Annex 35.6

Spatial and Temporal Patterns in Black-Tailed Godwit use of the Humber Estuary, with Reference to Historic Planning and Development at Killingholme Pits

(Dr. S. Percival)

SPATIAL AND TEMPORAL PATTERNS IN BLACK-TAILED GODWIT USE OF THE HUMBER ESTUARY, WITH REFERENCE TO HISTORIC PLANNING AND DEVELOPMENT AT KILLINGHOLME PITS

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November 2011

Client: Able UK.

Table of Contents

Executive Summary

Able UK is proposing to develop Able Marine Energy Park (AMEP) at Killingholme on the south bank of the Humber Estuary, which includes a quay and deep water port facilities to support the offshore renewable energy industry. Black-tailed Godwit has been identified as one of the key bird species that could be affected by this development. North Killingholme Haven Pits is the most important high tide roost for this species on the Humber Estuary and the foreshore in this area is one of their more important feeding areas.

The work reported here comprises a desk study to collate relevant information available on the numbers and distribution of Black-tailed Godwits in the Humber Estuary SPA, their potential susceptibility to disturbance and their habitat use.

Black-tailed Godwit is a widespread species but one that has declined rapidly in recent years. This decline has however been restricted to only some parts of the range, and the sub-species that uses the Humber Estuary (the Icelandic Black-tailed Godwit) has shown the opposite trend. Numbers in the UK have increased markedly over the last 20 year and this increase has been reflected in the numbers using the Humber Estuary.

The Humber Estuary is of primary importance to Black-tailed Godwits as a post-breeding moult site, with numbers reaching a peak during the autumn, though there is also a smaller number present through the winter and spring. The large majority (an average of 85% of the peak count over the last 5 years) of these birds use the North Killingholme Haven Pits as a roost over the high tide period, though on neap tides some birds remain on their feeding areas at high tide, particularly at Pyewipe and there has been increasing use documented of the recent managed realignment areas, both as roosting and feeding areas, particularly at Paull Holme Strays.

Feeding Black-tailed Godwits on the Humber are found mostly on the intertidal area at Killingholme and further to the south-east at Pyewipe. The new managed realignment sites on the Estuary have become important areas for this species, including at Paull Holme Strays.

The increase in Black-tailed Godwit numbers on the Humber and specifically at North Killingholme Haven Pits has been coincident with continuing industrialisation of the land adjacent to the Pits, without any apparent adverse effect on the birds' use of the Pits. All of these developments have however retained the open character of the Pits to the seaward eastern side, allowing the godwits and other roosting waders a clear flight line into the pits from their feeding areas on the shore to the south-east and from the north bank across the Humber. The birds other current main feeding area at Pyewipe is also heavily industrialised.

The AMEP development would result in the direct loss of 31.5ha of mudflat; indirect changes result in an additional net loss of 6.5ha. The mudflat is currently relatively heavily used by the Black-tailed Godwits as a foraging resource. Detailed counts through the tidal cycle have

reported a mean of 62 godwits in the development area and a further 11 on the adjacent mudflat that could be affected by disturbance, equating to 22,600 bird-days (26,600 taking into account the birds that could be disturbed as well as the direct habitat loss). Calculations using the values of invertebrate biomass density from the Paull Holme Strays monitoring programme and the godwits' energy/feeding requirement from the Stillman et al. (2005) Humber modelling study, indicate that the proposed 100 ha compensatory managed realignment site should be able to provide well over an order of magnitude greater feeding potential than would be lost to the development. A further 38 ha. site at Old Little Humber Farm would be developed into wet grassland to provide temporary feeding and roosting opportunities for the birds displaced by the development.

It is considered that the impact of the loss of habitat will result in a likely significant effect on Black-tailed Godwit under the 2010 Habitats Regulations and would therefore trigger the need for an appropriate assessment. The outcome of that assessment would likely require the provision of an alternative feeding area in compensation for the loss of inter-tidal feeding habitat, to avoid any adverse effect on the integrity of the SPA and the SAC. The new managed realignment site that is being proposed as such a compensation site should be able to deliver sufficient feeding resource such that there would be no net loss in the feeding potential of the Humber Estuary. These measures should therefore deliver a net benefit to the godwits over and above the loss of feeding habitat and other possible effects that would result from the AMEP development.

Author Experience

This report has been prepared by Dr Steve Percival, principal of Ecology Consulting, a consultancy specialising in ornithological survey and assessment, and in bird conservation management. Prior to setting up this consultancy, Dr Percival was a senior lecturer at the University of Sunderland's Ecology Centre, a senior research fellow at the University of Durham and a higher scientific officer at the British Trust for Ornithology. He has worked on a variety of Environmental Impact Assessment projects including ornithological survey, advisory and assessment work for over 300 wind farm projects in the UK, Ireland, Sweden, Poland, Canada, Mongolia, Australia and New Zealand, including both onshore and offshore developments. He has undertaken specific research on the effects of disturbance on waterfowl, including the Lindisfarne wildfowling refuge project for Natural England, on the effects of disturbance to geese, and on the disturbance effects of wind farms.

Introduction

Able UK is proposing to develop Able Marine Energy Park (AMEP) at Killingholme on the south bank of the Humber Estuary, which includes a quay and deep water port facilities to support the offshore renewable energy industry. The proposal includes facilities for the manufacturing, commissioning and installation of offshore wind turbines and also to provide resources and opportunities to the associated supply chain.

Black-tailed Godwit has been identified in the scoping and consultation processes as one of the key species that could be affected by this development. North Killingholme Haven Pits is the most important high tide roost for this species on the Humber Estuary and the foreshore in this area is one of their more important feeding areas (Catley 2000, Mander and Cutts 2005, Calbrade et al. 2010).

The work reported here comprises a desk study to collate relevant information available on the numbers and distribution of Black-tailed Godwits in the Humber Estuary SPA, their potential susceptibility to disturbance and their habitat use (to inform the design and management of the required mitigation/compensation areas). The specific objectives of the work are as follows:

- Collation and presentation of the information available on the spatial and temporal patterns of Black-tailed Godwit use of the Humber Estuary, including temporal population analysis and spatial mapping;
- An assessment of the habitat changes in the environment surrounding the Killingholme Pits over the recent period of development, including any evidence that any consequential change has caused disturbance (with reference to published studies of Black-tailed Godwits and disturbance).
- Comparison of the Black-tailed Godwit population changes on the Humber Estuary with those elsewhere in the UK and in the context of changes in the whole population flyway;
- Description of the parts of the estuary favoured by Black-tailed Godwits and their temporal and spatial extent of the use of these areas, focussing particularly on the Middle estuary.
- Description of the feeding requirements of Black-tailed Godwits and their preferred conditions on both intertidal and terrestrial areas. Determination of the likely feeding resource necessary to compensate for that lost.
- Description of the fidelity of the Black-tailed Godwits to their current feeding/roosting areas and their ability to adapt to change, in particular any evidence that they have used managed realignment sites elsewhere on the Humber.

- An assessment as to whether the loss of mudflat adjacent to Killingholme Pits is likely to lead to the loss of Black-tailed Godwits from the pits themselves and whether the pits could be managed to provide an improved habitat.
- An assessment of the likely effects of the proposed quay development on Black-tailed Godwit activity and their feeding resource.
- An assessment of the implications of these conclusions for Humber Estuary SPA Black-tailed Godwit population.

This report contains information that will contribute to informing both an Environmental Statement for the proposal and an appropriate assessment under the Habitat Regulations.

The nature conservation importance of Black-tailed Godwits on the Humber Estuary SPA

Black-tailed Godwit is a widespread species that breeds from Iceland to the far east of Russia and winters in Europe, Africa, the Middle East and Australasia. The estimated global population is about 750,000 birds. However its overall numbers have declined rapidly in parts of its range (thought primarily to be as a result of changes in agricultural practices). The rate of that decline (approximately 25%) is sufficient for the species to qualify as 'Near Threatened' (BirdLife 2011). The population is split into a number of flyway populations. Those Black-tailed Godwits wintering in Britain are of the *islandica* race that breeds in Iceland. This population numbers approximately 47,000 individuals (Gunnarson et al. 2005) and in contrast to the other flyway populations is thought to be increasing. This population breeds almost exclusively in Iceland and winters in Britain, Ireland, France, Portugal, Spain and Morocco (Delany et al. 2009).

