MAYOR OF LONDON

Transport for London

Inner Thames Estuary Feasibility Study

Response to Airports Commission Call for Evidence

The Mayor of London's Submission:
Supporting technical documents

23 May 2014

Title: **Ecology Desk Study Part B: Marine and Coastal Baseline (2013)**

Author: **ABP Marine Environmental Research Ltd**

Purpose of paper:

To present the baseline description of the marine ecology of the study area which includes, Thames, Medway, Swale, Crouch and Roach estuaries as well as open coastline.

Key messages:

- Produced in 2013 to support the Mayor of London's submissions to the Airports Commission: Outline proposals for long term aviation capacity.

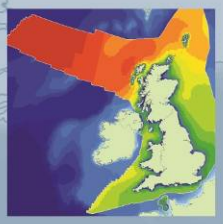
Atkins

Hub for London
Ecology Desk Study Part B: Marine and Coastal Baseline

Report R.2130

August 2013

Creating sustainable solutions for the marine environment


Atkins Global

Hub for London
Ecology Desk Study Part B:
Marine and Coastal Baseline

Date: June 2013

Project Ref: R/4155/1

Report No: R.2130

Version	Details of Change	Date
1.0	Draft for Comment	31.05.2013
2.0	2nd Draft for Comment	21.06.2013
3.0	Final	20.08.2013

Document Authorisation		Signature	Date
Project Manager:	N J Frost		20.08.2013
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Ecology Desk Study - Part B: Marine and Coastal Baseline

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1. Introduction

The Mayor of London Aviation Work Programme is currently investigating how to increase London's hub airport capacity. Transport for London (TfL) are co-ordinating this work stream which includes a review of a number of short listed options that meet the necessary requirements of a future hub airport. There are currently two short listed options that are located within the marine environment, namely the Inner Estuary and Outer Estuary options (Figure 1). A third shortlisted option, the expansion of Stansted, has not been considered further within this report as it is not located within the marine environment.

ABP Marine Environmental Research Ltd (ABPmer) has been contracted to undertake the following tasks as part of this programme of works:

1) Provide a baseline description of the marine ecology of the Thames Estuary;
2) Identify potential impacts that could arise in the marine environment through the introduction of a new airport;
3) The identification of possible mitigation and compensation measures that could be required in relation to such a development; and
4) A review of policy and precedents.

This report contains the baseline description of the marine ecology of the study area which has been assumed to include the Thames, Medway, Swale, Crouch and Roach estuaries as well as sections of open coastline (see Figure 1). The study area has been defined to capture the likely maximum spatial extent of potential impacts that could arise in the marine environment through the introduction of a new airport. The study area has been further extended for mobile species (particularly fish, marine mammals and seabirds) where it has been necessary to place the baseline information in a wider geographical context. The receptors that have been considered within this review include:

- Environmental Designations;
- Intertidal and Subtidal Habitats and Species;
- Plankton;
- Fish and Shellfish;
- Marine Mammals; and
- Seabirds.

The following sections each document the sources of information that have been reviewed and the current environmental baseline for each of these receptors in turn. A full list of abbreviations used within this report can be found at Section 9.

2. Environmental Designations

The nature conservation interest features of the study area are recognised through a number of international and national designations including (see Figures 2 and 3):

- Special Protection Areas (SPAs);
- Wetlands of International Importance (Ramsar sites);
- Special Areas of Conservation (SACs);
- European Marine Sites;
- Recommended Marine Conservation Zones (rMCZs); and

- Sites of Special Scientific Interest (SSSIs).

The following sections provide a description of the features for which these sites have been designated.

2.1 Special Protection Areas (SPAs)

The EC Birds Directive (79/409/EEC) requires all member states to identify areas to be given special protection for the rare or vulnerable species listed in Annex 1 of the Directive (Article 4.1), for regularly occurring migratory species (Article 4.2) and for the protection of wetlands, especially wetlands of international importance. These areas are known as Special Protection Areas (SPAs). In the UK, the provisions of the Birds Directive are implemented through the Wildlife and Countryside Act 1981 (as amended) and the Conservation of Habitats and Species Regulations 2010 (as amended), referred to hereafter as 'the Habitats Regulations'. The Habitats Regulations consolidate all the various amendments made to the Conservation (Natural Habitats, &c.) Regulations 1994 and implement the Birds Directive (and Habitats Directive – see below) as far as the limit of territorial waters (12 nautical miles (nm)).

There are nine SPAs within the study area (Table 1). The bird species qualifying under the Birds Directive using the marine component of the SPA sites according to the latest citations can be found in Appendix A.

Table 1. SPAs within the study area

Site	Area (ha)	SPA Qualifying Feature		
		Article 4.1	Article 4.2	Sub-Features
Benfleet and Southend Marshes	2,251		✓	Intertidal mudflat and sandflat communities; saltmarsh communities; eelgrass beds; shell banks.
Crouch and Roach Estuaries*	1,736	✓	✓	Intertidal mudflats and sandflats; boulder and cobble shores; saltmarsh; shallow coastal waters.
Dengie*	3,127	✓	✓	Intertidal mudflat and sandflat; sandbanks
Foulness*	10,969	✓	✓	Shell, sand and gravel shores; intertidal mudflat and sandflats; saltmarsh; shallow coastal waters; boulder and cobble shores.
Medway Estuary and Marshes	4,684	✓	✓	Mudflats; saltmarsh; shallow coastal waters; shingle beaches.
Outer Thames Estuary	379,268	✓		Shallow inshore waters; sandbanks
Thames Estuary and Marshes	4,839	✓	✓	Intertidal mudflats; saltmarsh; intertidal shingle.
Thanet Coast and Sandwich Bay	1,870	✓	✓	Intertidal mudflats and sandflats; saltmarsh; shingle beach; sand dune; rock.
The Swale	6,515		✓	Intertidal mudflats; saltmarsh.
* Sites form part of the phased mid-Essex Coast SPA				

(Source: English Nature, 2000: English Nature, 2001a: English Nature, 2001b, JNCC, 2012: JNCC & NE, 2013)

2.2 Ramsar Sites

Under the 1972 Ramsar Convention on Wetlands of International Importance, it is a requirement of signatory states to protect wetland sites of international importance, including those that are important waterfowl habitats (JNCC, 2011). There are eight Ramsar sites in and adjoining the study area as summarised in Table 2. An overview of the reasons for designation for each site is included within Table 2 (for more detail on qualifying plant, invertebrate and bird species see Appendix B).

Table 2. Ramsar sites designated within the study area

Site	Area (ha)	Ramsar Qualifying Criteria				
		Criterion 1	Criterion 2	Criterion 3	Criterion 5	Criterion 6
Benfleet and Southend Marshes	2,251				Waterfowl assemblage	Species of international importance.
Crouch and Roach Estuaries	1,736		Rare and scarce plant species and invertebrates.		Waterfowl assemblage	Species of international importance.
Dengie	3,127	Saltmarsh habitat	Rare and scarce plant species and invertebrates.	Extensive saltmarsh habitat	Waterfowl assemblage	Species of international importance.
Foulness	10,933	Saltmarsh habitat	Rare and scarce plant species and invertebrates.	Extensive saltmarsh habitat	Waterfowl assemblage	Species of international importance.
Medway Estuary and Marshes	4,697		Rare and scarce plant species and invertebrates		Waterfowl assemblage	Species of international importance.
Thames Estuary and Marshes	5,589		Rare and scarce plant species and invertebrates.		Waterfowl assemblage	Species of international importance.
Thanet Coast and Sandwich Bay	2,169		Rare and scarce invertebrate species.			Species of international importance.
The Swale	6,515		Rare and scarce plant species and invertebrates.		Waterfowl assemblage	Species of international importance.

(Source: JNCC, 2011)

2.3 Special Areas of Conservation (SACs)

The EC Habitats Directive (92/43/EEC) requires the establishment of a network of important high quality conservation sites that will make a significant contribution to conserving the 189 habitat types and 788 species identified in Annexes I and II of the Habitats Directive. These areas are known as Special Areas of Conservation (SACs). The listed habitat types and species are those considered to be most in need of conservation at a European level with the ultimate aim of the Directive being the conservation of biodiversity. In the UK, the provisions of the Habitats Directive are implemented through the Wildlife and Countryside Act 1981 (as amended) and the Habitats Regulations. The Habitats Regulations consolidate all the various amendments made to the Conservation (Natural Habitats, &c.) Regulations 1994 and implement the Habitats Directive (and Birds Directive – see above) as far as the limit of territorial waters (12 nm).

There are two SACs and one candidate SAC within the study area (Table 3). Candidate SACs (cSACs) are sites that have been submitted to the European Commission, but not yet formally adopted.

Table 3. SACs within the study area

SAC Site	Area (ha)	Annex I Habitats	Annex II Species
Essex Estuaries	46,141	▪ Estuaries; ▪ Mudflats and sandflats not covered by seawater at low tide; ▪ *Salicornia* and other annuals colonising mud and sand; ▪ *Spartina* swards (*Spartinion maritimae*); ▪ Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*); ▪ Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*); and ▪ Sandbanks which are slightly covered by seawater all the time*.	n/a
Thanet Coast	2,804	▪ Reefs; and ▪ Submerged or partially submerged sea caves	n/a
Margate and Long Sands (cSAC)	6,4914	▪ Sandbanks which are slightly covered by sea water all the time	n/a
* Habitats and species present as a qualifying feature, but not a primary reason for selection of this site.			

(Source: JNCC, 2013)

2.4 European Marine Sites

Where a SPA or a SAC incorporates subtidal and/or intertidal areas, they are referred to as European Marine Sites. All nine of the designated SPAs in the study area (Thames and Estuary Marshes, Medway Estuary and Marshes, The Swale, Foulness, Dengie, Crouch and Roach Estuaries, Outer Thames, Benfleet and Southend Marshes, Thanet Coast and Sandwich Bay) and all three of the SACs within the study area (Essex Estuaries, Thanet Coast and Margate and Long Sands) therefore constitute European Marine Sites (Natural England, 2013a). The conservation objectives for these sites can be found in the associated Regulation 33/35 Advice (English Nature, 2000; 2001a; b; JNCC and NE, 2013).

2.5 Marine Conservation Zones

The UK's Marine and Coastal Access Act 2009 provides for the designation of Marine Conservation Zones (MCZs). Together with SACs and SPAs with marine components, the MCZ network will deliver

England's contribution to the UK's vision of an ecologically coherent network of Marine Protected Areas (MPAs).

Proposals for a number of recommended MCZs (rMCZs) and Reference Areas (rRAs) were developed by the Balanced Seas MCZ Project (Balanced Seas, 2011). Within the study area these included:

- Thames Estuary rMCZ;
- Medway Estuary rMCZ;
- Swale Estuary rMCZ;
- Blackwater, Crouch, Roach and Colne Estuary rMCZ; and
- Thanet Coast rMCZ.

In December 2012 Defra launched a public consultation on the formal designation of MCZs. Designation will be taken forward in a number of phases (tranches). The Defra consultation identified three sites within the study area (Medway Estuary, Blackwater, Crouch, Roach and Colne Estuary and Thanet Coast) for designation within Tranche 1. The two remaining rMCZs (Thames Estuary and the Swale Estuary) within the study area are not being recommended for designation within Tranche 1 but remain under further consideration. The features and draft conservation objectives of these sites are listed in Table 4.

Table 4. rMCZs within the study area

rMCZ	Area (ha)	Features	Conservation Objective	Designation
Tranche 1 Sites				
Blackwater, Crouch, Roach and Colne Estuary	30,497	▪ A1.1 high energy intertidal rock	Maintain	Later tranche
		▪ A2.4 intertidal mixed sediments	Maintain	2013 tranche
		▪ Native oyster beds	Recover	Later tranche
		▪ Native Oyster (*Ostrea edulis*)	Recover	Later tranche
		▪ Lagoon Sea Slug (*Tenellia adspersa*)*	Maintain	2013 tranche
		▪ European Eel (*Anguilla anguilla*)	Maintain	2013 tranche
Medway Estuary	6,483	▪ A1.3 low energy intertidal rock;	Maintain	Later tranche
		▪ A2.2 intertidal sand/muddy sand;	Maintain	2013 tranche
		▪ A2.4 intertidal mixed sediments;	Maintain	Later tranche
		▪ A5.1 subtidal coarse sediment;	Maintain	Later tranche
		▪ A5.2 subtidal sand;	Maintain	Later tranche
		▪ A5.3 subtidal mud;	Maintain	2013 tranche
		▪ Estuarine rocky habitats;	Maintain	Later tranche
		▪ Peat and clay exposures;	Maintain	Later tranche
		▪ Sheltered muddy gravels; and	Recover	Later tranche
		▪ Tentacled Lagoon Worm (*Alkmaria romijni*).	Maintain	2013 tranche
Thanet Coast	6,279	▪ A3.2 moderate energy infralittoral rock	Maintain	2013 tranche
		▪ A4.2 moderate energy circalittoral rock	Maintain	2013 tranche
		▪ A5.1 subtidal coarse sediment	Maintain	2013 tranche
		▪ A5.2 subtidal sand	Maintain	2013 tranche
		▪ A5.4 subtidal mixed sediments	Maintain	2013 tranche
		▪ Blue mussel beds	Maintain	2013 tranche
		▪ Peat and clay exposures	Maintain	Later tranche
		▪ Rossworm (*Sabellaria spinulosa*) reef	Recover	2013 tranche
		▪ Subtidal chalk	Maintain	2013 tranche
		▪ Subtidal sands and gravels	Maintain	2013 tranche
		▪ St John's Jellyfish (*Lucernariopsis cruxmelitensis*)	Maintain	Later tranche
		▪ Kaleidoscope Jellyfish (*Haliclystus auricula*)	Maintain	Later tranche

rMCZ	Area (ha)	Features	Conservation Objective	Designation
Non Tranche 1 Sites				
Swale Estuary	5,105	▪ A1.3 low energy intertidal rock	Maintain	Later tranche
		▪ A3.3 low energy infralittoral rock	Maintain	Later tranche
		▪ A5.2 subtidal sand	Maintain	Later tranche
		▪ A5.3 subtidal mud	Recover	Later tranche
		▪ A5.4 subtidal mixed sediments	Recover	Later tranche
		▪ Blue mussel beds	Maintain	Later tranche
		▪ Peat and clay exposures	Maintain	Later tranche
		▪ Rossworm (*Sabellaria spinulosa*) reef	Maintain	Later tranche
		▪ Sheltered muddy gravels	Recover	Later tranche
		▪ Subtidal sands and gravels	Maintain	Later tranche
		▪ Native Oyster (*Ostrea edulis*)	Maintain	Later tranche
		▪ European Eel (*Anguilla anguilla*)	Maintain	Later tranche
Thames Estuary	13,214	▪ A2.2 intertidal sand/muddy sand	Maintain	Later tranche
		▪ A2.4 intertidal mixed sediments	Maintain	Later tranche
		▪ A5.1 subtidal coarse sediment	Maintain	Later tranche
		▪ A5.2 subtidal sand	Maintain	Later tranche
		▪ A5.3 subtidal mud	Maintain	Later tranche
		▪ Sheltered muddy gravels	Recover	Later tranche
		▪ Tentacled Lagoon Worm (*Alkmaria romijni*)	Recover	Later tranche
		▪ European Eel (*Anguilla anguilla*)	Maintain	Later tranche
		▪ Smelt (*Osmerus eperlanus*)	Maintain	Later tranche

* Occurs above MHW

Greyed boxes indicate features not currently proposed for designation within Tranche 1

(Source: Defra *et al*., 2013)

2.6 Sites of Special Scientific Interest (SSSI)

Within the study area there are 16 Sites of Special Scientific Interest (SSSI) which have been designated for marine features, the largest of these is Foulness SSSI at 10,702 ha (Figure 3, Table 5). The designated sites represent a range of geological and biological interests, many of which are contiguous including terrestrial, riverine and estuarine habitats and species.

Table 5. Summary of SSSIs within the study area

Site Name	Grid Reference	Area (ha)	Key Interests
Benfleet and Southend Marshes	TQ 854847	2,100	An extensive series of saltmarshes, mudflats, scrub and grassland, which support a diverse flora and fauna. Outside the sea walls there are extensive saltmarshes and mudflats, on which wintering wildfowl and waders reach both nationally and internationally important numbers. Nationally uncommon plants occur in all of the habitats and parts of the area are of outstanding importance for scarce invertebrates.
Crouch and Roach Estuaries	TQ 870970	1,736	The intertidal zone along the rivers Crouch and Roach is 'squeezed' between the sea walls on both banks and the river channel. This leaves a relatively narrow strip of tidal mud in contrast with other estuaries in the county. This, however, is used by significant numbers of birds, and together with the saltmarsh and grazing marsh which comprise the Crouch and Roach Estuaries SSSI regularly support internationally important numbers of one species, and nationally important numbers of three species of waders and wildfowl. Additional interest is provided by the aquatic and terrestrial invertebrates and by an outstanding assemblage of nationally scarce plants.
Dengie	TM 045030	3,105	Dengie is a large and remote area of tidal mudflat and saltmarsh at the eastern end of the Dengie peninsula. The saltmarsh is the largest continuous example of its type in Essex. Foreshore, saltmarsh and beaches support an outstanding assemblage of rare coastal flora. It is a resort for internationally and nationally important wintering populations of wildfowl and waders, and in summer supports a range of breeding coastal birds including rarities. The formation of cockleshell spits and beaches is of geomorphological interest.
Foulness	TR 030905	10,702	It comprises extensive intertidal sand-silt flats, saltmarsh, beaches, grazing marshes, rough grass and scrubland. The flats are of national and international importance as winter feeding grounds for nine species of wildfowl and wader, with the islands, creeks and grazing land forming an integral part as sheltered feeding and roosting sites. The shell banks support nationally important breeding colonies of Little Terns, Common Terns and Sandwich Terns. The complex matrix of habitats also supports nationally important numbers of breeding Avocets along with plants and invertebrates.
Holehaven Creek	TQ 750832	273	The intertidal mudflats and saltmarsh habitats of Holehaven Creek support a nationally important number of black-tailed godwit. This species also regularly occurs in numbers of international importance. In addition, the site regularly supports an assemblage of over 8,000 waterfowl during the winter.
Medway Estuary and Marshes	TQ 850720	6,840	A complex of mudflats and saltmarsh is present with grazing marsh behind the sea walls, which is intersected by dykes and fleets. The area holds internationally important populations of wintering and passage birds and is also of importance for its breeding birds. An outstanding assemblage of plant species also occurs on the site.
Mucking Flats and Marshes	TQ 696785	312	An extensive stretch of Thames mudflats and saltmarsh, together with sea wall grassland. Wintering wildfowl and waders reach both nationally and internationally important numbers on the mudflats, roosting and feeding on adjacent saltmarsh and disused silt lagoons.
Northward Hill	TQ 781763	53	There is a diverse breeding bird community and the largest population of heron in Britain (over 200 pairs).

Site Name	Grid Reference	Area (ha)	Key Interests
Pitsea Marsh	TQ 735863 - 740870	95	Pitsea Marsh SSSI comprises a mosaic of habitats, including scrub, grassland, reedbed and fen, open water and saltmarsh. The reedbed in Pitseahall Fleet is the largest known in South Essex. The diversity of habitats supports an outstanding range of invertebrates, including a number of local and nationally rare damselflies, dragonflies, moths, flies and beetles.
Sheppey Cliffs and Foreshore	TR 000731	302	The cliffs are of botanical interest in that they support a good population of the nationally rare plant dragon's teeth. A number of other uncommon species have also been recorded, including the nationally scarce bithynian vetch.
South Thames Estuary and Marshes	TQ 770785	5,449	The site consists of an extensive mosaic of grazing marsh, saltmarsh, mudflats and shingle characteristic of the estuarine habitats of the north Kent marshes. Freshwater pools and some areas of woodland provide additional variety and complement the estuarine habitats. The site supports outstanding numbers of waterfowl with total counts regularly exceeding 20,000.
Tankerton Slopes	TR 121673	2	This site supports the largest single population of the large umbellifer hog's fennel in Britain, a nationally rare plant confined to a few coastal localities in Essex and Kent.
Thanet Coast	TR 132675 – TR 394656	819	The Thanet Coast is particularly noted for its bird populations, supporting both internationally and nationally important numbers of wintering birds, with one species breeding in nationally important numbers. Associated with the various constituent habitats of the site are outstanding assemblages of both terrestrial and marine plant species, including communities of marine algae that are of limited occurrence elsewhere in the British Isles. Invertebrates are also of interest and there are recent records of three nationally rare and one nationally scarce species.
The Swale	TR 000670	6,568	The Swale includes the largest remaining areas of freshwater grazing marsh in Kent and is representative of the estuarine habitats found on the north Kent coast. The habitats comprise chiefly mudflats, saltmarsh, and freshwater grazing marsh, the latter being intersected by extensive dykes and fleets. The area is particularly notable for the internationally important numbers of wintering and passage wildfowl and waders, and there are also important breeding populations of a number of bird species.
Tower Hill to Cockham Wood	TQ 765714	48	A narrow grassy zone, dominated by sea couch-grass *Elymus pycnanthus*, occurs at intervals along the junction between woodland and intertidal mudflats, where the scarce species, bithynian vetch is found. The sandy areas support a very rich insect fauna.
Vange and Fobbing Marshes	TQ 730840 - 725867	165	Vange and Fobbing Marshes lie on the alluvial plain of the lower River Thames. The unimproved coastal grassland and associated dykes and creeks support a diversity of maritime grasses and herbs. Many of these species are nationally uncommon or rare, and together form an outstanding assemblage of plants.

