10 AQUATIC ECOLOGY

10.1 INTRODUCTION

10.1.1 This chapter of the ES addresses the impacts to aquatic ecology and nature conservation as a result of the AMEP.

10.1.2 To inform the assessment of impacts, this chapter provides an overview of the status and characteristics of the aquatic ecology of the Humber Estuary. This takes the form of a broad description of habitats found in the wider estuary followed by a more detailed description of the specific aquatic ecology observed at the AMEP site, based on dedicated surveys of the intertidal and subtidal seabed. The results of these surveys are presented in *Annex 10.1.*

10.1.3 The scope of this chapter is limited to impacts to aquatic ecology and nature conservation. The impacts on waders and other estuarine birds using the Humber Estuary are discussed in *Chapter 11*. The impacts on commercial or recreational fishing are addressed in *Chapter 12*.

10.2 LEGISLATION, POLICY AND GUIDANCE

Overview

10.2.1 There are several national policies and pieces of legislation that are relevant to the assessment of impacts on aquatic flora and fauna; these are summarised in this section.

International, European and National Biodiversity Legislation

Convention on Biological Diversity (CBD)

10.2.2 The CBD was signed by the representatives of many countries at the United Nations Conference on Environment and Development and came into force on 29 December 1993. The objectives of the convention are:

> '*the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.*'

10.2.3 The CBD is enacted through various pieces of national legislation.

1979 Berne Convention on the Conservation of European Wildlife and Natural Habitats

10.2.4 The Berne Convention is intended to aid the conservation of wild flora and fauna and their natural habitats, with particular emphasis on endangered and vulnerable species, especially migratory species. The Convention is enacted in the EU through the 1979 Birds Directive and the 1992 Habitats Directive, both of which are applicable to the Humber Estuary.

EC Directive 79/409/EEC on the Conservation of Wild Birds (The Birds Directive)

10.2.5 It is recognised in legislation that the protection of migratory birds is a transfrontier problem, and that national legislation cannot in itself provide complete or effective protection. This Directive is intended to protect wild migratory birds '*at a level which corresponds in particular to ecological, scientific and cultural requirements, whilst taking account of economic and recreational requirements*'. It aims to do this by the protection of nests and eggs, control of the hunting and killing of birds and by requiring the conservation of habitats in order to maintain populations of certain species, as identified in Annex 1 of the Directive. This contains a list of species requiring special habitat conservation measures. For regularly occurring migratory species not listed in Annex 1, particularly those using wetlands, similar measures are required. Member States are required to identify and protect these Special Protection Areas (SPAs) and consider their conservation in all planning decisions. The Humber Estuary is a designated SPA, providing areas used for breeding and staging by several species listed in Annex 1 of the directive. These are discussed further in *Chapter 11*.

EC Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (The Habitats Directive)

10.2.6 The Habitats Directive (EC 1992) is intended to 'contribute towards ensuring biodiversity through the conservation of natural habitats and of wild flora and fauna in the European territory of the Member States to which the Treaty applies'. This requires a system of protection both for certain species of plants and animals, and for their habitats. In the UK the Habitats Directive is enacted through the Conservation of Habitats and Species Regulations 2010. Article 12 of The Habitats Directive specifically details disturbance offences of European Protected Species.

10.2.7 The European Commission (EC) has produced the following guidance documents in respect of the Directive:

- Managing Natura 2000 Sites The Provisions of Article 6 of the 'Habitats' Directive 92/43/EEC (EC, 2000);

- Assessment of Plans and Projects Significantly Affecting Natura 2000 Sites (EC, 2001); and

- Guidance Document on Article 6(4) of the 'Habitats' Directive 92/43/EEC (EC, 2007).

10.2.8 The EC has also prepared specific guidance on the application of the Directive in respect of port developments. The overall objective of this guidance is to establish a better understanding of how to apply the Article 6 provisions of the Directive to port developments and, in particular, to provide further advice on how to carry out an appropriate assessment.

1971 Ramsar Convention on Wetlands of International Importance, Especially as Waterfowl Habitat

10.2.9 The Ramsar Convention, or Wetlands Convention, was adopted in Ramsar, Iran in February 1971 and was ratified in the UK in 1976. The Convention has three main "pillars" of activity: the designation of wetlands of international importance as Ramsar sites; the promotion of the wise-use of all wetlands in the territory of each country; and international co-operation with other countries to further the wise-use of wetlands and their resources.

10.2.10 In the UK, Ramsar sites are typically designated as Sites of Special Scientific Interest (SSSI) first, receiving statutory protection under the Wildlife and Countryside Act 1981. Sites then issued with policy statements under the Ramsar Convention are afforded the same protection at a policy level, in respect of new development, as SPAs and SACs that collectively form the Natura 2000 network.

1998 Convention for the Protection of the Environment of the North-East Atlantic (OSPAR Convention)

10.2.11 Annex V of the OSPAR Convention on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area was adopted in 1998 accompanied by a strategy for its implementation. The annex provides the legal basis for OSPAR Recommendation 2010/5 on the assessment of environmental impacts on threatened and/or declining species, which requires Contracting Parties to ensure that EIAs assess the environmental effects on those species and habitats on the OSPAR List of Threatened and Declining Species and Habitats (OSPAR Agreement 2008-6).

The Wildlife and Countryside Act 1981 (as amended) (W&CA)

10.2.12 The W&CA is the major legal instrument for wildlife protection in the UK. This legislation is the means by which the Convention on the Conservation of European Wildlife and Natural Habitats (the Berne Convention) and the European Union Directives on the Conservation of Wild Birds (79/409/EEC) and Natural Habitats and Wild Fauna and Flora (92/43/FFC) are implemented in Great Britain.

10.2.13 The W&CA protects the most important habitats as SSSI. It also requires that the Secretary of State takes special measures to protect certain rare or vulnerable bird species, as defined in Annex I of the EC Birds Directive, through the designation and protection of Special Protection Areas (SPAs).

10.2.14 The W&CA also prohibits the release of non-native species into the wild (Section 14). This is to prevent the release of exotic species that could threaten our native wildlife.

Conservation of Habitats and Species Regulations 2010

10.2.15 The Conservation of Habitats and Species Regulations 2010 are the principal means by which the Habitats Directive is transposed into national law in England and Wales. The Regulations apply in the terrestrial environment and in territorial waters out to 12 nautical miles, which covers the Humber Estuary. These Regulations offer full or partial protection for a number of animal and plant species and make certain actions against a species or its resting place an offence, whether intentional or not.

The Countryside and Rights of Way (CRoW) Act 2000 (as amended)

10.2.16 Part III of the CRoW Act deals specifically with wildlife protection and nature conservation. The CRoW Act amends the W&CA, by strengthening the protection of designated SSSIs. In addition, it increases the legal protection of threatened species, by also making it an offence to '*recklessly*' destroy, damage or obstruct access to a sheltering place used by an animal listed in Schedule 5 of the Act or '*recklessly*' disturb an animal occupying such a structure or place.

10.2.17 The Act also requires that Government Departments have regard for the conservation of biodiversity, in accordance with the Convention on Biological Diversity in 1992 (United Nations (UN) 1992). Section 74 requires that Statutory Nature Conservation Organisations (SNCOs) (Natural England) take steps to further the conservation of the living organisms and habitats in the UK. It requires the Secretary of State to publish a list of living organisms and habitat types that are considered to be of principal importance in conserving biodiversity. These species and habitats are now listed under Section 41 of the NERC Act (see below) and are also found within the UK Biodiversity Action Plan (BAP).

Natural Environment and Rural Communities (NERC) Act 2006

10.2.18 The NERC Act created a new integrated agency, Natural England, through the merger of the Countryside Agency's landscape, access and recreation functions, English Nature and part of the Rural Development Service (RDS) that dealt with nature conservation.

10.2.19 It also amends the CRoW Act, by further extending the requirement to have regard for biodiversity to all "public authorities", which includes local authorities and local planning authorities. It also requires the Secretary of State to consult Natural England in the publication of the list of living organisms and habitat types deemed to be of principal importance in conserving biodiversity.

Wild Mammals (Protection) Act 1996

10.2.20 It is an offence to cause wild mammals unnecessary suffering intentionally by certain methods, including crushing and asphyxiation.

Marine and Coastal Access Act, 2009

10.2.21 The Marine and Coastal Access Act introduced a new system of marine management, including a new marine planning system. The Act includes a provision for changing the system for licensing activities in the marine environment. It also provides for the designation of conservation zones. It changed the way marine fisheries are managed at a national and a local level and modifies the way licensing, conservation and fisheries rules are enforced. The Act also amended the system for managing migratory and freshwater fish, and enables recreational access to the English and Welsh coast.

Planning Policy Guidance/Statements

10.2.22 The Government promulgates national policies on different aspects of planning and the rules that govern the operation of the planning system. Relevant policies within the context of this chapter include:

National Policy Statements

10.2.23 In *Chapter 3* reference is made to the National Policy Statement (NPS) for Ports. The NPS requires an assessment of the effects of the proposed Project on marine ecology, biodiversity and the integrity and special features of protected sites.

10.2.24 Whilst the NPS recognises the need to halt, and if possible reverse, declines in priority habitats and species, it also notes that such an aim needs to be viewed in the context of the challenge of climate change. The NPS states that '*failure to address this challenge will result in significant impact on biodiversity*'.

10.2.25 The policy provides the following guidance:

> '*(a)s a general principle …. development should aim to avoid significant harm to biodiversity and geological conservation interests, including through mitigation and consideration of reasonable alternatives. Where significant harm cannot be avoided, then appropriate compensation measures should be sought*', (emphasis added, paragraph 5.1.8).

Planning Policy Statement 9 (PPS9)

10.2.26 PPS9, Biodiversity and Geological Conservation, superseded PPG 9 Nature Conservation: it brings the advice into line with European legislation and the current structure of local planning in this country. The policy's broad aim is:

> '*that planning, construction, development and regeneration should have minimal impacts on biodiversity and enhance it wherever possible*'.

10.2.27 PPS9 details the Government's policies for the conservation of England's natural heritage. The Statement embodies the Government's commitment to sustainable development and to the conservation of wildlife. The guidance advocates the protection of statutory designated sites and sites of particular nature conservation importance eg SSSI's. The guidance also expresses the importance of compliance with the relevant nature conservation and wildlife legislation and other key international obligations (eg the W&CA, CRoW Act, EC Birds Directive and EC Habitats Directive).

10.2.28 In the context of PPS9, biodiversity is the variety of life in all its forms as discussed in the UK BAP. Geological conservation relates to the sites that are designated for their geology and/or geomorphological importance. PPS9 presents the key principles that planning bodies should follow when considering biodiversity and geodiversity. PPS9 lays down a number of provisions that both plans and projects need to consider with regard to designated, non-designated sites and species protection. The document also stresses the importance of '*building in beneficial biodiversity*' to new developments and protecting networks of natural habitats. PPS9 should be read in conjunction with the Government Circular: Biodiversity and Geological Conservation, ODPM Circular 06/2005. The policy also recognises the importance of previously developed land which may contain '*significant biodiversity interests of recognised local importance*' and encourages developers to incorporate it into developments.

10.2.29 PPS9 specifically notes that,

> '*(m)any individual wildlife species receive statutory protection under a range of legislative provisions, and specific policies in respect of these species should not be included in local development documents*'.

Planning Circulars

ODPM Circular 06/2005

10.2.30 This Circular provides administrative guidance on the application of the law relating to planning and nature conservation as it applies in England. It complements the expression of national planning policy in PPS9, Biodiversity and Geological Conservation and the accompanying Good Practice Guide.

Local Plan Policy

North Lincolnshire Council Local Plan

10.2.31 Policy LC1 deals with SPAs, SACs and Ramsar sites and is a key policy with regards to the proposed development. It states that:

> '*Proposals for development, which may affect an SPA, a proposed SPA (pSPA), a SAC or candidate SAC (cSAC), will be assessed according to their implications for the site's conservation objectives, as stipulated in the Habitat Regulations 1994. Proposals not directly connected with, or necessary for, the site, and which are likely to have a significant effect on the site (either individually or in combination with other proposals), will not be permitted unless it can be conclusively demonstrated that:*

- *there is no alternative solution; and*
- *there are imperative reasons of overriding public interest for the development.*

> *Where the site hosts a priority natural habitat type or a priority species, proposals will not be permitted unless it can be conclusively demonstrated that it is necessary for reasons of human health or public safety, or for consequences of primary importance for nature conservation.*'

10.2.32 Policy LC2 deals with SSSI's and National Nature Reserves (NNRs):

> '*Proposals for development in, or likely to affect, SSSIs will be subject to special scrutiny. Where such development may have an adverse effect, directly or indirectly on the SSSI, it will not be permitted unless the reasons for the development clearly outweigh the nature conservation value of the site itself and the national policy to safeguard the national network of such sites.*'

10.2.33 Policy LC4 states that any development likely to have an adverse impact on a Local Nature Reserve and/or Site of Importance for Nature Conservation (SINC) will not be approved unless it can be demonstrated that the reasons for the proposed development outweighs the need to protect the intrinsic nature conservation value of the site. If the development is approved, any damage that may occur must be minimised. Conditions and planning obligations must be put in place for the approved development proposal to ensure that the nature conservation value of the site is protected and advanced.

10.2.34 Policy LC5 outlines the Council's approach on species protection and stresses that permission will not be granted for development that would have an adverse impact on badgers or species protected by Schedules 1, 5 or 8 of the W&CA. Where adverse impacts are identified, conditions or the use of planning agreements would be used to minimise disturbance and maintain the current population levels.

10.2.35 Policy LC6 states that, where appropriate, the Council will require developments to incorporate created habitats, including on land that is no longer required for long-term agricultural use. Particular emphasis will be placed on the creation of habitats such as wet woodland and reedbed, in keeping with local and national biodiversity targets and the provision of habitat for protected species.

Others

UK Biodiversity Action Plan

10.2.36 The UK Biodiversity Action Plan (UK BAP), published in 1994, was the UK Government's response to the Convention on Biological Diversity (CBD). The UKBAP describes the biological resources of the UK and provides detailed plans for conservation of these resources, at national and devolved levels. The list of Priority Species and Habitats of August 2007 contains 1 149 species and 65 habitats that have been listed as priorities for conservation action under the UK BAP. This includes marine and coastal habitats, standing water, and a number of species present within the Humber estuary.

10.2.37 Local BAPs are developed as a local, partnership response to the Convention on Biological Diversity. Lincolnshire has a local biodiversity action plan in place and a strategy has been prepared to do the same in East Riding of Yorkshire.

Humber Management Scheme

10.2.38 The Humber Management Scheme was launched in 2005 to co-ordinate the sustainable management of the estuary. It focuses on the marine areas (land covered continuously or intermittently by tidal waters) of the Humber Estuary SAC, the SPA and Ramsar sites that together form the Humber Estuary European Marine Site (EMS). The scheme was developed by a partnership of over 30 relevant authorities that have jurisdiction over the estuary known as the "Humber Estuary Relevant Authorities Group". Estuary management strategies like the one in the Humber are non-statutory and do not replace regional spatial strategies or Local Plans.

Humber Flood Risk Management Strategy

10.2.39 The Humber Flood Risk Management Strategy is a 25-year strategy approved by DEFRA in 2008 that looks at ways of managing flood risk. The strategy recognises the loss of intertidal habitat resulting from sea level rise and recommends the creation of new intertidal habitat to maintain the estuary's conservation status. The Environment Agency has already acted to compensate for some of these losses via managed realignment schemes (by moving back sea walls and allowing land to flood to create new intertidal habitats).

Humber Estuary Coastal Habitat Management Plan

10.2.40 Coastal Habitat Management Plans (CHaMPs) provide a framework for managing European and Ramsar sites that are located on or adjacent to dynamic coastlines. They provide a way of fulfilling the UK Governments obligations under the Habitats and Birds Directives and the Ramsar Convention, to avoid damage and deterioration to Natura 2000 and Ramsar sites.

10.3 ASSESSMENT METHODOLOGY AND CRITERIA

Overview

10.3.1 This section outlines the methodology to be applied during the ecological assessment.

10.3.2 An impact is defined as a change (which can be positive or negative) that occurs as a consequence of an activity.

10.3.3 Assessing impacts involves:

- identifying the source of the impact;
- identifying what environmental elements/features are impacted;
- predicting the magnitude of the impact;
- considering the need and effectiveness of mitigation measures;
- evaluating the significance of the impacts; and
- reporting the residual impacts.

10.3.4 Thus the assessment of impacts comprises four sequential stages: impact prediction, impact evaluation and identification of mitigation measures and assessment of residual impacts.

10.3.5 For the purpose of reporting, the impact assessment is activity led; impacts to aquatic ecology and nature conservation are divided by activities that will occur during construction and operation of AMEP.

Construction

10.3.6 Impacts to aquatic ecology receptors from construction activities will be assessed in four sequential stages as stated above.

10.3.7 Impact prediction is essentially an objective exercise in determining what could happen to an environmental receptor as a consequence of the intended activity inclusive of mitigation measures inherent to design. Impact prediction for this ecological assessment has relied on a quantitative element wherever this is possible. Where quantification has not been possible, past experience and professional judgement have been applied. The magnitude of impact encompasses the following:

- the nature of the change (what is affected and how);
- the type of impact;
- its size, scale or intensity;
- its geographical extent and distribution;
- its timing, duration, frequency, reversibility; and
- where relevant, the probability of the impact occurring as a result of accidental or unplanned events.

10.3.8 Evaluation of the impact takes the magnitude of impact and explains what it means in terms of its importance to society and the environment.

Operational Phase

10.3.9 Impacts to aquatic ecology receptors from operational activities will be assessed using the methodology as described above.

Sensitive Receptors

10.3.10 For the purposes of this assessment the following are considered sensitive aquatic receptors that occur within the vicinity of the proposed project:

- habitats:
- intertidal mudflats;
- intertidal gravel and sandflats;
- subtidal seabed;
- subtidal sandbanks;
- salt marshes;
- coastal lagoons;
- reed beds

- rare or nationally important benthic invertebrates associated with the estuary or saline/coastal lagoons;

- diadromous fish (e.g. river and sea lamprey, eel, smelt, Atlantic salmon, sea trout and allis and twaite shad);

- other fish fauna of conservation and/or commercial interest; and

- grey seals and other marine mammals.

Significance Criteria

10.3.11 The significance of ecological and nature conservation impacts has been assessed in the light of the habitats and species that are likely to be affected by the proposals taking into account two sets of Guidelines for Ecological Impact Assessment in the United Kingdom published by the Institute of Ecology and Environmental Management (IEEM, 2006, 2010). One refers to the terrestrial environment, and one deals specifically with the coastal and marine environment.

10.3.12 As part of the assessment the significance of potential ecological impacts has been evaluated taking into account the following factors:

- the magnitude of both positive and negative effects, as determined by intensity, frequency and by the effect extent in space and time;

- the vulnerability of the habitat or species to the changes likely to arise from the development;

- the ability of the habitat, species or ecosystem to recover, considering both fragility and resilience;

- the viability of component ecological elements and the integrity of ecosystem function, processes and favourable condition;

- value within a defined geographic frame of reference (eg , national, regional or district);

- the biodiversity value of affected species, populations, communities, habitats and ecosystems, considering aspects such as rarity, distinct sub-populations of a species, habitat diversity and connectivity, species-rich assemblages, and species distribution and extent; and

- designated site and protected species status, and Priority Biodiversity Action Plan (BAP) or Habitat Action Plan (HAP) status.

10.3.13 Significance was determined by the interaction of these criteria. The value of the affected feature is used to determine the geographical scale at which the impact is significant (eg international, national, regional and local levels). The determination of significance is based on whether the impact will affect the integrity or conservation status of the species, habitat, site or ecosystem within a given geographical frame of reference.

10.3.14 Site integrity is defined in qualitative terms in the UK Government Circular 06/2005 (ODPM, 2005): Biodiversity and geological conservation – statutory obligations and their impact within the planning system as follows:

> '*The integrity of a site is the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it was classified.*'

10.3.15 A protected site that achieves this level of coherence is considered to be at favourable condition when it is judged to be meeting established conservation objectives. It may be necessary to expand the parameters under consideration when looking at the wider ecological impacts of a project - ie not just at a protected area.

10.3.16 Impacts are considered to be either significant or non-significant in their residual effect on each ecological receptor, after taking into account the magnitude of the impact, zone of influence, mitigation measures and the confidence in predictions associated with the assessment.

10.4 *CONSULTATION*

10.4.1 *Annex 2.2* includes a summary of the consultation responses relevant to the aquatic ecology.

10.5 *BASELINE*

Overview

10.5.1 The Humber Estuary is the largest coastal plain estuary on the east coast of Britain and the fourth largest estuary in the UK. From a morphological and hydrodynamic point of view, the estuary can be divided into three units as shown in *Figure 10.1* [1]. The boundaries between these units mark the places where either the nature of the morphological processes taking place or the impact of these processes on the rest of the estuary change significantly. The outer estuary extends from Spurn Head to a line across the estuary between Grimsby and Hawkins Point. The middle estuary extends as far as the Humber Bridge. It leads to the inner estuary that extends to Trent Falls.

10.5.2 It is a muddy, macro-tidal estuary and its high levels of suspended sediment are transported to feed a dynamic rapidly changing system with accretion and erosion of intertidal and sub-tidal habitats. Sediments are largely of marine origin.

10.5.3 The intertidal area contains extensive mudflats in the inner estuary and in the shelter off the sand-capped shingle spit of Spurn. The mid and inner Estuary is characterised by fringing reedbeds while extensive areas of saltmarsh are present along the north bank and on the Lincolnshire coast east of Cleethorpes. Areas of sand dune occur past Cleethorpes. Twenty six coastal lagoons are also present in the estuary, although most are located in the Inner and Outer Estuary (Hemingway *et al*, 2008).

[1] It should be noted that the inner estuary with respect to the Humber designations extends considerably further upstream than shown in *Figure* .

