REPORT

Boston Alternative Energy Facility - Preliminary Environmental Information Report

Chapter 17 Marine and Coastal Ecology

Client: Alternative Use Boston Projects Ltd

Reference: PB6934-RHD-01-ZZ-RP-N-2017

Status: 0.1/Final

Date: 17/06/2019

baef
Boston Alternative Energy Facility

Royal HaskoningDHV
Enhancing Society Together

HASKONINGDHV UK LTD.

Rightwell House
Rightwell East
Bretton
Peterborough
PE3 8DW
Industry & Buildings
VAT registration number: 792428892

+44 1733 334455 **T**
+44 1733 262243 **F**
email **E**
royalhaskoningdhv.com **W**

Document title:	Boston Alternative Energy Facility - Preliminary Environmental Information Report
Document short title:	Marine and Coastal Ecology
Reference:	PB6934-RHD-01-ZZ-RP-N-2017
Status:	0.1/Final
Date:	17/06/2019
Project name:	Boston Alternative Energy Facility
Project number:	PB6934-RHD-01-ZZ-RP-N-2017
Author(s):	Melisa Vural

Drafted by:	Melisa Vural
Checked by:	Chris Adnitt
Date / initials:	CA 15/05/2019
Approved by:	Gary Bower
Date / initials:	GB 17/06/2019

Classification
Project related

Table of Contents

17	**Marine and Coastal Ecology**	**1**
17.1	Introduction	1
17.2	Legislation, Policy and Guidance	1
17.3	Consultation	6
17.4	Assessment Methodology	12
17.5	Scope	14
17.6	Existing Environment	16
17.7	Embedded Mitigation Relevant to Marine and Coastal Ecology	41
17.8	Impact Assessment	42
17.9	Cumulative Impacts	70
17.10	Inter-Relationships with Other Topics	74
17.11	Interactions	74
17.12	Summary	77
17.13	References	81

Table of Tables

Table 17.1 NPS for Energy Assessment Requirements 3

Table 17.2 Consultation and Responses 6

Table 17.3 Key Information Sources 15

Table 17.4 Records of Benthic Invertebrates, Characteristic of Freshwater and Brackish Water, Recorded Within 2km of the Boston Barrier Project (Greater Lincolnshire Nature Partnership, 2015). 23

Table 17.5 Species of Fish Recorded in the River Witham with Designation Under European, National and Regional Legislation (Environment Agency, 2014), Alongside Their Status Under the Lincolnshire BAP (Lincolnshire Biodiversity Partnership, 2011). Cells Highlighted in Green Signify the Protection of that Species Under the Relevant Legislation. 25

Table 17.6 Migration Periods for Diadromous Fish Species Found Near the Location of the Proposed Facility. Arrows Indicate Whether the Migration is Upstream (↑) or Downstream (↓). (Source: Environment Agency (2014) Boston Barrier Project Environmental Statement Volume 2b: Ecology and Nature Conservation Technical Report, Natural England). 29

Table 17.7 Fish Species in the Vicinity of the Proposed Facility that are Known to have Sensory Abilities, Their Distribution Throughout the Water Column, and Key References. 32

Table 17.8 Presence Patterns of Protected Bird Species Within the Wash SPA. Orange cells = summer; green cells = resident; blue cells = wintering; purple = passage (Source: Royal Society for the Protection of Birds). 36
Table 17.9 Potential Impacts on Marine and Coastal Ecology 44
Table 17.10 Summary of Impact Assessment 47
Table 17.11 Summary of Impact Assessment 52
Table 17.12 Data on Mortality and Recoverable Injury Caused from Pile Driving, Based on 960 Sound Events at 1.2 Second Intervals. (Source: Mortality and Recoverable Injury Data - (Halvorsen, et al., 2011; Halvorsen, et al., 2012a; Halvorsen, et al., 2012c), TTS data - (Popper, et al., 2005)) 56
Table 17.13 Guidelines for the Noise Impacts on Fish from Shipping and Other Continuous Sounds 56
Table 17.14 Guild Abundances of Noise-Sensitive Species Recorded During the Environment Agency's 2017 Survey (Waugh, 2017). 58
Table 17.15 Summary of Impact Assessment 60
Table 17.16 Summary of Impact Assessment 61
Table 17.17 Summary of Impact Assessment 68
Table 17.18 Summary of Impact Assessment 69
Table 17.19 Summary of Impact Assessment 70
Table 17.20 Projects in the Vicinity of the Facility with the Potential to have Cumulative Impact 71
Table 17.21 Potential Cumulative Impacts with the Boston Barrier 73
Table 17.22 Chapter Topic Inter-Relationships 74
Table 17.23 Interaction Between Impacts 75
Table 17.24 Impact Summary 78

Non-Technical Summary

This chapter of the Preliminary Environmental Information Report assesses the potential impacts of the proposed Facility on marine and coastal ecology. The baseline (existing) environment is described, informed through a desktop study comprising of existing data relevant to the Study Area for the Application Site, relating to the Environment Agency's Boston Barrier project, additional data from other sources, consultation and on-site surveys.

Using a standardised approach, all potential impacts during construction, operation and decommissioning of the Facility are identified and significance assessed. The Facility is located in close proximity to the Boston Barrier, with which any potential cumulative impacts are considered. Any other schemes that may have the potential to have cumulative impacts were also agreed with Boston Borough Council and have been included in this chapter.

The worst case scenario was considered when assessing the potential impacts. The main potential impacts arising from the construction period are habitat loss/alteration, increased suspended sediment concentrations and increased noise and vibration caused by piling and ship movements. The sensitive receptors include fish, benthic communities, birds, marine mammals, saltmarsh and mudflats.

For the operational phase, the key potential impacts are changes in vessel traffic and movement leading to increased ship wash, underwater noise, disturbance and collision risk with marine mammals. The potential impact of an increase in operational air emissions on habitats is also considered. Mitigation has been applied to the impact assessment for both the construction and operational phase, to reduce the significance of some impacts.

Potential effects of the Facility on European protected sites were assessed in the Habitats Regulations Assessment (HRA). The scope of the HRA identified that the following European sites were relevant:

- The Wash SPA.
- The Wash Ramsar site.
- The Wash and North Norfolk Coast SAC.

A summary table is included below, describing the potential significance of each impact identified during the construction, operation and decommissioning of the Facility, any proposed mitigation and the residual impact. No significant impacts on marine and coastal ecology are predicted for the decommissioning phase.

Cumulative impacts were only considered with the Boston Barrier, with respect to simultaneous maintenance dredging and operation activities, leading to increased human activity in The Haven. In line with **Chapter 16 Estuarine Processes**, the cumulative impact of suspended sediment concentrations and consequent smothering from the plume from dredging for both projects being operated at the same time is considered **negligible.** Although the Environment Agency's Haven Banks project has the potential for cumulative impacts to arise with the Facility, it was not considered any further in the cumulative impact assessment, as it is planned to be completed prior to the beginning of the Facility's construction works.

Phase	Impact	Receptor	Impact Significance	Mitigation	Residual Impact
Construction	Loss of and/or change to estuarine habitats and associated species within the footprint of the wharf and dredging area	Mudflats	Minor adverse	Material removed to be restricted to minimum. The design of the quay wall and wharf has been set to minimise the volume of capital dredging required.	Minor adverse
		Saltmarsh	Minor adverse		Minor adverse
	Increased suspended sediment concentrations from capital dredging, with potential for sediment-bound contaminants to be released	Fish	Moderate adverse	The need for, and nature of mitigation will be considered when the dredging programme has been confirmed.	Moderate adverse
		Benthic fauna	Minor adverse		Minor adverse
	Disturbance due to human activity/increased human presence (excluding underwater noise, but including airborne noise)	Birds	To be assessed when predictions of noise generation during construction have been undertaken		
	Underwater noise (piling and vessel movements)	Fish	Moderate adverse	The need for, and nature of mitigation will be considered when the impact assessment is further progressed and the potential for underwater noise generation is better understood.	Moderate adverse
		Marine mammals	Minor adverse		Minor adverse
Operation	Habitat alteration due to hydrodynamic changes	Intertidal and subtidal habitats	Minor adverse	Dredging works to be minimised according to best practice and monitor the seabed and habitat level through regular bathymetric and habitat surveys.	Minor adverse

Phase	Impact	Receptor	Impact Significance	Mitigation	Residual Impact
	Changes in vessel traffic and movement leading to increased ship wash, underwater noise, disturbance and collision risk	Increased risk of invasive species with ballast water	Negligible	Not applicable (N/A)	Negligible
		Increased risk of invasive species through ballast water use	Negligible	N/A	Negligible
		Intertidal habitats (increased ship wash)	Negligible	N/A	Negligible
		Fish, birds and marine mammals (increased noise)	Minor adverse	Shipping to be kept to a minimum, as necessary. Slow speed (max. 4 knots) to be kept for all vessels.	Minor adverse
		Marine mammals (vessel collision)	Minor adverse	Slow speed (max. 4 knots) to be kept for all vessels. Vessel movements to be incorporated in to recognised vessel routes.	Minor adverse
	Increased suspended sediment concentrations due to maintenance dredging	Fish (migration and behaviour)	Minor adverse	Given that the maintenance dredging will form part of the existing wider maintenance programme, and the nature of the predicted impacts, no specific measures are considered necessary.	Minor adverse
		Benthic fauna	Negligible		Negligible
	Beaching of vessels at low tide	Benthic fauna	Minor adverse	No mitigation was deemed necessary.	Minor adverse

Phase	Impact	Receptor	Impact Significance	Mitigation	Residual Impact
	Increased emissions to air and deposition on marine and estuarine habitats	Marine and coastal habitats	Potential impacts will be assessed when the results of the air quality assessment are available.		
Decommissioning	No impacts on marine and coastal ecology are anticipated during the decommissioning phase.				

17 Marine and Coastal Ecology

17.1 Introduction

17.1.1 This chapter of the PEIR describes the existing environment in relation to marine and coastal ecology and provides a preliminary assessment of the potential impacts during the construction, operational and decommissioning phases of the Boston Alternative Energy Facility (the Facility).

17.1.2 The chapter assesses potential impacts caused by the Facility on marine and coastal habitats (including saltmarsh and mudflat), benthic species, fish, marine mammals and birds. Mitigation measures are identified, and an assessment of the potential residual impacts provided.

17.1.3 This chapter draws on information within other chapters including **Chapter 10 Noise and Vibration**, **Chapter 14 Air Quality**, **Chapter 15 Marine Water and Sediment Quality**, **Chapter 16 Estuarine Processes** and **Chapter 18 Navigational Issues**. This chapter informs **Appendix 17.1 Habitats Regulation Assessment** (HRA) and **Appendix 13.1 Water Framework Directive** compliance assessment.

17.2 Legislation, Policy and Guidance

Legislation

17.2.1 International and European legislation and conventions relevant to marine and coastal ecology are:

- The Convention on Biological Diversity (1992);
- Convention on the Wetlands of International Importance, Ramsar (1971);
- EU Directive 2009/147/EC on the conservation of Wild Birds (Birds Directive); and,
- Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive).

17.2.2 Relevant UK legislation associated with designated sites and associated habitats and species which are protected through planning and other controls are as follows:

- Wildlife and Countryside Act (WCA) 1981 (as amended).
    - The WCA 1981 provides legal protection for specific species of birds, wild

animals and plants. All birds under the WCA are protected against killing, injuring and taking, whilst their nests (while in use or being built) and eggs are protected against taking, destroying or damaging. The bird species listed in Schedule 1 are given greater protection against disturbance of birds at or near the nest or their dependant young.

- Natural Environment and Rural Communities (NERC) Act 2006
    - The NERC Act 2006 has a general purpose of ensuring that the natural environment is conserved, enhanced and managed, contributing to sustainable development.
    - Section 40 of this Act places a duty to conserve biodiversity on English authorities, including public bodies, local authorities and the Environment Agency (EA), whilst carrying out their normal functions. Section 41 sets out a number of species of "principle importance" for conserving biodiversity in England.
- Conservation of Habitats and Species Regulations 2017
    - These Regulations provide for the protection of 'European sites', the protection of 'European species' and the adaptation of planning and other controls for the protection of European sites. As such, competent authorities, such as Government departments and public bodies, have a general duty to have regard to the Habitats Directive and Birds Directive in the exercise of any of their functions.
- Eels Regulations 2009
    - These Regulations give powers to the EA to implement measures for the recovery of European eel stocks.
- Salmon and Freshwater Fisheries Act 1975
    - This Act protects salmon and trout from commercial poaching, as well as protecting their migration routes, preventing wilful vandalism and neglect of fisheries, and ensuring correct licensing and water authority approval.

National Planning Policy Framework

17.2.3 The updated National Planning Policy Framework (February 2019) states the following in relation to habitats and biodiversity, relevant to the Facility.

- To protect and enhance biodiversity and geodiversity, plans should:
    - *"Identify, map and safeguard components of local wildlife-rich habitats and wider ecological networks, including the hierarchy of international, national and locally designated sites of importance for biodiversity; wildlife*

corridors and stepping stones that connect them; and areas identified by national and local partnerships for habitat management, enhancement, restoration or creation"; and

- *"Promote conservation, restoration and enhancement of priority habitats, ecological networks and the protection and recovery of priority species; and identify and pursue opportunities for securing measurable net gains for biodiversity".*

National Planning Policy and Guidance

17.2.4 The assessment of potential effects on marine and coastal ecology has been made with specific reference to the relevant National Policy Statements (NPS), which are the principal decision-making documents for Nationally Significant Infrastructure Projects (NSIP). The overarching NPS for Energy (EN-1) (July 2011) is relevant to marine and coastal ecology. The NPS for Renewable Energy (EN-3) was also checked, however there were no policy guidelines relevant to marine and coastal ecology for the technology type that the Facility will have.

17.2.5 The relevant aspects of EN-1 are presented in **Table 17.1**. This chapter of the PEIR either directly addresses these issues or provides information which enables these issues to be addressed in other, more relevant chapters, such as **Chapter 16 Estuarine Processes**.

Table 17.1 NPS for Energy Assessment Requirements

NPS Requirement	NPS Reference	PEIR Reference
NPS for Energy (EN-1)		
"Where the development is subject to EIA the applicant should ensure that the ES clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity The applicant should show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests."	Section 5.3, paragraph 5.3.3 and 5.3.4	These have been identified in **Section 17.2**, and have been considered throughout the impact assessment, specifically in **Appendix 17.1**, the HRA.

NPS Requirement	NPS Reference	PEIR Reference
The applicant should include appropriate mitigation measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works; During construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements; Habitats will, where practicable, be restored after construction works have finished; and Opportunities will be taken to enhance existing habitats and, where practicable, to create new habitats of value within the site landscaping proposals.	Section 5.3, paragraph 5.3.18	Mitigation measures for each impact identified has been included throughout **Section 17.8**, with the details required as part of the NPS accounted for.

17.2.6 The Marine Policy Statement (MPS) (HM Government, 2011) provides the high-level approach to marine planning and general principles for decision-making that contribute to achieving this vision. It also sets out the framework for environmental, social and economic considerations that need to be considered in marine planning. The key reference for marine ecological features is in Sections 2.6.1.3, 2.6.1.5 and 2.6.1.6 of the MPS which states:

> *"…As a general principle, development should aim to avoid harm to marine ecology, biodiversity and geological conservation interests (including geological and morphological features), including through location, mitigation and consideration of reasonable alternatives. Where significant harm cannot be avoided, then appropriate compensatory measures should be sought."*
> *"…The marine plan authority should ensure that appropriate weight is attached to designated sites; to protected species; habitats and other species of principal importance for the conservation of biodiversity; and to geological interests within the wider environment."*

"…The marine plan authority should ensure that development does not result in a significant adverse effect on the conservation of habitats or the populations of species of conservation concern and that wildlife species and habitats enjoying statutory protection are protected from the adverse effects of development in accordance with applicable legislation".

Local Planning Policy and Guidance

17.2.7 Although Boston Borough Council (BBC) will not be responsible for granting planning permission for the Facility, the relevant policies that have been set out in the South-East Lincolnshire Local Plan (adopted in March 2019) have been considered to be adhered to in this assessment on marine and coastal ecology (South-East Lincolnshire, 2019).

17.2.8 Policy 28: The Natural Environment, is (indirectly) relevant to marine and coastal ecology, and states that:

- development proposals that would cause harm to these assets (internationally designated sites, on land or at sea) will not be permitted, except in exceptional circumstances, where imperative reasons of overriding public interest exist, and the loss will be compensated by the creation of sites of equal or greater nature conservation value.
- a development proposal that would directly or indirectly adversely affect nationally or locally-designated sites (including Havenside Local Nature Reserve (LNR)) will not be permitted unless there are no alternative sites that would cause less or no harm; the benefits of the development at the proposed site, clearly outweigh the adverse impacts on the features of the site and the wider network of natural habitats; and suitable prevention, mitigation and compensation measures are provided.
- Addressing gaps in the ecological network: by ensuring that all development proposals shall provide an overall net gain in biodiversity, by:
    - protecting the biodiversity value of land, buildings and trees (including veteran trees) minimising the fragmentation of habitats;
    - maximising the opportunities for restoration, enhancement and connection of natural habitats and species of principal importance;
    - incorporating beneficial biodiversity conservation features on buildings, where appropriate; and maximising opportunities to enhance green infrastructure and ecological corridors, including water space; and

- conserving or enhancing biodiversity or geodiversity conservation features that will provide new habitat and help wildlife to adapt to climate change, and if the development is within a Nature Improvement Area (NIA), contributing to the aims and objectives of the NIA.

17.2.9 The Plan acknowledges that nationally protected wildlife sites will continue to be protected and enhanced, consistent with national legislation and the objectives in their management plans.

Lincolnshire Biodiversity Action Plan (BAP)

17.2.10 The Lincolnshire BAP (LBAP, 3rd Edition) identifies several habitats and species that are vulnerable to certain anthropogenic (e.g. urban development, agriculture) and natural pressures (e.g. climate change, sea level rise) that are in need of greater actions.

17.2.11 Saltmarshes and mudflats are listed as priority habitats under the Lincolnshire BAP, and also the UK BAP, so as to protect their current extent. Both habitats provide important areas for the refuge of fish, and feeding, breeding and roosting areas for overwintering and breeding birds found in the area. More detailed information on the priority habitats have been included in **Section 17.6**.

17.3 Consultation

17.3.1 Consultation undertaken throughout the pre-application phase, including the Planning Inspectorate's Scoping Opinion, informed the approach and the information provided in this chapter. A summary of the consultation relevant to marine and coastal ecology is provided in **Table 17.2**.

Table 17.2 Consultation and Responses

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
The Planning Inspectorate, July 2018	Impact of operation of the wharf facility: The Scoping Report intimates that impacts to marine ecology and fisheries from operation of the wharf facility are to be scoped out. However, paragraph 6.9.11 of the Scoping Report contradicts this position and this leads to uncertainty overall. There is also an absence of justification to support a decision to scope this matter out. Therefore, in the absence of such information the Inspectorate cannot agree to scope this matter out of the assessment in the ES. Therefore, the ES needs to include an assessment of the likely significant effects associated with the operation of the wharf, supported by appropriate evidence.	**Section 17.7** assesses the potential impacts of the wharf operation on the marine and coastal ecological receptors.

