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Vattenfall Wind Power Ltd

Thanet Extension Offshore Wind Farm

Annex 10-1: Navigation Risk Assessment

June, 2018, Revision A

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THANET EXTENSION OFFSHORE WIND FARM: NAVIGATION RISK ASSESSMENT

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MARINE AND RISK CONSULTANTS LTD

VATTENFALL WIND POWER LIMITED

THANET EXTENSION OFFSHORE WIND FARM: NAVIGATION RISK ASSESSMENT

Prepared for: Vattenfall Wind Power Limited

Author(s): Andrew Rawson

Checked By: Ed Rogers and Paul Fuller

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Marine and Risk Consultants Ltd
Marico Marine
Bramshaw
Lyndhurst
Hampshire
SO43 7JB
United Kingdom

Tel. + 44 (0) 2380 811133

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EXECUTIVE SUMMARY

This Navigation Risk Assessment considers the possible impacts to shipping and navigation associated with the proposed extension to the Thanet Offshore Wind Farm. The proposal is to increase the area of the wind farm and install up to an additional 34 wind turbine generators with a total additional generating capacity of 340 MW. Whilst the layout of these wind turbine generators within the development area is not known, this assessment considers the worst-case extent, such that turbines are positioned along the maximum extent of the development area. The export cable route would be to the south, making landfall in Pegwell Bay.

Based on consultation feedback and the results of the assessment, a revision to the Red Line Boundary was made to address concerns on the layout of the development. A reduction was made of the extent of the western boundary to increase the sea room available for both navigating vessels and pilotage transfers.

This assessment has been conducted to the guidance of the Maritime and Coastguard Agency's Marine Guidance Note 543 and has included the following steps:

- Review the layout, operations and construction methodology of the development;
- Review the existing environment in the Thames Estuary and management practices for navigation;
- Consult with regulators and local stakeholders to identify and better understand concerns as they relate to navigation;
- Conduct a vessel traffic survey and analyse the movements of vessels passed the existing wind farm by size, type and frequency;
- Analyse the historical incident record in the area;
- Assess the predicted future traffic profile during the lifecycle of the development;
- Review, analyse and model the predicted impacts of the development;
- Conduct a navigation risk assessment to measure the likelihood and consequence of risks posed by the development to navigating vessels;
- Identify risk control options which could be implemented to reduce the risks to "As Low as Reasonably Practicable"; and
- Make conclusions and recommendations on the impacts of the development on shipping and navigational safety.

Overview

The existing Thanet Wind Farm was commissioned in 2010 and lies to the south-east of the Thames Estuary, near to the approaches to the ports of London, Medway and Ramsgate. The wind farm is bounded by three major shipping routes; an inshore passage between North Foreland and the wind farm (with approximately 10 movements a day), a north/south route passing to the east of the development (with approximately 10 movements a day) and a route to the north into the Princes Channel (with approximately 25 movements a day). The area also supports a fishing fleet of more than 20 vessels based in Ramsgate, as well as larger offshore fishing vessels operating to the north-east of the development. Recreational traffic can be significant in the summer months but generally sails closer inshore and is well clear of the development. Furthermore, pilot boats and wind farm service vessels transit to and from Ramsgate and the North-East Spit pilot station and existing wind farm respectively.

The historical incident record held by the Marine Accident Investigation Branch shows few incidents within five nautical miles of the development. On average, there are six years between collisions and groundings, which were all of low consequence, and of which there are no recorded incidents related to the Thanet Wind Farm.

Navigation Risk Assessment

A Navigation Risk Assessment was undertaken in line with the Formal Safety Assessment and in compliance with MGN 543 for the construction/decommissioning phase and the operational phase, for which 38 and 29 distinct hazards were identified respectively. These hazards were identified and scored based on the data analysis, historical incident record, modelling and stakeholder feedback undertaken through this project. Each of the hazards were scored in three stages, the baseline situation with the Thanet Wind Farm, an inherent stage with the extension but without additional mitigation measures and finally at a residual stage with additional mitigation measures in place. This approach mapped the increase in risk as a result of the project against the effectiveness of possible additional mitigation measures. Of the hazards identified, all fall into or below the category of As Low as Reasonably Practicable, however several would increase as a result of the extension even with additional risk controls in place. The most significant hazards relate to the risks of collision involving vessels to the west of the development and contact risks between navigating or construction/maintenance vessels and the WTGs.

A suite of embedded and additional risk controls were identified which could be implemented to reduce the risks further. Several of these controls, whilst undoubtedly effective, would introduce operational challenges to the project, vessels or local port authorities.

Three key impacts were examined in detail based on concerns which were consistently raised by stakeholders:

- Reduction in sea room to the west of the extension;
- Impacts to pilotage operations at North East Spit; and
- Impacts associated with the cable and its laying.