Data sources

10.5.4 This baseline has been informed by a variety of sources including the following:

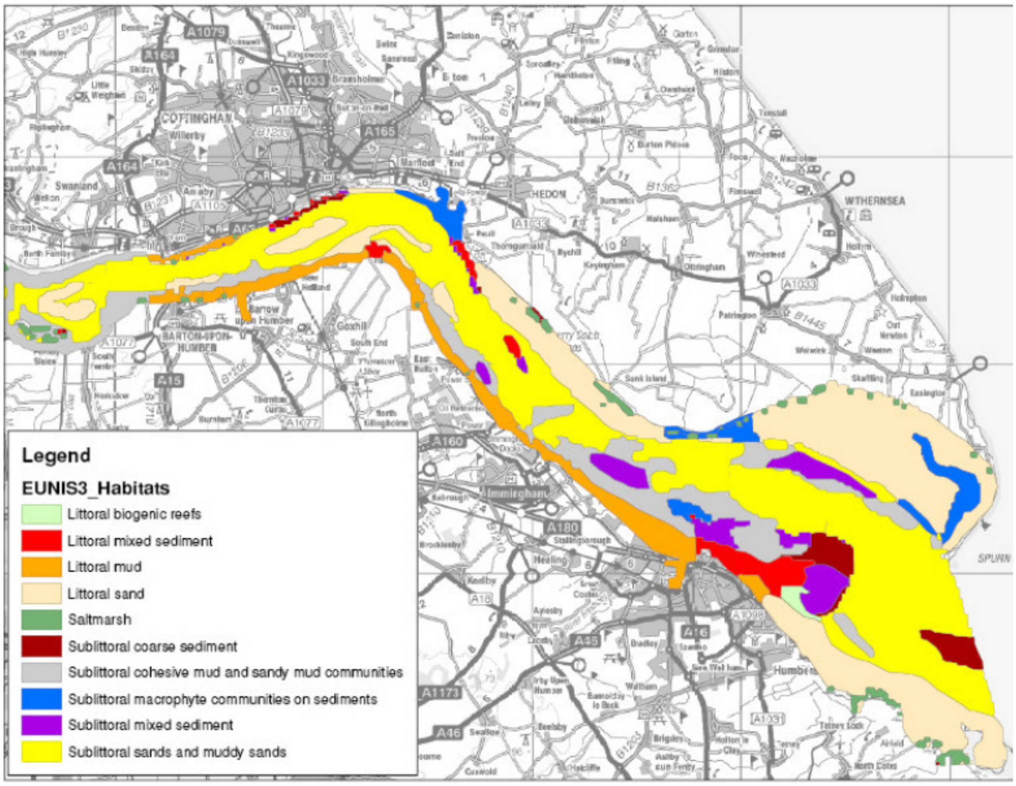
- Institute of Estuarine and Coastal Studies (2010) Intertidal and Subtidal Benthic and Fish Survey (*Annex 10.1*).
- ABPmer (2009) Grimsby Ro-Ro Berth Environmental Statement.
- ABPmer (2007) Humber Estuary Environmental Management and Monitoring Plan: Data 2007. Report No. R.1469.
- English Nature (2003) The Humber Estuary European Marine Site, English Nature's Regulation 33 Interim Advice, April 2003.
- English Nature (2009) Conservation objectives and definitions of favourable condition for designated features of interest, Draft version 2, December 2009.
- Hemingway, K.L., Cutts, N.D., Allen, J.H. & S. Thomson (2008) Habitat Status of the Humber Estuary, UK. Institute of Estuarine & Coastal Studies (IECS), University of Hull, UK. Report produced as part of the European Interreg IIIB HARBASINS project.
- Allen, J., Boyes, S., Burdon, D., Cutts, N., Hawthorne, E., Hemingway, K., Jarvis, S., Jennings, K., Mander, L., Murby, P., Proctor, N., Thomson, S., & Waters, R. (2003) English Nature Research Report No 547: The Humber Estuary: A comprehensive review of its nature conservation interest.

Overview of Habitats in the Humber Estuary

Introduction

10.5.5 Paragraphs 10.5.5 to 10.5.19 provide an overview of the main habitats found within the wider Humber Estuary. Habitats within the Humber Estuary include different types of saltmarsh, subtidal seabed, extensive intertidal mudflats and sandflats, rock and other hard substrata, sand dunes, reed beds and coastal lagoons. The section is largely based on information presented by English Nature (2003) and Hemingway et al (2008) unless noted otherwise. *Figure 10.2* presents a contemporary habitat distribution map across the Humber, after Hemmingway et al. (2008).

Figure 10.2 The Contemporary Habitat Distribution across the Humber



Source: *Annex 8.1* redrawn after Hemmingway *et al*. 2008

Coastal Lagoons

10.5.6 Coastal lagoons are typically (although not exclusively) areas of shallow, brackish or salt water, entirely or partially separated from the sea by sandbanks, shingle or, less frequently, rocks or other hard substrata. They retain a portion of their water at low tide and may develop as brackish (due to dilution of seawater by freshwater), fully saline or hypersaline due to evaporation of seawater (English Nature, 2003).

10.5.7 In terms of their conservation interest, spiral tassleweed (*Ruppia cirrhosa*), a nationally scarce seagrass has been found in the Easington and Kilnsea lagoons (Crackles, F.E. (1990), Selman, R. *et al* (1999)) and the tentacled lagoon worm (*Alkmaria romijni*) recorded in Killingholme pools (Bamber et al (2001), with Killingholme also supporting the spire snail *Hydrobia neglecta* (Smith, A.E. (ed.) (1996). Humberston Fitties is also the most northerly site in Europe for the lagoon sand shrimp *Gammarus insensibilis*, an amphipod protected under Schedule 5 of the Wildlife and Countryside Act 1981 (English Nature, 2003).

Intertidal Mudflats and Sandflats

10.5.8 The Humber Estuary supports a large area of intertidal sediment habitats that are highly representative of North Sea estuaries. Within the SAC boundary (see *Figure 10.6* at the end of chapter), the area of intertidal mudflat and sandflat measures some 9 382 ha (data provided by Natural England – Email Emma Hawthorne, 17 December 2010). These can be split into the following sub features:

- Intertidal gravel and sand communities. The high energy environment of the Humber Estuary and the large marine sediment component of the outer estuary imply that the intertidal flats of this area are predominantly sandy. They support high numbers of species such as polychaete worms, *Nephtys cirrosa* and *Scolelepis squamata*, amphipods crustaceans and the sand mason worm *Lanice conchilega*. The sandflats also support cockle beds on the North Lincolnshire coast. Areas of shingle are found around Hessle and South Ferriby.

- Intertidal muddy sand communities. These occur particularly on more sheltered shores and at the mouth of the estuary from Cleethorpes to Donna Nook where sediment conditions are relatively stable. A wide range of species, such as dense populations of lugworm *Arenicola marina*, other polychaete worms and bivalve molluscs colonise these sediments.

- Intertidal mud communities. There are extensive mudflats in the mid and outer estuary and the stable sediment supports communities that are often highly abundant, typically dominated by polychaete worms such as the lugworm *Arenicola marina* and the estuarine fanworm *Manayunkia aestuarina* and bivalve molluscs. The intertidal muds in the outer estuary support bivalves such as the Baltic tellin *Macoma balthica* and the common cockle *Cerastoderma edule* and the catworm *Nephtys hombergii*. The intertidal muds in the middle estuary support bivalves such as *Macoma balthica* and the estuarine fanworm *Manayunkia aestuarina*. The upper estuary supports the polychaete worms *Hediste diversicolor*, *Heterochaeta costata*, Tubificidae species and the crustacean *Corophium volutator*.

Littoral rock

10.5.9 Along artificial flood defences, piers and breakwaters from the outer estuary to the Humber Bridge and on intertidal rocks at Saltend, Paull and Killingholme, one finds assemblages of ephemeral green and red seaweeds, and brown algae such as spiral wrack *Fucus spiralis* and bladder wrack *Fucus vesiculosus*. Barnacles and snails of the genus *Littorina* spp. are also commonly found in this habitat.

Saltmarsh

10.5.10 There are an estimated 1 644 ha of coastal saltmarsh on the Humber.

10.5.11 The Humber estuary supports an area of approximately 783 ha of Atlantic salt meadows (Glauco-Puccinellietalia) on both its northern and southern banks, predominantly in sheltered areas such as Cherry Cobb sands and artificial embayments such as Welwick on the north bank. Salt-tolerant species, such as common saltmarsh-grass *Puccinellia maritima*, sea aster *Aster tripolium* and sea arrowgrass *Triglochin maritima* are characteristic of the habitat. On the south bank there are notable areas of saltmarsh near Tetney where the coast is sheltered by offshore banks, and south of Donna Nook where they front the North Lincoln shore coastal dunes systems and are again sheltered by extensive intertidal flats and offshore banks.

10.5.12 A variable extent of pioneer saltmarsh is present, found predominantly in the outer estuary on both the north and south banks with the largest concentration south of Cleethorpes. *Salicornia* known locally as samphire or glasswort is generally the first saltmarsh species to colonise the bare mudflats. Annual sea-blite *Suaeda maritima* is another common species of this habitat. These plants often form the lowest and most seaward zone of a saltmarsh where they are frequently flooded by the tide.

Reedbeds

10.5.13 Reed communities are common within the estuary and North Lincolnshire coasts, with extensive reedbed habitats in the middle to inner Humber estuary. Reedbed habitat are dominated by common reed *Phragmites australis* and sea club-rush *Scrirpus maritimus* especially in the inner estuary. Reedbeds are predominantly found throughout the inner estuary, with large areas being located at Blacktoft, Faxfleet-Broomfleet Island, Whitton Sand and the Barton and Barrow Clay Pits complex on the south bank. Blacktoft sands in the inner estuary is the second largest tidal reedbed in Britain and supports an almost continuous sward of *Phragmites australis* reedbed from the River Trent to opposite Blacktoft Clough. Additional smaller areas similarly line the banks of tidal rivers and main estuary.

10.5.14 In the outer estuary, *Phragmites australis* reedbeds account for only 0.4 ha of the North Lincolnshire coast. This community is restricted to brackish-freshwater areas of open water in borrowdykes, ponds south of Donna Nook, and at the head of a single saltmarsh creek system at Northcoates Point.

10.5.15 On the north shore, the majority of the *Phragmites* beds are located between Faxfleet and North Ferriby, although small and generally poor quality beds are present to the east and west (IECS, 1993). However, as with the south bank of the inner Humber, much of the reedbed vegetation along the north shore is restricted to a narrow strip between the flood defence embankment and the mean high water level (Allen *et al*, 2003).

Subtidal seabed

10.5.16 The subtidal environment of the Humber is highly dynamic with a variety of habitats (predominantly sandy with some patches of gravel and glacial till), comprising over 16 800 ha (46 percent) of the total area of the estuary.

10.5.17 Subtidal gravel and sands are variably distributed throughout the estuary. In the upper estuary, impoverished mobile sands support mysid shrimp and *Gammarus* species, whilst in the middle estuary, medium and fine sands support an infauna of polychaetes (*Capitella capitata*, *N. cirrosa*) and amphipod (Bathyporeia) species. The outer to middle estuary supports communities of polychaetes, crustaceans and bivalves found on very poorly sorted sandy shell gravel. More sheltered marine sands located on the southern side of the outer estuary are characterised by the polychaetes *Spiophanes bombyx* and *Spio filicornis.*

10.5.18 Subtidal muddy sands are found predominantly in the middle and outer estuary supporting "transitional" muddy sand communities with species such as the catworm *N. hombergii* and bivalve *M. balthica*.

Water Column

10.5.19 The estuarine water column provides habitat for free-living species such as plankton, fish and juvenile stages of benthic flora and fauna. Migratory fish species use the estuary to make the transition between the marine and freshwater environments.

Sand dunes

10.5.20 Sand dunes are restricted to the outer Humber on both the north and south bank of the estuary, most notably on Spurn Peninsula and further down the North Lincolnshire coast from Donna Nook to Mablethorpe. The supratidal dunes habitats of the outer estuary are dominated by sea-buckthorn (*Hippophae rhamnoides*) scrub. Other dune habitats present are fixed grey dunes, white dunes and embryonic shifting dunes (Allen *et al*, 2003).

Characteristic Flora and Fauna of the Middle Estuary

Introduction

10.5.21 The following paragraphs introduce the flora and fauna present in the middle part of the estuary with a focus on those species that are representative of the AMEP site. The site is characterised by a range of intertidal and subtidal estuarine habitats. It is considered typical of estuarine systems and associated habitats found along the North Sea coast of England.

Plankton and Algae

10.5.22 Most phytoplankton production is confined to the outer limits of the estuary and the plume extending into coastal waters. Surveys of intertidal macroalgae in the Humber Estuary indicate that species richness reduces upstream from the mouth of the estuary, with red and brown algae limited to lower estuarine stations and green algae predominant in the upper estuary. Common species include fucoid algae and opportunistic ephemerals such as *Enteromorpha* spp. and *Ulva* spp. These algae are also found attached to gravel high up in the intertidal mudflats at the AMEP site.

Salt marsh vegetation

10.5.23 At the proposed AMEP site, a very small patch of saltmarsh was recorded on the seaward side of the seawall, close to the mouth of the main drain onto the foreshore and also adjacent to the North Killingholme Haven Pits. During the Phase 2 Survey undertaken by Just Ecology in 2006 a number of different saltmarsh communities were identified within this area including sea couch (*Elymus pycnanthus*), saltmarsh rush (*Juncus gerardii*) and couch (*Elymus repens*).

Benthic invertebrate communities

10.5.24 Details of the benthic invertebrate communities identified for the estuary are included in *Table 10.1*. The following description is based on Hemingway *et al* (2008).

10.5.25 Sheltered hard substrata, intertidal mudflats and sandflats and subtidal sands and sandy mud dominate the middle estuary. The most extensive habitats at the AMEP site are the intertidal mudflats and subtidal muds. Salt marshes are found on the north shore and sheltered hard substrata are concentrated near port facilities and piers. Different benthic invertebrate communities are associated with these habitats.

Table 10.1 Characteristic benthic invertebrate communities in the Humber Estuary

	Habitat	Benthic invertebrate community	Extent Within the Estuary
Intertidal Sediment	Intertidal gravels and sands	Strand-line pebbles and sands with *Talitrus saltador*	Spurn, Cleethorpes
		Upper shore medium and fine sand with polychaetes	Found in the Outer Estuary (South bank) and some at Spurn
		Mid to lower shore clean mobile fine and medium sand with *Nephtys cirrosa*, *Scolelepis squamata* and amphipods	Extensive: Spurn Bight and Cleethorpes to Donna Nook
		Tide-swept mid to lower shore poorly sorted sand dense *Lanice conchilega*	Cleethorpes eastwards
	Intertidal muddy sands	Upper to mid shore muddy fine sand with dense *Arenicola marina* and bivalves	Cleethorpes to Donna Nook
	Intertidal muds	Mid shore sandy mud with *Macoma balthica* and *Cerastoderma edule*	Extensive in Outer Estuary, Spurn Bight and Cleethorpes eastwards
		Upper to mid shore mud with *Scrobicularia plana*	Part of Spurn Bight, South Bank. Extensive
		Variable salinity lower shore mud with *Nephtys hombergii* and *Caulleriella killariensis*	Ubiquitous in middle and Outer Estuary.
		Low salinity mid to lower shore mud with *Hediste diversicolor*, *Heterochaeta Costata*, Tubificidae spp. and *Corophium volutator*	Mid to upper estuary, on the South Bank
Subtidal Sediment	Subtidal muds	Subtidal sandy mud with *Scoloplos armiger* and *Phoronis muelleri*	Middle-Outer Estuary
		Subtidal mud with dense *Nephtys hombergii* and *Phoronis muelleri*	Outer Estuary
		Nearshore mud with *Macoma balthica*	Middle-Outer Estuary
		Subtidal mud/clay and sandy mud with *Polydora* sp., *Aphelochaeta* sp., *Pygospio elegans*, *Corophium* and *Tubificoides* spp.	Outer-Estuary
	Subtidal mixed sediment	Subtidal mixed muddy substrata with polychaetes, crustaceans and ascidians	Middle and Outer Estuary

Source: Allen *et al* (2003)

10.5.26 The benthic invertebrate communities at intertidal sites along the north and south banks of the Humber are typical for intertidal estuarine habitats and are largely controlled by salinity, shore height and sediment type/mobility. The intertidal muds and muddy sands in middle estuary support a benthic invertebrate community with a high abundance of individuals that is relatively more diverse than the communities in the less saline inner estuary upstream of Hull. Here, the banks include a series of relatively impoverished sites in mobile sand or cohesive mud. In the outer estuary, the marine sandy habitats are characterised by a less abundant but relatively diverse benthic invertebrate community.

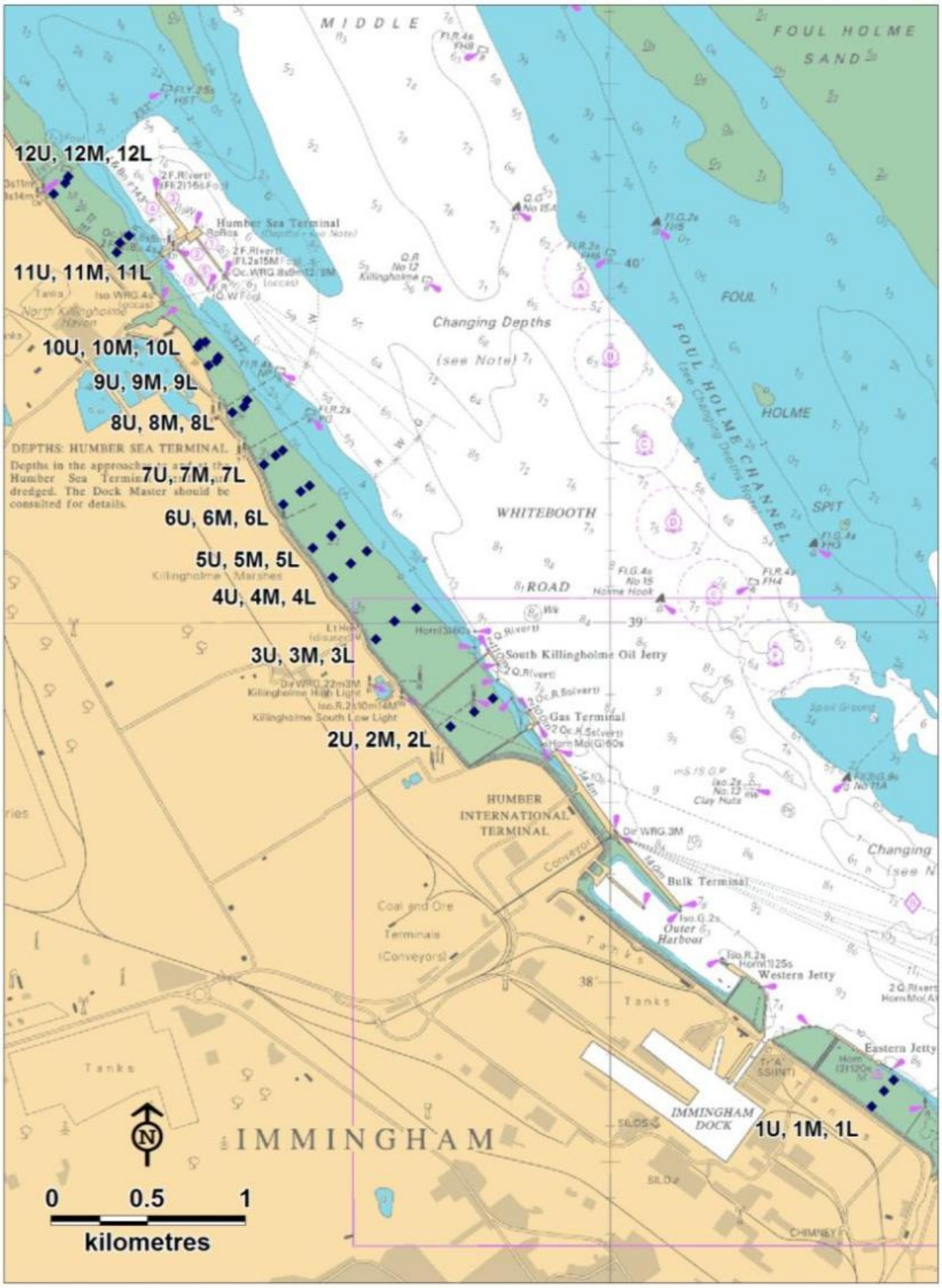
10.5.27 A more varied range of communities is evident in subtidal areas with species composition ranging from those characteristic of impoverished mobile upper estuarine or marine sands to those indicative of more stable muddy sands and muds. Species distribution appears to be primarily influenced by physical factors (salinity, sediment type, tidal regime). Four main groups of sites that appear to be consistent (classified by their position in the estuary) are broadly similar in extent to those defined for intertidal habitats but with the middle estuary section often showing some division between an inner area and an outer area. Research by Fugii (2007) has shown that intertidal habitats with higher macrobenthic biomass were significantly positively related to higher salinity, muddier sediments, wider beach and shallower beach slopes that are typical of the lower and outer regions of the estuary, where extensive shallow muddy intertidal areas can be found.

10.5.28 The epibenthic invertebrate fauna is characterised by crustaceans (Decapods). Species present in the Humber area include edible crab (*Cancer pagurus*), velvet crab (*Necora puber*) lobster (*Homarus gammarus*) and pink (*Pandalus* spp.) and brown shrimp (*Crangon* spp.) which are particularly abundant in the coastal area. Large seasonal abundances are also recorded for small crustacean groups like mysis and euphausiids (krill or opossum shrimp).

10.5.29 The AMEP site incorporates part of Killingholme Marshes intertidal mudflat, which is that habitat from Mean High Water Spring Tide (MHWS) to Mean Low Water Spring Tide (MLWS). The total intertidal mudflat between the Humber Sea Terminal and Immingham Port is approximately 54.6 ha. Of this an area of 31.5 ha (57.7 percent) is located within the footprint of the proposed AMEP.