It is also thought that smaller number of the *limosa* race use the Humber (Catley 2000). This population breeds across western Eurasia from the UK to Russia, but in contrast to the *islandica* population, has declined over the last 20 years (BirdLife 2011).

Studies have shown that large moulting flocks of Black-tailed Godwits build up at coastal sites in the UK following their arrival from Iceland post-breeding, then disperse south during the latter part of the autumn. The Humber Estuary is one such coastal site, holding the highest numbers at this time, though also smaller numbers through the winter and into the spring.

Black-tailed Godwits on the Humber Estuary have increased rapidly in recent years, and currently the site is used by internationally important numbers (Calbrade et al. 2010). The Humber Estuary has been designated for its international ornithological interest (as a Special Protection Area [SPA] and a Ramsar site) and as a nationally important site (a Site of Special

Scientific Interest [SSSI]). The SPA, Ramsar site and SSSI are largely synonymous. Black-tailed Godwit forms part of the internationally important wintering bird assemblage of the site and now occur in sufficient numbers to be considered a qualifying features of the SPA in its own right.

Any assessment of the effects of the proposed AMEP development would need to consider the potential impacts on all of the SPA qualifying and assemblage populations, including the Black-tailed Godwits, to ensure compliance with the Habitats Regulations (in relation to the SPA and Ramsar site) or the 1981 Wildlife and Countryside Act (as amended) in relation to the SSSI. This report provides information on the Black-tailed Godwits to assist in that assessment process.

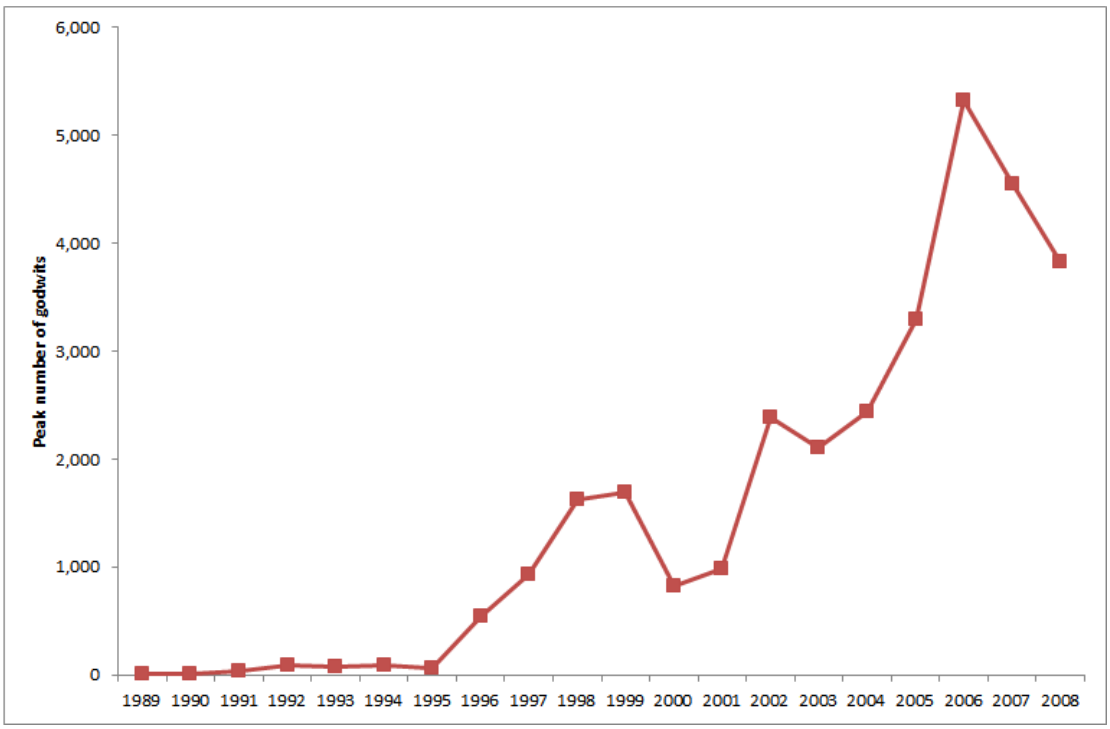
Spatial and temporal patterns of Black-tailed Godwit use of the Humber Estuary

The aim of this section of the report is to collate and present the information available on the spatial and temporal patterns of Black-tailed Godwit use of the Humber Estuary, including temporal population analysis and spatial mapping.

High Tide Counts

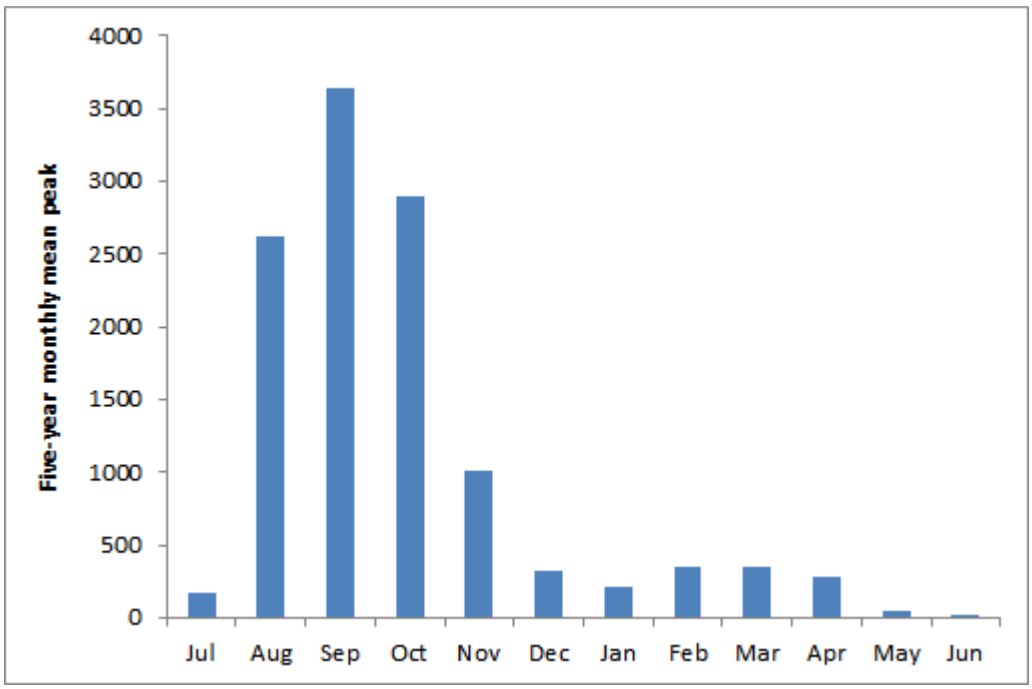
The main longer-term data set available on the numbers of godwits using the Humber is the Wetland Bird Survey monitoring scheme (Calbrade et al. 2010). The annual peak counts from the Humber over the last 20 years are shown in Figure 1. This Figure shows the large and rapid increase that has taken place over this period in godwit numbers found on the Humber.

Figure 1. Annual peak Black-tailed Godwit counts for the Humber Estuary 1989-2008 (source: WeBS counts).



The seasonal pattern of use of the Humber by Black-tailed Godwits is summarised in Figure 2, which shows the mean peak count in each month over the most recent five years for which data are available. This highlights the high numbers recorded during the autumn (Aug-Nov) period and the much lower numbers at other times, highlighting the Humber's primary importance to Black-tailed Godwits as a post-breeding moult site.

Figure 2. Five-year monthly mean peak counts of Black-tailed Godwits on the Humber Estuary, 2003-2008 (source: WeBS counts).



The North Killingholme Haven Pits is much the most important high tide roost used by Black-tailed Godwits on the Humber. The percentages that this location has supported of the Humber peak count over the last 10 years are shown in Figure 3 (averaging out at 85% of the total Humber Estuary peak count; most recent 5-year mean peak of 3,340). It is clearly therefore the main Humber high tide roost. The peak numbers recorded each year over the last 10 years are shown in Figure 4.

Figure 3. Percentages of the Humber Estuary WeBS peak count recorded at North Killingholme Haven Pits, 1999-2008.