(Source: Natural England, 2013b)

2.7 Protected Habitats and Species

OSPAR has established a list of threatened and/or declining species and habitats in the North-East Atlantic. The list provides an overview of the biodiversity in need of protection in the North-East Atlantic and is being used by the OSPAR Commission to guide the setting priorities for further work on the conservation and protection of marine biodiversity under Annex V of the OSPAR Convention. The list of species and habitats has been drawn up based upon nominations by Contracting Parties and observers to the Commission of species and habitats that they consider to be priorities for protection. The list seeks to complement, but not duplicate, the work under the EC Habitats and Birds directives and measures under the Bern Convention, the Bonn Convention and the Ramsar Convention and other relevant instruments (OSPAR Commission, 2012). Species included on the OSPAR list and present within the study area include European eel (*Anguilla anguilla*), Atlantic salmon (*Salmo salar*), sea lamprey (*Petromyzon marinus*), spotted ray (*Raja montagui*), thornback skate/ray (*Raja clavata*), Atlantic cod (*Gadus morhua*) and Harbour porpoise (*Marsouin commun*). Habitats include intertidal mudflat.

A number of UK Biodiversity Action Plan (BAP) and nationally important habitats and species are also found within the study area and are listed in Table 6 below. Descriptions of where these protected species and habitats are found are discussed in more detail below.

Table 6. Relevant UK BAP habitat and species action plans

Habitat Action Plans	Species Action Plans
▪ Coastal sand dunes ▪ Coastal vegetated shingle ▪ *Sabellaria alveolata* and *S. spinulosa* reefs ▪ Coastal saltmarsh ▪ Mudflats ▪ Seagrass beds ▪ Saline lagoons ▪ Sublittoral sands and gravels ▪ Reedbeds ▪ Coastal grazing marsh	▪ Commercial marine fish (grouped) ▪ Common skate ▪ *Atrina fragilis* (fan shell) ▪ Native oyster ▪ Northern hatchett shell ▪ Sea-fan anemone ▪ Ivell's sea anemone ▪ Starlet sea anemone ▪ Pink sea-fan ▪ Sunset cup coral ▪ *Anotrichium barbatum* (red alga) ▪ *Ascophyllum nodosum ecad mackaii* (brown alga) ▪ Twaite Shad ▪ Salmon

Local BAPs have been developed by the London Biodiversity Partnership, Essex Biodiversity Partnership and Kent Biodiversity Partnership. The Thames Estuary Partnership Biodiversity Action Group (TEP BAG) has integrated the priorities of London, Kent and Essex to produce the Tidal Thames Habitat Action Plan (TTHAP). A number of habitats and species are described within the TTHAP as characterising the Thames Estuary (TEP BAG, 2003). These are detailed below (Tables 7 and 8).

Table 7. Species characteristic of habitats in the Tidal Thames of London, Kent and Essex

Common Name	Scientific Name	Description
Algae and higher plants		
Bladder Wrack	*Fucus vesiculosus*	A seaweed found growing within the lower estuary that has started to colonise further up the tideway over recent decades. The spread has been attributed to changes in environmental conditions that include increased salinity and availability of habitat.
Enteromorpha	*Enteromorpha intestinalis*	This green alga is tolerant of varying salinities growing throughout brackish and marine zones. The growth of this species can offer important habitat to sterile flood defence structures and can be found growing on a variety of porous surfaces.
Golden samphire	*Inula crithmoides*	Widespread in Kent and Essex, often occurring on the outer face of seawalls and extending a shot distance onto saltmarsh where elevations are high. A Red Data Book (RDB) species.
Sea Aster	*Aster tripolium*	Characteristic of saltmarshes and inter-tidal habitats. It can be found throughout the middle and lower reaches of the river wherever suitable habitat exists.
Sea Barley	*Hordeum marinum*	Widespread on earthen seawall embankments, particularly in rutted saline areas on the berm and occasionally on the outer (seaward face). Nationally scarce.
Sea Clover	*Trifolium squamosum*	Widespread in short, open grassland, where grazed or trampled, often occurring on the crest of sea wall embankments. Nationally scarce.
Aquatic invertebrates		
Cockles	*Cerastoderma edule*	The common or edible cockle is found throughout the marine zone. The cockle is harvested within the Southend area providing an important commercial resource. Buried but located close to the surface it provides a food source for fish and birds during high and low tide.
Freshwater Shrimp	*Gammarus zaddachi*	This amphipod is one of the most dominant crustaceans within the fresh and brackish water zones. This species colonises a mixture of substrates and provides an important food source for fish and birds.
Ragworm	*Nereis diversicolor*	The common ragworm can be found in large numbers on mudflats within brackish and marine zones.
Fish		
Bass	*Dicentrachus labrax*	An important commercial fish species that has increased significantly in number over recent years. Juveniles migrate seasonally and are recorded regularly at Chiswick and often reach as far as Teddington.
Flounder	*Platichthys flesus*	A sea fish which spends its juvenile months in the Tidal Thames. The Tidal Thames provides a nursery area for fish spawned in the southern North Sea. Warm shallow waters, backwaters, creeks and the foreshore provide fish fry with habitat and food during the spring and summer. Although a sea fish, flounder are equally at home in the upper fresh water river during their juvenile years.
Salmon	*Salmo salar*	A regular Salmon run has occurred since 1982 and in 1993 over 500 fish returned. Receives additional protection under the EU Habitats Directive.
Sea Lamprey	*Petromyzon maximus*	Clearly established spawning grounds in the upper estuary in June and July. Protected under the EU

Common Name	Scientific Name	Description
		Habitats Directive.
Sole	*Solea solea*	The sole nursery positioned below Woolwich in now considered one of the most important strategic nurseries for its economic value in England and Wales.
Smelt	*Osmerus eperlanus*	A cousin of the salmon which has a characteristic smell of cucumber. This small fish is a particularly good indicator of water quality, and is once again spawning amongst the gravels and shallow waters near Wandsworth.
Twaite Shad	*Alosa fallax*	Twaite shad used to spawn at Greenwich. Adult and juvenile fish are now common again in the Estuary below Mucking. A priority species under the UK BAP. Receives additional protection under the EU Habitats Directive.
Birds		
Avocet	*Recurvirostra avosetta*	This bird's preferred non-breeding habitat is an estuary where the substrate is largely composed of fine silt. Mudflats at Higham Bight and Mucking are particularly important for this species and small numbers also breed amongst the saline lagoons at Cliffe.
Black-tailed Godwit	*Limosa limosa*	Feed on mudflats of the Estuary but roost on damp pasture, often inland. Overwinter in nationally important numbers in the Thames Estuary and Marshes SPA. Internationally important numbers also occur within Holehaven Creek in Essex.
Common Tern	*Sterna hirundo*	A summer visitor to the Tidal Thames. Breeds on derelict structures and purpose built 'tern-rafts' on adjacent docks. Regularly seen fishing on the River, tributaries and dock basins.
Dunlin	*Calidris alpina*	Large flocks of this small wader can be seen feeding on the mudflats of the Tidal Thames in winter.
Grey Heron	*Ardea cinerea*	This bird can be found throughout most of the Tidal Thames at all times of the year but is particularly associated with the upper freshwater river, islands and backwaters.
Redshank	*Tringa totanus*	Overwinter in nationally important numbers within the Thames Estuary. Small numbers also breed on the wetter grazing marsh areas adjacent to the Thames.
Ringed Plover	*Charadrius dubius*	Feed on invertebrates on sand and shingle shores, sandbanks and mudflats, as well as on saltmarshes, short grassland, flooded fields and shores of artificial habitats. Roost communally, close to feeding sites along the shoreline, on sandbanks or bare arable fields and in low vegetation.
Shelduck	*Tadorna tadorna*	A bird characteristic of sand and mudflats throughout the Estuary, feeding on snails and other small invertebrates.
Teal	*Anas crecca*	A bird that over-winters on the Tidal Thames associated mainly with the lower river, mudflats and saltmarsh. However, it also occurs on some of the tidal inlets.
Marine Mammals		
Harbour porpoise	*Phocoena phocoena*	In recent years the Tidal Thames has hosted a number of marine mammals. Dolphins, porpoises, seals and turtles are frequent visitors. These animals received additional protection under the EU Habitats Directive 1994.
Bottlenose dolphin	*Tursiops truncatus*	
Common seal	*Phoca vitulina*	

(Source: TEP BAG, 2003)

Table 8. Key habitats of the Tidal Thames in London, Kent and Essex

Habitat	Site Examples	Description
Mudflats	Mucking Flats, Benfleet and Southend Marshes	Intertidal substrate comprising mud and sands. Rich source of invertebrates (shellfish, worms and crustaceans) and provide feeding grounds for large numbers of wintering waterfowl. Priority habitat under the UK BAP.
Saltmarsh	Benfleet & Southend Marshes	Transitional mud habitat in the mid to lower river, predominantly vegetated, ranging from intertidal to terrestrial communities. Important feeding and roosting areas for wintering waterfowl. Priority habitat under the UK BAP.
Seagrass beds (*Zostera* spp.)	Nr. Two Tree Island close to Canvey	High to mid-shore. Support many invertebrates and are spawning grounds for fish. UK BAP and Local BAP priority habitats.
Sublittoral sands and gravels		Sands and gravels found below the lowest tides, continuously submerged loose sediment. Habitat for invertebrates and spawning substrate for fish e.g. smelt. Priority habitat under the UK BAP.
Tidal creeks	Holehaven Creek (Essex), Yantlet Creek - (Kent)	Tidal areas at the mouths of tributary rivers acting as 'mini-estuaries' and providing off-line refuge for fish. Support much of the remaining saltmarsh in the lower part of the estuary. Provide sheltered feeding and roosting habitat for waders and wildfowl.

(Source: TEP BAG, 2003)

3. Intertidal and Subtidal Habitats and Species

This chapter provides a description of the intertidal and subtidal benthic ecology within the study area structured according to a number of spatial subdivisions (Figure 4). It should be noted, however, that these are artificial boundaries and ecological linkages occur throughout the study area. The subdivisions that have been applied include:

- Thames Estuary (including the area westward from an indicative line drawn between Shoeburyness and the Isle of Grain up to Gravesend);
- Medway Estuary (including the area south-west of an indicative line drawn between the Isle of Grain and Sheerness up to Rochester);
- Swale Estuary (including the area westward from an indicative line drawn between Shellness and Whitstable up to Sittingbourne);
- Crouch and Roach Estuary (including the area westward from an indicative line drawn between Holliwell Point and Foulness Point); and
- Outer Thames (including the Foulness coastline, between Shoeburyness and Foulness Point, the Dengie coastline, between Holliwell Point and Dengie Flats at the northern edge of the study area, the east facing Isle of Sheppey coastline, between Sheerness and Shellness, and the Thanet coastline, between Whitstable and North Foreland at the eastern edge of the study area).

It should be noted that these artificial subdivisions only relate to the descriptions of the intertidal and subtidal habitats and species.

The intertidal and subtidal habitats and species within the study area have been described based on a number of key data sources including:

- Citations for international and national nature conservation designations;
- Environmental Statements (ESs) from offshore wind farm developments (Dong Energy, 2007; Galloper Wind Farm Ltd, 2011; Global Renewable Energy Partners (GREP), 2002; Greater Gabbard Offshore Winds Limited (GGOWL), 2005; London Array Ltd (LAL), 2005; Vattenfall, 2011);
- Wallasea Wild Coast Environmental Statement (RSPB, 2008);
- Analysis of benthic invertebrate data held by the Port of London Authority (ABPmer, 2007b);
- Thames Estuary 2100 (TE2100) Project Reports (ABPmer, 2006; ABPmer, 2008a; b);
- Greater Thames CHaMP (ABPmer, 2007a);
- The Outer Thames Estuary Regional Environmental Characterisation (Marine Aggregate Levy Sustainability Fund (MALSF), 2009);
- Marine Aggregate Regional Environmental Assessment of the Outer Thames Estuary (Thames Estuary Dredging Association (TEDA), 2010); and
- Environment Agency Digital Habitat Inventory and Thames Estuary Benthic Programme data.

These studies have all been set in the context of nationally and regionally available datasets including EUSeaMap and MESH.

3.1 Intertidal Habitats and Species

The intertidal habitats throughout the entire study area are comprised of a mosaic of intertidal mudflats and sandflats, saltmarsh, eelgrass beds, coastal grazing marshes and shingle. A map of the intertidal

habitats throughout the study area (based on the Environment Agency Digital Habitat Inventory) can be found at Figure 5. Intertidal assemblages across the study area are typically dominated by polychaetes (including *Pygospio elegans*, *Nereis* sp., *Nephtys* sp., *Scoloplos armiger*), oligochaetes (*Tubificoides benedii*), and molluscs such as the burrowing bivalve *Macoma balthica* and the gastropod *Hydrobia ulvae*. An approximation of the extent of broad scale intertidal assemblage types throughout the study area can be seen in Figure 6 with the corresponding characteristic species summarised in Table 9. This information has been derived from the Greater Thames ChaMP Scoping Document (ABPmer, 2007a). It should be noted that the boundaries of the assemblage types have largely been determined by the locations of sample points. The boundaries merely reflect an interpolation of the available datasets and should be viewed in this context.

The following sections provide a more detailed description of each of the component parts of the study area.

Table 9. Typical intertidal invertebrate species identified in assemblages throughout the study area

Assemblage	Characteristic Species	Organism Type
A	*Hydrobia ulvae*	Gastropod
	Cerastoderma edule	Bivalve
	Scoloplos armiger	Polychaete
	Nephtys hombergii	Polychaete
	Pygopsio total	Polychaete
	Macoma balthica	Bivalve
	Bathyporeia sarsi	Amphipod
	Urothoe poseidonis	Amphipod
B	*Oligochaetes*	Oligochaete
	Nephtys hombergii	Polychaete
	Macoma balthica	Bivalve
	Pygopsio total	Polychaete
	Hydrobia ulvae	Gastropod
	Eteone spp.	Polychaete
	Cerastoderma spp.	Bivalve
	Caulleriella spp.	Polychaete
	Capitellidae spp	Polychaete
	Lanice conchilega	Polychaete
C	*Oligocheates*	Oligochaete
	Corophium spp.	Amphipod
	Nereis spp.	Polychaete
	Macoma balthica	Bivalve
	Pygopsio spp.	Polychaete
See Figure 6 for location of assemblages		

3.1.1 Thames Estuary

The intertidal habitats towards the outer reaches of the Thames Estuary include areas of saltmarsh, eelgrass beds, and shingle. Extensive intertidal sand and mudflats are present, with the mudflats up to 2 km wide in places. Mucking Flats represent the largest continuous section of mudflat on the northern side of the Thames. However, as the estuary narrows, mudflat fringes also become narrower, at Coalhouse Fort, for example, mudflats extend into the estuary by a maximum of 0.5 km (Figure 5). The intertidal flats of the estuary are mostly fine, silty sediment, with a few sandy areas. Distinctly sandy areas occur immediately to the east of Canvey Island whilst extensive areas of intertidal gravel and shingle are located to the rear of the intertidal flats south of Southend on Sea. The total area of

intertidal which falls within the Thames Estuary (as classified within this section of the report – see Figure 4) is approximately 6,230 ha.

The benthic assemblage of the Thames Estuary has been described in a number of previous studies including the Thames Estuary Benthic Programme (TEBP), data held by the Port of London Authority, wind farm environmental statements (GREP, 2002) as well as the Greater Thames CHaMP (ABPmer, 2007a) and Thames Estuary 2100 (ABPmer, 2006; 2008a; 2008b).

Salinity is generally considered the most significant factor influencing species distributions in estuaries (Attrill, 2002). Changes in the invertebrate composition along the estuary reflect the tolerance that individual species have to variations in salinity. Invertebrate communities found in the inner estuary are mainly composed of freshwater invertebrate species that are tolerant of elevated salinity such as the gastropod *Lymnaea peregra*, leech *Helobdella stagnalis* and midges (*Chironomidae* spp.) Within the mid estuary the invertebrate community is characterised by estuarine species that can tolerate a wide fluctuation in salinity and increasing abundances of marine invertebrate species such as the ragworm *N. diversicolor*, oligochaetes (*Limnodrilus* spp. and *T. pseudogaster*) and the amphipod *Gammarus zaddachi*. The invertebrate community in the outer reaches of the estuary are dominated by marine molluscs such as *M. balthica*, *H. ulvae* and *Cerastoderma edule*, polychaetes (*Paradoneis lyra*, *N. hombergii* and *Caulleriella* spp.), oligochaetes and amphipods (*Corophium* spp.).

There is limited site specific data on macroalgae within the Thames Estuary itself. Although the spatial distribution of macroalgae species and abundance are not known, Table 10 provides a list of some common species that have previously been reported within the study area.

Table 10. Typical macroalgae species recorded within the Thames Estuary

Species	Comments
Sertularia cupressina	Fern-like hydroid with planktonic juvenile state
Fucus vesiculosus	Sheltered littoral rock e.g. seawalls and lower and moderately exposed mid eulittoral mixed substrata.
Enteromorpha intestinalis	Green algae.
Fucus ceranoides	Grows towards the upper zone of sheltered littoral rock
Ascophyllum nodosum mackaii	Co-dominant with *Fucus vesiculosus*. More common on very sheltered eulittoral rock. Species action plan (UK Biodiversity Action Plan).
Anotrichium barbatum	Species action plan (UK Biodiversity Action Plan).

Saltmarsh abuts intertidal flats in more sheltered locations such as the creeks, for example, around Benfleet and Holehaven Creek around Canvey Island (Figure 5). The saltmarsh of Benfleet and Southend Marshes has a diverse flora typical of middle-zone marshes, and includes sea purslane *Atriplex portaculoides*, common saltmarsh-grass *Puccinellia maritima* and sea aster *Aster olium*. On the south side of the estuary, the saltmarsh represented within the Thames Estuary and Marshes designations, changes from pioneer communities containing eelgrass (*Zostera* spp.) to saltmarsh dominated by sea purslane *A. portaculoides*.

An area of eelgrass beds is found on the intertidal flats east of Hadleigh Marsh whilst saline lagoons are present at Cliffe Pools, opposite Coalhouse Fort (Figure 5). These saline lagoons cover 180 ha, 10% of the total British resource of this habitat.

The grazing marsh grassland in the Thames Estuary and Marshes SPA and Ramsar site, is mesotrophic and generally species-poor. It does, however, contain scattered rarities, mostly annuals, which are characteristic of bare ground. Where the grassland is seasonally inundated and the marshes

are brackish, the plant communities are intermediate between those of mesotrophic grassland and of saltmarsh. The grazing marsh ditches contain a range of flora of brackish and freshwater. The aquatic flora is a mosaic of successional stages resulting from periodic clearance of drainage channels. The dominant emergent plants are the common reed *Phragmites australis* and sea club-rush *Bolboschoenus maritimus* (ABPmer, 2007a).

3.1.2 Medway Estuary

The Medway Estuary has a complex arrangement of tidal channels, which drain around large islands of saltmarsh and peninsulas of grazing marsh. The intertidal sections are mostly mudflats and saltmarshes, with some eelgrass beds and shingle beaches (Figure 5). The intertidal flats of the Medway comprise fine, silty sediment. The total area of intertidal which falls within the Medway Estuary (as classified within this section of the report – see Figure 4) is approximately 4060 ha.

Information on the invertebrate fauna of the Medway Estuary is limited and the data described below has been taken from studies by Wharfe in the late 1970s. Wharfe (1976; 1977) described the benthic invertebrate macrofauna of the lower Medway Estuary as being rich in numbers of oligochaetes, predominantly *Peloscolex benedeni*, polychaetes, predominantly *N. diversicolor*, and the mollusc *H. ulvae*. The blue mussel *Mytilus edulis* was also commonly recorded throughout the estuary in the late 1970s (Wharfe, 1976; 1977). A review of the Medway Estuary by the Balanced Seas Regional Steering Group (RSG) for the MCZ process concluded that although both subtidal and intertidal forms of Blue Mussel beds still occur within the Estuary, stakeholders suggested that these are not good examples of the feature (Balanced Seas, 2011b).

The saltmarsh within the estuary demonstrates a transition from pioneer communities containing eelgrass (*Zostera* spp.) and common cordgrass *Spartina anglica* to high saltmarsh dominated by sea purslane *A. portaculoides*. The majority of the grazing marsh in the Medway Estuary and Marshes area is species-poor improved grassland. The unvegetated shingle beaches of the Medway area also support many species which are rare in Britain, for example the Annex 1 species Little Tern uses the site for nesting. The site includes smaller areas of scrub, reedbeds and sand dune which add to the variety of interest. The shell sand beaches, particularly in the outer part of the estuary, are of interest in that they are the only remaining examples of such habitat so far up the Thames Estuary (Natural England, 2013b).

3.1.3 Swale Estuary

The Swale Estuary is a complex of brackish and freshwater, floodplain grazing marsh with ditches, low energy intertidal rock, and intertidal saltmarshes and mudflats. The total area of intertidal which falls within the Swale Estuary (as classified within this section of the report – see Figure 4) is approximately 2,540 ha. The intertidal mudflats are particularly extensive, especially in the east of the site (Figure 5). The mudflats comprise fine, silty sediment and are extremely rich in invertebrates, with over 350 species having been recorded (Natural England, 2013b). Some of these, such as the polychaete worm *Clymenella torquata* are not known to occur anywhere else in Britain, while other more widespread species are present at high densities and provide food for birds, especially waders, which use the Swale (Natural England, 2013b). The extensive intertidal flats in Whitstable Bay, in particular, support a dense invertebrate fauna. These invertebrates, together with beds of algae and eelgrass (*Zostera* spp.), are important food sources for waterbirds.