Reduction in Sea Room to the west of Extension

The proposed extension would necessarily alter the routes and navigable sea room available to commercial shipping. Whilst the extension fully encompasses the development, only the extension to the west and the south-west was raised as a significant concern by stakeholders. The inshore aspect of the wind farm is bounded to the west by shallows around Margate and North Foreland. The proposed extension would reduce the navigable sea room to the west by approximately a quarter, from four to three nautical miles. This would have impacts both to collision risk but also pilotage operations, which is discussed in the section below.

A reduction in sea room would constrict the flow of traffic and bring vessels closer together, increasing collision risk. Whilst there are on average 10 vessel movements through this area per day, there are a number of small crossing vessels to the pilot station and Thanet Wind Farm as well as general fishing and recreational users in the area, albeit most are further inshore. Furthermore, a practice exists of large commercial vessels passing to the north of the wind farm, dipping down to North East Spit to board or disembark a pilot which creates the possibility for additional vessel encounters.

To assess this collision risk, and how the collision likelihood might increase from one incident every six years, collision risk modelling was conducted. One month of Automatic Information System data from December 2016 was modelled to represent the flow of traffic around the extension, and the change in encounters between vessels compared with and without the proposed extension. The modelling found an increase of approximately 54% in encounters without any additional risk controls. This suggests an increase in the collision rate from once in six years to once in four years. Several risk controls were investigated to reduce this increase, including improved communication, and altering the flow of traffic and pilotage arrangements to reduce vessel encounters, and whilst they were found to be effective there would still be a small residual increase in collision risk in the area which would remain within ALARP. To reduce this risk even further, a reduction was made in the Red Line Boundary to the west of the Extension to increase the navigable sea room and reduce the constriction of traffic flow.

Impacts to Pilotage at North East Spit Pilot Boarding and Landing Area

A second key concern related to the reduction in sea room was the feasibility of conducting pilotage transfers at North East Spit pilot station. Approximately 16 transfers are undertaken per day from Ramsgate by Estuary Services Ltd, across 10 pilot boat trips, with more than one pilot being regularly carried per trip. A second pilot station exists to the north of Thanet Wind Farm, at the Tongue, that is less frequently used.

It was suggested by stakeholders that the reduction in sea room with the full RLB would make pilotage untenable in certain conditions; with an increased risk of grounding to the west; contacting with turbines to the east; and encountering other vessels in the reduced fairway width. Whilst it is noted that pilotage transfers are successfully conducted in more constrained waters elsewhere, it was necessary to test the feasibility of pilotage transfers under the local conditions of the Thames Estuary.

A pilotage simulation study was conducted that included Port of London pilots and Estuary Services Ltd pilot boat coxswains. Scenarios were developed with the local practitioners to test what they perceived were the critical vessel types/sizes, MetOcean conditions and background traffic situations. A series of simulation runs were then undertaken with the extension in place and each was assessed as successful, marginal or a failure. Of all the runs conducted, all were successful except for a single marginal run, which was not directly attributed to the proposed project. From the simulation, it was agreed that pilotage transfers would be feasible, however there would be a reduced margin for error to correct a potential incident. Furthermore, additional steps to improve the efficiency and safety of pilotage transfers were discussed.

A key step to mitigate both the impacts to pilotage but also reduce the collision risk would be to alter the pilotage arrangements in the southern Thames Estuary, by making greater use of Tongue and relocation of the North-East Spit pilot boarding and landing area into more open water. This would however have significant operational implications and may increase the susceptibility of the station to weather downtime and has therefore not been recommended. The project instead committed to a reduction in the Red Line Boundary in the western section to increase the available sea room.

Impacts associated with cable and cable laying

Local stakeholders in Ramsgate were particularly concerned with the laying of the export cable, especially following a challenging installation of another cable in 2017. In particular, they were concerned about the restrictions posed on navigation and fishing. The stakeholder groups commended the working relationship and engagement Vattenfall had with them, and appropriate mitigation strategies, such as use of rolling safety zones would successfully mitigate this impact.

To mitigate this impact, the project committed to a cable exclusion area which would result in the export cable routed away from the approach channel into Ramsgate to reduce the interference with the port's operations.

Other Impacts

Other impacts are considered in this assessment, such as communications, radar, and search and rescue. No other significant issues were identified by stakeholders or in this assessment which could not be appropriately mitigated.