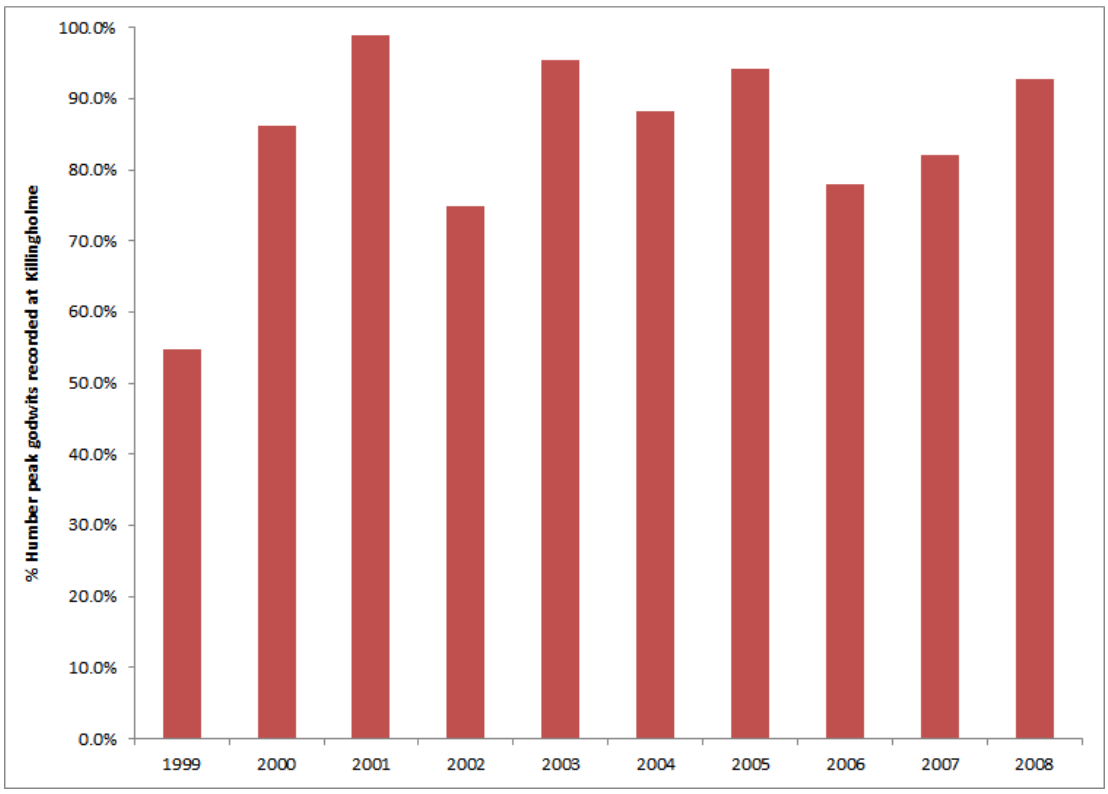
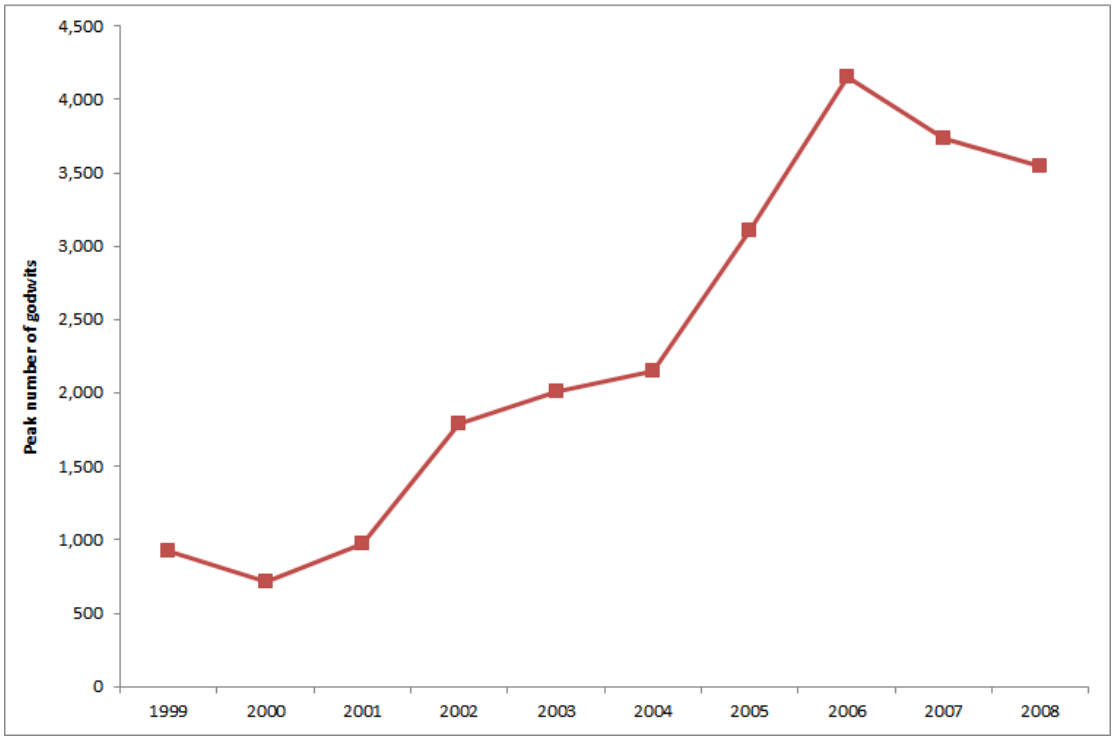


Figure 4. Annual peak Black-tailed Godwit counts for North Killingholme Haven Pits 1999-2008 (source: WeBS counts).



North Killingholme Haven Pits is not however the only high tide roost. On neap tides some birds remain on their feeding areas at high tide, particularly at Pyewipe (Catley 2009). There has also been increasing use documented of the recent managed realignment areas, both as roosting and feeding areas, particularly at Paull Holme Strays (IECS 2010a). The latter site is now regularly used by up to 1,000 Black-tailed Godwits as a high tide roost (Mander and Cutts 2005, IECS 2010a). The locations of the main high tide roost sites are shown in Figure 5.