Strips of species rich dense continuous saltmarsh occur within the Swale Estuary (Figure 5), containing species of alkali grass (*Puccinellia* spp.) and glasswort (*Salicornia* spp.) common in the UK. This

community is characteristic of the lower limits of saltmarsh and forms part of the transition from intertidal mud and sandflats to upper saltmarsh. The grazing marsh grassland in the Swale Estuary is mesotrophic and generally species-poor. It does, however, contain scattered rarities, mostly annuals, characteristic of bare ground. Where the grassland is seasonally inundated and the marshes are brackish, the plant communities are intermediate between those of mesotrophic grassland and those of saltmarsh. The grazing marsh ditches contain a range of flora of brackish and freshwater. The aquatic flora is a mosaic of successional stages resulting from the periodic clearance of drainage channels. The dominant emergent plants are the common reed *P. australis* and sea club-rush *B. maritimus* (ABPmer, 2007a).

3.1.4 Outer Thames

3.1.4.1 Foulness and Dengie coastlines

The northern coastline of the outer Greater Thames Estuary, between Shoeburyness and Dengie Flats, forms part of the open coast estuarine system. The intertidal habitats comprise mudflats and sandflats, saltmarsh, eelgrass beds and cockle-shell banks, and include one of the three largest continuous sand-silt flats in the UK. The total area of intertidal which falls within the Foulness and Dengie Coastlines subdivision (as classified within this section of the report – see Figure 4) is approximately 10,370 ha.

The Dengie foreshore is a large continuous area of mudflat extending nearly 13 km along the exposed eastern-facing frontage. It is composed of mud, silt and sand with varying amounts of shell or shingle forming firmer areas. The mudflats of the Foulness coastline support nationally and internationally important numbers of birds due to the rich invertebrate food supply in the mudflats such as; *Hydrobia* snails on the surface of the mud, mudhopper crustaceans and small bivalve molluscs, such as *Corophium* and *Macoma*, which inhabit the upper surface layers, and the polycheates, *Nereis* and *Nepthys*, which are found deeper in the mud. On sandier areas, the lugworm *Arenicola* and cockles *C. edule* also support bird species (Natural England, 2013b). The biomass of the benthic communities in the extensive mudflats from Foulness Point to Shoeburyness was described as being relatively high in the baseline description of the Environment Agency's TE2100 study area with bivalve molluscs dominating the fauna. Dengie mudflat also has an abundant invertebrate fauna including molluscs, marine worms and crustacea (ABPmer, 2006).

The Outer Thames area supports a full range of saltmarsh species from pioneer to mature marsh communities. The most extensive examples of saltmarsh habitat occur along the Foulness and Dengie coastlines, where a diverse and representative succession of saltmarsh plant communities covers the range of variation found in the UK. There are species-rich perennial and pioneer saltmarsh communities, which comprise small cordgrass (*Spartina maritima*), perennial glasswort (*Salicornia perennis)* and shrubby seablite (*Suaeda vera*), as well as mature saltmarsh communities composed of pedunculate sea-purslane (*A. pedunculata*). The saltmarsh in this area is also made up of Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*), which encompasses saltmarsh vegetation containing perennial flowering plants that are regularly inundated by the sea.

Along the seaward edge of some saltmarshes, the remains of estuarine shellfish accumulate in the form of shell banks. These shell banks are a particular feature of the Foulness area where empty cockle shells have washed up at Foulness Point to form the most extensive shell beach in Britain. These cockleshell spits and ridges also form beaches along the Dengie coastline. Whilst cockles usually constitute the bulk of the banks, they also contain varying proportions of other species, including mussels, oysters, periwinkles, and the invasive alien slipper limpet (ABPmer, 2007a). The unstable substrate and susceptibility of the habitat to both salt spray and drought ensure they are

unsuitable for all but a few well-adapted plants. Typically, the sparse vegetation is dominated by plants with more or less succulent tissues, waxy leaf coatings and deep tap roots to withstand drought, such species include yellow horned-poppy *Glaucium flavum*, sea kale *Crambe maritima* and sea beet B*eta vulgaris*.

All three species of eelgrass (*Zostera angustifolia*, *Z. marina* and *Z. noltii*) have been observed along the Dengie and Foulness coastlines, with the largest single expanse of *Z. noltii* (over 300ha) in Europe located in Foulness on the Essex coast.

Grazing marsh is an important habitat for waders and wintering wildfowl. The majority of the grazing marsh grassland in the Outer Thames area is species-poor improved grassland. The grazing marsh in the Foulness SPA and Ramsar site is mainly composed of water foxtail *Alopecurus geniculatus*, meadow barley *Hordeum secalinum* and fescues.

In addition the Foulness Bund is a unique shingle feature of the Thames region, located 4 km offshore on the Maplin Sands. Although artificial in origin, it has become an important nesting site for terns (ABPmer, 2007a).

3.1.4.2 Isle of Sheppey (Sheerness to Shell Ness) and Thanet Coast (Whitstable to North Foreland)

The coastal section of the Isle of Sheppey, between Warden Point and Shell Ness, consists of reclaimed land fronted by a beach comprising of sand, shell and some shingle. The foreshore is characterised by wide, muddy intertidal flats. The total area of intertidal which falls within the Isle of Sheppey and Thanet Coast subdivision (as classified within this section of the report – see Figure 4) is approximately 1,585 ha.

The shoreline between Whitstable and Herne Bay is generally characterised by a sloping shingle upper and middle shore, which grades into a lower shore of muddy sand. Exposures of the underlying London Clay may occur on the mid and lower shores, for example near Whitstable. Coastal defences, in the form of seawalls, are present along the coastline, sparsely colonised by ephemeral green algae species such as *Enteromorpha* sp. and brown wrack seaweed, *Fucus spiralis*. Communities present are considered typical of similar defended coastlines in the UK and are not considered to be of conservation importance (GREP, 2002; Vattenfall, 2011). Where the chalk cliffs are undefended along the Thanet coastline they contain a large number of sea caves which are rich in marine algae (JNCC, 2011).

The intertidal area between Whitstable and Herne Bay was surveyed as part of the Kentish Flats and Kentish Flats Extension Wind Farm Environmental Impact Assessments. The intertidal surveys reported low species abundance and diversity, with 14 species of invertebrates recorded. The community was dominated by polychaetes, mostly annelids such as *Nereis* spp. and *Nephtys* spp, with the lower shore dominated by *Scoloplos armiger*, the lugworm *Arenicola marina* and molluscs such as *H. ulvae* and *M. balthica* (GREP, 2002; Vattenfall, 2011).

Muddy sand shores backed by shingle beaches are relatively widespread throughout this part of the Thames Estuary (Emu, 2002). Large expanses of the Kent coastline support vegetated shingle, which is a globally restricted habitat confined largely to northwestern Europe, Japan and New Zealand. Shingle occurs around 30% of the UK coast, with Kent supporting more than 40% of the UK resource (KBP, 2013). This extensive shingle expanse supports many species, particularly invertebrates, which are rare in Britain. The value of the shingle is increased by its juxtaposition to other habitats such as

sand dune, grazing marsh, saltmarsh and saline lagoon. The classic pioneer species on the seaward edge of the shingle habitat along the Kent coast include sea kale *Crambe maritima*, sea pea *Lathyrus japonicus*, Babington's orache *Atriplex glabriuscula*, sea beet *Beta vulgaris* and sea campion *Silene maritime,* i.e. species that can withstand exposure to salt spray and some degree of burial or erosion.

Intertidal biotopes at Hampton Pier (the landfall of the Kentish Flats project) were described as being indicative of sheltered to moderately exposed coastal locations in fully marine conditions. Typical biotopes include:

- LS.LCS.Sh.BarSh: Barren littoral shingle;
- LS.LSa.MuSa.MacAre: *Macoma balthica* and *Arenicola marina* in littoral muddy sand; and
- LR.HLR.MusB.MytB: *Mytilus edulis* and barnacles on very exposed eulittoral rock.

The LS.LCS.Sh.BarSh biotope is regarded as nationally uncommon, but this probably relates to the limited number of locations surveyed under the review of UK biotope distribution. The biotopes LS.LSa.MuSa.MacAre and LR.HLR.MusB.MytB are regarded as nationally common, although the latter biotope may be quite rare in the Thames Estuary, where it would be restricted to harder substrates. The LR.HLR.MusB.MytB biotope is likely an extension of the mussel beds on mixed substrates present on the western side of Hampton Pier, with the remnants of the old pier providing a habitat and attachment site which has been exploited by the mussels (GREP, 2002; Vattenfall, 2011).

3.1.5 Crouch and Roach Estuaries

The total area of intertidal within the Crouch and Roach Estuaries (as defined by the Crouch and Roach Estuaries Ramsar Information Sheet (JNCC, 2011)) is approximately 1,040 ha. The intertidal zone within the Crouch and Roach Estuaries typically consists of relatively narrow strips of mudflat. The types of intertidal mudflat biotope in the Crouch and Roach Estuaries have previously been described in National Rivers Authority and English Nature surveys (these organisations are now the Environment Agency and Natural England respectively). These surveys showed that species typical of the estuaries included a mix of polychaetes, oligochaetes and bivalves. As part of the Wallasea Island Wild Coast Project as well as the Wallasea Island Defra realignment, more detailed intertidal surveys were undertaken within the Crouch and Roach Estuaries around Wallasea Island. The communities found in the Roach consisted of a range of taxa including nematode worms, polychaetes such as *P. elegans* or *Streblospio shrubsolii*, the oligochaete *T. benedii*, bivalves such as *M. balthica* and *Scrobicularia plana* and the gastropod *H. ulvae*. These species are typical of the soft mud conditions which occur in this area. The communities in the Crouch were found to be distinct from those recorded within the Roach. Relatively impoverished communities were recorded within the Crouch, being more polychaete-dominated than those within the Roach. These findings are due to the 'stresses' induced by physical disturbance from tidal scour which is more prevalent on this section of the Crouch because it is more highly canalised with steeper intertidal areas than the Roach (with associated higher flows and lower sediment deposition) (RSPB, 2008).

Most of the tidal reaches of the Crouch and Roach were originally fringed with saltmarsh but these areas have been progressively embanked to provide safe grazing and, more recently, arable land. Only relatively small areas of saltmarsh have never been embanked. Two of these sites are notable in that the natural transition from saltmarsh to grassland is uninterrupted by a sea wall, an increasingly rare feature on the Essex coast. Other saltmarshes have formed where the sea defences have been breached, most recently at Wallasea Island. Historic breaches also include Bridgemarsh Island, Brandy Hole and North Fambridge Marsh, which have formed important and extensive stretches of saltmarsh (Natural England, 2013b).

The sea walls, and their associated berms, form important integral parts of the coastal habitat, where a number of typically coastal species are found such as Narrow-leaved Bird's-foot trefoil *Lotus tenuis* and Grass Vetchling *Lathyrus nissolia* as well as a range of nationally scarce species such as Sea Barley *Hordeum marinum*, Sea Clover *Trifolium squamosum*, Curved-Hard-grass *Parapholis incurva*, Slender Hare's-ear *Bupleurum tenuissimum* and two scarce saltmarsh grasses *Puccinellia fasciculata* and *P. rupestris*. There are also some areas of grazing marsh landward of the sea wall. This is a characteristic, but increasingly uncommon, habitat in the county. The complex of saltmarsh, grazing marsh and intertidal mudflat is of major importance especially as feeding and roosting sites for large numbers of waders and waterfowl (JNCC, 2011).

3.1.6 Distribution and Abundance in the Vicinity of the Proposed Airport Locations

The Inner Thames option is the only airport location under consideration which overlaps directly with intertidal habitat (approximately 1,830 ha); an area composed predominantly of intertidal mudflats, with smaller areas of saltmarsh, reedbeds and saline lagoons (Figure 5). The invertebrate community of this area is characterised by polychaetes (*N. diversicolor* and *N. hombergii*), oligochaetes, molluscs (*M. balthica* and *H. ulvae*) and amphipods (*Corophium* spp.) (ABPmer, 2006; 2007a).

The Inner Thames option also overlaps with a number of internationally and nationally designated sites, which have been designated for their intertidal features. These are listed below in Table 11.

Table 11. Area of overlap of Inner Thames option with designated sites

Designation	Site	Approximate Area of Overlap (ha)	Percentage of Total Designated Site (%)
SPA	Thames Estuary and Marshes	2220	46
	Medway Estuary and Marshes	171	4
Ramsar	Thames Estuary and Marshes	2220	40
	Medway Estuary and Marshes	171	4
rMCZ	Thames Estuary	1262	11
	Medway Estuary	132	2
SSSI	South Thames Estuary and Marshes	2230	42
	Medway Estuary and Marshes	195	4

3.2 Subtidal Habitats and Species

An indication of the subtidal habitats that occur throughout the study area can be obtained from the predictive habitat maps produced as part of the EUSeaMap project (JNCC, 2010). The subtidal habitats of the entire area are comprised of a mosaic of subtidal sand, mud, coarse and mixed sediments (Figure 7). The subtidal habitats and species which occur in the study area are described in more detail below. The typical invertebrate assemblage changes throughout the estuary, which is largely a function of the range in salinity and physical condition, including substrate type. An approximation of the extent of broad scale assemblage types throughout the study area can be seen in Figure 8 with the corresponding characteristic species summarised in Table 12. This information has been derived from a study which collated a range of available data sources in 2007 (ABPmer, 2007b). It should be noted that the boundaries of the assemblage types have largely been determined by the locations of the sample points. The boundaries merely reflect an interpolation of the available datasets and should be viewed in this context.

Table 12. Typical subtidal invertebrate species identified in assemblages throughout the study area (see Figure 8 for location of assemblages)

Location	Assemblage	Characteristic Species	Organism Type
Outer Thames Estuary	1	*Nemertea*	Nemertea
		Spiophanes bombyx	Polychaete
		Actiniaria	Cnidaria
		Mediomastus fragilis	Polychaete
		Sabellaria spinulosa	Polychaete
		Scoloplos armiger	Polychaete
		Nephtys (juv)	Polychaete
		Tubificoides benedii	Oligochaete
		Nematoda spp.	Nematoda
	2	*Nephtys*	Polychaete
		Bathyporeia elegans	Amphipod
	3	*Magelona johnstoni*	Polychaete
		Nephtys cirrosa	Polychaete
Mid Estuary	4	*Potamopyrgus jenkinsi*	Gastropod
Inner Estuary	5	*Streblospio shrubsolii*	Polychaete
	6	*Boccardiella ligerica*	Polychaete
		Heterochaeta costata	Oligochaete
	7	*Capitella capitata*	Polychaete
Inner - mid Estuary	8	*Tubificoides benedii*	Oligochaete

3.2.1 Thames Estuary

The seabed of the Thames Estuary is made up of a combination of coarse sediments, sand and mud, some of which the Environment Agency considers may be in near pristine condition and important for preserving marine ecosystem services, especially in regard to fisheries (Balanced Seas, 2011a).

The species that characterise the Thames vary from the inner to the outer reaches of the estuary (see Table 12, Figure 8). Within the inner reaches of the study area typical species include the polycheate *Capitella capitata* and the oligocheate *T. benedii*. The middle and outer reaches of the Thames Estuary (as defined within this report) are characterised by a wider range of benthic species including nemerteans (ribbon worms), as well as a range of polychaetes (e.g. *Spiophanes bombyx* and *S. armiger*) and oligochaetes (*T. benedii*). The non-native slipper limpet *Crepidula fornicata* and the UK Biodiversity Action Plan (BAP) protected reef-forming polychaete *Sabellaria spinulosa* have also been recorded in the Thames Estuary (Holt *et al*., 1998; TEBP, 1999; London Array Ltd, 2005).

3.2.2 Medway Estuary

The subtidal environment within the Medway Estuary is composed of sand, shell fragments and mud dominated by species such as the polychaete worms *S. armiger*, *N. hombergii* and *Exogone naidina* and the bivalve *Abra alba* (London Array Ltd, 2005).

3.2.3 Swale Estuary

The Swale Estuary contains subtidal mixed sediments and mud. At the eastern end of the Isle of Sheppey there are extensive beds of the cockle *C. edule*. The oyster *Crassostrea* sp. and the slipper limpet *C. fornicata* are also common in this area (London Array Ltd, 2005).

3.2.4 Outer Thames

The seabed of the Outer Thames (as classified within this report) is predominantly sandy, with shallow sand banks common features within the estuary. The sediments are largely fine and medium sands but with considerable amounts of gravel or shell in the deeper areas, e.g. north and east of the Isle of Sheppey, where much of the coarser material is oyster and other shell material (London Array Ltd, 2005). Mud is also common in places (Figure 7). The sediment becomes more mixed at inshore locations where silt levels are generally increased (GREP, 2002). Although few rocky habitats exist, there are a number of man-made artificial structures and wrecks which provide hard substrate for colonisation.

The subtidal benthic environment in the Outer Thames Estuary is generally dominated by polychaetes, oligochaetes, amphipods and crustaceans which are typical of the benthic environments of this bio-geographic region (ABPmer, 2007; Dong Energy, 2007; GREP, 2002; London Array Ltd, 2005; MALSF, 2009; TEDA, 2010; Vattenfall, 2011). Species richness and diversity across the survey area generally correlates with sediment type with few species and low abundance found within the fine sand or gravelly sand substrates (e.g. off Foulness Point and at Barrow Deep disposal ground) whilst the muddy, gravelly sites (generally located further inshore e.g. between Herne Bay and Kentish Flats) are relatively species rich (GREP, 2002; Vattenfall, 2011). The relatively high turbidity within this area generally restricts plant life to shallow depths.

Benthic species typically observed within this area include nemerteans, polychaetes (*Nephtys* spp., *Magelona johnstoni*, *S. bombyx*), oligochaetes (*Tubificoides*) and the amphipod *Bathyporeia elegans*. Large epifaunal species found to be common within the Outer Thames Estuary include the bivalve A. alba, with higher numbers of bivalves from the genus Venus in fine grained sands. In muddier sediments and at depths of around 5-20 m, the brittle star *Amphiura filiformis* has been found to be more prevalent. Additional epifaunal species that have been observed include the echinoderms *Asterias rubens*, *Ophiura albida* and *O. ophiura*, the heart urchin *Echinocardium cordatum*, and the polychaete worm *Aphrodite aculeata*. Sea spiders, especially *Achelia echinata* and many species of colonial hydroids (e.g. sea fir (*Hydrallmania falcata*) and bryozoans (e.g. the sea mats *Electra monostachys*, *Conopeum reticulum*, *Penetrantia concharum*, *Aspidelectra melolontha*, *Vesicularia spinosa* and *E. pilosa*) are widespread in the area (ABPmer, 2007; Dong Energy, 2007; GREP, 2002; London Array Ltd, 2005; MALSF, 2009; TEDA, 2010; Vattenfall, 2011). The edible cockle *C. edule*, mussels and oysters have also been recorded sporadically throughout the study area. Relatively high abundances of *S. spinulosa* have been observed in the outer estuary around Kentish Flats (GREP, 2002; Vattenfall, 2011).

3.2.5 Crouch and Roach Estuaries

The subtidal habitats of the Crouch and Roach Estuaries are predominantly comprised of muddy sediments. Biotope information for these habitats is available for selected patches of the Crouch and Roach Estuaries with the areas around Wallasea Island and the Outer Roach being relatively well described. The biotope SS.SMu.SMuVS.AphTubi (*Aphelochaeta marioni* (marine bristle worm) and *Tubificoides* spp. (oligochaete) in variable salinity infralittoral mud) has been described in both the Crouch and Roach Estuaries. This biotope is found in stable cohesive muds sometimes with coarse material in both reduced salinity and fully marine conditions. The biotope assemblage SS.SMu.SMuVS.NhomTubi (*N. hombergii* and *Tubificoides* spp. in variable salinity infralittoral soft mud) has also been recorded within these estuaries. Wild oysters *Ostrea edulis* are abundant in the mouth of the Crouch Estuary and these are harvested across a large stretch of the outer Crouch (RSPB, 2008).

The status of the subtidal habitats in the Crouch has been reviewed by Cefas who carried out a series of surveys relating to the distribution of infauna and epifauna following the decline in TBT concentration in the estuary (Waldock *et al*., 1999 and Rees *et al*., 2001). The studies showed that the Crouch supported a moderately diverse faunal assemblage including species such as *O. edulis*, *C. fornicata*, *Carcinus meanas*, *Crangon crangon*, *Pagurus* spp. and *A. rubens*.

3.2.6 Distribution and Abundance in the Vicinity of the Possible Airport Locations

Both airport options located in the marine environment currently under consideration overlap with areas of subtidal habitat. The entire development area of the Outer Thames option is located within the subtidal environment (approximately 5530 ha). Conversely, only a small proportion of the Inner Thames option falls within the subtidal environment (approximately 480 ha).

The subtidal environment which falls within the footprint of the Inner Thames option is primarily comprised of mud and sand. Benthic species which characterise this area include nemertans, a range of polychaetes (*S. bombyx*, *S. armiger* and *Nephtys* sp.) and oligochaetes (*T. benedii*). This subtidal habitat does not fall within the boundary of any nationally or internationally sites.