10.5.30 An intertidal and subtidal benthic survey was undertaken at the AMEP site in May 2010. The aim of these surveys was to provide baseline data on the marine ecology within the area. A total of 36 intertidal samples were taken along 12 intertidal transects with 3 samples taken on each transect (*Figure 10.3*). Thirty subtidal benthic samples were taken using a 0.1 m² hamon grab. The sampling stations of this survey are illustrated on *Figure 10.4*. The following paragraphs provide a summary of the survey results. The full methodology and the results of the survey can be found in *Annex 10.1*.

Figure 10.3 Intertidal benthic sampling stations May 2010

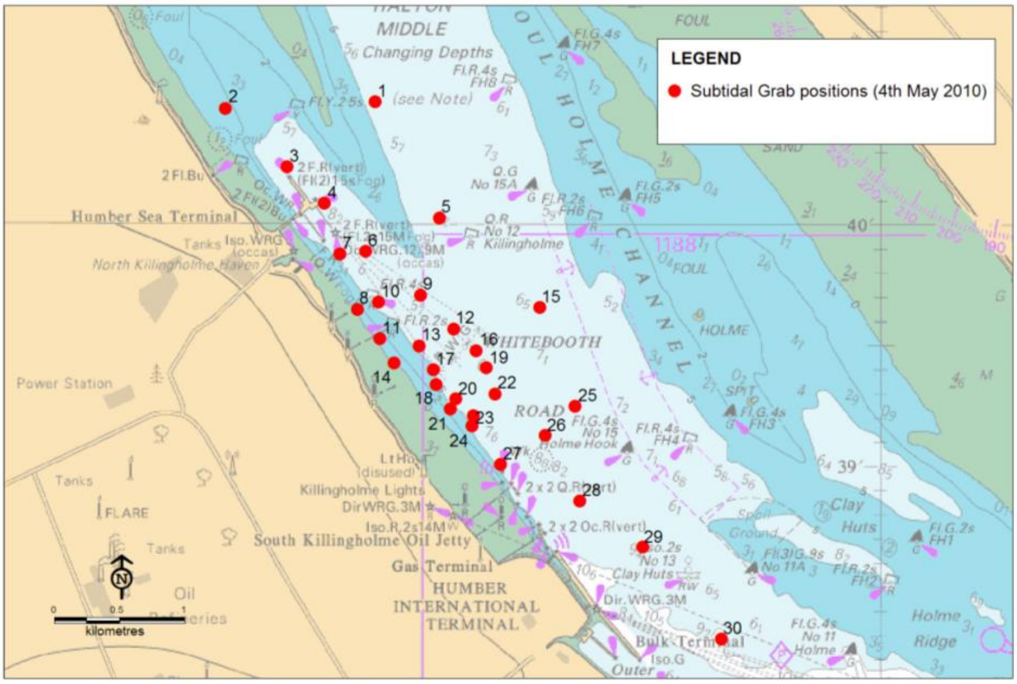


Source: IECS (2010). South Humber Channel Marine Studies: Intertidal and Subtidal Benthic & Fish Surveys 2010. Report to Yorkshire Forward. ZBB752-F1-2010-Benthic & Fish

10.5.31 The most commonly occurring species in the intertidal samples were the oligochaete *Tubificoides benedii*, Nematoda, the polychaete *Streblospio shrubsolii* and the amphipod crustacean *Corophium volutator*. These species were present in most of the samples and were present at higher abundances than all other species throughout the survey area. The bivalve *Macoma balthica* was widespread and the polychaete *Hediste diversicolor* was present at most of the upper shore stations.

10.5.32 *T. benedii* was the dominant species at the upper and mid shore intertidal stations. *S. shrubsolii* was dominant at the lower shore intertidal stations where the sediments were presumably sandier.

Figure 10.4 Location of subtidal benthic sampling stations



Source: IECS (2010). South Humber Channel Marine Studies: Intertidal and Subtidal Benthic & Fish Surveys 2010. Report to Yorkshire Forward. ZBB752-F1-2010-Benthic & Fish.

10.5.33 Species richness (number of species recorded) ranged from 2-9 species/sample (mean = 5.8). Abundance (number of individuals/sample) ranged from 5-197 (mean = 46.4) and biomass ranged from <0.001 to 1.37 g/sample (mean = 0.18 g/sample) and was generally higher at stations where *H. diversicolor* was found.

10.5.34 All species found are typical for the intertidal area of the middle region of the Humber Estuary, with moderate abundance and diversity of mostly common species. There are no species of particular conservation importance although those present are key prey species for birds.

10.5.35 The results of the spring/summer 2010 subtidal survey suggest a species richness that ranged from 0-17 (including colonial taxa) (mean = 4) with values of 5 or less being recorded from all but 2 stations. The most widespread species (occurring in the greatest number of samples) was the polychaete *Capitella capitata* with the barnacles *Balanus improvisus* and *Elminius modestus* being the most abundant species.

10.5.36 Abundance ranged from 0-184 individuals/sample (mean = 15) with abundance in most samples being less than 20. Biomass ranged from <0.001 to 15.5 g/sample (station 21) (mean = 0.56) with values at most stations being <0.05 g.

10.5.37 The highest species richness and abundance values were recorded from one particular station (station 21) where high numbers of barnacles were found together with *Actiniaria* (Anthozoa), *Hartlaubella gelatinosa* (Hydrozoa), the polychaetes *Polydora cornuta* and *Arenicola marina*, *Mytilus edulis* (Bivalvia) and the bryozoans *Electra crustulenta*, *E. monostachys* and *Flustra foliacea*. The species at this station were indicative of coarse sediments (many epifaunal, colonial and sedentary species.

10.5.38 Considering the whole data set, the barnacle *B. improvisus* was the dominant species, together with *Arenicola marina* and *Streblospio shrubsolii*. However, the distribution of *B. improvises* was patchy and should not be considered a characterising species for the survey area as a whole. There were no species of particular conservation interest.

10.5.39 Two dedicated fish surveys have also been undertaken. The results are reported in the following paragraphs. Part of the catch consisted of motile epibenthic invertebrate species, dominated by the common shrimp (*Crangon crangon*), a species of economical importance in the east coast. Occasional large catches of mysids and euphausiids were also recorded although the mesh size used in the beam trawl was too large to provide a truly quantitative assessment. It is likely, however, that these organisms are present in large numbers throughout and represent the base of the local food chain leading to the subtidal fish fauna recorded in this assessment. A gear effect probably also confounded the shellfish assessment resulting in the recording of large shore crabs only.

Overview of fish fauna

10.5.40 The estuarine habitat in the Humber is an important habitat for fish. Over the course of several years of fish surveys, the Institute of Estuarine & Coastal Studies of the University of Hull has recorded a total of 86 species in the Humber (Pérez-Dominguez, 2008). The fish assemblage is made up of estuarine, freshwater, marine and migratory species.

10.5.41 Fish communities in the middle and lower reaches of the Humber Estuary are dominated by small bodied demersal gobid species of the genus *Pomatoschistus* and juvenile stages of larger species that use the estuary as a nursery ground (especially shallow areas and the intertidal zone). This component is often the most common with typically 80 percent or more of the total abundance. Typical examples are flounder (*Platichthys flesus*), plaice (*Pleuronectes platessa*), sole (*Solea solea*), whiting (*Merlangius merlangus*), spratt (*Sprattus sprattus*), seabass (*Dicentrarchus labrax*), cod (*Gadus morhua*), herring (*Clupea harengus*), lesser weaver fish (*Echiichthys vipera*), and pollock (*Pollachius virens*).

10.5.42 In addition to this large group of mostly demersal or benthic juveniles (exceptions are sprat and herring juveniles that are pelagic), the Humber Estuary features a number of estuarine residents, and diadromous fish species which use the estuary as passage to or from fresh water areas. The most common examples of the resident group are flounder, five-bearded rockling (*Ciliata mustela*), pogee (*Agonus cataphractus*), sea snail (*Liparis* sp.), Nilsson's pipefish (*Syngnathus rostellatus*) and three-spined stickleback (*Gasterosteus aculeatus*). Smelt (*Osmerus eperlanus*), eel (*Anguilla anguilla*) and river lamprey (*Lampreta fluviatilis*) are on the other hand the most common of the diadromous species.

10.5.43 Finally a number of marine species appear occasionally in catches, most of them following a marked seasonality with higher probability of capture in the summer and early autumn. Of relevance for this last group are sand eels (*Ammodytes* sp.), lumpsucker (*Cyclopterus lumpus*), witch (*Glyptocephalus cynoglossus*), dab (*Limanda limanda*), grey mullets (*Liza* sp.), brill (*Scopthalmus rhombus*), short-spined sea scorpion (*Taurulus bubalis*), bib (*Trisopterus luscus*), and dragonet (*Callionymus lyra*).

10.5.44 The presence of migratory species reflects the importance of the Humber Estuary. Migratory fish species of particular conservation importance within the Humber Estuary include the Atlantic salmon, sea trout, twaite shad, eel and smelt. Both the eel and the smelt are listed as a BAP priority species and the sea and river lamprey form part of the Humber Estuary SAC and SSSI designations. The latter two species are present in the estuary to some degree all year round, although numbers increase during summer and autumn periods when migration takes place. Areas particularly important for salmon migration are far upstream from AMEP site in the estuary's tributaries: the Rivers Ouse, Ure, Wharfe and Derwent.

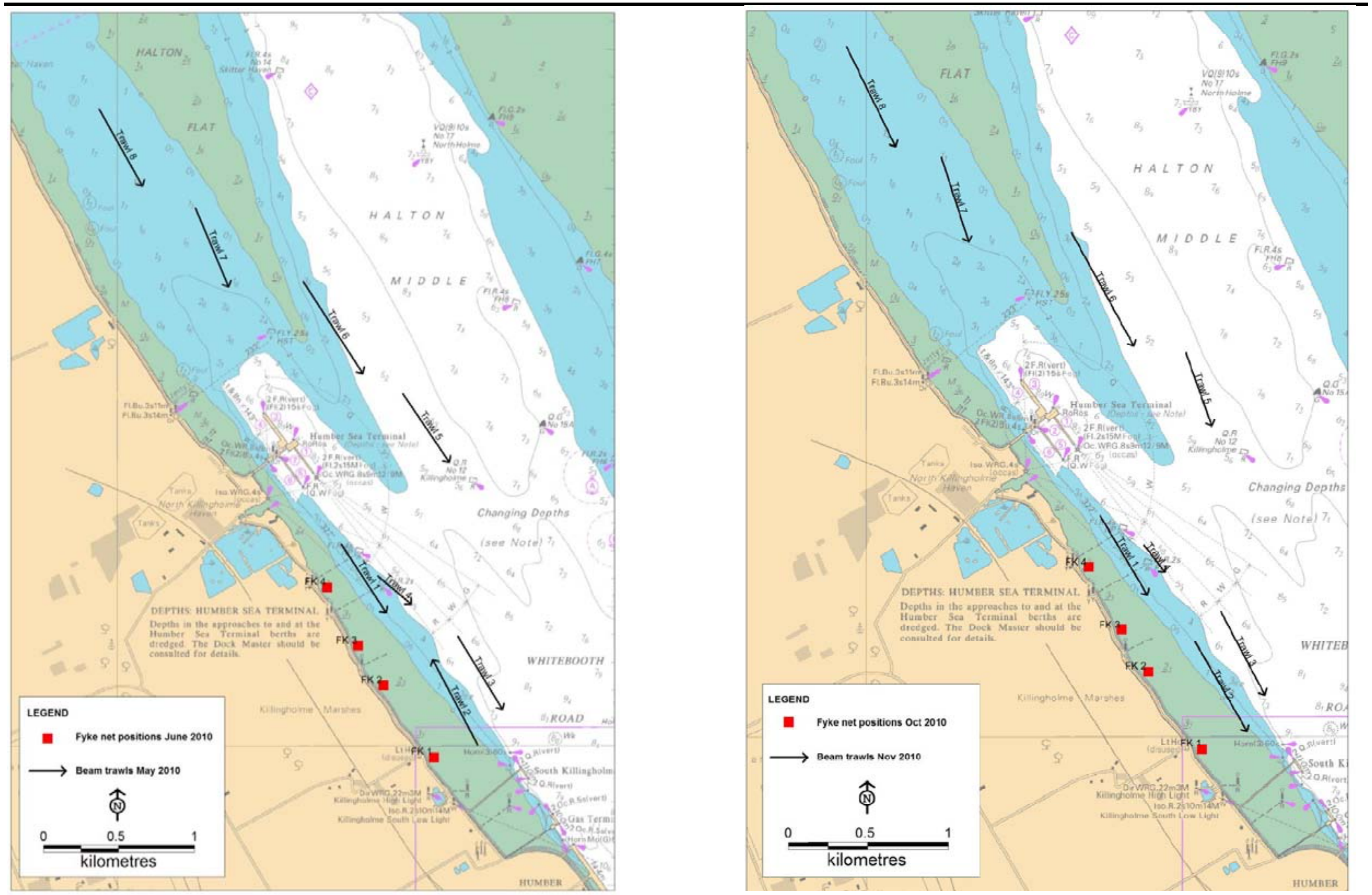
10.5.45 The majority of the fish species rely on benthic food sources, in particular the benthic infauna and mysid shrimps. Larger species prey on brown shrimp and shellfish. Almost all fishes produce eggs, but there is a large degree of reproductive strategies. Eggs are released in open water where they become part of the plankton, or are deposited on suitable substrates.

Fish Fauna at the AMEP Site

10.5.46 Two fish and shellfish surveys were conducted in the immediate area around the project site in May / June 2010 and October / November 2010, each comprising four fixed fyke net positions in the intertidal and eight 2 metre beam trawls over subtidal habitat (see *Figure 10.5*).

10.5.47 Details of the intertidal and subtidal fish surveys, including methodology, station positions, deployment and retrieval information, and weather conditions, is presented in *Annex 10.1*.

Figure 10.5 Fyke net and trawl locations - May / June 2010 (left) and October / November (right)



Source: IECS (2010). South Humber Channel Marine Studies: Intertidal and Subtidal Benthic & Fish Surveys 2010. Report to Yorkshire Forward. ZBB752-F1-2010-Benthic & Fish. (left); IECS (2011) South Humber Channel Marine Studies: Intertidal and Subtidal Fish Surveys 2010. Data Report to Able UK. ZBB764-F-2011- Fisheries (right)

10.5.48 The abundance of each species within each fyke net for the May / June survey and the October / November survey is presented in *Table 10.2* and *Table 10.3* respectively.

Table 10.2 ***Abundance data for each of the four intertidal double ended fyke nets (west and east) – May/June survey***

Taxon	**Common Name**	**Fyke Net 1**		**Fyke Net 2**		**Fyke Net 3**		**Fyke Net 4**	
		West	East	West	East	West	East	West	East
Carcinus maenas	Shore crab							5	
Ciliata mustela	5-bearded rockling					1			
Pollachius pollachius	Pollack							1	
Pomatoschistus minutus	Sand goby								1
Platichthys flesus	European flounder	2			3	3		4	10
Solea solea	Common sole							6	3
	Total Taxa	**1**	**0**	**0**	**1**	**2**	**0**	**4**	**3**
	Total Abundance	**2**	**0**	**0**	**3**	**4**	**0**	**16**	**14**

Source: IECS (2010) South Humber Channel Marine Studies: Intertidal and Subtidal Benthic & Fish Surveys 2010. Report to Yorkshire Forward. ZBB752-F1-2010-Benthic & Fish.

Table 10.3 ***Abundance data for each of the four intertidal double ended fyke nets – October/November survey***

Taxon	**Common Name**	**Fkye Net 1**	**Fyke Net 2**	**Fyke Net 3**	**Fyke Net 4**
Carcinus maenas	Shore crab	1	1	2	54
Crangon crangon	Brown shrimp	94	50	62	61
Ciliata mustela	5-bearded rockling	1	3	8	9
Merlangius merlangus	Whiting	11	18	28	3
Pollachius pollachius	Pollack				1
Pomatoschistus minutus	Sand goby	1		1	
Platichthys flesus	European flounder	6	17	12	
Solea solea	Common sole	6	26	39	4
	Total Taxa	**7**	**6**	**7**	**3**
	Total Abundance	**120**	**115**	**152**	**132**

Source: IECS (2011) South Humber Channel Marine Studies: Intertidal and Subtidal Fish Surveys 2010. Data Report to Able UK. ZBB764-F-2011- Fisheries

10.5.49 Given the background information available for the Humber Estuary and adjacent coastal area, and the gear selectivity profile of fyke nets, the fish and shellfish assemblage found during the surveys was considered normal. However, the summer abundance was low compared to previous survey programs (Pérez-Dominguez, 2008).

10.5.50 The summer catch was dominated by benthic flatfishes (flounder and sole) most probably year class 1+ flounder (born the year before) and mostly year class 0+ sole (born in present year), which highlights the role of the area (typical mudflat) as a flatfish nursery. Sand goby (*Pomatoschistus minutus*) was recorded but due to the small size of this fish it is normally misrepresented in fyke net catches.

10.5.51 Whiting, common sole, five-bearded rockling and flounder dominated the fyke net catches (intertidal) during the autumn survey. Common sole juveniles and whiting were also present.

10.5.52 The following tables present the raw fish abundance data from each of the eight beam trawls for the summer and autumn surveys.

Table 10.4 Abundance data for the subtidal trawl survey – May/June survey

Taxon	**Common name**	**Trawl Number**							
		1	2	3	4	5	6	7	8
Gastrosaccus spinifer	Opossum shrimp		1			6	1		
Neomysis interger	Opossum shrimp	14		6		144	7	2	7
Praunus flexuosus	Chameleon shrimp	1			3	8	2		1
Schistomysis kervillei	Mysid shrimp	25	6	35	50	696	86	19	28
Schistomysis spiritus	Mysid shrimp	3		2	5	96	3	1	7
Dexamine spinosa	Gammarid amphipod	1	2	5	4				1
Gammarus zaddachi	Gammarid amphipod				8	3		2	
Idotea linearis	Isopod						1		
Diastylis rathkei	A cumacean				1				
Pelaemon longirostris	Delta prawn			4	1				
Crangon crangon	Common shrimp	68	19	84	77	87	103	17	84
Carcinus maenas	Shore crab	1		1		1	3		1
Lampetra fluviatilis	River lamprey			1					
Ciliata mustela	Fivebeard rockling	4							
Merlangius merlangus	Whiting			1		3			
Trisopterus luscus	Bib					2	1		
Syngnathus rostellatus	Nilsson's pipefish	1		1					
Liparis liparis	Sea snail						1		
Pomatoschistus minutus	Sand goby	10	15	4	8	30	7		4
Platichthys flesus	European flounder			1					
Solea solea	Common sole	2	6			2	3	1	2
	Total Taxa	**10**	**6**	**12**	**9**	**11**	**13**	**6**	**10**
	Total Abundance	**126**	**52**	**145**	**150**	**1077**	**226**	**41**	**137**

Source: IECS (2010). South Humber Channel Marine Studies: Intertidal and Subtidal Benthic & Fish Surveys 2010. Report to Yorkshire Forward. ZBB752-F1-2010-Benthic & Fish.

Table 10.5 Abundance data for the subtidal trawl survey – October/November survey

Taxon	Common name	Trawl Number							
		1	2	3	4	5	6	7	8
Pandalus montagui	Aesop shrimp			10			3	5	1
Crangon crangon	Brown shrimp	57	21	236	49	164	272	156	408
Carcinus maenas	Shore Crab		3	2	1	4	4	3	
Merlangius merlangus	Whiting	12	7	31	3	2	1	7	2
Agonus cataphractus	Pogee						1		
Liparis montagui	Seasnail	1		4			1	2	2
Pomatoschistus minutus	Sand goby	1	5	64	6	16	29	31	10
Glyptocephalus cynoglossus	Witch			1		4		2	1
Platichthys flesus	European Flounder						4		2
Pleuronectes platessa	Plaice								1
Solea solea	Common sole	1	2	1		1	2	2	7
	Total Taxa	**5**	**5**	**8**	**4**	**6**	**9**	**8**	**9**
	Total Abundance	**72**	**38**	**349**	**59**	**191**	**317**	**208**	**434**

IECS (2011) South Humber Channel Marine Studies: Intertidal and Subtidal Fish Surveys 2010. Data Report to Able UK. ZBB764-F-2011- Fisheries

10.5.53 Similar to the intertidal assessment, the subtidal assemblage is consistent with previous results for the area with a real dominance of sand goby in both the summer and autumn surveys. Interestingly flounder (the more abundant species in the intertidal catch) was recorded only once in the summer survey and 6 times in the autumn survey. This observation suggests the greater importance of the intertidal zone for flounder. Whiting were also common in the autumn survey, although not so in the summer survey. Common sole juveniles and whiting were also present.

10.5.54 Sole caught in the summer subtidal assessment were substantially larger that those found in the fyke nets. This is remarkable and clearly shows a segregation of sole year classes and indicates a distinct habitat dependency between 0+ sole and older juveniles. This segregation was not observed in autumn, although sole juveniles were present.

10.5.55 The remaining species recorded are common but similar to the intertidal assessment; these were recorded at somewhat lower abundances than expected. This effect, found to be consistent across the two survey techniques, may be associated with natural fluctuations of fish stocks as a consequence of recruitment failure.

10.5.56 The results of the surveys have highlighted the importance of the area as a nursery habitat especially for flounder, common sole and whiting. It also confirmed the presence of brown shrimp, which has a dual fishery importance; as a target fishery species and a key element of the local fish food webs.

Marine Mammals

10.5.57 The Humber Estuary supports populations, or is regularly visited by, a number of marine mammals. Notable species are the harbour porpoise *Phocoena phocoena* and the grey seal *Halichoerus grypus* and the common or harbour seal *Phoca vitulina vitulina.*

10.5.58 The harbour porpoise is the smallest and most abundant of all cetaceans. It is the most frequently sighted cetacean species in the North Sea, sighted throughout the year, particularly between July and November when calving occurs. Harbour porpoises are generally seen in small groups of up to three individuals. Population estimates suggest that approximately 280 000 occur in the North Sea (Reid et al, 2003).

10.5.59 The area around Spurn Head and the outer Humber Estuary is considered to be an important coastal site in England for harbour porpoise. Rare sightings have been reported in the Humber Estuary including in the vicinity of the development site and further upstream.

