TIDAL LAGOON CARDIFF

Chapter 15.0
Coastal Birds

15.0 Coastal Birds

15.1 Overview of existing situation

15.1.1 General overview

15.1.1.1 The Severn Estuary is considered to be of national and international importance for wild birds. The Severn Estuary is designated under Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the "Habitats Directive") as a Special Area of Conservation (SAC), and a Special Protection Area (SPA) under Council Directive 2009/147/EC on the conservation of wild birds (the codified version of the earlier Council Directive 79/409/EEC as amended). It is also designated under the 1971 Ramsar Convention for internationally important wetlands (a "Ramsar" site). The location of these sites in relation to the Project are illustrated in Figure 15.1.

15.1.1.2 In addition there are six Sites of Special Scientific Interest (SSSIs) along both the northern (Welsh) and southern (English) coastlines with coastal birds as features. These are: the Upper Severn Estuary, the Severn Estuary, Flat Holm, Steep Holm, Sully Island and Bridgewater Bay. Penarth Coast SSSI is a well-known observation point for migratory birds but coastal birds are not a feature of this SSSI. The wading bird features of Sully Island SSSI were lost when the Cardiff Bay Barrage was built and permanently flooded the intertidal mudflats. The location of the remaining sites in relation to the Project are illustrated in Figure 15.2.

15.1.1.3 The coastal habitats of the Severn Estuary complex include saltmarshes, intertidal mudflats and sandflats. Populations of wildfowl, waders and other shorebirds (collectively known as coastal birds) use the habitats of the estuary, particularly in the non-breeding season (including autumn and spring migration). The presence of approximately 78,000 birds during the winter, based on the latest five year mean counts (2008/9-2012/13), make it the 11th most important non-breeding waterbird site in the UK (Austin et al., 2014). The tenth most important site is the Somerset Levels with approximately 103,500 birds over the same period (Austin et al., 2014).

15.1.1.4 The Severn Estuary SPA and the Severn Estuary Ramsar site qualify for classification on two counts: the overall assemblage of waterbirds; as well as presence of specific species occurring in internationally important numbers.

15.1.1.5 Individually qualifying species occurring in numbers of international importance within the SPA and Ramsar site that may be associated with the Project include shelduck (*Tadorna tadorna*), dunlin (*Calidris alpina*) and redshank (*Tringa tetanus*) (Austin et al., 2014). Assemblage species reaching nationally important numbers include pintail (*Anas acuta*), wigeon (*Anas Penelope*) and curlew (*Numenius arquata*) (Austin et al., 2014).

15.1.1.6 During the winter period, the Severn Estuary is of particular importance to feeding shelduck, dunlin, redshank and curlew. The population of dunlin within the entire Severn Estuary is the third highest in the UK, with approximately a third of those birds falling on the Welsh side of the estuary. The population of redshank within the entire Severn Estuary is the ninth highest in the UK, with approximately one third of those birds found in the Severn Estuary falling on the Welsh side (Austin et al., 2014).

15.1.1.7 The Severn Estuary is also an important refuelling and resting stop for many waders and wildfowl on their migrations during spring and autumn periods.

15.1.2 Legislative and policy requirements

15.1.2.1 The following provides a list of relevant legislation, policies and guidance relating to coastal birds which will be reviewed (the list is not exhaustive):

International Legislation

i. The Ramsar Convention on Wetlands of International Importance 1971

ii. The Convention on Biological Diversity 1992

European Legislation

iii. Council Directive 2009/147/EC on the Conservation of Wild Birds (the 'Birds Directive')

iv. Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (the 'Habitats Directive')

UK legislation

v. The Conservation of Habitats and Species Regulations 2010 as amended (the Habitats and Species Regulations)

vi. The Wildlife and Countryside Act 1981 (WCA)

vii. Natural Environment and Rural Communities (NERC) Act 2006

Policy

viii. Planning Policy Wales (Edition 7, 2014)

ix. The National Planning Policy Framework

x. The UK Post-2010 Biodiversity Framework

15.2 Scope of potential impact to be assessed

15.2.1 Introduction

15.2.1.1 The identification of potential significant effects has also been informed by consideration of the published studies into tidal power options in the Severn Estuary (DECC, 2010a). Potentially significant issues for coastal birds relating to the construction of a tidal lagoon within an estuary were assessed as part of the Severn Tidal Power Strategic Environmental Assessment (SEA) (Burton et al. 2010a) and were summarised by Burton et al. (2010b). These effects (some of which may operate over the construction phase as well as the operational phase of a lagoon) include: disturbance, loss of and changes to intertidal habitat and saltmarsh, changes to water quality, changes to, changes to fish populations, far-field changes in water levels, displacement effects, and effects on other sites in the Natura 2000 network.

15.2.1.2 The assessment of potentially significant effects on coastal birds will therefore need to consider effects caused by the construction, operation and decommissioning of the Project within the Zone of Influence (ZoI). This will be informed by the results of the coastal process modelling undertaken as described in Chapter 8 Coastal Processes, Sediment Transport and Contamination, and effects on water level changes within the lagoon and in the wider area. This is described further below in the section on geographical scope.

15.2.1.3 Potential coastal bird receptors that may need to be considered in the assessment include:

i. Species and assemblages listed as features of SPAs, Ramsar Sites and SSSIs;

ii. Species included on the UK Biodiversity Action Plan (UKBAP) list;

iii. Species included on the Section 41 BAP Species of Principal Importance in England, and Section 42 Species of Principal Importance in Wales;

iv. Species on the Red and Amber lists of Birds of Conservation Concern (BoCC) (Eaton et al. 2009) and the equivalent Red and Amber lists of Birds of Conservation Concern in Wales (Welsh Ornithological Society et al. 2009);

v. Species classified as Near Threatened in the IUCN Red List;

15.2.1.4 For further information on these species please see Table 2.1 and 2.2 of Appendix 15.1 which is a summary of the ornithology survey and modelling methodologies required to inform the EIA and HRA (Burton, 2015).

15.2.1.5 Potential effects to be assessed encompass:

i. Those arising during each phase of the Project (construction, operational and decommissioning). This is the temporal scope of the assessment;

ii. An appropriate geographical scale over which effects arise from the proposed Project may occur;

iii. Those that affect coastal birds directly and those that have an indirect effect, for instance through affecting their food supply;

iv. Applying a worst-case scenario (Rochdale Envelope) where there is uncertainty on the final parameters for the Project (see Chapter 3 Structure of the Environmental Statement); and

v. Those associated with the Project alone and in-combination with other plans and projects (see Chapter 3 Structure of the Environmental Statement).

15.2.1.6 The specific types of impact that will be considered and their potential effects on coastal birds are set out below for the three phases of the Project, together with explanatory text. It should be noted that these assessments will utilise information from other EIA studies including coastal processes, marine water quality, fish, intertidal and subtidal benthic ecology, marine ecology as well as terrestrial noise and vibration. There will therefore be a close link between specialists working on these various topic areas to confirm data required and to share findings of assessments.

15.2.2 Potential effects arising in the construction phase

15.2.2.1 Construction phase effects that might impact upon coastal birds include the following in Table 15.2, which are discussed further below.

Table 15.2 Potential impacts of the Project on coastal birds during construction

Construction		
Potential source of impact	**Potential development impact**	**Potential effect**
Construction vehicles, vessels and plant and artificial light	Visual disturbance	Behavioural disturbance and displacement, effect on fitness
	Noise disturbance	
Construction of lagoon breakwater, piling, dredging, temporary construction compounds, access routes	Temporary noise disturbance from piling	Behavioural disturbance and displacement
	Temporary changes in suspended sediment concentration leading to effects on prey availability and habitat degradation	Effect on fitness and mortality
	Habitat loss (temporary and permanent)	Behavioural disturbance and displacement, effect on fitness and mortality
	Changes in coastal processes and hydrodynamic regime leading to habitat degradation	Effect on fitness and mortality

Construction		
Potential source of impact	**Potential development impact**	**Potential effect**
Temporary discharges from construction works to environment, accidental spillages Release of contaminants from disturbed bottom sediments	Changes to water quality	Effect on fitness

Visual Disturbance

15.2.2.2 Coastal bird species can be sensitive to human activity (including people, machinery and vessels). In particular, wildfowl are likely to be sensitive to people on the foreshore and offshore vessel movements associated with the construction process have potential to disturb offshore birds. People working within construction vehicles are less likely to disturb coastal birds, for instance, as vehicles can act like a hide which obscures the characteristic outline of the human body resulting in much less disturbance (measured as an escape response) compared to when a person is out of a vehicle (Klein, 1993).

Noise Disturbance

15.2.2.3 The effects of temporary noise disturbance throughout construction on coastal birds will be assessed. This will take into account the timing, methodology and location of construction activities in relation where the birds are found and their activity in these areas e.g. roosting, feeding. The findings of the noise assessments (Chapter 20 Marine Noise and Vibration and Chapter 21 Terrestrial Noise and Vibration) will be used to assess the area over which noise thresholds for specific species might be exceeded.

Light Disturbance

15.2.2.4 The introduction of artificial lighting (particularly during the construction phase) may disturb some coastal bird species whilst benefitting others. Dunlin for example, have been shown to benefit from the artificial illumination of intertidal habitats which allows continuation of foraging during hours of darkness in winter months (Rehfisch et al. 1993). An assessment of the impacts of light disturbance on individual species will be undertaken where relevant.

Temporary and Permanent Habitat loss

15.2.2.5 Temporary habitat losses associated with construction such as from cofferdams, laydown areas and other supporting infrastructure will be addressed in the

construction phase assessment. The assessment will cover all habitats used by coastal birds, for which the inter-tidal and saltmarsh areas are likely to be the most important. The loss will be assessed as temporary where there are clear and deliverable plans for the restoration of temporarily lost habitats after the construction phase has finished. Permanent losses are those that will start at the time of construction and last the lifetime of the Project i.e. loss of habitat under permanent structures e.g. breakwater, turbine housing. The assessment of habitat loss will include losses to all habitats of value to coastal birds (designated and not designated). The assessment of impacts will account for any habitat mitigation identified to offset any significant impacts on habitats that affect coastal birds.

15.2.2.6 As well as direct loss of habitat during the construction phase, consideration will be given to the potential effects of habitat fragmentation. Given the mobility of coastal birds, fragmentation is not expected to be an effect of more than minor magnitude and it is expected to be scoped out of further assessment.

Habitat degradation or change

15.2.2.7 As well as direct loss of habitat during the construction phase there may be effects that reduce the quality of habitat i.e. habitat degradation, which could affect roosting or foraging areas. This aspect will be included in the assessment.

15.2.2.8 Changes in the hydrological regime (including the quality, quantity and energy levels within estuarine and coastal waters) have the potential to alter ecological communities. Alteration of habitat affecting food chain species such as fish and benthic invertebrates has potential to impact coastal birds. This could result in reduced condition and fitness of birds or higher risk of mortality. Aspects including age of birds and site fidelity will also be considered. Hydrological and sediment modelling described in Chapter 8 Coastal Processes, Sediment Transport and Contamination, and those effects on fish and benthic invertebrates described in Chapter 13 Fish including Commercial and Recreational Fisheries and Chapter 12 Intertidal and Subtidal Benthic Ecology respectively will be used to predict resultant effects on coastal birds. In addition, modelling including the potential use of Habitat Association Modelling (HAM) and Individual Behaviour Modelling (IBM) (see Section 15.4 and Appendix 15.1 for further details) will be undertaken to further refine the assessment. The use of these modelling techniques will be discussed with statutory authorities.

Chemical emissions and pollution

15.2.2.9 Construction activities may result in a variety of emissions, including dust, surface water discharge and accidental spillages. These emissions could affect coastal birds both directly (e.g. oiling of plumage) and indirectly through habitat degradation and impacts on the food chain.

15.2.3 Potential effects arising in the operation phase

15.2.3.1 Operational phase effects that might impact upon coastal birds include the following outlined in Table 15.3.

Table 15.3: Potential impacts of the Project on coastal birds during operation

Operation		
Potential source of impact	**Potential development impact**	**Potential effect**
Maintenance vehicles and vessels, recreational use of lagoon, artificial light	Visual disturbance	Behavioural disturbance and displacement, effect on fitness and mortality
	Noise disturbance	
Presence of lagoon breakwater	Permanent habitat loss	Behavioural disturbance and displacement, effect on fitness and mortality
	Changes in coastal processes and hydrodynamic regime leading to habitat degradation (through alterations in prey availability)	Effect on fitness and mortality
Release of contaminants from disturbed bottom sediments during maintenance dredging	Changes to water quality	Effect on fitness and mortality

Visual and noise disturbance

15.2.3.2 There are potentially coastal bird species present in the vicinity of the Project that are likely to be sensitive to noise. Sources of operational noise may arise from any incidental activity within the lagoon (such as boating). Given that turbines are permanently submerged and located at some distance offshore, this noise source is likely to have minimal potential to disturb non-breeding birds associated with habitats closer to shore. As noise becomes attenuated with distance, the findings of the noise assessments (see Chapters 20 and 21) will be used to assess the area over which noise thresholds for specific species might be exceeded.

15.2.3.3 The feeding and roosting opportunities presented by habitats enclosed within the lagoon has the potential to benefit coastal bird species. The extent to which such birds are able to benefit depends upon the intensity and spatial extent of human use of the lagoon and its enclosing breakwater.

Artificial light disturbance

15.2.3.4 An assessment of the impacts of any artificial lighting required during operation including the potential disturbance of individual species will be undertaken.

Permanent habitat loss

15.2.3.5 Permanent habitat loss under the lagoon breakwater will be addressed in the construction phase assessment. The assessment of habitat loss for the operational phase will relate to losses associated with the presence of the lagoon breakwater and the operation of sluice gates and turbines. These may include alteration in the extent or distribution of intertidal and subtidal habitats, or changes in tidal phasing compared to areas outside of the lagoon footprint. The assessment of habitat loss will include losses to all habitats of value to coastal birds (designated and not designated). The assessment of impacts will account for any habitat mitigation identified to offset any significant impacts on habitats that affect coastal birds.