The subtidal environment which falls within the footprint of the Outer Thames option is predominantly comprised of subtidal sands with areas of mixed and coarse sediment overlapping the eastern area of this option. The sandier sediments are dominated by species characteristic of these habitats such as the amphipod *B. elegans*. The coarse and mixed sediments have invertebrate communities similar to those which occur within the habitat that overlaps the Inner Thames option, including nemerteans, polychaetes and oligochaetes. The Outer Thames option overlaps with a number of internationally and nationally designated sites which have been designated for their subtidal features. These are listed in Table 13 below.

Table 13. Area of overlap of Outer Thames option with designated sites

Designation	Site	Approximate Area of Overlap (ha)	Percentage of Total Designated Site (%)
SPA	Outer Thames Estuary	5527	1
cSAC	Margate and Long Sands	1954	3

3.3 Non-Native Species

There is considered to be a high or very high likelihood of introduction for non-native species to the Thames Estuary and north Kent coast in general (Cefas, 2012). This is due to the high levels of commercial shipping, recreational boating and imports of animals for aquaculture or the seafood trade within the Thames Estuary. Several non-native invasive species have been recorded within the Thames Estuary (ZSL, 2013). These include the following:

- Chinese mitten crab (*Eriocheir sinensis*);
- Zebra mussel (*Dreissena polymorpha*);
- Asiatic clam (*Corbicula fluminea*);
- Slipper limpet (*Crepidula fornicata*);
- Carpet sea squirt (*Didemnum vexillum*); and
- Pacific oyster (*Crassostrea gigas*).

The placement of an airport in the Thames Estuary has the potential to generate an introduction pathway for non-native species. The following section provides a brief overview of each of the non-native species that are already known to occur within the estuary.

3.3.1 Chinese Mitten Crab

This species originates from Asia, but over the past 20 years has become increasingly prevalent in British river systems. British wildlife is affected by the Chinese mitten crab because it is a voracious predator. It also poses a threat to habitats through the burrowing activity of adults, which leads to the erosion of river banks.

3.3.2 Zebra Mussel

The Thames Estuary was invaded by the zebra mussel during the early 18th century and they are still commonly found in high abundances (ZSL, 2013). The major threat to British wildlife is from their sheer abundance. Each female can release up to 1,000,000 eggs, and adults are capable of reaching densities of 10,000 or more per square metre. These high abundances affect other wildlife by using up space for attachment needed by native species, and even colonizing the shells of other species (e.g. native swan mussel) which affects their ability to feed and burrow.

3.3.3 Asiatic Clam

This species was first discovered in Western Europe during the 1980's. They are capable of self-fertilisation and release 2,000 juveniles each per day. The Asiatic clam competes with native mussel species for food and space, but is also responsible for altering benthic substrates upon which other species rely. Furthermore, the Asiatic clam has a greater resilience against pollution, increasing its potential to outcompete the more sensitive species found in the UK. They also foul water intake pipes of power plants and other industrial water systems.

3.3.4 Slipper Limpet

Slipper limpet competes for food and space with other filter-feeding species, and has been known to displace mussel beds (NNSS website). The modern British population is known to have been introduced to Essex between 1887 and 1890 in association with the oyster, *Crassostrea virginica*, which was imported from North America (MarLIN, 2008).

3.3.5 Carpet Sea Squirt

This invasive sea squirt grows in colonies, often in a carpet-like form on the seabed and other substrates. The sea squirt is able to spread rapidly, and become dominant in new environments, thus excluding other benthic organisms and creating a homogenous habitat (Lengyel *et al*., 2009). Fragments from a colony are able to break off and establish in a new location. The colonies may overgrow fish spawning grounds and hinder the ability of fish to feed on benthic species (Bullard *et al*., 2007). Commercially, the carpet sea squirt poses a risk to aquaculture, for example through the colonisation of substrates preventing scallop recruitment (Cefas, 2012).

3.3.6 Pacific Oyster

The Pacific oyster was first introduced from Portugal into the River Blackwater, Essex, in 1926 as a commercial crop and has since established itself in the wild. Pacific oysters themselves attach to almost

any hard surface in sheltered waters. Whilst they usually attach to rocks in their native range, the oysters can also be found in muddy or sandy areas and will also settle on adult specimens of the same or other mollusc species. Impacts on native populations include displacement through competition for food and space; habitat change and hybridization with local oyster species (NOBANIS, 2011).

4. Plankton

This chapter provides an overview of the plankton populations that occur within the study area. Specific data on plankton within the Thames Estuary itself is limited and as such information has been derived from scientific references including Lemaire *et al*. (2002) and Edwards and John (1998) as well as the Greater Thames CHaMP (ABPmer, 2007a) and Kentish Flats Environmental Statement (GREP, 2002).

4.1 Overview

Plankton includes bacteria and small plants (phytoplankton) and animals (zooplankton). Populations within the study area are strongly influenced by the various physical and chemical factors operating within the estuary including the hydrodynamic regime, light availability, turbidity, vertical mixing of water and temperature. Specific data on plankton within the Thames Estuary itself is limited, however, Thames Estuary plankton communities are thought to be characterised by those species which are commonly associated with coastal locations although some oceanic species, such as the arrow worm, *Sagitta setosa*, may occur at certain times of the year via the English Channel. Typical southern North Sea zooplankton include calanoid copepods such as *Temora longicornis*, *Pseudocalanus elongatus* and *Acartia clausi* (Edwards and John, 1998). A study by Lemaire *et al*. (2002) analysed the distribution of photosynthetic pigments throughout the Thames Estuary and discovered the majority of the pigment measured corresponded to diatoms. Diatoms were dominant along the entire salinity transect in the Thames Estuary and were present throughout the year. Other diagnostic pigments included lutein and chlorophyll b, in the upstream part of the estuary, indicating that chlorophytes also constitute part of the estuarine phytoplankton assemblage. However, levels of alloxanthin, peridinin, zeaxanthin, echinenone, myxoxanthophyll and prasinoxanthin were below the detection limits, suggesting that no or very few cryptomonads, dinoflagellates, cyanobacteria and prasinophytes were present in the estuary during the sampling.

Seasonal variations in plankton abundance within the Thames Estuary broadly follow the general pattern seen throughout UK waters, such that greatest abundance occurs during summer months in response to higher sea temperatures and greater light availability. Greatest abundance of phytoplankton occurs between March and July when temperature and light conditions promote the rapid growth of these small plants. Zooplankton graze upon the phytoplankton and increase in abundance in response to the phytoplankton growth. There is a slight lag in the increase of zooplankton numbers such that greatest abundance occurs between April and August. Over autumn there is a gradual decline to low winter levels (GREP, 2002).

Excessive growth or blooms of one type of phytoplankton, *Phaeocystis* have also been recorded within the Thames Estuary and have been related to the retentive nature of the estuary, which prolongs the presence of elevated levels of nutrients. Blooms of this phytoplankton cause foaming at the water surface, which may come ashore. *Phaeocystis* blooms have been noted across the southern North Sea where the waters converge with the English Channel and have been associated with eutrophication in Dutch coastal waters (Edwards and John, 1998).

4.2 Distribution and Abundance in the Vicinity of the Possible Airport Locations

There is limited information available on the distribution of plankton in relation specifically to the possible airport locations located in the marine environment. It is expected that the plankton assemblage will be generally similar for both development options. However, planktonic species more typical of estuarine environments may be expected to occur within the vicinity of the Inner Thames option, with microphytobenthos (which can occur on the surface of sediments in the shallow marine ecosystem) also having the potential to occur. The area in the vicinity of the Outer Thames option would be expected to support planktonic species more typical of fully marine conditions.

5. Fish and Shellfish

The fish and shellfish ecology of the Thames Estuary has been described based on a number of data sources. These data were used to inform the understanding of the relative importance and functionality of the Thames Estuary in the context of the wider southern North Sea. The key data sources reviewed include:

- FishBase (www.fishbase.org): An online database containing data on fish ecology, distribution and biological information.
- Marine Aggregate Regional Environmental Assessment of the Outer Thames Estuary: Summary of the distribution and ecology of fish and shellfish in the southern North Sea and Thames Estuary (ERM, 2010).
- Spawning and nursery grounds of selected fish species in UK waters: During the late 1990s, a collaborative project between the national fisheries laboratories (Cefas and the then Fisheries Research Services, Aberdeen), the UK Offshore Operator's Association (UKOOA), the Scottish Fishermen's Association (SFF) and the National Federation of Fishermen's Organisations (NFFO) produced the Fisheries Sensitivity Maps in British Waters. This report (Coull *et al*., 1998) included maps of the main spawning and nursery grounds for 14 commercially important species (cod, haddock, whiting, saithe, Norway pout, blue whiting, mackerel, herring, sprat, sandeels, plaice, lemon sole, sole and Norway lobster). This data has since been updated by CEFAS based on more recent survey data and additional analyses to complement the original maps (Ellis *et al*., 2012).

Of particular relevance are a number of recent monitoring projects and reviews which have been undertaken specifically in the Thames Estuary area. These data sources include the following:

- Benthic Ecology of the Thames Estuary: Trawl data held by the Port of London Authority (PLA) from between February 2002 and November 2005 from a large number of surveys undertaken in the Thames Estuary (ABPmer, 2007b).
- Outer Thames Estuary Trawl Surveys: Standardisation of beam and otter trawl surveys between April 2003 and August 2008 undertaken as part of aggregate dredging licences, offshore wind farm developments as well as for the Thames Marine Aggregate Regional Environmental Assessment (MAREA) and the Thames Regional Environmental Characterisation (REC) (ERM, 2010).
- Kentish Flats Beam, Otter and Bass Trawl Surveys: Trawl surveys undertaken during pre-construction and post-construction of the Kentish Flats offshore wind farm between 2002 and 2007 (Vattenfall, 2011).

A number of other surveys and scientific studies on fish and shellfish have also been included where appropriate.

5.1 Overview

In summary the Thames Estuary supports a diverse fish fauna with over 100 fish species having been recorded in the estuary over the past 30 years (Potts and Swaby, 1993; London Biodiversity Partnership, 2005; Vattenfall, 2011). Fish species with known spawning and nursery locations within the Thames Estuary include; herring *Clupea harengus*, lemon sole *Microstomus kitt* and Dover sole *Solea solea*, with sandeel *Ammodytes marinus* spawning grounds further offshore. Other species which also utilise the Thames Estuary and coastal habitats for nursery areas are mackerel *Scomber scombrus*, whiting *Merlangius merlangus*, plaice *Pleuronectes platessa*, sprat *Sprattus sprattus* and bass *Dicentrarchus labrax*. The inshore zone of the Thames Estuary is an important commercial fishing ground for sprats *S. sprattus*, plaice *P. platessa*, Dover sole *S. solea* and whiting *M. merlangus*. Diadromous fish which migrate through the estuary include the European eel *Anguilla anguilla,* sea lamprey *Petromyzon maximus*, salmon *Salmo salar*, river lamprey *Lampetra fluviatilis* and the twaite shad *Alosa fallax*. The Thames Estuary is also an important area for many shellfish species, with large beds of cockle *C. edule*, oyster *O. edulis* and mussel *M. edulis* being present throughout the Estuary.

Certain fish species are protected under a range of legislation including the EU Habitats Directive, the Wildlife and Countryside Act 1981 (and amendments) and the Bern Convention, as well as being on OSPAR threatened species list, IUCN red list and BAP priority species/grouped plan list. A summary of legislation protecting species relevant to the Thames Estuary can be seen in Table 14.

Table 14. Summary of UK protection legislation for fish and shellfish species within the Thames Estuary

Group	Species	Conservation Status and Importance
Diadromous fish species	European eel *Anguilla anguilla*	UK BAP, OSPAR listed and on the global red list.
	Salmon *Salmo salar*	UKBAP, Appendix III of Bern Convention; Annexes II, V of the EC Habitats Directive, OSPAR.
	Sea lamprey *Petromyzon marinus* and River lamprey *Lampetra fluviatilis*	Annexes II, V of the EC Habitats Directive, UK BAP, Appendix III of Bern Convention (river lamprey), OSPAR (sea lamprey).
	Shads *Alosa alosa* and *A. fallax*	UK BAP, Appendix III Bern Convention, Annexes II and V EC Habitats Directive, Wildlife and Countryside Act
	Brown/Sea Trout *Salmo trutta*	UK BAP
Pelagic bony fish species	Atlantic herring *Clupea harengus*	UK BAP (grouped plan); of commercial importance
	Bass *Dicentrarchus labrax*	Of commercial importance
	Mackerel *Scomber scombrus*	UK BAP (grouped plan); of commercial importance
	Sprat *Sprattus sprattus*	Of commercial importance
	Smelt *Osmerus eperlanus*	UK BAP
Elasmobranchs species	Spotted ray *Raja montagui*	OSPAR threatened / declining
	Thornback skate/ray *Raja clavata*	OSPAR threatened / declining; of commercial importance
Demersal bony fish species	Atlantic cod *Gadus morhua*	Vulnerable (IUCN red list); OSPAR threatened / declining, UK BAP (grouped); of commercial importance
	Dover Sole *Solea solea*	UK BAP (grouped plan); of commercial importance
	European Plaice *Pleuronectes platessa*	UK BAP (grouped plan); of commercial importance
	Lemon Sole *Microstomus kitt*	Of commercial importance
	Sandeel *Ammodytes* species	UK BAP; of commercial importance
	Whiting *Merlangius merlangus*	UK BAP (grouped plan); of commercial importance
	Short-snouted seahorse *Hippocampus hippocampus* and	UK BAP, Wildlife and Countryside Act

Group	Species	Conservation Status and Importance
	long-snouted seahorse *Hippocampus guttulatus*	

(Source: JNCC, 2011 http://www.jncc.gov.uk/page-3408)

The status of demersal fish, pelagic fish, elasmobranchs, diadromous fish and shellfish within the study area are reviewed in more detail below (Sections 5.2 to 5.6). The review has primarily focused on key species which are of either commercial and/ or conservation importance.

5.2 Demersal Bony Fish Species

Demersal species are bottom-dwelling or mid-water fish that have a close association with the seabed. Frequently recorded demersal species in trawl surveys undertaken between 2002 and 2008 in the Thames Estuary as part of various impact assessment and monitoring studies included gobies *Pomatoschistus* spp., pogge *Agonus cataphractus* and dragonet *Callionymus lyra* (Vattenfall, 2011, ERM, 2010, ABPmer, 2007b). The most commonly recorded commercially important gadoid species during the surveys was whiting *M. merlangus*. Whiting have been found to have patchy abundance in the Thames Estuary in spring, a low abundance in the summer and are most abundant and widely distributed in the winter (ERM, 2010). Other gadoids including poor cod *Trisopterus minutus* were also frequently recorded in the trawl surveys. The commercially important cod *Gadhus morhua* was typically recorded in low numbers during the surveys. Sole *S. solea* were the most abundant flatfish with dab *Limanda limanda* and plaice *P. platessa* also recorded in broadly similar numbers (Vattenfall, 2011, ERM, 2010, ABPmer, 2007b).

A summary of the distribution and ecology of key demersal species in the Thames Estuary is provided in Table 15. This table also provides a summary of the relative abundance of these species within the immediate vicinity of each of the possible airport locations based on previous trawl survey results.

Table 15. Summary of the ecology and distribution key demersal fish species in the Thames Estuary

Species	Ecology in the North Sea and Thames Estuary [1,2,3]	Distribution and Abundance in the Thames Estuary [3,4,5]	Abundance of Species in the Vicinity of the Possible Airport Locations [4,5,6]	
			Inner Estuary	Outer Estuary
Atlantic cod (*Gadus morhua*)	Demersal, from shoreline to 600m depth. Associated with sandy substrate. Feeds on other fish (e.g. herring, capelin, haddock and even other cod). Spawns January to April (peak February/ March) in North Sea. Nursery grounds are found throughout the North Sea. Juveniles aggregate in shallow coastal areas in winter and deeper waters in summer.	Spawning grounds appear to be wide-spread and not restricted to specific areas. In fact, spawning aggregations may be found offshore all over the North Sea (Figures 9 and 10). Cod are found all around the coasts of Britain, the population in the Thames does not constitute a significant proportion of the UK population. The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figure 12.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	Very few individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.
Dab (*Limanda limanda*)	Demersal, mostly shallow coastal waters (10 to 15m). Dab migrates offshore in winter. Feeds on small fish and invertebrates. Dab spawn January to June. Thought to spawn (pelagic eggs) in the wider study area (distribution uncertain). Nurseries are in shallow coastal waters.	One of Britain's most common flatfish, occurring all around the coast. The Thames population does not constitute a significant proportion of the UK population. The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figure 13.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.
Dover sole (*Solea solea*)	Demersal, inhabits sandy and muddy areas in waters down to 150 m depth, with adults tending to occur in deeper waters than juveniles. Spawns in shallow inshore areas, close to sandbanks – February to June (peak April/May) (incl. in wider study area). Main	Sole represent a commercially important target species in the Outer Thames Estuary. The Thames Estuary represents one of the major North Sea spawning grounds and is also a nursery ground (Figure 9 and 11). Discussions with local fishermen have also indicated spawning grounds	Moderate numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.	Moderate numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.

Species	Ecology in the North Sea and Thames Estuary [1,2,3]	Distribution and Abundance in the Thames Estuary [3,4,5]	Abundance of Species in the Vicinity of the Possible Airport Locations [4,5,6]	
			Inner Estuary	Outer Estuary
	nursery grounds in shallow waters of 5 to 10m depth.	in inshore areas in and around an area known as Shipwash, located just off the coast around Felixstowe and Harwich. The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figure 13.		
European plaice (*Pleuronectes platessa*)	Demersal, ranges from 0-200m depth. Primarily found with sandy substrates on gravel, mud and sandy patches in rocky areas in shelf waters. Spawns in shallower parts of southern North Sea, in spring (peak in February) (incl. wider study area). Nursery areas in shallow, sandy bays and estuaries.	The Thames Estuary is known to represent a low intensity plaice nursery ground (Figure 10). The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figure 13.	Moderate numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.	Moderate numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.
Lemon sole (*Microstomus kitt*)	Found on gravelly bottoms from depth of 20m to 200m. Little is known about the spawning habits; it is thought to spawn everywhere it is distributed in deeper waters. Spawn April to September with a peak in spring.	Lemon sole is thought to spawn everywhere it is found. UK distribution predominantly in the southern half of UK. Few recorded in the Thames Estuary. The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figure 13.	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.
Sandeel (*Ammodytes* species)	5 sandeel species exist in the North Sea (lesser sandeel, *A. marinus* most abundant). Found from mid-tide level to shallow sublittoral (30m). Burrows into sandy substrates (incl. sandy gravel) – to 20-50cm depth in winter. Spawns November to February in the central and southern North Sea. Eggs deposited on sandy sediments.	Spawning maps highlight the Thames and much of the southern North Sea being low intensity spawning grounds for sandeel (Figure 9). Sandeel show a close association with sandy substrates into which they burrow and exhibit specific substrate preferences. They favour coarse sand with fine to medium gravel and low silt content, avoiding sediment containing >4% silt	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	Very few individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.

Species	Ecology in the North Sea and Thames Estuary [1,2,3]	Distribution and Abundance in the Thames Estuary [3,4,5]	Abundance of Species in the Vicinity of the Possible Airport Locations [4,5,6]	
			Inner Estuary	Outer Estuary
		(particle size <0.063 mm). The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figure 14.		
Whiting (*Merlangius merlangus*)	Benthopelagic species, ranging from 30-100m (up to 200m). Associated with mud and gravel but also sand and rock. One of the most abundant and widespread species in the North Sea. Spawns January to June, peak April/May (incl. in the wider study area). Juveniles found throughout much of the North Sea.	Whiting are widely distributed off the UK coasts. Thames Estuary forms part of the North Sea nursery ground for this species (Figure 10). The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figure 12.	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.	Moderate numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.
Short-snouted seahorse (*Hippocampus hippocampus*) and long-snouted seahorse (*Hippocampus guttulatus*)	Both species are coastal and found in eel grass beds (spiny seahorse) and rocky/macro algae areas (short-snouted seahorse) in spring and summer, moving to deeper waters in the winter. The breeding period is from April to October.	In the last few years there have been increasing records and reports of short snouted seahorses in the Thames Estuary. Spiny seahorse also thought to be found in the region.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	Single individual of short-snouted seahorse recorded in proximity to the possible airport location.
Derived from: [1] MarLIN website; [2] FishBase; [3] Ellis *et al.* 2012, [4] Vattenfall, 2011, [5] ERM, 2010, [6] ABPmer, 2007b.				

5.3 Pelagic Bony Fish (Osteichthyes) Species

Pelagic species are free-swimming fish that inhabit the mid-water column. They tend to have little association with the seabed and as a result are often distributed over widespread and indistinct grounds, often forming large shoals. Pelagic fish, such as clupeids (herring *C. harengus* and sprats *S. sprattus*) and mackerel *S. scombrus* are important prey resources for seabirds and marine mammals (DECC, 2009).

Of the pelagic species, the largest catches recorded in trawl surveys between 2002 and 2008 in the Thames Estuary, undertaken as part of various impact assessment and monitoring studies, were of herring and sprat (ERM, 2010, ABPmer, 2007b; Vattenfall, 2011). Herring have been found to be most commonly recorded in spring and summer in the Thames Estuary, with only very small catches inshore in winter (ERM, 2010). Overall, there were lower numbers and a decreased distribution of pelagic species compared to demersal species in the trawl surveys, however this is likely to be a function of the type of trawl used in these surveys, which is designed to target benthic fauna. In the Outer Thames Estuary there was a concentration of herring in the south of the Thames Estuary and a patchy distribution of sprat throughout the area (ERM, 2010).