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
The Planning Inspectorate, July 2018	WFD ecological classification: The Applicant should ensure that the ES includes accurate baseline information regarding sensitive receptors. In this regard the Applicant is referred to comments by the EA noting that The Haven has a bad ecological potential, and not a moderate ecological potential as stated within the Scoping Report.	WFD compliance assessment has been included in **Appendix 13.1.**
The Planning Inspectorate, July 2018	Study Area: The ES should clearly define the Study Area applied to the assessment. The Study Area must be established having regard to the extent of impacts and likely significant effects. Assumptions applied when establishing the Study Area should be clearly set out in the ES.	The Study Area for the marine and coastal ecology assessment is defined in **Section 17.5**.
The Planning Inspectorate, July 2018	Potential effects: The Scoping Report describes impacts as temporary for construction and permanent for the operational phase. The Inspectorate considers that resulting effects may not adhere to the same timescales, for example permanent effects can result from temporary construction activities. The ES should characterise the duration of predicted effects, and define any terms used e.g. temporary, intermittent, short term, long term etc. in terms of days/months/years.	The timescales have been applied to predicted impacts, outlined in **Section 17.8**, and it has been identified if an impact is of temporary or permanent nature.
The Planning Inspectorate, July 2018	Mitigation/monitoring: The ES should demonstrate how mitigation and monitoring measures relied upon in the assessment would be secured and how any necessary remedial action would be undertaken. For example, if the proposed in-construction bathymetric surveys indicate that erosion and deposition are exceeding predicted values. The Inspectorate notes the intention to carry out surveys during operation to assess the need for channel maintenance. The Inspectorate advises that the anticipated nature of the maintenance dredging should be set out in the ES, where this information has been relied upon for the assessment of significant effects.	Mitigation measures have been listed for each potential impact, detailed in **Section 17.8**. Embedded mitigation is also considered an important method of reducing impacts and have been identified in **Section 17.7**.
The Planning Inspectorate, July 2018	Methodology: The ES should explain how desk-study and modelling data has been used to inform the assessment. The Applicant should make effort to agree the approach with the relevant consultation bodies.	All consultee comments are incorporated in to the relevant sections, with the relevant signposting highlighted in **Section 17.3.** The assessment methodology is included in **Section 17.4** and the data sources in **Section 17.5.**
Environment Agency, 3rd July	The EIA must consider and address risks to resident fish species within the tidal Witham as well as the listed	**Section 17.6** identifies the key fish

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
2018	migratory species and where possible net gains and adequate mitigation included for at all stages of the proposed development.	species (migratory and non-migratory). **Section 17.8** details the potential impacts on fish and relevant mitigation measures.
Environment Agency, 3rd July 2018	Noise and vibration operating levels need to be agreed to minimise impact upon resident and migratory species that are known to be present.	**Section 17.6** outlines fish species sensitive to underwater noise and vibration, and the threshold values have been considered in the relevant mitigation measures listed in **Section 17.8**. Noise and vibration operating levels will be agreed in advance of the construction phase and identified in the working methodology for the Construction Environmental management Plan (CEMP).
Environment Agency, 3rd July 2018	The new wharf should be designed to minimise future maintenance needs at the Wharf and within the wider Witham in regard to upstream and downstream sediment transport, erosion and bank stability.	The wharf design and justification have been presented in **Section 17.5**. Any design alterations relating to minimising future maintenance have been included in **Chapter 5 Project Description**.
Environment Agency, 3rd July 2018	More information may be required to inform the final EIA for this proposed development as the Boston Barrier may not have considered any in combination impacts or information within the immediate area of this proposed development.	Cumulative impacts including the presence of the Boston Tidal Barrier have been considered in **Section 17.9**.
Environment Agency, 3rd July 2018	We disagree with the conclusion that the impact of the project's operational phase on marine ecology and fisheries can be scoped out of the EIA. This is because the impacts of the operational phase on estuarine and geomorphological processes during the operational phase is scoped in. Estuarine processes and ecology are	Operational phase impacts of the Facility have been assessed in **Section 17.8**.

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
	intrinsically linked. The applicant will need to determine the impacts on geomorphology and estuarine processes before concluding whether or not there is a risk of impacts to ecological elements.	
Marine Management Organisation, July 2018	The MMO would expect the ES to have detailed the statutory sites of importance for nature conservation nearest to the proposed development and justified why they can be screened out. These sites are: The Wash (SPA) The Wash (Ramsar) The Wash and North Norfolk Coast (SAC).	These European protected sites have not been screened out. Impacts on these sites have been included in the HRA in **Appendix 17.1**.
Marine Management Organisation, July 2018	The MMO welcomes the consideration of potential impacts to species in the Havenside Local Nature Reserve (LNR). Additional points for consideration of the impact on marine mammals at the site has been included in section 5.8 of this advice.	The Havenside LNR has been considered in **Section 17.6** and **17.8.** Impacts on marine mammals have also been assessed in **Section 17.8**, and in **Appendix 17.1** (relating to European protected sites).
Marine Management Organisation, July 2018	Any fisheries data taken from past surveys that are used in the ES, should include or signpost to relevant information such as dates and times of surveys, locations, gear used, mesh size, duration of tow / soak times. The limitations of any data sources used in the assessment are presented in the ES.	The relevant information and signposting for fisheries data used in this impact assessment is included in **Section 17.6**.
Marine Management Organisation, July 2018	The ES should provide information on any known spawning and nursery grounds of fish. For migratory species, the impact assessment should consider the timing of upstream and downstream migrations in relation to construction and dredging activities. Areas of substrate suitable for smelt spawning should also be identified where possible.	**Section 17.6** details known spawning and nursery grounds for fish, as well as the migratory timing of relevant fish. The impact assessment in **Section 17.8** has also considered the timings of fish migration.
Marine Management Organisation, July 2018	A construction schedule indicating the months when dredging and piling works will be carried out should be presented within the ES. This will help identify the months that piling /dredging activity will overlap with the peak migratory seasons of fish.	The dredging and piling works schedule will be identified in the final Environmental Statement.

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
Marine Management Organisation, July 2018	The MMO would expect a precautionary approach to the impacts of noise and vibration (from all forms of piling) on fish to be taken, to ensure that the mitigation is adequate.	This has been considered in the form of mitigation in **Section 17.8**.
Marine Management Organisation, July 2018	The MMO expect the ES to include detailed descriptions of marine and migratory fish in the Study Area, especially in relation to the seasonal movements of migratory fish.	**Section 17.6** includes detailed baseline information on fish movements in the Study Area in The Haven.
Marine Management Organisation, July 2018	Section 6.9.31 of the Scoping Report, within the Marine Ecology and Fisheries chapter, states that "the impact of operation of the wharf facility is not anticipated to have any significantly adverse effects". The MMO consider that this requires further assessment given that the vessels using the wharf will ground on the seabed.	The operational impact of the wharf facility has been considered and included in **Section 17.8**. This includes the increased number of vessel movements as well as the grounding of vessels using the wharf at low tide.
Environment Agency (December 2018)	The meeting with the Environment Agency was focused on the amendment of the flood defence due to the construction of the wharf. No specific issues or concerns relevant to marine and coastal ecology were mentioned.	Not Applicable
Natural England, February 2019	Consideration of how you will be able to demonstrate that the works across the inland fields (where the main facility is based) and along the channel (where the wharf is situated) will not affect breeding or over-wintering/ passage birds that are qualifying features of The Wash SPA. Project specific evidence will be needed to show that this area is not used as a supporting feature. We are aware from discussions with the Environment Agency that data is not held for the Boston Barrier or Boston Haven projects. In our opinion bird surveys should be started immediately for breeding birds, showing likely nesting and feeding areas, and for passage/ over-wintering. We understand that with your proposed submission in September – the over-wintering bird data will need to be submitted during the examination process. Considering the importance of this data we would suggest ensuring the survey protocol is sufficiently robust *i.e.* with 2 monthly visits between now and the project examination. We would like to review the survey protocol.	The impact of works across the inland fields has been assessed in **Chapter 12 Terrestrial Ecology**. Impacts that are likely to occur along the channel have been assessed in **Section 17.8.** Up-to-date bird data has been purchased from the British Trust for Ornithology to provide information on roosting birds that may be using the site for roosting and potentially feeding. In addition, data used by the EA (from 2010 overwintering bird

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
		survey) to assess the impact of the Boston Barrier construction and operational phases, as well as overwintering bird information in The Haven obtained from Woodward *et al.*, 2014 have been used to inform the PEIR.
Natural England, February 2019	Further details on the number of boat movements along the Boston Haven and into The Wash are necessary for the assessment. Please confirm the number of return boat trips related to the operation of the Facility, and the size and type of the vessels. Will there be any seasonal differences throughout the year? The number of boat trips may affect marine mammals in The Wash as you highlighted, but also may cause erosion damage to the channel through wave action. We are also concerned about the use of water from the channel as ballast as this could cause a dewatering of the channel and could also cause the spread of invasive species.	The number and sizes of vessels that will be used as part of the operation of the facility have been outlined in the impact assessment of increased ship wash and the risk of invasive species being introduced, in **Section 17.8**.
Natural England, February 2019	Considering the newly constructed wharf area will result in the dredging and loss of mudflat by ca. 40m you will need to demonstrate (by sediment modelling both during the construction and operation phase) that the modification of the shoreline with the construction of the wharf at this location will not have a knock on affect to the adjacent priority habitats *i.e.* saltmarsh and mudflats and also to the SPA and SAC further downstream. Also that changing the channel will not cause a change in the erosion/ deposition rates along the channel. I understand as a general policy on The Wash, sediments dredged from the system need to be returned to The Wash offshore so that sediment is not lost.	Any changes on the hydrodynamics of the region have been assessed in **Section 17.8**. Additionally, it was agreed with Natural England that the HRA in **Appendix 17.1** includes only impacts on marine mammals and birds in The Wash.
Natural England, February 2019	The provision of an up-to-date botanical survey of the saltmarsh (to National Vegetation Classification level and reference to the Common Standards Monitoring approach for saltmarsh) which will be lost within the footprint of the wharf as well as the adjacent downstream section. This is necessary to assess the impacts to the priority habitat. There is a small chance that the Boston Horsetail (*Equisetum ramosissimum*) may be present. This is a Schedule 8 Plant species. There is also potential for Sea	Findings from the 2011, 2014 and 2017 surveys carried out by the EA were used to inform the existing status of the saltmarshes adjacent to the Project site. A site visit was also undertaken by RHDHV in October 2018. Classifications

Consultee and Date	Response	Chapter Section Where Consultation Comment is Addressed
	Wormwood (*Artemisia maritima*) which has a local distribution along the Boston Haven in The Wash.	of the most recent saltmarsh survey are presented in **Sections 17.6** and **17.6**.
Marine Management Organisation, April 2019	Expressed concern over repeated berthing with contaminant metals moving back out of the sediment. There was also a concern that disturbing deeper sediments could lead to a potential pathway to The Wash SPA and Frampton Marshes.	Impacts from resuspended contaminants have been assessed in detail in **Chapter 15 Marine Water and Sediment Quality** and have been addressed in **Section 17.8.**
Eastern Inshore Fisheries and Conservation Authority (May 2019)	Expressed concern over navigation and impacts of dredging, impacts of piling noise on fish and any potential waste entering the water.	All impacts arising from dredging and piling, relating to fish have been assessed in **Section 17.8**. Any impacts relating to navigation are assessed in **Chapter 18 Navigational Issues.**

17.4 Assessment Methodology

Impact Assessment Methodology

17.4.1 A desktop study was carried out to review all available information on the marine and coastal ecological baseline in The Haven. The Boston Barrier Environmental Statement (Environment Agency, 2014) provided a valuable source of information in this respect, as well as the Environment Agency's monitoring data in The Haven for sediment quality, saltmarsh quality and fish.

17.4.2 Consultation was undertaken with the Environment Agency to discuss the work undertaken for the Boston Barrier and to ensure that all relevant available data was being reviewed to inform this assessment. Consultation was also undertaken with other statutory bodies (Marine Management Organisation, Natural England, Eastern Inshore Fisheries and Conservation Authority) to inform this assessment.

17.4.3 A site visit was undertaken on the 8th October 2018 to the site of the proposed Facility to map the habitats within the intertidal areas. This was undertaken at a low spring tide to maximise the area available for survey.

17.4.4 The proposed methodology for the construction works and design of the Facility were considered to identify the potential for impacts. In addition, the results of other relevant assessments (such as the Boston Barrier Environmental Statement, subsequent sampling events in The Haven for fish, water and sediment quality etc.) were reviewed to obtain information on likely changes due to the construction and operation of the Facility that have the potential to impact on marine and coastal ecology. This included potential changes to water and sediment quality during construction and operation, changes to noise and vibration levels during the works, vessel numbers transiting to and from the Facility both during construction and operation and changes to estuarine geomorphology because of the Facility.

17.4.5 Three phases of development are considered, in conjunction with the present-day baseline, over the proposed life cycle of the Facility (at least 25 years). These are:

- Construction phase;
- Operational phase; and,
- Decommissioning phase.

17.4.6 Consideration of the potential impacts of the above phases on marine and coastal ecology was considered on two different spatial scales to determine the Study Area:

- Near-field – the area adjacent to the footprint of the proposed Facility, within tens or hundreds of metres.
- Far-field – the wider area downstream and upstream of the footprint of the proposed Facility that may also be affected by construction and operation (e.g. increased vessel movements, ship wash).

17.4.7 The Study Area depends on the results of the assessments for other parameters (e.g. water and sediment quality, noise and vibration and estuarine processes) and will be confirmed in the ES. The Study Area criteria used for this PEIR is discussed further in **Section 17.5**.

17.4.8 Potential impacts have been assessed according to the methodology outlined in **Chapter 6 Approach to EIA.** Consideration of the sensitivity of each receptor to the potential impact is a key aspect, drawing on the tolerance to the change and recoverability potential of the receptor, together with the importance of the receptor (e.g. whether the receptor is of international, national, regional or local importance in a conservation context). The magnitude of the potential impact is also important and includes a prediction of the characteristics of the potential impact in terms of the area affected, frequency and duration of change and the

scale of effect. The impact is then assessed to determine the likely significance both before and after mitigation, if necessary.

Cumulative Impact Assessment

17.4.9 Potential cumulative impacts are assessed through consideration of the extent of influence of changes or effects on marine and coastal ecology arising from the Facility alone and cumulatively with other projects.

17.4.10 A screening process has been undertaken in consultation with Boston Borough Council to define which projects will be considered in the Cumulative Impact Assessment. The full list of projects that were considered in the Cumulative Impact Assessment have been tabulated in **Section 17.9**.

Transboundary Impact Assessment

17.4.11 Potential transboundary impacts are assessed through consideration of the extent of influence of changes or effects and their potential to impact upon marine and coastal ecological receptor groups that are located within other countries.

17.4.12 Given the distance of the Facility from international boundaries, it is concluded that there is no pathway for transboundary impacts on marine and coastal ecology.

17.5 Scope

Study Area

17.5.1 This chapter addresses the potential effects on marine and coastal ecology along The Haven and into The Wash.

17.5.2 For the marine and coastal ecology assessment, the Study Area includes the direct zone of influence from the estuarine component of the Facility, covering the wharf area in the intertidal area of The Haven, and the indirectly affected zone which includes vessel transition routes and areas potentially influenced by noise, water quality and changes to estuarine geomorphology.

17.5.3 It is expected that the zone of potentially significant impact will be within 8 km of the Facility in a downstream direction, thereby capturing The Haven and The Wash, following the line of The Haven. The potential for impact in an upstream direction is lower than in a downstream direction and is restricted to potential hydrodynamic effects. Consequently, the Study Area currently extends a distance of 1 km upstream.

17.5.4 As the EIA progresses further and the outcomes of the impact assessment are confirmed, the Study Area will be refined if necessary.

Data Sources

17.5.5 The assessment was undertaken with reference to several sources, as detailed in **Table 17.3**.

Table 17.3 Key Information Sources

Data Source	Reference
Boston Barrier Scoping Report	*Boston Barrier Order Updated Scoping Report*, Environment Agency (2014)
Boston Barrier Environmental Statement	*Boston Barrier Tidal Project Environmental Statement Volume 2b: Ecology and Nature Conservation Technical Report*, Environment Agency (2014)
Lincolnshire Biodiversity Action Plan	*Lincolnshire Biodiversity Action Plan 2011-2020 (3rd Edition),* Lincolnshire Biodiversity Partnership (2011). [Online] Available at: https://www.nelincs.gov.uk/wp-content/uploads/2016/02/201110-LincolnshireBAP-3rd-edition.pdf
Saltmarsh Monitoring Report from the Environment Agency	*Boston Barrier Tidal Project: 2017 Saltmarsh Survey Report,* Holden, E. (2017)
Boston Barrier Fish Report from the Environment Agency	*Boston Barrier Witham Estuary Fish Report,* Waugh *et al*., (2017). Document reference: 17NEAS_Fish_2017
Boston Barrier Baseline Acoustic Report	*Boston Barrier – Baseline Acoustic Report,* Environment Agency (2018) Document Reference: ENVIMAN001472-BMM-00-00-RP-U-0306018
Boston Barrier Baseline Water and Sediment Quality Report	*Boston Barrier Project: 2017 Water quality and sediment quality report,* Newton, T. (2017) Report No: EA02/17NEAS
The Wash Bird Decline Investigation 2014	*The Wash Bird Decline Investigation 2014,* Woodward, I.D.; Ross-Smith, V.H.; Perez-Dominguez, R.; Rehfisch, M.M and Austin, G.E. (2015). BTO Research Report No. 660, *British Trust for Ornithology*.
Core Bird Count Data from: Frampton North 23, Frampton North 60, Slippery Gowt Pits, South Forty Foot Drain – Wyberton Fen to Hubbert's Bridge	British Trust for Ornithology, dates from: 2011 – 2016, 2011 – 2016, 2000 – 2005 and 2007 – 2012 (respectively)

17.5.6 The assessment uses available literature and data, including the Environmental Statement which supported the recently approved Boston Barrier scheme. Marine and coastal ecology data reported and cited in that document provided a useful baseline of relevance to the Facility, and this was obtained from the Environment Agency as appropriate. It was agreed with the Environment Agency that data from

the Boston Barrier scheme was suitable to be used as a baseline for the Facility. Furthermore, the Marine Management Organisation confirmed that these data would be representative of the Facility location, in relation to the water and sediment quality.

17.5.7 With the exception of the observations during the site visit on 8th October 2018, no new marine ecology or fisheries data collection has been undertaken for this PEIR.

Assumptions and Limitations

17.5.8 Due to the large amount of data that was collected for the Boston Barrier EIA, and subsequent monitoring that has taken place in The Haven, there is a good understanding of the existing marine ecology status in the vicinity of the location of the proposed Facility and the adjacent areas in The Haven that cover the proposed Study Area.

17.6 Existing Environment

Designated sites

17.6.1 The following nature conservation designations with a marine and coastal interest are found within the Study Area, shown in **Figure 17.1**;

- The Wash Special Protection Area (SPA);
- The Wash Ramsar site;
- The Wash and North Norfolk Coast Special Area of Conservation (SAC);
- The Wash Site of Special Scientific Interest (SSSI); and,
- Havenside Local Nature Reserve (LNR).