Recommendations

In order to reduce the risks to "As Low as Reasonably Practicable", it is recommended that a suite of risk controls is implemented by the project, these include:

1. The developer to apply to the Secretary of State for 500m Safety Zones during the construction of the wind farm and 50m during operation.
2. Guard vessels should be in place to manage vessel traffic during construction of the site and installation of the cable.
3. Coordination during cable laying with the Port of Ramsgate and local user groups to minimise disruption.
4. A means of coordination and information provision between the developer and the Port of London VTS should be in place for construction and maintenance activities.
5. Communication between project, sub-contractors and fishermen/leisure groups should be maintained throughout the construction period and continued thereafter.
6. Line of orientation and symmetry should be maintained in the wind farm layout to aid Search and Rescue.
7. Existing buoyage should be relocated or removed as appropriate.

Summary

This assessment has considered a variety of impacts and hazards associated with Thanet Extension, drawing upon evidence presented from analysis and stakeholders. The assessment concludes that the extension would heighten the risks to navigation in the southern Thames Estuary. These risks, whilst heightened, are considered to fall within "As Low as Reasonably Practicable". Additional risk controls could be implemented to manage them further, several of which would introduce operational challenges to the project, vessels or local port authorities and may not be cost-effective and have therefore not been recommended within this NRA. In particular, pilotage operations at NE Spit will become more operationally challenging, albeit still feasible; additional management of activities in this area were discussed but have not been considered necessary with the reduced Red Line Boundary.

Several stakeholders raised concerns about the restriction of sea room to the west of the extension during the process of this assessment. In order to mitigate these concerns and reduce the level of impact, the project took the decision to reduce the Red Line Boundary of the extension in this area.

In summary, this study has outlined the methodology, evidence base and results that demonstrate that the impacts to navigational safety of the proposed extension, would be heightened but can be managed to ALARP using proposed risk control measures.

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FIGURES

TABLES

ANNEXES

ABBREVIATIONS

Abbreviation	Detail
AIS	Automatic Identification System
ALARP	As Low as Reasonably Practicable
CAA	Civil Aviation Authority
CBRA	Cable Burial Risk Assessment
CCTV	Closed Circuit Television
CGOC	Coast Guard Operating Centres
CHA	Competent Harbour Authority
CNIS	Channel Navigation Information Service
CTV	Crew Transfer Vessel
DECC	Department for Energy and Climate Change
DGNSS	Differential Global Navigation Satellite Systems
DSC	Digital Selective Calling
ERCOP	Emergency Response Cooperation Plan
ESL	Estuary Services Ltd
GLA	General Lighthouse Authorities
GMDSS	Global Maritime Distress and Safety Systems
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HAT	Highest Astronomical Tide
HMCG	Her Majesty's Coastguard
HSE	Health and Safety Executive
HW	High Water
ICW	In Collision With
IALA	International Association of Lighthouse Authorities
ICPC	International Cable Protection Committee
IMO	International Maritime Organization
JUV	Jack Up Vessels
KISCA	Kingfisher Information Services Cable Awareness
kHz	Kilohertz
kt	Knot (unit of speed equal to nautical mile per hour, approximately 1.15 mph)
LOA	Length Over All

Abbreviation	Detail
LRIT	Long Range Identification and Tracking
LW	Low Water
m	Metre
MAIB	Marine Accident Investigation Branch
Marico Marine	Marine and Risk Consultants Ltd
MCA	Maritime and Coast Guard Agency
MF	Medium Frequency
MGN	Marine Guidance Note
MHWS	Mean High Water Springs
ML	Most Likely
MMO	Marine Management Organization
MRCC	Maritime Rescue Co-ordination Centre
MSI	Marine Safety Information
MW	MegaWatt
NAS	Navigational Assistance Authority
nm	Nautical Mile
NOREL	Navigation and Offshore Renewable Energy Liaison
NPS	National Policy Statement
NRA	Navigation Risk Assessment
O&M	Operations and Maintenance
OECC	Offshore Export Cable Corridor
OREI	Offshore Renewable Energy Installations
OSS	Offshore Substation
OWF	Offshore Wind Farm
PEC	Pilotage Exemption Certificate
PEIR	Preliminary Environmental Impact Report
PEXA	Practice and Exercise Areas
PLA	Port of London Authority
PPE	Personal Protective Equipment
PWC	Personal Water Craft
RIB	Ridged Inflatable Boat
RLB	Red Line Boundary