A summary of the distribution and ecology of key pelagic species in the Thames Estuary is provided in Table 16. This table also provides a summary of the relative abundance of these species within the immediate vicinity of each of the possible airport locations based on previous trawl survey results.

Table 16. Summary of the ecology and distribution key pelagic fish species in the Thames Estuary

Species	Ecology in the North Sea and Thames Estuary [1,2,3]	Distribution and Abundance in the Thames Estuary [3,4,5]	Abundance of Species in the Vicinity of the Possible Airport Locations [4,5,6]	
			Inner Estuary	Outer Estuary
Atlantic herring (*Clupea harengus*)	Pelagic (surface to 200m depth), mostly feeds on small shrimps or copepods; also known to filter-feed should the need arise (MarLIN). Spawn in shoals on coarse sand, gravel, shells and small stones in shallow water between 15-40m depth.	Herring represent an important commercial fish species within the Thames Estuary. The 'Thames herring' are recognised as a separate stock to the North Sea. Thames herring are spring spawners. The principal recognised spawning site in the Thames is the Eagle Bank at the mouth of the Blackwater Estuary, although there is historical evidence of limited spawning at Stone (opposite Osea Island) and spawning is also known to take place in Herne Bay. Spawning and nursery grounds can be seen in Figure 10. The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figures 15.	Very few individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.
Bass *(Dicentrarchus labrax)*	Pelagic, shallow estuarine waters (non-spawning) and offshore ((pre)spawning). Feeds on small shoaling fish and wide range of invertebrates. Spawning mainly occurs in the western Channel outside of the wider study area. Migrate through the wider study area / southern North Sea during summer / autumn (to spawning areas).	Bass generally show a southern distribution and are found off the south coast of England and into the southern part of the North Sea, with targeted fisheries for bass occurring in the Thames Estuary. Bass spawn in the English Channel and adjacent regions from February to June. Bass which may appear around the Thames Estuary in the summer spend the winter offshore in the western Channel. Thames population unlikely	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.

Species	Ecology in the North Sea and Thames Estuary [1,2,3]	Distribution and Abundance in the Thames Estuary [3,4,5]	Abundance of Species in the Vicinity of the Possible Airport Locations [4,5,6]	
			Inner Estuary	Outer Estuary
		to be significant proportion of UK population.		
Mackerel (*Scomber scombrus*)	Pelagic, migrates extensively. Can be extremely common and found in huge shoals feeding on small fish and prawns (MarLIN). North Sea resident stock was overfished in 1960s and never recovered. Western stock is now mixing with North Sea stock. Spawn between May and July in the central North Sea at depths of up to 60m, but often above 26m.	There are no spawning grounds in the Thames Estuary although the area is a low intensity nursery ground (Figure 10).	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.
Smelt (*Osmerus eperlanus)*	Generally found in transitional waters; only occasionally occurs in fully marine inshore waters. Move upriver to spawn. During May to August smelt migrate upriver to spawn in freshwater before then returning to mouth of the estuary. Smelt generally adheres to nursery and spawning grounds in transitional waters; it only occasionally occurs in fully marine inshore waters.	The strongest and most permanent stocks seem to be those associated with the larger estuaries (e.g. the Thames), especially where there is a complexity of minor or nearby smaller estuaries. In the Thames smelt ascend from the lower estuary below Gravesend to spawn in the Wandsworth area in March/April (Maitland, 2003). After spawning the adults return to the sea.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.
Sprat (*Sprattus sprattus)*	Pelagic, very common. Shoals in the shallow waters of the southern North Sea. Spawning occurs in coastal waters.	Thames Estuary used as a nursery area and potentially a spawning ground. The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figures 15.	Moderate numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.	Moderate numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.

Derived from: [1] MarLIN website; [2] FishBase; [3] Ellis *et al*. 2012, [4] Vattenfall, 2011, [5] ERM, 2010, [6] ABPmer, 2007b.

5.4 Elasmobranchs

Elasmobranchs are fish which posses a cartilaginous skeleton and include sharks and rays. Thornback rays *Raja clavata* and lesser dogfish *Scyliorhinus canicula* were the most commonly recorded elasmobranchs in trawl surveys in the Thames Estuary between 2002 and 2008 (ERM, 2010, ABPmer, 2007b; Vattenfall, 2011). These species are distributed throughout the area, particularly along the sandbanks, however, few have been sampled within the estuary mouth itself (Vattenfall, 2011, ERM, 2010, ABPmer, 2007b).

The Outer Thames Estuary is considered to be of regional importance for thornback ray. This species is one of the most commercially important skate species in UK waters and in the Thames can account for some 93–100% of the skate catch. Studies of ray movements in the Thames Estuary showed that 96% of rays tagged were recaptured there, suggesting that these rays form distinct sub-populations and exhibit small scale movements. A summary of the distribution and ecology of thornback ray in the Thames Estuary is provided in Table 17. This table also provides a summary of the relative abundance of this species within the immediate vicinity of each of the possible airport locations based on previous trawl survey results.

Table 17. Summary of the ecology and distribution of thornback ray in the Thames Estuary

Species	Ecology in the North Sea and Thames Estuary [1,2,3]	Distribution and Abundance in the Thames Estuary [3,4,5]	Abundance of Species in the Vicinity of the Possible Airport Locations [4,5,6]	
			Inner Estuary	Outer Estuary
Thornback skate/ray (*Raja clavata*)	Demersal; inshore, generally 10-60m depth. Associated with a variety of substrate including mud, sand, shingle and gravel. Feeds on crustacea and small fish. Breeds/lays eggs inshore (likely also in the wider study area), February to September (peak May/June). Juveniles more likely in shallower, coastal waters (used as nursery grounds).	Thornback ray is the most abundant skate (Rajidae) in the south-western North Sea, and the Thames Estuary is a nursery ground for this species (Figure 11). Thornback ray have been recorded in particularly high abundances off the coasts of West Mersea, Isle of Sheppey and Margate. A shift in the distribution of thornback rays inshore in winter has been observed. The spatial distribution of this species based on beam and otter trawl surveys between April 2003 and August 2008 in the Thames Estuary can be seen in Figure 16.	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.
Derived from: [1] MarLIN website; [2] FishBase; [3] Ellis *et al.* 2012, [4] Vattenfall, 2011, [5] ERM, 2010, [6] ABPmer, 2007b.				

5.5 Diadromous Fish Species

Diadromous fish migrate between salt and freshwater and in the Thames Estuary include the salmon *S. salar*, sea trout *S. trutta*, European eel *A. anguilla*, river lamprey *L. fluviatilis,* sea lamprey *P. marinus*, twaite shad *A. fallax* and allis shad *A. alosa*. The only diadromous species sampled in trawl surveys undertaken between 2002 and 2008 in the Thames Estuary was the European eel (Vattenfall, 2011, ERM, 2010, ABPmer, 2007b). The Thames Estuary is considered to be particularly important for the European eel. In their multi-method sampling surveys for estuaries, the Environment Agency have collected numerous records for the species throughout the Upper and Lower Thames Estuary, and the estuary has the second highest density of eels in all surveyed estuaries in the UK (Environment Agency, 2010).

A summary of the distribution and ecology of diadromous fish in the Thames Estuary is provided in Table 18. This table also provides a summary of the relative abundance of these species within the immediate vicinity of each of the possible airport locations based on previous trawl survey results.

Table 18. Summary of the ecology and distribution of diadromous fish in the Thames Estuary

Species	Ecology in the North Sea and Thames Estuary [1,2,3]	Distribution and Abundance in the Thames Estuary [3,4,5]	Abundance of Species in the Vicinity of the Possible Airport Locations [4,5,6]	
			Inner Estuary	Outer Estuary
European eel (*Anguilla anguilla)*	Catadromous species which migrates to marine environment (Sargasso Sea) to spawn. Population has dwindled across Europe (reasons unclear). Larvae drift towards Europe, changing into glass eels and then elvers upon reaching freshwater.	The European eel has long been associated with the River Thames. Monitoring of eels within the River Thames has indicated that very few one year old eels are present and it has been suggested that most eels may spend their first year in the lower estuary.	Small numbers recorded during trawl surveys within (or in close proximity) to the possible airport location.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.
Salmon (*Salmo salar*)	Anadromous species, so migrates to freshwater to spawn, whilst spending most of its life in the marine environment. They spawn in upper reaches of rivers, where they live for one to three years before migrating to sea as smolts. At sea, salmon grow rapidly and after one to three years return to their natal river to spawn.	Salmon are known to migrate through the Thames Estuary. Reintroduced into the River Thames in recent years but population only maintained by periodic stocking.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.
Brown/Sea Trout (*Salmo trutta*)	The life cycle of the migratory sea trout is similar to that of salmon. However, in contrast to the salmon, the majority of sea-trout survives spawning and will return to their natal spawning river on numerous occasions during their life time. Do not appear to undertake the same sea migration but remain in coastal waters, probably close to their natal river.	Status unknown	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.
Sea and River Lamprey *(Petromyzon marinus and Lampetra fluviatilis)*	River lamprey remain in estuaries when not breeding; parasitizes fish (incl. herring, flounder (Maitland,	Have begun to recolonise the catchment areas of the Thames Estuary in recent years.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.

Species	Ecology in the North Sea and Thames Estuary [1,2,3]	Distribution and Abundance in the Thames Estuary [3,4,5]	Abundance of Species in the Vicinity of the Possible Airport Locations [4,5,6]	
			Inner Estuary	Outer Estuary
	2003b)). Sea lamprey is widespread along European Atlantic coasts; precise habitat requirements are unknown.			
Shads (*Alosa alosa* and *A. fallax)*	Very little is known about their distribution at sea. If shad does occur within the wider study area it is likely that they will occur in low abundances whilst passing through the area during migrations to spawning grounds.	Numbers appear to be in decline. JNCC grade both species as having a 'non-significant presence' in the Essex Estuaries SAC.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.	No individuals recorded during trawl surveys within (or in close proximity) to the possible airport location.
Derived from: [1] MarLIN website; [2] FishBase; [3] Ellis *et al*. 2012, [4] Vattenfall, 2011, [5] ERM, 2010, [6] ABPmer, 2007b.				

5.6 Shellfish Species

The Thames Estuary is an important area for many shellfish species, with large beds of cockle *C. edule* and oyster *O. edulis.* The most important cockle-harvesting area in the Thames Estuary is the Maplin Sands (off the Essex coast) and surrounding area. Oysters are widely distributed through the Outer Thames Estuary with major oyster fishing grounds located at Whitstable (Vattenfall, 2011). The Estuary also provides important habitat for other shellfish species including mussel *Mytilus edulis,* whelk *Buccinum undatum*, pink shrimp *Pandalus montagui* and brown shrimp *Crangon crangon*, lobster *Homarus gammarus* and crabs (Vattenfall, 2011; ERM, 2010). Within the Thames Estuary there are currently 12 designated shellfish waters:

- Dengie;
- Upper Roach;
- Roach and Lower Crouch;
- Upper Roach;
- Foulness;
- Outer Thames;
- Southend;
- Sheppey;
- Swalecliffe;
- Margate;
- Swale Central; and
- Swale East.

The location of these designated shellfish waters can be seen in Figure 17.

Limited shellfish species were recorded in fish trawl surveys between 2002 and 2008 in the Thames Estuary as the trawl survey techniques employed were not designed to target these species (Vattenfall, 2011, ERM, 2010, ABPmer, 2007b). However, based on the known distribution of shell fish species in the Thames Estuary both cockle and oyster, along with a variety of other shellfish species, would be expected to occur in the possible airport locations.

6. Marine Mammals

Numerous sources of information have been reviewed to inform the marine mammal baseline description. These include a number of national and regional studies to provide information on marine mammal distribution and ecology. The data was used to inform the understanding of the relative importance and functionality of the Thames Estuary in the context of the wider southern North Sea and eastern English Channel area. The main data sources include:

- Small Cetacean Abundance in the European Atlantic and North Sea programmes (SCANS and SCANS-II): The surveys undertook widespread ship based and aerial surveys of cetaceans in UK and adjacent waters in the summers of 1994 and 2005 (SCANS-II, 2008). The programme provides detailed wide-scale survey data on cetacean abundance, distribution and density in North West European waters.
- Atlas of Cetacean Distribution in North West European Waters: Comprehensive information on cetacean distribution in North West European waters is presented in Reid *et al*. (2003). This report provides a compilation of cetacean sighting records from a variety of systematic surveys

and opportunistic sightings amounting to over 2,500 days of observation carried out since 1973.

- Offshore Energy Strategic Environmental Assessment (SEA): Detailed reviews of marine mammal distribution and ecology in UK waters have been carried out by the Sea Mammal Research Unit (SMRU), University of St. Andrews, as a contribution to the UK Department of Energy and Climate Change (DECC) Offshore Energy Strategic Environmental Assessment (SEA) (DECC, 2009).
- Towards Marine Protected Areas for Cetaceans in Scotland, England and Wales: The Whale and Dolphin Conservation Society (WDCS) undertook a review identifying critical habitat for cetaceans to help highlight potential Marine Protected Areas (MPA's) for cetacean species (Clark *et al.* 2010).
- Special Committee on Seals Annual Report: Information on the status of seals around the UK coast is reported annually by the SMRU-advised Special Committee on Seals (SCOS) (SCOS, 2012).

Of particular relevance are a number of recent monitoring and survey projects which have been undertaken specifically in the Thames area. These data sources include the following:

- Kentish Flats and Kentish Flats Extension Wind Farm monitoring: Boat and aerial based bird surveys undertaken as part of the Kentish Flats Wind Farm development from 2001-2010. During these surveys incidental sightings of marine mammals were also recorded (Vattenfall, 2011).
- Galloper and Greater Gabbard Wind Farm monitoring: Boat based surveys between June 2008 and May 2011 (during which marine mammal observations were also collected) were undertaken at Galloper Offshore Wind Farm (GGOWF). These surveys were completed alongside the Greater Gabbard Wind Farm monitoring. Pre-construction boat-based transect surveys were conducted between June 2008 and May 2009 (construction at the GGOWF actually started in August 2009), with during-construction surveys underway between June 2009 to May 2010 (phase 1) and June 2010 to May 2011 (phase 2) (Galloper Wind Farm Limited, 2011). In addition, pre-consent surveys were undertaken concurrently with boat-based bird surveys between April 2004 and April 2006 to inform the baseline of the Greater Gabbard Wind Farm (Galloper Wind Farm Limited, 2011). Data up to July 2005 was reviewed as part of the EIA for this development (PMSS, 2005).
- London Array Wind Farm monitoring: Boat-based bird surveys were undertaken between October 2002 and June 2004. During these periods mammal observations were also collected (RPS, 2005).
- Thames Strategic Environmental Assessment (SEA) Area aerial surveys (2002-2006): A series of larger scale aerial surveys were undertaken by WWT to cover the Thames Strategic Environmental Assessment (SEA) Area, as part of the Round 2 programme, supported and funded by both the Department of Trade and Industry (DTI, now DECC) and the offshore wind farm developers. These surveys were primarily undertaken to survey marine waterbirds although observations of marine mammals were also recorded (Vattenfall; 2011; RPS, 2006).
- Thames Marine Mammal Sightings Survey (2004-2007): Shore based opportunistic sightings of marine mammals in the Thames compiled by the Zoological Society London (ZSL) (Kowalik *et al.,* 2008).
- Kent Mammal Group Seal Surveys: Pinniped abundances surveys were carried out by the Kent Mammal Group in 2010 at haul out sites on sandbanks in the Greater Thames Estuary and Goodwin Sands area (Bramley, *In Prep*).

- Monitoring of a Colony of Common Seal on the Southend Foreshore: Survey of a haul out site used by common seals at Westcliff Ray, Southend from the 8 September to 5 November 2003 (South Essex Action for Mammals, 2003).
- Common Seal Satellite Telemetry Surveys in the Thames Estuary: Satellite tagging surveys undertaken by ZSL and SMRU in January 2012. In total ten seals were tagged from seal colonies near Southgate and Margate Sands https://www.zsl.org/conservation/regions/uk-europe/thames-estuary/seals-in-the-thames,1586,AR.html.
- Common Seal Satellite Telemetry Surveys in the Thames Estuary: Satellite tagging surveys undertaken by SMRU in February 2006. Nine common seals were tagged from Margate and Long Sands cSAC (Sharples *et al.,* 2008).

A number of other surveys and scientific studies on marine mammals have also been included where appropriate.

6.1 Overview

The cetacean fauna (whales and dolphins) of the southern North Sea is relatively poor, both in terms of the number of animals and diversity of species (Jones *et al.*, 2004). There is a general trend of increasing diversity and abundance of cetaceans with increasing latitude in the southern and central North Sea; a greater number and range of cetaceans are sighted off the coast of northeast England and Scotland than in southern regions (Sea Watch Foundation, 2006a). While over ten species of cetaceans have been recorded in the southern North Sea, only harbour porpoise and white-beaked dolphin can be considered as regularly occurring through much of the year, and minke whale as a frequent seasonal visitor (Sea Watch Foundation, 2006a). The bottlenose dolphin is occasionally observed in the eastern part of the English Channel and Thames Estuary (Sea Watch Foundation, 2006b; Kowalik *et al.,* 2008).

Fin whale, sperm whale, northern bottlenose whale, short-beaked common dolphin, killer whale and long-finned pilot whale can be considered uncommon visitors in the southern North Sea and eastern English Channel (Reid *et al.,* 2003; DECC, 2009).

With regard to Pinnipeds (seals), both grey and common seals breed at haul out sites along the Norfolk coast, Kent coast and Thames Estuary and are regularly recorded foraging in the southern North Sea and Thames Estuary (SCOS, 2012; Kowalik *et al.,* 2008).

All cetaceans are protected under Schedule 5 of the Wildlife and Countryside Act 1981 (and amendments), under which it is an offence to take, injure or kill these species. Disturbance in their place of rest, shelter or protection is also prohibited. All species of cetacean are also protected under the EU Habitats Directive, in Annex II and IV and the Bern Convention. In addition, harbour porpoise are listed as an OSPAR threatened species and in Appendix II of the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals).

Pinnipeds are protected under the Conservation of Seals Act 1970 (England, Scotland, Wales). Grey and common seals are also listed in Annex II of the EU Habitats Directive and protected from disturbance both inside and outside the designated sites. The grey seal is also listed as an Appendix III species under the Bern Convention (1979), which prohibits their deliberate disturbance, capture or killing and the disturbance of their breeding grounds.

The baseline review has focused on common and grey seals along with the four most commonly occurring cetaceans (harbour porpoise, white-beaked dolphin, bottlenose dolphin and minke whale).

The subsequent sections provide information on the distribution, abundance and ecology of each of these species.

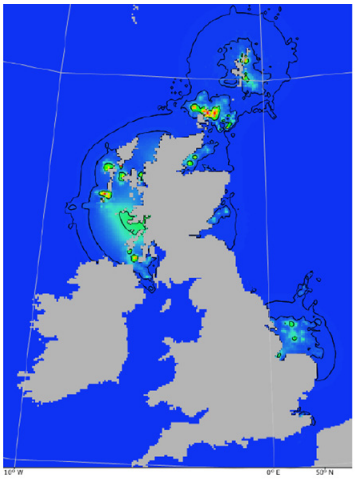
6.2 Common Seal (*Phoca vitulina*)

The common seal (also known as harbour seal) is the smaller of the two native UK seals measuring up to approximately 1.85 m in length. Britain is home to approximately 30% of the population of the European sub-species of common seal (having declined from approximately 40% in 2002). Scotland holds approximately 71% of the UK and Ireland common seal population (SCOS, 2012). On the east coast of England, their distribution is more restricted with concentrations in the major estuaries of the Thames, The Wash, Firth of Tay and the Moray Firth. In the North Sea, common seals are typically found hauling out on sandbanks (SCOS, 2012).

6.2.1 Distribution and Abundance in the Southern North Sea

Approximately half of the east coast population of common seals is recorded in The Wash Blakeney Point has the second largest English colony of common seal, followed by Donna Nook (outer Humber). Colonies are also present at Scroby Sands east of Great Yarmouth and in the greater Thames area (DECC, 2009). The extensive intertidal mud and sandflats of The Wash and the north Norfolk coast provide ideal breeding and haul-out sites. Females haul out onto the intertidal sand and mudflats to give birth and suckle pups between June and July (Jones *et al.,* 2004). Hall *et al.* (1998) found that the diet of common seals found around The Wash primarily consisted of gadoids such as whiting, flatfish such as sole and dab, dragonet and sand goby. Overall, the combined count for the east coast population (Donna Nook-Scroby Sands) in 2010 was 5% higher than the 2009 count which was 21% higher than the 2008 count. The 2010 total count was close to the pre epidemic count in 2002 (epidemic caused by the *phocine distemper* virus in 1988 and 2002). Current population estimates for the main seal colonies found off the Norfolk coast are as follows: 391 at Blakeney Point, 3,086 in The Wash, and 201 at Scroby Sands (SCOS, 2012).

Models of marine usage by harbour seals in the southern North Sea show a large area of fairly diffused activity extending from The Wash, with the greatest activity offshore of the Humber (Image 1).



(Source: Sharples *et al.*, 2008)
Warmer colours show areas of higher usage, contours show log-transformed usage to reveal detail in areas used less frequently

Image 1. The estimated usage of the marine environment by the common seal population

6.2.2 Distribution and Abundance in the Thames Estuary

A number of surveys have analysed common seal populations in the Thames Estuary. These are described below in geographical order, describing numbers observed in the Outer Thames first progressing towards those observed in the Inner Thames.