15.2.3.6 Consideration will also be given to the potential effects of habitat fragmentation resulting from the operation of the sluice gates and turbines. Given the mobility of coastal birds fragmentation is not expected to be an effect of more than minor magnitude and it is expected to be scoped out of further assessment.

Permanent habitat degradation

15.2.3.7 As well as direct loss of habitat as a result of the lagoon, there may be effects that permanently reduce the quality of habitat i.e. habitat degradation. Degradation may result in changes to feeding or roosting habitats or availability of prey species. This assessment will be informed by the Coastal Processes (Chapter 8), Intertidal and Subtidal Benthic Ecology (Chapter 12) and Fish (Chapter 13) assessments. In addition, the use of modelling techniques (potentially HAM and IBM) **(**see Section 15.4 and Appendix 15.1 for further details) will further refine the assessment.

Pollution

15.2.3.8 Maintenance dredging throughout operation has the potential to release contaminants that may affect coastal birds directly or indirectly, through the food chain. The results of hydrological and sediment modelling described in Chapter 8 Coastal Processes, Sediment Transport and Contamination will be used to inform this assessment.

15.2.4 Potential effects arising in the decommissioning phase

15.2.4.1 The Project has a design life of 120 years. As discussed in Chapter 6 Project Description, decommissioning is likely to involve either upgrade of the generating station or removal of the electricity generating infrastructure. The potential decommissioning scenarios will be assessed. With such a long project life it is not known to what extent the coastal bird population will have responded to effects outside the control of the developer such as climate change. In addition, the size and composition of any coastal bird population that might become dependent on the enclosed water body of the lagoon is not known. These factors will be discussed as part of the assessment.

15.2.5 Geographical scope of the assessment

15.2.5.1 The geographical scope of the assessment will be based on the maximum geographical area around the Project where potential for impacts on coastal birds are likely to occur. Potential in-combination plans and projects are discussed in Chapter 3 Structure of the Environmental Statement. Relevant to the potential effects on coastal birds are the proposed Tidal Lagoon Swansea Bay lagoon at Swansea, the proposed Longbay Seapower lagoon in West Somerset and Hinkley Point (amongst others).

15.2.5.2 The geographical area will vary with the type of effect and the bird feature affected. A Zone of Influence (ZoI) is expected to be identified through hydrological and sediment effects that arise from the Project alone and in-combination with other plans and projects. This process is further discussed in Chapter 8 Coastal Processes, Sediment Transport and Contamination. It will also take into account the results of any HAM and IBM undertaken.

15.3 Existing baseline data, consultation and need for survey

15.3.0.1 This section sets out the current understanding of the available baseline data and identifies any requirements for additional surveys to fill knowledge gaps to inform the EIA. The survey methodologies consider the key coastal birds features of the Severn Estuary SPA and Ramsar site.

15.3.1 Existing baseline data

15.3.1.1 The principal source of data for non-breeding waterbirds occurring in the UK, including the Severn Estuary, is that collated by the Wetland Bird Survey (WeBS). WeBS is a partnership between the British Trust for Ornithology, the Royal Society for the Protection of Birds and the Joint Nature Conservation Committee (the last on behalf of the statutory nature conservation bodies: Natural England, Natural Resources Wales and Scottish Natural Heritage and the Department of the Environment Northern Ireland), in association with the Wildfowl and Wetlands Trust.

15.3.1.2 Numbers of waterbirds and general population trends of birds wintering at coastal and wetland sites across the United Kingdom are monitored by the WeBS Core (high tide) Counts and Low Tide Count programmes. The area covered by the WeBS data for the Severn Estuary are shown in Figure 15.3.

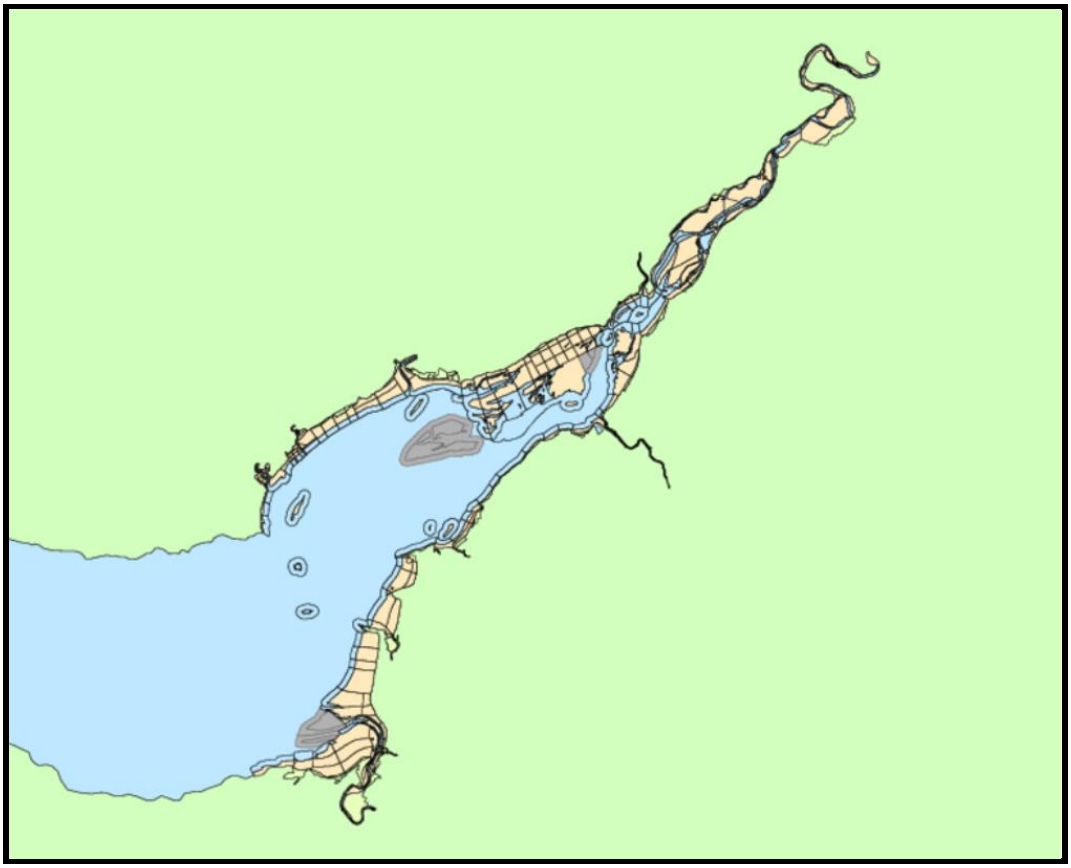

Figure 15.3 Severn Estuary WeBS Survey Areas (source BTO Website)

15.3.1.3 Core Counts for birds of the Severn Estuary are typically from high tide roosts and are recorded on a monthly basis. The latest data on Core Counts (high tides) being for the winter of 2012/13 with five year mean peak counts available for 2008/09 to 2012/13. Further data on the more recent surveys is anticipated in the next few months.

15.3.1.4 Low Tide Counts which provide an insight into feeding distributions of waterbirds, are carried out less frequently. The Severn Estuary was last covered for WeBS Low Tide Counts during the period of the Severn Tidal Power SEA in 2008/09 (Burton et al. 2010).

15.3.1.5 The WeBS Core (high tide) Counts and Low Tide Count programmes provide a valuable baseline resource for assessment of potential impacts on coastal birds. Typically, the information available for project specific assessment is strengthened through commissioning of surveys by professional ornithologists enabling a certain degree of information gap-filling.

Baseline data gathered by ongoing field surveys

15.3.1.6 TLC commissioned Link Ecology to undertake bird surveys in line with BTO WeBS methodology for high and low tide counts in February 2014, under the proposed shoreline footprint of the Project and up to the Second Severn Crossing. The

surveys have been commissioned up until May 2015 in order to cover a complete biological year.

15.3.1.7 In addition to counts, data have been collected on bird activity across the study area in order to gather information on the general usage and movement of birds during a variety of tidal cycles and weather conditions. Non-wetland birds of note or specific interest (i.e. Red or Amber status (WOS, 2009)) observed within the site have also been recorded. Incidental notes have also been made on disturbance events, originating onshore or from the estuary itself, including reaction of birds to them.

Baseline data gathered by gap analysis desk study

15.3.1.8 TLP commissioned APEM Ltd to complete a gap analysis (APEM, 2014), which included an extensive review of existing data sets available for the Severn Estuary and beyond. These included (but are not limited to) the following:

i. SPA and Ramsar citations;

ii. 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 and JNCC, in association with WWT. British Trust for Ornithology, Thetford;

iii. Clark, N.A. (1983) *The ecology of dunlin (*Calidris alpina *L.) wintering on the Severn Estuary*. Ph.D. thesis. University of Edinburgh;

iv. Clark, N.A. (1990) Distribution studies of waders and Shelduck in the Severn estuary. Report to UK Department of Energy's Renewable Energy Research Development Programme (ETSU TID 4076), 111pp;

v. DECC. (2010) *Severn Tidal Power SEA Topic Paper 01 Feasibility Study Conclusions & Summary Report*. DECC, London;

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

vii. Burton, N., Rehfisch, M., Clark, N. & Dodd, S. 2006. Impacts of sudden winter habitat loss on the body condition & survival of redshank *Tringa totanus*. *Journal of Applied Ecology* 43, 464-473; and

viii. WWT. (2008) *Aerial Surveys for Waterbirds and Seabirds in the South West of England and Wales: 2007 Final Report*. WWT Consulting. Report to Department for Business, Enterprise and Regulatory Reform.

15.3.1.9 The gap analysis concluded that although a wide range of data and reports are available to support a desk study and subsequent EIA and HRA work for the Project

there were some gaps, such as the very limited information available on offshore waterbirds. Much of these data provide the historical context for any assessment of the impacts on the Severn Estuary and Bristol Channel waterbird populations, however, data currently being gathered and the proposed surveys (see Section 15.3.3) should provide sufficient baseline information upon which to base an assessment.

15.3.2 Consultations

15.3.2.1 Given the location of the Project within sites of international nature conservation interest, consultation will be a key part of the EIA and HRA process. Parties expected to be consulted would include:

i. Natural Resources Wales (NRW);

ii. Natural England;

iii. Royal Society for the Protection of Birds (RSPB);

iv. Wildfowl and Wetland Trust (WWT);

v. Wildlife Trust Wales;

vi. Glamorgan Bird Club; and

vii. Gwent Ornithological Society.

15.3.2.2 In relation to HRA requirements it is expected that an 'Evidence Plan' approach will be adopted to agree each stage of the assessment and its findings in an iterative manner. Please see Chapter 2 Proposed Approach for further details.

15.3.3 Proposed surveys

15.3.3.1 Burton et.al (2014) (Appendix 15.1) states that it is important to ensure that adequate baseline information exists on the numbers and distributions of birds across the Severn Estuary as a whole. This is because:

i. It is necessary to be able to put the numbers of birds found within the Project area in context;

ii. Waterbirds will also be impacted by effects outside the Project area (as indicated above); and

iii. Due to the complexity of changes to the estuary resultant from construction of a tidal lagoon project, the impacts on waterbirds cannot be reliably assessed without modelling work, which itself is reliant on data for the estuary as a whole.

15.3.3.2 The recommendations and rationale for surveys are included in detail in Appendix 15.1 and are summarised below.

WeBS Core (High Tide) Counts

15.3.3.3 The populations of species supported on the Severn Estuary SPA and, indeed, across the UK SPA network as a whole, have changed over time (Cook et al. 2013). This is apparent in the differences between the population sizes provided in the Natura 2000 Data Forms for the Severn Estuary SPA, the Information Sheet for the Severn Estuary Ramsar Site and Austin et al. (2014), which are based on data from WeBS for 1991/92-1995/96, 1998/99-2002/03 and 2008/09-2012/13 respectively.

15.3.3.4 Given these changes, it is recommended that baseline information for both the EIA and the HRA on the numbers of birds on the Severn Estuary would best be provided by the up-to-date five-year mean peak values supplied by BTO to understand variation between years. In areas of the coastline where no data are available within the Severn Estuary survey coverage (Figure 15.3), it is proposed to undertake professional gap-filling surveys over a minimum of at least one 'WeBS' year (July to June). Similar gap-filling was undertaken during 2008/09 to inform the Severn Tidal Power SEA (Burton et al. 2010a).

15.3.3.5 Extra Core (high tide) Count surveys during spring migratory passage periods are also proposed in all areas. Large numbers of waders of certain species may pass through the estuary during spring, but over a relatively short time period, and thus may be missed by the monthly Core Counts (Burton et. al.2010a).

15.3.3.6 Data from the WeBS Core Counts were used in the Severn Tidal Power SEA programme to inform HAM, one of the two approaches taken to predict densities and thus numbers of waterbirds on intertidal areas following proposed tidal power options (Burton et al. 2010a).

WeBS Low Tide Counts

15.3.3.7 As part of the Severn Tidal Power SEA programme, the 2008/09 and 2002/03 WeBS Low Tide Counts were supported by additional funding provided by DECC and English Nature and the Countryside Council for Wales respectively. This funding helped to fill gaps in volunteer coverage and enabled boat-based surveys of the central intertidal areas of the estuary to be undertaken (Burton et al. 2003, 2010a).

15.3.3.8 These previous surveys have highlighted that, with the exception of these central areas of the estuary, adequate survey by ground-based observations is possible. The central areas were successfully surveyed through boat-based surveys both in 2002/03 and 2008/09. Baseline information for EIA/HRA on the distributions of waterbirds on the Severn Estuary would thus best be provided by up-to-date WeBS Low Tide Counts of the estuary (extent shown in Figure 15.1), with enhanced coverage in the areas not previously surveyed provided by professional gap-filling.

Through The Tidal Cycle (TTTC) surveys

15.3.3.9 The detailed information provided by Through The Tidal Cycle (TTTC) surveys on the variation in numbers and activity of birds using study sites means that they

have the potential to help validate modelling approaches, such as IBM. Targeted surveys within the areas of the footprint of the Project may be useful in this respect and will be the subject of ongoing consultation with the statutory nature conservation bodies.