Abbreviation	Detail
RNLI	Royal Nautical Lifeboat Institute
RTYC	Royal Temple Yacht Club
RYA	Royal Yachting Association
SAR	Search and Rescue
SART	Search and Rescue Transponders
SHA	Statutory Harbour Authority
SMS	Safety Management System
SOLAS	Safety of Life At Sea
SOV	Special operations Vessel
SPS	Significant Peripheral Structures
SSAS	Ship Security Alerting System
STCW	Standards of Training Certification and Watchkeeping
TH	Trinity House
TOWF	Thanet Offshore Wind Farm
TSS	Traffic Separation Scheme
ULCC	Ultra Large Crude Carrier
UKC	Under Keel Clearance
VHF	Very High Frequency (radio communication)
VMS	Vessel Monitoring System
VTS	Vessel Traffic Service
VTSO	Vessel Traffic Services Operator
VWPL	Vattenfall Wind Power Limited
WC	Worst Credible
WFSVs	Wind Farm Service Vessels
WTG	Wind Turbine Generators

1 INTRODUCTION

Offshore Renewable Energy Installations (OREIs) can have impacts upon the safety and navigation of vessels transiting passed or through them. As such, it is recognised that these impacts should be thoroughly investigated prior to their development so that any adverse impacts can be mitigated to acceptable levels. Vattenfall Wind Power Limited (VWPL) have commissioned Marine and Risk Consultants Ltd. (Marico Marine) to undertake a Navigation Risk Assessment (NRA) for the proposed extension to the Thanet Offshore Wind Farm with up to an additional 34 Wind Turbine Generators (WTGs).

This NRA has been conducted to the standard as laid out by the Maritime and Coastguard Agency (MCA) in Marine Guidance Note 543.

1.1 REDUCTION OF THE RED LINE BOUNDARY

Following a review of the consultation responses received during this assessment, a reduction was made in the maximum extent of the western boundary of the footprint of the wind farm. This reduction increases the available sea room for transiting vessels and pilotage transfers. The responses of consultees in this report refers to the maximum red line boundary and therefore represents the worst-case layout. A comparison of the previous and submitted red line boundaries is presented below in **Figure 1**. This reduction of the western corner is from 2 nm to 1 nm from the western limit of the existing Thanet Wind Farm.