Satellite tagging of nine common seals in February 2006 by ZSL/SMRU and ten common seals in January 2012 by SMRU from haul out sites in the Thames Estuary showed that common seals travel widely throughout the Thames with high usage recorded (Figure 17). Common seals are not believed to travel as far as grey seals, usually staying closer to haul out sites (typically within 40-60km) (SCOS, 2012). However, one of the tagged animals travelled into the English Channel, hauling-out near Saint-Valery-sur-Somme in France and foraged and hauled out in The Wash, more than 660km between the southern and northern extent of its movements (Sharples *et al*., 2008).

During the aerial surveys undertaken as part of the offshore energy SEA an estimated 137 common seals were identified between 2002 and 2006. In addition, 475 unidentified seals were recorded (RPS, 2006). Figure 18 provides an overview of seal distribution as recorded during the 2004 to 2006 aerial surveys (Vattenfall, 2011). The results of recent wind farm monitoring indicates that seals are regularly observed but typically in low numbers (Table 19).

Table 19. Total number of common seal sightings and maximum encounter rates recorded from wind farm monitoring programmes in the Outer Thames

Survey	Total Number of Sightings	Encounter Rate (number per km)
Galloper and Greater Gabbard Wind Farm monitoring (2008-2011)	3	Maximum encounter rate- 0.02
Greater Gabbard Wind Farm monitoring (2004-2005)	2	Average encounter rate 0.002*
London Array Wind farm monitoring (2002-2004)	40	Average encounter rate 0.021
Kentish Flats and the Kentish Flats Extension monitoring (2002-2010)	37	Not specified
* Combined density estimate for common and grey seal		

(Source: RPS, 2005; PMSS, 2005 Galloper Wind Farm Limited, 2011; Vattenfall, 2011)

Common seal are found hauled out on a number of sandbanks within the Thames Estuary. Numbers of common seal hauled out on sandbanks during an aerial survey carried out over three days in August 2010 in the Greater Thames Estuary and Goodwin Sands area undertaken by the Kent Mammal Group and SMRU can be seen in Table 20 and Figure 19[1]. Approximately 233 common seal were recorded with the largest numbers hauling out on sandbanks in the River Stour, West Barrow and Buxley Sand.

Table 20. Common seals recorded in the 2010 pinniped survey of the Greater Thames Estuary and Goodwin Sands Area

Sandbank	Common Seals Recorded
Foulness Sand	23
Horse Sand	4
River Stour	47
Goodwin Sands	1
Margate Sand	15
Last	2
Ridge	24

[1] Results represent minimum numbers of seals, on some occasions sea mist prevented accurate recordings of every animal, where for example it is written 50+ that is the minimum number of animals seen. (J. Bramley, Pers Comm.)

Margate Hook	6
West barrow	39+
South West Sunk	1
Middle Sunk	3
Sunk Sand	2
Buxley Sand	36+
Long Sand	10
Shingles Patch	17
Shingles	3
Total	233+

(Source: Vattenfall; 2011)

Common seals also haul out further upstream in the Thames Estuary on Westcliff Ray sandbank near the Southend foreshore (Figure 20). During a survey undertaken between 8 September to 5 November 2003 seals were observed on the sandbank and in the adjacent channel in 50 out of 58 daily surveys with a maximum and average daily count of 29 and 7 seals respectively during the monitoring period (South Essex Action for Mammals, 2003).

The Thames Marine Mammal Sightings Survey 2004-2007 (Kowalik *et al.,* 2008) recorded 74 sightings of common seal (representing 21% of sightings). In total 169 animals were recorded of which 76 were adults, 31 were juveniles, 13 were calves and 49 of unknown age. The sightings ranged from Benfleet and Southend Marshes, Southend-on-Sea and Canvey Island in the outer estuary to the Isle of Dogs, and upstream to Richmond Bridge (Figure 20).

6.2.3 Distribution and Abundance in the Vicinity of the Possible Airport Locations

The two possible airport locations currently being considered are both in relatively close proximity to sandbanks which common seals are known to use as haul out sites. These include the Ridge, West Barrow, Westcliff Ray and Margate Sands and are located approximately 2-10km away. In addition, sightings and monitoring data suggests common seals are regularly recorded foraging widely throughout the Thames Estuary (Sharples *et al*., 2008; Kowalik *et al.,* 2008; Vattenfall, 2011 South Essex Action for Mammals, 2003) and would therefore be expected to occur relatively frequently in low numbers in the vicinity of both of the possible development sites.

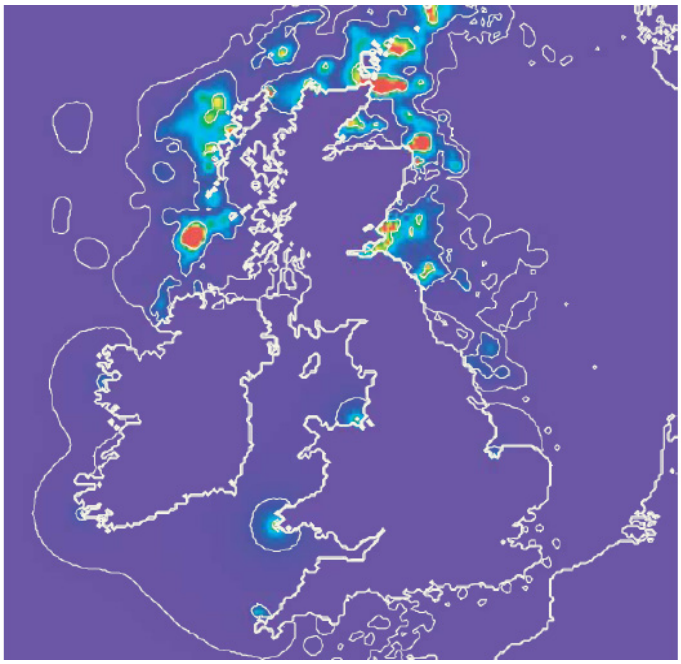
6.3 Grey Seal (*Halichoerus grypus*)

The grey seal is the larger of the two seal species found in British waters, with males reaching a length of 2.45 m and weight of over 300kg (SCOS, 2012). Grey seals predominantly inhabit remote islands and coastline, breeding on undisturbed beaches of cobble and boulders or within sea-caves along the coast. Pupping time occurs primarily from August through to December with September generally being the busiest month. About 38% of the world population of grey seals is found in Britain and over 88% of British grey seals breed in Scotland, the majority in the Hebrides and in Orkney (SCOS, 2012).

6.3.1 Distribution and Abundance in the Southern North Sea

The main grey seal colonies in the southern part of the North Sea area are at Donna Nook, Blakeney Point and at Horsey. Pup production at these sites was 2,566 in 2010 (a 14.4% increase on the 2009). The overall exponential growth in pup production in the North Sea is in part due to the expansion of colonies in East Anglia (SCOS, 2012).

Prime and Hammond (1990) investigated the diet of grey seals found at Donna Nook, Lincolnshire and identified that sandeels, cod and Dover sole accounted for over half the fish consumed. Dab, flounder and plaice were also consumed. Tracking of individual seals has shown that they can feed up to several hundred kilometres offshore although most foraging probably occurs within 100 km of a haul-out site (SCOS, 2012). A range of studies have shown that grey seals can undertake long distance travel between different haul-out sites but foraging trips are generally much smaller. McConnell *et al.* (1999) investigated the movements of North Sea grey seals using satellite tagging. Seal movements were broadly split into two geographical scales: long and distant travel (up to 2,100km away) and local, repeated trips from haul-out sites to discrete offshore foraging areas. For example, one seal was observed travelling 265 to 400 km on three separate occasions. In general however, most tagged seals stayed close to the coast (mean maximum extent of 39.8 km for a foraging trip) with an average of 43% of a seal's time spent within 10 km of a haul-out site. In 88% of trips to sea, individual seals returned to the same haul-out site from which they departed. The durations of these trips were short (mean 2.33 days). Models of marine usage by grey seals show a generally low density of activity in the southern North Sea, with greatest activity within The Wash and off Flamborough Head (Image 2).



(Source: Matthiopoulos *et al.*, 2004)
Warmer colours show areas of higher usage, contours show log-transformed usage to reveal detail in areas used less frequently.

Image 2. The estimated usage of the marine environment by the grey seal population

6.3.2 Distribution and Abundance in the Thames Estuary

A number of surveys have analysed grey seal populations in the Thames Estuary. These are described below in geographical order, describing numbers observed in the Outer Thames first progressing towards those observed in the Inner Thames.

During the aerial surveys undertaken as part of the offshore energy SEA, four grey seals were identified between 2002 and 2006. In addition, 475 unidentified seals were recorded (RPS, 2006). Figure 19 provides an overview of seal distribution as recorded during the 2004 to 2006 aerial surveys (Vattenfall, 2011). Low numbers of grey seals have also been recorded in recent boat -based windfarm surveys (Table 21).

Table 21. Total number of grey seal sightings and encounter rates recorded from wind farm monitoring programmes in the Outer Thames

Survey	Total Number of Sightings	Encounter Rate (km)
Galloper and Greater Gabbard Wind Farm monitoring (2008-2011)	6	Maximum encounter rate 0.035
Greater Gabbard Wind Farm monitoring (2004-2005)	6	Average encounter rate- 0.002*
London Array Wind farm monitoring (2002 to 2004)	32	Average encounter rate- 0.0217
Kentish Flats and the Kentish Flats Extension monitoring (2002-2010)	0	N/A
* Combined density estimate for common and grey seal		

(Source: RPS, 2005; PMSS, 2005 Galloper Wind Farm Limited, 2011; Vattenfall, 2011)

The Goodwin Sands complex is the main grey seal haul out in the region (Bramley and Lewis, 2004). Numbers of grey seal hauled out on sandbanks during an aerial survey carried out over three days in August 2010 in the Greater Thames Estuary area undertaken by the Kent Mammal Group can be seen in Figure 18[2]. Grey seals were only sighted at Goodwin Sands with over 70 recorded hauling out.

The Thames Marine Mammal Sightings Survey 2004-2007 (Kowalik *et al*., 2008) recorded 74 sightings of grey seal (representing 21% of sightings). Of the 86 animals observed 46 were classified as adults, 4 as juveniles, 1 calf and 35 of unknown age. Sightings ranged from the Isle of Grain and Blyth Sands in the outer estuary to the Isle of Dogs and upstream as far as Teddington Lock (Figure 22).

6.3.3 Distribution and Abundance in the Vicinity of the Possible Airport Locations

Goodwin Sands, the main grey seal haul out site, is located over 30 km from the nearest marine option site (Outer Estuary). However, sightings and monitoring data suggests grey seals are regularly recorded foraging widely throughout the Thames Estuary in low numbers (Kowalik *et al.,* 2008; Vattenfall, 2011) and would therefore be expected to occur occasionally in the vicinity of both of the possible development sites.

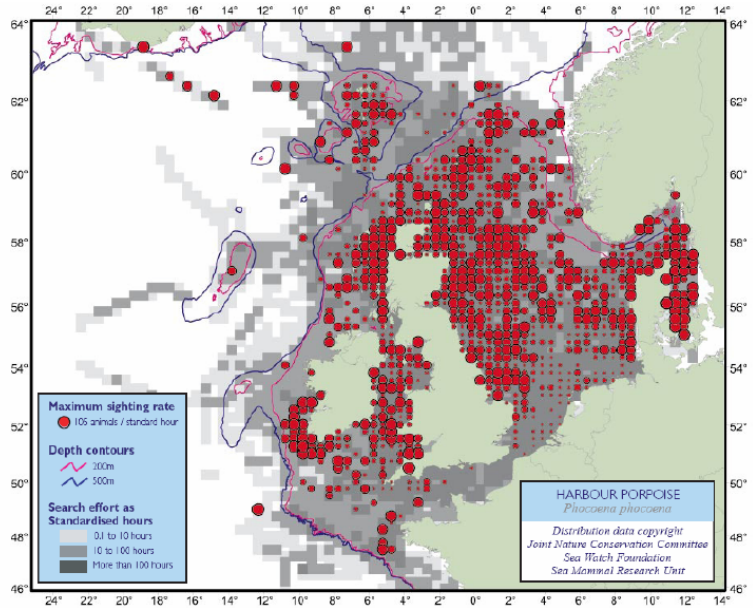
6.4 Harbour Porpoise (*Phocoena phocoena*)

Harbour porpoise distribution is restricted to temperate and sub-arctic (primarily 5-14ºC) seas of the Northern Hemisphere. The harbour porpoise is the most commonly recorded cetacean in UK waters, primarily occurring on the continental shelf (DECC, 2009). In coastal waters, they are often encountered close to islands and headlands with strong tidal currents (Pierpoint, 2008; Marubini *et al.,* 2009 and DECC, 2009). The seasonal pattern in the southern North Sea appears to be for an early spring peak in numbers in coastal waters, followed by a northward migration towards more offshore waters. Harbour porpoise forage on a range of species including sandeels, gadoids such as whiting and clupeids (herring and sprats) (Santos *et al.,* 2004; MacLeod *et al.,* 2007; Pierpoint, 2008).

6.4.1 Distribution and Abundance in the Southern North Sea

Harbour porpoise are distributed relatively widely in the southern North Sea (Image 3). The estimated abundance of harbour porpoise in the 2005 SMRU survey was 40,927 animals with a density of 0.331 animals/km^2 for the southern North Sea (DECC, 2009).

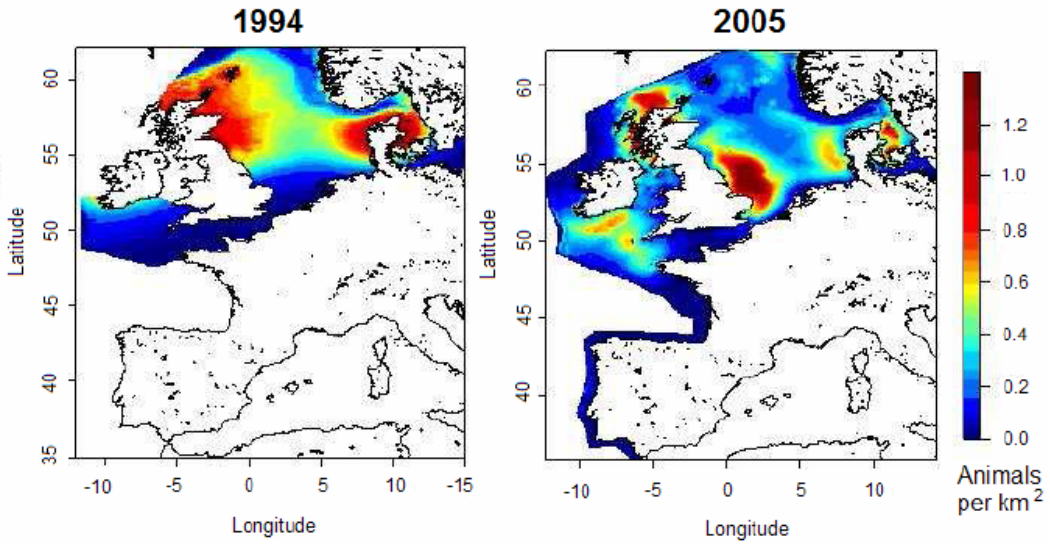
[2] Results represent minimum numbers of seals, on some occasions sea mist prevented accurate recordings of every animal, where for example it is written 70+ that is the minimum number of animals seen. (J. Bramley, Pers Comm.)



(Source: Reid *et al.,* 2003)

Image 3. Sighting rates of harbour porpoise

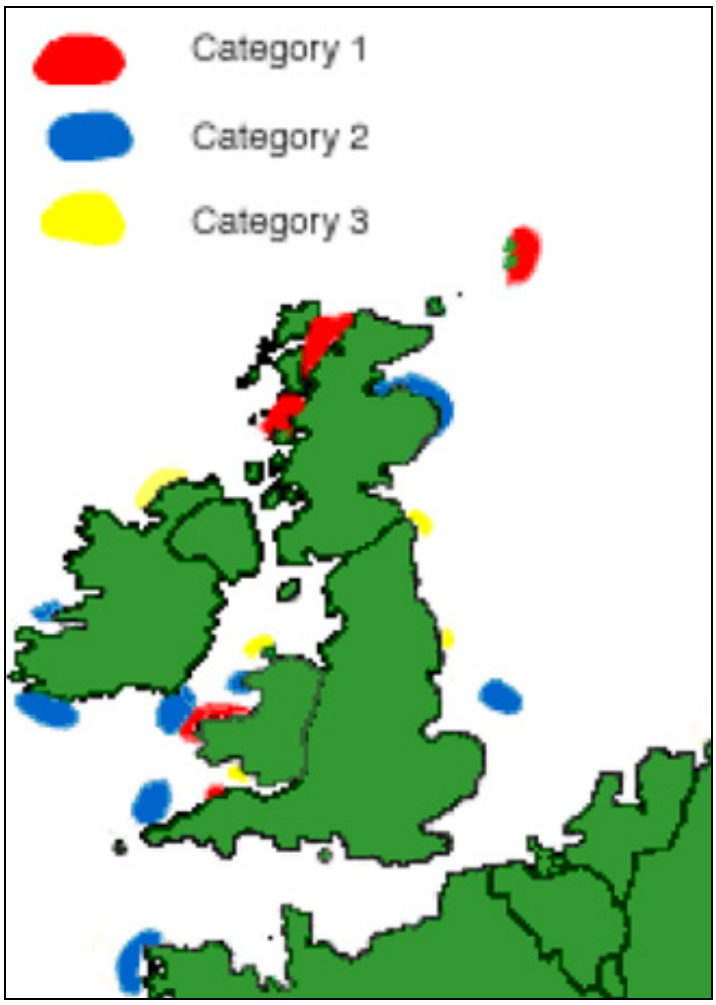
Density surface modelling of harbour porpoise from the SCANS project in 1994 suggested high densities of animals north of Scotland and in the western central and northern North Sea. Repeat surveys for SCANS-II in 2005 showed considerable differences in distribution (DECC, 2009). In summer 2005, harbour porpoise were observed in high densities throughout much of the UK southern North Sea, an area from which they were largely absent in the 1994 SCANS survey (Image 4). Within the southern North Sea, harbour porpoises were most frequently sighted in the north and west (including offshore from the north Norfolk coast, in The Wash and off Lincolnshire coasts) (SMRU, 2008). Many sandbanks exist in this area which are important habitat for sandeel and other prey species utilised by harbour porpoises (Clark *et al.,* 2010).



(Source: DECC, 2009)

Image 4. Modelled density of harbour porpoise in 1994 SCANS and 2005 SCANS II surveys

Evans and Wang (2008) used spatial modelling to identify areas where greater than average numbers of porpoises are regularly present during April-September; this identified only one area in the southern North Sea, located north-east of The Wash (Image 5). Clark *et al.* (2010) undertook a scientific review to identify critical habitats for cetaceans. No areas of the southern North Sea were identified as critical habitat for porpoises. However, the study acknowledged that large-scale surveys such as SCANS provide no information on the relative importance of habitats at a fine scale and that a greater number of smaller scale surveys may be necessary to determine if some areas remain important to harbour porpoises.



(Source: Evans and Wang, 2008)

Image 5. Map showing primary harbour porpoise areas around the UK

6.4.2 Distribution and Abundance in the Thames Estuary

Harbour porpoise were found to be the most abundant cetacean and indeed the most common marine mammal recorded during the aerial surveys undertaken as part of the offshore energy SEA between 2002 and 2006, with 952 records, representing an estimated 1,121 porpoises. Recordings from the aerial surveys obtained unadjusted numbers of porpoises of up to 0.9 animals/km^2 (RPS Energy, 2006). Figure 23 provides an overview of harbour porpoise distribution as recorded during the 2004 to 2006 aerial surveys (Vattenfall, 2011). Harbour porpoise densities were highest offshore in the Outer Thames Estuary and North Sea. Boat based surveys at wind farms further offshore in the Outer Thames (such as Galloper, Great Gabbard and London Array) have also generally recorded higher abundances than at Kentish Flats, further inshore (Tables 22 and 23).

Table 22. Summary of the results from boat-based surveys undertaken for wind farm monitoring in the Outer Thames

Survey	Summary of Results
Galloper and Greater Gabbard Wind Farm monitoring (2008-2011)	Harbour porpoise recorded frequently (although generally in low numbers) throughout the majority of the year, with a peak in sightings during the spring (Galloper Wind Farm Limited, 2011). In total 568 harbour porpoise were recorded with a maximum encounter rate of 0.9 animals/km^2.
Greater Gabbard Wind Farm monitoring (2004-2005)	During the Greater Gabbard baseline surveys (April 2004 to July 2005) a total of 166 harbour porpoise were recorded with an average encounter rate of 0.04 harbour porpoise per km^2 (PMSS, 2005).
London Array Wind farm monitoring (2002 to 2004)	The monitoring recorded for harbour porpoise in 2002 (transect length of 561km), 15 in 2003 (transect length of 1426km) and 76 in 2004 (1323km). The overall encounter rate for boat based surveys was 0.04 porpoise per km (RPS, 2005).
Kentish Flats and the Kentish Flats Extension monitoring (2002-2010)	During the boat based ornithological surveys the only cetacean recorded was the harbour porpoise (with between 0 and seven porpoises annually) (Table 24).