15.3.3.10 Despite the added detail that TTTC surveys may provide, given the limited extent of areas that can be practicably surveyed, low tide surveys provide the best means for informing on the distributions of waterbirds across large estuaries, and high tide surveys on their overall populations.

Breeding seabird surveys

15.3.3.11 Lesser black-backed gull (*Larus fuscus*) and herring gull (*Larus marinus*) are features of Steep Holm and Flat Holm SSSIs. Great cormorants (*Phalacrocorax carbo*) also breed on Steep Holm and would be a potential receptor in any EIA. Up to date breeding information for these species may be available from the relevant statutory authorities. It is not proposed to undertake any Project specific breeding seabird surveys.

Surveys beyond the Severn Estuary

15.3.3.12 Data from WeBS Core Counts and Low Tide Counts will be the main source of information to inform the assessment of potential effects beyond the Severn Estuary. The far-field effects will be informed by the results of coastal process modelling (Chapter 8 Coastal Processes, Sediment Transport and Contamination) and it is not proposed to undertake any Project specific surveys of waterbirds outside the Severn Estuary.

Tracking studies

15.3.3.13 Tracking technologies have the potential to:

i. Inform on the migratory movements of bird species that utilise the Severn Estuary;

ii. Inform on movements of birds within winter and thus use of adjacent habitats around the Severn Estuary and potential connectivity with adjacent protected sites; and

iii. Contribute to future monitoring to validate potential effects and use of any compensatory or mitigation habitats created.

15.3.3.14 Further information about potential tracking studies is given in Appendix 15.1. The use of tracking studies will be considered as part of discussions with the statutory nature conservation bodies regarding survey methodologies.

15.4 Proposed assessment methodology

15.4.1 Impact Assessment Methodology

15.4.1.1 The impact assessment methodology for coastal birds is based on that described in Chapter 3 Structure of the Environmental Statement. That methodology has been adapted to make it applicable to ornithology receptors and aligned with the key guidance document produced on impact assessment on ecological receptors in the marine and coastal environment (IEEM, 2010).

15.4.1.2 The assessment will be undertaken accounting for embedded mitigation, that is elements of project design or practice that are accepted as an integral part of the project that avoid or reduce particular types of impact. Relevant construction (Construction Environmental Management Plan (CEMP)) and / or operational management plans (Operational Environmental Management Plan (OEMP)) will also include such embedded mitigation (see Chapter 26 Mitigation, Monitoring and Compensation).

15.4.1.3 The assessment approach uses the conceptual 'source-pathway-receptor' model. The model identifies likely environmental impacts resulting from the proposed construction, operation and decommissioning of the Project. This process provides an easy to follow assessment route between impact sources and potentially sensitive receptors ensuring a transparent impact assessment. The parameters of this model, using construction activities as an illustrative example, are defined as follows:

i. Source – the origin of a potential impact (noting that one source may have several pathways and receptors) i.e. an activity such as lagoon breakwater construction and a resultant effect e.g. re-suspension of sediments.

ii. Pathway – the means by which the effect of the activity could impact a receptor e.g. for the example above, re-suspended sediment could settle and smother the seabed.

iii. Receptor – the element of the receiving environment that is impacted e.g. for the above example, bird prey species living on or in the seabed.

15.4.1.4 To determine the significance of possible impacts, standard EIA criteria will be taken into account:

i. Magnitude of the impact;

ii. Spatial extent of the impact;

iii. Duration of the impact;

iv. Likelihood of occurrence; and

v. Confidence in accuracy of predicted impact.

15.4.1.5 Confidence in the predictions of the assessment will be assigned according to a three point scale based on expert judgement (High, Probable, Uncertain).

15.4.1.6 Potential impacts will be identified for the three phases of the Project: construction, operation and decommissioning. In addition, any potential in-combination impacts of the Project with other plans and projects in the area will be assessed (See Chapter 3 for more details).

Evaluation

15.4.1.7 The value of ornithological receptors will be evaluated according to the following scale:

i. International;

ii. National

iii. Regional/County;

iv. District/Borough; and

v. Parish/Local (within the zone of influence of the Project only).

15.4.1.8 Table 15.4 provides for each an example based on sites with ornithology interest features.

Table 15.4: Example Definitions of the Value Levels for Ornithology Receptors

Evaluation	
Value	**Example Description**
International	An internationally designated site or candidate site (SPA, pSPA, SAC, cSAC, pSAC, Ramsar site, etc) or an area which the country agency has determined meets the published selection criteria for such designation, irrespective of whether or not it has yet been notified. Under the Ramsar Convention a wetland is considered internationally important if it regularly holds at least 1% of the individuals in a population of any species (or sub-species) of waterbird, or if it regularly supports 20,000 or more waterbirds (Ramsar, 2008). Regularly occurring, globally threatened species (i.e. International Union for Conservation of Nature (IUCN) Red listed) or species listed on Annex 1 of the Berne Convention. Regularly occurring populations of internationally important species that are rare or threatened in the UK or of uncertain conservation status. A regularly occurring, nationally significant population/number of any internationally important species.
National	A nationally designated site (SSSI, NNR, MNR) or a discrete area, which the country conservation agency has determined meets the published selection criteria for national designation (e.g. SSSI selection guidelines) irrespective of whether or not it has yet been notified. A wetland regularly holding 1% or more of the estimated British population of any species (or sub-species) of waterbird. Regularly occurring populations of UKBAP species. Regular occurring populations of SSSI citation listed qualifying species.
Regional/County	Any regularly occurring significant population that is listed in a Local Red Data Book or County Local Biodiversity Action Plan (LBAP). Regularly occurring populations (<1% winter or summer) of a regionally/county important species. Regular occurring populations of Red listed species in the UK or Wales.
District/Borough	Regularly occurring populations of a locally important/rare species. Regularly occurring populations of Amber listed species in the UK or Wales.
Parish/Local	Regular populations of species that are common and widespread. Regularly occurring populations of Green listed species in the UK or Wales.

Sensitivity

15.4.1.9 The sensitivity of ornithological receptors will be defined for each species and related to sensitivities to specific impact types, informed by guidance published that relates to similar types of renewable energy developments (e.g. Furness *et al.*, 2012 for tidal stream turbines and wave energy devices).

15.4.1.10 Table 15.5 provides definitions of sensitivity, using as an illustrative example the different sensitivity levels applied to the potential impact of disturbance through construction activity.

Table 15.5 Illustrative Example Definitions of the Different Sensitivity Levels for Ornithology Receptors

Sensitivity	
Level	**Definition**
High	Bird species has very limited tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people
Medium	Bird species has limited tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people
Low	Bird species has some tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people
Negligible	Bird species is generally tolerant of sources of disturbance such as noise, light, vessel movements and the sight of people

15.4.1.11 It should be noted that high value (defined below) and high sensitivity are not necessarily linked within a particular impact. A receptor could be of high value (e.g. an interest feature of a SPA) but have a low or negligible physical/ecological sensitivity to an effect and vice versa. Potential impact significance will not be inflated simply because a feature is 'valued'. Similarly, potentially highly significant impacts will not be deflated simply because a feature is not "valued". The narrative behind the assessment is important here; the value of an ornithological receptor can be used where relevant as a modifier for the sensitivity (to the effect) already assigned to the receptor.

Magnitude

15.4.1.12 The definitions of the magnitude of effects for ornithology receptors are set out in Table 15.6. This set of definitions has been determined on the basis of changes that the effect is predicted to make to bird populations.

Table 15.6 Definitions of the Magnitude of Effects

Magnitude Level	Definition
Major Negative	The change is likely to cause a permanent adverse effect on the integrity of an ecological receptor. The Project will have effects which would adversely impact on the integrity of a site (at regional to international level).
Moderate Negative	The Project will not adversely impact upon the integrity of a site, but the effect on the site is likely to be significant in terms of its ecological objectives (e.g. key attributes of a site will be altered, but not so much as to result in a change in the site's evaluation). The Project will have permanent and severe impacts upon undesignated habitats of county importance. The Project will result in changes in the distribution of a legally protected species, but not affect its population status or conservation status but the population will become more vulnerable.
Minor Negative	Neither of the above applies, although some negative impact to a designated site or undesignated habitat of regional / county importance is evident. The Project will have permanent and severe impacts upon undesignated habitats of local / negligible importance. The Project will have an adverse effect on a legally protected species but with no significant reduction in conservation status.

Magnitude Level	Definition
Neutral	Although it is not always possible to state categorically that there will be no impact on a receptor the term neutral will be used where the level of exposure is considered to be less than the tolerance of the receptor, therefore an impact is unlikely. Or there will be no impact at all on that habitat or species/faunal group.
Positive	The change is likely to benefit the receptor in terms of its conservation status, but not so far as to achieve favourable conservation status.

Impact Significance

15.4.1.13 Following the identification of the receptor value and the determination of the magnitude of the effect, the significance of the impact will be determined. That determination will be guided by the matrix that is presented in Table 15.7. Impacts shaded red or orange are regarded as being significant for the purposes of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2009 (the 'EIA Regulations') and the Marine Works (Environmental Impact Assessment) Regulations 2007.

Table 15.7: Matrix to Guide Determination of Impact Significance

Nature Conservation Value	Magnitude of Potential Impact				
	Major Negative	Moderate Negative	Minor Negative	Neutral	Positive
International / Very High	Major Adverse	Major Adverse	Moderate to Minor Adverse	No Impact	Major to minor Beneficial
National / High	Major Adverse	Major to Moderate Adverse	Minor Adverse	No Impact	Major to minor Beneficial
Regional / Medium	Moderate Adverse	Moderate to Minor Adverse	Minor Adverse	No Impact	Moderate Beneficial
District / Low	Minor Adverse	Minor Adverse	Insignificant	No Impact	Minor Beneficial
Local / Negligible	Minor/ Insignificant	Insignificant	Insignificant	No Impact	Insignificant

15.4.1.14 It is important that the matrix (and indeed the definitions of sensitivity and magnitude) is seen as a framework to aid understanding of how a judgement has been reached from the narrative of each impact assessment and it is not a prescriptive formulaic method. Expert judgement has been applied to the assessment of likelihood and ecological significance of a predicted impact. For the purpose of this assessment, the IEEM (2010) guidance will be followed, which states that an ecologically-significant impact is: *'an impact that has a negative, or positive, effect on the integrity of a site or ecosystem and/or the conservation objectives for habitats or species populations within a given geographical area. In*

this way significant impacts are distinguished from other, lesser (and, in the context of EIA, unimportant) effects'

15.4.2 Inter-relationships

15.4.2.1 The assessment will account for and address inter-relationships between sources of effect arising from the Project and receptors (sources of effect from other plans and projects are addressed within the cumulative and in-combination section). For birds these are in particular those that operate through the food chain (e.g. sediment movements affecting benthic invertebrates that are in turn fed on by birds). Such inter-relationships will be captured within the coastal birds ES chapter and further presented within a specific chapter within the ES.

15.4.2.2 Inter-relationships relevant to coastal birds might include links between the following:

i. Coastal processes and sediment transport;

ii. Marine water quality;

iii. Intertidal and subtidal benthic ecology;

iv. Fish populations; and

v. Marine and terrestrial noise.

15.4.3 Transboundary effects

15.4.3.1 The assessment will consider whether there is any potential for significant effects on coastal birds in other European Economic Area (EEA) states by completion of a transboundary screening process, and if necessary, specific assessment (Planning Inspectorate, 2012). Transboundary effects will be reported within a specific chapter within the ES.

15.4.4 Residual effects and mitigation actions in addition to embedded mitigation

15.4.4.1 The assessment of impacts on coastal birds will be an iterative process with identified effects being addressed through mitigation actions that become embedded within the design of the Project. If at the final stage of assessment there are residual effects that are not addressed through embedded mitigation then these will be identified. Additional actions may be identified to mitigate these effects or they may remain unmitigated and considered in the final weighing of the balance of positive and adverse impacts arising from the Project.

15.4.4.2 This process will consider any specific recommendations from the Severn Tidal Power SEA (Burton *et al.,* 2010) and the associated assessment of the issues surrounding potential habitat creation mitigation / compensation measures (Wright *et al.,* 2010) regarding work that might be required to inform ornithological assessment and mitigation / compensation options of future tidal power proposals on the Severn Estuary.

15.4.5 Methods proposed to assess specific effects

Outputs from other workstreams

15.4.5.1 The coastal bird assessment will be informed by data streams and modelling outputs from other topics within the EIA. Key interfaces are listed in Table 15.8.

Table 15.8 Outputs from other workstreams required to inform the impact assessment

EIA topic area	Modelling/study outputs required	Application within coastal birds assessment
Water Quality Processes (Chapter 9)	Modelling of changes to water quality that might affect fish and invertebrate populations that are bird food	Food chain effects on all coastal bird populations
Coastal Processes, Sediment Transport and Contamination (Chapter 8)	Modelling of changes to sediments that might affect fish and invertebrate populations that are bird food	Food chain effects on all coastal bird populations
Intertidal and Subtidal Benthic Ecology (Chapter 12)	Modelling of changes to invertebrate populations, distribution and accessibility including those species and size classes that are bird food	Food chain effects on invertebrate feeding bird populations
Fish, including Recreational and Commercial Fisheries (Chapter 13)	Modelling of changes to fish populations and distribution including those species and size classes that are bird food	Food chain effects on fish-eating bird populations
Marine and Terrestrial Noise and Vibration (Chapters 20 and 21)	Noise modelling output which identifies areas over which noise effects could occur and the likely noise levels.	Since noise becomes attenuated with distance, noise modelling will be used to assess the area over which noise thresholds for specific species might be exceeded

Methods to assess effects on populations

15.4.5.2 The majority of the potential effects arising from the construction, operation and decommissioning of the Project may act on coastal birds by causing reduced access to food supplies and / or increased energy expenditure. In turn such reduced access to food supplies and / or increased energy expenditure can result in decreased survival or decreased productivity. Either of these, subject to density dependent effects, can lead to reduced populations.