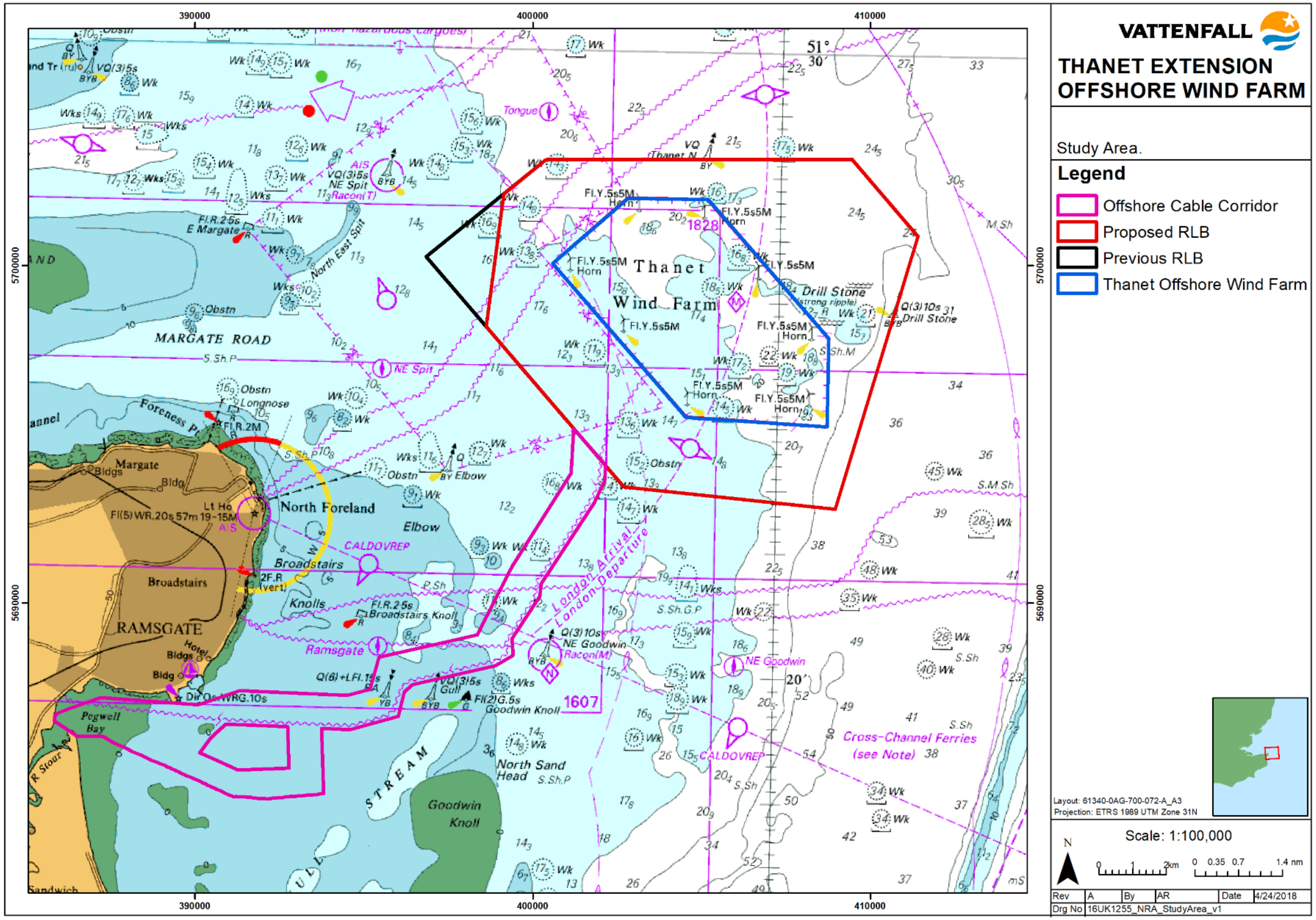

Figure 1: Project Site Showing Reduced Red Line Boundary (RLB).

1.2 SCOPE AND METHODOLOGY

The scope and objectives of this assessment are as follows:

1. Describe the Thanet Extension Offshore Wind Farm; including its layout, marking, construction methodology and decommissioning plan;
2. Provide a description of the existing environment and activities in the outer Thames Estuary; including but not limited to:
    a. Local ports and harbours;
    b. MetOcean conditions;
    c. Existing vessel management plans;
    d. Other users of the area such as aggregates, oil and gas, anchorages, military and renewable energy installations;
    e. Existing vessel traffic patterns, including frequency and types; and
    f. Existing risk profile for navigational incidents.
3. Determine likely future traffic profile during the period when the Wind Farm would be operational;
4. Identify and assess impacts of the development to shipping and navigation, including:
    a. Traffic routeing;
    b. Pilotage operations;
    c. Collision risk;
    d. Cable risk;
    e. Communications, Radar and Positioning Systems;
    f. Search and Rescue; and
    g. Cumulative and In-Combination Effects.
5. Undertake an NRA that identifies the hazards during the construction, operation and decommissioning phases of the development. These hazards are then assessed, and risk controls identified to reduce the risk to As Low as Reasonably Practicable (ALARP); and
6. Make recommendations as to the safety of the development and what measures should be implemented to improve it.

1.3 GUIDANCE

Marine Guidance Note (MGN) 543 (M+F) replaces MGN 371 and advises the correct methodology to evaluate navigational safety around OREIs through traffic surveys and this report adheres to this standard accordingly; this NRA is considered compliant with MGN 543 (M+F).

Table 1: Guidance Document Table.

Policy / legislation	Key provisions
MGN 543 Guidance on UK Navigational Practice, Safety and Emergency Response Issues	This MGN highlights issues to be considered when assessing the impact on navigational safety and emergency response, caused by OREI developments. Including traffic surveys, consultation, structure layout, collision avoidance, impacts on communications/ radar/ positioning systems and hydrography.
Department of Energy and Climate Change (DECC) Methodology for Assessing Marine Navigational Safety Risks of Offshore Wind Farms	The DECC document provides a template for preparing NRA's for offshore wind farms. This template has been used throughout to define the methodology of assessment and is read in conjunction with MGN 543.
MGN 372 Guidance to Mariners Operating in the Vicinity of UK OREIs	Issues to be considered when planning and undertaking voyages near OREI off the UK coast.
International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA AISM) 0-139 the Marking of Man-Made Offshore Structures.	Guidance to national authorities on the marking of offshore structures including wind farms.
International Maritime Organisation (IMO) Formal Safety Assessment.	Process for undertaking marine navigation risk assessments.
Royal Yachting Association (RYA) Position on Offshore Energy Developments	Outlines recreational boating concerns for offshore renewable energy developments.
Paragraph 2.6.153 of NPS EN-3	Stakeholders in the navigation sector should be engaged in the early stages of the development phase and this should continue throughout construction, operation and decommissioning.
Paragraph 2.6.154 of NPS EN-3	Consultation should be undertaken with the Marine Management Organisation (MMO), MCA, relevant General Lighthouse Authority (GLA), relevant industry bodies and representatives of recreational users.
Paragraph 2.6.155 of NPS EN-3	Information on internationally recognised sea lanes should be considered prior to undertaking assessments.
Paragraph 2.6.158 of NPS EN-3	Where there is a possibility that safety zones will be sought around offshore infrastructure, potential effects should be included in the assessment on navigation and shipping.
Paragraph 2.6.160 of NPS EN-3	The potential effect on recreational craft, such as yachts, should be considered in any assessment.