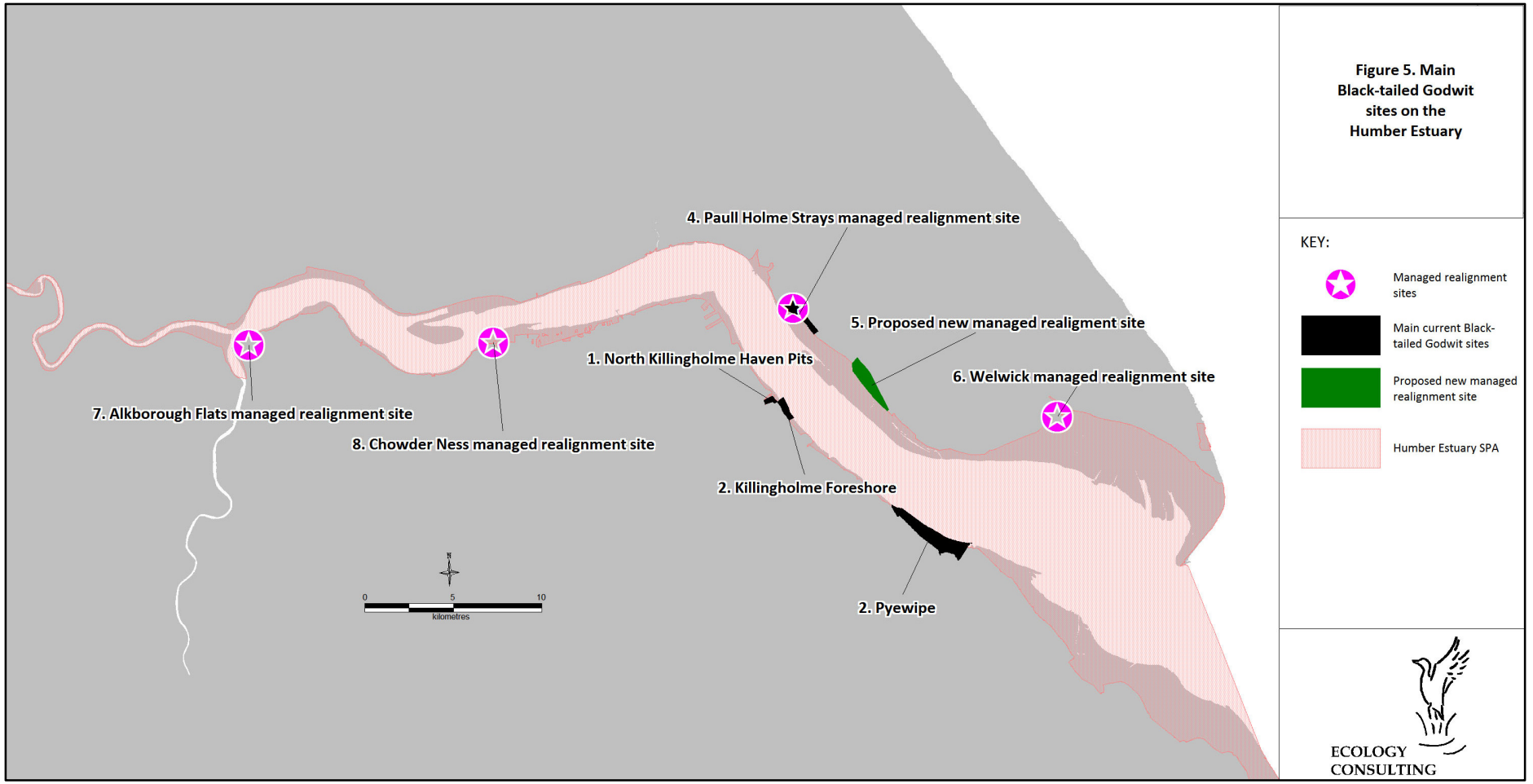


Figure 5. Main Black-tailed Godwit sites on the Humber Estuary

Low Tide Counts

The whole estuary distribution of birds at low tide is less well known, as this has only been fully covered during two winters' survey as part of the BTO Low Tide Count Survey, 1998/99 (Catley 2000) and 2003/04 (Mander and Cutts 2005). Mander and Cutts (2005) noted that the godwit low tide distribution during the autumn was concentrated around the Killingholme area, with birds using the North Killingholme Haven Pits roost through the rest of the tidal cycle as well as a high tide roost. They found that during the autumn the birds spent long periods roosting and loafing while they undergo their post-breeding moult, and that feeding appeared to take up a relatively short period of available daylight hours with birds often lingering on their roosting sites to around mid-water. Overall low water distribution was summarised as 40% on the Killingholme Haven Pits site and 30% on the adjacent mudflat. In winter, the feeding population concentrated on the mudflats of Pyewipe (Mander and Cutts reported 90% of the Humber population used this sector at this time of year and a similar result was also found in the previous low tide counts, Catley 2000). In spring a high proportion (88%) were found on the new realignment site at Paull Holme Strays.

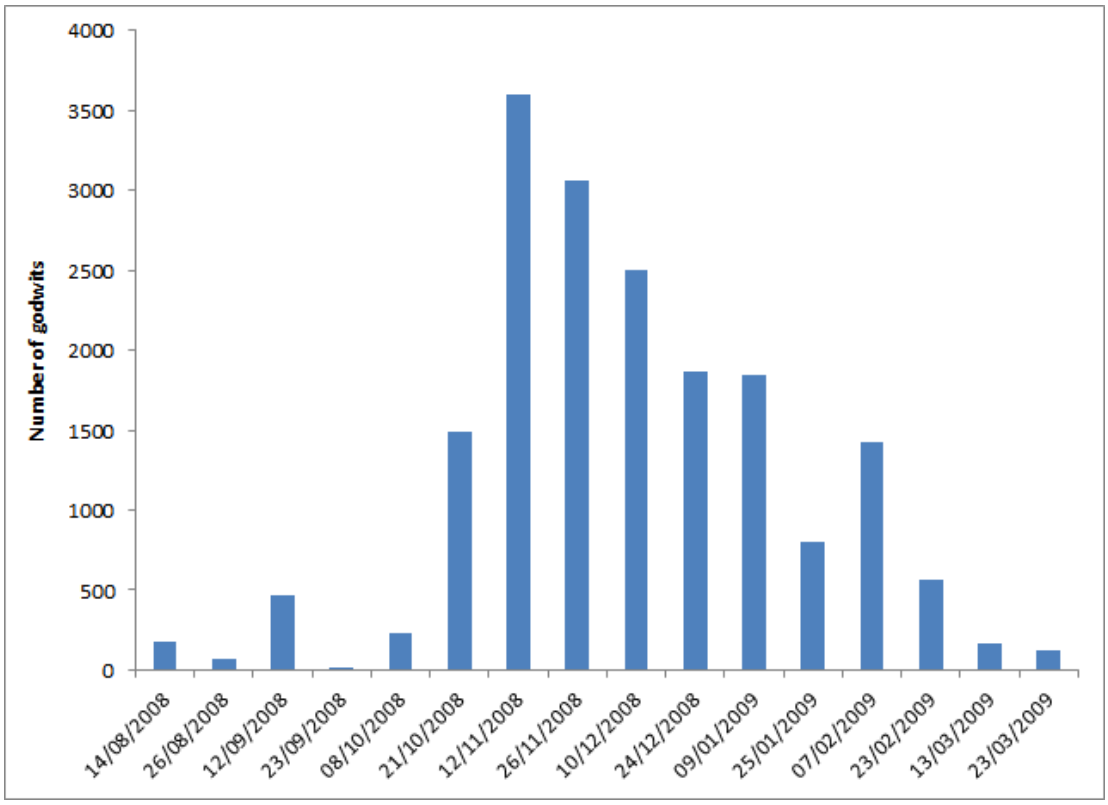
The older data from the 1998-99 low tide surveys reported a similar pattern of distribution (Catley 2000), with use of three main feeding areas in the autumn (the upper estuary between Blacktoft and Read's Island (roosting on Read's Island or at Blacktoft on spring high tides), the north shore from Saltend to Cherry Cobb, and the south shore from East Halton Skitter to Immingham Docks (with birds from both of the latter two sites roosting at North Killingholme Haven pits, though with north bank birds staying on their feeding areas on neap high tides). Later in the autumn birds were almost all roosting at North Killingholme Haven pits and feeding on the north shore around Cherry Cobb and on the south shore down river to Pyewipe, and then from November onwards were using the Pyewipe area for both feeding and roosting (Figure 5).

The BTO has undertaken a recent analysis of the trends in bird numbers by sector of the Humber (Austin et al. 2008). This study reported that the proportion of the population has increased in the north shore of the estuary, and confirmed that the sectors that support a significant proportion include Pyewipe and North Killingholme Haven Pits.

There is also a large amount of data available from more geographically restricted studies on the Humber, mostly associated with specific development proposals.

The importance of the Pyewipe area has been further reinforced by the results of the surveys reported by Catley (2009) and used for the assessment of the Grimsby Roll-on Roll-off terminal. The numbers counted in the Pyewipe area during those surveys are summarised in Figure 6. These counts support the conclusion that the Pyewipe area is one of the most important areas for foraging Black-tailed Godwits on the Humber Estuary.

Figure 6. Black-tailed Godwit counts from the Pyewipe area, 2008-09 (source: Catley 2009).



As noted above, the north shore of the Humber has also been an important feeding area, though in general supporting lower numbers than the south shore, and with regular flights across the estuary reported (IECS 2006, Catley 2009). Since the managed realignment sites have been established on the Humber, these too have become important areas for this species. IECS (2010a) reported that the Paull Holme Strays site "*over the first four years since breaching, the Paull Holme Strays site has developed as a major roosting/loafing site for Black-tailed Godwit on the Humber, supporting on many occasions flocks of national importance in autumn, as well as increasing numbers of foraging birds*". After Killingholme Pits and Pyewipe, this is now the most important site for Black-tailed Godwits on the Humber. Mean counts on the realignment area over the six years since the breach of the sea wall have been 377, 72 and 26 for the autumn, winter and spring periods respectively.

Less detailed monitoring data are available from the other managed realignment schemes but Catley (2009) reported that the Alkborough Flats scheme supported significant numbers of godwits on the managed realignment scheme and ABP Marine Environmental Research Ltd (2011) reported that the Welwick site is being used with increasing frequency. These sites are used extensively by the godwits for both roosting and feeding.

The locations of the main Black-tailed Godwit feeding sites are shown in Figure 5.

