005 Report. Wash Wader Ringing Group. UK.

Gillings, S., Austin, G.E., Fuller, R.J. & Sutherland, W.J. 2006. Distribution shifts in wintering Golden Plover *Pluvialis apricaria* and Lapwing *Vanellus vanellus* in Britain. *Bird Study* **53**, 274–284.

Goss-Custard J.D., Jones R.E. & Newbery P.E. 1977. The ecology of The Wash: I Distribution and diet of wading birds (charadrii). *Journal of Applied Ecology* **14**, 681-700.

Goss-Custard, J.D. & Moser, M.E. 1988. Rates of change in the numbers of Dunlin, Calidris alpina wintering in British estuaries in relation to the spread of Spartina anglica. *J. Appl. Ecol*. **25**, 95-109

Goss-Custard, J.D., McGrorty, S. & Durell, S.E.A. le V. Dit. 1996. The effect of oystercatchers *Haematopus ostralegus* on shellfish populations. *Ardea* **84**, 453-468.

Goss-Custard JD, Stillman RA, West AD, Caldow RWG, Triplet P, Durell SEA le V dit, McGrorty S. 2004. When enough is not enough: shorebirds and shellfishing. *Proc R Soc Lond B* **271**, 233–237.

Harris, S., Risely, K., Massimino, D., Newson, S.E., Eatonm M.A., Musgrove, A.J., Noble, D.G., Procter, D. & Baillie, S.R. 2014. *The Breeding Bird Survey 201*3. BTO Research Report 658.

Hartwell, V. 2011. *Wash Biodiversity Action Plan. Ensuring the Wash remains a special place, for people and wildlife, for generations to come*. The Wash Estuary Project. Spalding.

Heinen, F. 1986. *Untersuchung über den Einfluss des Flugverkehrs auf brütende und rastende Küstenvögel an ausgewählten Stellen des niedersächsischen Wattenmeergebietes*. Unpublished report (Diplomarbeit). University Essen.

Hemphill, P., Whittle, A. & Meakins, N. 2003. *NVC Survey of Saltmarsh and Other Habitats in The Wash European Marine Site*. English Nature. Peterborough.

Hill, M.J. 1988. *Saltmarsh vegetation of The Wash. An Assessment of Change from 1971 to 1985*. Nature Conservancy Council, Peterborough.

Hill, D.A., Hockin, D., Price, D., Tucker, G., Morris, R. 1997. Bird disturbance: Improving the quality of disturbance research. *Journal of Applied Ecology* **34**, 275-288.

Hirons, G. & Thomas, G. 1993. Disturbance on estuaries: RSPB Nature Reserve experience. *Wader Study Group Bulletin* **68**, 72-78.

Horwood, J.W. & Goss-Custard, J.D. 1977. Predation by the oystercatcher, *Haematopus ostralegus* (L.) in relation to the Cockle *Cerastoderma edule* (L.) fishery in the Burry Inlet, South Wales. *Journal of Applied Ecology* **14**, 139-158.

Hulscher, J.B. 1996. Food and feeding behaviour. In Goss-Custard, J.D. (ed.). *The Oystercatcher. From Individuals to Populations*. Oxford. Oxford University Press, pp7-30.

IPCC. 2007. *Fourth Assessment Report: Climate Change*
. http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

Jessop, R.W., Hinni, S., Skinner, J. & Woo J. R. 2010. Eastern IFCA Research Report 2010.

Jessop, R.W., & Maxwell, E. 2011. Eastern IFCA Research Report 2011.

Jessop, R.W., Strigner, R., Thompson, S., & Welby, P.R. 2013. Eastern IFCA Research Report 2013.

JNCC 2008. Information Sheet on Ramsar Wetlands (RIS). Version 3.0, 13/06/2008. Joint Nature Conservation Committee. Downloaded from http://jncc.defra.gov.uk/pdf/ris/uk11072.pdf on 15/10/2014.

JNCC 2014. UK SPA data form for The Wash, Joint Nature Conservation Committee. Downloaded from http:// jncc.defra.gov.uk/pdf/SPA/UK9008021.pdf on 02/10/2014.