17.6.2 Further details of these sites are provided below. The SPA, Ramsar site and SAC (all of which are located approximately 3 km away from the location of the proposed Facility at the closest point) are further considered in **Appendix 17.1**, which provides initial consideration of potential effects of the proposed Facility under the **Appendix 17.1** describes the qualifying features and conservation objectives of these sites.

<u>The Wash SPA</u>

- The Wash SPA comprises very extensive mudflats, sand and mud banks, shallow waters and deep channels. The sheltered nature of the area present provides suitable breeding conditions for shellfish (mussels, cockles and shrimps). The infauna-rich intertidal flats also provide an ideal and important

food source for the breeding water birds dependent on the site, such as oystercatchers.

- The SPA is particularly important for internationally significant populations of breeding and non-breeding water birds.

The Wash Ramsar site

- The varied and rich habitats that are found in The Wash support a healthy and diverse ecosystem, due to the inter-relationship between its various features such as saltmarshes, intertidal sand and mudflats and the estuarine waters. The saltmarshes alongside the plankton in the water provide an important source of organic material. This forms the basis for a highly productive estuary, alongside other organic matter (JNCC, 1988).

The Wash and North Norfolk Coast SAC

- The Wash and North Norfolk Coast SAC covers a total area of 1,077 km^2 and is considered to be one of the best areas in the UK for sand banks, mudflats and sandflats and large shallow inlets and bays together with diverse saltmarsh communities (English Nature, 2000).
- This designation is based on the habitats present in the area as well as the species which occur in the proximity of the SAC boundaries. The following Annex I habitats that are a primary reason for selection of the site are as follows (JNCC, 2005):
    - Sandbanks which are slightly covered by sea water all the time.
    - Mudflats and sandflats not covered by sea water at low tide.
    - Large shallow inlets and bays.
    - Reefs.
    - Salicornia and other annuals colonising mud and sand.
    - Atlantic salt meadows.
    - Mediterranean and thermo-Atlantic halophilous scrubs.

The Wash SSSI

- The intertidal mudflats and saltmarshes of The Wash are one of Britain's most important winter-feeding areas for waders and wildfowl outside of the breeding season. Similar to the designation of the SPA in the same location,

a very large number of birds are dependent on the habitats found in The Wash for the rich supply of invertebrates for food (English Nature, 1972).

- The plant species found in the saltmarshes and shingle communities are also of notable botanical interest and the mature saltmarshes are valuable bird breeding zones.
- Additionally, The Wash is a very important breeding ground for the common seal.

Havenside LNR

- The Havenside LNR is locally important, with mixed habitats, such as grassland with scrub, cattle grazed meadows, shallow seasonal ponds, estuarine mudflats and saltmarshes. Common fauna includes oystercatchers, barn owls, bats and common seals. The most common saltmarsh species are sea lavender and glasswort (Boston Borough Council, 2018).

Habitats

17.6.3 The site visit carried out in October 2018 identified both coastal saltmarsh and mudflats as the main habitats in and around the location of the proposed wharf for the Facility. These habitats are listed under Section 41 of the NERC Act 2006 and the Lincolnshire BAP (Lincolnshire Biodiversity Partnership, 2011). These are, therefore, habitats of principal importance. Saltmarsh and mudflats are also priority habitats as identified within the Lincolnshire BAP, which also includes habitat action plans.

17.6.4 Intertidal mudflats, such as found within The Haven, are listed as an important feature of Lincolnshire in the Lincolnshire BAP, and are of high conservation value. These habitats support many species of benthic infauna, as well as representing feeding grounds for several bird species (Lincolnshire Biodiversity Partnership, 2011). However, as the needs of these habitats are well addressed through the management of the Humber and Wash European Marine Sites, a new habitat action plan was not included in the latest Lincolnshire BAP. Nonetheless, the UK BAP states that land claim, barrage schemes, human disturbance are some of the relevant threats to these habitats (JNCC, 2011).

17.6.5 The Lincolnshire BAP states that saltmarshes are in a good condition within the county. Their natural extent, however, is at the expense of mudflats. It is considered important to maintain the current extent of the Lincolnshire saltmarshes, particularly in light of the national losses of the habitat.

17.6.6 Saltmarshes provide a suitable high-tide refuge for associated bird species that are feeding on the adjacent mudflats in the winter. These habitats can also act as nursery sites for several fish species and can export nutrients to nourish neighbouring mudflats (Lincolnshire Biodiversity Partnership, 2011).

17.6.7 The greatest threats to the saltmarshes in the Witham estuary are considered to be coastal squeeze and erosion, changes in sediment supply and eutrophication (Holden, 2017). The targets and actions for the saltmarshes up until 2020 include monitoring losses and gains to ensure no net loss, collect information on changes in the extent and quality of the habitat, ensure all saltmarsh is covered by appropriate designation, identify suitable sites for creation of saltmarsh habitat, if opportunities were to arise, and ensure appropriate management of the habitat through agreeing management plans and offering advice to key organisations (Lincolnshire Biodiversity Partnership, 2011).

17.6.8 The October 2018 site visit confirmed that the habitats surrounding the wharf location of the Facility consist of shallow mud banks on either side of The Haven, with the middle of the channel being approximately 4 m below the level of the shore. The width of the mudflats on either side of The Haven is approximately 15-20 m, with the slope of the mudflats steepening nearer the middle of the channel (**Plate 17.1**). A biotope map of the European Nature Information System (EUNIS) habitats in The Haven confirms the presence and extent of the mudflats along The Haven (**Figure 17.2**).

Plate 17.1 Mudflats adjacent to the Facility. Photographs taken by RHDHV on 8th October 2018.

17.6.9 Worm burrows and evidence of bird use (footprints and faeces) on the mudflats were observed. Shallow channels running down the mudflats were also recorded, as seen in **Plate 17.1**.

17.6.10 The intertidal saltmarshes on either side of the channel are approximately 10 m wide, stretching from the base of the flood defence embankment to a small wall

of boulders where the mudflats begin. The key species recorded on the saltmarsh were *Salicornia* sp., *Spergularia* sp., the sea lavender *Limonium vulgare*, alongside improved grassland species (**Plate 17.2**).

Plate 17.2 Saltmarshes adjacent to The Haven and the site of the proposed Facility.

17.6.11 A survey carried out in 2011 near the location of the proposed wharf for the Facility defined the saltmarshes as of poor quality due to the limited extent, low diversity and negligible zonation (Jacobs, 2011). This definition was confirmed by a survey carried out in 2014 (Environment Agency, 2014) and the site visit (as highlighted above) in October 2018 by Royal HaskoningDHV marine ecology staff. The poor quality of the saltmarshes generally in The Haven (which includes the location of the Facility) was also confirmed by the most recent monitoring survey carried out by the Environment Agency in 2017 (Holden, 2017).

17.6.12 The most recent survey (Holden, 2017) recorded 18 saltmarsh species in 2017, compared to 19 in 2014 and 17 in 2011 (**Plate 17.3**). The two transects taken in 2017, classified the saltmarshes to the north of the Project as SM13a *Puccinellietum maritimae* saltmarsh, *Puccinellia maritima* dominant sub-community (mid-low marsh), SM24 *Elymus pycanthus* (*Elytrigia atherica*) saltmarsh, dominated by *Elytrigia atherica* (high marsh) and SM10 transitional low marsh vegetation with *Puccinellia maritima*, annual *Salicornia* species and *Suaeda maritima* (Joint Nature Conservation Committee's (JNCC) National

Vegetation Classification). The saltmarshes to the south of the Project site were classified to be SM16d tall *Festuca rubra* sub-community (high marsh), SM13a *Puccinellietum maritimae* saltmarsh, *Puccinellia maritima* dominant sub-community (mid-low marsh), SM13d *Puccinellietum maritimae* saltmarsh, *Plantago maritima-Armeria maritima* sub-community (mid-low marsh) and SM10 transitional low-marsh vegetation with *Puccinellia maritima*, annual *Salicornia* species and *Suaeda maritima*.

Plate 17.3 Saltmarsh areas surveyed by the Environment Agency – Transects B1 and B2 on the South Bank are the closest to the Facility location. Source: Holden, 2017.

17.6.13 During the saltmarsh surveys carried out for the Boston Barrier, JNCC's Common Standards Guidance for saltmarsh habitats was used in determining the characteristics of saltmarsh zones.

17.6.14 Boston Horsetail (*Equisetum ramosissimum*) and Sea Wormwood (*Artemisia maritima*) were not recorded in the most recent 2017 survey carried out by the Environment Agency, which included the area that will be directly affected by the Facility.

17.6.15 The 2017 survey also recorded erosion on the banks of The Haven, which could be indicating erosion of saltmarsh habitats, specifically on the bank opposite to the Facility (the North Bank).

17.6.16 The saltmarsh directly adjacent to the location of the Facility were confirmed to be heavily grazed in areas, and trampling was evident due to dog walkers and other

members of the public passing by (Jacobs, 2011). The section of the saltmarsh at the lower end of the intertidal zone was recorded to be often quite narrow, limited and fragmented. However, the flatter larger areas of the saltmarsh were typically more extensive with higher vegetation coverage.

17.6.17 Some grazing by semi-wild horses was observed during the 2014 surveys. Although the observed grazing can be attractive to wintering and passage birds due to the low sward height, overgrazing can have a negative impact on the saltmarsh habitat (Lincolnshire Biodiversity Partnership, 2011).

17.6.18 The site visit undertaken by Royal HaskoningDHV in October 2018 covered the area that would be affected by the Facility and an adjacent area, in order to determine whether the affected area was unique for any attributes. The area within the footprint of the proposed Facility appeared comparable with the adjacent areas in terms of habitat type present.

Benthic ecology

17.6.19 Benthic ecology surveys were undertaken by the Environment Agency in The Haven between 2010 and 2014. Additionally, a benthic invertebrate survey was carried out in 2010 at four sites by the Environment Agency, Jacobs and Halcrow Group Ltd, using a 0.05 m^2 Van Veen Grab with three replicate samples at each site. These samples were analysed for faunal and physicochemical content.

17.6.20 The survey carried out in 2010 recorded 15 species across the mudflats of The Haven, including oligochaetes, polychaetes, crustaceans (shrimp and crab species). These species were considered to be of district importance and are typical for estuarine habitats with fine sediments.

17.6.21 Additionally, 17 species were recorded within a 2 km radius of the Boston Barrier Project (approximately 1 km from the location of the Facility), most of which were annelids (Greater Lincolnshire Nature Partnership, 2015). These species are typical considering the fine sediment estuarine environment of The Haven. These species recorded by the Greater Lincolnshire Nature Partnership are presented in **Table 17.4** and are considered to be of district importance.

Table 17.4 Records of Benthic Invertebrates, Characteristic of Freshwater and Brackish Water, Recorded Within 2km of the Boston Barrier Project (Greater Lincolnshire Nature Partnership, 2015).

Common Name	Scientific Name
Aquatic worm species (annelid)	*Baltidrilus costatus*
Aquatic worm species (annelid)	*Caulleriella killariensis*
Estuarine ragworm	*Hediste diversicolor*
Bristle worm	*Eteone longa*
Aquatic worm species (annelid)	*Manayunkia aestuarina*
Catworm	*Nephtys sp.*
Aquatic worm species (annelid)	*Nephtys hombergii*
Aquatic worm species (annelid)	*Nereis sp. (*also see above *Hediste diversicolor)*
Aquatic worm species (annelid)	*Oligochaeta*
Aquatic worm species (annelid)	*Paranais litoralis*
Aquatic worm species (annelid)	*Pygospio elegans*
Aquatic worm species (annelid)	*Streblospio shrubsolii*
Aquatic worm species (annelid) 'sludge worm'	*Tubifex tubifex*
Aquatic worm species (annelid) 'sludge worm'	*Tubificoides benedii*
Aquatic worm species (annelid) 'sludge worm'	*Tubificoides diazi*
Aquatic worm species (annelid) 'sludge worm'	*Tubificoides pseudogaster*
White worm	*Enchytraeidae*

17.6.22 Some non-native species have previously been recorded from the lower Witham, which include the shrimps *Dikerogammarus haemobaphes* and *Hemimysis anomala* (Environment Agency, 2014). Additionally, the mitten crab *Eriocheir sinensis* and signal crayfish *Pacifastacus leniusculus*, both of which are Schedule 9 species (of the Wildlife and Countryside Act 1981 (as amended)), are likely to be present in the lower Witham, upstream of the Grand Sluice.

17.6.23 Some species that have been recorded in The Haven are known to have sensory sensitivities, although the level of sensitivity and responses of invertebrates are virtually unknown. As these benthic species lack air-filled cavities, they are only likely to be sensitive to the particle motion component of noise/vibration only, rather than pressure (Popper, 2001). Due to the lack of mobility of benthic invertebrates, they are likely to be more susceptible to being affected from noise and vibration than more mobile species.

17.6.24 There is also uncertainty around the sensory abilities and sensitivities of the above-mentioned non-native species, due to the lack of data regarding this pressure. However, given their similar lifestyle and habitat preference to the species present, it is unlikely that their sensitivities or responses to noise/vibration (if present) would vary from the native species.

Fish

17.6.25 Previous fish surveys carried out in The Haven during 2010-11 (carried out quarterly at three sites along The Haven using a scientific beam trawl towed 2m with a 15mm cod-end mesh) and 2013-14, at locations close to the proposed Facility, recorded a total of 33 fish species (Environment Agency, 2014). The Boston Barrier EIA concluded that the fish community at the site was dominated by bottom-dwelling species that feed on benthic prey such as mysids, shrimps, amphipods and fish larvae (Environment Agency, 2014). Sand goby and flounder were the species found in highest abundance, recorded in all catches during the fish surveys. Of these fish species, some of them are protected under European, national or local legislation (**Table 17.5**).

17.6.26 None of the species are included as qualifying features of The Wash Ramsar site, The Wash and North Norfolk Coast SAC and The Wash SSSI. Additionally, The Haven itself is not designated for international or national importance. There is a local designation for the Havenside LNR.

Table 17.5 Species of Fish Recorded in the River Witham with Designation Under European, National and Regional Legislation (Environment Agency, 2014), Alongside Their Status Under the Lincolnshire BAP (Lincolnshire Biodiversity Partnership, 2011). Cells Highlighted in Green Signify the Protection of that Species Under the Relevant Legislation.

Common name	OSPAR	Bern Conv. A.III	EU Hab&Sp	NERC S.41	WCA Sch.5	Eel Regulations	SAFFA	LBAP
European Eel								The numbers of European eel entering local rivers from the sea have declined. Alongside flood barriers, disease, parasite, over exploitation and loss of freshwater habitats are contributing factors to this decline.
Herring								
Spined Loach								The spined loach population in Lincolnshire is considered healthy in low numbers.
Bullhead								
Cod								

Common name	OSPAR	Bern Conv. A.III	EU Hab&Sp	NERC S.41	WCA Sch.5	Eel Regulations	SAFFA	LBAP
River lamprey								The river lamprey has only been recorded at one site on the Rive Lymn and in the Humber Estuary.
Burbot								
Whiting								
Smelt								Smelt is limited to a small number of sites at low numbers in Lincolnshire. They're found in the lower reaches of the Witham.
Plaice								Lincolnshire has major nursery grounds. Large amount of discard from fishing vessels which has reduced the reproductive capacity of the species.
Common Goby								

Common name	OSPAR	Bern Conv. A.III	EU Hab&Sp	NERC S.41	WCA Sch.5	Eel Regulations	SAFFA	LBAP
Sand Goby								
Sea trout								Sea trout is present within the Witham but typically restricted to areas downstream of tidal sluices. It is essential that these species are able to migrate upstream to spawn.
Sole								The Wash is part of an important nursery ground for this species. Stock is declining and at risk of having reduced reproductive capacity.

OSPAR: OSPAR List of Threatened and/or Declining Species and Habitat; Bern Conv. A.III: Bern Convention on the Conservation of European Wildlife and Natural Habitats, Annex III (Protected fauna species); EU Hab & Sp: EU Council Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC); NERC S.41: Natural Environment and Rural Communities Act 2006, Section 41 (Species of Principal Importance in England); WCA SCH.5: Wildlife and Countryside Act 1981 (Schedule 5); Eel regs: Council Regulation (EC) No 1100/2007 establishing measures for the recovery of the stock of European eel, and Eel (England &Wales) Regulations 2009; SAFFA: Salmon and Freshwater Fisheries Act 1975; LBAP: Lincolnshire Biodiversity Action Plan 2011-2020.

17.6.27 Some of the fish found in The Haven are migratory fish, most of which are marine species that spawn at sea and use inshore coastal waters such as estuaries for nursery grounds (Environment Agency, 2014). The main migratory species previously found in The Haven are:

- *Anguilla anguilla* (eel);
- *Osmerus eperlanus* (smelt);
- *Lampreta fluviatilis* (river lamprey); and,
- *Salmo trutta* (sea trout).

17.6.28 All of these species are listed in Section 41 of the NERC Act 41 (2006) and are also priority species on the Lincolnshire BAP.

17.6.29 The Environment Agency (2014) reports that these species were caught in low abundance during the baseline surveys for the Boston Barrier scheme, showing variable occurrences, which would suggest low importance of the estuary to the species. High levels of canalisation along the Witham could be reducing the availability and extent of suitable mudflats and shallow subtidal habitats, particularly when compared to other nursery grounds in the adjacent areas of The Wash which provide greater shelter for refuge from predators.

17.6.30 Eel is a catadromous species, meaning it migrates downstream to the sea to spawn, using the rivers as pathways. The adult individuals of eels (silver eels, 400-600 mm length) migrate downstream to spawn at sea, and the juveniles (elvers, 50-70 mm length) migrate upstream to use the upper reaches of the river as nursery grounds.

17.6.31 Eel is a critically endangered species across Europe and is listed on the IUCN Red List, with a generally decreasing population trend. Thus, eels are considered a species of principal importance under the NERC Act 2006, as well as being a UK BAP Priority Species.

17.6.32 The main reason for the decline in eel numbers is habitat loss due to residential and commercial development. In the case of The Haven, river bank modification through canalisation and artificial management of the water flows for flood protection purposes may likely be restricting the migration routes of eels through the Witham catchment (Defra, 2010).

17.6.33 The migrating times of eels and the other migratory species are visualised in **Table 17.6**. Fish species of extra sensitivity to noise are also included in **Table 17.6** so as to understand their seasonal presence in The Haven.

Table 17.6 Migration Periods for Diadromous Fish Species Found Near the Location of the Proposed Facility. Arrows Indicate Whether the Migration is Upstream (↑) or Downstream (↓). (Source: Environment Agency (2014) Boston Barrier Project Environmental Statement Volume 2b: Ecology and Nature Conservation Technical Report, Natural England).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eel (juvenile)				↑	↑	↑	↑	↑	↑			
Eel (adult)										↓	↓	
Smelt (juvenile)				↓	↓	↓						
Smelt (adult) (spawning in estuary)			↑	↑								
River lamprey (juvenile)							↓	↓	↓			
River lamprey (adult)										↑	↑	↑
Sea trout (juvenile)			↓	↓								
Sea trout (adult)				↑	↑	↑	↑	↑	↑			
Herring												
Sprat												
Cod												
Whiting												

17.6.34 All other migratory fish species that use The Haven as a migratory pathway are anadromous, meaning they are mainly marine species, migrating upstream from the sea into less saline waters to spawn. They typically have adhesive eggs and will lay them on substratum such as coarse sandy or gravelly river beds, or vegetation.