Mid-tide Counts

Very few data are available from this period of the birds' feeding cycle, though this can be an important feeding period and birds can use different areas at this time (Dias et al. 2006a). Black-tailed Godwits are known to abandon important feeding areas at low tide in some cases (Dias et al. 2006b), leading to a considerable under-estimation of usage of some inter-tidal areas when reliant on counts made at low tide. Recent coverage of the AMEP site at this time is however comprehensive as counts at that site have been made on a Through the Tide basis, covering the whole tidal cycle (IECS 2010b).

Effects of recent environmental changes at Killingholme on Black-tailed Godwits

The section makes an assessment of the habitat changes in the environment surrounding the Killingholme Pits over the recent period of development, to determine whether there is any evidence of any consequential disturbance effects on Black-tailed Godwits.

The recent planning consents granted and implemented in the area around the North Killingholme Haven Pits have included the conversion of arable land adjacent to the south and west of the pits to pavement for vehicle storage and this development has been ongoing through the last 8 years, development of the North Killingholme Industrial Access Road in 2006 and the development of the Humber Sea Terminal between 1999 and 2008. The first two berths of the Humber Sea Terminal were constructed in 2000, the third and fourth in 2003 and the fifth and sixth in 2007. This has all increased the potential for disturbance to birds using the pits through noise and human activity.

As noted above, the Black-tailed Godwit population over this same period has increased substantially, with no indication that the rate of increase has in any way been affected by the proximity of these developments to the Pits. Numbers have continued to increase at a sustained rate (Figure 4) and the proportion of the Humber population using the Pits as a high tide roost site has remained high (Figure 3).

As a result of this new development the Pits are now surrounded on all but the seaward easterly side by development (Figure 7). The Humber Sea Terminal lies adjacent to its northern edge.

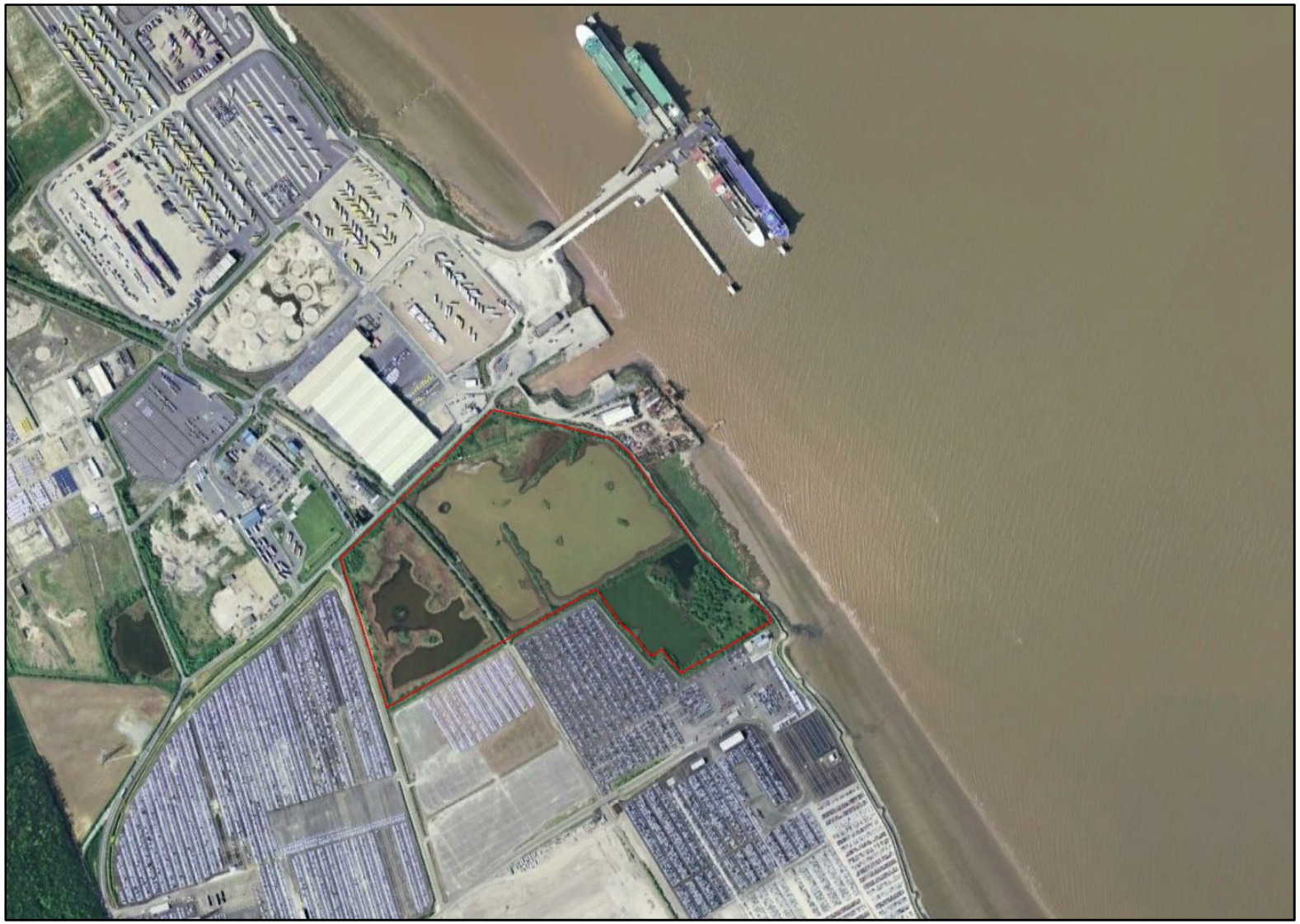


Figure 7. Aerial photograph of Killingholme Pits and its surrounds in July 2007 (source: Google Earth)

It is clear that there has been major increase in use of the pits by Black-tailed Godwits for roosting at high tide at the same time as these developments have been implemented; there is no apparent adverse effect on the birds' use of the Pits.

All of these developments have not affected the open character of the Pits to the seaward eastern side, allowing the godwits and other roosting waders a clear flight line into the pits from their feeding areas on the shore to the south-east and from the north bank across the Humber.

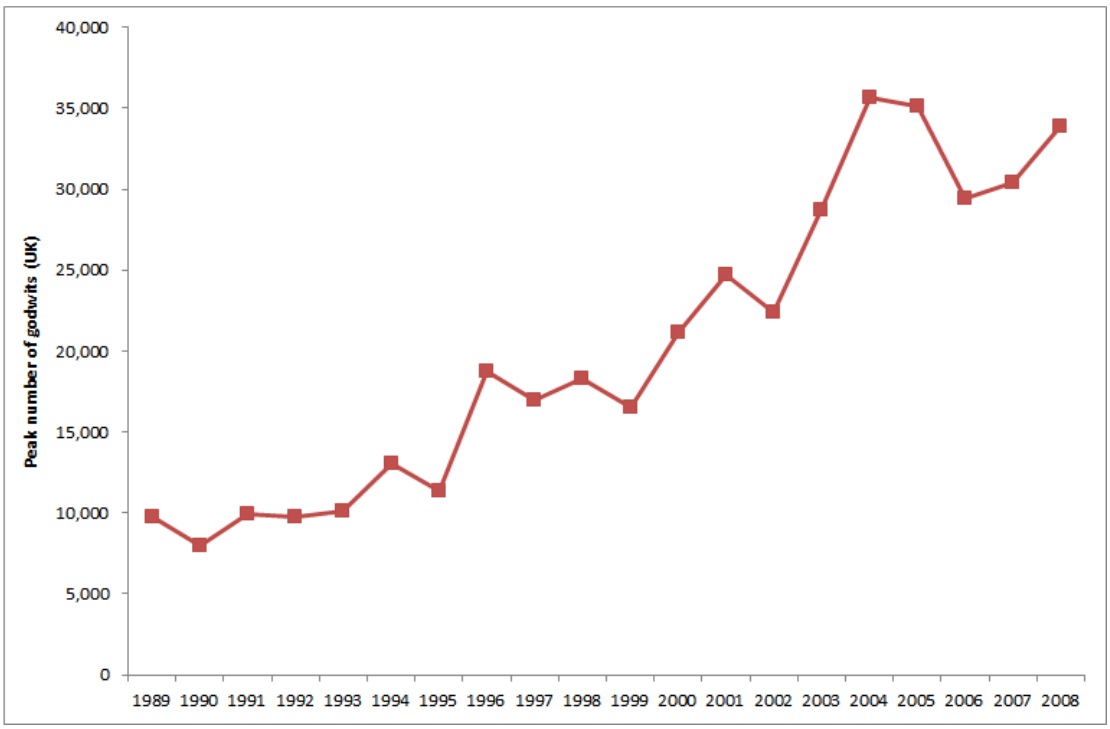
The Killingholme foreshore has also clearly been able to support substantial numbers of feeding and roosting/loafing Black-tailed Godwits in proximity to both the Humber Sea Terminal, the vehicle storage areas on the Able UK land and other industrial developments to the south. The shore adjacent to the important godwit feeding area at Pyewipe is also heavily industrialised. The available evidence would not suggest that there has been any consequential disturbance of feeding or roosting godwits on the south bank of the Humber, and that the population continues to increase and maintain its favourable status on the SPA.