Johnsgard, P.A. 1978. *Ducks, geese and swans of the World*. University of Nebraska Press, Lincoln and London.

Johnsgard, P.A. 1981. *The plovers, sandpipers and snipes of the world*. University of Nebraska Press, Lincoln, U.S.A. and London.

JNCC 2014. UK SPA data form for The Wash, Joint Nature Conservation Committee. Downloaded from http:// jncc.defra.gov.uk/pdf/SPA/UK9008021.pdf on 02/10/2014.

Kear, J. 2005a. *Ducks, geese and swans volume 1: general chapters; species accounts (Anhima to Salvadorina).* Oxford University Press, Oxford, U.K.

Kear, J. 2005b. *Ducks, geese and swans. volume 2: Species Accounts (Cairina to Mergus).* Oxford University Press, Oxford, U.K.

Kelin, C. & Qiang, X. 2006. *Conserving migratory shorebirds in the Yellow Sea region*. In: Boere, G.; Galbraith, C., Stroud, D. (ed.), *Waterbirds around the world*, pp. 319. The Stationery Office, Edinburgh, UK.

Kelly, C. 2008. S*anderling Studies on the Wash.* In Wash Wader Ringing Group 2006-2007 Report. Wash Wader Ringing Group. UK.

Kennedy, K. & Holmes, S. 2004. *The Wash Estuary Management Plan 2nd Revised Edition 2004*. Report produced for the Wash Energy Strategy Group.

Kirby, J.S., Clee, C. & Seager, V. 1993. Impact and extent of recreational disturbance to wader roosts on the Dee Estuary: Some preliminary results. *Wader Study Group Bulletin* **68**, 53-58.

Koepff, C. & Dietrich, K. 1986. Störungen von Küstenvögeln durch Wasserfahrzeuge. *Vogelwarte* **33**, 232-248.

Koolhas, A., Dekinga, A & Piersma, T. 1993. Disturbance of foraging Knots by aircraft in the Dutch Wadden Sea in August – October 1993. *Wader Study Group Bulletin* **68**, 20-22.

Leopold, M.F., Dijkman, E.M., Cremer, J.S.M., Meijboom, A. & Goedhart, P.W. 2004a. *De effecten vanmechanische kokkelvisserij op de benthische macrofauna en hun habitat. Eindverslag EVA II (Evaluatie Schelpdiervisserij tweede fase).* Deelproject C1 ⁄ 3. Alterra rapport 955. Alterra, Wageningen, The Netherlands.

Leopold, M.F., Smit, C.J., Goedhart, P.W., van Roomen, M., van Winden, A.J. & van Turnhout, C. 2004b. *Langjarige trends in aantallen wadvogels in relatie tot de kokkelvisserij en het gevoerde beleid in deze.* Eindverslag EVA II (Evaluatie schelpdiervisserij tweede fase). Deelproject C2. Alterra rapport 954; SOVON onderzoeksrapport 2004 ⁄ 07. Alterra, Wageningen, The Netherlands.

Maclean, I.L.M.D, Austin, G.E, Rehfisch, M.M., Blew, J., Crowe, O., Delany, S., Devos, K., Deceuninck, B., Gunther, K., Laursen, K., Van Roomen, M., & Wahl, J.S. 2008. Climate change causes rapid changes in the distribution and site abundance of birds in winter. *Global Change Biology* **14**, 2489–2500

Madge, S. & Burn, H. 1988. Wildfowl. Christopher Helm, London.

Meire, P.M., Schekkerman, H. & Meininger, P. 1994. Consumption of benthic invertebrates by waterbirds in the Oosterschelde estuary, SW Netherlands. *Hydrobiologia* **282/283**, 525-546.

Meltofte, H., Blew, J., Frikke, J., Rösner, H.-U. & Smit., C.J. 1994. Numbers and distribution of waterbirds in the Wadden Sea. Results and evaluation of 36 simultaneous counts in the Dutch-German-Danish Wadden Sea 1980 - 1991. IWRB Publication 34/Wader Study Group Bull. 74, Special issue.