15.4.5.3 These population effects will be assessed using a combination of:

i. Knowledge of the distribution and population of coastal birds derived from desk study and field survey;

ii. Knowledge of the ecology (food supply, energy expenditure, survival, productivity etc) of coastal birds from desk study;

iii. Knowledge of the distribution and population of coastal bird food supply from field survey (principally fish and benthic invertebrates, survey methods described in Chapters 13 and 12 respectively of this scoping report);

iv. Predictions of hydrological and sediment changes from modelling (methods described in Chapter 8 of this scoping report); and

v. Knowledge of the effects that hydrological and sediment changes have on bird food supplies through desk study.

15.4.5.4 For the Severn Tidal Power SEA (DECC, 2010), the assessment of the changes in intertidal habitat for waterbird populations was informed through two modelling approaches: Habitat Association Modelling (HAM) and Individual Based Modelling (IBM) which predicted densities and thus numbers of waterbirds on intertidal areas following proposed tidal power options (Burton et al. 2010a). The two approaches were used in conjunction to inform the assessment, so as to provide a measure of uncertainty in predictions.

15.4.5.5 In summary, HAMs aim to explain densities of waterbirds under the different options using measures of estuary morphology as a proxy for sediment and so in turn (invertebrate) food supplies. IBMs make predictions of the number of birds that can be supported by a site from the underlying physiology and behaviour of individuals (assuming that animals behave in ways that maximise their chances of survival) and require data on birds, biomass, area and tidal exposure of food resources.

15.4.5.6 A more detailed discussion of the information requirements for both these modelling techniques is described in Appendix 15.1. It is known through consultation that Natural Resources Wales have a preference for Individual Based Models (IBMs). It is proposed to continue consultation with Natural Resources Wales (and Natural England) on the most appropriate population modelling technique.

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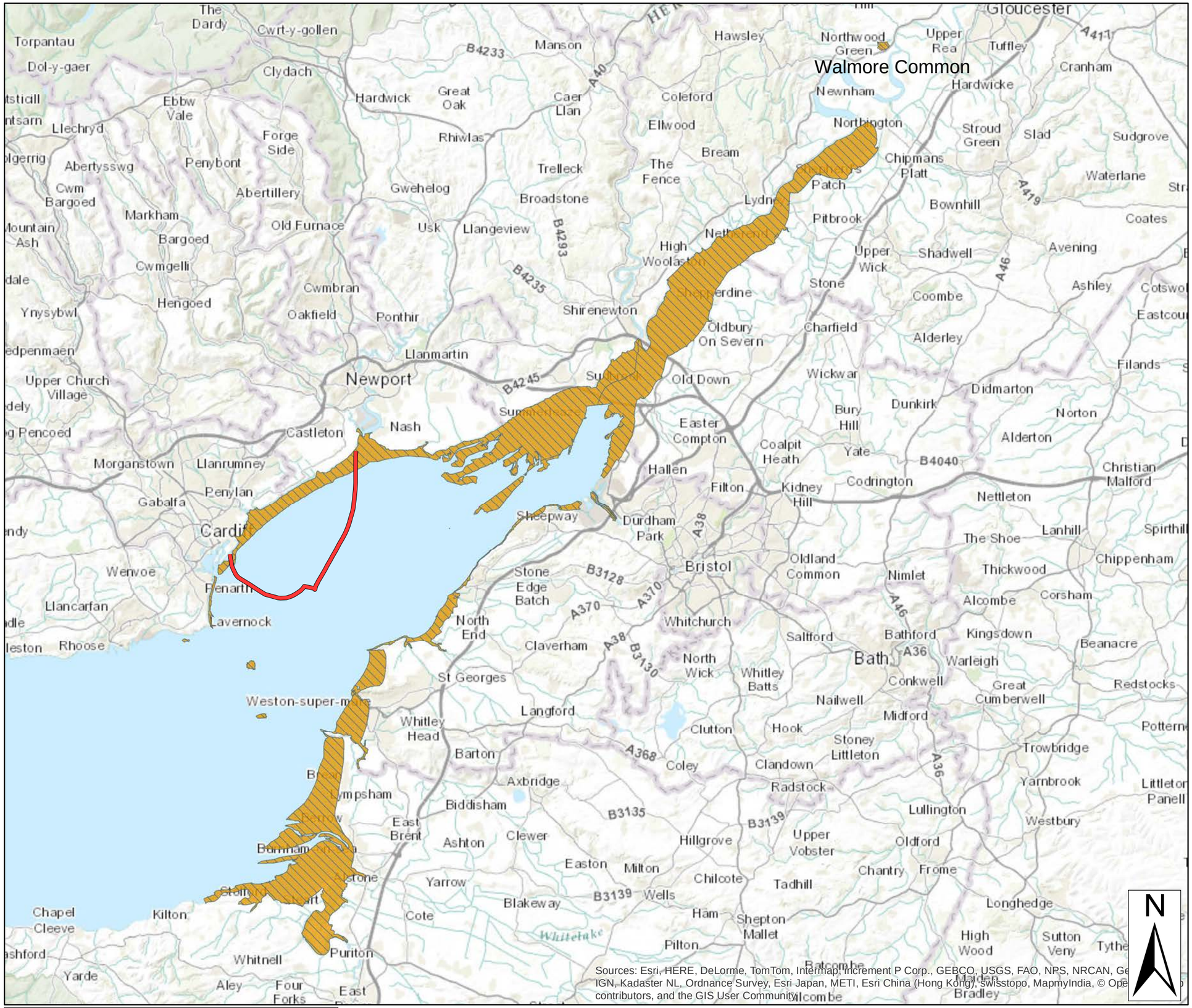
Figures



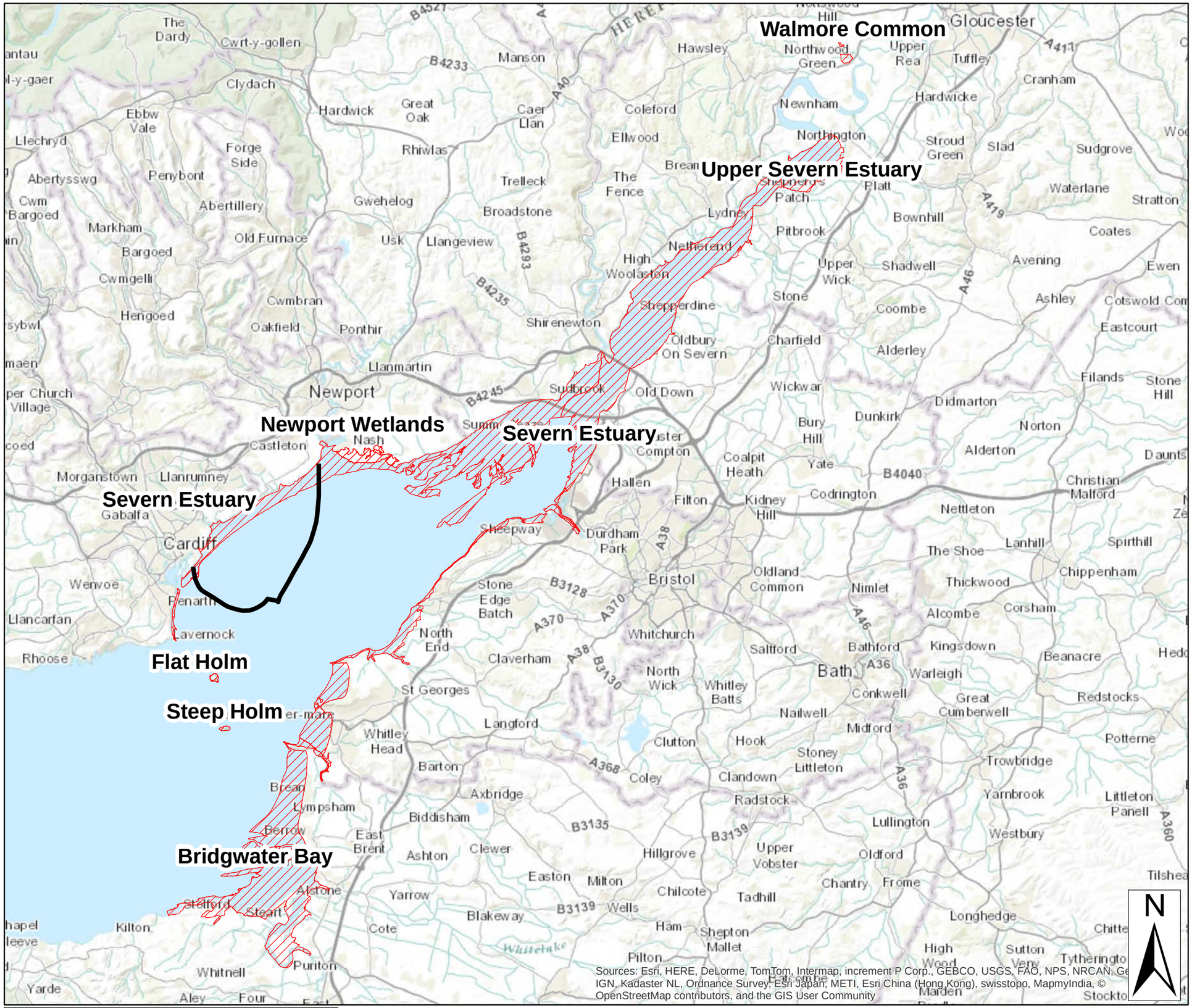
Scale @ A3 1:500,000

Location of internationally designated sites with coastal bird features within the Severn Estuary

Figure 15.1

Date	Drawn By
FEB 2015	SC
Project No. CARDIFF LAGOON	Issue 1

TIDAL LAGOON CARDIFF



Lagoon Wall

SSSI

Location of Sites of Special Scientific Interest (SSSIs) with coastal bird features within the Severn Estuary

Figure 15.2

Date	Drawn By
FEB 2015	SC
Project No. CARDIFF LAGOON	Issue 1

TIDAL LAGOON CARDIFF

Scale @ A3 1:500,000

Appendix 15.1

A summary review of the survey and modelling methodologies required to inform Environmental Impact Assessment and Habitats Regulations Assessment in relation to proposed tidal power lagoons on the Severn Estuary

Combined Ecology | Safeguarding global biodiversity by supporting sustainable development

Research report No: TLPL06/25.2.2015

A summary review of the survey and modelling methodologies required to inform Environmental Impact Assessment and Habitats Regulations Assessment in relation to proposed tidal power lagoons on the Severn Estuary

Report of work carried out by Combined Ecology (a division of BTO Services Ltd) on behalf of Tidal Lagoon Power Ltd

Authors: Niall H.K. Burton, Kathryn E. Ross, Lucy J. Wright and Nigel A. Clark

February 2015

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Executive summary

1. This summary paper has been prepared to inform a scoping report from Tidal Lagoon Power for proposals for a tidal power lagoon at Cardiff on the Severn Estuary and provides an overview of the potential survey and associated modelling methodologies that would inform Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) requirements.

2. In order that the impacts of these potential developments on birds can be assessed through EIA, and also that impacts on the specific features of designated sites can be assessed through HRA, it is necessary to ensure that there are adequate baseline data on the numbers and distributions of birds at a number of scales: (i) within the area of a proposed tidal power lagoon; (ii) within the area of the Severn Estuary as a whole; (iii) within the wider Severn Estuary floodplain; and (iv) at other sites outwith the Severn Estuary.

3. Baseline information for EIA / HRA on the numbers of birds on the Severn Estuary would best be provided by up-to-date five-year mean peak values from WeBS Core Counts with enhanced coverage provided by professional gap-filling over a minimum of at least one 'WeBS' year (July to June), although preferably two years. Similarly, baseline information for EIA / HRA on waterbird distributions on the Severn Estuary would best be provided by up-to-date WeBS Low Tide Counts, with enhanced coverage also provided by professional gap-filling. A programme of surveys undertaken through the WeBS volunteer network, enhanced by professional gap-filling, through 2015/16 would provide information that would both inform the baseline and be used directly in the modelling and for qualifying the results obtained.

4. An overview is provided of the additional information that might be provided by tracking technology in relation to proposals for a tidal power lagoon on the Severn Estuary. Tracking technology has the potential to: (i) inform on the migratory movements of bird species that utilise the Severn Estuary; (ii) inform on movements of birds within winter and thus use of adjacent habitats around the Severn Estuary and potential connectivity with adjacent protected sites; and (iii) contribute to future monitoring to validate potential effects and use of any compensatory or mitigation habitats created.

5. For the previous Severn Tidal Power Strategic Environmental Assessment (SEA) (Burton *et al.* 2010a), the assessment of the principal effect for waterbirds of the loss and changes to intertidal habitat that would result from the development of a tidal power option was informed through two modelling approaches – Habitat Association Modelling and Individual-

Based Modelling. An overview is provided of each of these two approaches, their information requirements and associated limitations, and thus how they would inform assessment of the potential effects of a tidal power lagoon on the Severn Estuary. Recommendations are also provided for a programme of modelling work, including initial work based on existing data and an update based on survey results from 2015/16.

6. In addition, an overview is provided of the recommendations from the Severn Tidal Power SEA of the work that might be required to inform ornithological assessment and mitigation / compensation options of future tidal power proposals on the estuary.

1. Introduction

1.1. Background and objectives

This summary paper has been prepared to inform a scoping report from Tidal Lagoon Power for a proposal for a tidal power lagoon at Cardiff on the Severn Estuary and provides an overview of the potential survey and associated modelling methodologies that would inform Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) requirements.

The paper includes:

i. A summary overview of potential survey methodologies that would inform the EIA and HRA required for proposals for potential tidal power lagoons on the Severn Estuary;

ii. Consideration of the additional information that might be provided by tracking technology;

iii. An overview of how modelling would inform the EIAs / HRAs and the associated information requirements;

iv. Recommendations for a programme of modelling work, including initial work based on existing data and an update based on survey results from 2015/16;

v. An overview of the recommendations from the Severn Tidal Power Strategic Environmental Assessment (SEA) of the work that might be required to inform ornithological assessment and mitigation / compensation options of future tidal power proposals on the estuary.