Black-tailed Godwit population changes

This section of the report compares the changes that have been reported in the Black-tailed Godwit population on the Humber Estuary with those elsewhere in the UK, and examines the context of those changes in relation to the whole population flyway.

The UK wintering Black-tailed Godwit population derived from the WeBS surveys over the last 20 years is shown in Figure 8. This gives the peak count of each of those 20 years. As can be seen there has been a large increase in the population, in a similar pattern to that found on the Humber Estuary. There is a very strong and statistically significant correlation between the Humber and UK populations (r_{20}=0.84, $p<0.001$), with the Humber consistently supporting about 10% of the UK population since 1999. The recent changes observed on the Humber therefore clearly reflect changes that have occurred across this species' UK range.

Figure 8. Trends in the UK Black-tailed Godwit wintering population 1989-2008 (source: WeBS counts).



There is rather less detailed information available about the total flyway population, though all of the indications are that this has also increased markedly over the last 20 years. An increase of 30% between 1980s and 1990s has been reported (Stroud et al. 2004) and it is thought that increase is continuing (Delany et al 2009). The trends in the flyway population as a whole therefore are in line with those observed both at the UK national level and on the Humber.

Black-tailed Godwit use of the Humber Estuary

This section describes the parts of the estuary favoured by Black-tailed Godwits and their temporal and spatial extent of the use of these areas, focussing particularly on the Middle estuary. The birds' main ecological requirements in the area are feeding sites, and site for roosting/loafing.

High Tide Roosting

As described above, the North Killingholme Haven Pits are used as the main Black-tailed Godwit roost on the Humber Estuary over the high tide period. They do however use a range of other sites over high tide: on neap tides they may remain on their feeding areas, they

roost in large numbers at Pyewipe in the latter part of the winter period, and more recently they have started to make use of several of the managed realignment sites for high tide roosting (IECS 2010a). The latter in particular demonstrated their adaptability to exploit new areas where suitable opportunities occur. The most recently published report on the Paull Holme Strays managed realignment site reported mean counts of 164 Black-tailed Godwits roosting there over high tide during the autumn and 47 during the winter (IECS 2010a).

The ecological requirements of waders include a range of factors but essentially relate to the availability of a safe place to rest whilst their foraging areas are unavailable, to minimise their energy expenditure over this non-feeding period. Their main requirement is therefore a lack of disturbance from predators (or perceived predators such as humans). Studies of the factors affecting wader roost selection have shown that they are often variable in their use of roost sites but are influenced by a range of factors including human disturbance, shelter, aspect and the extent of the roost site (Peters and Otis 2006). The availability of suitable roost sites has been suggested as a factor that could limit access to feeding areas and hence limit population size in some waders (Rodgers et al. 2006; Dias et al. 2006a), though this has also been reported as being of lesser importance in other studies (Conklin et al. 2008). It is clear however that adequate provision and management of roost sites is an important consideration in wintering wader conservation management.

A further consideration of the suitability of the North Killingholme Haven Pits roost now and into the future is that the birds' main flight route to/from the Pits from the seaward eastern side has remained open and free from obstructions despite the development elsewhere around the pits.

Feeding

The large majority of the foraging areas used by the Humber Black-tailed Godwits are inter-tidal mudflats. The *islandica* population of godwits is well known to be a largely inter-tidal feeder outside the breeding season (Alves et al. 2010). The Black-tailed Godwit is considered to be primarily a tidal edge feeder (Granadeiro et al. 2006).

The main areas used for feeding by the godwits, as described above, are on the Killingholme foreshore, at Pyewipe and on the north shore in the Paull-Cherry Cobb area, with the high use of the first two of these illustrating the birds' tolerance of feeding in proximity to large-scale industrial complexes. The regular tidal movements between the main high tide roost at North Killingholme Haven Pits and the main feeding area at Pyewipe also involve the birds flying through/around Immingham Docks on a regular basis.

The Humber Black-tailed Godwits have shown an adaptability to use novel feeding areas as well when they become available, through their use of several of the managed realignment sites. Their use of these new resources has been particularly well-documented at Paull

Holme Strays, where mean counts over the six years since the breach of the sea wall have been 377, 72 and 26 for the autumn, winter and spring periods respectively (IECS 2010a).

Black-tailed Godwit use of feeding areas outside the inter-tidal zone on the Humber is much less frequent, though birds at the high tide roost at North Killingholme Haven pits have been reported feeding (IECS 2010b). Black-tailed Godwits do make extensive use of wet grassland and other terrestrial habitats in other areas. Indeed, Gill et al. (2007) note that part of the reason for the population increase has been the availability of both intertidal and wet grassland habitats. Gunnarsson et al. (2005) reported Black-tailed Godwit foraging on both saline (estuarine mudflats and saltpans) and freshwater (lowland wet grassland) habitats during winter.

Another aspect of Black-tailed Godwit feeding ecology is their behaviour at night. Night feeding can be important to species such as godwits (e.g. Lourenco et al. 2008), and it is possible that the nocturnal illumination from industrial developments may be beneficial to godwits feeding at night through increased prey visibility, as has been shown elsewhere (Santos et al. 2010). This might be a factor in the birds' choice of feeding areas on the Humber in proximity to such industrial areas.

Black-tailed Godwit feeding requirements

The purpose of this section is to describe the feeding requirements of Black-tailed Godwits and their preferred conditions on both intertidal and terrestrial areas. It also examines the likely feeding resource necessary to compensate for that lost to the AMEP development. It will be an essential requirement of that development and its associated compensatory measures to ensure that it does not result in the loss of overall feeding potential for the Black-tailed Godwits in the Humber Estuary SPA.

Black-tailed Godwits take a wide range of food items, including adult and larval insects (especially beetles), annelid and polychaete worms, molluscs, ragworms, crustaceans, spiders, fish eggs, and the spawn and tadpoles of frogs (Birdlife 2011). Their daily energy requirement is approximately 420 kJ/day (Stillman et al. 2005). On the Humber the birds principally use inter-tidal feeding areas, and their main prey is likely to comprise *Macoma* bivalves and annelid worms (Stillman et al. 2005). They do however also use grassland and coastal lagoons (Gill et al. 2002), where their diet would be likely to be more diverse.

The feeding distribution of Black-tailed Godwits is largely concentrated in a small number of sites within the estuary. Feeding densities can be estimated from the available count data, though the precision of those estimates is dependent on the detail of the surveys undertaken. The most comprehensive counts through the whole tidal cycle have been carried out on the Killingholme foreshore (IECS 2010b). That area was divided into five count

sectors (A-E, running south from the Humber Sea Terminal). Table 1 shows the godwit feeding densities recorded per area of mudflat through the winter period.

Table 1. Black-tailed Godwit feeding densities at Killingholme foreshore, 2010-11.

Sector	Area (ha)	Mean count	Density/km^2
A	5.8	1.8	30.7
B	8.6	7.9	91.9
C	11.9	17.9	150.1
D	13.4	36.5	272.6
E	10.2	8.8	86.1
All (A-E)	49.9	72.9	146.0
Development (B-D)	33.9[1]	62.3	183.8

Direct comparison of bird densities with other studies on the Humber is not straightforward as most have used slightly different data collection protocols that mean it is not possible to gain a complete picture of the birds' use of some of the other sites. The counts at Killingholme have been made through the whole tidal cycle and through the whole year, and can therefore be used to estimate the birds' total use of the area at all stages of the tide. At other sites where counts have been restricted to certain states of the tide and/or time of year, the data are not directly comparable.