Minton, T. 1978. The migration and mortality of Curlews in Britain and Ireland. *Bird Study* **25**, 39-50.
Mitchell, P.I., Scott, I. & Evans, P.R. 2000. Vulnerability to severe weather and regulation of body mass of Icelandic and British Redshank. *Journal of Avian Biology* **31,** 511-521.

Mossman, H.L., Davy, A.J., Grant, A. 2012. Does managed coastal realignment create saltmarshes with 'equivalent biological characteristics' to natural reference sites? *Journal of Applied Ecology* **49:6**, 1446-1456.

Musgrove, A.J., Langson, R.H.W., Baker, H. & Ward, R.M. (eds). 2003. *Estuarine waterbirds at low tide: The WeBS Low Tide Counts 1992/93 to 1998/99*. WSG/BTO/WWT/RSPB/JNCC. Thetford.

Natural England. 2008. *Conservation Objectives and Definitions of Favourable Condition for Designated Features of Interest*. The Wash SSSI. Natural England, Grantham.

Natural England 2010a. *Generic plan for recreational activities causing disturbances in European marine sites*. Report to Defra.

Natural England 2010b. *European marine site risk review - The Wash and North Norfolk Coast site plan*. Report to Defra. Natural England, Sheffield.

NCP (2014) Visitor Management Strategy Zones. Norfolk Coast Partnership. Online. Viewed at http://www.norfolkcoastaonb.org.uk/pages/pspage.php?PageID=157 on 16/10/2014.

Pethick. 2002. Coastal Data Analysis: *The Wash. Study 3: long-term intertidal profile evolution modelling*. Report to Environment Agency.

Pfister, C., Harrington, B.A. & Lavine, M. 1992. The impact of human disturbance on shorebirds at a migration staging area. *Biological Conservation* **60**: 115-126.

Piersma, T. 1994. *Close to the edge. Energetic bottlenecks and the evolution of migratory pathways* in Knots. De Volharding. Amsterdam.

Piersma, T. 2006 *Migration in the balance: tight ecological margins and the changing fortunes of seabird populations*. In Boere, G.C., Galbraith, C.A. & Stroud, D.A. (Eds). *Waterbirds around the world*. The Stationary Office. Edinburgh.

Piersma, T., Hoekstra, R., Dekinga, A., Koolhas, A., Wolf, P., Battley, P. & Wiersma, P. 1993. Scale and intensity of intertidal habitat use by Knots Calidris canutus in the western Wadden Sea in relation to food, friends and foes. Netherlands Journal of Sea Research **31**: 331–357.

Piersma, T., van Gils, J., de Goeij, P. & van der Meer, J. 1994a. *Signals from the sediment: does Holling's functional response model adequately describe the intake rate of probe-feeding Knots*. In Piersma, T. Close to the edge. *Energetic bottlenecks and the evolution of migratory pathways in Knots*. De Volharding. Amsterdam.

Piersma, T., Hoekstra, R., Dekinga, A., Koolhas, A., Wolf, P., Battley, P. & Wiersma, P. 1994b. *Scale and intensity of intertidal habitat use by Knots Calidris canutus in the western Wadden Sea in relation to food, friends and foes*. In Piersma, T. Close to the edge. *Energetic bottlenecks and the evolution of migratory pathways in Knots*. De Volharding. Amsterdam.

Piersma, T., van Aelst, R., Kurk, K., Berkhoudt, H. & Maas, L.R.M. 1998. A new pressure sensory mechanism for prey detection in birds: the use of principles of seabed dynamics? *Proc. Royal. Soc. Lond. B* **265**: 1377-1383.

Posford Duvivier. 1997. *Wash extended shoreline evolution analysis.* Report to Environment Agency

Pye, K. 1995. Controls on long-term Saltmarsh Accretion and Erosion in The Wash, Eastern England. *Journal of Coastal Research* **11:2**, 337-356.

Quaintenne, G., van Gils, J.A., Bocher, P., Dekinga, A. & Piersma, T. 2011. Scaling up ideals to freedom: are densities of Red Knot across western Europe consistent with ideal free distribution? *Proc. R. Soc. B*. doi:10.1098/rspb.2011.0026.