17.6.35 The extensive mudflats and shallow sedimentary habitats found in The Haven are of particular importance to fish species such as smelt, due to their feeding habits, consisting of crustaceans and shrimps. Smelt is a UK BAP Priority species and is a species of principal importance under the NERC Act 2006. The adults migrate upstream in the spring to spawn on sandy or gravelly bottoms (Kottelat, 1997). The eggs have a 3-4-week long incubation period before hatching (Maitland, 2003).

17.6.36 Historically, smelt has been abundant in the estuarine waters of Boston Docks (Smith, 1915). The species was also frequently and consistently recorded during the fish surveys carried out as part of the Boston Barrier Project baseline study in 2010-11 and 2013-2014. Smelt can locally be threatened due to pollution and barriers to migration.

17.6.37 The river lamprey is anadromous, the UK populations of which are considered important for the conservation of the species at an EU level. Typically, they live on hard bottoms, or attached to larger fish such as cod and herring (Fricke, 2007). The adults are parasitic, and feed on such larger fish by sucking their blood and consuming their flesh afterwards (Scott & Crossman, 1998).

17.6.38 The upstream migration of adults usually takes place in the autumn, to the shallow middle or upper reaches of rivers and streams with strong currents (1–2 m/s) and gravel (Kottelat & Freyof, 2007). Mature migrating adults require a route free of obstacles (man-made weirs, barriers, dams, etc.) to reach their spawning grounds. The larvae (ammocoetes) live for 3-5 years buried in fine sediments before metamorphosing and migrating to the sea. No feeding takes place during reproductive migration and reproduction; instead, the adults use up their lipid reserves (Billard, 1997).

17.6.39 Adult sea trout typically feed in the sea or estuary, and migrate upstream from April onwards, throughout the summer until September, to reach gravelly shallows for spawning and laying their eggs. The hatched fry typically continue to live in the gravelly river bed, until after 1-3 years, when they metamorphose into smolts and are able to survive in salt water. They then migrate to sea, generally at night in shoals. Many adults return back to sea after spawning (Wild Trout Trust, 2018).

The young feed on insects such as mayflies and freshwater invertebrates, while the adults are hunters and their diet will consist of smaller fish.

17.6.40 Although the Boston Barrier project presents a physical barrier to fish migration, the Environmental Statement states that the barrier would lay flat (no obstruction) for most of the time and would only be raised in situations of flooding events or maintenance. Thus, the presence of this barrier is not expected to have a long-term significant impact on fish migration.

Vibroacoustic detection abilities of fish species

17.6.41 Fish vary in their ability to detect underwater noises, and their sensitivity to sound varies depending on the species. One of the most important factors that determines their sensitivity to sound is the presence of a swim (gas) bladder in the body, which make fish more vulnerable towards pressure-mediated injury to the ears and general body tissues (Stephenson, et al., 2010). Additionally, the presence of a swim bladder can increase the sound-detection ability of many fish species over a broader frequency range and at greater distances from the sources. Therefore, although fish with swim bladders are more susceptible to damages caused by man-made underwater noises, they are able to detect sound sources from further away than fish without bladders (Popper, et al., 2014).

17.6.42 Popper et al. (2014) grouped fish into three categories for analysing the effects of sounds upon them:

- **Category 1** - Fish with no swim bladder or other gas chamber
    - Less susceptible to barotrauma, and only detect particle motion, not sound pressure.
- **Category 2** - Fish with swim bladders in which hearing does not involve the swim bladder or other gas volume
    - Susceptible to barotrauma, although hearing only involves particle motion, not sound pressure.
- **Category 3** - Fish in which hearing involves a swim bladder or other gas volume
    - Susceptible to barotrauma and detect sound pressure as well as particle motion

17.6.43 As such, **Table 17.7** summarises the species that are known to be present in or near the location of the proposed Facility, alongside their known sensory abilities, distribution in the water column and associated references (Environment Agency, 2014).

Table 17.7 Fish Species in the Vicinity of the Proposed Facility that are Known to have Sensory Abilities, Their Distribution Throughout the Water Column, and Key References.

Common name	Scientific name	Family	Sensitivity to Sound	Sensitivity reason	Highest frequency Detected (Hz)	Distribution in water column	Reference	Notes
European sea bass	*Dicentrarchus labrax*	Moronidae	Medium	Pressure and particle motion	1,000	Demersal	Ramcharitar (unpublished) Nedwell *et al*. (2004); Lovell *et al*. (2005)	-
Common goby	*Pomatoschistus microps*	Gobidae	Medium	High sensitivity to pressure	400	Demersal	Lu & Xu (2009)	-
Crystal goby	*Crystallogobius linearis*							-
Rock goby	*Gobius paganellus*							-
Sand goby	*Pomatoschistus minutus*							-
Atlantic cod	*Gadus morhua*	Gadidae	Medium - high	Pressure and particle motion	500	Benthopelagic	Chapman and Hawkins (1969); Offutt (1970); Sand and Karlsen (1986)	Can likely detect infrasound (below 40 Hz). Best hearing between 100 – 300 Hz
Whiting	*Merlangius merlangus*							
Atlantic herring	*Clupea harengus*	Clupeidae	High		4,000		Enger (1967); Ladich and	Cannot detect ultrasound, and

Common name	Scientific name	Family	Sensitivity to Sound	Sensitivity reason	Highest frequency Detected (Hz)	Distribution in water column	Reference	Notes
Sprat	*Sprattus sprattus*					Pelagic	Fay (2013), Mann *et al.* (2001)	relatively poor sensitivity
Plaice	*Pleuronectes platessa*	Pleuronectidae	Low	Particle motion	400	Demersal	Ladich and Fay (2013); Nedwell *et al*. (2004)	-
European flounder	*Platichthys flesus*							-
Dab	*Limanda limanda*							-
Sole	*Solea solea*	Soleidae						-
Three and nine spined stickleback	*Gasterosteus aculeatus* *Pungitius pungitius*	Gasterosteidae	Low – medium	Pressure and particle motion	< 400	Benthopelagic		-
European eel	*Anguilla anguilla*	Anguillidae	Low	Pressure	300	Demersal	Jerkø *et al*. (1989)	-
Northern pike	*Esox lucius*	Esocidae	Low - medium	Particle motion	<400		Ladich and Fay (2013)	-
European smelt	*Osmerus eperlanus*	Osmeridae	-	-	-	Pelagic-neritic	-	-
Sea trout	*Salmo trutta*	Salmonidae	Low - medium	Particle motion sensitive	-	Pelagic	Ladich and Yan (1998)	-

Common name	Scientific name	Family	Sensitivity to Sound	Sensitivity reason	Highest frequency Detected (Hz)	Distribution in water column	Reference	Notes
River lamprey	*Lampetra fluviatilis*	Petromyzontidae	Low	Particle motion	-		Popper (2005)	-
Lesser pipefish	*Syngnathus rostellatus*	Syngnathidae	Unknown	-	-	Demersal	-	-
Spined loach	*Cobitis taenia*	Cobitidae	Unknown	-	-		-	-

17.6.44 Fish species such as herring (*Clupea harengus*), and sprat (*Sprattus sprattus*) are of high hearing sensitivity, as they can detect sound pressure as well as particle motion, with a specialised auditory system (Blaxter, et al., 1981; Enger, 1967). They are classed as category 3 species according to the Popper et al. (2014) classification. The hearing range of these fishes extends to at least 4,000 Hz. Considering this information, and the results of the previous fisheries surveys undertaken near the location of the Facility, herring and sprat are likely to be the species most affected species by noise related to the Facility.

17.6.45 Species such as cod (*Gadus morhua*) and whiting (*Merlangius merlangus*) are also considered to be category 3 species, due to their benthopelagic feeding habits as well as their similar hearing abilities and sensitivities to the aforementioned gadoids. They are sensitive to both particle motion and pressure changes.

17.6.46 Gobies, three- and nine-spined sticklebacks (*Gasterosteus aculeatus, Pungitius pungitius*) and pike (*Esox lucius*), being sensitive to both pressure and particle motion are likely to have medium sensitivity to sound, despite their hearing not involving the swim-bladder.

17.6.47 Species lacking a swim bladder are typically only sensitive to the particle motion of sound. With regards to the proposed Facility, this mainly comprises flatfish caught in The Haven during the 2010-11 and 2013-14 fish surveys, such as plaice (*Pleuronectes platessa*), European flounder (*Platichthys flesus*), dab (*Limanda limanda*) and Dover sole (*Solea solea*) (Ladich & Fay, 2013; Nedwell, et al., 2004). Dab is considered to be the most sensitive of flatfish to underwater noise, although it is generally of low sensitivity (Nedwell & Barham, 2014).

17.6.48 There is little data on the noise sensitivity of fish eggs and larvae. However, the species studied do appear to have similar hearing ranges to the adults. The larvae of some fish species may develop swim bladders which would render them vulnerable to pressure-related injuries. All of these species are known to lay their eggs in coarse sediment and gravelly environments. Considering the section of The Haven which is likely to be affected by the construction of the proposed Facility is intertidal and comprises mudflats which are thought to continue into the subtidal area, it is unlikely that eggs or larvae would be present at any time of the year.

Ornithology

17.6.49 The Wash (the closest point of any designated area within the Wash is about 3 km away from the proposed Facility) constitutes an internationally important area

for birds because of the high level of habitat diversity and the rich feeding and roosting grounds that the area supports. Most species are overwintering in the area, feeding on the extensive mud and sand flats exposed at low tide and roosting on the marshes bordering the feeding grounds at high tide. The area also supports resident species and breeding birds. **Table 17.8** summarises the protected species that use The Wash and their seasonality.

Table 17.8 Presence Patterns of Protected Bird Species Within the Wash SPA. Orange cells = summer; green cells = resident; blue cells = wintering; purple = passage (Source: Royal Society for the Protection of Birds).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Common tern												
Little tern												
Marsh harrier												
Avocet												
Bar-tailed godwit												
Golden plover												
Whooper swan												
Ringed plover												
Sanderling												
Black-tailed godwit												
Curlew												
Dark bellied Brent goose												
Dunlin												
Grey plover												
Knot												
Oystercatcher												
Pink-footed goose												
Pintail												

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Redshank												
Shelduck												
Turnstone												
Red-throated diver												
Little gull												
Common scoter												
Sandwich tern												

17.6.50 Several species of birds that use The Wash also use The Haven, moving from areas of higher abundance to feed and roost. The birds are most likely to be flying into The Haven from roosting grounds further out into The Wash or from nearby fields.

17.6.51 The species of invertebrates and plants colonising the intertidal mudflats and shallow subtidal areas in The Haven will provide a source of food for birds, particularly those species overwintering in The Wash. The following species are known to use The Haven area (Woodward, et al., 2015):

- Dark bellied Brent goose
  - High concentrations (out of the 22,248 population in 2014) in The Haven (Woodward, et al., 2015). This species feeds on plants below the high-water mark and roosts on estuaries. It has increasingly begun to use coastal grassland and winter cereal crops as a feeding habitat.
- Shelduck
  - The distribution of this species is closely associated with the muddier sections of The Wash, especially the areas in the vicinity of The Haven. It feeds on invertebrates in the intertidal area such as worms, crabs, amphipods and bivalves.
- Lapwing
  - Higher densities of this species are associated with muddier areas adjacent to the inflows of The Haven. Lower densities occur on sandier sectors. This species feeds mainly on pasture, wet meadows and arable farmland in winter. It uses estuarine and saltmarsh habitats for roosting. Use of estuarine sites are important in cold weather when other sites

freeze (Delany *et al*., 2009)

- Dunlin
    - The distribution of dunlin is widespread across The Wash, but there is also a clear association with muddier areas adjacent to the inflows of The Haven. This species mainly eats polychaete worms and small gastropods during winter (Birdlife, 2014). Dunlin prefer estuarine mudflats and uses open fields for roosts near feeding areas during highest tides (Delany et al 2009, Shepherd and Lank, 2004).
- Black-tailed godwit
    - This species occurs across The Wash, with greatest concentrations found in areas adjacent to the inflows of The Haven. These areas represent where British Trust of Ornithology (BTO) data is available (i.e. Frampton North, approximately 3km from the Facility) and has been reviewed for this report. The black-tailed godwit is known to commonly feed on mudflats in the upper reaches of estuaries, preying on invertebrates such as beetles, polychaetes, molluscs and crustaceans (Birdlife, 2014).
- Redshank
    - Redshank are widespread across The Wash, with higher densities being supported by areas adjacent to the river mouths, particularly the inflows of The Haven. This species feeds on invertebrates such as insects, spiders, annelid worms, molluscs and amphipods.
- Turnstone
    - This species only occurs in relatively small numbers on The Wash. However, the highest densities are found in the vicinity of the inflow of The Haven. Their diet comprises of a range of food sources including small worms, crustaceans and molluscs which are exposed by the receding tide.

17.6.52 Wintering bird surveys were carried out by the Environment Agency on six occasions between January and March 2010 in The Haven (from Boston town centre to The Wash). Seventy-two wintering bird species were recorded, of which 12 were from the regular wintering bird community of The Haven. This community included the Brent goose, shelduck, oystercatcher, grey plover, dunlin, turnstone, curlew and redshank.

17.6.53 The wintering bird populations towards the more downstream reaches of The Haven are more diverse and support the wintering bird assemblage of The Wash SPA and Ramsar site. The narrower, channel-like area of The Haven (where the proposed Facility would be located) supports a restricted community of wintering

birds (Environment Agency, 2014). This conclusion is confirmed by the British Trust for Ornithology's core bird counts, obtained from the four nearest count sectors to the Project location (**Figure 17.3**):

- South Forty Foot Drain (Wyberton Fen to Hubbert's Bridge) (counts available from 2008 to 2012);
- Slippery Gowt Pits (counts available from 2001 to 2006);
- Frampton North 23 (counts available from 2012 to 2017); and
- Frampton North 60 (counts available from 2012 to 2017).

17.6.54 Across all available bird count data, the highest diversity of birds was recorded at Frampton North 23, at the mouth of The Haven, in The Wash with 41 species of birds recorded to be using the sector across six years. Waders were the most abundant group of birds (16,065 individuals across six years), followed by gulls and terns (4,625 individuals across six years). Gulls and terns were the most abundant group in the sector closest to the Project site, at Slippery Gowt Pits, with 2,729 individuals counted across five years (**Figure 17.4**). This sector had a total of 25 species recorded, much less diverse and abundant than the sectors closer to The Wash.

17.6.55 This would suggest that the habitat available for birds at Frampton North 23 and Frampton North 60 is more suitable for nesting and feeding, considering the mudflats are backed by wide saltmarshes. Upstream of these sectors, although the mudflats are observed to be slightly wider and of a shallower gradient, the mudflats are backed by the sea wall for 2.2km up to the Facility location. Therefore, the available data suggests that birds of importance, especially designated species would not necessarily choose to travel further upstream of The Haven towards Boston to feed and roost.

Marine mammals

17.6.56 The location of the proposed Facility site is approximately 3 km from The Wash and North Norfolk Coast SAC, which includes the common, or harbour seal, *Phoca vitulina* as a qualifying feature.

17.6.57 The extensive intertidal flats at The Wash provide ideal conditions for the breeding and hauling-out of the harbour seal. The seal colony present in The Wash is the largest colony of harbour seals in the UK, containing 7% of the total UK population.

17.6.58 The final 3km of The Haven before it reaches The Wash is part of The Wash and North Norfolk Coast SAC. As such, it is likely that the seals would utilise the subtidal area in The Haven on occasions whilst transiting through the area. One

individual seal was observed in The Haven channel close to the Application Site by Royal HaskoningDHV staff during the site visit on the 8th October 2018. As reported in the Boston Barrier Environmental Statement, there are no other recent records of harbour seals within 2 km of the Facility area (Environment Agency, 2014). The area would not be expected to provide a haul-out or breeding area for seals.

17.6.59 Marine Scotland commissioned the Sea Mammal Research Unit (SMRU) to produce maps of grey seal distribution in UK waters (Russell *et al.,* 2017). These maps were produced by combining information about the movement patterns of electronically tagged seals with survey counts of seals at haul-out sites. The resulting maps show estimates of mean seal usage (seals per 5km x 5km grid cell) within UK waters. The maps indicate that harbour seal usage is high in and around the shipping channel for the Facility and anchorage area, with a harbour seal density of 3.189 per km^2 within the shipping channel and anchorage location (**Figure 17.1**; Russel *et al.,* 2017).

17.6.60 There is an estimated 4,965 harbour seal in the south-east England Management Unit (MU), based on the most recent August counts (2017) at haul-out sites (Special Committee on Seals (SCOS), 2018). The August 2017 counts of harbour seal at haul-out sites on the south-east coast of England were 290 at Donna Nook, 3,210 at The Wash, 399 at Blakeney Point, 271 at Scroby Sands and 694 along the Essex and Kent coast (the Essex and Kent sites were not surveyed in 2017, and so the 2016 count is noted here) (SCOS, 2018).

Anticipated Evolution of the Baseline Condition

17.6.61 If the Facility was to not go ahead, the baseline conditions would only be impacted by the existing natural events and activities, as well as consented schemes in the area. The distribution and abundance of species/habitats assessed in the sections above are unlikely to change. Erosion of the salt marshes was observed during the Environment Agency surveys and the Royal HaskoningDHV site visit mentioned previously. This erosion is likely to continue in the absence of the Facility, due to the vessel movements related to the Port of Boston commercial traffic and the fishing and leisure craft using The Haven, and the naturally-occurring wind-waves.

17.6.62 All other baseline conditions relating to marine and coastal ecology are unlikely to evolve in the absence of the Facility, due to the disturbed nature of the existing environment.

17.7 Embedded Mitigation Relevant to Marine and Coastal Ecology

17.7.1 As part of the project design, several embedded mitigation measures have been proposed to reduce potential impacts on marine and coastal ecology. Embedded mitigation is a type of primary mitigation and is an inherent aspect of the EIA process.

Design mitigation

17.7.2 The design has committed to several techniques and engineering designs/modifications, during the pre-application phase, to avoid several impacts or reduce the impacts as far as possible. Five main embedded mitigation measures have been proposed to reduce potential impacts on marine and coastal ecology, as outlined below:

- The volume of capital dredging will be minimised by setting the wharf as close to the channel as possible, whilst still allowing safe passage of other vessels when vessels are moored at the wharf of the Facility;
- The design of the wharf will likely be an open structure (e.g. a suspended deck), as opposed to the other option of a double sheet-piled wall (see **Chapter 5 Project Description** for more detail on the design);
- Capital dredged sediment will be managed on land rather than disposed at sea;
- Capital and maintenance dredging will be mainly carried out from land, in order to minimise the resulting sediment plume;
- Use of maintenance dredged sediment as a binding agent for aggregate production at the Facility; and
- Use of the water run-off from maintenance dredged sediment in the aggregate production at the Facility.

17.7.3 Good environmental practices (as set out in the Construction Industry Research and Information Association (CIRIA): Coastal and Marine Environmental Site Guide, second edition, August 2015) during construction works will be followed to reduce the scale of certain impacts, particularly with respect to potential changes to water quality. This relates to maintaining equipment in good working order to reduce spillages and incidents that could cause pollution, ensuring that works where spillages could occur and could leak into the natural environment are bunded and that contingency planning measures are put into place to reduce the likelihood of issues arising if spillages do occur.