Feeding densities have been reported for the Paull Holme Strays managed realignment areas, and for the adjacent mudflat on managed retreat areas, though these need to be interpreted with caution as they are largely based on counts only made at low tide rather than through the tidal cycle. Densities over the year were estimated at 9 birds per km^2 on the existing mudflat adjacent to the managed realignment and 29 per km^2 on the managed realignment itself (values calculated from densities presented in IECS 2010a). The birds are feeding predominantly on inter-tidal mudflat habitat in both of these areas. Even though lower feeding densities have been reported, this is not to say that these feeding areas on the north bank could not potentially hold higher numbers in the future, but rather just that they currently support lower numbers. The most important factor is determining the impact of the proposed AMEP scheme is the overall change in feeding potential of the Humber Estuary SPA that will result as a combination of the loss of habitat to the development and the gain from the compensatory managed realignment. Assessing that impact requires a common currency to measure the losses and gains, and a currency that is practical, empirical and ecologically meaningful. As well as comparing bird numbers across areas and the areas of habitats lost, it may also be helpful to compare the feeding potential of the areas lost to the development and the proposed compensation area, based on the feeding resource likely to be available and the birds' feeding requirement. This feeding potential is not a definitive

[1] Sectors do not map exactly to the development boundary, hence the discrepancy between the 33.9 ha. here and the actual loss which would be 33ha.

measure of food that would actually be consumed by the godwits but rather a measure of the maximum feeding capacity that a site might support. The actual consumption would depend on a range of additional factors such as intra- and inter-specific competition, prey behaviour and prey population dynamics. As discussed above though, the daily feeding requirement of a Black-tailed Godwit is reported to be about 420 kJ/day, which, given knowledge of the energetic content and available biomass of food supply, could provide useful information on the feeding potential of a site (and with account taken of removal rates – the proportion of the available food supply typically consumed - provide a means to derive at least an approximation of the likely carrying capacity).

Black-tailed Godwit feeding and roosting site fidelity

This section examines the fidelity of the Black-tailed Godwits to their feeding/roosting areas and their ability to adapt to change. Some species of wader that have been studied in detail have been shown to exhibit high fidelity to roost sites and their associated feeding sites, with dunlin forming what have been termed 'functional units' or social groups (Luis and Goss-Custard 2005, Conklin and Colwell 2008). Redshank (Burton 2000) and turnstone and purple sandpiper (Burton and Evans 1997) have also been shown to exhibit high winter site fidelity.

Black-tailed Godwit site fidelity has been less well documented, though colour-ringing studies have shown variable degrees of site fidelity through the winter, being generally higher at sites on the south coast of Britain and lower elsewhere (Gill et al. 2002).

As a species, Black-tailed Godwits have shown considerable use of novel resources, including the use of rice fields in southern part of their winter range (Masero et al 2006). It is clear that on the Humber they adopt a flexible strategy, with variation in use of roost sites through the winter and the tidal cycle, indicating that these birds are not completely dependent on North Killingholme Haven Pits as their sole high tide roost. They have also demonstrated the ability to use new resources too, both for feeding and roosting, in their use of the new managed realignment sites discussed above. They appear well able to adapt to new opportunities – the density of foraging birds in the Paull Holme Strays realignment site were greater than on the adjacent intertidal, for example and godwits now regularly use that area as a high tide roost as well (IECS 2010a).

Potential effects of the AMEP development on Black-tailed Godwit roosting behaviour

This section presents an assessment as to whether the loss of mudflat adjacent to Killingholme Pits is likely to lead to the loss of Black-tailed Godwits from the pits.

Currently the Humber Black-tailed Godwits appear tolerant of a relatively high disturbance environment whilst using their main high tide roost on the North Killingholme Haven Pits. That roost is located adjacent to the Humber Sea Terminal and to car import compounds. There is no evidence that this industrialisation is currently reducing the ability of the pits to support the godwits.

Reviews of the experience on the Humber, for example in relation to the Humber International Terminal, have concluded that disturbance from walkers, fishermen and flood defence maintenance have in general been more significant to wader roost disturbance than disturbance from industrial construction (IECS 2008). Even though, as discussed above, Black-tailed Godwits have been shown not to be particularly susceptible to disturbance, it would be important to maximise the benefit of the compensation area to include consideration of management of such potentially disturbing activities (e.g. the routing of footpaths away from the site to reduce human disturbance).

Whilst increasing industrialisation around the pits to date has not resulted in any decline in the godwit numbers using the Killingholme roost, it may be an important consideration that the birds flight route into/from the pits from the shore has remained open. These birds largely follow the same flight route to/from the pits, flying along the shore to the pits from feeding areas to the south-east rather than over land (Ecology Consulting, unpublished data). It is likely that this route would change slightly following construction of the development to avoid the new quay, but that birds would just fly around this. This would not constitute a significant increase in journey distance/energy expenditure. No new development would block their usual flight route into the pits from the shore – this would still remain open. It is clear from the data available that godwits roosting on the Pits do not solely feed on the adjacent Killingholme shore but also along the southern shore of the estuary to Pyewipe and across to the northern shore.

The provision of the managed realignment and wet grassland compensation area on the north shore of the Humber could have the additional benefit of providing the godwits with additional roosting alternatives in an area where suitable roost sites are more limited, potentially enabling them to increase their use of the inter-tidal feeding resources on the north shore (which are currently used rather less than sites on the south bank). The Paull Holme Strays site already supports substantial numbers of roosting godwits at high tide (with mean counts of 164 Black-tailed Godwits roosting there over high tide during the autumn and 47 during the winter; IECS 2010a).

Potential effects of the AMEP development on Black-tailed Godwit feeding behaviour

This section presents an assessment of the likely effects of the proposed quay development on Black-tailed Godwit feeding activity and their feeding resource.

The development would result in the loss of 31.5 ha of mudflat directly (approximately mapping to count sectors B, C and D; IECS 2010b). This mudflat supports an average of 62 feeding Black-tailed Godwits (Table 1), based on the most recent 2010-11 Through the Tide counts over the whole tidal cycle, with a peak count of 2,358 in that area. This area is clearly currently an important feeding site for these birds.

There is also potential for displacement of birds through displacement in the two adjacent areas to the north and south of the proposed development (sectors A and E respectively), though the most detailed study of Black-tailed Godwit feeding ecology and disturbance (Gill 2001, 2007) found no difference in the proportion of available invertebrate prey consumed by the birds on sites with varying levels of disturbance. Direct habitat loss is therefore likely to be the greatest risk to this species, rather than disturbance.

In terms of determining the significance of any direct habitat loss (or indeed any disturbance), the most important consideration is the ecological consequence of that habitat loss. If there are alternative feeding areas to which any displaced birds could go (without any significant additional energetic cost), then such displacement may not be ecologically significant. However, if such alternatives are not available, then the displacement would be likely to result in reduced feeding opportunity and potentially increased over-winter mortality.

The key question is therefore whether such alternative areas exist on the Humber Estuary. Firstly, could the existing mudflats accommodate more feeding Black-tailed Godwits? High densities of feeding godwits are currently largely restricted to two small areas of the estuary, at Killingholme foreshore and particularly at Pyewipe. Elsewhere, such as on the inter-tidal mudflats of the north shore, numbers are lower, including where godwit prey resource/feeding habitat are found. This suggests that there may be opportunities for these other areas to support any displaced godwits. However, notwithstanding this, a compensation area is being created as part of the development on the north bank of the Humber at Cherry Cobb, approximately 4km to the south-east of the Paull Holme Strays managed realignment. The proposal for this location is to create 100ha of managed realignment to provide new inter-tidal feeding areas. An additional 38 ha of wet grassland is proposed close to the Paull Holme Strays realignment site that was breached in 2003. Both of these will be created from existing arable land. The extent of the new inter-tidal will be almost three-fold greater than the area of inter-tidal that would be lost to the development, and there would be additional benefit to the godwits of the wet grassland. Wet grassland has been documented as a well-used feeding habitat for *islandica* Black-tailed Godwits, for example in Ireland (Hutchinson and O'Halloran 1994).

In judging the likely efficacy of these compensation measures to ensure the overall coherence of the Natura 2000 network, two specific factors need to be addressed, viz.