(Source: RPS, 2005; PMSS, 2005 Galloper Wind Farm Limited, 2011; Vattenfall, 2011)

Table 23. Abundance of harbour porpoise from boat-based surveys at the Kentish Flats

Year	Harbour Porpoise	Number of Surveys Undertaken Per Year
2002	0	2
2003	2	19
2004	2	16
2005	2	17
2006	7	16
2007	1	16
2010	0	7
Total	14	93

(Source: Vattenfall, 2011)

The Thames Marine Mammal Sightings Survey 2004-2007 (Kowalik *et al.*, 2008) recorded 88 sightings of harbour porpoise (the most commonly recorded species representing 26% of sightings). The number of porpoise for each sighting ranged from 1-15 with a total of 184 animals recorded. The sightings ranged from the outer estuary at Benfleet and Southend Marshes, Southend-on-Sea to the Isle of Dogs and upstream to Kew Bridge (Figure 24).

6.4.3 Distribution and Abundance in the Vicinity of the Possible Airport Locations

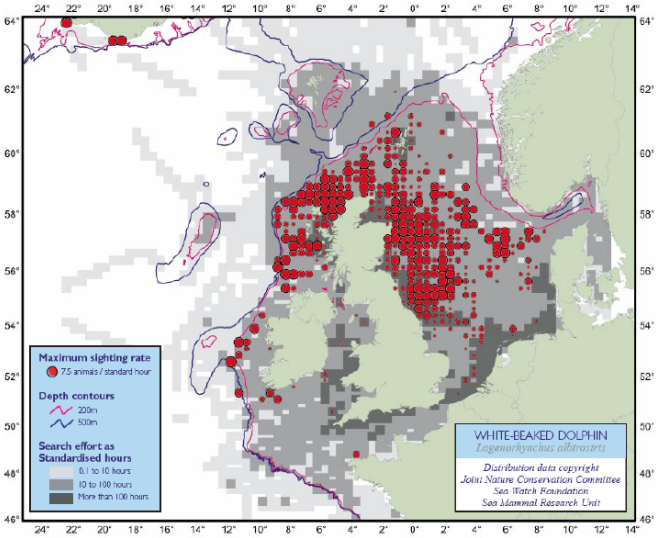
Sightings and monitoring data suggest that harbour porpoise have been regularly observed throughout the Thames Estuary with the highest densities generally found in the Outer Thames Estuary (Vattenfall, 2011; Galloper Wind Farm Limited, 2011; Kowalik *et al.*, 2008; RPS, 2005; RPS, 2006; PMSS, 2005). Harbour porpoise would therefore be expected to occur relatively frequently in the vicinity of both of the possible airport locations.

6.5 White-beaked Dolphin (*Lagenorhynchus albirostris*)

White-beaked dolphins are found over a large part of the northern European continental shelf, favouring colder northern shelf waters, less than 200m deep (Clark *et al.,* 2010). Analysis of summer sightings on shelf waters around the UK from 1983-1998 showed the vast majority of white-beaked dolphins to occur in waters below 13°C in temperature (DECC, 2009).

6.5.1 Distribution and Abundance in the Southern North Sea

The distribution of white-beaked dolphins is generally restricted to the northern half of UK waters, with sightings rare below 54°N in the North Sea (Image 6). Very few sightings of white-beaked dolphins were recorded along the east coast of England south of the Humber in the 2005 SCANS II surveys with a limited number of offshore sightings in the shallower parts of the North Norfolk Sandbanks and Dogger Bank (DECC, 2009). Marine mammal monitoring in the Galloper Wind Farm study area between 2008-2010 recorded a single sighting of a pod of four white-beaked dolphins in June 2009.



(Source: Reid *et al.*, 2003)

Image 6. Sighting rates of white-beaked dolphins

6.5.2 Distribution and Abundance in the Thames Estuary

Four white-beaked dolphin were recorded in the Galloper and Greater Gabbard Wind Farm monitoring studies in June 2009 (Galloper Wind Farm Limited, 2011). No white-beaked dolphin sightings have been recorded in any of the other windfarm monitoring surveys or from the data compiled in the Thames Marine Mammal Sightings Survey 2004-2007 (Vattenfall, 2011; Kowalik *et al.*, 2008; RPS, 2005; RPS, 2006; PMSS, 2005). The species is therefore only likely to occur very rarely in the Thames Estuary.

6.5.3 Distribution and Abundance in the Vicinity of the Possible Airport Locations

Sightings and monitoring data suggest that white-beaked dolphins are not typically observed in the Thames Estuary (Vattenfall, 2011; Galloper Wind Farm Limited, 2011; Kowalik *et al*., 2008; RPS, 2005; RPS, 2006; PMSS, 2005) and so would therefore not be expected to occur in the vicinity of either of the possible airport locations.

6.6 Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin in the North Atlantic appears to consist of two forms, coastal and offshore. The coastal form is locally common in the Irish Sea (particularly Cardigan Bay), English Channel and off North East Scotland (particularly the inner Moray Firth), and in smaller numbers in the Hebrides (West Scotland). Little is known about the offshore form of bottlenose dolphin, including the relationship

between the offshore and coastal forms (Clark *et al*., 2010). More detailed studies in the North West Atlantic suggest that inshore and offshore populations are ecologically and genetically discrete (Hoelzel *et al.,* 1998).

Based on the current understanding of near-shore bottlenose dolphin population and community structure the ASCOBANS / HELCOM small cetacean population structure workshop advised that the following populations are each proposed as separate management units (although it is quite possible that some areas have overlapping communities with different movement patterns) (Evans and Teilmann, 2009):

i. NS-North Sea (Eastern Scotland from Caithness to the borders with England);
ii. OH-Outer Hebrides (Island of Barra);
iii. IH-Inner Hebrides;
iv. IS-Irish Sea;
v. SHE-Shannon Estuary;
vi. WEI-Western Ireland;
vii. SE-Southern England;
viii. NF- North France (Channel Islands and Normandy coast);
ix. BR-Brittany coast and islands (West France);
x. SGA-Southern Galicia; and
xi. SAE-Sado Estuary (Portugal).

6.6.1 Distribution and Abundance in the Southern North Sea

The bottlenose dolphin is typically recorded annually as a seasonal visitor to the southern North Sea with the nearest known population found ranging along the south-west of England and English Channel (Sea Watch Foundation, 2006a; Sea Watch Foundation, 2006b Clark *et al*., 2010). This small population of bottlenose dolphin is documented to be wide-ranging but has generally been resident to the coast of South West and South of England since the early 1990s (Clark *et al*., 2010; Marine Connection & The Wildlife Trusts, 2007). Comparisons of images of recognisable individuals have shown no evidence for interchange between bottlenose dolphins between the southern coasts (Normandy and the Channel Islands) and the northern coasts of the English Channel (South coast of England) (Liret *et al*., 2006; Evans and Teilmann, 2009).

6.6.2 Distribution and Abundance in the Thames Estuary

The Thames Marine Mammal Sightings Survey 2004-2007 (Kowalik *et al*., 2008) recorded 28 sightings of bottlenose dolphin (representing 8% of total sightings). The maximum pod size reported was of approximately ten animals. Out of 54 animals sighted, 24 were adults, 7 were juveniles, 2 were calves and 21 of unknown age. Sightings ranged from the area between Hammersmith Bridge and Putney Bridge and Shoeburyness (Figure 25). The bottlenose dolphin was also identified during recent boat and aerial monitoring surveys in the Thames Estuary. Four sightings occurred during an aerial survey while only one possible sighting occurred during the boat survey, all in the vicinity of the London Array wind farm (RPS, 2005; RPS, 2006).

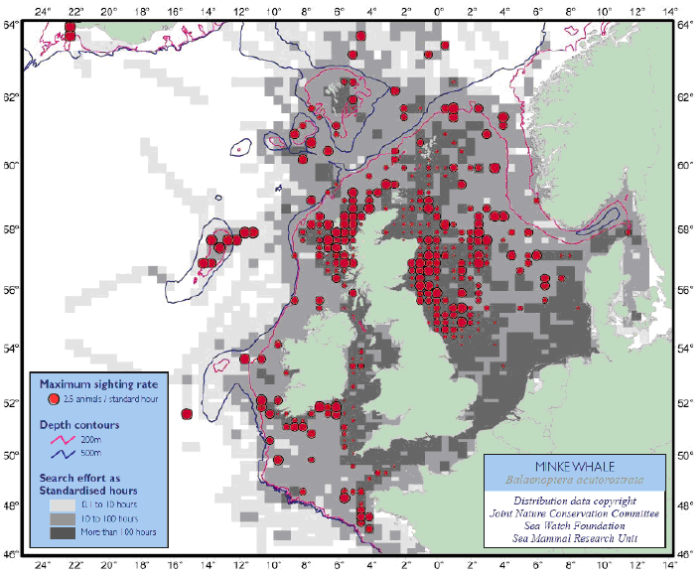
6.6.3 Distribution and Abundance in the Vicinity of the Possible Airport Locations

Sightings and monitoring data suggest that bottlenose dolphin are infrequently recorded in the Thames Estuary (Vattenfall, 2011; Galloper Wind Farm Limited, 2011; Kowalik *et al*., 2008; RPS, 2005; RPS,

2006; PMSS, 2005) and so would therefore be expected to occur sporadically in the vicinity of both of the possible airport locations.

6.7 Minke Whale (*Balaenoptera acutorostrata*)

Minke whales are the smallest and most abundant of the baleen whales encountered around the UK coast. They appear to favour areas of upwelling or strong tidal currents and are usually seen singly or in pairs but sometimes aggregate in greater numbers in areas of rich feeding (Reid *et al.,* 2003). Within UK waters, minke whales are most frequently sighted in the western central-northern North Sea, and west of Scotland around the Hebrides (Image 7).



(Source: Reid *et al.,* 2003)

Image 7. Sighting rates of minke whales

6.7.1 Distribution and Abundance in the Southern North Sea

Minke whales are present in very low numbers in the southern-most North Sea (DECC, 2009). An estimated abundance of 1,202 minke whales was recorded in the Southern North Sea and Channel in the SCANS II surveys (SMRU, 2008).

6.7.2 Distribution and Abundance in the Thames Estuary

No minke whale sightings were recorded in any of the windfarm monitoring surveys or from the data compiled in the Thames Marine Mammal Sightings Survey 2004-2007 (Vattenfall, 2011; Galloper Wind Farm Limited, 2011; Kowalik *et al*., 2008; RPS, 2005; PMSS, 2005; RPS, 2006;). The species is therefore only likely to occur very rarely in the Thames Estuary.

6.7.3 Distribution and Abundance in the Vicinity of the Possible Airport Locations

Sightings and monitoring data suggest that minke whale are not typically observed in the Thames Estuary (Vattenfall, 2011; Galloper Wind Farm Limited, 2011; Kowalik *et al*., 2008; RPS, 2005; RPS, 2006; PMSS, 2005) and so therefore would not be expected to occur in the vicinity of either of the possible airport locations.

7. Seabirds

A large number of information sources have been reviewed to inform the seabird baseline description. These include a number of national and regional studies to provide background information on seabird distribution and ecology. These data sources include:

- Wetland Bird Survey (WeBS) data: Inshore counts of some seabirds for the Thames Estuary are described in the most recent Wetland Bird Survey (WeBS) report[3] such as gulls, terns and divers (Holt *et al.,* 2012). However, as WeBS counts are land based, offshore aggregations of seabirds are not captured during these surveys.
- European Seabirds at Sea (ESAS): The most comprehensive information on seabird distributions at sea comes from the European Seabirds at Sea (ESAS) database. This is a collaborative dataset with inputs from the JNCC, and other north western European organisations. The dataset was established in 1991 with the aim of collating data on the distribution of seabirds in north-west European offshore areas. Much of the information for this database comes from a series of boat and aerial surveys carried out from 1979-2002 in the marine environment in the north-east Atlantic by the JNCC Seabirds at Sea Team (SAST). This data is available via the OBIS (Ocean Biogeographic Information System - Spatial Ecological Analysis of Megavertebrate Populations) Seamap website (www.seamap.env.duke.edu).
- Birdlife International seabird database: BirdLife International (2012) provides information on seabird ecology and behaviour.
- Foraging ranges data: The foraging ranges of 25 species of UK seabirds have been prepared jointly by BTO, RSPB and Birdlife International (Thaxter *et al*., 2012).

Of particular relevance are a number of recent monitoring and survey projects which have been undertaken specifically in the Thames Estuary area. These data sources include the following:

- The numbers of inshore waterbirds using the Greater Thames during the non-breeding season; an assessment of the area's potential for qualification as a marine SPA: The report reviewed data collected from a large number of aerial surveys conducted in the Greater Thames. Aerial surveys of the Greater Thames were carried out over a total of 58 days over eight winter seasons between 1988/89 and 2006/07. The surveys were carried out by the Nature Conservancy Council (NCC) (1988/9 and 1989/90), the Joint Nature Conservation Committee (JNCC) (January 2002), the Wildfowl & Wetlands Trust (WWT) (January 2003 – January/February 2005; February/March 2005, March 2005, November 2006 – March 2007) and the Natural Environmental Research Institute, Denmark (NERI) (January 2005 and March 2005). Surveys carried out by WWT and NERI were commissioned in response to proposals to develop wind farms in the Greater Thames and in other areas around the UK. The surveys were commissioned by a consortium of private companies, as well as DBERR (Department for Business Enterprise and Regulatory Reform, formerly Department of Trade and Industry (DTI), the Department for the Environment, Food and Rural Affairs (DEFRA) and the Crown Estates (Webb *et al.,* 2009).
- Red-throated Divers and Offshore Wind Farms in the Outer Thames: Historic Data Review: This report represents a comprehensive review of Red-throated Diver data between 2001 and

[3] The annual WeBS report presents the results of WeBS and includes data from other national and local waterbird monitoring schemes. It provides a single, comprehensive source of information on the current status and distribution of waterbirds in the UK.

2010 for the Outer Thames area. This included both aerial surveys commissioned by DTI / DBERR (as described above) as well as boat based surveys undertaken as part of specific wind farm developments. In summary, boat based data was available for Greater Gabbard for the winters of 2003-04 to 2005-06 and then again for the winters of 2008-09 to 2009-10; for Gunfleet Sands for the winters of 2007-08 and 2008-09; for Kentish Flats for the winters 2001-02 to 2008-09; for London Array for the winters of 2002-03 and 2004-05, and for Thanet for the winters of 2004-05 and 2005-06 and then again for the winters of 2008-09 and 2009-10 (APEM, 2011).

- Marine Aggregate Regional Environmental Assessment of the Outer Thames Estuary: The report summarised seabird distribution in the Outer Thames based on data collected during the aerial surveys undertaken by WWT (as described above). The review was based on two years data from the aerial surveys (2004/05 and 2005/06) combined, taking into account survey effort, to produce figures of distribution for key species groups (ERM, 2010).
- Kentish Flats and Kentish Flats Extension Wind Farm monitoring: Boat and aerial based bird surveys undertaken as part of the Kentish Flats Wind Farm development from 2001-2010 (Vattenfall, 2011).

A number of other surveys and scientific studies on seabirds have also been included where appropriate.

7.1 Overview

The marine and coastal habitats in the study area support a number of overwintering, passage and resident waterfowl, waders and seabirds, providing important feeding, roosting and breeding grounds. This baseline review focuses on those species that depend wholly or mainly on the marine environment for their survival. In the UK these species consist of seabirds (within the families Procellariidae – petrels and shearwaters, Hydrobatidae – storm-petrels, Phalacrocoracidae – cormorants/shags, Stercoraridae – skuas, Sternidae - terns; Sulidae – gannets, Laridae – gulls and Alcidae – auks); divers (within the family Gaviidae); grebes (within the family Podicepididae); and sea ducks. Seabirds generally are described below in Section 7.2 with a subset of seabirds (including divers, grebes and sea ducks) discussed separately in Section 7.3. Other species of waterbird are being considered in a separate report authored by Atkins (Atkins, 2013a and b).

Seabirds can undertake long distance foraging excursions and migrations. For example, some species such as Northern Gannet *Morus bassanus* and Fulmar *Fulmarus glacialis* have been recorded travelling over 600 km away from nesting colonies (Thaxter *et al*., 2012; BirdLife International, 2012). Given the highly mobile nature of seabirds, not only the Thames Estuary but also the wider southern North Sea area has been used as a study area.

Seabirds such as auks, Gannet and Fulmar are most frequently recorded offshore in the Outer Thames Estuary. Overwintering Red-throated Diver *Gavia stellata* are particularly prevalent in the Thames Estuary both inshore and offshore. Terns are commonly recorded inshore during breeding and passage periods with Cormorant *Phalacrocorax carbo*, Great-crested Grebe *Podiceps cristatus* and Common Scoter *Melanitta nigra* also frequently recorded inshore. Gull species are widely distributed throughout the Thames Estuary both offshore and inshore.

All bird species are protected under the Wildlife and Countryside Act 1981 (and amendments), under which it is an offence to take, injure or kill these species. This protects all birds, their nests and eggs (a wild bird is defined as any bird of a species that is resident in or is a visitor to the European Territory of any member state in a wild state). All species of naturally occurring birds in the wild state in Europe

(applies to birds, their eggs, nests and habitats) are also protected under Directive 2009/147/EC on the conservation of wild birds (The Birds Directive) implemented in the UK through the Habitats Regulations.

7.2 Seabirds

As discussed in Section 2, a number of sites have been designated to provide protection for breeding seabird species. The species listed under these designations consist of tern species (Little Tern *Sterna albifrons*, Common Tern *S. hirundo* and Sandwich Tern *S. sandvicensis*) and Great Cormorant *P. carbo*. Based on information on known foraging range, habitat, abundance and distribution, other species which would be expected to occur with any frequency in the Thames Estuary include gull species (Black-headed Gull *Chroicocephalus ridibundus*, Black-legged Kittiwake *Rissa tridactyla*, Common Gull *Larus canus*, Lesser Black-backed Gull *L. fuscus*, Great Black-backed Gull *L. marinus* and Herring Gull *L. argentatus*), auk species (Common Guillemot *Uria aalge* and Razorbill *Alca torda*), Northern Fulmar *F. glacialis* and Northern Gannet *M. bassanus*. Table 24 presents a summary of the ecology and distribution of the seabird species most commonly recorded at sea within the Thames Estuary. This includes a review of the distribution of seabirds in the Outer Thames based on WWT aerial surveys for 2004/05 and 2005/06 as summarised in ERM (2010). Due to the nature of aerial survey, it was not always possible to distinguish individual birds down to species level and so records are often only provided down to family or species group level.

Table 24. Summary of seabird ecology and distribution within the Thames Estuary

Taxonomic Group	Species	Max. Foraging Range from Colony[1, 2]	Diet	Foraging Behaviour, Dive Depth	Sightings in the Southern North Sea and Thames Estuary[3, 4]	Aerial Surveys 2004/05-2005/06 (Summer)[5]	Aerial Surveys 2004/05-2007/08 (Winter)[5]	Abundance of Species in the Vicinity of the Possible Airport Locations[4,5,6]
Alcidae-auks	Atlantic Puffin	200, 200	Sandeel, sprat, herring, rockling and small gadoids.	Pursuit diver Max 70 m, mean 37.03 m.	Occasional	The aerial surveys recorded sightings of Puffins, Guillemots and Razorbills. Levels of auk activity within the study area were low during the summer breeding season. This may be due to the fact that during the summer auks generally feed in very close proximity to their nest sites (no colonies of auks breed in the study area). During chick rearing (Period 6) there were no records of auks within the survey area, and during incubation (Period 5) there were very low numbers recorded. Higher numbers were recorded during Period 7, mostly in the north of the study area off the coast south of Lowestoft, mostly between 15-30 km offshore (see Figure 26). (Details of periods can be found in the relevant survey report).	Although relatively high numbers have been recorded during the winter in the Thames, in a UK context the numbers are low (Figure 30). Over the two most recent years of survey, the highest average count has been 2,844 Guillemots, Puffins and Razorbills combined, with the majority likely to be Guillemots as they are the most common auk species in the UK. The estimated total UK breeding population of these three species is c. 4 million birds with wintering numbers likely to be greater still as the breeding counts do not include juvenile birds and non-breeders. Therefore, the numbers recorded are not significant in a national context, representing approximately 0.07% of the combined UK breeding total for auks.	Inner Estuary- Infrequent Outer Estuary- Infrequent
	Razorbill	51, 95	Sandeel, sprat, herring and rockling	Max 140 m, mean 41.09 m.	Common			
	Common Guillemot	200, 135	Sandeel, sprats herring and small gadoids	Pursuit diver. Max 200 m, mean 90.06 m	No data available			
Laridae–gulls, (excluding Kiitwake)	Herring Gull	-, 92	Omnivorous-fish, discards, offal	Splash diver, kleptoparasitism (will also prey on other seabirds and small mammals)	Common	Summer distribution of *Larus* gull species in the study area is shown in Figure 27. The highest numbers of any gull species recorded during the 2005-06 or 2004-05 survey were, 213 Black-headed Gull recorded during 2005-06. Relatively high numbers of unidentified gulls were recorded on a number of survey periods, with 767 the highest number recorded during any one survey period. Current breeding population estimates for Black-	Gull species recorded during the winter aerial surveys are shown in Figure 31. Records of gulls were widespread across the study area, with the highest concentrations recorded within the Inner Thames. The two midwinter counts (Periods 3 and 4) recorded the most widespread distribution of gulls, but also the highest concentration of gulls, especially around the coast of	Inner Estuary- Common Outer Estuary- Common
	Black-headed Gull	-, 40	Worms, insects, small fish, crustacea and carrion	Surface feeder	Common			