Risks of spillages

17.7.4 All work practices and vessels would adhere to the requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78; specifically Annex 1 Regulations for the prevention of pollution by oil concerning machine waters, bilge waters and deck drainage and Annex IV Regulations for the prevention of pollution by sewage from ships concerning black and grey waters.

Introduction of invasive species

17.7.5 The risk of spreading marine non-native invasive species (MNNS) would be mitigated through use of best-practice techniques, including appropriate vessel maintenance following guidance from The International Maritime Organisation (IMO). These commitments would be secured in the Project Environmental Management Plan (PEMP). Additionally, impacts relating to the introduction of invasive species have been assessed in **Section 17.8** below.

17.7.6 The above measures are considered standard good practice measures and/or legal requirements. The risks of spillages and the introduction of MNNS during both the construction and operational phase are not, therefore, considered further in the assessment.

17.8 Impact Assessment

17.8.1 A full project description of the Facility is provided in **Chapter 5 Project Description**.

17.8.2 The main component of the proposed Facility that is most likely to impact the marine and coastal ecology during both construction and operation are the proposed wharf and the capital and maintenance dredging necessary for vessel access. Full details of the worst case envelope assumed for the prediction and assessment of geomorphological changes because of the construction and operation of the wharf and the results of the assessment are provided in **Chapter 16 Estuarine Processes**.

17.8.3 Potential impacts on water quality (described in **Chapter 15 Marine Water and Sediment Quality**) have an influence on marine and coastal ecological receptors and are assessed in this chapter.

17.8.4 There is potential for partial infilling of the dredged area during the operational phase, as the deepened areas would be expected to act as a sink for sediment and, therefore, future maintenance dredging of the berthing area is anticipated to

be required.

17.8.5 Natural accretion rates on the mudflats and saltmarsh along areas like The Haven are estimated at about 0.1 – 0.3 m/year (Van Rijn, 2016), where there are low suspended sediment concentrations (less than 100 mg/L) and major density current effects. These rates would be conservative for The Haven because of the potential erosional effect of opening the sluice structures during high winter fluvial flows.

17.8.6 The Port of Boston currently dredges and average of 24,000 tonnes of sediment per year from the Port and various locations along The Haven (Marine Management Organisation, 2015). However, given the greater potential for the dredging areas to accumulate sediment during times of sluice closure, a conservative estimate of 0.05 m/year (5cm/year) is assumed for the purposes of assessment.

17.8.7 Using 0.05 m/year as a baseline sedimentation rate in the berthing area over an area of 32,850 m^2 (dredged footprint of the berthing area) would lead to accumulation of sediment of approximately 1,643 m^3/year (**Chapter 16 Estuarine Processes**).

17.8.8 The number of vessels using The Haven would increase during the operational phase of the scheme. This has the potential to increase the frequency of ship wash on the intertidal areas of The Haven, which could potentially lead to erosion. It also has the potential to increase the levels of disturbance to birds, fish and marine mammals using The Haven area.

17.8.9 With regard to decommissioning, after the operational lifetime of the proposed Facility of 25 years, it is proposed that the wharf will not be decommissioned and will be kept in place. As such, no significant adverse impacts from decommissioning are predicted. There would be potential benefits from the reduction in number of vessels using the area and from reduced disturbance from activities associated with the wharf.

17.8.10 Full details of the proposed design, including proposed dredging and piling activities, will be confirmed at detailed design stage. Consequently, the assessment in this PEIR is undertaken on the current assumed design as described in **Chapter 5 Project Description** and the potential impacts will be reviewed and re-assessed as necessary through the later stages of the EIA process.

17.8.11 **Table 17.9** summarises the potential impacts of the proposed Facility on marine and coastal ecology.

Table 17.9 Potential Impacts on Marine and Coastal Ecology

Impact	Receptor
Construction	
Loss of and/or change to estuarine habitats and associated species within the footprint of the wharf and dredging area	Saltmarsh habitat and species Mudflat habitat and species
Increased suspended sediment concentrations from capital dredging, with potential for sediment-bound contaminants to be released	Fish (migration and behaviour) Benthic communities
Disturbance due to human activity/increased human presence (excluding underwater noise but including airborne noise)	Birds
Underwater noise (piling and vessel movements)	Fish (migration and behaviour) Marine mammals
Operation	
Habitat alteration due to hydrodynamic changes	Intertidal and subtidal habitats
Changes in vessel traffic and movement leading to increased ship wash, underwater noise, disturbance and collision risk	Invasive species Intertidal habitat Fish Birds Marine mammals
Increased suspended sediment concentrations due to maintenance dredging	Benthic communities Fish (migration and behaviour)
Beaching of vessels at low tide	Benthic communities
Increased emissions to air and deposition on marine and estuarine habitats	Marine and coastal habitats
Decommissioning	
No significant adverse impacts are anticipated	-

Potential Impacts during Construction

Loss of and/or change to estuarine habitats and associated species within the footprint of the wharf and dredging area

17.8.12 Part of the mudflats and the saltmarshes adjacent to the location of the proposed Facility will need to be removed to allow for the construction of the wharf. Impacts of the wharf construction and capital dredging on these habitats are, therefore, certain to occur and there would be a permanent loss of the existing saltmarsh and mudflat with a resulting change to the remaining mudflat habitat in relation to the emergence pattern.

17.8.13 The existing mudflat would be removed through dredging which would leave an area of intertidal mudflat which is much lower in relation to the tidal levels and

therefore will have a much shorter pattern of tidal emergence. It is expected that the remaining habitat would re-colonise but this would not provide such a valuable habitat given its position in relation to the tidal cycle. The remaining mudflat will be much flatter and much deeper in the water with only limited emergence. It will also have boats beached on it during low tide as they wait for higher water to re-float and exit The Haven (this impact is considered further below in this section). It is expected that saltmarsh would regrow in the upper intertidal area once the wharf is in place. The wharf is an open structure and as such the habitats beneath it will still be subject to tidal influence. With saltmarsh adjacent to the wharf, species should recolonise from such areas onto appropriate habitat. Seeds will also assist with recolonisation. The specific habitat loss will be within the footprint of the wharf as well as the adjacent working areas that will be required for the construction of the wharf.

17.8.14 It is proposed that approximately 150,000 m^3 of material will be removed by capital dredging, allowing development of a 400 m long and 40 m wide wharf, as a worst case scenario. This estimate has assumed a material removal depth of approximately 7 m. Part of this will be dredging of silty material from the intertidal mudflats, and part of it is within the intertidal saltmarsh.

17.8.15 At least two-thirds of the dredging is planned to be undertaken using land-based equipment, and one-third using floating plant.

17.8.16 To estimate the amount of existing habitat that will be affected during construction in the context of The Haven, the approximate area of similar mudflat and saltmarsh habitat in The Haven has been calculated. This has then been compared against the area of habitat (comprising both mudflats and saltmarsh) that will be lost.

17.8.17 The Haven stretches for approximately 9km from the Grand Sluice in Boston to The Wash, with saltmarsh of 10 m width and mudflat of 20 m width on either side of The Haven, this equates roughly to 0.18 km^2 of saltmarsh and 0.36 km^2 of mudflat in The Haven from the location of the proposed Facility to just before the mouth of The Haven where the saltmarsh and mudflat habitats widen considerably.

17.8.18 Based on the proposed size of the wharf (400 m long and 40 m wide), the predicted habitat loss from the proposed Facility in the context of The Haven is approximated to be 2.2% of the total habitats (saltmarsh and mudflat combined). It should be noted that this only accounts for 30m width of habitat being lost, as approximately 10m of the wharf will be over terrestrial habitats.

17.8.19 The loss of mudflat and saltmarsh and the presence of the wharf during the construction phase will mean the loss of feeding and roosting habitat for bird species that utilise the area. However, this area does not represent the main feeding area for birds which are more likely to be feeding on the extensive flatter mudflats closer to the mouth of The Haven. For the Boston Barrier Environmental Statement, it was concluded that the barrier was unlikely to have a significant effect on bird species designated under The Wash SPA and Ramsar site. It was also concluded that the amount of habitat loss was minimal, considering the availability of alternative feeding and roosting habitats along The Witham. This accounted for a loss of mudflat of 735m^2, as well as a 160m section on one bank of the river, as opposed to the 120,000m^2 estimation of habitat loss resulting from the Facility.

17.8.20 Saltmarsh and mudflat are both BAP priority habitats and represent supporting habitat for fish and birds, as well as the invertebrates and vegetation that colonise these habitats. As these habitats are not designated as national or international habitats of importance at this location, they are considered to have a value of regional importance.

17.8.21 The habitat that will be lost is considered to be of regional conservation importance for non-breeding birds and is larger than what was deemed acceptable for the Boston Barrier, the magnitude of this impact is considered to be low, due to the small-scale of loss in the context of The Haven as a whole. It should also be noted that the area of habitat that will be impacted is similar in nature to the adjacent areas of habitat. Thus, it is not considered unique in the context of The Haven.

17.8.22 The saltmarsh in this area is only a very thin strip because it is restricted by the flood defence embankment. Previous surveys identified above (**Section 17.6**) describe the saltmarsh as of poor quality. Due to the construction activities resulting in direct loss of existing saltmarsh and mudflats, these habitats will not have an opportunity to recover to provide habitat for the same species because the wharf will be located on this area. However, some recovery of habitat (i.e. saltmarsh and habitat for fish and benthic invertebrates) is likely to occur in the area within the footprint of works albeit still affected by operational activities. Therefore, overall, these receptors can be considered of medium sensitivity.

17.8.23 In line with the significance determination matrix set out in **Chapter 6 Approach to EIA**, the significance of this impact is considered to be **minor adverse**.

Table 17.10 Summary of Impact Assessment

Impact: Loss of habitats (Construction)	Magnitude	Sensitivity	Significance
Loss of saltmarshes	Low	Medium	Minor adverse
Loss of mudflats	Low	Medium	Minor adverse

Mitigation

17.8.24 The area of mudflat and saltmarsh affected will be restricted to only what is necessary for the construction of the wharf. Additionally, the dimensions of the quay wall and wharf have been set to minimise the volume of capital dredging required to minimise impacts and also allow a safe clearance between a berthed vessel and others passing through the channel. With saltmarsh adjacent to the wharf, it is expected that species will recolonise from such areas onto appropriate habitat. It is also expected that seeds will assist with recolonisation.

17.8.25 As the above measures are embedded, they have been considered in the impact assessment. Consequently, the residual impact is assessed as **minor adverse** significance.

Increased levels of suspended sediments due to capital dredging

17.8.26 To create the berthing pocket for the wharf, capital dredging of approximately 150,000 m^3 of sediment from the intertidal area would be undertaken. The dredging activities will disturb sediment, resulting in localised and short-term increases in suspended sediment concentrations. The dredging method would be excavators / backhoe operating mostly from the land but also where necessary from within The Haven. The land-based method reduces the plume dispersion and retains the sediment structure more when compared to a hydraulic dredger. This results in less of a plume and less run-off from the sediment when placed on land. The dredged sediment would not be disposed to sea but managed on land in accordance with the waste hierarchy (see **Chapter 23 Waste**).

17.8.27 A small volume of the dredged sediment would be lost from the excavator during the dredging process which could enter the water column. Expert-based assessment would suggest that a low concentration plume of suspended sediment would be created, which would be dispersed by tidal currents (and waves) away from the site. This dispersion would either be upstream on the flood tide or downstream on the ebb tide. Larger particles such as sand would rapidly fall (within minutes) to the estuary bed upon the disturbance of the sediment, which would be expected to occur within a few tens of metres along the axis of

the tidal flow (**Chapter 16 Estuarine Processes**).

17.8.28 Due to the small volume of sediment released and the fine size of the particles (silt and clay), the plume is likely to be rapidly dispersed. As such, the dredging works are not anticipated to have knock-on impacts on priority habitats adjacent to the Facility such as saltmarshes, mudflats, or The Wash SPA and SAC located further downstream. The plume is predicted to contain measurable, but modest, suspended sediment concentrations (less than 100 mg/l close to the excavator, reducing to less than tens of mg/l within a few hundred metres of the excavator). These suspended sediment concentrations are much lower than the natural variability in The Haven (134 mg/l to 1,790 mg/l) and are expected to be indistinguishable from background levels within a very short distance from the dredger.

17.8.29 Sediment disturbance could also lead to the mobilisation of contaminants which may be bound within the sediment and which could be harmful to the benthos and fish. Vibracore samples of sediment along The Haven were collected in 2017 by Environment Agency Estuarine and Coastal Monitoring and Assessment Service (ECMAS) to assess the sediment conditions of the area which may be impacted by dredging during the Boston Barrier flood alleviation scheme (Newton, 2017). Trace metals were analysed, and the following metals were present at levels below Cefas Action Level 1 in all samples taken: cadmium, copper, lead, mercury and zinc. Other metals were present at levels, which for some of the samples slightly exceeded level 1, such as arsenic (one sample out of 19 exceeded level 1), chromium (two out of 19 exceeded level 1), nickel (10 out of 19 exceeded level 1) and zinc (one out of 19 exceeded level 1). None of the samples exceeded the Cefas Action Level 2 value.

17.8.30 The vibracore samples were also analysed for hydrocarbons and the results were compared to the Environment Canada guideline values below (Canadian Council of Ministers of the Environment, 2014):

- Below the Thresholds Effect Level (TEL); the minimal effect range within which adverse effects rarely occur.
- Between the TEL and Probable Effect Level (PEL); the possible effect range within which adverse effects occasionally occur.
- Above the PEL; the probable effect range within which adverse effects frequently occur (Canadian Council of Ministers of the Environment, 2014).

17.8.31 The results showed that the samples were either below the TEL or between the TEL and the PEL. No samples exceeded the PEL.

17.8.32 The results of the analysis of the vibracores showed that the concentrations of chemicals in the samples were relatively consistent from the sampling zone. There were some anomalies generally associated with deeper samples, specifically, adjacent to the port entrance.

17.8.33 Additionally, intertidal sediment samples were taken (via grab sample) from three stations along The Haven in 2010. The main contaminants recorded during this sampling event were the trace metals such as arsenic, chromium, copper, lead, nickel and zinc, all of which were recorded above their respective TELs (Jacobs/Halcrow, 2011) but below the PELs. When compared to Cefas Action levels the following were below the Level 1 action level: arsenic, cadmium, copper, lead, mercury and zinc. Samples which exceeded level 1 but were below level 2 were: one out of 11 chromium samples (the rest were on or below the level) and five out of 11 nickel samples (the rest were on or below the level). All samples analysed were below Cefas Action level 2.

17.8.34 Three of the samples collected during the ECMAS study were within the footprint of the proposed dredge area for the Facility.

17.8.35 In light of the available data it is not proposed that further sampling will be required. This conclusion was confirmed with the MMO during a consultation meeting. Sediment data from the samples taken at depth is not likely to have changed at all because it has remained covered by other layers of sediment which will bind in any chemicals. The sediment is being mechanically dredged which will reduce the potential for mobilisation of any contaminants and it is not proposed that the material will be used for placement in the marine environment.

Fish migration and behaviour

17.8.36 Increased levels of suspended sediments are expected during capital dredging and installation/construction of the quay wall. As stated above, levels of certain chemicals are between the TEL and PEL levels which infers that they are in the possible effect range within which adverse effects occasionally occur. Although the contaminants are within this range, the dredging method and removal of the sediment from the system are expected to reduce any impacts. The release of such sediments with limited elevated concentrations of contaminants, over a short timescale, is unlikely to influence the health and/or behaviour of fish feeding or migrating near the proposed dredge footprint. The guidance levels show that there is limited chance of contamination.

17.8.37 Increased levels of suspended sediments lead to an increase in turbidity, which can have both positive and negative impacts on fish. Fish are likely to appear

more hidden and have more visual protection from predators. However, at levels of suspended sediment concentrations higher than 14 g/L (approximately 2,800 Nephelometric Turbidity Units (NTU)), the suspended sediment can lead to negative impacts such as clogging of the gills, producing sub-lethal effects (Franco, et al., 2006), (Environment Agency, 2014), (Marshall, 1998).

17.8.38 The fish species found in The Haven are likely to be able to tolerate conditions of elevated suspended sediment concentrations and highly turbid conditions, as demonstrated by their presence and abundance in other highly turbid environments, such as the Humber estuary (Marshall, 1998). Suspended sediment concentrations measured during the baseline studies for the Boston Barrier project showed background concentrations of 134 – 1,790 mg/L, with the highest concentrations being recorded nearest the seabed. Predicted increases due to dredging are likely to be in the lower range and will only be temporary as dredging occurs. The plume will disperse along the channel and merge with background levels.

17.8.39 Any impacts on fish during construction will be temporary for the duration of the construction works, which is estimated to be a maximum of 18 months. However, the dredging works will not last for the whole of this period.

17.8.40 Fish species found in The Haven are also susceptible to increased levels of contaminants that could occur during re-suspension of sediment during the capital dredging activities. Species such as smelt are often used as indicators for clean waters, therefore can be sensitive to pollution in the water.

17.8.41 The exposure for the migratory species found in The Haven will likely be limited to when they are present in The Haven. Migratory species such as the European eel migrate at night time. No dredging works is anticipated to be undertaken at night time, the exposure of such species will be minimised.

17.8.42 Although the subtidal area in this location is relatively narrow, the dredge has been assessed as having a low likelihood of resulting in a significant impact on water quality in relation to background beyond the immediate vicinity of the dredging activity (as mentioned above and assessed in **Chapter 16 Estuarine Processes**).

17.8.43 Thus, on a conservative basis given the dredge programme and duration, the magnitude of this impact on fish is considered to be medium. This assumes that the works will be undertaken outside of the key fish migration times., The sensitivity of the receptor is considered to be medium because of the regional importance of the receptor (as stated in the baseline description for fish) and the likely tolerance of high levels of turbidity. Therefore, it is concluded (on a worst

case basis) that the impact will be of **moderate adverse** significance on fish behaviour and migration.

17.8.44 The level of impact will be dependent on the dredging schedule. Mitigation could include avoidance of seasonal sensitivities and key migration periods.

Benthic communities

17.8.45 The possible increased amount of suspended sediments in the water column, as discussed above, has the potential to deposit and smother the benthic communities, whilst also potentially releasing contaminants in the sediment. The disturbed sediment resulting from capital dredging is very likely to deposit within The Haven, and not be carried down to The Wash as discussed above. However, there is the potential for the very fine sediment to be flushed out to The Wash on an ebb tide.

17.8.46 Given the low release rate of sediment from the dredging, the low suspended sediment concentrations in the dredge plume (**Chapter 16 Estuarine Processes**), and the likelihood of resuspension of any settled sediment as part of the natural sediment movement within The Haven, it is predicted that the deposited sediment layer within The Haven will be less than one millimetre (**Chapter 16 Estuarine Processes**), which is considered to be within the range of natural deposition on the habitats in this area (mudflats and saltmarshes).