Rehfisch, M.M., Clark, N.A., Langston, R.H.W. & Greenwood, J.J.D. 1996. A Guide to the Provision of Refuges for Waders: An Analysis of 30 Years of Ringing Data from the Wash, England. *Journal of Applied Ecology* **33**, 673-687.

Rehfisch, M.M., Austin, G.E., Freeman, S.N., Armitage, M.J.S. & Burton, N.H.K. 2004. The possible impact of climate change on the future distribution and numbers of waders on Britain's non-estuarine coast. *Ibis* **146**, 70-81.

Reneerkens, J., Benhoussa, A., Boland, H., Collier, M., Grond, K., Günther, K., Hallgrimsson, G.T., Hansen, J., Meissner, W., de Meulenaer, B., Ntiamoa-Baidu, Y., Piersma, T., Poot, M., van Roomen, M., Summers, R.W., Tomkovich, P.S. & Underhill, L.G. 2009. Sanderlings using African-Eurasian flyways: a review of current knowledge. *Wader Study Group Bulletin* **116**: 2-20.

Riddington, R., Hassall, M., Lane, S.J., Turner, P.A. 1996. the impact of disturbance on the behaviour and energy budgets of Brent Geese *Branta b. bernicla*. *Bird Study* **43**, 269-279

Ross-Smith, V.H., Calbrade, N.A. & Austin, G.E. 2011. *Analysis of Wetland Bird Survey (WeBS) data for The Wash SSSI/NNR*. BTO Research Report No. 587, BTO, Thetford.

Sauter, A., Korner-Nievergelt, F., Jenni, L. 2010. Evidence of climate change effects on within-winter movements of European Mallards *Anas platyrhynchos*. *Ibis* **152**, 600-609.

Scheiffarth, G. 2001. Bar-tailed Godwits (Limosa lapponica) in the Sylt-Rømø Wadden Sea: which birds, when, from where, and where to? *Vogelwarte* **41**: 53-69.

Scott, D. A. & Rose, P. M. 1996. *Atlas of Anatidae populations in Africa and western Eurasia*. Wetlands International, Wageningen, Netherlands.

Shepherd, P.C.F. & Lank, T.B. 2004. Marine and agricultural habitat preferences of Dunlin wintering in British Columbia. *Journal of Wildlife Management* **68**, 61-73.

Shrubb, M. 2007. *The Lapwing*. T&AD Poyser. London.

Simpkin, A. 2006. *Lincolnshire Biodiversity Action Plan 2nd Edition*. Lincolnshire Wildlife Trust, Horncastle.

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

Smart, J. 2006. *Colour-ringing as a means of monitoring Turnstone on the Wash*. In Wash Wader Ringing Group 2004-2005 Report. Wash Wader Ringing Group. UK.

Smit, C.J. & Visser, G.J.M. 1985. *Studies on the effects of military activities on shorebirds in the Wadden Sea*. Proc. CCMS-Seminar of flora and fauna in the military training areas, 1984. Soesterberg. The Netherlands: 34-51.

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

Snow, D.W. & Perrins, C.M. 1998. *The Birds of the Western Palearctic vol. 1: Non-Passerines*. Oxford University Press, Oxford.

Stillman, R.A., Atkinson, P.W. & Clark, N.A. 2004. *Assessing the impacts of shell-fishing and mussel farming on oystercatcher populations in the Wash, England. Phase 1: identification of model parameters to be refined*. BTO Research Report 354. BTO. Thetford.

Stillman, R.A. and Goss-Custard, J.D. 2010. Individual-based ecology of coastal birds. *Biological Reviews* **85**, 413-434.

Stock, M. 1993. Studies on the Effects of Disturbance on Staging Brent Geese: a Progress Report. *Wader Study group Bulletin* **68**, 29-34.

Stroud, D.A., Chambers, D., Cook, S., Buxton, N., Fraser, B., Clement, P., Lewis, P., McLean, I., Baker, H. & Whitehead, S. (eds). 2001. *The UK SPA network: its scope and contents*. JNCC, Peterborough.