10.5.60 Grey seals are the larger and more abundant of the two seal species in British waters, with around 120 000 animals (over 40 percent of the world's population) breeding in Britain. Distribution in the UK is centred in the north west around the Hebrides and Northern Isles, although grey seals are common around the coasts of Scotland and Northern England.

10.5.61 The Humber Estuary SSSI is a nationally important site for a breeding colony of grey seals and is one of the largest breeding colonies in England with a high rate of pup production compared to other UK sites. The majority of grey seal activity is believed to take place at a large colony at Donna Nook, approximately 30 km south east of the development site on the Lincolnshire coast. This site is one of the largest and most accessible breeding colonies of grey seals in the UK. The most recent years count (2008) revealed the grey seal pup production at Donna Nook to be 1 358. The number of pups born at monitored sites (which include Donna Nook) has shown an increasing trend since 1984. The total UK population in 2005 was estimated to be between 97 000 and 159 000. A total of 1 276 pups were born at Donna Nook during 2005 (SCOS, 2006).

10.5.62 Grey seals pup during the winter between October and January, with males coming ashore before females and securing a territory. Females give birth and suckle their young for three weeks, during which time females will often not feed. This is particularly the case if there is no immediate sea access from the rookery. The Stonebridge rookery at

Donna Nook has limited access to the sea and females here have been reported to stay with their pups until they are weaned (Lidgard, 1996). Grey seals feed primarily on fish living on or close to the seabed, particularly sandeels, whitefish and flatfish, averaging 4-7 kg of fish per seal per day (SCOS, 2006). They are likely to be found in the Humber Estuary and have the potential to be found in the vicinity of the development site.

10.5.63 There are 50 000 to 60 000 common seals in British waters. The main concentrations on the east coast are in the Moray Firth, Tay Estuary and The Wash: 88 percent of the population is in Scotland and 12 percent in England, with The Wash harbouring the largest population in England. The common seal Donna Nook population is fairly healthy but decreased to 231 after the phocine distemper virus epidemic. In 2000, population estimates in The Wash stood at around 2 124 animals and 470 at Donna Nook (SCOS, 2006). In 2008 the population was 250. Variation between 200-300 may be due to day to day variability in haul out counts rather than population decline or increase. Current pups produced in 2009 were 1417.

10.5.64 Common seals feed locally, taking a variety of prey but mainly sandeels, whitefish, herring, sprat, flatfish, octopus and squid. They have a requirement for 3-5 kg of food per day. Common seals forage generally within 50 km of their haul out site (Fedak and Thompson, 1993). Common seals may change haul out sites to be closer to better foraging grounds, to join new social groups or to move to a site more suitable for pupping. Females tend to be faithful to pupping grounds and return to breed between June and September year after year. Donna Nook, a known haul out area for common seals, is located approximately 30 km to the south east of the development site, on the Lincolnshire coast. It is possible that common seals may be found in the vicinity of the development site, although less likely than grey seals.

10.5.65 Very rare visitors include the white-beaked dolphin and the bottle-nose dolphin. Both are rarely reported around the Humber Estuary area.

Protected Sites

Introduction

10.5.66 The Humber is an important estuary from the point of view of marine nature conservation, with a number of international and national designations in and around the AMEP site (see *Figure 10.1* at the end of the chapter). The following section elaborates on specific nature conservation status of the estuary.

10.5.67 The conservation of habitats through their designation as key sites has been Government strategy at European, national and local level for many years. The development site lies partly within the Humber Estuary SPA (Special Protection Area) which is also a Special Area of Conservation (SAC), a Site of Special Scientific Interest (SSSI) and a Ramsar site.

International and National Designated Marine and Coastal sites

10.5.68 *Table 10.6* lists the main designated sites and the reasons for their designation.

Table 10.6 Designated sites in and near the Humber Estuary

Site Name and distance from AMEP site (km)	**Reasons for Designation**
Humber Estuary SPA AMEP lies partly within SPA	The Humber Estuary qualifies as a SPA under Article 4.1 of the Birds Directive as it supports bird populations of several species of European importance that are listed on Annex I of the Directive and by regularly supporting at least 20,000 waterfowl. Details are presented in *Chapter 11*.
Humber Estuary SAC AMEP lies partly within SAC	This SAC was designated for habitats listed in Annex I, namely estuaries; and mudflats and sandflats not covered at low tide The Humber Estuary also includes other habitats which are listed as Annex I Habitats, including: • sandbanks which are slightly covered by seawater all the time; • coastal lagoons; • *Saliconia* and other annuals colonising mud and sand; • Atlantic sea meadows (*Glauco-Puccinallietalia maritimae*); • embryonic shifting dunes; • shifting dunes along the shoreline with *Ammophilia arenaria* ('white dunes'); • fixed dunes with herbaceous vegetation ('grey dunes'); and • dunes with *Hippophae rhamnoides*. Grey seals *Halichoerus grypus*, river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus* are Annex II species present in the Humber Estuary and are a qualifying feature, but again not a primary reason for the site selection.
Humber Estuary Ramsar Site AMEP lies partly within Ramsar site	The Humber Estuary is designated as a Ramsar Site due to it meeting the following criteria: Ramsar criterion 1: The site is a representative example of a near-natural estuary with various component habitats including dune systems and humid dune slacks, estuarine waters, interitidal mud and sandflats, saltmarshes, and coastal brackish/saline lagoons;

Site Name and distance from AMEP site (km)	Reasons for Designation
	Ramsar criterion 3: The Humber Estuary Ramsar site supports a breeding colony of grey seals *Halichoerus grypus* at Donna Nook. It is the second largest grey seal colony in England and the furthest south regular breeding site on the east coast. The dune slacks at Saltfleetby-Theddlethorpe on the southern extremity of the Ramsar site are the most north-easterly breeding site in Great Britain of the natterjack toad *Bufo calamita*; Ramsar criterion 5: Assemblages of international importance (153 934 waterfowl, non-breeding season, five year peak mean 1996/97 - 2000/01); Ramsar criterion 6: species / populations occurring at levels of international importance including Eurasian golden plover (*Pluvialis apricaria*), Red knot (*Calidris canutus*), Dunlin (*Calidris alpine*), Black-tailed godwit (*Limosa limosa*), Common redshank (*Tringa tetanus*), Common shelduck (*Tadorna tadorna*), Eurasian golden plover (*Pluuvialis apricaria*), Red knot (*Calidris canutus*), Dunlin (*Calidris alpina*), Black-tailed godwit (*Limosa limosa*), Bar-tailed godwit (*Limosa lapponica lapponica*), Common redshank (*Tringa totanus*); and Ramsar criterion 8: the Humber Estuary acts as an important migration route for both river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus* between coastal waters and their spawning areas.
Humber Estuary SSSI AMEP lies partly within SSSI boundaries	The Humber Estuary is a nationally important site and includes a series of nationally important habitats such as the estuary itself and the associated saline lagoons, sand dunes and standing waters. The site is of national importance for the geological interest at South Ferriby Cliff and for the coastal geomorphology of Spurn. The estuary supports nationally important numbers of 22 wintering waterfowl and nine passage waders, and a nationally important assemblage of breeding birds of lowland open waters and their margins. It is also nationally important for a breeding colony of grey seals *Halichoerus grypus*, river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus*, a vascular plant assemblage and an invertebrate assemblage.
North Killingholme Haven Pits SSSI 0.05 km from AMEP site	This SSSI comprises a complex of four flooded clay pits with associated rough grassland and scrub. It attracts a variety of waders and wildfowl and is important for its saline lagoon habitat. Nine species of specialist lagoonal invertebrates have been recorded from the pits which include the polychaete worm *Alkmaria romijni*, which is known from just four sites in Great Britain. Other species of note include the prawn *Palaemonetes varians*, the molluscs *Hydrobia ventrosa* and *Hydrobia neglecta* and the bryzoan *Conopium seurati*. The number of specialist lagoonal species is exceptionally high in North Killingholme Haven Pits and particularly so for their latitiude.

Site Name and distance from AMEP site (km)	Reasons for Designation
	It provides suitable habitat for diving ducks, such as pochard (*Aythya ferina*), tufted duck (*Aythya fuligula*) and, occasionally, scaup (*Aythya marila*). Breeding species including little grebe (*Tachybaptus ruficollis*), and reed (*Acrocephalus scirpaceus*), sedge (*Acrocephalus schoenobaenus*), willow (*Phylloscopus trochilus*) and grasshopper warblers (*Locustella naevia*). Spotted redshank (*Tringa erythropus*), dunlin, greenshank (*Tringa nebularia*), common sandpiper (*Actitis hypoleucos*), little ringed plover (*Charadrius dubius*), ruff and black-tailed godwit, the latter often in large numbers, are regular visitors.
Kirmington Pits, SSSI 8.5 km from AMEP site	Geological SSSI. Designated for its national geological importance for its complex sequence of glacial and interglacial deposits up to 30 metres thick occupies a buried channel.
Kelsey Hill Gravel Pits, SSSI 8.8 km from AMEP site	Geological SSSI. Designated for its national geological importance due to exhibiting the representative exposure of a sequence of Ice Age (Pleistocene) deposits typical to this area.

Source: Natural England

Humber Estuary Ramsar Site

10.5.69 The Ramsar Convention on Wetlands is an intergovernmental treaty providing a framework for national action and international cooperation for the conservation of wetlands and their resources. Criteria used to assess this site for inclusion within the Ramsar listings are presented in *Table 10.6* above.

10.5.70 The Humber Estuary Ramsar site is designated for vegetation interests including extensive reedbeds, areas of mature and developing saltmarsh, grazing marsh or low sand dunes and brackish pools. The site regularly supports internationally significant numbers of various species of breeding and wintering birds as well as many passage birds, notably internationally important populations of Ringed plover *Charadrius hiaticula* and Sanderling *Calidris alba*. The site supports Britain's most south easterly breeding colony of Grey seal *Halichoerus grypus*. The Humber Estuary acts as an important migration route for both river lamprey and sea lamprey between coastal waters and their spawning areas.

Humber Estuary SAC

10.5.71 Special Areas for Conservation (SACs) are designated under the EC Habitats Directive. Article 3 of the Directive requires a European ecological network of special areas of conservation to be set up under the title Natura 2000. This network, composed of sites hosting the natural habitat types listed in Annex I and habitats of the species listed in Annex II, shall enable the natural habitat types and the species' habitats concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range. The listed habitat types and species are those considered to be in most need of conservation at a European level (excluding birds, which are covered by Special Protection Areas under the EC Birds Directive).

10.5.72 The conservation objectives for this site, subject to natural change, are to maintain the habitats and geological features in favourable condition, with particular reference to any dependent component special interest features (habitats, vegetation types, species, species assemblages etc.) for which the land is designated (SSSI, SAC, SPA, Ramsar) (Natural England, 2009).

10.5.73 The favourable condition of habitats is defined at this SAC in terms of the following site-specific standards (*Table 10.7*).

Table 10.7 Humber Estuary European Marine Site Conservation Objectives - Habitats

Habitat Feature (BAP Broad Habitat level, or more detailed level if applicable)	Estimated extent (ha) and date of data source/ estimate	Site Specific Target
Estuary	Total: 36 657 ha (SAC boundary)	No reduction in extent of estuary feature, except due to natural processes. The intra- and inter estuarine tidal prism / cross section ratio, average temperate and average salinity should not change significantly, except due to natural change.
Littoral sediment: (Coastal Saltmarsh)	Total: 1 643 ha Source: Humber Estuary SSSI – Supporting information – Issued by English Nature's Humber	No reduction in extent from the established baseline, subject to natural change.

Habitat Feature (BAP Broad Habitat level, or more detailed level if applicable)	Estimated extent (ha) and date of data source/ estimate	Site Specific Target
	to Pennines Team on 3 February 2004	
Littoral sediment (mudflats and sandflats)	9 382 ha Estimated using Ordnance Survey (OS) Landline intertidal and OS Mastermap.	No reduction in extent of the littoral sediment biotope(s) identified for the site allowing for natural succession/known cyclical change. Shore profile should not change significantly, except due to natural change. Average abundance of macroalgal mats should not increase, except due to natural change. Average sediment characteristics should not change significantly, except due to natural change. Intertidal communities range and distribution should not change significantly, except due to natural change.
Inshore sublittoral sediment (Sandbanks which are slightly covered by sea water at all times)	Grimsby Middle; 206-236 ha Middle Shoal; 252-340 ha Bull Sand; 355-486 ha Extents were calculated in 2000, 2002, 2005, 2007. Source: Humber Subtidal Sandbanks (R.1489) 2008. ABPmer Ltd	No reduction in extent of inshore sublittoral sandbanks allowing for natural succession /known cyclical change. Depth and average grain size parameters should not change significantly, except due to natural change. Distribution and extent of gravel and sands and / or muddy sands biotopes should not change significantly, except due to natural change.
Saline Lagoons	Total: 22.77 ha	No reduction in extent of

Habitat Feature (BAP Broad Habitat level, or more detailed level if applicable)	Estimated extent (ha) and date of data source/ estimate	Site Specific Target
	Humberston Fitties: 1.75 ha Northcoates Point A 1.82 ha Northcoates point B 2.2 ha Blacktoft Sands 17 ha Source: Humber Estuary SSSI – Supporting information – Issued by English Nature's Humber to Pennines Team on 3 February 2004	saline lagoon area. N.B. Northcoates Point lagoons lie outside the coastal protection works and are subject to natural coastal processes which may affect extent. Seasonal salinity and average light penetration should not change significantly, except from natural changes. No increase in extent or cover of green algal mats, except due to natural change. Average shoot density of *Chaetomorpha linum* and *Ruppia spp* should not change significantly, except due to natural change.
Sand dunes (Fixed-dunes with herbaceous vegetation, "grey dunes"	Total: 31.63 ha Source: Bullens (2001), Dargie (2001) as summarised in Humber Estuary SSSI – Supporting information – Issued by English Nature's Humber to Pennines Team on 3 February 2004	No reduction in extent from the established baseline, subject to natural change.
Sand dunes (Fixed-dunes with herbaceous vegetation, "grey dunes"	Total: 66.13 ha *Hippophae rhamnoides* scrub Source: Bullens (2001), Dargie (2001) as summarised in Humber Estuary SSSI – Supporting information – Issued by English Nature's Humber to Pennines Team on 3 February 2004	No reduction in extent from the established baseline, subject to natural change.
Sand dunes Strandline, embryo and mobile dunes	Total: 39.14 ha Source: Bullens (2001), Dargie (2001) as	No reduction in extent from the established baseline, subject to natural

Habitat Feature (BAP Broad Habitat level, or more detailed level if applicable)	Estimated extent (ha) and date of data source/ estimate	Site Specific Target
	summarised in Humber Estuary SSSI – Supporting information – Issued by English Nature's Humber to Pennines Team on 3 February 2004	change, although location may change.
Sand dunes Dune slacks	Total: 11.49 ha Source: Bullens (2001), Dargie (2001) as summarised in Humber Estuary SSSI – Supporting information – Issued by English Nature's Humber to Pennines Team on 3 February 2004	No reduction in extent from the established baseline, subject to natural change.
Standing open water and canals	Total 209.3 ha Source: ENSIS Units 111, 113, 116-122, 124, 126, 127, 129-137, 140-143, 145-146, Freshwater wetlands, last modified 06/06/06)	No reduction in the extent of standing water

Source: Natural England (2003, 2009) and references therein.

10.5.74 The favourable condition of species is defined at this site in terms of the following site-specific standards (*Table 10.8*).

Table 10.8 Humber Estuary European Marine Site Conservation Objectives - Species

Species Feature (species or assemblage)	Population Attribute (e.g. presence/absence, population size or assemblage score)	Site Specific Target
Grey seal Halichoerus grypus	Pup production in the SAC/SSSI	A stable or increasing number of breeding female grey seals in the SAC/SSSI/ASSI
	Distribution of grey seal pups within the SAC/SSSI	A stable or increasing area of usage within the SAC/SSSI/ASSI

Species Feature (species or assemblage)	**Population Attribute (e.g. presence/absence, population size or assemblage score)**	**Site Specific Target**
	Accessibility of SAC/SSSI for breeding	An accessible breeding site
River lamprey (*Lampetra fluviatilis*) Sea lamprey (*Petromyzon marinus*)	Population a. Age structure (*Lampetra* sp. only)	For samples of 50 or less, at least two distinct size classes should normally be present. If more than 50 ammocoetes are collected, at least three size classes should be present.
	Population b. Distribution within catchment	Lampreys should be present at not less than 2/3 of sites surveyed. As a minimum, there should be no reduction in the distribution of ammocoetes within the catchment. Where barriers to migration or pollution issues are thought to be a problem, the population should be classed as being in unfavourable condition and targets for an appropriate increase should be set.
	Population c. Ammocoete density	*Lampetra* spp: Optimal habitat: >10 m^{-2}, Chalk streams >5 m^{-2}, Overall catchment mean:>5m^{-2} *Petromyzon*: Ammocoetes should be present in at least four sampling sites, each not less than 5 km apart.
	Population d. Spawning Activity (Sea Lamprey only)	No reduction in extent of spawning activity year on year
	River morphology	No artificial barriers significantly impairing adults from reaching existing and historical spawning grounds.
	Negative indicators	No stocking of other fish species at excessively high densities

Species Feature (species or assemblage)	Population Attribute (e.g. presence/absence, population size or assemblage score)	Site Specific Target
	Water quality	Biological GQA Class: b/B Chemical GQA Class: B Dissolved Oxygen (DO): - DO should not fall below 2mg/l - DO should not fall below 5mg/l for more than 5 consecutive days - Following a period of DO of less than 5mg/l there should be at least 2 consecutive days where DO remains above 5mg/l Suspended solids: Annual mean <25 mg/l
	Flow	As a guideline, flow should be at least 90% and not more than 110% of the naturalised daily flow throughout the year.
	River morphology	Maintain the characteristic physical features of the river channel, banks and riparian zone.

Source: Natural England (2009) and references therein.

Humber Estuary SPA

10.5.75 Special Protection Areas (SPAs) are designated under Article 4 of the EC Directive on the Conservation of Wild Birds, also known as the Birds Directive, which came into force in April 1979. SPAs are classified for rare and vulnerable birds, listed in Annex I to the Directive, and for regularly occurring migratory species, many of which depend on the estuary for food. The outline of the Humber Estuary SPA coincides with the Humber Estuary SAC. Details of the species of conservation interest present and conservation objectives are presented in *Chapter 11*.

National Designated Marine and Coastal Sites

10.5.76 Sites of Special Scientific Importance (SSSIs) are areas of special interest for wildlife, geology and landforms as notified under the *Wildlife and*

Countryside Act 1981. *The Countryside and Rights of Way Act 2000* gives additional protection to SSSIs, which are awarded a particular level of protection against damaging activities to preserve the natural heritage. PPS9 (Biodiversity and Geological Conservation) 2005 sets out government policy with regard to protecting such areas. Some coastal SSSIs (below) could potentially be affected by AMEP.

North Killingholme Haven Pits SSSI

10.5.77 North Killingholme Haven Pits (22 ha) are situated on south bank of the Humber Estuary near Immingham, adjacent and to the north of the development site. They are also part of the Humber Estuary SPA and Ramsar site. The site is designated primarily because of the importance of the pits as large saline lagoons with an exceptionally rich fauna, and their significance as roosting and feeding grounds for waterfowl, which occur in internationally important numbers in the Humber Estuary in winter. The site comprises three pits of differing size and salinity, both factors which contribute to its national and local importance.

10.5.78 Nine species of specialist lagoonal species recorded from the pits include the polychaete worm *Alkmaria romijni*, which is known from just four sites in Great Britain. Other species of note include the prawn *Palaemonetes varians*, the molluscs *Hydrobia ventrosa* and *Hydrobia neglecta* and the bryzoan *Conopium seurati*. Water levels within the lagoons vary and provide expanses of open mud for visiting waterfowl, especially waders. Amongst these are nationally important numbers of black-tailed godwits, which have visited the site in increasing numbers since the late 1980s. There are also occasional visits by large flocks of roosting redshank. These visitors indicate that the site forms an integral part of the estuarine feeding and roosting opportunities for the internationally important populations of winter waterfowl for which the Humber Estuary is noted.

10.5.79 The lagoons are fringed with common reed *Phragmites australis* and sea club-rush *Scirpus maritimus*, providing valuable feeding and breeding grounds for a range of summer migrants such as reed and sedge warblers. The seed heads of the reeds are also a food supply for bearded tit, which occur along the Humber Estuary in nationally important numbers. Bittern are also regular winter visitors. The site is fringed in places with thick hawthorn scrub which also provides important bird habitat.

10.5.80 The SSSI comprises four lagoons (that make up the collection of disused clay extraction pits at the site. The small western most pit is a deep water pit with a reedbed at the northern end and a narrow reed fringe along the western side. It lies alongside the access road to industrial compounds and is fairly heavily disturbed.

10.5.81 The pit which lies to the west of the railway track is quite shallow and in recent years it has been invaded by *scirpus* and *phragmites* to the extent that it is now principally a large reedbed with some enclosed areas of open water. A series of small islands within the pit have been surrounded by *phragmites*. Thorn scrub has also grown high along the northern and eastern edges of the pit. The pit was formerly important for roosting waders but the spread of *scirpus* and *phragmites* and the development of scrub around the water areas has all but removed this facet of the pit's importance.

10.5.82 The large pit to the east of the railway track is now the major site for roosting waders and waterfowl within the site. Water levels within the pit can be altered by a pipe connected with the adjacent Humber Estuary. Typically water levels are maintained at a level which provides a variable expanse of open mud within the pit to attract roosting and feeding waders. This shallow water and mud area lies along the northern end of the pit; the remainder of the pit has deeper water and is more attractive to waterfowl.

10.5.83 The smallest of the pits comprises two areas of open water with a variable reed fringe adjacent to a thicket of thorn on the south eastern side, and bounded by the car parking area to the south and west. The water is deep and attracts small numbers of diving duck and has occasionally produced records of wintering Bittern. Water Rails are frequent.