17.8.47 During the previous baseline surveys undertaken in The Haven, in very close proximity to the location of the proposed Facility, and during the site visit undertaken specifically for this project, the benthic community identified was comprised of a variety of annelids, including oligochaetes and polychaetes. All of these species are characteristic of the estuarine environment and are mobile and burrowing fauna, although some are filter feeders, which are more susceptible to increased levels of suspended solids and smothering, regardless of their mobility. However, benthic mud communities (especially oligochaete dominated) are resilient to smothering up to a deposit of 5cm because they are able to burrow and reposition within the new sediment (Whomersley, et al., 2010). Furthermore, the benthic community in the location of the proposed Facility is considered to have low sensitivity to smothering, which is supported by sensitivity data from The Marine Life Information Network (MarLIN) (https://www.marlin.ac.uk/) ((where available) for the invertebrate species present within The Haven.

17.8.48 The impacts of the increased levels of contaminants are expected to be temporary, as this will be caused during the capital dredging, prior to the construction of the wharf. Additionally, due to the potential for rapid dispersion of

the fine sediment that is likely to be suspended from capital dredging activities, a negligible amount of smothering is expected to occur in any one localised area (**Chapter 16 Estuarine Processes**, **Section 16.7**). This can be classified as light siltation, defined as siltation of up to 5 cm (Tillin & Tyler-Walters, 2015). Thus, the magnitude of this effect on benthic communities is considered to be low.

17.8.49 In line with the significance determination matrix set out in **Chapter 6 Approach to EIA**, the significance of this impact is considered **minor adverse**.

Table 17.11 Summary of Impact Assessment

Impact: Increased levels of suspended sediments (Construction)	Magnitude	Sensitivity	Significance
Increased levels of suspended sediments impacting fish migration and behaviour	Medium	Medium	Moderate adverse
Smothering of benthic communities	Low	Low	Minor adverse

Mitigation

17.8.50 It is concluded that the residual impact for fish receptors will be of **moderate adverse** significance.

17.8.51 No mitigation is considered necessary specifically for the potential smothering impact on benthic communities. The residual impact for benthic communities is therefore assessed as **minor adverse** significance.

Disturbance due to human activity/increased human presence (excluding underwater noise, but including airborne noise)

17.8.52 The presence of humans and the increased levels of activity resulting from the construction works will inevitably generate airborne noise, with the potential to result in disturbance to birds.

17.8.53 The potential impact of underwater noise is considered separately below.

Birds

17.8.54 Human presence and increased levels of activity, alongside increased levels of airborne noise, can result in disturbance effects to marine and coastal bird species mentioned in **Section 17.6**, namely the dark-bellied Brent goose, shelduck, lapwing, dunlin, black-tailed godwit, redshank and turnstone, all of which are sensitive to airborne noise. All these species are also considered to be sensitive to visual disturbance (Woodward, et al., 2015). Impacts on terrestrial species are considered in **Chapter 12 Terrestrial Ecology**).

17.8.55 The bird species mentioned in the paragraph above (and also the species that are qualifying interest features of The Wash SPA and Ramsar site) are sensitive to such disturbance as they use the mudflats in The Haven and The Wash as feeding areas (noting that birds supported by habitats within boundaries of The Wash are too distant to be affected by construction noise).

17.8.56 It should be noted that the BTO count sectors where core count data was obtained from, showed that the most ideal habitat for bird species (assessed from the density and diversity of bird species) that would be sensitive to construction works are located at the mouth of The Haven, in The Wash SPA and Ramsar site – far enough from the site to not be impacted by construction works.

17.8.57 Wright *et al.* (2010) investigated the effects on waterbirds from impulsive noise and identified a range of L_{Aeq} values which caused a behavioural response (based on a measured L_{Aeq}). These can be generally outlined as:

- no observable behavioural response: 54.9 to 71.5dBA (with a high proportion of extreme outliers);
- non-flight behavioural response: 62.4 to 79.1dBA;
- flight with return: 62.4 to 73.9dBA; and,
- flight with all birds abandoning the site: 67.9 to 81.1dBA.

17.8.58 The above information highlights that below 50dBA, no behavioural effect would be expected, but when noise levels increase, particularly approaching 70dBA, there is a range of bird responses, with the potential for birds to experience significant effects.

17.8.59 Further information on noise levels affecting water birds is provided by Cutts *et al*. (2008). This provides a useful figure of water bird response to construction disturbance, reproduced below within **Plate 17.4**. Cutts *et al.* (2008) comment that:

"…. ambient construction noise levels should be restricted to below 70dBA, birds will habituate to regular noise below this level. Where possible sudden irregular noise above 50dBA should be avoided as this causes maximum disturbance to birds".

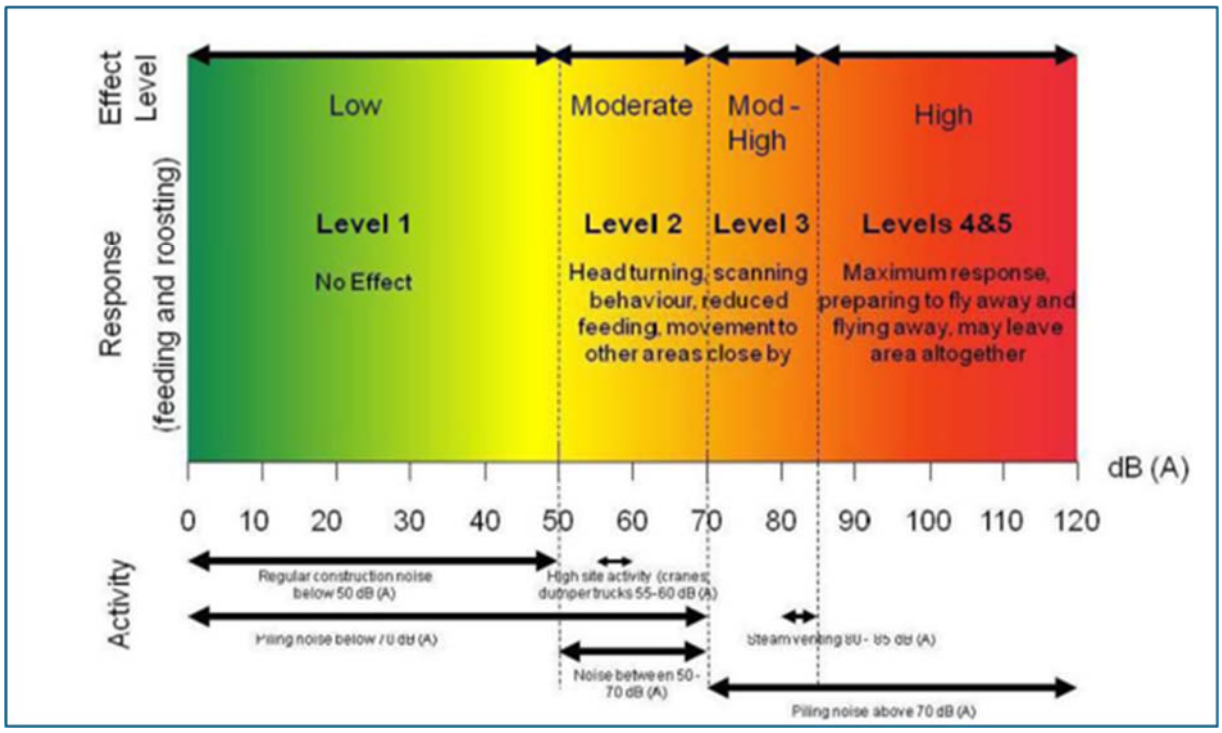

Plate 17.4 Waterbird response to construction disturbance (source Cutts et al., 2008)

17.8.60 Based on these studies, a noise level of <50dBA for general construction noise is considered to be a suitable threshold to indicate a level of effect where disturbance due to noise would not cause a behavioural response. Piling noise, which would be expected to generate noise in excess of 70dBA, would be expected to result in disturbance to water birds.

17.8.61 The noise generated during construction works, including piling, will be predicted and this will then inform the assessment of potential impacts on waterbirds. It is expected that the results will indicate that there is the potential for some localised disturbance during piling activities, with redistribution of birds to mudflats further away from the site of the proposed construction works. However, no effect on the populations of The Wash SPA and Ramsar site are predicted.

17.8.62 The potential impact, and the requirement for mitigation, will be assessed in the ES. The critical factor will be the timing of the noisy activities.

Marine mammals

17.8.63 It is likely that seals use The Haven just for passing through occasionally, rather than for hauling out or use for breeding sites, both of which occurs in The Wash, which therefore, represents a key habitat for such activities. It is not, therefore, expected to be a key route for seals as they would mostly remain in The Wash or in the lower estuarine areas. Additionally, the location of the proposed Facility is unlikely to be used as a haul-out site for the seals, unlike The Wash where there are large numbers of seal haul-outs at various locations.

17.8.64 In light of the above, no consideration is given to effect of airborne noise on marine mammals.

Underwater noise (piling and vessel movements)

Fish behaviour and migration

17.8.65 The fish species at greatest risk from the underwater noise generated by the construction activities are the migratory species (European eel, smelt, river lamprey, sea trout) and the species with highest sensitivity to noise (herring, sprat, cod and whiting).

17.8.66 Herring, sprat, cod and whiting all are considered to be Category 3 species as they have sensitivity to both pressure and particle motion (**Table 17.6**) (Popper, et al., 2014). However, it should be noted that these species are mobile, which may reduce their risk for impact (Environment Agency, 2014).

17.8.67 Pile-driving and increased vessel movements are likely to be the most significant source of noise for fish, eggs and larvae in relation to the proposed Facility. The values in **Table 17.12** broadly present the guideline sound exposure levels. Although the values in **Table 17.12** were obtained from studies carried out on Chinook salmon, Nile tilapia, hybrid striped sea bass and lake sturgeon, these fish are widely variable in their morphologies and body types, so it is considered that the guideline values in the table can broadly be applied to a wider range of fish species.

Table 17.12 Data on Mortality and Recoverable Injury Caused from Pile Driving, Based on 960 Sound Events at 1.2 Second Intervals. (Source: Mortality and Recoverable Injury Data - (Halvorsen, et al., 2011; Halvorsen, et al., 2012a; Halvorsen, et al., 2012c), TTS data - (Popper, et al., 2005))

Type of Fish	Mortality and potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Category 1	>219 dB SEL_{cum} or >213 dB peak	>216 dB SEL_{cum} or >213 dB peak	>> 186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Category 2	210 dB SEL_{cum} or >207 dB peak	203 dB SEL_{cum} or >207 dB peak	>186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Category 3	207 dB SEL_{cum} or >207 dB peak	203 dB SEL_{cum} or >207 dB peak	186 dB SEL_{cum}	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Eggs and larvae	>210 dB SEL_{cum} or >207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes: Peak and route-mean-square (rms) sound pressure levels dB re 1 µPa; SEL dB re 1µPa^2.s. All criteria are presented as sound pressure even for fish without swim bladders, since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source, defined in relative terms as near (N) (10s of meters from source), intermediate (I) (100s of meters from source) and far (F) (1000s meters from source).
TTS: temporary threshold shift – temporary reduction in hearing sensitivity.
Masking: Reduction in the detectability of a given sound (signal) as a result of the simultaneous occurrence of another sound (noise).

17.8.68 Increased levels of vessel movements are also likely to impact the hearing of fish within The Haven. Although there is no direct evidence of mortality or life-threatening injuries to fish from ship noise, this is known to cause temporary damage to the hair cells and auditory tissue effects. **Table 17.13** provides an approximate guideline of values or relative risks to different categories of fish (as classed by Popper *et al*. (2014) according to their sensitivities to vibroacoustics).

Table 17.13 Guidelines for the Noise Impacts on Fish from Shipping and Other Continuous Sounds

Type of Animal	Mortality and potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Category 1	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate

Type of Animal	Mortality and potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
					(I) Moderate (F) Low
Category 2	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Category 3	(N) Low (I) Low (F) Low	170 dB rms for 48 hours	158 dB rms for 12 hours	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Eggs and larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Notes: rms sound pressure levels dB re 1 µPa. All criteria are presented as sound pressure even for fish without swim bladders, since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N) (10s of meters from source), intermediate (I) (100s of meters from source) and far (F) (1000s meters from source).

17.8.69 The specific noise levels that will be generated by the piling activity is currently unknown, although it is anticipated that there will be 300 piles. A literature search for available data regarding potential noise levels and impact ranges was carried out.

17.8.70 Previous studies carried out on the impacts of underwater impact piling noise on fish indicate the following noise thresholds assuming the installation of 0.9 m diameter piles, with a blow energy of 125 kJ (Collet & Mason, 2014):

- 220 dB re 1µPa, occurring 6m from the noise source;
- 200 dB re 1µPa, occurring 42m from the noise source;
- 190 dB re 1µPa, occurring 160m from the noise source;
- 180 dB re 1µPa, occurring 600m from the noise source;

- 170 dB re 1µPa, occurring 1,930m from the noise source; and,
- 160 dB re 1µPa, occurring 2,750m from the noise source.

17.8.71 It should be noted that the pile size, state of the tide during piling (high or low) and a soft start are all parameters that can change the range of impact (Mason & Collett, 2011).

17.8.72 Noise modelling was also recently carried out by the Environment Agency and showed that the baseline background underwater noise level in The Haven is approximately 100dB re 1µPa and passing vessels can increase this level (Sartori, 2018).

17.8.73 **Table 17.13** shows that all category species that are known to have auditory sensitivities, low or high, are typically at low risk from shipping noises, with relation to fatal or serious injuries, from all considered distances. All category species are, however, at high risk at most distances for masking.

17.8.74 According to **Table 17.12** and the information presented above, the most sensitive Category 3 species would be at risk of serious injury or fatality if they were closer than 42 m to the source of the piling noise. Any further than this, and the risk and severity of injury is lowered. For less sensitive fish species (Category 1 and 2), the threshold for injury and damage is higher. Nonetheless, the sensitivity of fish species to underwater noise is considered to be high, with underwater noise from piling playing a larger part in the overall sensitivity.

17.8.75 Considering the narrow width of the channel, it is likely that the sensitive fish species in the area will have less of an area/buffer zone to avoid the zones where noise is generated. It should be noted however, that the most recent fish survey carried out by the Environment Agency in 2017 for the Boston Barrier project recorded higher numbers of the Category 3 fish species during the autumn than in the spring, in the area just upstream of the Facility location (**Table 17.14**) (Waugh, 2017).

Table 17.14 Guild Abundances of Noise-Sensitive Species Recorded During the Environment Agency's 2017 Survey (Waugh, 2017).

Species name	Spring 2017	Autumn 2017
Herring, *Clupea harengus*	3	220
Sprat, *Sprattus sprattus*	1	16
Whiting, *Merlangius merlanguis*	-	3

17.8.76 As such, considering the number of piles and the width of the channel, the impact will be of medium magnitude. The receptor (fish species) is considered to be of medium sensitivity.

17.8.77 In line with the significance determination matrix set out in **Chapter 6 Approach to EIA** (**Table 6.1**), the significance of this impact is considered **moderate adverse**. However, this impact will be revisited in the ES when further detail of the piling method, timing for piling and the potential for underwater noise generation is better understood.

Marine mammals

17.8.78 It is likely that seals use The Haven just for passing through occasionally rather than as a key habitat. It is not, therefore, expected to be a key route for seals as they would mostly remain in The Wash or in the lower estuarine areas.

17.8.79 During construction works, seals are likely to avoid noisy activities. Nonetheless, seals are very sensitive to underwater noises, in particular, piling noise.

17.8.80 The injury criteria level for pinnipeds in water for a single piling event have been suggested as 218 dB re 1µPa (peak) (Collet & Mason, 2014), whereas for cumulative exposure over a 24-hour period would be 185 dB, detected from 600 m. For behavioural changes (using the temporary threshold (TTS) shift criteria) the level for a single piling event is suggested as 212 dB (detected from 42 m) and 170 dB for cumulative exposure over a 24-hour period. Considering this information, if the seals are any closer than 600 m to the source of the piling noise in a worst case scenario, then they would be at high risk of permanent threshold shift (PTS) (National Marine Fisheries Service, 2018).

17.8.81 As mentioned above, the vessels related to the proposed Facility will be slow moving, and the noise emitted is likely to be of lower frequency. Noise levels reported by Malme *et al*. (1989) and Richardson *et al*. (1995) for large surface vessels indicate that physiological damage to auditory sensitive marine mammals is unlikely. However, the levels could be sufficient to cause local disturbance to sensitive marine mammals in the immediate vicinity of the vessel, depending on ambient noise levels.

17.8.82 Thomsen *et al*. (2006) reported that ship noise around 2 kHz can be detected by harbour seals at a distance of approximately 3 km (ambient noise = 94 and 91 dB rms re 1µPa at 0.25 and 2 kHz, respectively). The Southall *et al*. (2009) disturbance threshold (TTS / fleeing response) for seal species underwater is 172dB re 1µPa. The noise levels for vessels estimated by Thomsen *et al*. (2006) are lower than this disturbance threshold for seals. Therefore, there is currently

no evidence to suggest that vessel noise adversely affects seals, suggesting they may have a lower sensitivity than cetacean species.

17.8.83 Given the low numbers and frequency of occurrence of seals, the magnitude of impact is considered negligible. The sensitivity for seals is considered high, based on potential for piling activity impacts. On this basis, it is concluded that the impact is expected to be of **minor adverse** significance.

Table 17.15 Summary of Impact Assessment

Impact: Underwater noise (Construction)	Magnitude	Sensitivity	Significance
Fish behaviour and migration	Medium	Medium	Moderate adverse
Marine mammals	Negligible	High	Minor adverse

Mitigation

17.8.84 The need for, and nature of, mitigation measures will be considered when the impact assessment is further progressed and the potential for underwater noise generation is better understood.

Potential Impacts during Operation

Habitat alteration due to hydrodynamic changes

17.8.85 During the operational phase, there is a potential for indirect impact on estuarine habitats within The Haven due to the following potential effects on the hydrodynamic and sedimentary regime:

- Changes to the tidal current regime and erosion/accretion patterns due to the presence of the wharf and berthing areas.
- Changes to the wave regime (ship wash) due to the increase in vessel traffic.
- Changes in suspended sediment concentrations due to maintenance dredging of the berthing areas.
- Changes in estuary-bed level due to maintenance dredging of the berthing areas.

17.8.86 The above potential effects are assessed in **Chapter 16 Estuarine Processes**, which concludes that all effects will be of negligible magnitude.

17.8.87 However, an additional impact could occur from a marine and coastal ecological perspective, the vessels that will be berthed at the wharf during the operation of the Facility are likely to be grounded on the mudflats during low tide until the next high tide floods berthing pocket to allow the vessel to leave the Facility. This is

likely to cause permanent habitat disturbance and continual fluxes of possibly contaminated sediment as the vessel is lifted on and off the mudflats with the flooding and ebbing tides because the vessels are likely berthed in the same locations each time.

17.8.88 The grounding of one vessel at the same location at the wharf will occur approximately once a day. Although there are no ground vessels currently at the Facility location, the Port of Boston does have some NAABSA (not always afloat but safely aground) berths further upstream the River Witham. However, the grounding of vessels during the operation of the Facility will result in less intertidal areas being available at certain states of the tide and result in a loss of feeding area for birds. As such, this impact is considered to be of medium magnitude.

17.8.89 However, as the habitat is likely to be impacted from this is very localised and small in relation to the total habitat available in The Haven, it is considered to be of low sensitivity. This results in a **minor adverse** impact significance.