1.2 Legislative background

A summary of relevant legislation, policies and guidance relating to ornithological EIA and HRA requirements for tidal power lagoon proposals on the Severn Estuary is provided by APEM (2014). This includes international, European and UK legislation and UK policy frameworks.

Waterbird receptors that may need to be considered in assessment will be informed by this legislative background and have the potential to include:

- Species and assemblages listed as features of Special Protection Areas (SPAs)[1], Ramsar Sites[2] and Site of Special Scientific Interest (SSSIs);
- Species included on the UK Biodiversity Action Plan (UKBAP) list[3];
- Species included on the Section 41 BAP Species of Principal Importance in England[4], and Section 42 Species of Principal Importance in Wales[5];
- Species on the Red- and Amber- lists of Birds of Conservation Concern (BoCC) (Eaton *et al.* 2009) and the equivalent Red- and Amber- lists of Birds of Conservation Concern in Wales (Welsh Ornithological Society *et al.* 2009);
- Species classified as Near Threatened in the IUCN Red List[6].
- All waterbird species which occur on the Severn Estuary, and are features of the Severn Estuary SPA, Severn Estuary Ramsar Site[3], or one of the component SSSIs (Table 3.1), or are listed as a UK Biodiversity Action Plan (BAP) species[7], Section 41 BAP Species of Principal Importance in England[8], Section 42 Species of Principal Importance in Wales[9], Amber or Red Listed Birds of Conservation Concern (BoCC) in the UK (Eaton *et al.* 2009) or Wales (Welsh Ornithological Society *et al.* 2009), or IUCN Red list species[10] (Table 3.2), are considered as potential receptors.

(See Burton & Clark 2015 and previous work for the Severn Tidal Power SEA Waterbirds Topic Paper: Burton *et al.* 2010a).

[1] E.g. for the Severn Estuary SPA: http://jncc.defra.gov.uk/page-1409, updated 1 Sep 2014, accessed 8 Jan 2015; http://jncc.defra.gov.uk/page-1400
[2] E.g. for the Severn Estuary Ramsar site: http://jncc.defra.gov.uk/page-5163
[3] http://jncc.defra.gov.uk/page-5163
[4] http://webarchive.nationalarchives.gov.uk/20140605090108/http:/www.naturalengland.org.uk/ourwork/conservation/biodiversity/protectandmanage/habsandspeciesimportance.aspx
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[9] http://www.biodiversitywales.org.uk/49/en-GB/Section-42-Lists
[10] http://www.iucnredlist.org/

2. A summary overview of potential survey methodologies that would inform the EIA and HRA required for proposals for potential tidal power lagoons on the Severn Estuary

2.1 Background

Potentially significant issues for waterbirds relating to the construction of a tidal power lagoon (or barrage) within an estuary were assessed as part of the Severn Tidal Power Strategic Environmental Assessment (SEA) (Burton *et al.* 2010a) and were summarised by Burton *et al.* (2010b). These effects (some of which may operate over the construction phase as well as the operational phase of a lagoon) include: disturbance, loss of and changes to intertidal habitat (and also changes to water quality), changes to saltmarsh, changes to fish populations, changes to freshwater wetlands, far-field changes in water levels, displacement effects, and effects on other sites in the Natura 2000 network.

In order that the impacts of these potential effects on birds can be assessed through EIA, and also that impacts on the specific features of designated sites can be assessed through HRA, it is necessary to ensure that there are adequate baseline data on the numbers and distributions of birds at a number of scales:

i. Within the area of a proposed tidal power lagoon (e.g. in relation to disturbance, direct loss of habitat, loss of and changes to intertidal habitat and changes to saltmarsh);
ii. Within the area of the Severn Estuary as a whole (e.g. in relation to loss of and changes to intertidal habitat and changes to saltmarsh);
iii. Within the wider Severn Estuary floodplain (e.g. in relation to indirect effects such as changes to freshwater wetlands); and
iv. At other sites outwith the Severn Estuary (in relation to far-field effects such as changes in water levels or displacement of birds from the estuary).

Here we consider the information required to inform assessment of the impacts of these potential effects across the scales at which they would likely operate. The focus is on the survey requirements with respect to waterbirds and seabirds. Additional surveys would also be required with respect to those terrestrial bird species that might be impacted through the onshore effects associated with a tidal power lagoon project.

2.2 Effects within the area of a proposed tidal power lagoon and within the area of the Severn Estuary as a whole

2.2.1 Introduction

Potential waterbird or seabird receptor species within the area of the Severn Estuary are summarised in Tables 2.1 and 2.2. In addition to species that are of primary importance for their non-breeding populations, three species – Great Cormorant *Phalacrocorax carbo*, Lesser Black-backed Gull *Larus fuscus* and European Herring Gull *Larus argentatus* are also of interest for their breeding populations (Burton *et al.* 2010c).

Tidal Lagoon Power commissioned Link Ecology in February 2014 to undertake high and low tide counts, in line with Wetland Bird Survey methodology (see below), of the area within the intertidal footprint of the area within the intertidal footprint of the proposed Cardiff lagoon and up to the Second Severn Crossing. The surveys have been commissioned up until May 2015 in order to cover a complete biological year.

In addition to the counts, data has been collected on bird movement across the study area in order to gather information on the general usage and movement of birds within it, on a variety of tidal cycles and weather conditions. Any non-wetland birds of note or specific interest (e.g. Species on the Red- and Amber- lists of Birds of Conservation Concern; Eaton *et al.* 2009) observed within the site have also been recorded.

However, it is important to also ensure that there is adequate baseline data on the numbers and distributions of birds across the Severn Estuary as a whole. This is because:

i. It is necessary to be able to put the numbers of birds found within the proposed project areas in context;
ii. Waterbirds will also be impacted by effects outside these areas (as indicated above); and
iii. Due to the complexity of changes to the estuary resultant from construction of a tidal power project, the impacts on waterbirds cannot be reliably assessed without modelling work, which itself is reliant on data for the estuary as a whole (see section 4).

The principal source of data on the internationally important numbers of non-breeding waterbirds that occur in the UK is the Wetland Bird Survey (WeBS: http://www.bto.org/volunteer-surveys/webs). This scheme is a partnership between the British Trust for Ornithology, the Royal Society for the Protection of Birds and the Joint Nature Conservation Committee (the last on behalf of the statutory nature conservation bodies:

Natural England, Natural Resources Wales, Scottish Natural Heritage and the Department of the Environment Northern Ireland) in association with the Wildfowl and Wetlands Trust.

The WeBS Core (high tide) Counts and Low Tide Count programmes described below represent the established methodology used for statutory purposes to inform on the numbers and status of waterbirds at national and site-levels (Cook *et al.* 2013, Austin *et al.* 2014), and on their distributions within estuarine protected sites. The same programmes / methodologies have also been extensively used to inform previous assessment work on the Severn Estuary and in relation to previous tidal power assessments (and numerous other developments) elsewhere in the UK.

2.2.2 High tide surveys

The numbers and population trends of waterbirds wintering on coastal and wetland sites across the UK are monitored by monthly co-ordinated WeBS Core Counts, which are made by volunteers at around 2,000 wetland sites across the UK (Austin *et al.* 2014). On coastal sites, such as the Severn Estuary, birds are typically counted at high tide roosts. The volunteers undertake high quality counts of the numbers of birds using established count sectors (coordinated by the National Organiser of the WeBS Core Counts at the BTO and WeBS Local Organisers), although there may be parts of the estuary that are missed on each month's survey.

Five-year mean peak values – i.e. means of annual peak numbers over a five-year period – from WeBS Core Count data have been used to define the waterbird features of SPAs and Ramsar Sites in the UK, such as the Severn Estuary[11,12] (Tables 2.1 and 2.2). Data from the WeBS Core Counts are also used to inform on the status of feature species of SPAs and SSSIs (Cook *et al.* 2013).

The populations of species supported on the Severn Estuary SPA and, indeed, across the UK SPA network as a whole, have changed over time (Cook *et al.* 2013). This is apparent in the differences between the population sizes provided in the Natura 2000 Data Forms for the Severn Estuary SPA, the Information Sheet for the Severn Estuary Ramsar Site and Austin *et al.* (2014), which are based on data from WeBS for 1991/92-1995/96, 1998/99-2002/03 and 2008/09-2012/13 respectively.

[11] http://jncc.defra.gov.uk/page-1409, updated 1 Sep 2014, accessed 8 Jan 2015; http://jncc.defra.gov.uk/page-1400
[12] http://jncc.defra.gov.uk/page-5163

Given these changes, baseline information for EIA / HRA on the numbers of birds on the Severn Estuary would best be provided by up-to-date five-year mean peak values – to understand variation between years – with enhanced coverage provided by professional gap-filling over a minimum of at least one 'WeBS' year (July to June), although preferably two years, i.e. covering two winters and two passage periods. Similar gap-filling was undertaken during 2008/09 to inform the Severn Tidal Power SEA (Burton *et al.* 2010a). (Note, recommendations with respect to monitoring from the Severn Tidal Power SEA (Burton *et al.* 2010a) are summarised in section 6 of this report.)

Extra high tide surveys during spring migratory passage periods are also recommended. Large numbers of waders of certain species may pass through the estuary during spring, but over a relatively short time period, and thus may be missed by the monthly Core Counts (Burton *et al.* 2010c).

Data from the WeBS Core Counts were used in the Severn Tidal Power SEA programme to inform Habitat Association Modelling, one of the two approaches taken to predict densities and thus numbers of waterbirds on intertidal areas following proposed tidal power options (Burton *et al.* 2010a). For more details of the information needs of modelling approaches, see section 4 of this report.

2.2.3 Low tide surveys

Feeding distributions of waterbirds on major estuaries are recorded by the rolling programme of WeBS Low Tide Counts (Austin *et al.* 2014), also undertaken principally by volunteers. As with WeBS Core Counts, the volunteers undertake high quality counts of the numbers of birds using established count sectors (coordinated by the National Organiser of the WeBS Low Tide Counts at the BTO and WeBS Local Organisers). The Severn Estuary was last covered for WeBS Low Tide Counts during the period of the Severn Tidal Power SEA in 2008/09 (Burton *et al.* 2010a) and prior to this in 2002/03. A report on the 2002/03 survey (Burton *et al.* 2003a) also provided a historical analysis of all previous low tide surveys of waterbirds on the Severn Estuary, including WeBS Low Tide Counts undertaken in 1998/99 and earlier BTO surveys undertaken using the same methodologies between 1987/88 and 1991/92 to inform the Department of Trade and Industry's Energy Technology Support Unit (ETSU) tidal power programme (Clark 1988, 1989, 1990, McCulloch & Clark 1992, Warbrick *et al.* 1992).

The 2008/09 and 2002/03 WeBS Low Tide Counts were supported by additional funding provided by DECC, as part of the Severn Tidal Power SEA programme, and by English Nature and the Countryside Council for Wales respectively. This funding helped to fill gaps in volunteer

coverage and enabled boat-based surveys of the central intertidal areas of the estuary to be undertaken (Burton *et al.* 2003a, 2010a).

These previous surveys have highlighted that, with the exception of these central areas, the estuary can be adequately surveyed by ground-based observations. The central areas were successfully surveyed through boat-based surveys both in 2002/03 and 2008/09. Baseline information for EIA / HRA on the distributions of waterbirds on the Severn Estuary would thus best be provided by up-to-date WeBS Low Tide Counts of the estuary, with enhanced coverage provided by professional gap-filling.

Aerial surveys have not been required for previous low tide surveys of intertidal waterbirds on the Severn Estuary. Elsewhere their use, to date, for surveys of intertidal waterbirds has largely been restricted to sites less accessible to ground-based observers (e.g. Salvig *et al.* 1997) or more extensive surveys of major components of species populations (e.g. Clark *et al.* 1993, Sprandel *et al.* 2000), often where species diversity is limited (Ruthrauff *et al.* 2013) and where detailed within-site data is not required. In the UK, aerial surveys of intertidal waterbirds have been undertaken at Morecambe Bay, these surveys highlighting the issues of disturbance associated with visual aerial surveys and observers' ability to successfully spot and identify often small or well-camouflaged species against the substrate (Banks *et al.* 2006) (see also guidance produced in relation to the International Waterbird Census: Wetlands International 2010). Given the potential difficulties of successfully counting all birds present, calibration may be needed to provide a better representation of actual numbers (Driscoll *et al.* 2012).

More recently, developments in high definition imagery technology have led to the use of digital aerial surveys (Thaxter & Burton 2009) as the primary means for surveying seabirds in offshore waters, at least in the UK (Buckland *et al.* 2012). Digital (video and stills) aerial surveys can be conducted from aircraft flying at increased heights that are sufficiently high to avoid disturbance, while still being able to detect and identify most species of seabirds (Buckland *et al.* 2012). Such surveys are typically flown using a transect-based survey design, with estimates of the numbers of birds using an area generated through design-based or modelling-based analyses (Buckland *et al.* 2012). Their use for surveys of intertidal waterbirds remains limited. Typically, surveys of whole estuaries are required to provide detailed information concerning the distributions of waterbirds within sites rather than transect-based sampling; however, undertaking complete surveys of estuaries through aerial-based methods may be prohibitively expensive in comparison to ground-based or boat-based counts. Given ongoing advances in resolution, there may be potential in these methods in the future, for coverage of areas that are otherwise difficult to survey, provided that they prove able to detect and identify birds using the intertidal against the substrate.

2.2.4 Through-the-tide surveys

Surveys based on low tide counts may be limited if the total numbers of birds using a study site change across the tidal cycle or if low tide distributional patterns and habitat availability do not reflect those at other states of tide (Burton *et al.* 2004). Such studies may also assume that low tide is the most important stage of the tidal cycle for foraging and that bird distributions do not differ between day and night. This may not be the case for all species, however. More targeted studies have thus used through-the-tide-count (TTTC) surveys to inform on variation in the numbers and activity of birds using study sites across the tidal cycle (Burton *et al.* 2004).