Humber Estuary SSSI

10.5.84 The Humber Estuary SSSI is a large site covering some 37 000 ha over the entire estuary from the entrance to the North Sea at Spurn Head upstream past Hull. The site contains a series of nationally important habitats, including the estuary itself (with its component habitats of intertidal mudflats and sandflats and coastal saltmarsh) and the associated saline lagoons, sand dunes and standing waters. The site is also of national importance for the geological interest at South Ferriby Cliff (Late Pleistocene sediments) and for the coastal geomorphology of Spurn Head. The estuary supports nationally important numbers of 22 wintering waterfowl and nine passage waders, and a nationally important assemblage of breeding birds of lowland open waters and their margins. It is also nationally important for a breeding colony of Grey seals *Halichoerus grypus*, River lamprey *Lampetra fluviatilis* and Sea lamprey *Petromyzon marinus*, a vascular plant assemblage and an invertebrate assemblage.

Local Designated Marine and Coastal Sites

10.5.85 The *National Parks and Access to the Countryside Act 1949* gives local planning authorities the power to acquire, declare and manage Local Nature Reserves (LNRs). These reserves are designated as being of particular importance to nature conservation and public understanding of nature conservation issues is encouraged. Within the Humber Estuary there are two Local Nature Reserves; Waters Edge and Cleethorpes.

Waters Edge LNR

10.5.86 Waters Edge LNR is located on the south bank of the Humber Estuary upstream of the development site at Barton upon Humber (approximately 15 km north west of North Killingholme). In winter, dunlin, ringed and grey plover, redshank, knot and bar-tailed godwit all feed on the mudflats at low tide. In May and August passage waders such as curlew, sandpiper and whimbrel are present, whilst black-tailed godwit and oystercatcher have been frequent visitors in recent winters. The upper shore supports saltmarsh with cord-grass, sea plantain, scurvy grass and sea aster. There are also areas of common reed. Kingfishers are frequently seen at the site in winter and mixed flocks of finches feed on the seeds of the saltmarsh plants. The site's freshwater lakes are important for wildlife, and the clay pits provide some substitute for the wetlands of Lincolnshire lost through drainage. The water at Far Ings is rich in microscopic life which provides food for many invertebrates, which in turn support fish such as eel, roach, rudd and perch. Heron, grebes and kingfisher feed on the fish. Many duck – including mallard, pochard and tufted duck – nest on the islands and margins. In winter many more wildfowl visit the site, including wigeon, teal, goldeneye and gadwall, goosander and occasionally smew. Great crested grebe, little grebe and water rail also nest.

Cleethorpes LNR

10.5.87 Cleethorpes LNR is a coastal site covering Cleethorpes beach. It is designated for the reasons described above for the Humber Estuary SSSI and is also covered by that designation.

Non-statutory Marine and Coastal Sites

10.5.88 There are several Local Wildlife Trust reserves within and adjacent to the Humber Estuary. Details of these sites are set out in *Table 10.9*.

Impacts of AMEP on these sites are considered, where such impacts are relevant to the receptors identified in *Section 10.3.10*.

Table 10.9 Local Wildlife Trust Reserves Within or Adjacent to Humber Estuary

Site	Local Wildlife Trust	Size (ha)
Dawson City Clay Pits	Lincolnshire Wildlife Trust	16
Far Ings National Nature Reserve	Lincolnshire Wildlife Trust	59
Pasture Wharf	Lincolnshire Wildlife Trust	21
Barrow Haven Reedbed	Lincolnshire Wildlife Trust	13
Fairfield Pit	Lincolnshire Wildlife Trust	9
Killingholme Haven Pits	Lincolnshire Wildlife Trust	32
Winteringham Foreshore	Lincolnshire Wildlife Trust	21
Donna Nook National Nature Reserve	Lincolnshire Wildlife Trust	1150
Saltfleetby-Theddlethorpe Dunes NNR	Lincolnshire Wildlife Trust - managed by Natural England	952
Spurn Point National Nature Reserve	Yorkshire Wildlife Trust	320
Welwick Saltmarsh	Yorkshire Wildlife Trust	42
Hodgsons Field	Yorkshire Wildlife Trust	43

Source:
http://www.hull.ac.uk/coastalobs/general/conservation/designationsites.html#lnr
http://www.lincstrust.org.uk/reserves/nr/index.php

Priority Biodiversity Action Plan (BAP) or Habitat Action Plan (HAP) status.

10.5.89 Different priority species and habitats can be found in the Humber Estuary, including habitats and species of principal importance for the purpose of conserving of biodiversity under the *Natural Environment and Rural Communities Act 2006*. The habitats and species of international conservation interest have been addressed in *Table 10.7* and *Table 10.8*. *Table 10.10* lists species designated as species of national conservation importance and describes their particular sensitivities and seasonal presence in the Humber Estuary.

Table 10.10 National Priority Species and Sensitivities

Species	Importance	Sensitivity	Seasonality
FISH			
Allis Shad (*Alosa alosa*)	Diadromous species. Protected by national and international legislation. SAP and BAP species. Also listed on Annexes II and V of the Habitats Directive. The only documented recordings of allis shad have come from power station impingement data.	Noise pollution, avoidance to high frequency sounds. Potentially affected by piling noise	May - June (spawning run). Summer (juveniles migrating to sea).

Species	Importance	Sensitivity	Seasonality
Twaite Shad (*Alosa fallax*)	Diadromous species. SAP and BAP species. Also listed on Annexes II and V of the Habitats Directive. Migration upriver usually occurs in May. Juveniles migrate to the river mouth during the summer.	Noise pollution, avoidance to high frequency sounds. Potentially affected by piling noise	May- June (spawning run). Summer (juveniles migrating to sea).
European eel (*Anguilla anguilla*)	Diadromous species. Estuary used for habitat by elvers (young eels) and adults. Currently there is much concern about decreasing numbers across Europe. Humber estuary LBAP species.	Demonstrated avoidance behaviour to low frequency noise. Potentially affected by piling noise. Pollution, overfishing, habitat degradation, parasite infection and changes in climate have all been forwarded as potential causes of the decline in numbers.	All year
River lamprey (*Lampetra fluviatilis*)	Jawless diadromous species. In August adults undergo a reproductive migration from the sea to rivers. Adults die after spawning. Juveniles migrate to sea after metamorphosis at approximately 13 cm. Protected by national and international legislation. UK BAP species. Also listed on Annexes II and V of the Habitats Directive.	Noise and electro-magnetic frequency (EMF) effects unknown. The species has no swim bladder and are thus believed only to be susceptible to noise in the near field. Pollution, river engineering works and changes in land use have impacted upon this species. It is believed that River lamprey tend to migrate up the banks of the estuary and are therefore more vulnerable to disturbance localised to the shore.	August to November (spawning run). Juveniles spend four to six years buried in estuarine substrate.
Sea lamprey (*Petromyzon marinus*)	Jawless diadromous species. Adults migrate up rivers in March and April, but spawning takes place the following year between May and July. Shortly after spawning they die. After hatching, the larvae burrow into the sediment where they live for three to five years. Current population much reduced from historical	Unknown sensitivity to underwater noise or EMF. The species has no swim bladder and are thus believed only to be susceptible to noise in the near field. Pollution and changes in land use have affected this species. River construction works have prevented migration along many traditionally used rivers.	All year for both adults and juveniles. Sea lampreys spawn in June – August and are usually easily observed at traditional spawning sites during these months

Species	Importance	Sensitivity	Seasonality
	levels. Protected by national and international legislation. UK BAP species. Also listed on Annex II of the Habitats Directive.	Sea lamprey tend to migrate up the middle of the estuary and are therefore less vulnerable to disturbance localised to the shore.	
Smelt (*Osmerus eperlanus*)	Inshore diadromous fish most common in estuaries and river mouths. These fish group together in the estuarine zone for reproduction and spawns on sandy or gravely bottoms. Reproduction takes place between February and April, depending on water temperature. Of conservation importance protected by national and international legislation. Humber estuary LBAP species.	Species is considered to have medium population resilience and moderate vulnerability.	Concentrate in winter at estuaries. February - April (spawning run)
Atlantic salmon (*Salmo salar*)	Diadromous species that return to freshwater to spawn in the streams in which they were born. Estuary is part of their migratory route. Predatory fish important for coastal and fresh water zones. UK BAP Species. Humber estuary LBAP species	Sensitive to underwater noise. Unknown effects of EMF on orientation during migration. River pollution can affect this species and man-made obstacles such as dams, weirs or the alteration of watercourses make migration impossible.	June to October / November (Adults - spawning run). Predominantly during March to June smolt migrate to sea.
Brown trout (*Salmo trutta*)	Migratory species of conservation interest in the Humber. Migratory ecotype of the species closely related to *S. salar*. Similar ecology to *S. salar*. UK BAP Species. Humber estuary LBAP species.	Same as *S. salar*.	
Plaice (*Pleuronectes platessa*)	Marine migrant species. Uses estuaries, mudflats and saltmarsh as nursery habitats (entering as juveniles, staying there until the sub-adult stage is attained, then migrating	Like most flatfishes, not particularly sensitive to noise. Population stocks may be affected by coastal squeeze, but this has not been confirmed.	

Species	Importance	Sensitivity	Seasonality
	seawards). Humber Estuary supports 15 % of the population of east coast juvenile plaice. Grouped commercial fish action plan species.		
Marine Mammals			
Common seal (*Phoca vitulina*)	Found in coastal waters of the continental shelf and slope. The common seal lives mainly along shorelines and in estuaries. May occasionally visit the estuary. UK BAP species. Also listed on Annexes II and V of the Habitats Directive.	Sensitivity to underwater noise and noise in air.	All year.
Grey seal (*Halichoerus grypus*)	Donna Nook, at the mouth of the estuary supports a breeding colony of grey seals. Pupping occurs in autumn. Listed on Annexes II and V of the Habitats Directive. Also protected under Schedule 5 of the Wildlife and Countryside Act 1981.	Grey seals are sensitive to disturbance by people and dogs, particularly when lactating. Sensitivity to underwater noise and noise in air.	All year. Pupping occurs in autumn.
Harbour porpoise (*Phocoena phocoena*)	Found in shallow water, most often nearshore. It frequents relatively shallow bays, estuaries, and tidal channels and will swim a considerable distance up river. May occasionally visit the estuary. UK BAP species. Also listed on Annexes II and V of the Habitats Directive.	Noise pollution is an identified threat. Sensitive to underwater noise.	All year.
Saline Lagoon Species			
Lagoon Sand Shrimp (*Gammarus insensibilis*)	The lagoon sand shrimp is a lagoonal specialist species for which little published biological and ecological information exists. Species found in the Humberston Fitties Lagoon (Lincolnshire). UK BAP species. Saline lagoons are a Habitat	Sensitive to changes in their habitat, such as changes in the salinity regime or changes caused by anthropogenic coastal activities. High sensitivity to an increase in turbidity.	All year.

Species	Importance	Sensitivity	Seasonality
	action plan habitat and are an Annex I habitat. Protected under Schedule 5 of the Wildlife and Countryside Act 1981. Nationally scarce species.		
Tentacled lagoon worm (*Alkmaria romijni*)	Inhabits lagoons and sheltered estuarine sites, where it lives in a mud tube in muddy sediments. Has been recorded in the Killingholme pool. Nationally scarce species. Protected under Schedule 5 of the Wildlife and Countryside Act 1981.	Lagoonal habitats are threatened by pollution, sea level rise and natural development into other habitats.	All year.
Spire snail (*Hydrobia neglecta*)	Lagoonal species. Found in the Killingholme pool. Rare species.		All year.

Sources: Fishbase.org, ARKive.org, Harbasins Report: Habitat Status of the Humber Estuary, UK, Harbasins Report; Harbasins Report: Fish Pilot Studies in the Humber Estuary, UK JNCC, UKBAP, sealifebase.org
Note: Species Action Plan (SAP); Local Biodiversity Action Plan (LBAP).

10.6 IMPACTS

10.6.1 This section identifies and assesses the potentially significant impacts associated with the construction and operational phases of the AMEP. Mitigation measures can be found in *Section 10.7* and Residual Impacts after mitigation has been taken into account can be found in *Section 10.8*.

Construction Phase

10.6.2 There are a number of impacts to the estuarine environment and aquatic ecology receptors that may arise during the construction phase of AMEP. Full details of the description of the AMEP and the proposed construction processes are set out in *Chapter 4*. The assessment also looks at impacts to the aquatic ecosystem in general, noting that many of the marine habitats and organisms present in the area are key to the estuary-dependent bird species and fisheries. Impacts on the latter receptors are discussed in *Chapter 11* and *Chapter 12* respectively.

10.6.3 The activities / causes of impact that are discussed in this section are:

10.6.4 Dredging

- Habitat change from substrate removal;
- Habitat and benthic communities disturbance from the sediment plume;
- Disturbance to fish from construction activity noise and vibration due to dredging;
- Indirect changes to habitats from project-induced changes in hydrodynamic and morphodynamic regimes; and
- Disturbance to fish and fish eggs/larvae from habitat loss and disturbance.

10.6.5 Dredge Disposal

- Loss of subtidal habitat and benthic communities from dredge spoil disposal;
- Habitat and benthic communities disturbance from the sediment plume;
- Indirect changes to habitats from project-induced changes in hydrodynamic and morphodynamic regimes; and
- Disturbance to fish and fish eggs/larvae from habitat loss and disturbance.

10.6.6 Quay Construction

- Loss of habitat (intertidal and subtidal) and benthic communities from land take required for the quay;
- Creation of new hard substrata habitat;
- Habitat disturbance from water quality changes in the vicinity of outfalls;
- Indirect changes to habitats from project-induced changes in hydrodynamic and morphodynamic regimes;
- Disturbance to fish from habitat loss and construction activity noise and vibration;
- Disturbance to marine mammals from construction activity noise and vibration;
- Disturbance to marine mammals from reduced prey availability; and
- Changes to aquatic environment in adjacent water bodies.

10.6.7 Construction Run Off

- Habitat and benthic community disturbance from water quality reduction due to site drainage;
- Habitat and benthic community disturbance from water quality reduction due to oil or maintenance products from machinery run off; and

- Disruption to fish from habitat disturbance due to a change in water quality.

10.6.8 In the assessment below impacts are grouped together by activities or impacts of a similar nature that will occur during the construction phase. As such, impacts from several activities have been assessed together. For example, impacts from underwater noise from dredging and piling have been assessed together within the assessment of construction noise, inherently assessing the impact collectively. Cumulative impacts with other projects are assessed in *Section 10.9*.

Loss of Habitat and Benthic Communities

10.6.9 Loss of benthic habitat will occur as a result of dredging, dredge spoil disposal and the development of the quay in the estuarine environment. Loss of habitat may have indirect impacts on fish distribution, as discussed in *Indirect Impacts to Fish* below. Dredging will cause a direct change to subtidal habitat through substrate removal. Removal of the substrate may also alter the habitat type due to the alteration of sediment particle size distribution and remove the benthos with the dredged sediment. The sediment plume from both dredging and dredge spoil disposal may also smother benthic species and cause a change in habitat by altering the sediment particle size distribution, especially where large volumes of sediment are released to the seabed at the dredge disposal site (see *Habitat Disturbance* below). Construction of the quay will cause a loss of intertidal and subtidal habitat beneath the direct footprint of the structure. The combined loss of habitat is therefore considered likely to significantly damage the ecosystem structure and function.

10.6.10 Loss of habitat and benthic communities is assessed to be of a local scale restricted to the zone of influence (ie the dredged area, dredge disposal sites and the quay footprint). The total volume of dredged sediment amounts up to approximately 1.9 million m^3. The total subtidal project footprint at the AMEP site is estimated at 13.5 ha, which is <0.1 percent of the overall subtidal estuarine habitat of 16 800 ha. Similarly, 31.5 ha of intertidal habitat will be lost under the quay footprint. This includes a few individual salt marsh plants close to the mouth of the main drain onto the foreshore and also adjacent to the North Killingholme Haven Pits. Benthic communities in the direct footprint of the quay will be lost, however, once completed the quay itself will provide limited additional habitat (see *Creation of New Hard Substrata Habitat* below). Recovery of benthic communities following dredging and dredge disposal may occur, however, it depends on the nature of the new sediment as well as sources and types of re-colonising animals. Full recovery of macrobenthic invertebrates from dredging activities in soft subtidal habitats has been recorded to take between two and three years (Borja *et al*, 2010), however, given the predicted sedimentation at the AMEP (see *Chapter 8*) regular maintenance dredging will be required and benthic communities will not fully recover. Full recovery at the disposal sites is also unlikely given the regular use of the sites and a recovery time of more than 1.5 years (Borja *et al*, 2010). The disturbed areas are therefore likely to become dominated by opportunistic species. Considering the above, benthic community loss as a result of habitat loss at the quay and dredging sites is regarded as a permanent effect.

10.6.11 The subtidal habitat (predominantly mud – see ***Error! Reference source not found.***) is widespread in the vicinity of AMEP and in the estuary, however, the type of habitat may locally differ due to sediment particle size changes and there will be a reduction of intertidal and shallow subtidal area. The presence of the quay is also conducive to the development of additional intertidal areas at the expense of subtidal area (see *Indirect Changes to Intertidal and Subtidal Habitats* below). The contribution of the site to wider ecosystem structure and functioning in terms of intertidal and subtidal habitat availability and complexity may therefore be adversely affected.

10.6.12 The effect of habitat and benthic community loss arising from the AMEP is considered permanent, although no loss of benthic species diversity or benthic species of conservation concern is expected. However, a significant negative impact to habitats and benthic communities is predicted as a proportion of subtidal and intertidal habitat will be lost.

Creation of New Hard Substrata Habitat

10.6.13 Construction of the quay will provide hard substrata habitat that will over time become colonised by benthic species typical of hard substrate. This new habitat may provide additional food sources and shelter for fish. However, creation of new hard substrata habitat is not considered likely to significantly alter the ecosystem structure and function given the limited area available for colonisation and the existence of other hard substrata areas in the estuary, such as gravel beds and littoral rock.

10.6.14 As hard substrata are already present in the estuary construction of the quay will not introduce a new habitat type to the estuary, however, it will marginally increase the proportion of this habitat. The extent of habitat creation is therefore considered very small at the local scale.

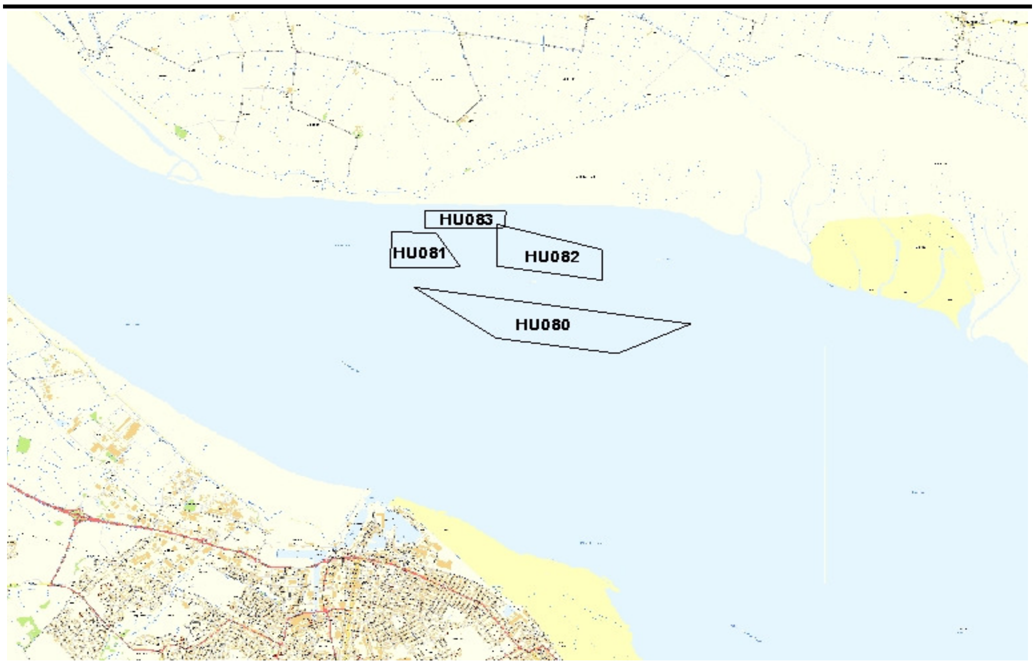
10.6.15 Although the effect of habitat creation arising from AMEP is long term (for the life of AMEP), a significant impact is not predicted due to the very small proportion of additional hard substratum habitat created.

Habitat Disturbance

10.6.16 Habitat disturbance will occur as a result of sediment plumes from dredging and dredge spoil disposal as well as water quality changes due to construction run off and site drainage. Habitats that may be affected are the intertidal, subtidal and water column habitats. Habitat disturbance to fish in the vicinity of the AMEP is discussed in *Indirect Impacts to Fish* below. Habitats may also be disturbed by underwater noise, which has been assessed separately below (see *Direct Impacts to fish and Marine Mammals*).

10.6.17 The construction of the AMEP requires a significant capital dredging operation. The dredged material consists of erodible (soft clay, silt, sands and gravels) and unerodible (glacial till) material, which will be dumped at separate sites. Site HU080 (Middle Shoal) has been proposed as the disposal ground for the erodible material, whereas the sites HU081, HU082 and/or HU083 have been proposed as the non-erodible material disposal site (*Figure 10.7*). The disposal of the stiff glacial till clay is unlikely to affect habitats as it is not expected to add significantly to background suspended sediment concentrations or disperse outside the dumping ground in the form of a plume due to the strongly cohesive nature of the material; monitoring results of similar material dumped at the site also suggest that this material will add a negligible amount to the background suspended sediment concentrations (*Chapter 8)*. The erodible material, however, may affect the water column habitats and smother benthos as a passive plume is likely to develop. Sediment plumes from dredging disperse both vertically and horizontally in the water column and the extent and area over which they disperse are dependent on several factors, including the strength and direction of currents and winds and the sediment particle size (Posford Duvivier Environment and Hill, 2001). Although the majority of erodible material will be contained within the dynamic plume and settle on the bed of the estuary (ie virtually all coarse material, such as sand and gravels) immediately around the disposal site (approximately within a radius of 100 m), a proportion of the finer material will be entrained into the passive plume and will disperse away from the disposal site with the currents.