Sutherland, W.J., Ens, B.J., Goss-Custard, J.D. & Hulscher, J.B. 1996. Specialization. In Goss-Custard, J.D. (ed.) *The Oystercatcher*. From Individuals to Populations. Oxford. Oxford University Press, pp56-76.

Swennen, C., Leopold, M.F. & de Bruijn, L.L.M. 1989. Time-stressed oystercatchers, *Haematopus ostralegus*, can increase intake rate. *Anim. Behav*. **38**, 8-22.

Thomas, K. 2014. Managed Realignment in the UK: Role of the Environment Agency. In Esteves, L.S. *Managed Realignment: A viable long-term Coastal Management Strategy?* 83-94

Thomas, K., Kvitek, R.G. & Bretz, C. 2003. Effects of human activity on the foraging behavior of sanderlings *Calidris alba*. *Biological Conservation* **109**, 67-71.

Townshend, D.J. 1981. The Importance of Field Feeding to the Survival of Wintering Male and Female Curlews *Numenius arquata* on the Tees Estuary. *Feeding and Survival Strategies of Estuarine Organisms. Marine Science* **15**: 261-273

Townshend, D.J. & O'Connor, D.A. 1993. Some effects of disturbance to waterfowl from bait-digging and wildfowling at Lindisfarne National Nature Reserve, north-east England. *Wader Study Group Bulletin* **68**, 47-52.

Urban, E.K., Fry, C.H.; &Keith, S. 1986. *The birds of Africa vol. II*. Academic Press, London.

Van der Meer, J. 1985. *De verstoring van vogels op de slikken van de Oosterschelde*. Report 85.09 Deltadienst Milieu en Inrichting, Middelberg.

Vickery, J. A. & Gill, J. A. 1999. Managing grassland for wild geese in Britain: a review. *Biological Conservation* **89**: 93-106.

Visser, G. 1986. *Verstoring en reacies van overtijende vogels op de Noordvaarder (Terschelling) in samenhang met de omgeving*. RIN report 86/17, Texel. The Netherlands.

WEMP 1996. *Wash Estuary Management Plan June 1996*. Report produced for the Wash Energy Strategy Group.

Wernham, C. V., Toms, M. P., Marchant, J., Clark, J.A., Siriwardena, G.M. & Baillie, S.R. (Eds) 2002. *The Migration Atlas: Movements of the Birds of Britain and Ireland*. T&D Poyser. London.

West A.D., Durell, S.E.A. le V. Dit, & Gray, C. 2006. *Severn Estuary Bird Food Monitoring - Phase 1. Report to CCW*. CEH, Dorset.

WWRG (2006) Wash Wader Ringing Group Report 2004-2005. Wash Wader Ringing Group. UK.

WWRG (2012) Wash Wader Ringing Group Report 2010-2011. Wash Wader Ringing Group. UK.

WWRG (2014) Wash Wader Ringing Group Report 2012-2013 (draft in prep). Wash Wader Ringing Group. UK.

WWT (2014) Dark-bellied Brent Goose Branta bernicla bernicla. Online at http://monitoring.wwt.org.uk/our-work/goose-swan-monitoring-programme/species-accounts/dark-bellied-brent-goose/ viewed on 29/08/2014. Wildfowl and Wetlands Trust.

Yates M. G., Garbutt R. A., Barratt D. R., Turk A., Brown N. J., Rispin W. E., McGrorty S., le Vdit Durell S. E., Goss-Custard J. D., Murray E. & Russell D. 2002. *Littoral sediments of The Wash and North Norfolk Coast SAC: The 1998 and 1999 surveys of intertidal sediments and invertebrates*. CEH, Dorset and English Nature, Peterborough.

Yates, M., Rispin, E., Garbutt, A., Turk, T., Bellamy, P., Walker, K. & Brown, N. 2007. *National Environment Programme: Monitoring of the Denver Licence. The 2006-2007 Surveys of Inter-tidal Sediments, Invertebrates and Birds of the S.E. Wash*. Centre of Ecology and Hydrology, Huntingdon.

Zwarts, L. & Blomert, A.M. 1992. Why Knot *Calidris canutus* take medium-sized *Macoma balthica* when six prey species are available. *Marine Ecology Progress Series* **83**, 113-128.

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