On the Severn Estuary, detailed TTTC surveys of Cardiff Bay and nearby areas at Orchard Ledges (adjacent to Cardiff Docks) and the Rhymney Estuary were used to inform on the impacts of the Cardiff Bay barrage on the waterbirds that formerly used the intertidal habitat there (Burton *et al.* 2003b, 2006, 2010c, Burton 2006). During the fieldwork for the Severn Tidal Power SEA programme, TTTC surveys were undertaken at five sites on the estuary – Clevedon, Oldbury, Rhymney, St. Brides and Undy (Burton *et al.* 2010a). Similar surveys were undertaken to inform the assessment for the recently consented Hinkley C nuclear power development.

The detailed information provided by TTTC surveys on the variation in numbers and activity of birds using study sites means that they have the potential to help validate modelling approaches, such as Individual-Based Models (see section 4 of this report). Targeted surveys within the areas of the footprint of proposed tidal lagoons may thus be useful in this respect.

Despite the added detail that TTTC surveys may provide, given the limited extent of areas that can be practicably surveyed, low tide surveys provide the best means for informing on the distributions of waterbirds across large estuaries, and high tide surveys on their overall populations.

2.2.5 Breeding seabird surveys

Lesser Black-backed Gull is listed as a species for possible future consideration and European Herring Gull listed as noteworthy fauna in the Severn Estuary Ramsar designation, both due to the national importance of their local breeding populations. Both species are also mentioned in the SSSI citations for Flat Holm and Steep Holm. Numbers of Apparently Occupied Nests (AONs) of Lesser Black-backed Gulls on Flat Holm (part of the Ramsar site) rose from 1,800 in 1985-1988 to 3,309 in 1998-2002 (Mitchell *et al.* 2004) and to an average of 3,733 between 2003 and 2008 (Burton *et al.* 2010c). On Steep Holm, numbers of nests averaged 459 between 2003 and 2008 (Burton *et al.* 2010c). Numbers of AONs of European Herring Gulls on Steep Holm (also part of the Severn Estuary Ramsar site) rose from 750 in 1985-1988 to 956 in 1998-2002 (Mitchell *et al.*

2004). Numbers of AONs on Steep Holm and Flat Holm averaged 1,109 and 338 respectively between 2003 and 2008 (Burton *et al.* 2010c). Both species also breed in urban areas around the estuary and at other sites in the wider Bristol Channel, e.g. on Lundy. Great Cormorants also breed on Steep Holm and would also be a potential receptor species in any assessment of the impacts of a tidal power lagoon on the Severn Estuary (Table 2.2).

These species feed on fish and, in the case of gulls, in intertidal habitats and thus would potentially be exposed to effects associated with the development of a tidal power lagoon. Hence, it would be beneficial to obtain up-to-date breeding information for these species at Steep Holm and Flat Holm for the baseline assessment. The most recent counts for these species in the national Seabird Monitoring Programme database (http://jncc.defra.gov.uk/smp/) are for 2008, although up-to-date breeding count data may be available from ongoing studies on the islands.

2.3 Effects within the wider Severn Estuary floodplain and at other sites outwith the Severn Estuary

Existing data sources might be expected to form the principal source of information for the assessment of effects at sites within the wider Severn Estuary floodplain or outwith the Severn Estuary (e.g. changes to freshwater wetlands, far-field changes in water levels and displacement effects) (APEM 2014). Data from the WeBS Core Counts will be particularly important in providing baseline information on the non-breeding populations of waterbirds at these wider sites.

3. Consideration of the additional information that might be provided by tracking technology

3.1 Background

A wide variety of methodologies now exist to track the movements of wild animals, including birds. These include: radio-tracking, satellite tracking (including Global Positioning System (GPS) devices), geolocator loggers, Passive Integrated Transponders (PIT) tags and Global System for Mobile Communication (GSM) tracking (Bridge *et al.* 2011, Fiedler 2009).

In relation to proposals for a tidal power lagoon on the Severn Estuary, tracking technology has the potential to:

i. Inform on the migratory movements of bird species that utilise the Severn Estuary;

ii. Inform on movements of birds within winter and thus use of adjacent habitats around the Severn Estuary and potential connectivity with adjacent protected sites; and

iii. Contribute to future monitoring to validate potential effects and use of any compensatory or mitigation habitats created.

3.2 Migratory movements of bird species that utilise the Severn Estuary

Tracking has great potential to inform on the annual movements of species (Bridge *et al.* 2011, Fiedler 2009) and can be especially valuable where the geographic regions used by a population during a particular season – breeding, migratory passage or winter – are poorly understood (e.g. Summers *et al.* 2014) or to better quantify relative use of such areas (e.g. Linnebjerg *et al.* 2013, Montevecchi *et al.* 2012, Thaxter *et al.* 2014).

With respect to the assessment of the potential effects of a tidal power lagoon on the Severn Estuary, a key need is to better understand which other sites in the Natura 2000 network the waterbirds that use the Severn Estuary may also use on their annual cycle. A review of the UK sites within the Natura 2000 network and broad regions of Europe that could potentially be affected by proposals for tidal power lagoons on the Severn was thus provided by Burton & Clark (2015). This review, which drew from and updated previous work for the Severn Tidal Power SEA Waterbirds Topic Paper (Burton *et al.* 2010a) was based on understanding of the broad migration patterns of key potential receptor species, as assessed using published information, e.g. the BTO 'Migration Atlas' (Wernham *et al.* 2002) and BTO 'Migration Mapping

Tool' (Atkinson *et al.* 2007). Further information on migratory routes was collected from Clark (1989), which used information gathered from ringing recoveries to describe the movements of waders to and from the Severn Estuary, other relevant literature and broad summaries provided in Stroud *et al.* (2001) and Delaney *et al.* (2009). The review also drew on a recent review and delimitation of the migratory routes of species features of UK SPAs (and other Annex 1 species) undertaken to help inform assessments of the risk of offshore wind farm development to these species (Wright *et al.* 2012[13]).

While tracking may have the potential to demonstrate direct connectivity between the Severn Estuary and particular sites, it will not be possible to rule out use of other sites within species' annual ranges or gauge the relative use of sites by birds from the Severn given the limited numbers of birds that might be tracked. To track birds across the year, it may be necessary to use a harness to attach devices, so that they are not lost during moult periods and these may not be suitable for all species. Licencing of such procedures will limit sample sizes that can be used, and thus several years of study may be required to obtain a representative sample size. Hence, the overview of species' migratory routes and breeding ranges provided by the review of Burton & Clark (2015) provides the best means of understanding the potential connectivity between the Severn Estuary and other sites within the Natura 2000 network.

3.3 Movements of birds within winter

Tracking has previously been widely used to inform on the movements of waterbirds within their wintering sites (e.g. Legagneux *et al.* 2009, Leyrer *et al.* 2006, Sanzenbacher & Haig 2002, Warnock & Takekawa 1996). For example, using radio-tags, Burton & Armitage (2005) explored differences of the diurnal and nocturnal use of intertidal feeding grounds by Common Redshank *Tringa totanus* from Cardiff Bay. More recently, GPS devices have been used to inform on the movements of Eurasian Oystercatcher *Haematopus ostralegus* in relation to food resources within the Wadden Sea (Shamoun-Baranes *et al.* 2012, Ens *et al.* 2014).

With respect to the assessment of the potential effects of a tidal power lagoon on the Severn Estuary, tracking may thus have considerable potential to inform not only on within-winter habitat use within the estuary, but also on use of adjacent habitats around the estuary and potential connectivity with adjacent protected sites such as the Newport Wetlands SSSI and the Somerset Levels and Moors SPA. As devices would only be needed within a season, greater options may exist for the type of device that might be used and for their attachment (Bridge *et*

[13] Report and GIS shapefiles of migratory zones available at: http://www.bto.org/science/wetland-and-marine/soss/projects

al. 2011, Fiedler 2009). Key species of interest for such work may potentially include Eurasian Curlew *Numenius arquata* and wildfowl species such Eurasian Wigeon *Anas penelope*, Eurasian Teal *Anas crecca* and Northern Shoveler *Anas clypeata* that forage within the footprint area of the proposed Cardiff tidal power lagoon, for example, and that may also use terrestrial and freshwater habitats as well as intertidal areas for foraging.

Data collected during tracking studies focussing on the movements of birds within winter would also be valuable in relation to the design and location of any mitigation or compensatory habitat, as it is important that a range of ecologically-linked sites that provide habitat for birds at all stages of the tidal cycle are available within the distance the birds would normally move during a tidal cycle (see section 6.3 for further details).

3.4 Future monitoring to validate potential effects and use of any compensatory or mitigation habitats created

As described above, tracking is invaluable in informing on the movements of waterbirds within their wintering sites. As such, tracking may be particularly useful as part a future monitoring programme to validate the potential effects associated with the development of a tidal power lagoon on the Severn Estuary and use of any compensatory or mitigation habitats created.

Tracking would be particularly informative in understanding the effects of the loss and changes to intertidal habitat and changes in tidal exposure that would result from the construction of a tidal power lagoon. At Cardiff Bay, both tracking and a colour-ringing programme were used to inform on the movements of birds following the loss of intertidal habitat that followed the construction of the barrage there (Burton & Armitage 2008); the colour-ringing programme was also used to examine impacts on fitness (body condition, survival) (Burton *et al.* 2006). Similar programmes would be invaluable in both validating predictions with regards movements and fitness of wintering birds from, for example, Individual-Based Models (see section 4 of this report), and for assessing use of any compensatory or mitigation habitats created. As above, a number of options may exist for the type of device that might be used and for their attachment (Bridge *et al.* 2011, Fiedler 2009) that might inform such a study.

4. An overview of how modelling would inform the EIAs / HRAs required and the associated information requirements

4.1 Background

The principal effects for waterbirds of any tidal power scheme would relate to the changes to intertidal habitat that would follow its implementation (Clark 2006; Burton *et al.* 2010b). Within the area of the tidal power option, the tidal range would be considerably reduced following its implementation, leading to an immediate reduction in the intertidal area available for feeding birds. However, the effect of this for waterbirds would not be directly proportional to the amount of habitat lost due to variations in intertidal habitat quality across the estuary and subsequent changes in the nature of intertidal areas. Reduced turbidity upstream of schemes would lead to a considerable fall-out of suspended sediments and, should this remain on the intertidal, this could benefit invertebrate communities (Warwick & Somerfield 2010) and so potentially increase bird densities in remaining habitat. Any changes to the tidal curve may also potentially affect the time available for waterbirds to feed. For some schemes, increased wave action (in conjunction with a reduction in accretion due to reductions in suspended sediments) may lead to further erosion of intertidal mudflats over the scheme's operational lifetime. However, considerable changes in intertidal habitat would also occur outside of the area of the tidal power option through alteration of currents and thus the distribution of sediments.

For the Severn Tidal Power SEA, the assessment of this principal effect for waterbirds was informed through two modelling approaches – Habitat Association Modelling and Individual-Based Modelling – which predicted densities and thus numbers of waterbirds on intertidal areas following proposed tidal power options (Burton *et al.* 2010a). The two approaches were used in conjunction to inform the assessment, so as to provide a measure of uncertainty in predictions.

In summary, Habitat Association Models (HAMs) aim to explain densities of waterbirds under the different options using measures of estuary morphology as a proxy for sediment and so in turn (invertebrate) food supplies. Individual-Based Models (IBMs) make predictions of the number of birds that can be supported by a site from the underlying physiology and behaviour of individuals (assuming that animals behave in ways that maximise their chances of survival) and require data on birds, biomass, area and tidal exposure of food resources.

Under the Severn Tidal Power SEA (Burton *et al.* 2010a) both approaches aimed to estimate the number of birds that might be expected to be supported on the Severn Estuary as a result of the immediate (short-term) changes following implementation of each of the options considered by the programme, and thus the percentage change relative to baseline figures. To be able to do

this, both approaches used hydrological and geomorphological predictions on the short-term changes in the extent of intertidal habitats under each alternative option. IBMs also quantitatively evaluated the effects of the further long-term changes predicted in the extent of intertidal habitats.

This section draws from the modelling undertaken to inform the Severn Tidal Power SEA (Burton *et al.* 2010a) to provide an overview of each of these two approaches, their information requirements and associated limitations, and thus how they would inform assessment of the potential effects of a tidal power lagoon on the Severn Estuary.

4.2 Habitat Association Modelling (HAM)

4.2.1 Rationale

UK estuaries hold internationally important numbers of waterbirds (Austin *et al.* 2014). The densities of waterbirds supported by these sites are governed by the availability of their main food resources, notably invertebrates (Goss-Custard 1977a, 1977b, Colwell & Landrum 1993). The abundance of these food supplies is determined by processes operating within ecosystems, including sediment composition, river water inflow, and sediment loads, and previous studies have shown how densities can thus be predicted through the proxy measure of sediment type (Goss-Custard & Yates 1992, Yates *et al.* 1995). Sediment characteristics are themselves influenced by the size and shape of estuaries, and another earlier study found that, in the UK, densities of waterbirds at an estuary scale can be successfully predicted by secondary proxy measures of estuary morphology (Austin *et al.* 1996, Austin & Rehfisch 2003).

Building on these previous studies, as part of the Severn Tidal Power SEA programme, HAMs were developed to examine the variation in densities of waterbirds on estuaries across England and Wales – based on data from WeBS Core Counts – in relation to measures of estuary morphology and climate (Burton *et al.* 2010a). These models were then used to initially predict densities and thus numbers of waterbirds for the Severn Estuary in a baseline year (the last included in the study). Densities and numbers of birds were then predicted for the areas within and outwith each alternative option following changes in estuary morphology resulting from alternative tidal power options. Predictions of numbers within and outwith the alternative option areas were summed to provide an estimate of the numbers of each receptor that would be supported on the Severn Estuary with each option in place and thus the percentage change relative to the baseline year.

4.2.2 Data requirements for HAMs

The HAMs developed for the Severn Tidal Power SEA programme used WeBS Core Count data from 48 estuarine sites in England and Wales to develop models that enabled predictions to be made as to the densities of birds that might be supported on estuaries of given morphology (Burton *et al.* 2010a). These models could be re-used, although would need updating to utilise more up-to-date WeBS and climate data.