Figure 10.7 *Dredge Disposal Sites*

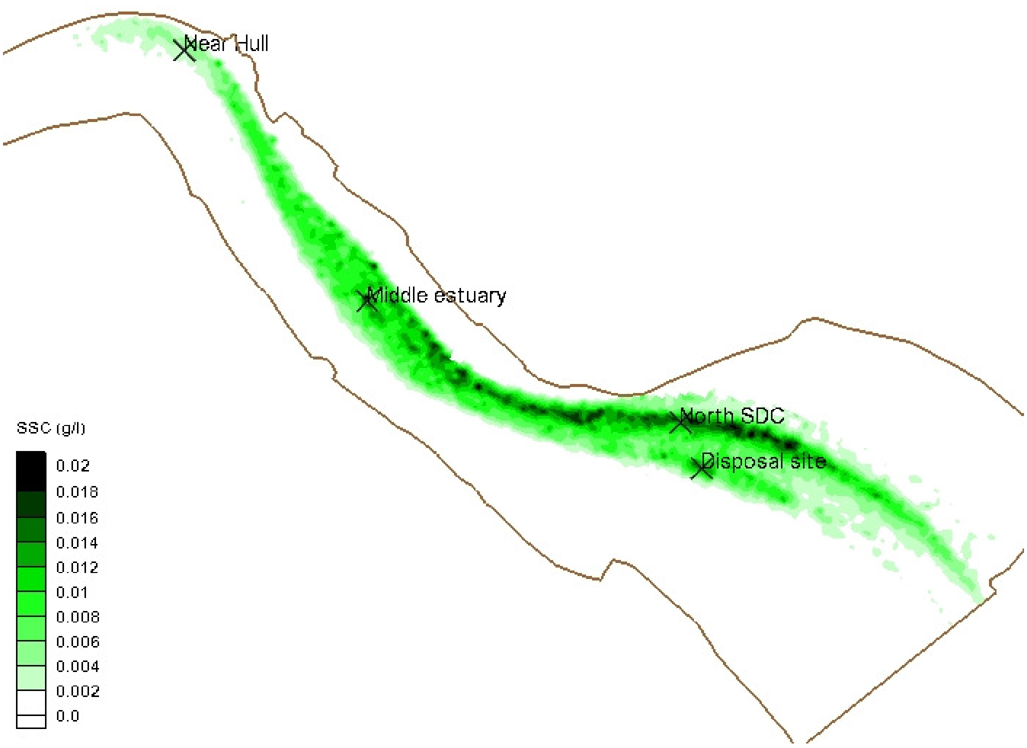


Source: CEFAS (2011) Pers. Comm.

10.6.18 Disposal of the erodible material has been assessed using sediment plume modelling (*Chapter 8*). Model results of the fate of the passive plume resulting from sediment dumped at the Middle Shoal disposal site are presented in *Figure 10.7*. For model details see *Chapter 8*. *Figure 10.8* shows the average suspended sediment concentration (in addition to background levels) over the last day of sediment release throughout the Humber Estuary as the suspended sediment travels back and forth with the tidal currents up to Hull and down to the estuary mouth. Short-term increases in suspended sediment concentration occur in the tidal channels within the estuary of up to 80-100 mg/l by the end of the disposal programme, although short lived peaks of 250 mg/l may occur at the dumping site. Upon cessation of sediment release suspended sediment concentrations quickly decrease as the sediment disperses within the estuary or leaves the estuary on successive outgoing tides.

10.6.19 Sediment plumes also occur at the dredge site (ie at and in the vicinity of the AMEP) through the action of the draghead on the seabed and overspill from the hopper. However, the plume resulting from dredging is likely to be relatively small compared to the dredge disposal plume due to the much smaller quantity of sediment suspended.

Figure 10.8 ***Average Suspended Sediment Concentration during the Last Day of a 14-day Period of Intermittent Sediment Release at the Middle Shoal Disposal Site***



Source: *Annex 8.1 AMEP Modelling Studies*

10.6.20 There is high natural variation and range in suspended sediment concentrations in the Humber Estuary. This may be in part due to regular sediment disturbance, such as dredging and sediment disposal, that occurs frequently in the Humber Estuary as part of other projects and ongoing maintenance dredging. Recent measurements at the Humber Sea Terminal (to the north of the AMEP) give a range of 200 mg/l to 1,600 mg/l (IECS, 2010). Concentrations are even greater further upstream. Therefore increases in sediment concentration due to dumping and the likely concentrations during dredging are within the general range of suspended sediment concentrations found in the Humber and no significant impacts to the water column habitat are expected.

10.6.21 The Humber Estuary supports high macrobenthic biomass but low diversity and few rare species (Mieszkowska, 2010). Benthic communities from habitats with high natural turbidity, such as the Humber, are generally less sensitive and more resilient to disturbance by increased levels of turbidity (Eggleton *et al*, 2011). However, some changes in benthic communities (ie a reduction in density and diversity) may occur as a result of smothering and/or changes in sediment composition; these changes will be greatest in the areas subject to highest deposition rates (Ware *et al*, 2010). Disposal sites within the Humber are frequently used and benthic communities in these areas are likely to already be disturbed. Disposal sites for non erodible material are separate to those for erodible material and are used less frequently. Some individuals may be lost at the dredge disposal site or in areas of high deposition through smothering and/or the clogging filter feeding apparatus. However, many benthic organisms found in the Humber, such as the cockle *Cerastoderma edule* and the ragworm *Hediste diversicolor* (Fujii, 2007), are relatively tolerant to physical disturbance and smothering and able to survive a thin covering by sediments or will be able to move away, burrow up or extend siphons into the water column. Recovery of benthic communities is also expected within 3 years, as described in *Paragraph 10.6.10*. Given the high natural variability of suspended sediments in the Humber Estuary and the natural recoverability of benthic communities no significant impacts to the benthic communities and their role in ecosystem functioning are expected due to habitat disturbance from the sediment plume. Furthermore, all dredged sediment will be retained in the Humber Estuary system through disposal at the designated sites with the exception of a fraction of resuspended finer sediments that leaves the estuary on successive tides.

10.6.22 Construction site drainage and run off may also reduce water quality. Impacts to water quality are assessed in *Chapter 9*. Non-contaminated drainage and drainage containing oil or maintenance products may run off into the marine environment resulting in gully formation and local water quality changes (see *Chapter 9*). Water quality changes from construction run off are likely to be limited to the immediate area surrounding the quay and are not likely to cause changes to intertidal habitats in the vicinity of the quay. Any contaminants will quickly become diluted to background levels and will therefore not adversely affect the water column habitat or benthic communities.

10.6.23 Given the above assessment a significant negative impact on habitats or benthic communities from the effect of habitat disturbance arising from construction of AMEP is not predicted.

Indirect Changes to Intertidal and Subtidal Habitats

10.6.24 Changes to intertidal and subtidal habitats may occur as a result of changes to the hydrodynamic and morphodynamic regimes; for details on changes to hydrodynamic and morphodynamic regimes see *Chapter 8*. Changes to the hydrodynamic and morphodynamic regimes at both the quay site and disposal site may result in changes to the amount and distribution of intertidal habitat, such as salt marsh and mudflats. Indirect impacts to fish may also occur and are discussed in *Indirect Impacts to Fish* below.

10.6.25 Modelling studies have been conducted to determine where changes to the hydrodynamic and/or morphodynamic regime may result in short to medium term changes to the intertidal habitat in the vicinity of the quay (ie within a few years) (see *Chapter 8*). The results of the hydrodynamic modelling suggest that away from the proposed quay the combined impact of the development on intertidal and subtidal areas will be negligible in comparison with natural variation; no major morphologic change is likely in the wider estuary and the character of mudflat and saltmarsh areas will be maintained following the development. Overall estuarine morphology and morphodynamics will continue to be controlled by wider estuary processes. However, locally to the quay a dynamic change can be expected to occur that may cause a local shift in morphologic pattern; limited development of intertidal mudflat and saltmarsh is expected to occur adjacent to the development at the expense of other intertidal and subtidal habitat (*Annexes 8.2* and *8.3*). Mudflat development is likely to dominate, although extreme low energy zones may be conducive to saltmarsh development. Evidence of intertidal morphologic development associated with man made structures elsewhere in the estuary suggest that this will be a slow process with saltmarsh establishing over several decades (*see Chapter 8*).

10.6.26 As explained in *Chapter 8*, the morphology and habitat assemblage of the Humber Estuary is both varied and dynamic responding to process change over both long and short timescales. Long term change has been recorded across the entire estuary and consistent erosion or deposition is not apparent across much of the estuary, with areas frequently switching between a stable morphology, erosion and deposition. Overall the estuary is in a dynamic equilibrium with morphological response keeping pace with gradual sea level rise. As described above, the proposed quay is likely to cause local sedimentation around the immediate structure and mudflats/saltmarsh will develop. A dynamic equilibrium will be reached, although it may take several decades. The ecosystem structure and function of the area around AMEP will therefore be altered.

10.6.27 Dredge spoil disposal will not lead to significant morphological change as shear stresses (ie hydrodynamic forces exerted on the seabed) in the vicinity of the disposal site are insufficient to break up and transport the highly cohesive glacial sediments (ie non-erodible deposits) (*Chapter 8*). As described in *Habitat Disturbance* above increases in suspended sediment concentration at the disposal sites will quickly be dwarfed by background levels; natural variability on suspended sediment concentrations will be greater than the increases due to disposal of dredged material. Therefore the impacts of localised dredging and dumping are not significant when compared to the magnitude of sediment transport processes operating in the estuary with natural spatial and temporal variability rapidly masking any apparent anthropogenic sediment redistribution.

10.6.28 Subtidal sand banks, notably the Middle Shoal, located a short distance away from the disposal site (HU080) are unlikely to be affected long term by any deposition of fine grained sediments as a result of sediment disposal. These habitats are not located within the main path of the sediment plume and prevailing tidal currents and wave action in these areas are strong enough to suspend freshly deposited fine sediments, which are then carried away by the currents. As a result any change in sediment composition will be short lived.

10.6.29 Given the above assessment a significant indirect negative impact on intertidal habitats from changes in the hydrodynamic or morphological regimes arising from AMEP is not predicted. A local gain of intertidal saltmarsh and mudflat may be considered a positive impact, however, given the limited extent of additional intertidal area this is not considered significant. No loss of existing saltmarsh is predicted. Given the loss of subtidal area to intertidal saltmarsh and mudflats a significant indirect negative impact on subtidal areas along the shoreline either side of the quay is predicted; other subtidal areas are unlikely to be significantly impacted.

Direct Impacts to Fish and Marine Mammals

10.6.30 Direct impacts to fish and marine mammals may occur as a result of construction noise and vibration. Noise and vibration will occur during dredging of the approach channel, turning circle and quay location as well as during the piling required for quay construction. Dredging and piling generates a certain amount of underwater noise and vibration, which can impact fish distributions and marine mammal behaviour. A description of noise levels in air can be found in *Chapter 16.* Underwater noise is considered below.

Box 10.1 Underwater Noise Measurements

Since there is a range of ways in which underwater noise can be quantified, a variety of noise metrics are often referred to in literature. Underwater noise levels are commonly referred to in terms of decibels (dB). The decibels are based on a ratio of the underwater sound pressure to a common reference of 1 micropascal (dB re µPa).

The acoustic pressure referred to above can be expressed as either the peak to peak (p-p), peak (peak) or root mean square (rms). The type of pressure measurement used is an important consideration when comparing noise levels and criteria and the type of pressure measurement should be stated when quoting noise levels. The peak pressure is the maximum absolute pressure for an instantaneous signal. However, acoustic pressure varies from positive to negative to form the pressure fluctuations that can be heard by fauna. Therefore, it is also possible to refer to the peak to peak value (p-p), which is the algebraic difference between the highest (positive) point to the lowest (negative) point of a sound pressure signal. The peak to peak value is higher for a given signal than the peak value.

These measures do not reflect average values of sound and an additional quantity is used to reflect this, which is referred to as the root mean squared (or rms) value. This quantity is the square root of the mean of the instantaneous pressures squared.

With a continuous signal a measurement of the root mean square (rms) sound pressure is an appropriate metric. With a sound impulse (i.e. in impact piling), however, a metric must be chosen which adequately describes the potential for damage to fauna of pulses of different lengths and energy distribution; that is, which measures the acoustic energy in the transient event. The sound exposure level (SEL) is one such metric. The SEL is defined as that level which, normalised to 1 second, has the same acoustic energy as the transient event and is expressed as dB re $1 \mu Pa^2$ s. For a discussion of piling impacts, a cumulative SEL value is derived that considers the SEL of a single-strike value and the number of strikes required to place a pile at its final depth.

The assessment of the impact of noise on marine and aquatic organisms depends not only on the characteristics of the source but also on the characteristics of the surrounding environment, how these affect the sound field and on the species-specific response and sensitivity. Species specific thresholds have been proposed for each of these metrics that are based on an ever increasing body of scientific literature. Basic criteria for the assessment of lethality, physical injury and behavioural responses have been described in Southall *et al* (2007) and Popper *et al* (2006) for marine mammals and fish respectively. An alternative set of criteria for behavioural responses based on the dB_{ht}(species) concept has been proposed by Nedwell et al (2007).

10.6.31 Marine development on the AMEP site, including piling and dredging, is expected to be undertaken over a period of a minimum of 2 years. Marine development required for AMEP will take place within several Humber Estuary designated sites, including the Humber Estuary SAC, which is an important migration route for river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus* and to a lesser extent for salmonids (salmon *Salmo salar*, brown trout *Salmo trutta*) between coastal waters and their spawning areas. The estuary also supports several other UK BAP species such as allis shad *Alosa alosa*, twaite shad *Alosa fallax*, European eel *Anguilla anguilla*, smelt *Osmerus eperlanus* and plaice *Pleuronectes platessa*. The grey seal *Halichoerus grypus* (also a UK BAP species) is found and breeds at Donna Nook, which is approximately 30 km from the AMEP at the mouth of the estuary. The harbour porpoise *Phocoena phocoena* may also be present in the estuary. Of these species allis shad, twaite shad, European eel, smelt, Atlantic salmon and brown trout may be affected by underwater noise due to their sensitivity and hearing mechanisms (see *Box 10.2*). The harbour porpoise and grey seal are also considered sensitive to underwater noise. For flatfishes, lampreys and invertebrates, the general consensus is that there are very few effects either behaviourally or physiologically, unless the organisms are very close to a powerful noise source (Popper, 2005; Popper and Hastings, 2009). These have not been considered further.

Box 10.2 ***Sound Detection in Fish***

Fish have differing sensitivities to noise depending on various anatomical and physiological structures. Two sound detection mechanisms are present in those marine fish species that have the ability to hear: the inner ear system of otolithic bones, and a lateral line system comprising a series of sensory cell that run from the gills to the tail fin. These cells allow the fish to detect relative motion and sound in the aquatic environment.

Many species also use the gas-filled swim bladder in the abdominal cavity for detecting sound. Underwater noise causes the swim bladder gas to vibrate and links between the swim bladder and the ear allow the sound wave energy to be re-directed to the ear. The use of the swim bladder allows fish to detect sounds with hearing sensitivity increased in species where the ear and swim bladder are more closely connected.

Hearing specialists such as herring-like species are characterised by high auditory sensitivity and bandwidth. The majority of fish species possess a swimbladder but no special connections to the inner ear. Their sensitivity is moderate and the bandwidth of frequencies that they are able to hear tends to be narrow. These are commonly referred to as hearing generalists and include species such as the Atlantic salmon. Little is known about the hearing sensitivity of the lamprey but based on their anatomy it is believed that these fish are less sensitive than Atlantic salmon.

10.6.32 Dredging emits continuous broadband sound during operations, mostly in the lower frequencies. Source levels range from 160 to 180 dB re 1 μPa at 1 m (maximum ~ 100 Hz) (Götz *et al*, 2009). Most energy has been found to be below 500 Hz. Dredging noise is expected to occur for longer periods than piling, however, given that the estuary is busy and dredging noise is within the range of the general shipping noise that is likely to exist in the estuary it is considered unlikely to affect the distributions of fish or marine mammals. As such only the impacts of pile driving are considered.

10.6.33 Piling source levels vary depending on the diameter of the pile and the method of pile driving (impact or vibropiling). Both methods will be used during AMEP construction, although vibropiling will be used initially and final driving will then be completed using impact piling. The frequency spectrum ranges from less than 20 Hz to more than 20 kHz with most energy around 100 - 200 Hz (Götz *et al*, 2009). *Table 10.11* presents reported exposure levels from pile driving.

Table 10.11 Single Strike Noise from Pile Driving (measured at 10 m)

Pile	Peak Pressure Level dB re 1 µPa	RMS Sound Pressure Level dB re 1 µPa	Sound Exposure Level (dB re 1µPa² s)
Timber (12 inch) drop	177	165	157
Cast-in-shell steel (CISS) (12 inch) drop	177	165	152
Concrete (24 inch) impact	193/183	175/171	160
Steel H-type impact	190	175	Not available
CISS (12 inch) impact	190	180	165
CISS (12 inch) impact	200	184	174
CISS (30 inch) impact	208	190	180
CISS (96 inch) impact (at 25 m)	212	197	188

Source: California Department of Transportation (2009)

10.6.34 Piling will be undertaken in overlapping phases for the different types of piles. The tubular piles that support the front wall of the quay will be driven using a large hammer, and the concrete piles behind using a slightly smaller hammer. Tubular piling is planned to be carried out from two rigs. The front wall construction is expected to involve a period of 6 months piling works, operating on a 2-shift basis, i.e. 16 hours a day, 6am-10pm, 7 days a week. An additional rig will install the intermediate sheet piles but the hammer for these will be much smaller. Other piling operations for the concrete piles supporting the relieving slab behind the quay may continue over the full length of the construction period of two years, but only once the front wall is complete.

10.6.35 For an evaluation of pile driving impacts on marine organisms it is necessary to estimate the cumulative Sound Exposure Level associated with a series of pile strike events. The number of strikes needed to install a pile depends on many factors including the size and type of pile, substrate and size of the hammer. Using an empirical prediction approach developed by a multiagency Fisheries Hydroacoustic Working Group for the California Department of Transportation (2009), it is possible to establish impact zones for hearing damage to different marine organisms.

10.6.36 Using this approach, impact zones for damage changes have been derived for grey seals, harbour porpoise and fish with the following assumptions:

- impact piling method to assess the worst case, although initial driving of piles is carried out by vibration piling;

- 1.8 m diameter piles, 20,000 to 40000 pile strikes per day [(1)] ;
- propagation of underwater noise based on piling in relatively shallow water (< 20m) but does not account for reflections from opposite banks; and
- two piling rigs in operation achieving the number of pile strikes stated above.

10.6.37 Studies of marine mammal responses to underwater noise have documented a significant difference in response thresholds for sequences of short impulsive sounds compared to the response thresholds for continuous or slowly varying sound levels (Richardson *et al*, 1995). The behavioural response of the marine mammal and fish not only depends on the properties of the sound source but also on the specific circumstance of the animal, such as age, condition, behaviour, season, social state and sex (Thomsen *et al*, 2006). Behavioural effects can range from a visible acknowledgement by an animal that it has heard the sound, such as a brief startle response to strong and prolonged avoidance. Most commonly, marine mammals and fish react by changing their direction and/or speed of movement or behavioural activity or by changing how they vocalise (marine mammals only).

10.6.38 The zone of physical effects is the area near the noise source where the received sound level is high enough to cause auditory fatigue or tissue damage resulting in either temporary threshold shift (TTS) or permanent threshold shift (PTS) or even more severe damage (Thomsen *et al*, 2006). The level of damage resulting from exposure to loud noises is a combination of the duration of the impact as well as the noise level. For example, PTS can occur as the result of a single high level of sound or as the result of repeated occurrences of TTS. As such, underwater noise can elicit strong or mild responses from fish or marine mammals depending on their hearing ability and the distance to the noise source.

10.6.39 Vibration may also impact on marine mammals and fish, however, little information is currently available on the sensitivity to vibration of the species under consideration. Vibration that may be produced as a result of dredging is not considered to be at a level that will significantly impact the species for which vibration sensitivity information is available. Piling vibration will be higher than for dredging.

10.6.40 The key factors in the calculation of noise levels are given in *Box 10.3*.

[1] Number of pile strikes are based on data from the project engineers and refer to the number of strikes from a single rig and two rig operation respectively.

Box 10.3 Propagation Calculation

The propagation calculations follow the Fisheries Hydroacoustic Working Group guidance provided in California Department of Transportation (2009). The source term used for the calculated zones has been chosen from a range of reported measurements. The values used are based on CISS (96 inch) impact (measured at 25 m) with a Peak Pressure of 212 dB re 1 µPa, an RMS sound pressure level of 197 dB re 1 µPa or Sound Exposure Level of 188 dB re 1µPa2 s (see *Table 10.11*) but adjusted downward by 4 dB re 1µPa2 s to reflect the slightly smaller pile size of 1.8 m and corresponding blow energy in line with a correlation described in Matuschek and Betke (2009). These measurements are conservative in view of the higher blow energy and smaller depths used in the AMEP piling operation.

The propagation has been calculated using propagation characteristics based on measurements made by Greeneridge Sciences at Port MacKenzie during the driving of 36-inch diameter piles. These were reported in the Fisheries Hydroacoustic Working Group publication. The attenuation is of the form F x Log (distance/25 m) where F was found to be 18 to 21 for Peak Pressure Levels, 18 to 23 for RMS levels and 16 to 22 SEL values. The minimum values have been used for calculating each parameter (as a conservative estimate).

M-weighting values of 6 dB for grey seals and 2 dB for harbour porpoise. No weighting is applicable for the assessment of noise on fish.