1.3.1 MGN 543 Compliance Table

The following table (**Table 2**) acts an aid for developers when completing and submitting the NRA to ensure all guidance has been considered and addressed. The full compliance table can be found in **Annex A**.

Table 2: MGN 543 Compliance Table.

Annex 1		Report Section
1	An up to date traffic survey of the area.	**Section 5**
2	OREI Structures.	**Section 2**
3	Assessment of Access to and Navigation within, or close to, an OREI.	**Sections 2, 5, 7** and **8**
Annex 2		**Report Section**
1	Effects of Tides and Tidal Streams.	**Section 3.3**
2	Weather.	**Section 3.3**
3	Visual Navigation and Collision Avoidance.	**Section 7.8**
4	Communications, Radar and Positioning Systems.	**Section 7.9**
5	Marine Navigational Marking	**Sections 2.3** and **8.5**
Annex 3		**Report Section**
1	OREI Risk Register and Risk Mitigation Measures for Development	**Section 8** and **Annex D**

1.4 CONSULTATION

A summary of all consultation meetings conducted to support this NRA is given in **Section 4**. This includes:

- Maritime and Coastguard Agency;
- Port of London Authority;
- Trinity House;
- Chamber of Shipping;
- Port of Ramsgate;
- Estuary Services Ltd;
- Royal Temple Yacht Club; and
- Royal Yachting Association.

Comments were also received from other organisations and are considered in **Section 4.**

1.5 STUDY AREA

The area for assessment is the outer Thames Estuary, analysis has been undertaken for vessel traffic within 5nm of the development site and a further 2nm from the cable route, given the more local impacts on navigation. Where necessary and appropriate, reference is made to navigation routes in the wider context.

2 THANET EXTENSION OFFSHORE WIND FARM

2.1 DESCRIPTION OF THANET WIND FARM

The Thanet Wind Farm (TOW) became operational in 2010 and consists of 100 Vestas V90 3MW WTGs. TOW has a maximum installed capacity of 300MW and at the time of construction it was the largest offshore wind farm in the world. Two export cables bring the electricity to shore at Pegwell Bay, Ramsgate.

2.2 THE EXTENSION

The proposed extension to the TOW would have a generating capacity of up to 340MW. Key components of the Thanet Extension Offshore Wind Farm would include:

- Offshore WTGs;
- Offshore Substation (if required);
- Meteorological mast or floating lidar (if required)
- Foundations
- Subsea Inter-array cables linking the individual WTGs;
- Subsea export cables from the wind farm to shore; and
- Scour protection around the foundations and on inter-array and export cables (as required).

Table 3: Basic site information.

Parameter	Maximum Design Envelope
Total site area array (km^2)	68.8
Total Offshore Export Cable Corridor (OECC) area (km^2)	30
Closest distance from array to shore (km)	8
Site capacity (MW)	340
Maximum number of WTGs	34
Maximum number of Offshore Substations (OSS)	1

2.2.1 The Layout

The final layout of the project will be determined post-consent and therefore this NRA considers the impacts of the full red line boundary development area. For information purposes the red line boundary with an indicative layout is presented in **Figure 2.**