The models used for the Severn Tidal Power SEA programme explored the potential of a number of morphological variables to explain waterbird densities across the sample estuaries. The principal morphological variables used in final models were tidal range (the maximum for the estuary), fetch (a measure reflecting turbidity and the strength of wave action, measured as the average distance perpendicular from the centre line of the intertidal to the centre line of the intertidal on the opposite shore) and estuary depth (the mean low tide channel width / mean estuary width, a measure reflecting differences in bird densities between wider estuaries, that tend to have deeper channels, and narrower estuaries, which have shallower channels) (Burton *et al.* 2010a). Data on these and other morphological variables were derived for each estuary using geographic information system (GIS) shape-files of mean high and low water levels. For the baseline, these were derived from Ordnance Survey information. To be able to predict densities and thus numbers of birds within and outwith the area of any future tidal power development on the Severn Estuary, predictions of mean high and low water levels resulting from the development would be required to enable morphological characteristics to be derived.

4.3 Individual-Based Modelling (IBM)

4.3.1 Rationale

An IBM is a simulation model in which population-level consequences are inferred from the local-scale interaction between individuals. The models consist of a simulated environment that captures the key environmental variables of the system (e.g. for an intertidal mudflat, these would be the tidal exposure regime and the abundance and distribution of prey) and individuals that interact with the environment and each other according to 'decision rules'.

The basic model assumption is that individuals behave so as to maximise their perceived fitness. In the case of overwintering shorebirds, this means that they attempt to maximise their energy intake rates, such that they can survive the winter with adequate fat reserves to return to their breeding grounds and reproduce successfully. Using fitness-maximising behaviour as the basis of prediction for how a model animal will behave under novel environmental conditions is much

more likely to maintain predictive power compared with the empirical relationships of other modelling approaches (Stillman 2003).

IBMs make it possible to account for the behavioural responses of birds to environmental changes (e.g. habitat loss, changes in levels of disturbance, or climate change) and allow one to assess the demographic impacts of these changes (Stillman *et al.* 2007). IBMs capture individual differences in foraging efficiency and social dominance, such that the least efficient foragers die first and the most efficient survive. This sets them apart from simple spatial models of prey depletion, in which all foragers must die or emigrate when prey resources become depleted (Sutherland & Allport 1994, Percival *et al.* 1998, Goss-Custard & Stillman 2008).

The MORPH modelling platform

MORPH is an IBM developed for modelling coastal bird species, and has been used to predict overwinter mortality and foraging behaviour at various European sites and contexts including habitat loss (Goss-Custard *et al.* 1995), sea-level rise (Durell *et al.* 2006), wind farm development (Kaiser 2006), shell-fishing (Stillman *et al.* 2001) and human disturbance (West *et al.* 2002). MORPH has been used to model a range of shorebird species including Eurasian Oystercatcher, Eurasian Curlew, Black-tailed Godwit *Limosa limosa*, Dunlin *Calidris alpina* and Common Redshank, and it has been applied to a number of European sites including the Exe Estuary, Poole Harbour, UK, the Baie de Somme, France, the Bahia de Cadiz, Spain, the Burry Inlet, the Humber and the Solent (Stillman *et al.* 2005, Durell *et al.* 2006, Durell *et al.* 2008). MORPH was applied to retrospectively predict an increase in mortality rate in Common Redshank displaced from Cardiff Bay following the construction of the barrage that converted intertidal mudflats into a freshwater lake (Goss-Custard *et al.* 2006).

4.3.2 Data requirements for IBMs

There are five key parameters that need to be measured or obtained from the literature to apply an IBM to a new system:

i. Prey distribution, abundance and quality throughout the season of interest;
ii. Availability of foraging habitat (e.g. tidal exposure rates);
iii. Energy intake rates of foragers, given the abundance of prey and competitors;
iv. Forager metabolic rates (e.g. the efficiency of conversion of food to energy, the rate of energy expenditure, etc.);
v. The distribution and occurrence of other factors that may influence foraging behaviour and survival (e.g. human disturbance).

Generally, iii-v can be gleaned from the literature, so the key data that need to be collected for a particular site are to do with the prey abundance and availability throughout the tidal cycle. Models are typically parameterised using invertebrate prey data from an autumn survey, potentially supplemented with additional data from a spring survey. To calculate prey biomass, both the numerical abundance (prey items per m^2) and size (in mm) of prey must be measured. Data on tidal exposure can be determined from tidal models, the relative heights of the patches or local knowledge. Once these data are available, models can be parameterised within a relatively short period of time (a few months), and once parameterised, model simulations can be run in a matter of hours. Thus, the models can be developed within a timescale appropriate for addressing conservation issues.

For an IBM to be useful, it also needs to offer a way for its predictions to be tested. Observations of the behaviour of real birds (e.g. how long they spend feeding, how much time they spend in each 'patch', prey choice) can be used to assess how well the model represents reality.

4.3.3 Data availability for the Severn Estuary

The existing IBMs developed for the Severn Tidal Power SEA programme incorporated all intertidal habitat upstream of the proposed Cardiff-Weston barrage and the intertidal habitats of Bridgwater Bay. The simulated model environment was divided into 13 patches, based on differences in sediment. The tidal cycle was simulated based on an average spring-neap cycle, repeated throughout the winter. The prey abundance and distribution was based on an extensive survey of the Severn and other SW English estuaries conducted during autumn of 1987 (Goss-Custard & Warwick 1991, Warwick *et al.* 1991).

The existing IBMs developed for the Severn Tidal Power SEA programme considered the 12 most abundant overwintering waterbird species on the Severn for which feeding rates could be predicted: Eurasian Oystercatcher, European Golden Plover *Pluvialis apricaria*, Grey Plover *Pluvialis squatarola*, Northern Lapwing *Vanellus vanellus*, Common Ringed Plover *Charadrius hiaticula*, Eurasian Curlew, Black-tailed Godwit, Ruddy Turnstone *Arenaria interpres*, Red Knot *Calidris canutus*, Dunlin, Common Redshank and Common Snipe *Gallinago gallinago*. The population sizes for these species used within the model were based on WeBS Core Counts recorded between November 2008 and February 2009 and the initial distribution of birds between patches was determined from the WeBS Low Tide Counts recorded over the same period.

Several types of simulation were run using this model: those based on short-term predictions which ignored any changes in intertidal habitat due to long-term erosion or deposition; and those based on long-term predictions which included the long-term erosion or deposition.

4.4 Assumptions, limitations and uncertainties

There are a number of further assumptions, limitations and uncertainties associated with both approaches and it is important to note that the predictions from the two approaches may not necessarily provide final answers as to magnitudes of effect, as there may be uncertainty in the fit and accuracy of predictions and how well they take into account the predicted geomorphological and hydrological changes and consequent changes in sediments and invertebrate food supplies.

In this respect, the following points should be noted:

i. The predictions from HAMs are most critically reliant on the accuracy of hydrological and geomorphological predictions of mean high and low tide levels on the estuary within and outwith the proposed tidal power lagoon area. It is also assumed that the morphological variables do reflect the sediments present within estuaries and consequently the food resource available for birds, and that the morphologies of the estuaries considered have not changed appreciably over the data period considered.

ii. HAMs do not take into account any reductions in the time available for feeding (only reductions in tidal range). Expert judgement is thus required as to whether the predictions account for the negative effects associated with changes in the tidal curve.

iii. Previously, HAMs developed to investigate variation in waterbird densities on UK estuaries have considered an 'estuary mouth width' term (Austin *et al.* 1996). However, as the combination of turbines, sluices and navigation channels in a tidal lagoon power option could in no way be equated to a traditional estuary mouth, such a term could not be used in models aiming to predict future densities resulting from the development of a tidal power lagoon option. The omission of such a term may limit the fit of models and thus power to accurately predict future densities.

iv. The HAMs make predictions at an estuary scale and thus make no assumptions about the relative quality of the areas of intertidal habitat that might be lost to the options, e.g. whether the sediments that might be lost are muddier or sandier than on average for the estuary as a whole or the relative importance of the areas within the options for each receptor.

v. The predictions from IBMs are reliant on the accuracy of predictions of the extent of intertidal sediments and effects on the diversity, abundance and biomass of benthic invertebrates within and outwith the proposed tidal power lagoon area and there may be considerable uncertainty in these predictions in the long-term. For the Severn Tidal Power SEA programme, predictions suggested that (currently suspended) muddy sediments would settle out following implementation of each of the options, but that much of this sediment would settle in subtidal channels. Increases in muddy sediments in intertidal areas would likely benefit the overall species richness, density and biomass of the benthos, thus potentially ameliorating for losses of inter-tidal area (Warwick & Somerfield 2010). However, the mud that settles in intertidal areas is likely to be subject to winnowing and erosion. There is inevitably some uncertainty in the long-term predictions of the nature of the intertidal, in particular, the extent and stability of the muddy (more productive) sediments that typically support higher densities of invertebrates and thus birds.

vi. Data on intertidal invertebrates on the Severn Estuary and other south-west English estuaries used to parameterise the IBMs developed in the Severn Tidal Power SEA programme came from the 1980s and, though this was the best dataset available, invertebrate communities may have changed since then.

vii. Predictions will not be possible for all receptor species using either modelling approach. The existing IBMs developed for the Severn Tidal Power SEA programme considered the 12 most abundant overwintering waterbird species on the Severn for which feeding rates could be predicted. While HAMs were developed for more species, the fit of models and thus power to accurately predict future densities varied between species.

5. Recommendations for a programme of modelling work, including initial work based on existing data and an update based on survey results from 2015/16

Both IBMs and HAMs were developed for the Severn Tidal Power SEA programme to predict densities and thus numbers of waterbirds on intertidal areas following proposed tidal power options (Burton *et al.* 2010a). Both sets of models could be re-used to predict the potential impacts on waterbird numbers of a tidal power lagoon on the Severn Estuary, although would require updated information.

As outlined above, the key requirement for HAMs would be predictions of the mean high and low water levels within and outwith the proposed tidal power lagoon area resulting from the development that would enable morphological characteristics to be derived. Ideally, more up-to-date data would also be used to update model relationships and to make predictions. At the present time, this would mean WeBS Core Counts (for the 48 estuarine sites used to develop models) up to 2012/13 (the most recently available) and more recent climate data. (Note, WeBS Core Count data for 2013/14 will be available from spring 2015.)

With respect to IBMs, the key data required relate to prey abundance and the availability of foraging habitat. Data exist for these aspects for the baseline environment, but predictions would be required for the areas of the estuary within and outwith the proposed tidal power lagoon area. For the Severn Tidal Power SEA, data on waterbird population sizes were based on WeBS Core Counts recorded between November 2008 and February 2009, and the initial distribution of birds between patches was determined from the WeBS Low Tide Counts recorded over the same period. Ideally, more up-to-date data would be used to make predictions. At the present time, this would mean the most recently available WeBS Core Counts for 2012/13, although it should be noted that there have not been low tide surveys of the estuary since 2008/09. (Note, again, that WeBS Core Count data for 2013/14 will be available from spring 2015.)

Both modelling approaches would best be informed by comprehensive up-to-date baseline data on the populations and distributions of waterbirds using the Severn Estuary. Baseline information for EIA / HRA on the numbers of birds on the Severn Estuary would best be provided by up-to-date five-year mean peak values from WeBS Core Counts – to understand variation between years – with enhanced coverage provided by professional gap-filling over a minimum of at least one 'WeBS' year (July to June), although preferably two years. Similarly, baseline information for EIA / HRA on the distributions of waterbirds on the Severn Estuary would best be provided by up-to-date WeBS Low Tide Counts of the estuary, with enhanced

coverage also provided by professional gap-filling. A programme of surveys undertaken through the WeBS volunteer network, enhanced by professional gap-filling, through 2015/16 would provide information that both inform the baseline and be used directly in the modelling and for qualifying the results obtained.

6. An overview of the recommendations from the Severn Tidal Power SEA of the work that might be required to inform ornithological assessment and mitigation / compensation options of future tidal power proposals on the estuary

6.1 Background

As part of the Severn Tidal Power SEA (Burton *et al.* 2010a) and the associated assessment of the issues surrounding potential habitat creation mitigation / compensation measures (Wright *et al.* 2010), a range of recommendations were developed regarding work that might be required to inform ornithological assessment and mitigation / compensation options of future tidal power proposals on the Severn Estuary. These recommendations are pertinent to the potential future development of tidal power lagoons on the estuary and an overview is provided below.

6.2 Recommendations relating to monitoring

The following recommendations were made in relation to ornithological monitoring (before, during and after construction) as part of the Severn Tidal Power SEA:

- The main element of the monitoring programme should be to ensure that complete coverage by WeBS Core Counts of the Severn Estuary is achieved annually. It is recommended that counts should be undertaken twice (rather than once) a month during the key periods to provide greater power in being able to detect changes in numbers.

- WeBS Core Count data from other sites that might be affected by the options (e.g. as identified in this assessment, the Burry Inlet, Somerset Levels & Moors, Chew Valley Lake and Dyfi Estuary SPAs) should be assessed to determine whether gap-filling is also required to ensure complete coverage of these sites. Data should then be evaluated annually to determine whether there have been increases in bird numbers at those sites that might be concurrent with declines on the Severn Estuary.

- To monitor changes in distributions within the Severn Estuary, the monitoring programme should also ensure complete annual coverage by WeBS Low Tide Surveys for a five year baseline period, and that further comprehensive Low Tide Surveys are undertaken regularly through construction and operation.

- The WeBS Core and Low Tide Counts should also be supplemented by a regular programme of through-the-tide counts and nocturnal surveys, and these should be used to inform the baseline assessment.

- Any habitat created through topographic modification or as compensation should be more intensively monitored in order that its success could be properly assessed. Such areas should be included in those covered by the programme of WeBS Core and Low Tide Counts described above, though it should be noted that it would not be possible to monitor any offshore habitat created through the WeBS volunteer network.

- Annual surveys of breeding seabirds on Flat Holm and Steep Holm and breeding waders using saltmarsh areas are also recommended.