17.8.90 This impact will be further assessed when further information is available on the operation of the wharf and the hydrodynamic changes that could occur.

Table 17.16 Summary of Impact Assessment

Impact: Habitat alteration due to hydrodynamic changes (Operation)	Magnitude	Sensitivity	Significance
Habitat alteration	Medium	Low	Minor adverse

Increased vessel traffic and movement

17.8.91 The number of vessels that will be arriving and leaving The Haven will increase from 400/year to approximately 1024/year due to the operation of the Facility. As such, there will be 624 extra vessels. This equates to approximately 1.7 vessels per day. No seasonal changes in the number of operation-related vessels are anticipated throughout the year. Each vessel will be 90-100m long and will be travelling at a maximum speed of 4 knots. This increased vessel traffic has the potential to result in increased ship wash, underwater noise, disturbance to birds and marine mammals and increased risk of collisions for marine mammals.

17.8.92 To put this in context of the wider area of The Wash, there are approximately 77,441 vessels entering the whole of The Wash annually, or 212 movements per day, as shown by the Vessel Density Grid Data 2015 from the MMO (MMO, 2017). Additionally, the proposed shipping channel to be used by the operation of the Facility is currently being used by 11,000 vessels annually (30 vessels per day)

(www.marinetraffic.com, 2017). The increase of 624 vessel movements per year through the operational period of the Facility is a small increase compared to the number already present within The Wash and the shipping channel (equating to an additional 0.8% and 5.6% vessels, respectively).

Increased risk of invasive species with ballast water

17.8.93 There negligible anticipated risk of invasive species being introduced to The Haven with the daily delivery vessels visiting the Facility. Vessels delivering RDF to the Facility will arrive fully-laden and depart empty. Advice from the proposed shipping and logistics handler for the proposed wharf has indicated that the ships used to deliver material to the Facility will not require to take on ballast water when leaving empty. Vessels delivering clay to the Facility as binder in the aggregates process, will arrive full, the hold will be emptied of the clay and washed out (with the wash water retained on-site in sealed sumps prior to being used in the aggregate manufacture process. These vessels will then leave full with aggregate. As such, a negligible impact from the introduction of invasive species through ballast water can be concluded.

Increased ship wash

17.8.94 On Royal HaskoningDHV's site visit on the 8th October 2018, erosion of the saltmarsh was observed further upstream from the location of the proposed Facility, most likely caused by the tidal patterns and natural waves (**Plate 17.5**).

17.8.95 As a worst case scenario for this impact, it is assumed that the energy of a wave created by an individual vessel in the Haven is above the threshold for the erosion of mud from the intertidal areas and that the increase in the shipping traffic would result in an increase in the potential for erosion.

Plate 17.5 Erosion of the saltmarshes upstream of the location of the proposed Facility.

17.8.96 The increased vessel movements would mean increased wave movements, which would impinge on the intertidal mudflats and saltmarsh. However, as stated in **Chapter 16 Estuarine Processes** (**Section 16.7**), the natural wind-caused wave conditions would not change. Although the magnitude of the ship waves would be larger than that of the natural wind-generated waves, the frequency that the natural waves occur will be much higher, as they can occur all year round, any time of the day. Thus, it is considered, on an annual basis, that the effect of the natural windborne waves would significantly exceed that of ship waves.

17.8.97 Saltmarsh and mudflat are both BAP priority habitats and represent supporting habitat for fish and birds, as well as the invertebrates and vegetation that colonise these habitats. As these habitats are not designated as national or international habitats of importance at this location, they are considered to have a value of regional importance. Therefore, overall, these receptors can be considered of medium sensitivity.

17.8.98 The increase in vessel traffic is unlikely to cause a significant increase in the erosion of the intertidal habitats. This is because the contribution to the overall erosion of these habitats by locally generated wind waves is expected to significantly exceed the contribution from ship waves. Therefore, a negligible impact is predicted.

Increased disturbance (visual and airborne noise)

17.8.99 Increased vessel movements can result in visual disturbance effects to bird species including those mentioned in **Section 17.6**, namely the dark-bellied Brent goose, shelduck, lapwing, dunlin, black-tailed godwit, redshank and turnstone, all of which are sensitive to airborne noise. All these species are also considered to be sensitive to visual disturbance (Woodward, et al., 2015). Marine mammals are also sensitive to visual disturbance from increased vessel movements

17.8.100 Similar to the construction phase, the bird species mentioned in the paragraph above (and also the species that are qualifying interest features of The Wash SPA and Ramsar site) are sensitive to such disturbance because they use the mudflats in The Haven and The Wash as feeding areas. It is noted that birds supported by habitats within boundaries of The Wash are likely to be affected by the increases in vessel movements too as the vessels will be transiting via The Wash.

17.8.101 It should be noted that the BTO count sectors where core count data was obtained from, showed that the most ideal habitat for bird species (assessed from the density and diversity of bird species) that would be sensitive to disturbance from vessel movements are located at the mouth of The Haven, in The Wash SPA and Ramsar site. However, in this area and all the way up to the proposed wharf at the Facility, vessels will only be able to navigate along the channel close to high water (within one hour of high tide) to ensure enough water to keep afloat. In this respect, disturbance would be reduced as vessels will not be accessing the site during or close to low water when birds will be feeding on the extensive flats near the entrance to The Haven; and also within The Haven and at the Facility.

17.8.102 The information presented in the previous section of construction-phase impacts highlights that below 50dBA, no behavioural effect would be expected, but when noise levels increase, particularly approaching 70dBA, there is a range of bird responses, with the potential for birds to experience significant effects. The operational noise modelling carried out for the Facility (**Chapter 10 Noise and Vibration**) identified no impact to the two sites on the shores of the Haven (on the bank opposite to the Facility), in relation to background noise levels. The predicted noise levels ranged from 34 to 42 dBA, which accounted for operation of the Facility, as well as the increased vessel movements.

17.8.103 Based on previous studies and the operational noise modelling, a noise level of <50dBA for operational vessel noise is considered to be a suitable threshold to indicate a level of effect where disturbance due to noise would not cause a behavioural response. It is expected that the vessel movements will cause short-

lived increases in noise. In terms of vessel presence this could affect roosting birds using the habitats at high water. In the area of the proposed wharf the coastal habitats are not considered to be suitable as roosting sites as the saltmarsh is only a narrow strip and does not provide dense cover to provide a haven from predation. In the entrance to The Haven the saltmarshes are much wider and the distance from the channel areas to the roosting sites is considered to be enough to act as a buffer against disturbance. As such, no effect on the populations of The Wash SPA and Ramsar site are predicted. However, this is further assessed in **Appendix 17.1.**

17.8.104 With regards to seals, it is likely that they use The Haven just for passing through occasionally, rather than the estuary representing a key habitat. It is not, therefore, expected to be a key route for seals as they would mostly remain in The Wash or in the lower estuarine areas. The vessels will be passing through The Wash and as such could cause some disturbance from their presence in this area, within which there are several areas used as haul out sites by seals. Although the numbers of vessels accessing The Haven will increase, the vessels will be following the same routes as existing vessels and as such are not expected to cause disturbance because the seals that already use these areas are expected to be habituated to vessel presence, albeit at lower densities. The location of the proposed Facility is unlikely to be used as a haul-out site for the seals.

17.8.105 In conclusion, although the increased vessel activity will be significant, the operational phase is not considered to have a significant impact because seals using areas close to existing vessel routes are expected to be habituated to vessel presence. The magnitude of the impact is therefore considered to be low.

Increased underwater noise

17.8.106 The potential impacts on marine and coastal ecological receptors from underwater noise during operation are limited, and significantly lower than during the construction phase. There will be no piling during the operational phase, the only underwater noise that will be generated will be the noise from the increased vessel movements. The maintenance dredging that will be carried out will be temporary and intermittent; and carried out using land-based plant.

17.8.107 Other than the information presented in **Table 17.13**, there is insufficient data from shipping operations to define accurate exposure criteria. However, **Table 17.13** shows that fish have low sensitivity to noise generated by shipping. All fish species in categories 1-3, however, have high sensitivity to masking (interference with the fish hearing ability), but this is not a fatal impact.

17.8.108 As stated in the impacts of underwater noise during the construction phase on marine mammals, marine mammals are unlikely to be impacted by shipping noise significantly unless they are within direct vicinity of the vessel. The vessels travelling to and from the Facility will be slow moving (< 4 knots), or stationary within the Boston anchorage area. Most noise emitted is likely to be of a low frequency. Noise levels reported by Malme *et al.* (1989) and Richardson *et al.* (1995) for large surface vessels indicate that physiological damage to auditory sensitive marine mammals is unlikely. As stated in the HRA (**Appendix 17.1**), it is expected that any marine mammals present within or near the Facility shipping channel in The Wash would be habituated to the presence of vessels given the high level of marine traffic in the area.

17.8.109 Additionally, Thomsen *et al.* (2006) reviewed the effects of ship noise on seal species. As seals use lower frequency sound for communicating (with acute hearing capabilities at 2kHz) there is the potential for detection, avoidance and masking effects in seals. Thomsen *et al.* (2006) consider that ship noise around 2kHz will be detected at a distance of approximately 3km for harbour seals (ambient noise = 94 and 91dB rms re 1µPa at 0.25 and 2 kHz, respectively); and the zone of audibility will be approximately 20km. However, there is no evidence to suggest that vessel noise adversely affects seals, suggesting they may have a lower sensitivity than cetacean species. As such, considering the lower level usage of this area compared to other areas of The Wash, as well as the above points, harbour seals are considered to have a low sensitivity to vessel noise.

17.8.110 Although the increased vessel activity will be significant, this phase is considered to have a much lower impact than the construction phase. The magnitude of the impact, considering the small increase overall in The Wash, is therefore considered to be low.

17.8.111 **Appendix 17.1** assesses the impacts of underwater noise on the marine mammal population of The Wash and North Norfolk Coast SAC.

<u>Increased risk of collisions for marine mammals (impact zone includes the Wash as a transit area)</u>

17.8.112 The additional vessel movements associated with the operation of the proposed Facility could have the potential to increase the collision risk with marine mammals, both within The Haven and The Wash. There will be approximately 1.6 slow-moving vessels per day coming in and out of The Haven due to the operation of the proposed Facility, all of which will be coming through The Wash. Each vessel will be 90-100m long and will be travelling at a maximum speed of 4 knots. These vessel movements will be additional to the approximate number of 1.1

vessels per day using this route at present to access the Port of Boston.

17.8.113 Marine mammals are able to detect and avoid vessels. However, vessel strikes are known to occur, possibly due to distraction whilst foraging and socially interacting, or due to the marine mammals' inquisitive nature (Wilson, et al., 2007). Therefore, increased vessel movements, especially those out-with recognised vessel routes, can pose a risk of vessel collision to seals and/or harbour porpoise. However, the vessels for the operation of the Facility will be following a set navigation route through The Wash (**Chapter 18 Navigational Issues**), with a pilot on board. Whilst waiting for the pilot vessel to arrive, the delivery vessels will be situated in the Port of Boston Anchorage area in The Wash.

17.8.114 Studies have shown that larger vessels are more likely to cause the most severe or lethal injuries, with vessels over 80m in length causing the most damage to marine mammals (Laist, et al., 2001). Vessels travelling at high speeds are considered to be more likely to collide with marine mammals, and those travelling at speeds below 10 knots would rarely cause any serious injury (Laist, et al., 2001). The large vessels (100m in length) associated with the proposed Facility will be slow moving (< 4 knots in The Haven), therefore minimising the potential collision risk with seals in the area. The speed limit within The Wash is 6 knots.

17.8.115 Essentially, it is the seal population of The Wash and North Norfolk Coast SAC that will be at risk from the Facility. Although the risk of collision related to the operation of the Facility is likely to be low, as a precautionary worse-case scenario, the number of harbour seals that could be at increased collision risk with vessels during the operation of the Facility has been assessed based on 5% to 10% of the number of individuals that could be present in the shipping channel and anchorage location in The Wash.

17.8.116 A total of 1.7 harbour seals could be at collision risk if it is considered that 5% would be at risk, and a total of 3.3 harbour seals may be at risk of collision with vessels if it is considered that 10% could be at risk. Taking into consideration the small proportionate increase in the total number of vessels in the area of The Wash, their slow speed of travel (of 4 knots or less), the likelihood that harbour seals would be able to detect and avoid any vessels in order to avoid collision and the small number of seals that could be at risk; it can be concluded that marine mammals relevant to this assessment are of low sensitivity to the risk of vessel collision.

17.8.117 However, as this impact will be permanent (due to the permanent nature of the increase in vessels), the magnitude of this impact can be considered medium.

17.8.118 In line with the impact assessment matrix set out in **Chapter 6 Approach to EIA**, this impact is considered to be of **minor adverse** significance.

17.8.119 **Appendix 17.1** assesses the impacts of underwater noise on the marine mammal population of The Wash and North Norfolk Coast SAC.

Table 17.17 Summary of Impact Assessment

Impact: Increased vessel traffic and movement (Operation)	Magnitude	Sensitivity	Significance
Increased risk of invasive species with ballast water	Negligible	Negligible	Negligible
Loss of habitat (increased ship wash)	Negligible	Negligible	Negligible
Increased visual disturbance	Low	Low	Minor adverse
Increased underwater noise	Low	Medium	Minor adverse
Increased risk of collisions for marine mammals (impact zone includes the Wash as a transit area)	Medium	Low	Minor adverse

Mitigation

17.8.120 It is recommended (as also specified in **Chapter 16 Estuarine Processes**, **Section 16.8**) that bathymetric surveys be undertaken every six months to monitor any potential erosion of the intertidal habitats.

17.8.121 Vessel movements will be incorporated into recognised vessel routes where marine mammals are accustomed to vessel presence, to reduce any disturbance and any increased collision risk.

17.8.122 Further mitigation will be revised as necessary in the ES. No changes to the residual impact significance are anticipated.

Increased levels of suspended sediments due to maintenance dredging

17.8.123 Similar to the construction phase, there is a potential impact to the fish and benthic communities of The Haven to be affected by the maintenance dredging regime and the resulting increase in suspended sediments. It should be noted that the significance of this impact has been estimated from available information. The annual volume of sediment that would deposit in the bething areas has calculated to be approximately 1,643m^3. This has been assumed to be the same as the volume of maintenance dredging (**Chapter 16 Estuarine Processes**).

17.8.124 Sediment recovered from the maintenance dredge (using a mechanical land-based plant) of the wharf area will be lifted directly on to the wharf for subsequent draining in a settling pond, where the drained water will be used for the on-site aggregate production. A small volume of the dredged sediment would naturally be lost from the excavator during the dredging process and would enter the water column.

17.8.125 The berthing areas would also potentially create a sink for deposition of fine sediment, which will require maintenance dredging during the operational phase. It is assumed that the method of dredging will be from a mechanical, land-based plant. On any one occasion, the volume of maintenance dredging would be significantly less than the capital dredge and, therefore, the loss of sediment during dredging would be less than during the capital dredging. As such, the effects on both the fish and benthic communities are expected to be lower magnitude, with the sensitivities of these receptors being as described for the construction phase. The impact is considered to be of **minor adverse** significance (fish) and **negligible** (benthic communities).

Table 17.18 Summary of Impact Assessment

Impact: Increased levels of suspended sediments (Operation)	Magnitude	Sensitivity	Significance
Effects on fish migration and behaviour	Negligible	Medium	Minor adverse
Smothering of benthic communities	Negligible	Low	Negligible

Mitigation

17.8.126 Given that the maintenance dredging will form part of the existing wider maintenance programme, and the nature of the predicted impacts, no specific measures are considered necessary.

Beaching of vessels at low tide

17.8.127 Vessels that will be berthed at the wharf during the operation of the Facility will to be grounded on the mudflats during low tide until the tide floods when the vessel will be able to leave the Facility. This is likely to cause permanent habitat disturbance and continual fluxes of possibly contaminated sediment as the vessel is lifted on and off the mudflats with the flooding and ebbing tides.

17.8.128 The grounding of one vessel at the same location at the wharf will occur approximately once a day.

17.8.129 Benthic communities are considered to be of low sensitivity to resuspended contaminants, as they are largely sediment dwelling organisms, accustomed to the level of contamination existent in the sediment. Furthermore, the benthic communities are at risk of being compressed with the grounded vessel. However, as the affected area will only be the size of the vessel itself, which is considered to be **negligible** in terms of the total available mudflat habitat within The Haven, the benthic communities can be classed of low sensitivity. This results in a **minor adverse** impact significance.

Table 17.19 Summary of Impact Assessment

Impact: Beaching of vessels at low tide (Operation)	Magnitude	Sensitivity	Significance
Compressing of benthic communities	Negligible	Low	Minor adverse

Increased emissions to air and deposition on marine and estuarine habitats

17.8.130 The following designated sites (with a marine and coastal interest) are located within the distance criteria specified in Defra Environment Agency guidance as requiring consideration for potential impacts of air emissions (Defra and Environment Agency, 2016):

- The Wash and North Norfolk Coast SAC.
- The Wash SPA.
- The Wash Ramsar site.
- Havenside LNR.

17.8.131 The potential for nitrogen oxides (NO_x), sulphur dioxide (SO_2), nitrogen, acid and ammonia deposition on these sites during the operation of the Facility was assessed as a result of air quality dispersion modelling, carried out in **Chapter 14 Air Quality.** Currently, this did not identify any deposition on these sites. However, further analysis of the modelling results will be carried out at the ES stage.

17.9 Cumulative Impacts

17.9.1 **Table 17.20** presents projects that are likely to have cumulative impacts when considered alongside the Facility. Each of these projects has been scoped either in or out of the marine and coastal ecology aspect of the cumulative impact assessment according to its relevant merits.

Table 17.20 Projects in the Vicinity of the Facility with the Potential to have Cumulative Impacts.

Project	Status	Development period	Distance from the Facility (km)	Project definition	Project data status	Included in CIA	Rationale
Boston Barrier Flood Defence	Transport and Works Act Order consented	2017 - ongoing	Boston Barrier at closest point to the Facility is 500 m.	Environmental Statement	Complete/high	Yes	Although the Boston Barrier Flood Defence is located in close proximity to the Facility, there is no potential for the construction programmes to overlap. The Boston Barrier is aimed to be finished by the end of 2020, by which time consent for the Facility is unlikely to have been granted. However, there is potential for there to be an overlap in the operation of both projects, leading to a cumulative impact.
Triton Knoll Offshore Wind Farm	DCO consented	2008 - ongoing	Onshore cable corridor and Construction compound at Langrick 9.7 km from the Facility.	Environmental Statement	Complete/ high	No	Land based, therefore no interaction with marine and coastal ecology.
Viking Link Interconnector B/17/0340	Application approved	2014 - 2023	Bicker Fen substation 14.4 km from the Facility.	Environmental Statement	Incomplete	No	Land based, therefore no interaction with marine and coastal ecology.