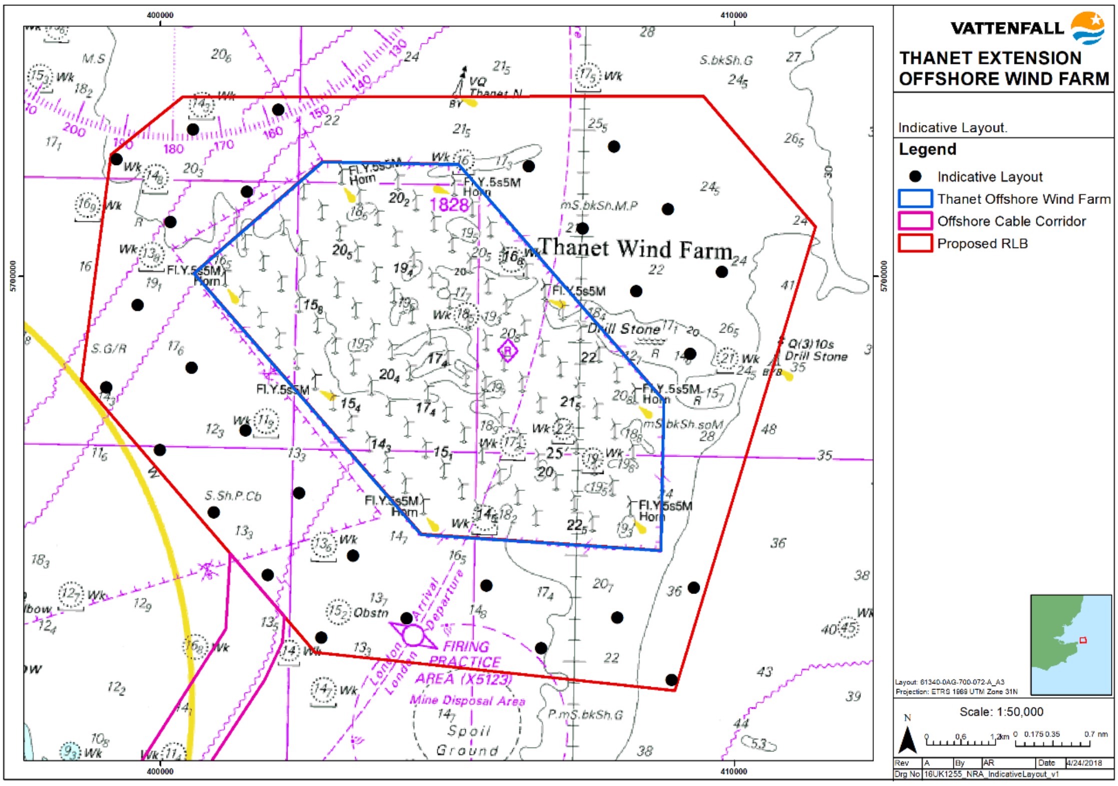

Figure 2: Indicative project layout.

2.2.2 Wind Turbine Generators

The project will involve up to 34 WTGs installed around the existing Thanet Wind Farm. Several turbine designs are being investigated from between 8MW and more than 12MW. The designs are all however traditional offshore WTGs with three blades and a horizontal rotor axis. The blades are connected to a central hub, forming a rotor which turns a shaft connected to a generator or gearbox. The generator and gearbox are located within a containing structure known as a nacelle situated adjacent to the rotor hub. The nacelle is supported by a tower structure affixed to the transition piece or foundation. The nacelle can rotate or 'yaw' on the vertical axis in order to face the oncoming wind direction.

Each WTG configuration will have its own characteristics; however all designs will have a minimum clearance between the Highest Astronomical Tide (HAT) sea level and the lowest point of the rotor at 22m. The worst-case design characteristics for turbine size are shown below in **Figure 3**.

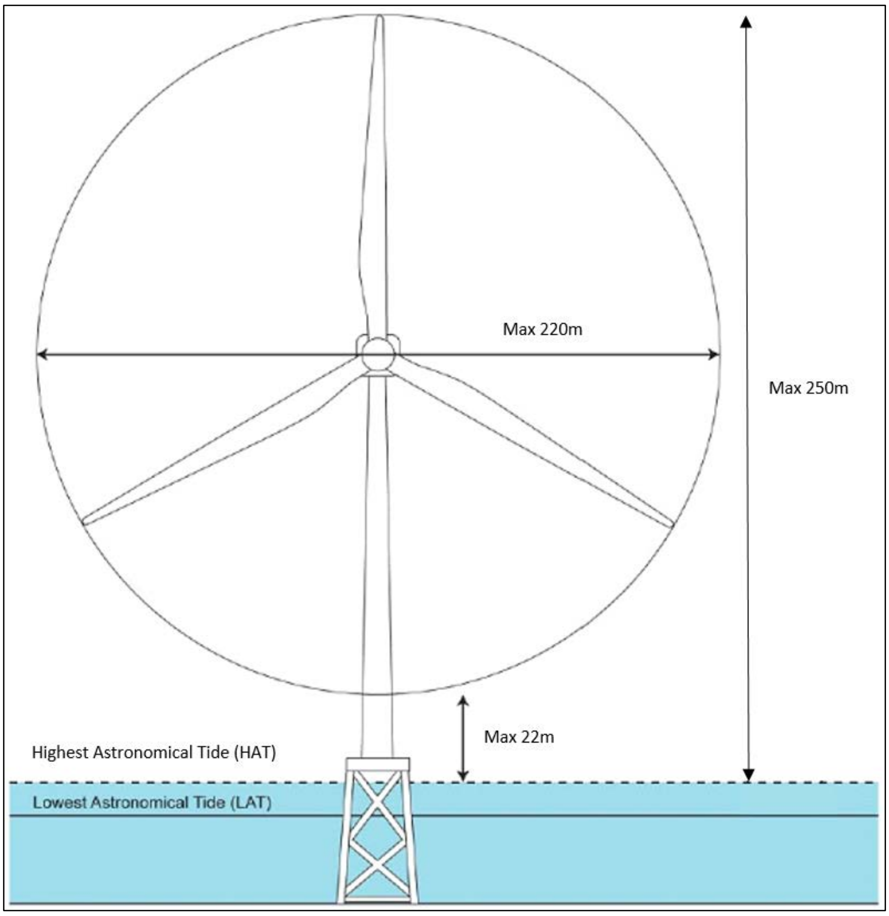

Figure 3: Maximum and minimum design parameters assessed.