- In addition to monitoring changes in numbers, it is also important to be able to understand the mechanisms behind such changes. It is thus important to establish a marking programme for key species during the baseline phase to monitor changes in juvenile recruitment, movements, body condition and survival before, during and after the development. This could be done either through traditional bird ringing or using the tracking technologies described in section 3 – the most appropriate methods will vary by species and site and should be determined at the start of the baseline phase.

- It is also recommended that annual benthic invertebrate surveys are undertaken in order that changes in waterbird numbers can be understood in relation to changes in their food supplies. This would be important both in remaining areas of existing habitat and in assessing the success of any habitat created through topographic modification or as compensation.

6.3 Recommendations relating to mitigation / compensation

The assessment of the issues surrounding potential habitat creation mitigation / compensation measures (Wright *et al.* 2010) conducted alongside the Severn Tidal Power SEA identified a number of areas of uncertainty, listed below. Recommended work programmes to minimise this uncertainty, and thus maximise the effectiveness and value for money of habitat creation mitigation / compensation measures, are detailed in sections 6.3.1-6.3.8.

Key areas of uncertainty are as follows:

- The numbers of birds of each species likely to be lost from the Severn under each tidal power option.

- How to create optimal intertidal habitat for birds through managed realignment or topographic modification, and our ability to engineer the required types of intertidal habitat.

- The density of waterbirds of each species likely to be supported on created intertidal habitat, compared to natural intertidal habitat (and therefore the ratio of compensatory habitat that would need to be provided), and how long it would take to reach this density after creation.

- The density of waterbirds of each species likely to be supported on freshwater habitats, relative to intertidal habitats that would be lost under tidal power options (and therefore the ratio of compensatory habitat that would need to be provided).

- Through-the-tide movement distances of birds (for example from high-tide roosts to mid-tide feeding sites, to low-tide feeding sites). This limits our ability to define the distance within which all of these requirements need to be sited in any compensation packages.

- Within- and between-winter movements of birds between estuaries in the UK (and beyond). This is important in understanding the likelihood of new habitat created at a distance from the Severn being colonised by the same individual birds that currently use the Severn, and the rate at which this might happen.

- Colonisation rates of new sites by new birds, and demography of site-faithful species. This is important in understanding how long it might take for new populations of site-faithful species to build up on newly created habitat at a distance from the Severn.

- The rate at which the wintering distributions of some bird species might change in response to future climate change.

- Cold weather movements of birds. A better understanding of this would improve our certainty of the importance of the Severn as a cold weather refuge.

6.3.1 Number of birds likely to be lost from the Severn Estuary under each tidal power option

Some methods for reducing the uncertainty surrounding the number of birds likely to be lost from the Severn Estuary under each tidal power option are given in the waterbirds topic paper

of the SEA (Burton *et al*. 2010a). Improving predictions regarding the type of sediments in the reduced-energy system following the implementation of a tidal power lagoon, and predictions of the types and densities of invertebrates likely to occur in that sediment, would be extremely valuable in improving predictions for changes to waterbirds through individual-based modelling. A number of other measures could also improve predictions of the likely number of waterbirds that would be lost, and these are detailed in the waterbirds topic paper.

6.3.2 How to create optimal intertidal mudflat habitat for waterbirds, and densities of waterbirds supported on created compared to natural intertidal habitat

One option proposed as part of the Severn Tidal Power SEA was the creation of new intertidal habitat through topographic modification. Our understanding of the best areas and methods to create new intertidal mudflats for birds could be greatly improved through a detailed investigation and review of all situations where intertidal mudflat has been created either inadvertently or by design. Such a study could compare the densities of different waterbird species supported on created mudflats and on natural mudflats in nearby estuaries. The long-term development of created mudflats and their bird populations (over decades) could be studied in situations where new mudflat has been created inadvertently. This includes many east-coast estuaries where sea walls were breached in the 1953 floods and not rebuilt in the same places. For example the Blythe and Alde estuaries have relatively new mudflats dating from this time. Studies of more recent managed realignment sites (where bird numbers have been monitored) could help to determine the time before a stable density of birds is achieved. Improving our understanding of the effects of changes to estuaries on birds would be very valuable in informing a wide range of future conservation management including managed realignment, not just in relation to the potential development of tidal power lagoons on the Severn Estuary.

Developing the habitat association modelling used in the waterbirds topic paper of SEA to predict waterbird densities at a mudflat level (rather than the whole-estuary scale) would improve our understanding of the within-estuary distribution of birds and may enable predictions of the capacity of topographic modification areas at given locations in the estuary. The advantage of this approach over individual-based models is that where it is difficult to predict future invertebrate densities, using estuary morphology as a proxy means that realistic predictions of future waterbird densities can still be generated. Habitat association models can also be used to predict the likely future densities of a wider range of waterbird species than individual-based models.

6.3.3 The density of waterbirds supported on freshwater wetlands compared to intertidal habitat

The creation of freshwater wetlands is only likely to be effective as compensation for losses of the generalist wetland species, gulls and freshwater species. It could not compensate for the predicted losses of intertidal invertebrate feeders or intertidal bivalve specialists. However, if the creation of freshwater wetlands were considered as a compensatory measure for generalist wetland species, it would be possible to conduct more detailed analyses of existing Wetland Bird Survey data to calculate the proportion of these species' populations that are recorded on freshwater sites, and estimates of the average density of each species supported at freshwater and intertidal sites. This would reduce the uncertainty regarding the habitat equivalency of freshwater wetlands compared to intertidal sites for this species guild and allow recommendations to be made regarding the ratio of the area of freshwater habitat creation compared to the area of intertidal habitat loss that would be required to support equivalent numbers of each species. Such a study would be relatively straightforward as the data required already exist.

6.3.4 Through-the-tide movement distances of birds

For intertidal feeding species (e.g. Common Shelduck *Tadorna tadorna*, Dunlin, Common Redshank, Common Ringed Plover, Grey Plover) in particular, it is important that a range of ecologically-linked sites that support the needs of the species at different stages of the tidal cycle are provided close together (within the distance that the birds would normally move during a tidal cycle). It would be possible to provide more detailed information regarding through-the-tide movement distances of birds by conducting detailed studies of waterbird movements. GPS tracking techniques using tags that record almost continuously would be the best method to use for such a study because very regular information on the location of birds would be required to establish movement patterns within a single tidal cycle. However other techniques such as colour-ringing and re-sighting or alternative tracking technologies could also provide useful (although less detailed) information. Ideally, movement patterns should be studied on a range of estuaries, including the Severn, to establish the range of distances that birds will move between roosting sites and feeding sites at different stages of the tidal cycle.

6.3.5 Within- and between-winter movements of waterbirds

If the creation of new intertidal habitats at a distance from the Severn is to be considered, it would be valuable to investigate the within- and between-winter movements of the key waterbird species that the measure is targeted for. This analysis could be done using existing ringing data (although there may not be sufficient data for all species). This would help to

determine the likelihood of birds of non-site-faithful species colonising compensatory habitat at a distance from the Severn if they were displaced from the Severn following the implementation of a tidal power option. It would also reduce the uncertainty as to which of the more site-faithful species are unlikely to move to sites at a distance from the Severn.

6.3.6 Colonisation rates of new sites and demography of site-faithful species

The colonisation rates of new sites and the demography of site-faithful species in relation to changing distributions is uncertain as it depends on a range of factors. These include the rate of change of distributions in response to climate change, settlement patterns of first-winter birds and the typical lifespan of the species in question. Reducing uncertainty regarding colonisation rates of new sites could be undertaken through studies of changes in bird numbers on existing or planned (in the near future) habitat creation schemes such as managed realignment.

6.3.7 Rate of change of wintering distributions in response to climate change

The rate of change in the distribution of some wader species has already been quantified using data from the Wetland Bird Survey and other surveys across Europe (Maclean et al. 2008). It would be possible to conduct a similar analysis using the same existing data to determine the rate of change in the distributions of other waterbirds such as wildfowl (for example Bewick's Swan *Cygnus columbianus*, European White-fronted Goose *Anser albifrons albifrons*, Gadwall *Anas strepera*, Eurasian Wigeon, Eurasian Teal, Northern Pintail *Anas acuta*, Northern Shoveler, Common Pochard *Aythya ferina* and Tufted Duck *Aythya fuligula*).

6.3.8 Cold weather movements of birds

Analyses of existing ringing data and data from the Wetland Bird Survey in relation to weather could potentially improve our understanding of the cold weather movements of birds, but there may not be sufficient data for all species to quantify the importance of the Severn as a cold weather refuge. Since these data already exist it would be relatively inexpensive to conduct an exploratory analysis to determine whether cold-weather movements can be quantified.

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Table 2.1 Feature waterbird or seabird species of the Severn Estuary SPA, Severn Estuary Ramsar Site and component SSSIs.

Site	Severn Estuary	Severn Estuary	Severn Estuary	Severn Estuary	Bridgwater Bay[4]	Flat Holm[4]	Severn Estuary[4]	Sully Island[4]	Upper Severn Estuary[4]
Designation	**SPA[1]**	**SPA[2]**	**SPA[3]**	**Ramsar**	**SSSI**	**SSSI**	**SSSI**	**SSSI**	**SSSI**
Bewick's Swan	✓	✓	✓	✓					✓
European White-fronted Goose	✓	✓	✓	✓					✓
Common Shelduck	✓	✓	✓	✓	+		✓		
Eurasian Wigeon	✓		✓	✓	+				✓
Gadwall	✓	✓	✓	✓					✓
Eurasian Teal	✓		✓	✓	+		✓[5]		
Mallard			✓						
Northern Pintail	✓		✓	✓			✓[5]		
Northern Shoveler			✓	✓			✓[5]		✓
Common Pochard	✓		✓	✓			✓[5]		✓
Tufted Duck	✓		✓						
Little Egret				✓					
Water Rail				✓					
European Golden Plover							✓		
Grey Plover	✓		✓		✓		✓	✓[6]	
Northern Lapwing			✓						
Common Ringed Plover	✓		✓	✓	✓		✓	✓[6]	
Whimbrel	✓		✓	✓	✓				
Eurasian Curlew	✓		✓	✓	✓		✓		

Site	Severn Estuary	Severn Estuary	Severn Estuary	Severn Estuary	Bridgwater Bay[4]	Flat Holm[4]	Severn Estuary[4]	Sully Island[4]	Upper Severn Estuary[4]
Designation	**SPA[1]**	**SPA[2]**	**SPA[3]**	**Ramsar**	**SSSI**	**SSSI**	**SSSI**	**SSSI**	**SSSI**
Black-tailed Godwit					✓		✓[5]		
Ruff				✓					
Dunlin	✓	✓	✓	✓	✓		✓	✓[6]	
Spotted Redshank	✓			✓					
Common Greenshank				✓					
Common Redshank	✓	✓	✓	✓	✓		✓	✓[6]	
Lesser Black-backed Gull				✓		✓			
European Herring Gull				✓					
Waterbird assemblage	✓	✓	✓	✓					

[1] Listed under the SPA's original citation in 1995.

[2] Listed on the Natura 2000 Standard Data Form for the SPA updated in 1999.

[3] Listed in the SPA Review (Stroud *et al.* 2001).

[4] Component SSSIs of the Severn Estuary SPA (the Penarth Coast and Steep Holm SSSIs which are also components are not notified for their bird interest).

[5] Features that are not notified but qualify following a recent CCW review.

[6] Features that are notified but failing following a recent CCW review.

Table 2.2 Waterbird or seabird species that regularly occur within the area of the Severn Estuary and are listed as UK Biodiversity Action Plan (BAP) species, Section 41 BAP Species of Principal Importance in England, Section 42 BAP Species of Principal Importance in Wales, Amber- or Red-listed Birds of Conservation Concern (BoCC) or IUCN Red list species.

Receptor	UKBAP	Section 41 BAP England	Section 42 BAP Wales	BoCC	BoCC Wales[2]	IUCN Red List
Mute Swan[1]				Amber	Amber	
Bewick's Swan[1]	✓	✓	✓	Amber	Amber	
European White-fronted Goose[1]	✓	✓	✓	Amber	Red[3]	
Common Shelduck				Amber	Amber	
Eurasian Wigeon[1]				Amber	Amber	
Gadwall[1]				Amber	Amber	
Eurasian Teal[1]				Amber	Amber	
Mallard[1]					Amber	
Northern Pintail[1]				Amber	Amber	
Northern Shoveler[1]				Amber	Amber	
Common Pochard[1]				Amber	Red	
Tufted Duck[1]					Amber	
Great Cormorant				Amber	Amber	
Little Egret[1]				Amber		
Water Rail[1]				Amber		
Pied Avocet				Amber	Amber	
Eurasian Oystercatcher				Amber	Amber	
European Golden Plover[1]			✓		Red	
Grey Plover				Amber	Red	

Receptor	UKBAP	Section 41 BAP England	Section 42 BAP Wales	BoCC	BoCC Wales[2]	IUCN Red List
Northern Lapwing[1]	✓	✓	✓	Amber	Red	
Common Ringed Plover			✓	Amber	Amber	
Whimbrel[1]				Amber	Amber	
Eurasian Curlew[1]	✓	✓	✓	Amber	Red	Near Threatened
Black-tailed Godwit	✓	✓		Red	Amber	Near Threatened
Bar-tailed Godwit			✓	Amber	Red	
Ruddy Turnstone				Amber	Amber	
Red Knot				Amber	Amber	
Ruff				Amber	Amber	
Sanderling					Amber	
Dunlin[1]				Amber	Red	
Spotted Redshank				Amber	Amber	
Common Redshank[1]				Amber	Amber	
Common Snipe[1]				Amber	Amber	
Black-headed Gull			✓	Amber	Red	
Common Gull				Amber	Red	
Lesser Black-backed Gull				Amber	Amber	
European Herring Gull	✓	✓	✓	Amber	Red	

[1] Species regularly occurs both on the Severn Estuary and in the study area floodplain.

[2] See Welsh Ornithological Society *et al.* (2009).

[3] White-fronted Goose is a Red-list species in Welsh Ornithological Society *et al.* (2009), although the main subspecies that occurs in Wales is the Greenland White-fronted Goose *Anser albifrons flavirostris* which is largely restricted to the Dyfi Estuary.