The accumulated SEL has been calculated by taking the SEL at the relevant distance and adding a factor of 10 x log (no of pile strikes in a day which is estimated to be 20,000 to 40,000 based on information from the project piling team and using the calculation methods in the Fisheries Hydroacoustic Working Group publication). There are uncertainties in predicting sound levels at long range using a single propagation coefficient, which are likely to result in overestimates of the noise impact zones. Temperature gradients, bottom topography, and currents are noted to cause sound levels to attenuate more rapidly than geometric spreading. The calculation method proposed in the guidance document limits the noise exposure calculation for fish to a 150 dB SEL single strike as a practical means of limiting the distances that are predicted, and this method has been in use in the US for some time. The distance from the pile driver at which a single strike SEL drops to 150 dB is understood to be the maximum distance from a pile that fishes can be injured, regardless of how many times the pile is struck. One disadvantage of this method is that the derivation of the cut-off level of 150 dB SEL Single Strike is not clearly explained in the guidance but in the absence of other guidance to the contrary, this approach has been used.

10.6.41 It is predicted that damage due to individual peak noise levels during events will be limited for all species to within about 120 m of the piling activity as shown in *Table 10.12* . The piling of the front wall will take approximately six months. Since this piling will be undertaken using the largest piling hammer and noise will be able to propagate unobstructed into the estuary, it is likely to be the most significant phase of piling in terms of underwater noise. Other piling operations will involve concrete filled piles behind the front quay wall, which will be driven with a smaller piling hammer, or by vibratory piling, and will therefore be of less concern. With two impact piling rigs in operation it is conceivable that the distances at which the criterion for peak noise would be met would be larger. However, this would only occur in the unexpected event that two blows occurred at exactly the same time and the peak noise would still be within the same order of magnitude.

Table 10.12 Distances at which Damage due to the Peak Noise Level is Predicted

Species	**Criterion dB re 1 µPa (Peak)**	**Range where Criterion is exceeded**
Grey seal	218 (1)	0-12 m
Harbour porpoise	200 (2)	0-116 m
Fish	206 (3)	0-54 m

1) Criterion for permanent threshold shift from Southall *et al* (2007)
2) Criterion for permanent threshold shift based on Lucke *et al* (2009)
3) Criterion based on the Fisheries Hydro acoustics Working Group for potentially lethal effects and tissue damage

10.6.42 Distances at which damage due to the accumulation of energy are likely to occur are presented in *Table 10.13*. The predictions for the accumulation of energy take into account the two rigs. It is noted that, for Grey seal and Harbour porpoise the calculated distances exceed the width of the estuary at the location of AMEP.

Table 10.13 Distances at which Damage due to the Accumulation of Energy is Predicted

Species	**Criterion dB re 1µPa^2 s (SEL)**	**Distance at Which Criterion Will be Met (Range for 20,000 to 40,000 pile strikes per day)**
Grey seal	186 (1)	6.9 to 10.6 km
Harbour porpoise	179 (2)	25.0 to 38.6 km
Fish	187 (3)	3.3 km

1) Criterion for permanent threshold shift from Southall *et al* (2007)
2) Criterion for permanent threshold shift based on Lucke *et al* (2009)
3) Criterion based on 150 dB SEL Single Strike as provided in California Department of Transportation (2009).

Note: The accumulated energy assumes that an animal stays in one place and is subject to noise from a high number of hammer blows per day and so even though it is further away from the noise source than for behavioural effects to occur damage may result; this represents a worst case scenario. An animal that is moving might experience fewer noise events, which would reduce the energy that it experiences. The distances are calculated on the premise of two piling rigs working at the same time with a total number of blows ranging between 20,000 and 40,000 per day.. With two impact piling rigs in operation at some distance of one another, it is conceivable that the distances at which the criterion will be met are larger albeit still within the same order of magnitude. It is noted that the calculated distances exceed the width of the estuary at the location of AMEP.

10.6.43 The distances at which the criteria for behavioural disturbance are met are shown in *Table 10.14*.

Table 10.14 Distances at which Behavioural Changes is Predicted

Species	Criterion dB re 1 µPa (RMS)	Distance up to which Behavioural Changes are Predicted
Grey seal	160	1.7 km
Harbour porpoise	160	1.7 km
Fish	-	not included in assessment

1) Criterion for significant behavioural response based on Southall *et al* (2007) and rms levels derived from Lucke *et al* (2009) and US NMFS criterion.

Note: Behavioural changes to fish have not been considered given the lack of data on behavioural responses to pile driving (as reviewed by Popper and Hastings, 2009).

10.6.44 Grey seals at Donna Nook would not be affected by behavioural or auditory damage. They are not likely to change behaviour, and are unlikely to be discouraged from using the estuary entrance based on the noise levels that have been predicted. They would only suffer potential auditory damage if they regularly approach within approximately 6.8 - 10.6 km of the piling. The data indicate that although they may experience high noise levels that can lead to longer term damage, they may not leave this area so auditory damage cannot be completely ruled out. However, while some seals may venture into the estuary, most will prefer to hunt for food at sea or the outer estuary and so not regularly approach the AMEP site within 6.8 - 10.6 km.

10.6.45 Pinnipeds, such as the grey seal, communicate acoustically in air and water and have significantly different hearing capabilities in the two media (Southall *et al*, 2007). Given the distance from the piling location to the seal colony at Donna Nook (approximately 30 km) together with intervening undulating coastline noise levels are unlikely to affect hauled out seals. Monitoring of seal disturbance at the haul-outs at Seals Sand in the Tees in 2008 has not shown an impact of nearby routine piling and dredging activities which was carried out within a few hundred metres at Graythorp Dock (INCA, 2008). Therefore, seals whilst in air are not considered to be affected and are not considered further.

10.6.46 In a worst case scenario, harbour porpoises may display behavioural responses within a distance of 1.7 km from the piling due to the maximum rms noise during a pulse [(1)]. This will mean that their use of the estuary for foraging could be affected. However, they would only suffer potential auditory damage if they regularly approach within approximately 25.0 to 38.6 km of the piling. These conclusions are based on work by Lucke *et al*, 2009 which related to seismic survey noise and its effects on a single captive harbour porpoise. Whilst this

(1) This is based on the typical criteria used by the National Marine Fisheries Service (NMFS) in the United States, which is confirmed by the work of Lucke et al 2009. The SEL criterion proposed by Lucke et al has not been applied.

study met a gap in the scientific literature available to Southall *et al* in 2007, and showed that harbour porpoise are likely to be sensitive to hearing damage as a result of exposure to low frequency noise, its application to other high frequency cetaceans is necessarily cautious.

10.6.47 Fish may experience damage over time if they are present within approximately 3.3 km of the piling for substantial periods of time. Both peak sound pressure level and SEL can affect hearing through auditory tissue damage (damage to sensory hear cells of the ear) or TTS (temporary hearing loss). Smaller fish are also susceptible to non-auditory tissue damage. Fish, however, possibly also display behavioural changes such as an avoidance response, which would tend to reduce the zone over which fish would be likely to be affected.

10.6.48 It should be noted that there are no specific data on the likelihood of damage to hearing specialist fish such as herring and shad and the criteria and conclusions are based on hearing generalist fish such as the Atlantic salmon. The zones of impact would be expected to be different for hearing specialist fish, but it cannot be established what the differences would be given the current state of research. The fish species of interest, commercial fish species that use the mudflats as nursery area, and the BAP species other than the allis and twaite shad are considered hearing generalists.

10.6.49 Fish larvae and plankton mortality may occur at very close range to multiple noise pulses, such as piling. However, the effects of multiple noise pulses on fish larvae and plankton populations are considered to be inconsequential given the size of planktonic populations, their high natural mortality rate and their mortality rate due to entrainment in nearby power station cooling systems. Fish larvae and plankton populations are therefore not expected to be affected by piling noise.

10.6.50 Given the above assessment underwater noise may elicit behavioural responses from marine mammals in the vicinity of AMEP. Auditory damage from the accumulation of energy is also possible but considered unlikely for marine mammals given the distances at which this may occur. Grey seals and harbour porpoise are considered occasional visitors of the middle estuary and are therefore unlikely to be exposed to the noise for a sufficiently long time to sustain auditory damage. Harbour porpoise are only rarely sighted. Moreover, they will return to the area once piling operations cease as has been demonstrated for the harbour porpoise (Brandt *et al*, 2011). Seals on land or in the water at Donna Nook will not be affected. As the above assessment is for a worst case scenario of hammer piling, which will only occur over a 6 months period during AMEP construction and that further piling operations in the remainder of the construction period are of a lesser magnitude it is likely that noise and vibration from the AMEP works will not significantly affect marine mammal populations.

10.6.51 Taking a conservative approach, one has to assume that fish that are resident or roam around in the area of influence may build up auditory damage over time. A portion of the fish that experience loss of hearing suffer from a temporary threshold shift, and fish can be expected to have their original hearing fully restored upon cessation of the activities. Recovery from TTS may occur within minutes to days following exposure. Popper *et al* (2006) noted that both hearing specialists and generalists were able to recover from varying levels of TTS in less than 18 hours. Hearing loss in some fish, in particular smaller specimens, will be more permanent which may reduce their overall fitness and ability to locate prey or communicate and increase their vulnerability to predators.

10.6.52

10.6.53 Exposure of migratory fish will be of relatively short duration. The fish's transit speed through the area of influence and its location in the channel in relation to the pile driven will substantially affect the accumulated sound exposure. Maximum swimming speeds for adult salmon of 0.5 – 0.9 m/s have been reported (Tang and Wardle, 1992). Atlantic salmon smolts have been reported to swim at average speeds of 0.5 to 1.4 km per hour (Malcolm et al 2010). This would limit the potential exposure of an individual crossing the area of influence at the lowest speed to a maximum of 0.6 day one way with many individuals passing outside the area of influence along the northern bank. The transit period of other BAP fish species including lamprey is likely of similar magnitude. The impact is thus shortlived.

10.6.54 It is not known if the piling noise acts as a 'non-physical barrier' that elicits a behavioural response that prevents fish from swimming upriver. Salmon smolt for instance show avoidance to certain noise sources (Knudsen et al, 1994). This has been the basis for the development of acoustic deterrents near power plant intakes. Hearing sensitive fish have been shown to learn to avoid acoustic deterrents (Taylor et al., 2005). There are also indications that species can habituate to piling noise as has been suggested for cod in response to the noise emitted by piling operations for offshore windfarms (Mueller-Blenkle et al. 2010).

10.6.55 If piling of the front wall coincides with the main spawning reason, some migratory fish of conservation interest (Atlantic salmon, sea trout, allis and twaite shad and smelt) may be prevented from swimming upriver while other individuals continue their upstream journey unaffected. If a number of migratory fish would be prevented from reaching spawning grounds upriver (eg in the Ouse river) the overall

Humber population numbers for that particular year class and their offspring is possible. This will slightly set back the on-going recovery of these species in the estuary. As it is not known if and what proportion of adults will be prevented from reaching spawning grounds upriver, it is not possible to quantify this change. It is noted that actual population size of Atlantic salmon passing through the Humber, measured by juvenile salmon density, rod catch and catches in coastal waters, is very small in comparison to the principal salmon rivers in England and Wales (CEFAS/EA, 2011).

10.6.56 On the basis of the area in which hearing loss may result and overall duration of piling operations it cannot be ruled out that the resident fish population, among which juveniles of offshore commercial fish stocks, may suffer from the noise emitted by piling operations and a locally significant impact on resident fish population has to be assumed. The impact would not affect the fish in the wider estuarine ecosystem because prey availability is not affected.

10.6.57 The present assessment is based on a worst case scenario of impact piling at the front quay wall, a conservative noise propagation method and the assumption that fish show an active behavioural response to noise. This piling operation will last over 6 months and it is this piling that causes the most impact. Other piling operations (concrete filled piles behind the front quay and sheet piles driven) will be piled with a smaller hammer or by vibration piling and are therefore of less concern.

10.6.58 Subsequent to the assessment described above, a separate assessment was carried out by SubAcoustech (see *Annex 10.3*) which uses a depth integrated noise propagation model. The results of this study confirm the small range at which fatal injury or tissue damage of fish from peak noise levels would occur. The study does not report on auditory damage over time due to accumulation of energy (SEL) but instead calculates the distance at which behavioural avoidance reactions of Atlantic salmon can be expected based on the dB_{ht}. concept that assumes a species-specific level at which a certain proportion of the population demonstrates an active avoidance reaction. In line with these findings, a significant proportion of Atlantic salmon is expected to move across the estuary unperturbed. The distance at which 50 percent of the salmon would demonstrate a strong avoidance response with a piling operation of 1.8 m lies at 2.1 km, less than the width of the estuary at AMEP. These results suggest a limited effect on migratory salmon and other fish species with a similar hearing sensitivity.

Indirect Impacts to Fish

10.6.59 Underwater noise is a direct impact on fish. Indirect impacts to fish may occur as a result of loss of habitat under the footprint of the project and habitat disturbance from dredging, dredge disposal and construction run off. As described above there are a number of UK BAP species that may occur in the vicinity of AMEP. Twaite and allis shad are known to use the Humber between May and June for their spawning run, while juveniles migrate to sea during the summer. The European eel is present year round. Sea lamprey are also present year round for both adults and juveniles; they spawn between June and August. The river lamprey is present from August to November (spawning run) and their juveniles spend four to six years buried in estuarine substrate. Smelt concentrate in winter at estuaries and enter the estuary between February and April for their spawning run. Atlantic salmon occur between June and October/November for adult spawning runs, while smolt migrate to sea predominantly during March to June. Cod are also known to regularly enter the estuary. The impacts to fish from habitat loss and disturbance may result in behavioural changes, for example temporary avoidance of areas with low water quality due to runoff or increased turbidity. In particular river lamprey are thought to migrate up along the banks of the estuary and may be more vulnerable to habitat disturbance localised to the shore.

10.6.60 Habitat disturbance from dredging and dredge disposal operations is unlikely to have long-term impacts on fish as they are mobile and will avoid any area affected by disturbance and are able to return once the disturbance has ceased (Posford Duvivier Environment and Hill, 2001). The Humber Estuary is one of the most turbid estuaries in Europe, however, the fish assemblage within the Humber is not influenced by turbidity (Marshall and Elliott, 1998). Turbidity levels above 14 g/l have been found to have a physiological effect on fish (eg clogging of the gills with suspended solids) (Marshall and Elliott, 1998). This value is more than double the maximum concentrations found naturally within the Humber and significantly higher than concentrations predicted by the sediment plume (see *Habitat Disturbance* above). Fish eggs and larvae are more sensitive to suspended sediment impacts than older life stages and concentrations of suspended material have to be on the scale of milligram per litre (mg/l) to be lethal to fish eggs and larvae (compared to g/l for adult fish) (Engell-Sorensen and Skyt, 2003). However, given the naturally high suspended sediment concentrations found in the Humber it is unlikely dredging operations will have an impact on fish populations.

10.6.61 Dissolved oxygen concentrations in the water column may be temporarily reduced as a result of dredging or dredge disposal (see *Chapter* 9), which can affect fish growth and cause mortality. Oxygen demand following dredge disposal has been shown to rapidly increase for 5-10 minutes, followed by a five to ten time slower rate of dissolved oxygen consumption (Jabusch *et al*, 2008), allowing enough time for fish to avoid the area if dissolved oxygen levels are reduced significantly. However, given the current good dissolved oxygen concentrations and strong tidal currents in the middle section of the Humber Estuary oxygen levels are unlikely to be reduced to potentially adverse levels. Reduced dissolved oxygen concentration due to sediment resuspension is expected to be localised and short term (Jabusch *et al*, 2008).

10.6.62 River lamprey, which are thought to migrate up along the banks of the estuary, may be impacted by habitat disturbance as a result of AMEP. The structures put in place and reclamation works do not pose a permanent barrier preventing the lampreys from moving upriver. They will be able to move through other parts of the estuary and move up along the banks during breaks in construction. Also, the number of previous projects along the banks of the Humber and that river lamprey populations in the upstream Ouse catchment are in favourable condition (Nunn *et al*, 2008) indicates they will not be significantly affected by construction works related to AMEP.

10.6.63 Indirect impacts to fish, as described above, are considered temporary and localised. Although some behavioural changes may occur the area affected is not considered likely to significantly affect the life cycle or migration routes of these fish populations given the total available area of the estuary for foraging and the potential for avoiding disturbed areas during spawning runs. Given the above assessment habitat disturbance and loss due to AMEP are unlikely to result in a significant negative impact on fish populations within and passing through the Humber Estuary.

10.6.64 The exception is the loss of nursery area for commercial fish species, which constitutes a permanent impact. Intertidal and shallow subtidal mudflat areas act as a nursery area to commercial fish species caught in the North Sea, such as common sole and whiting. In total approximately 45 ha of intertidal and subtidal area will be lost due to AMEP from a total of 26,180 ha of the available intertidal and subtidal area in the lower and middle estuary. A recruitment loss to commercial fish stocks and marine and coastal fisheries may occur as the intertidal and shallow subtidal area is an important influence on juvenile growth and recruitment. Taking a conservative view a significant impact on the nursery function of the estuary is expected, although the small gain in intertidal area on both sides of the quay (see Indirect Changes to

Intertidal and Subtidal Habitats below) may compensate part of this loss. The actual number of adult fish potentially lost as a result of loss of nursery area is not easily quantifiable. .

Indirect Impacts to Marine Mammals

10.6.65 As described in *Paragraph 10.6.46* harbour porpoises may display behavioural responses over a wide area (1.7 km) from the piling, which will mean that their use of the estuary and the coast adjacent to it could be affected. This may have effects on harbour porpoise feeding within the estuary as they will avoid the area near the piling and thus not have access to prey fish that this part of the estuary provides. However, given their range over the North Sea, that their diet is not limited to species found only within the Humber Estuary, the 6 months duration of the worst type of piling operations, and their current frequency of occurrence in the Humber Estuary no significant impacts are predicted and this impact is not considered further.

Changes to the Aquatic Environment in Adjacent Water Bodies

10.6.66 The Killingholme Pits are located on the south Bank of the Humber to the north of the AMEP site. They may be sensitive to increased sedimentation, especially given the rare and diverse species in the Killingholme Pits. The Killingholme Pits provide an important habitat for nine species of specialist lagoonal invertebrates, including the polychaete worm *Alkmaria romijni*, which is known from just four sites in Great Britain. Other species of note include the prawn *Palaemonetes varians*, the molluscs *Hydrobia ventrosa* and *Hydrobia neglecta* and the bryzoan *Conopium seurati*.

10.6.67 Modelling studies have shown that placement of the quay will alter the circulation pattern on the rising tide at the Humber Sea Terminal and lead to increased shear stress near the foreshore around North Killingholme Pits, which may potentially cause erosion ie suspension of sediment into the water column (Chapter 8). However, given that water exchange into and out of the Killingholme Pits is governed by a manually-controlled pipe system that is located within the small inlet to the south of the Humber Sea Terminal and north of Humber workboats, ie it is not on the foreshore, the resulting suspended sediment is unlikely to enter the Killingholme Pits and hence no impacts to the Killingholme Pits are predicted.

10.6.68 Along similar lines it can be expected that a proportion of fine sediments from the dredge plume will enter the coastal waters. The sediments are likely to disperse far and wide and the excess levels will be indiscernable from natural variation in suspended matter. It is not likely that this will have an impact on the coastal marine ecosystem.

10.6.69 Given the above assessment a significant negative impact on the Killingholme Pits and coastal waters, their ecosystems and/or species is not predicted.

Operational Phase

10.6.70 Once AMEP is constructed, and operations are ongoing there are a number of other impacts that warrant discussion within the context of the ecosystem functioning in general.

10.6.71 The main activities / causes of impact discussed in this section are:

10.6.72 Physical presence of the quay:

- Indirect long term changes in intertidal and subtidal habitat from morphodynamic changes (as assessed in Construction Phase above); and
- Disruption to fish from habitat loss.

10.6.73 Increased vessel presence:

- Disturbance to fish due to the operational noise of an increased number of vessels.

10.6.74 Discharges and emissions:

- Habitat and benthic communities disturbance from water quality reduction due to planned discharges and emissions from vessels and the quay; and
- Disturbance to fish due to a change in water quality.

10.6.75 Maintenance dredging:

- Loss of subtidal habitat and benthic communities from substrate removal;
- Habitat and benthic communities disturbance from the sediment plume;

- Disturbance to fish from maintenance dredging noise and vibration; and

- Disturbance to fish from habitat loss and disturbance.

Loss of Habitat and Benthic Communities

10.6.76 Loss of benthic habitat and benthic communities will occur as a result of regular maintenance dredging of the approach channel (although a large part of this is already regularly dredged for access to the Humber Sea Terminal), turning circle and berth. Loss of habitat may also have indirect impacts on fish distribution, as discussed in *Impacts to Fish* below. This loss of habitat is not considered likely to significantly damage the ecosystem structure and function given the already disturbed nature of the habitat from the capital dredging required for construction, the vast availability of the habitat type and the period required for full benthic recovery (ie maintenance dredging is likely to be required before full benthic community recovery).

10.6.77 Effects from the loss of estuarine habitat caused by maintenance dredging will be the same as those from dredging required during construction, except the volume of dredge material is likely to be reduced and the quay location will not require further dredging. A description of the impacts can be found in *Loss of Habitat and Benthic Communities* in the *Construction Phase* impact section above. Conservative model estimates [1] indicate up to 1.25 million m^3 of sediment may accumulate in the AMEP dredged area over the course of one year. Given the regular nature of the maintenance dredging and the habitat recovery time (>1.5 years; Borja *et al*, 2010) this effect is permanent.

10.6.78 As the estuary is large (36 657 ha to the SAC boundary) there is a widespread availability of subtidal habitat. Dredging will not cause a loss of extent of the subtidal habitat, although as with the capital dredging the habitat type may be altered due to changes in sediment particle size. The effect of habitat loss from maintenance dredging is limited to the area around the AMEP site and is therefore localised. Benthic communities that are removed by dredging will begin to recover between dredging events, however, full recovery between events is unlikely.

10.6.79 Although the effect of habitat loss arising from AMEP is permanent, a significant negative impact is not predicted due to the very small

[1] Estimates are considered conservative due to the lack of representation of cohesive forces between fine particles in the model.

proportion of subtidal habitat affected and the existing level of modification to the area.