(a) the numbers of birds that could be displaced as a result of the development, and

(b) the increase in feeding potential that would result from the proposed compensation scheme.

The numbers of Black-tailed Godwits that would be displaced by the proposed development are well known, particularly as a result of the detailed counts made recently through the tidal cycle and summarised in Table 1 above. The mean count of godwits in the development area of 62 would equate to 62 x 365 = 22,600 bird-days through the year. Assuming displacement of birds from the adjacent mudflat as well would increase this figure to 73 x 365 = 26,600 bird-days. Given that one godwit-day equates to an energy intake of about 420 kJ/day (Stillman et al. 2005), these birds would require an alternative food supply equivalent to about 9.5 x 10^6 kJ over a whole year (1.1 x 10^7 kJ assuming displacement from the adjacent mudflat as well).

The inter-tidal compensation site would provide 100 ha. of new inter-tidal habitat; this would be supplemented in the short term by 38 ha of wet grassland. Monitoring of the Paull Holme Strays managed realignment (which is similar in ecological character to that proposed) has shown that the benthic invertebrates on which the godwits feed have rapidly colonised this area, such that after three years the biomass density in the realignment was similar to that on the adjacent mudflat (IECS 2007), at about 40 g/m^2 wet weight, equivalent to about 6.4 g/m^2 ash-free dry weight (Ricciardi and Bourget 1998). The new managed realignment site, could therefore support a theoretical feeding potential of 6.4 x 10,000 g/ha = 64 kg/ha, or 0.064 tonnes/ha.

Stillman et al. (2005) used an energy density value of 23.5 kJ/g (ash-free dry weight) for annelid prey (the main godwit prey group that has become established in the Paull Holme Strays managed realignment site, IECS 2007), and a 75% assimilation rate (Stillman et al. 2005), and those values are also used here. The 0.064 tonnes/ha of invertebrate biomass would then equate to 0.064 x 10^6 x 23.5 kJ = 1.5 x 10^6 kJ/ha, of which with a 75% assimilation rate would equate to 1.13 x 10^6 kJ/ha of theoretical feeding potential. Consideration also needs to be given to the availability of that feeding potential and hence the proportion that the godwits would be able to consume. Waders typically remove 25-40% of their prey over a winter (Goss-Custard 1984, Szekely and Bamberger 1992) though removal rates as high as 80-90% have been reported by Evans et al. (1979) and 53-100% by Frank (1982).

Wet grassland habitat has been reported to support a soil macro-invertebrate fauna biomass density of about 6.5 g/m^2 formaldehyde-preserved weight, equivalent to 1.28 g/m^2 ash-free dry weight for winter flooded grassland and 74.2 g/m^2 formaldehyde-preserved weight, equivalent to 14.6 g/m^2 ash-free dry weight for unflooded grassland (Ausden et al. 2001). The proposed wet grassland compensation site would comprise a mix of flooded and unflooded land in approximately similar proportions, so an average of these two values has

been used. Applying the same calculations as for the inter-tidal habitat, this equates to about 1.4 x 10^6 kJ/ha of theoretical feeding potential (allowing for a 75% assimilation rate, as above).

The timing of the availability of the feeding potential of the new managed realignment site will also need careful consideration. This will need to include two specific aspects, (a) the time for the godwits' food supply to become established on the managed realignment site and (b) the loss of intertidal mud within the realignment site that will occur through colonisation by saltmarsh.

In terms of the availability of a food resource for the godwits in the initial period of the realignment immediately following the breach, the evidence from other similar schemes suggests that the benthic invertebrate colonisation process is rapid. At Paull Holme Strays, for example, the site achieved benthic biomass densities comparable to those on main inter-tidal within 3 years of the breach, and that site actually attracted feeding godwits in the first season after breach (IECS 2010a). Rapid colonisation of sites by intertidal invertebrates has also been reported at Welwick and Chowder Ness (ABPMer 2011). Black-tailed godwit numbers reached a high level soon after the breach, with the numbers recorded in the first year after breach very similar to the mean counts over the average of the following five years at Paull Holme Strays (IECS 2010a).

With regard to the second point, it is assumed at this stage (for the purposes of this report) that the managed realignment site will comprise a minimum of 40 ha. of intertidal mudflat that will be sustained in the long term. The amount of feeding potential from the realignment site for the godwits will therefore change through time, though at least 40ha of feeding habitat is assumed to persist into the long term.

As a result, the compensation areas will likely provide a varying food resource for the godwits through time. Initially the managed realignment will provide about 100ha of inter-tidal feeding habitat, with a feeding potential of about 1.13 x 10^6 kJ/ha. The area of mudflat within the realignment will decline over time through colonisation by saltmarsh, though the realignment will be engineered such that a minimum 40ha. of mudflat should be sustained over the long term (Black and Veatch, letter to Able dated 27 October 2011.). This would give a peak godwit feeding potential of 100 x 1.13 x 10^6 = 1.13 x 10^8 kJ, and a feeding potential of 40 x 1.13 x 10^6 = 4.5 x 10^7 kJ over the long term. These equate to 269,000 and 107,000 godwit feeding-days respectively. Applying a conservative removal rate of 25% would reduce these figures to 67,000 and 26,750 godwit feeding-days that could potentially be supported on this area.

The 38ha of wet grassland would provide an additional feeding potential of about 38 x 1.4x 10^6 = 5.3 x 10^7 kJ equivalent to 127,000 godwit feeding-days, or 32,000 godwit feeding-days applying a conservative 25% removal rate.

Though a simplistic calculation, this still serves to illustrate that given the experience of rapid inter-tidal invertebrate colonisation of the managed realignment at Paull Holme Strays and

the likelihood of similar changes at the proposed new realignment site, it is very likely that the new realignment site will support a godwit feeding potential in excess of that of the proposed development site. The 38 ha. of wet grassland would provide roosting habitat and feeding potential delivering a further additional benefit to the godwits if required. However careful design of the intertidal site may enable a larger area of sustainable mudflat to be created than 40 ha. It is therefore concluded that this area could accommodate any godwits displaced from the development site. The measures proposed are also very much in line with the conservation management recommendation provided by Gill et al (2007): "*Improved conservation of winter habitat mosaics, particularly in areas, such as Ireland, England and France, where grasslands, coastal lagoons and salinas may be necessary to maintain populations when estuarine food supplies are depleted*".

Potential effects of the AMEP development on the Humber Estuary Black-tailed Godwit population

This final section of the report assesses the implications of the conclusions reached on the potential impacts for Humber Estuary SPA Black-tailed Godwit population.

The proposed development would result in the direct loss of 31.5ha of foraging habitat from an area that is currently well-used by Black-tailed Godwits.

There is also a possibility of indirect losses of a further 6.5ha of mudflat and also disturbance into adjacent feeding areas, though the latter would probably be a limited additional effect to the direct/indirect habitat loss as Black-tailed Godwits are not a species particularly susceptible to disturbance (Gill 2001, 2007).

Finally there could also be an impact on roosting birds, as the proposed development would be adjacent to the most important Black-tailed Godwit high tide roost on the Humber. This is however considered very unlikely given:

(a) the existing conditions – the proposed development would not constitute a major change in the existing impact on that area,

(b) the proposed development would not compromise the existing open flight route into pits from the estuary and

(c) there is an existing operational buffer around the roost site in which potentially disturbing activities are minimised and which would be maintained under the proposed development.

It is considered that the impact of the loss of habitat will result in a likely significant effect on Black-tailed Godwit under the 2010 Habitats Regulations and would therefore trigger the need for an appropriate assessment. The outcome of that assessment would likely require

the provision of an alternative feeding area in compensation for the loss of inter-tidal feeding habitat, to avoid any adverse effect on the integrity of the SPA and the SAC. A new managed realignment site is being proposed as such a compensation site, resulting in the creation of 100ha. of new inter-tidal. A supplementary area of grassland is proposed to provide the godwits with further additional feeding and roosting habitat. The additional terrestrial habitat would be managed as wet (as per HLS HK11-14 prescription; Natural England 2010). This area may only be required as a short term measure if sufficient sustainable mudflat can be created.

These measures should therefore deliver a net benefit to the godwits over and above the loss of feeding habitat and other possible effects that would result from the AMEP development. The compensation site would provide additional roosting habitat for the birds and would provide new feeding potential that would be considerably greater than that lost as a result of the development.

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