Taxonomic Group	Species	Max. Foraging Range from Colony[1, 2]	Diet	Foraging Behaviour, Dive Depth	Sightings in the Southern North Sea and Thames Estuary[3, 4]	Aerial Surveys 2004/05-2005/06 (Summer)[5]	Aerial Surveys 2004/05-2007/08 (Winter)[5]	Abundance of Species in the Vicinity of the Possible Airport Locations[4,5,6]
	Lesser Black-backed Gull	-, 181	Omnivorous- fish, discards, offal	Feeds on the surface or shallow plunge dives. Mainly coastal foraging range in summer	Common	headed Gull are approximately 138,000, Herring Gull approximately 139,000 and Lesser Black-backed Gull approximately 112,000. Therefore, although not all of the gulls recorded during surveys have been identified to species level, it is possible to conclude that the numbers recorded during the surveys are unlikely to represent nationally significant numbers of these species.	Essex. Most records of gulls peaked in either Period 2 or 3. Smaller concentrations were recorded off the coast north of Felixstowe. Total numbers of most wintering gulls recorded are still relatively low compared to UK totals. (Details of periods can be found in the relevant survey report).	
	Common Gull	-, 50	Worms, insects, carrion, fish, small birds, small mammals, eggs, berries.	Surface feeder	No data available			
	Great Black-backed Gull	-, -	Carrion, seabirds, small mammals, fish and shellfish.	Surface feeder, theft and also other seabirds.	Common			
	Black-legged Kittiwake	200, 120	Sandeel and clupeids	Surface feeder using dipping or shallow plunge diving.	Common	Figure 28 shows that records of Kittiwakes were largely confined to the north of the survey area, with only low numbers recorded.	Outside of the breeding season Kittiwakes are largely oceanic, spending most of their time foraging over the North Atlantic or North Sea. During the winter surveys show they were recorded over a much wider area than during the summer surveys, being recorded at low densities across the entire survey area. The highest concentrations were recorded off the east coast of Kent to the south of the study area (Figure 32).	Inner Estuary- Rare Outer Estuary- Common
Sternidae-terns	Little Tern	11, 11	Small fish such as clupeids and sandeel. Small invertebrates	Shallow plunge diver and dipper	Common	Figure 29 shows the average relative density of all tern species recorded during the aerial surveys. The highest densities of terns were recorded from within the Thames Estuary, south west of a line drawn between Margate and Clacton-on-Sea. This is possibly due to the high density of Common Terns, and	Not surveyed	Inner Estuary- Common Outer Estuary- Common
	Common Tern	37, 30	Small marine and freshwater fish and aquatic invertebrates	Shallow plunge diver	Common			

Taxonomic Group	Species	Max. Foraging Range from Colony[1, 2]	Diet	Foraging Behaviour, Dive Depth	Sightings in the Southern North Sea and Thames Estuary[3, 4]	Aerial Surveys 2004/05-2005/06 (Summer)[5]	Aerial Surveys 2004/05-2007/08 (Winter)[5]	Abundance of Species in the Vicinity of the Possible Airport Locations[4,5,6]
	Sandwich Tern	70, 54	Clupeids, gadoids and sandeel	Plunge diver. Max 20 m, mean 20 m	Common	in certain areas Little Tern, breeding around the estuary. Another reason may be habitat, with Common, Sandwich and Little Tern all foraging over offshore sandbanks, which are plentiful within the Thames Estuary. Due to the distance from shore, the majority of records are likely to be Common and Sandwich Terns, although the distribution data from the survey only identified birds down to a generic tern group rather than to species. It is also possible that these records are from post breeding birds which will forage over a wider area, although it is not possible to tell from the survey data which is not broken down into specific survey periods.		
Phalacrocoracidae -cormorants	Great Cormorant	50, 35	Feeds on fish such as flatfish, blennies, gadoids, sandeel, salmonid and eels.	Pursuit diver. Max 35 m, mean 12.07 m.	Common	Not recorded		
Procellariidae– petrels and shearwaters	Northern Fulmar	664, 580	Sandeel, sprat, zooplankton, squid, fish discards and offal.	Surface feeder. Also splash dives	Common	Fulmar were regularly recorded during the year over both survey years, with much larger counts during the winter surveys.		Inner Estuary- Rare Outer Estuary- Infrequent
	Northern Gannet	640, 590	Mackerel, herring, sandeel, gadoids, fish discards.	Plunge diver. Max 34 m, mean 8.8 m.	No data available	Gannets were recorded at low levels within the study area during summer aerial surveys, with a high count of 152 in the late summer of 2005. In a UK context therefore, the study area does not appear to be important for Gannets. Although the numbers of Gannets recorded during the aerial surveys was provided in the reports the spatial distribution data was not. The nearest breeding colony of gannets to the study area is at Bempton in East Yorkshire.	The highest concentrations were recorded off the east Kent coast and north into the Outer Thames Estuary, with another smaller concentration off the coast of Norfolk. The highest number of Gannets recorded during the two aerial surveys was 2,404 recorded during late winter (Period 4) in 2005/06. (Details of periods can be found in the relevant survey report).	Inner Estuary- Rare Outer Estuary- Infrequent
Derived from: [1] BirdLife International (2012); [2] Thaxter *et al* (2012); [3] ESAS data, [4] Holt *et al*. 2012, [5] ERM, 2010, [6] Vattenfall, 2011								

7.3 Seaducks, Grebes and Divers

Inshore UK waters host large numbers of wintering seaduck, divers (*Gaviidae*) and grebes (*Podicepididae).* Seaducks undertake surface diving to capture molluscs such as mussels and clams as well as crustacea. Divers and grebes are piscivores, preying on a variety of small fish such as clupeids, sandeel and small gadoids by undertaking pursuit diving (BirdLife International, 2012). As discussed in Section 2, a number of sites are designated as protected sites for breeding grebe and divers. The species listed under these designations consist of Red-throated Diver *G. stellata* and Great-crested Grebe *P. cristatus*.

The numbers of inshore seabirds using the Greater Thames during the non-breeding season were reviewed by Webb *et al.* (2009). This included a total of 58 days aerial surveys over eight winter seasons between 1988/89 and 2006/07. Species reviewed included the Common Eider *Somateria mollissima*, Common Scoter *M. nigra*, Red-breasted Merganser *Mergus serrator*, Red-throated Diver *G. stellata*, Great-northern Diver *G. immer*, Black-throated Diver *G. arcticaa* and Great Crested Grebe *P. cristatus*. In addition a comprehensive review of Red-throated Diver data between 2001 and 2010 for the Outer Thames Estuary collected from WWT aerial surveys and boat based surveys, has been undertaken as part of specific wind farm developments (APEM, 2011). A summary of the distribution and abundances of seaduck, grebe and diver species based on the results of these reviews can be seen in Figures 33 to 36 and Table 25. Red-throated Diver was, by far, the most prevalent species recorded with peak estimates ranging from 2,460 to 10,884 individual birds, and a mean peak count of 6,618 individuals. Highest numbers tended to occur during January and February, with the highest estimated numbers occurring in January 2003. Numbers recorded represent the single largest aggregation of divers to have been observed in UK waters, and one of the largest in northwest Europe. Peak estimated numbers of Red-throated Divers exceeded the appropriate Stage 1 threshold (170 individuals) under the UK SPA site selection guidelines in all five of the most recent winter seasons.

Table 25. Summary of seaduck, grebe and diver distribution within the Thames Estuary

Species	Webb *et al.* (2009)		APEM (2011)	Abundance of Species in the Vicinity of the Possible Airport Locations[4]
	Mean of Peak Estimate (2002/03-2006/07)	Summary of Distribution		
Common Eider	646	Common Eiders were recorded during nine out of 19 surveys and were observed in high numbers only in January 2003. They were recorded mainly in the inshore areas of the survey area, in water less than 10m very close to the shore.	Not reviewed	Inner Estuary- Infrequent Outer Estuary- Rare
Common Scoter	1406	Few flocks of Common Scoter were recorded but more than half the surveys observed moderate numbers up to 650 of individuals (January 2002, February 2003, February 2004, November/December 2004 and January/February 2005). Common Scoters were recorded mainly in the inshore areas, in water less than 20m deep. During all surveys in which birds were recorded, T1 was the most favoured area (Figure 33a-c). (Details of surveyed areas can be found in the relevant survey report).	Not reviewed	Inner Estuary- Common Outer Estuary- Common
Red-breasted Merganser	14	Numbers considered too low to draw any meaningful conclusions about their distribution.	Not reviewed	Inner Estuary- Rare Outer Estuary- Rare

Species	Webb *et al.* (2009)		APEM (2011)	Abundance of Species in the Vicinity of the Possible Airport Locations[4]
	Mean of Peak Estimate (2002/03-2006/07)	Summary of Distribution		
Red-throated Diver	6618	Red-throated Divers were recorded during all surveys of the Greater Thames, mainly in waters less than 20m deep. High numbers of divers were recorded mainly in December and January/February of each year. Survey areas T1 and T2 held divers more frequently compared with other areas. Birds were regularly recorded in flocks of 5-10 individuals, and frequently up to 20, although the largest aggregation was 150 individuals (Figure 36). (Details of surveyed areas can be found in the relevant survey report).	Although coverage was not equal in all years, mean distributions and mean centres of these distributions, weighted by numbers of Red-throated Divers, indicate that within the Outer Thames area, Red-throated Divers are fairly evenly spread. In 2003-04, Red-throated Divers were distributed fairly evenly in a band from the Kent coast north to the London Array area; densities tended to be highest in this wind farm area. In the winter of 2004-05, distribution was more evenly spread throughout the Outer Thames, with less defined large concentrations than in 2003-04. The same pattern as seen in 2004-05 was repeated in 2005-06, although there was largely an absence of birds in the north east of the survey area. The winter of 2006-07 did not experience the same extent of spatial coverage as previous years, meaning comparisons of distribution are difficult. However, Kentish Flats wind farm area supported very low densities of Red-throated Divers. High resolution digital image surveys in 2009-10 showed a patchy distribution of divers in the London Array area, tapering off towards Kentish Flats (Figure 36)	Inner Estuary- Common Outer Estuary- Common
Great-northern Diver	21	Numbers considered too low to draw any meaningful conclusions about their distribution.	Not reviewed	Inner Estuary- Rare Outer Estuary- Rare
Great Crested Grebe	105	Grebes were recorded in low numbers but with up to 20 individuals in one flock (January 2003 and January/February 2005). The survey areas where Grebes were most frequently recorded were T1 and T2. (Details of surveyed areas can be found in the relevant survey report).	Not reviewed	Inner Estuary- Common Outer Estuary- Common

7.4 Distribution and Abundance in the Vicinity of the Possible Airport Locations

Based on sightings and monitoring data, the species expected to occur in highest abundances within the vicinity of both possible airport locations are Gull species, Red-throated Diver and Tern species (see Tables 24 and 25).

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9. Abbreviations

%	percent
ABPmer	ABP Marine Environmental Research Ltd
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
BAP	Biodiversity Action Plan
BTO	British Trust for Ornithology
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CHaMP	Coastal Habitat Management Plan
cSAC	candidate Special Area of Conservation
DBERR	Department for Business Enterprise and Regulatory Reform, formerly
DECC	Department of Energy and Climate Change
DEFRA	Department for the Environment, Food and Rural Affairs
DTI	Department of Trade and Industry
EC	European Community
EIA	Environmental Impact Assessment
ES	Environmental Statement
ESAS	European Seabirds at Sea
EU	European Union
GGOWF	Galloper Offshore Wind Farm
GGOWL	Greater Gabbard Offshore Winds Limited
GREP	Global Renewable Energy Partners
ha	hectare(s)
HELCOM	Baltic Marine Environment Protection Commission
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
kg	kilogram(s)
km	kilometre(s)
km^2	square kilometre(s)
LAL	London Array Ltd
m	metre(s)
MALSF	Marine Aggregate Levy Sustainability Fund
MAREA	Marine Aggregate Regional Environmental Assessment
MCZ	Marine Conservation Zone
MESH	Mapping European Seabed Habitats
MPA	Marine Protected Area
NCC	Nature Conservancy Council
NERI	Natural Environmental Research Institute
NFFO	National Federation of Fishermen's Organisations
OBIS	Ocean Biogeographic Information System
ºC	degree(s) centigrade
OSPAR	Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic
PLA	Port of London Authority
Ramsar Sites	Wetlands of International Importance
REC	Regional Environmental Characterisation
rMCZ	Recommended Marine Conservation Zone
rRA	Reference Area
RSG	Regional Steering Group
RSPB	Royal Society for the Protection of Birds

SAC	Special Area of Conservation
SAST	Seabirds at Sea Team
SCANS	Small Cetacean Abundance in the North Sea and Adjacent waters
SCOS	Special Committee on Seals
SEA	Strategic Environmental Assessment
SFF	Scottish Fishermen's Association
SMRU	Sea Mammal Research Unit
SPA	Special Protection Areas
SSSI	Sites of Special Scientific Interest
TBT	Tributyltin
TE2100	Thames Estuary 2100
TEBP	Thames Estuary Benthic Programme
TEDA	Thames Estuary Dredging Association
TEP BAG	Thames Estuary Partnership Biodiversity Action Group
TfL	Transport for London
TTHAP	Tidal Thames Habitat Action Plan
UK	United Kingdom
UKOOA	UK Offshore Operator's Association
WDCS	Whale and Dolphin Conservation Society
WeBS	Wetland Bird Survey
WWT	Wildfowl & Wetlands Trust
ZSL	Zoological Society London

Figures

(See Figures Document)

Appendices

Appendix A

Bird Species Qualifying Under the Birds Directive Using the Marine Component of SPA Sites (JNCC, 2012)

Appendix A. Bird Species Qualifying Under the Birds Directive Using the Marine Component of SPA Sites (JNCC, 2012)

Common Name	Scientific Name	Site								
		Benfleet and Southend Marshes	Crouch and Roach Estuaries	Dengie	Foulness	Medway Estuary and Marshes	Outer Thames Estuary	Thames Estuary and Marshes	Thanet Coast and Sandwich Bay	The Swale
Avocet	*Recurvirostra avosetta*				✓	✓		✓		
Little Tern	*Sterna albifrons*				✓	✓			✓	
Dark-bellied Brent Goose	*Branta bernicla bernicla*	✓	✓	✓	✓	✓				✓
Shelduck	*Tadorna tadorna*									✓
Pintail	*Anas acuta*					✓				
Grey Plover	*Pluvialis squatarola*	✓		✓	✓	✓		✓		✓
Ringed Plover	*Charadrius hiaticula*	✓			✓	✓		✓		✓
Knot	*Calidris canutus*	✓		✓	✓	✓		✓		
Dunlin	*Calidris alpina*	✓				✓		✓		✓
Redshank	*Tringa totanus*				✓	✓		✓		✓
Great crested Grebe	*Podiceps cristatus*					✓				
Wigeon	*Anas penelope*					✓				
Teal	*Anas crecca*					✓				✓
Shoveler	*Anas clypeata*					✓				
Oystercatcher	*Haematopos ostralegus*				✓	✓				✓
Black-tailed Godwit	*Limosa limosa*					✓		✓		
Bar-tailed Godwit	*Limosa lapponica*				✓					
Curlew	*Numenius arquata*					✓				✓
Spotted Redshank	*Tringa erythropus*									
Greenshank	*Tringa nebularia*					✓				
Turnstone	*Arenaria interpres*					✓			✓	
Lapwing	*Vanellus vanellus*					✓				✓
Mallard	*Anas platyrhynchos*					✓				✓
Shelduck	*Tadorna tadorna*					✓				
Pochard	*Aythya ferina*					✓				
Common Tern	*Sterna hirundo*				✓	✓				
Red-throated Diver	*Gavia stellata*					✓	✓			
Cormorant	*Phalacrocorax carbo*					✓				
Bewick's Swan	*Cygnus columbianus bewickii*					✓				
Hen Harrier	*Circus cyaneus*		✓	✓	✓	✓		✓		
Merlin	*Falco columbarius*					✓				
Golden Plover	*Pluvialis apricaria*								✓	
Sandwich Tern	*Sterna sandvicensis*				✓					
Bittern	*Botaurus stellaris*									
Gadwall	*Anas strepera*									✓
Eurasian Coot	*Fulica atra*									✓
Common Moorhen	*Gallinula chloropus*									

Appendix B

Plant, Invertebrate and Bird Species Found at Each Site Qualifying Under Ramsar Criterion 2

Appendix B. Plant, Invertebrate and Bird Species Found at Each Site Qualifying Under Ramsar Criterion 2

B1. Plant Species Found at Each Site Qualifying Under Ramsar Criterion 2

Scientific Name	Benfleet and Southend Marshes	Crouch and Roach Estuaries	Dengie	Foulness	Medway Estuary and Marshes	Thames Estuary and Marshes	Thanet Coast and Sandwich Bay	The Swale
Alopecurus bulbosus				✓		✓		
Atriplex pedunculata				✓				
Cynodon dactylon				✓				
Bupleurum tenuissimum		✓		✓	✓	✓		✓
Carex divisa		✓		✓		✓		✓
Chenopodium chenopodioides					✓	✓		✓
Hordeum marinum		✓	✓	✓	✓	✓		✓
Inula crithmoides		✓	✓	✓	✓	✓		✓
Limonium humile		✓	✓	✓				
Parapholis incurva		✓		✓	✓			
Poa bulbosa				✓				
Polypogon monspeliensis				✓	✓	✓		
Puccinellia fasciculata		✓		✓	✓	✓		
Puccinellia rupestris		✓		✓		✓		
Ruppia cirrhosa		✓		✓				
Salicornia perennis			✓		✓			
Salicornia pusilla		✓	✓	✓	✓	✓		
Spartina maritima		✓	✓	✓				✓
Stratiotes aloides						✓		
Suaeda vera		✓	✓	✓				
Trifolium glomeratum						✓		
Trifolium squamosum		✓		✓	✓	✓		✓
Trifolium suffocatum				✓				
Vulpia fasciculata				✓				
Zostera angustifoli			✓	✓		✓		
Zostera noltii			✓	✓		✓		
Zostera marina			✓					
Myriophyllum verticallatum								
Crambe maritima			✓					
Peucedanum officinale								✓

B2. Invertebrate Species Found at Each Site Qualifying Under Ramsar Criterion 2

Latin Name	Benfleet and Southend Marshes	Crouch and Roach Estuaries	Dengie	Foulness	Medway Estuary and Marshes	Thames Estuary and Marshes	Thanet Coast and Sandwich Bay	The Swale
Bagous longitarsis						✓		
Henestaris halophilus						✓		
Bagous cylindrus						✓		✓
Polystichus connexus					✓	✓		
Erioptera bivittata						✓		
Hybomitra expollicata		✓		✓		✓		✓
Lejops vittata				✓		✓		✓
Poecilobothrus ducalis				✓	✓	✓	✓	✓
Pteromicra leucopeza						✓		
Philanthus triangulum						✓		
Lestes dryas		✓		✓		✓		
Cercyon bifenestratus						✓		
Hydrochus elongatus						✓		
H.ignicollis						✓		
Ochthebius exaratus						✓		
Hydrophilus piceus						✓		
Malachius vulneratus		✓			✓	✓		✓
Philonthus punctus					✓	✓		✓
Telmatophilus brevicollis						✓		
Campsicnemus magius					✓	✓		✓
Haematopota bigoti						✓		
Stratiomys singularior		✓						
Stratiomys longicornis				✓		✓		
Aethes margarotana				✓				
Malacosoma castrensis		✓		✓	✓			
Parydroptera discomyzina		✓		✓		✓		
Paragus albifrons				✓				
Tachys scutellaris				✓				
Berosus spinosus				✓	✓			
Gammarus insensibilis				✓				
Cephalops perspicuus					✓	✓		
Anagnota collini					✓			
Micronecta minutissima								✓
Baris scolopacea			✓		✓			
Atylotu latistriatuus			✓		✓			
Limonia danica					✓			
Cantharis fusca					✓			
Graptodytes bilineatus		✓						
Eucosoma catoprana		✓						
Baryphyma duffeyi						✓		

Latin Name	Benfleet and Southend Marshes	Crouch and Roach Estuaries	Dengie	Foulness	Medway Estuary and Marshes	Thames Estuary and Marshes	Thanet Coast and Sandwich Bay	The Swale
Euophrys browningi			✓					
Elachiptera rufifrons								✓
Myopites eximia								✓
Lixus vilis							✓	
Stigmella repentiella							✓	
Bagous nodulosus							✓	
Deltote bankiana							✓	
Emblethis verbasci							✓	
Pionosomus varius							✓	
Nabis brevis							✓	
Euheptauclacus sus							✓	
Melanotus punctolineatus							✓	
Eluma purpurescens							✓	
Ectemnius ruficornis							✓	
Alysson lunicornis							✓	
Orthotylus rubidus							✓	

B3. Bird Species Found at Each Site Qualifying Under International Ramsar Criterion 6

Latin Name	Benfleet and Southend Marshes	Crouch and Roach Estuaries	Dengie	Foulness	Medway Estuary and Marshes	Thames Estuary and Marshes	Thanet Coast and Sandwich Bay	The Swale
Limosa limosa islandica						✓		
Calidris alpina alpina					✓	✓		
Pluvialis squatarola	✓		✓	✓	✓	✓		✓
Calidris canutus	✓		✓	✓	✓	✓		
Tringa totanus				✓	✓	✓		✓
Limosa lapponica				✓				
Branta bernicla bernicla	✓	✓	✓	✓	✓			✓
Anus clypeata								
Anus acuta					✓			
Anas strepera								
Tadorna tadorna					✓			
Haematopos ostralegus				✓				
Charadrius hiaticula					✓	✓		
Arenaria interpres							✓	