Project	Status	Development period	Distance from the Facility (km)	Project definition	Project data status	Included in CIA	Rationale
Battery Energy Storage Plant (Marsh Lane) B/17/0467	Application approved	2017 - ongoing	Beeston Farm less than 10 m from the Facility.	Detailed application	Incomplete	No	Land based, therefore no interaction with marine and coastal ecology.
The Quadrant Mixed-use development of 502 dwellings and commercial/ leisure uses B/14/0165	Application approved Construction started	2014 - ongoing	Quadrant 1 1.2 km from the Facility.	Details within ES	Quadrant 1 – Complete/ high Quadrant 2 - Incomplete/low	No	Land based, therefore no interaction with marine and coastal ecology.
Land to the west of Stephenson Close Residential Development of up to 85 dwellings B/17/0515	Application not yet determined	2017 - ongoing	From the most eastern part of the Scheme to the Facility is 550 m.	Outline only	Incomplete/low	No	Land based, therefore no interaction with marine and coastal ecology.
Havenside Flood Banks Scheme	Construction started	Ongoing	Adjacent to the Facility	-	-	No	These works will be complete by the end of 2020, which is before the construction of the Facility. As such, there is no potential for cumulative impacts.

17.9.2 It is likely that only Boston Barrier is close enough to the proposed Facility to have the potential to result in significant cumulative impacts. Cumulative impacts may arise due to simultaneous operation.

17.9.3 The construction programmes of the proposed Facility and the Boston Barrier are unlikely to overlap because of the likely consent determination period for the Facility. However, operation of the Barrier and maintenance dredging will occur simultaneously with construction and operation of the Facility (depending on the final construction programmes) and so there is potential for cumulative impacts.

17.9.4 The worst case scenario from a marine and coastal ecology perspective would be for the maintenance for Boston Barrier and capital dredging for the Facility to occur at the same time. This would represent the greatest risk of a cumulative increase in suspended sediment concentrations leading to cumulative impacts on fish and benthic ecology. The combined change in suspended sediment concentrations could affect a greater spatial area.

17.9.5 A summary of the potential cumulative impacts with the Boston Barrier is set out in **Table 17.21**.

Table 17.21 Potential Cumulative Impacts with the Boston Barrier

Impact	Potential for cumulative impact	Data confidence	Rationale
Construction phase			
None	N/A	N/A	N/A
Operational phase			
Habitat alteration due to hydrodynamic changes	Yes	High	Where the maintenance dredging windows overlap for both projects, there could be potential for cumulative impact.
Changes in vessel traffic and movement leading to increased ship wash, underwater noise, disturbance and collision risk	Yes	High	
Increased suspended sediment concentrations due to maintenance dredging	Yes	High	
Increased emissions to air and deposition on marine and estuarine habitats	Yes	High	

17.10 Inter-Relationships with Other Topics

17.10.1 The potential impacts on marine and coastal ecology as assessed in this chapter have inter-relationships with other chapters. **Table 17.22** presents the impacts considered in this chapter and highlights that the chapter has been informed by the assessments described in **Chapter 10 Noise and Vibration, Chapter 14 Air Quality, Chapter 16 Estuarine Processes** and **Chapter 15 Marine Water and Sediment Quality**.

Table 17.22 Chapter Topic Inter-Relationships

Topic and description	Related Chapter	Where addressed in this Chapter
Airborne and underwater noise (piling and vessel movements)	**Chapter 10 Noise and Vibration**	**Section 17.8**
Effects on water column (suspended sediment concentrations and water quality)	**Chapter 16 Estuarine Processes** **Chapter 15 Marine Water and Sediment Quality**	**Section 17.8**
Changes in vessel traffic and movement leading to increased ship wash, underwater noise, disturbance and collision risk	**Chapter 10 Noise and Vibration** **Chapter 16 Estuarine Processes**	**Section 17.8**
Increased levels of contaminants in water column	**Chapter 16 Estuarine Processes** **Chapter 15 Marine Water and Sediment Quality**	**Section 17.8**
Increased emissions to air and deposition on marine and estuarine habitats	**Chapter 14 Air Quality**	**Section 17.8**

17.11 Interactions

17.11.1 The potential impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts because of that interaction. The worst case impacts assessed within the chapter take these interactions into account and for the impact assessments are considered conservative and robust.

17.11.2 For clarity, the areas of interaction between impacts are presented in **Table 17.23**, along with an indication as to whether the interaction may give rise to synergistic impacts.

Table 17.23 Interaction Between Impacts

Potential interaction between impacts Construction	Loss of and/or change to estuarine habitats due to capital dredging	Increased suspended sediment concentrations from capital dredging, with potential for sediment-bound contaminants to be released	Disturbance due to human activity/increased human presence (excluding underwater noise but including airborne noise)	Underwater noise (piling and vessel movements)
Loss of and/or change to estuarine habitats due to capital dredging and reclamation due to quay construction	-	Yes	Yes	No
Increased suspended sediment concentrations from capital dredging, with potential for sediment-bound contaminants to be released	Yes	-	Yes	No
Disturbance due to human activity/increased human presence (excluding underwater noise but including airborne noise)	Yes	Yes	-	Yes
Underwater noise (piling and vessel movements)	No	No	Yes	-

Potential interaction between impacts				
Operation				
	Habitat alteration due to hydrodynamic changes	**Changes in vessel traffic and movement leading to increased underwater noise, disturbance and collision risk**	**Increased suspended sediment concentrations due to maintenance dredging**	**Increased emissions to air and deposition on marine and estuarine habitats**
Habitat alteration due to hydrodynamic changes	-	Yes	Yes	No
Changes in vessel traffic and movement leading to increased ship wash, underwater noise, disturbance and collision risk	Yes	-	Yes	Yes
Increased suspended sediment concentrations due to maintenance dredging	No	Yes	-	No
Increased emissions to air and deposition on marine and estuarine habitats	No	Yes	No	-
Decommissioning				
No impacts on marine and coastal ecology are anticipated during the decommissioning phase.				

17.12 Summary

17.12.1 The significance of potential impacts on the marine and coastal ecological receptors arising from the construction and operation of the Facility have been assessed. No impact is predicted for the decommissioning phase as it is planned that the wharf will be left in place.

17.12.2 The main potential impacts arising from the construction phase are habitat loss/alteration, increased suspended sediment concentrations and increased noise caused by piling and ship movements. The sensitive receptors include fish species, benthic communities, birds, marine mammals, saltmarsh and mudflats.

17.12.3 A summary of all impacts, associated mitigation and residual impact has been included in **Table 17.24**.

17.12.4 Potential impacts of the proposed Facility during the construction and operational phases have also been assessed in the HRA (**Appendix 17.1**), which covers the following European sites:

- The Wash SPA.
- The Wash Ramsar site.
- The Wash and North Norfolk Coast SAC.

Table 17.24 Impact Summary

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Loss of and/or change to estuarine habitats and associated species within the footprint of the wharf and dredging area	Mudflats	Medium	Low	Minor adverse	Material removed to be restricted to minimum. The design of the quay wall and wharf has been set to minimise the volume of capital dredging required.	Minor adverse
	Saltmarshes	Medium	Low	Minor adverse		Minor adverse
Increased suspended sediment concentrations from capital dredging, with potential for sediment-bound contaminants to be released	Fish	Medium	Medium	Moderate adverse	The need for, and nature of mitigation will be considered when the dredging programme has been confirmed.	Moderate adverse
	Benthic fauna	Low	Low	Minor adverse		Minor adverse
Disturbance due to human activity/increased human presence (excluding underwater noise, but including airborne noise)	Birds	To be assessed when predictions of noise generation during construction have been undertaken			The need for, and nature of mitigation will be considered when the predicted construction noise levels have been confirmed.	-
Underwater noise (piling and vessel movements)	Fish	Medium	Medium	Moderate adverse	The need for, and nature of mitigation will be considered when the impact assessment is further progressed and the potential for underwater noise	Moderate adverse
	Marine mammals	High	Negligible	Minor adverse		Minor adverse

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
					generation is better understood.	
Operation						
Habitat alteration due to hydrodynamic changes	Intertidal and subtidal habitats	Low	Medium	Minor adverse	Dredging works to be minimised according to best practice and monitor the seabed and habitat level through regular bathymetric and habitat surveys.	Minor adverse
Changes in vessel traffic and movement leading to increased ship wash, underwater noise, disturbance and collision risk	Increased risk of invasive species with ballast water	Negligible	Negligible	Negligible	Shipping to be kept to a minimum, as necessary. Slow speed (max. 4 knots) to be kept for all vessels.	Negligible
	Intertidal habitats (increased ship wash)	Negligible	Negligible	Negligible		Negligible
	Birds and marine mammals (visual disturbance)	Low	Low	Minor adverse		Minor adverse
	Fish, birds and marine mammals (increased underwater noise)	Medium	Low	Minor adverse		Minor adverse
	Marine mammals (vessel collision)	Low	Medium	Minor adverse	Slow speed (max. 4 knots) to be kept for all vessels. Vessel movements to be incorporated in to recognised vessel routes.	Minor adverse

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Increased levels of suspended sediments due to maintenance dredging	Fish (migration and behaviour)	Medium	Negligible	Minor adverse	Given that the maintenance dredging will form part of the existing wider maintenance programme, and the nature of the predicted impacts, no specific measures are considered necessary.	Minor adverse
	Benthic fauna	Low	Negligible	Negligible		Negligible
Beaching of vessels at low tide	Benthic fauna	Low	Minor	Minor adverse	No mitigation was deemed necessary	Minor adverse
Increased emissions to air and deposition on marine and estuarine habitats	Marine and coastal habitats	Potential impacts will be assessed when the results of the air quality assessment are available				-
Decommissioning						
No impacts on marine and coastal ecology are anticipated during the decommissioning phase.						

17.13 References

Billard, R., 1997. Les poissons d'eau douce des rivières de France. In: *Identification, inventaire et répartition des 83 espèces.* Lausanne: Delachaux & Niestle, p. 192.
Blaxter, J., Gray, J. & Denton, E., 1981. Sound and startle responses in herring shoals. *Journal of the Marine Biological Association of the United Kingdon,* Volume 61, pp. 851-869.
Boston Borough Council, 2018. *Havenside Country Park and Local Nature Reserve.* [Online]
Available at: http://www.boston.gov.uk/index.aspx?articleid=3763
[Accessed 31 January 2019].
Broome, S., Seneca, E. & Woodhouse Jr., W., 1988. Tidal salt marsh restoration. *Aquatic Botany,* 32(1-2), pp. 1-22.
Canadian Council of Ministers of the Environment, 2001. *Canadian sediment quality guidelines for the protection of aquatic life: Summary tables.,* s.l.: s.n.
Canadian Council of Ministers of the Environment, 2014. *Canadian Sediment Quality Guidelines.* [Online]
Available at: http://cegg-rcqe.ccme.ca/en/index.html
[Accessed 31 January 2019].
Collet, A. & Mason, T., 2014. *York potash Project Harbour Facilities: Underwater Noise Impact Assessment,* s.l.: Subacoustech.
Cutts, N., Phelps, A. & Burdon, D., 2008. *Construction and Waterfowl: Definiting Sensitivity Response, Impacts and Guidance. Report to Humber INCA.,* s.l.: Institute of Estuarine and Coastal Studies, University of Hull.
Defra, 2010. *Eel Management Plans for the United Kingdom Anglian River Basin District, March 2010,* s.l.: s.n.
Enger, P., 1967. Hearing in Herring. *Comparative Biochemistry and Physiology ,* Volume 22, pp. 527-538.
English Nature, 1972. *Citation for The Wash SSSI.* [Online]
Available at:
https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1002591.pdf
[Accessed 21 January 2019].
Environment Agency, 2013. *Humber Fish Population Review,* s.l.: UHULL (IECS & HIFI).
Environment Agency, 2014. *Boston Barrier Tidal Project - Volume 2b: Ecology and Nature Conservation Technical Report,* Bristol: Environment Agency.
Franco, A. et al., 2006. Environmental influences on fish assemblages in the Venice Lagoon, Italy. *Chemistry and Ecology,* Volume 22, pp. S105-S118.
Fricke, R., 2007. *Helsinki Comission.* [Online]
Available at:
http://www.helcom.fi/environment2/biodiv/endangered/Fish/en_GB/Lampetra_fluviatilis/

Greater Lincolnshire Nature Partnership, 2015. *Lincolnshire Environmental Records Centre data search report: Boston,* s.l.: s.n.
Halvorsen, M. et al., 2012c. Effects of exposure to pile driving sounds on the lake sturgeon, Nile tilapia and hogchoker. *Proceedings of the Royal Society of Biology,* Volume 279, pp. 4705-4714.
Halvorsen, M. et al., 2011. Predicting and mitigating hydroacoustic impacts on fish from pile installations. In: *NCHRP Res Results Digest.* Washington, D.C.: National Cooperative Highway Research Program, Transportation Research Board, National Academy of Sciences, pp. 25-28.
Halvorsen, M. et al., 2012a. Threshold for onset of injury in Chinook salmon from exposure to impulsive oile driving sounds. *PLoS ONE,* 7(6).
Holden, E., 2017. *Boston Barrier Tidal Project: 2017 Saltmarsh Survey Report,* s.l.: Environment Agency.
J.R. Stephenson, A. G. R. B. B. P. Z. D. T. C. M. L. M. A. R. J. A. S., 2010. Assessing barotrauma in neutrally and negatively buoyant juvenile salmonids exposed to simulated hydro-turbine passage using a mobile aquatic barotrauma laboratory. *Fisheries Research,* 106(3), pp. 271-278.
Jacobs/Halcrow, 2011. *Boston Barrier and Haven Works, Water Quality and Sediment Chemistry technical Note,* s.l.: V Guerra.
Jacobs, 2011. *Boston Barrier Saltmarsh Surveys September 2011,* s.l.: Environment Agency.
JNCC, 1988. *Information Sheet on Ramsar Wetlands.* [Online]
Available at: http://jncc.defra.gov.uk/pdf/RIS/UK11072.pdf
[Accessed 21 January 2019].
JNCC, 2004. *The Wash SPA.* [Online]
Available at: http://jncc.defra.gov.uk/default.aspx?page=2003
[Accessed 21 January 2019].
JNCC, 2005. *The Wash and North Norfolk Coast SAC.* [Online]
Available at:
http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUCode=UK0017075
[Accessed 21 January 2019].
JNCC, 2011. *UK Biodiversity Action Plan Priority Habitat Descriptions.* [Online]
Available at: http://jncc.defra.gov.uk/PDF/UKBAP_PriorityHabitatDesc-Rev2011.pdf
[Accessed 21 January 2019].
Knudsen, F., Enger, P. & Sand, O., 1994. Avoidance responses to low frequency sound in downstream migrating Atlantic salmon smolt, Salmo salar. *Journal of Fish Biology,* 45(2), pp. 227-233.
Kottelat, M., 1997. *European freshwater fishes,* s.l.: Biologia 52, Suppl. 5:1-271.
Kottelat, M. & Freyof, J., 2007. Handbook of European fishes. In: *Handbook of European fishes.* Berlin: Publications Kottelat, Cornol and Freyof, p. 646.
Ladich, F. & Fay, R., 2013. Auditory evoked potential audiometry in fish. *Reviews in Fish Biology and Fisheries,* Volume 23, pp. 317-364.

Laist, D. et al., 2001. Collisions between ships and whales. *Marine Mammal Science,* 1(17), pp. 30-75.
Lincolnshire Biodiversity Partnership, 2011. *Lincolnshire Biodiversity Action Plan 2011-2020 (3rd Edition).* [Online]
Available at: https://www.nelincs.gov.uk/wp-content/uploads/2016/02/201110-LincolnshireBAP-3rd-edition.pdf
[Accessed 21 January 2019].
Maitland, P. S., 2003. *The status of smelt Osmerus eperlanus in England,* s.l.: English Nature.
Marine Management Organisation, 2015. *The Wash and North Norfolk Coast Maintenance Dredging Baseline Document, submitted as part of an MMO license application,* s.l.: s.n.
Marshall, S. a. E. M., 1998. Environmental influences on the fish assemblage of the Humber Estuary, UK. *Estuarine and Coastal Shelf Science,* Issue 46, pp. 175-184.
Mason, T. & Collett, A., 2011. *MEP Impacts of Underwater Piling Noise on Migratory Fish,* s.l.: Subacoustech Environmental Ltd..
National Marine Fisheries Service, 2018. *2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0),* s.l.: National Oceanic and Atmospheric Administration.
Natural England, 1972. *Citation for The Wash SSSI.* [Online]
Available at:
https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1002591.pdf
[Accessed 21 January 2019].
Nedwell, J. & Barham, R., 2014. Noise assessment for the proposed Rhuannon Wind Farm. *Subacoustech,* Volume Environmental Report No. E411R010.
Nedwell, J., Edwards, B., Turnpenny, A. & J., G., 2004. *Fish and marine mammal audiograms: a summary of available information,* s.l.: s.n.
Newton, T., 2017. *Boston Barrier Project 2017 Water quality and sediment quality report,* s.l.: Environment Agency.
Popper, A. et al., 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles,* s.l.: Springer.
Popper, A. S. M. H. K., 2001. Acoustic detection and communication by decapod crustaceans. *Journal of Comparative Physiology A,* Volume 187, pp. 83-89.
Popper, A., Smith, M. & Cott, P., 2005. Effects of exposure to seismic airgun use on hearing of three fish species. *Journal of the Acoustical Society of America,* Volume 117, pp. 3958 - 3971.
Sand, O. et al., 2000. Avoidance responses to infrasound in downstream migrating European silver eels, Anguilla anguilla. *Environmental Biology of Fishes,* Volume 57, pp. 327-336.
Sartori, I., 2018. *Boston Barrier - Baseline Acousic Report,* Cambridge: Environment Agency.

Scott, W. & Crossman, E., 1998. Freshwater fishes of Canada. In: Ontario, Canada: Galt House Publications, p. 966.
Smith, A., 1915. The fishes of Lincolnshire. *Transactions of the Lincolnshire Naturalists' Union,* pp. 3, 239-256.
South-East Lincolnshire, 2019. *South-East Lincolnshire Local Plan 2011 - 2036,* s.l.: s.n.
Stephenson, J. et al., 2010. Assessing barotrauma in neutrally and negatively buoyant juvenile salmonids exposed to simulated hydro-turbine passage using a mobile aquatic barotrauma laboratory. *Fisheries Research,* 106(3), pp. 271-278.
Tillin, H. & Tyler-Walters, H., 2015. *Revised list of definitions of pressures and benchmarks for sensitivity assessment. Internal report to MarLIN Steering Commuttee and SNCB representatives.,* Plymouth: Marine Biological Association.
Waugh, A., 2017. *Boston Barrier Witham Estuary Fish Report,* s.l.: Environment Agency.
Whomersley, P. et al., 2010. Response of intertidal macrofauna to multiple disturbance types and intensities – an experimental approach. *Marine Environmental Research,* 69(5), pp. 297-308.
Wild Trout Trust, 2018. *Wild Trout Trust.* [Online]
Available at: https://www.wildtrout.org/content/sea-trout
[Accessed 1 November 2018].
Wilson, B., Batty, R., Daunt, F. & Carter, C., 2007. *Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive.,* Oban, Scotland, PA37 1QA: Scottish Association for Marine Science.
Woodward, I. et al., 2015. *The Wash Bird Decline Investigation 2014,* s.l.: The British Trust for Ornithology.
Wright, M., Goodman, P. & Cameron, T., 2010. Exploring behavioural responses of shorebirds to impulsive noise. *Journal (Wildfowl). Wildfowl and Wetlands Trust,* Volume 60, pp. 150-167.