Habitat and Benthic Communities Disturbance

10.6.80 Habitat disturbance will occur as a result of sediment plumes from maintenance dredging as well as water quality changes due to planned discharges and emissions from vessels and the quay. Habitats that may be affected are the intertidal, subtidal habitats and associated benthic communities and water column habitats. Habitat disturbance may have indirect impacts on fish, which is discussed in *Impacts to Fish* below.

10.6.81 Impacts from the sediment plume caused by maintenance dredging will be the same as those from dredging required during construction, except the duration and volume will be reduced. Given that no significant effects are expected due to the capital dredge programme it is unlikely there will be significant effects from the maintenance dredge programme as the duration and suspended sediment volumes are likely to be less. See *Habitat Disturbance* in the *Construction Phase* impact section above for a description of habitat disturbance from the sediment plume.

10.6.82 Only non-contaminated drainage from the quay or vessels may run off into the estuarine environment and affect water quality (See *Section 8*). Contaminants such as hydrocarbons and heavy metals are not expected in non-contaminated run off. Given that water quality is not expected to be affected by contaminants and any turbidity increase is likely to be within the naturally high range found in the Humber Estuary there is no expected impact to aquatic ecology at the quay from run off.

10.6.83 An assessment of emissions to air can be found in *Chapter 13* Air Quality. Given the relatively low levels of emissions associated with the planned facilities and the ability of emissions to disperse over large areas and the continuous water exchange no impacts to aquatic ecology will occur. This impact is not considered further as no significant impacts are expected from emissions to air.

10.6.84 Habitat disturbance during operation of AMEP is limited and is not likely to significantly damage the ecosystem structure and function. Suspended sand particles are likely to settle out of the water column within a few hundred metres from the dredge location, whereas fine silt may disperse a few kilometres from the dredge location, however, turbid plumes covering wide areas are likely to have only low concentrations of suspended sediment (Sutton and Boyd, 2009). At Hull, the dredge plume assessment predicts maximum elevated levels of suspended sediments to be in the order of 10-20 mg/l (*Chapter 8*). Run off is likely to increase turbidity in the immediate vicinity of the quay only. Habitat disturbance is considered temporary and intermittent.

10.6.85 Given the above assessment a significant negative impact on habitats and associated benthic communities from habitat disturbance arising from operation of AMEP is not predicted.

Indirect Changes in Intertidal and Subtidal Habitat

10.6.86 Indirect changes in intertidal and subtidal habitat may occur as a result hydrodynamic and morphodynamic changes caused by the physical presence of the quay and the dredged approach channel / turning circle. Changes to the intertidal habitat include loss or gain of saltmarsh and mudflats, while changes in subtidal habitat include changes in sediment type and / or availability.

10.6.87 Changes to the intertidal and subtidal habitat are likely to affect the areas directly up and downstream of the quay, as described in *Changes to Intertidal Habitats* in the *Construction Phase* impact section above. In summary, modelling results (*Chapter 8*) suggest changes to local flow patterns and energy levels are likely to cause a morphologic response across intertidal areas promoting both erosion and deposition. The placement of the quay is likely to increase sedimentation around the immediate structure and mudflat with a small proportion of saltmarsh will develop. Development of new intertidal areas is likely to take several decades to reach an equilibrium. These changes are likely to be permanent, or exist for the lifetime of the quay. Away from the quay the combined impact of the development on intertidal and subtidal areas will be negligible in comparison with natural variation.

10.6.88 It follows that during operation of the AMEP there is likely to be an increase of intertidal habitat due to changes in the hydrodynamic and morphodynamic regime. Some subtidal habitat will be lost to the development of intertidal habitat on either side of the quay, although this will be small. In addition the type of subtidal habitat may differ due to sediment particle size changes.

10.6.89 Given the above assessment no further significant impacts to intertidal and subtidal habitat will occur other than those described for the construction phase. A significant negative impact on intertidal and subtidal habitats due to hydrodynamic and morphodynamic alterations during operation of the AMEP is therefore not predicted.

Impacts to Fish

10.6.90 Impacts to fish may be direct or indirect. Direct impacts to fish may result from increased vessel presence causing underwater noise. Indirect impacts to fish may result from loss of habitat due to the physical presence of the quay and maintenance dredging and habitat disturbance due to the dredge plume and discharges to the estuarine environment. Impacts to fish are likely to result in a change of behaviour, for example avoidance of areas with reduced water quality or increased underwater noise. Impacts to habitats are discussed above.

10.6.91 The physical presence of the quay may affect river lamprey migration up along the banks of the estuary. However, given that the quay will form part of the new coastline where lamprey can migrate along and does not prevent migration, there are no predicted impacts to river lamprey migration and this impact is not considered further.

10.6.92 Vessel movements generate a certain amount of underwater noise, which can impact fish distributions and behaviour. The exact underwater noise characteristics of vessels depend on the ship type, size, mode of propulsion, operational characteristics and speed as well as other factors (Götz *et al*, 2009). Much of the incidental noise results from propeller cavitation, though onboard machinery and turbulence around the hull can also result in underwater noise being transmitted. *Table 10.15* presents typical vessel noise for a range of vessel sizes that may occur in the Humber Estuary. The Humber estuary is the country's busiest trading estuary[1] and as such it can be expected that underwater noise is already widespread throughout the estuary. Vessel movements as part of operation of the AMEP are unlikely to significantly affect the availability of fish foraging areas or migration routes given existing levels of underwater noise and although increases in traffic are likely to be long term, vessel movements for the AMEP site will be intermittent.

Table 10.15 Typical Vessel Noise

Vessel	Description	Source level	Frequency
Small leisure craft and boats	Length up to 50m; e.g., recreational craft, jet skis, speed boats, operational work boats, hover craft	160-175 dB (re: 1µPa),	1 - 10 kHz
Medium-size ships	Length 50 - 100m; e.g., support and supply ships, many research vessels	165 - 180 dB (re: 1µPa)	Below 1 kHz
Large vessels	Length greater than 100m; e.g., container/cargo ships, super-tankers, cruise liners	180 - 190 dB (re: 1µPa)	Below several hundred Hz

Source: Götz, T. et al (2009)

[1] http://www.abports.co.uk/custinfo/ports/grimsby.htm

10.6.93 Indirect impacts to fish are likely to occur in the immediate vicinity of the quay where run off from the quay may occur and in the footprint of the maintenance dredge plume. Run off is unlikely to be contaminated due to quay containment facilities (see *Chapter 13: Drainage and Flood Risk* for details), although run off may cause higher suspended solids load in the waters in the vicinity of the quay. Rainfall is unpredictable therefore the duration and frequency of run off and increased turbidity is unquantifiable, however, this impact is likely to be limited to the immediate vicinity of the quay and is considered an intermittent effect. Similarly dredge plumes are also intermittent as maintenance dredging is required periodically. Given the high naturally turbidity variability of the Humber environment (IECS, 2010), and the fact that fish are mobile enough to avoid disturbed areas (Posford Duvivier Environment and Hill, 2001) and the fish assemblage is not affected by turbidity changes (Marshall and Elliott, 1998) indirect impacts to fish are unlikely to significantly affect the availability of fish foraging areas or migration routes.

10.6.94 Migration routes and foraging areas are also considered unlikely to be significantly affected during operation. Fish migration and foraging can proceed uninterrupted by any of the foreseen activities. UK BAP fish species populations present in the estuary are therefore considered unaffected.

10.6.95 Although temporary displacement of some fish species may occur as a result of impacts to fish a significant negative impact on fish populations is not predicted from operation of AMEP.

10.7 MITIGATION

10.7.1 This section highlights the mitigation measures that can be used to avoid, reduce or mitigate the potentially significant impacts associated with the construction and operational phases of AMEP.

Construction Phase

10.7.2 Mitigation measures proposed within the context of the construction phase include:

Dredging and Dredge Disposal

10.7.3 Reduce the dredged area to as small as reasonably practicable for the quay and for safe manoeuvring of vessels.

10.7.4 Reduce the percentage of solids in the overspill to be as low as possible using suitably qualified and experienced contractors.

10.7.5 Inspection and monitoring of dredging activities to evaluate the effectiveness of impact prevention strategies, and adjust where necessary.

10.7.6 Optimise the trailing velocity of the dredger to minimise raising suspended sediments during dredging operations.

10.7.7 Minimise the need for overflowing during dredge operations by recirculation of jetting water.

Quay Construction

10.7.8 Mitigation measures to reduce noise for aquatic ecology receptors will be the same for reducing noise generally. See mitigation measures in *Chapter 16* – Noise for mitigation measures for piling noise.

10.7.9 With reference to underwater noise impacts, the following additional measures will be implemented: use a vibratory hammer and smaller hammer whenever possible, slow start procedure to scare away marine mammals and fish in the immediate vicinity of the piling operation. Noise impacts from the use of thrusters or dredging equipment can be reduced by careful manoeuvring and positioning of the vessels, and choice of vessels. The use of flap anchors also reduces the number of piles and intensity of pile driving required.

10.7.10 Accidental spillages from construction equipment and activities can be prevented by the appropriate storage of oils and fuels in sealed containers away in a sealed bunded area from water, briefing of site staff highlighting the need for tight control of potentially polluting chemicals and ensure clean up procedures are in place in case of accidental spillages of oils and fuels.

Construction Run Off

10.7.11 Mitigation measures for run off will be the same as for discharges to water. See mitigation measures in *Chapter 9* - Water quality.

Operational Phase

10.7.12 Mitigation measures proposed within the context of the operational phase include:

10.7.13 In areas directly adjacent to the quay, where the new hydrodynamic regime immediately permits, allow for the natural formation of intertidal habitat provided that functioning of the water intakes is not compromised.

10.7.14 Minimise the need for maintenance dredging, and where necessary, adopt mitigation measures as discussed in construction phase mitigation above.

10.7.15 Adherence to the environmental and safety regulations of the relevant harbour authority. This will avoid and reduce unnecessary impacts from shipping over the lifetime of AMEP. Port regulations are to be enforced and continually improved in accordance with the regulatory context and best practice at the time.

10.7.16 Proper maintenance and regular clean-up of drains and outfall structures. Effluent, waste management and spill prevention to be carried out in accordance with the relevant management plans adopted for AMEP. Such plans are to be updated over time in line with the regulatory context and best practice at the time.

10.8 RESIDUAL IMPACTS

10.8.1 Residual impact significance incorporate mitigation measures in addition to those that are inherent to the design of AMEP.

Construction Phase

Loss of Habitat and Benthic Communities

10.8.2 The combined loss of intertidal and subtidal habitat may significantly damage the ecosystem structure and functioning of the Humber estuary. A total area of 31.5 ha of intertidal and 13.5 ha subtidal mud habitat is lost along the southern bank of the middle section of the estuary.

Creation of New Hard Substrata Habitat

10.8.3 Given that the new habitat type (quay wall) is an existing habitat type within the estuary and that it is limited in extent the impact of the creation of new hard substrata habitat in this region of the estuary is considered not significant.

Habitat Disturbance

10.8.4 Given the vast extent of similar undisturbed habitat types available, the high natural variability of habitat in the Humber Estuary and the natural recoverability of benthic communities it is likely that the habitat disturbance arising from AMEP will not be significant.

Changes to Intertidal and Subtidal Habitat

10.8.5 Given that there will be a loss of subtidal area to intertidal saltmarsh and mudflats a significant impact on subtidal areas along the shoreline either side of the quay is predicted. Impacts to other subtidal areas and intertidal areas from changes in the hydrodynamic or morphological regimes arising from AMEP are considered not significant.

Direct Impacts to Fish and Marine Mammals

10.8.6 Direct impacts to marine mammals arising from underwater noise associated with AMEP will not be significant. However, a significant impact to local resident fish populations beyond those that would succumb to the loss of subtidal habitats is possible. Migratory fish of conservation interest passing through the area are unlikely significantly affected from prolonged exposure to piling works as their exposure is limited to a few hours, but it is not known if the piling operations act as an acoustic barrier to the spawning runs.

Indirect Impacts to Fish

10.8.7 Given that the Humber Estuary provides a wide availability of similar habitat for foraging and reproduction for fish of conservation interest and the ability of fish to avoid disturbed areas it is probable that the indirect impacts to fish arising from dredging and dredge disposal operations will not be significant.

10.8.8 Exception is the impact on commercial fish species through loss of nursery area for juvenile fish. This is considered a significant negative impact.

Changes to the Aquatic Environment in Adjacent Water Bodies

10.8.9 Given that any additional influx of sediment to the Killingholme Pits or coastal waters has been assessed as not causing a reduction in diversity and abundance of species it is probable that changes to these adjacent water bodies arising from the Project will not be significant.

Operational Phase

Loss of Habitat and Benthic Communities

10.8.10 Given that the intertidal and subtidal habitats in the Humber Estuary are vast and naturally highly dynamic the very small proportion of subtidal habitat affected from maintenance dredging operations and the existing level of modification to the area and the zone of influence does not critically support benthic species of conservation interest indicates that it is probable that the habitat and benthic community loss arising from operation of the AMEP site will not be significant.

Habitat Disturbance

10.8.11 The intertidal and subtidal habitats in the Humber Estuary are vast and naturally highly dynamic, while only a small proportion of the overall available habitats may be disturbed as a result of the dredge plume and smothering associated with the maintenance dredging operations. Therefore it is probable that the habitat disturbance arising from operation of the AMEP site will not be significant.

Indirect Changes in Intertidal and Subtidal Habitat

10.8.12 Given that no further impacts to intertidal and subtidal habitat will occur than for the construction phase, a significant negative impact on intertidal and subtidal habitats due to hydrodynamic and morphodynamic alterations brought about by the operation of the AMEP is therefore not predicted.

Impacts to Fish

10.8.13 Given that migration routes and foraging areas are considered unlikely to be significantly affected during operation of the AMEP site it is probable that the impacts to fish arising from operation of the AMEP site will not be significant.

10.9 CUMULATIVE IMPACTS

10.9.1 Several other projects in the Humber Estuary have been identified, which may have cumulative effects with the AMEP Project on aquatic ecology. However, there is insufficient information on these projects to enable an assessment of the construction, piling and dredging activities that will occur. It would be unrealistic to assume a worst case scenario whereby all construction activities concur in place and time. The following paragraphs highlight potential interactions and base preliminary conclusions on the limited information available.

10.9.2 It is predicted that cumulative effects from the following impacts could occur:

- long term changes in the hydrodynamic and morphodynamic regime;
- dredge plumes from capital and maintenance dredging;

- dredging and piling noise;
- increase in shipping (associated noise); and
- water quality changes.

10.9.3 These potential cumulative impacts have been divided by construction and operational impacts and are discussed separately.

Construction Phase

Long Term Changes in the Hydrodynamic and Morphodynamic Regime

10.9.4 Changes in the hydrodynamic and morphodynamic regime have been modelled by JBA Consulting (see *Chapter 8*) and the results indicate that while sedimentation may occur in the vicinity of the quay, away from the quay the impact of the development on intertidal and sub-tidal areas will be negligible in comparison with natural changes. This indicates that cumulative effects with other projects will not occur as impacts to aquatic ecology from AMEP site are localised to AMEP site.

Dredge Plumes

10.9.5 Dredge plumes as a result of AMEP are considered a temporary phenomenon and discrete in time and space. It is possible that dredge plumes from AMEP site and another project may interact (for example maintenance dredging and channel deepening) particularly when the same disposal area is used, however, given that sediment plumes are temporary and quickly dispersed and the natural variability of suspended sediment concentrations in the Humber it is unlikely any significant cumulative impacts to aquatic ecology will occur.

Dredging and Piling Noise

10.9.6 Dredging and piling noise as a result of AMEP is considered a temporary phenomenon. The piling of the front quay, which has the largest potential impact, will last for 6 months. Other planned projects that involve piling operations may interact, however, the nature of these projects suggests that less piling will be undertaken. The noise from dredging operations is not an issue of concern. It is unlikely that any significant cumulative impacts to aquatic ecology will occur.

Operational Phase

Increase in Shipping

10.9.7 An increase in shipping as a result of operation of AMEP will increase shipping noise in the estuary, which may affect aquatic ecology. However, AMEP site will only marginally increase shipping frequency in an already busy estuary. Therefore no significant negative cumulative impacts to aquatic ecology are expected.

Water Quality Changes

10.9.8 Water quality may be affected due to the presence of the quay and the associated run off into the estuary, which has the potential to impact on aquatic ecology, especially when combined with impacts from other projects. However, only a negligible contribution towards reduced water quality will occur from the AMEP site as there is wide dispersion and high natural variability in the estuary and no contaminated run off is expected (see mitigation measures in *Chapter 9* – Water and Sediment Quality). No significant negative cumulative impacts are therefore predicted.

Key

- Application Boundary
- Estuary Divisions

PROJECTION: British National Grid

Rev	Date	Comments	Drw	Chk	App
C	00/00/0000	General Amendments			
B	00/00/0000	General Amendments			
A	25/07/2011	General Amendments	MTC	WB	

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ERM

Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

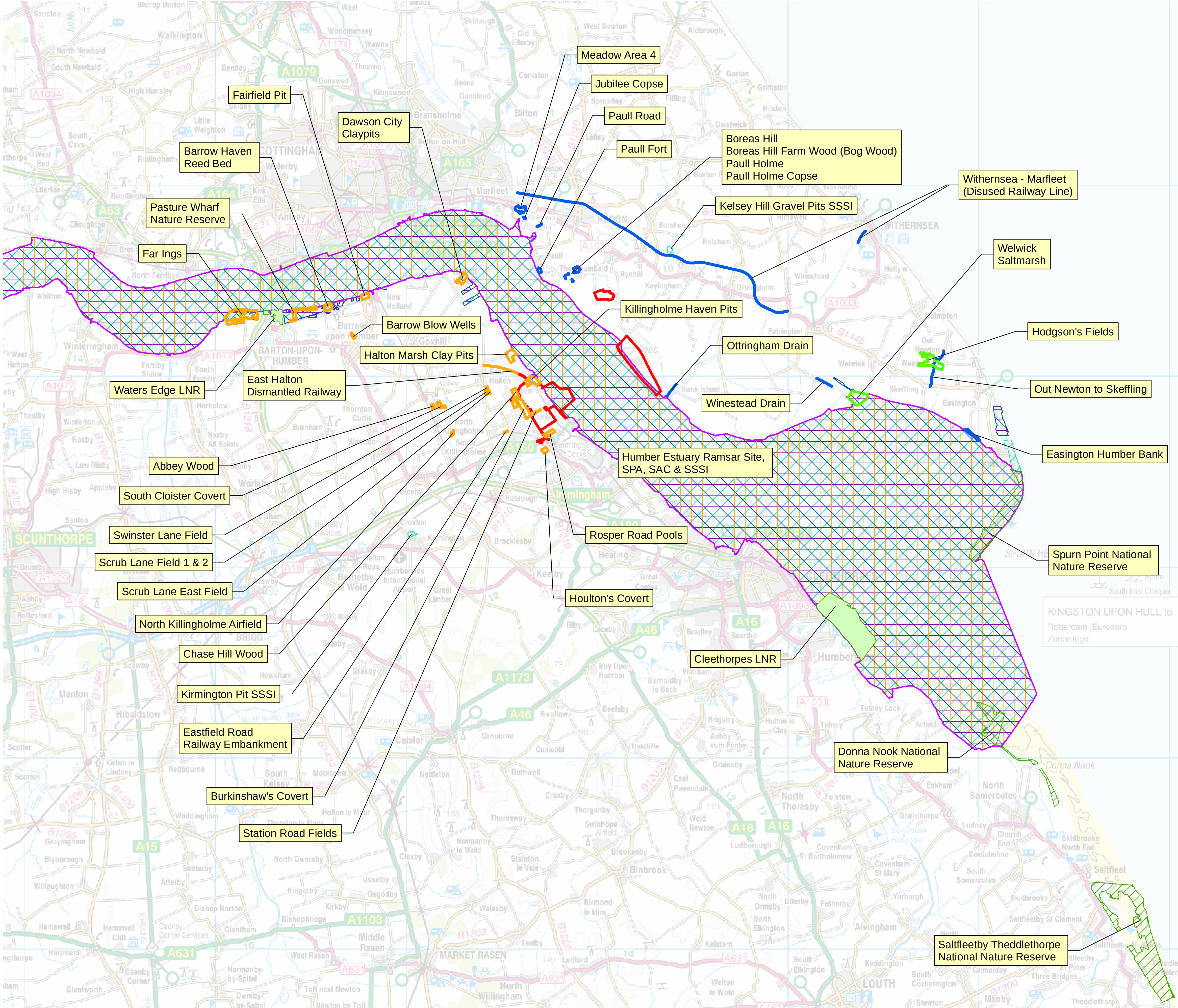
Title: Figure 10.1 Overview of Humber Estuary

Scale:	Drawn	Checked	Approved
1:200,000@A3	MTC	WB	RC
Date	25/07/2011	25/07/2011	00/00/0000

Drawing No.: ABLE_Estuary.mxd

Revision: A

File: 0120872AHP_MarineEnergyPark\GIS_MTC_MKMAPS\ABLE Template Maps\ABLE_Estuary.mxd



Key

- Application Boundaries
- Yorkshire Wildlife Trust Nature Reserves
- Lincolnshire Local Wildlife Sites
- East Riding of Yorkshire Local Wildlife Sites
- LNR
- NNR
- Humber Estuary IBA
- RAMSAR
- SAC
- SPA
- SSSI

PROJECTION: British National Grid

Rev	Date	Comments	Drw	Chk	App
B	01/12/2011	General Amendments	MTC	WB	SP
A	21/01/2010	Preliminary Issue	MTC	WB	SP

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ERM

Project: ABLE Marine Energy Park

Client: ABLE UK Ltd

Title: Figure 10.6
Designated Sites Within or Adjacent to the Humber Estuary

PRELIMINARY

Scale:	Drawn	Checked	Approved
1:200,000@A3	MTC	WB	SP
Date	01/12/2011	01/12/2011	01/12/2011

Drawing No.: ABLE_EcologicalConstraints.mxd

Revision: B

File: 0120872AHP_MarineEnergyPark\GIS_MTC_MKMAPS\ABLE Template Maps\ABLE_EcologicalConstraints.mxd