Access to the WTGs will be either through boat landings or by hoisting to a heli-hoist platform on the nacelle.

2.2.3 Inter-array cables

Cables carrying the electrical current produced by the WTGs will link the WTGs to one another and to an Offshore Substation (OSS) (if required), from where the electricity generated can be transferred to shore. A small number of WTGs will typically be grouped together on the same cable 'string', with multiple 'strings' connecting back to the OSS. The inter-array cables will consist of multiple conductor cores, usually made from copper or aluminium. These will be surrounded by layers of insulating material as well as material to armour the cable for protection from external damage and material to keep the cable watertight.

2.2.4 Cable Route

In some cases, normal subsea installation methods may not be suitable and it could be necessary to use alternative methods to provide an adequate degree of protection for the cable. Details of some of the techniques employed are given below:

- Rock placement involves the laying of rocks on top of the cable to provide protection which is effective on crossings and other areas requiring protection;
- Concrete mattresses, which are prefabricated flexible concrete coverings that are laid on top of the cable, are an alternative to rock placement. The placement of mattresses is slow and as such is only used for short spans. Grout or sand bags may be used as an alternative to concrete mattressing; this method is generally applied on smaller scale applications than concrete mattressing;
- Frond mattresses can be used to provide protection by stimulating the settlement of sediment over the cable. This method develops a sand bank over time protecting the cable but is only suitable in certain water conditions. This method may be used in close proximity to offshore structures though experience has shown that storms can strip deposited materials from the frond; and
- Uraduct or similar, is effectively a protective shell which come in two halves and is fixed around the cable to provide mechanical protection. Uraduct is generally used for short spans at crossings or near offshore structures where there is a high risk from falling objects. Uraduct does not provide protection from damage due to fishing trawls or anchor drags.

2.3 NAVIGATION AIDS AND MARKING

The wind farm layout has yet to be determined and therefore reference is made to industry best practice and consultation feedback, but no direct comment is made on the indicative layout shown in **Figure 2**. The layout and lighting and marking arrangements should be submitted as part of the "Layout Plan" to the MCA and Trinity House for agreement prior to construction, and in line with the consent requirements should the project be granted a Development Consent Order.

A key aspect to consider would be the integration between the existing marking and lighting of TOW and that of the extension. Firstly, the numbering of turbines should be logical following a consistent grid pattern and integrates between the two developments. Secondly, the lighting of the internal wind farm may be extinguished (for the purposes of Civil Aviation Authority (CAA) lighting) and the periphery of the extension marked as per convention and industry best practice.

Notwithstanding these observations on alignment with the existing wind farm, the wind farm should be designed and constructed to satisfy the requirements of the CAA and Trinity House in respect of marking, lighting and fog-horn specifications. CAA recommendations on "Lighting of Wind Turbine

Generators in United Kingdom Territorial Waters", September 2004 will be adhered to. Trinity House recommendations will be followed as described in "Renewable Energy Installation Farms and Fields- Provision and Maintenance of Local Aids to Navigation by Trinity House" and "International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) Recommendation 0-117 on the Marking of Offshore Wind Farms, Edition 2, December 2004".

The colour scheme for nacelles, blades and towers is generally RAL 7035 (light grey). Foundation steelwork is generally in RAL 1023 (traffic light yellow) up to HAT +15m or to Aids to Navigations, whichever is higher.

During operations, lighting will be as per the above guidance and take into account any new directives from the current lighting trials being undertaken by the Navigation and Offshore Renewable Energy Liaison (NOREL) group. As a minimum, all WTGs will comply with paragraph 5 of IALA Recommendation O-117 and the wind farm Paragraph 6. For aviation lighting compliance, as a minimum, will be with "Section 1, Part 28, Paragraph 220 of CAP 393 Air Navigation: The Order and the Regulations".

2.3.1 Site Marking

Site marking for maritime safety is described in MGN 372 and IALA 0-117 guidance documents. They stipulate that the turbines should be:

- Painted yellow all-round from the level of HAT. (highest astronomical tide) to 15 m, or the height of any Aid to Navigation if fitted, whichever is greater;
- Marked with a unique alphanumeric identifier;
- Fitted with red aviation navigation lights, on turbine nacelle;
- Fitted with Significant Peripheral Structures (SPS) lighting, as described below; and
- Fitted with RACON transponders, fog signals and possible AIS on selected WTGs as appropriate.

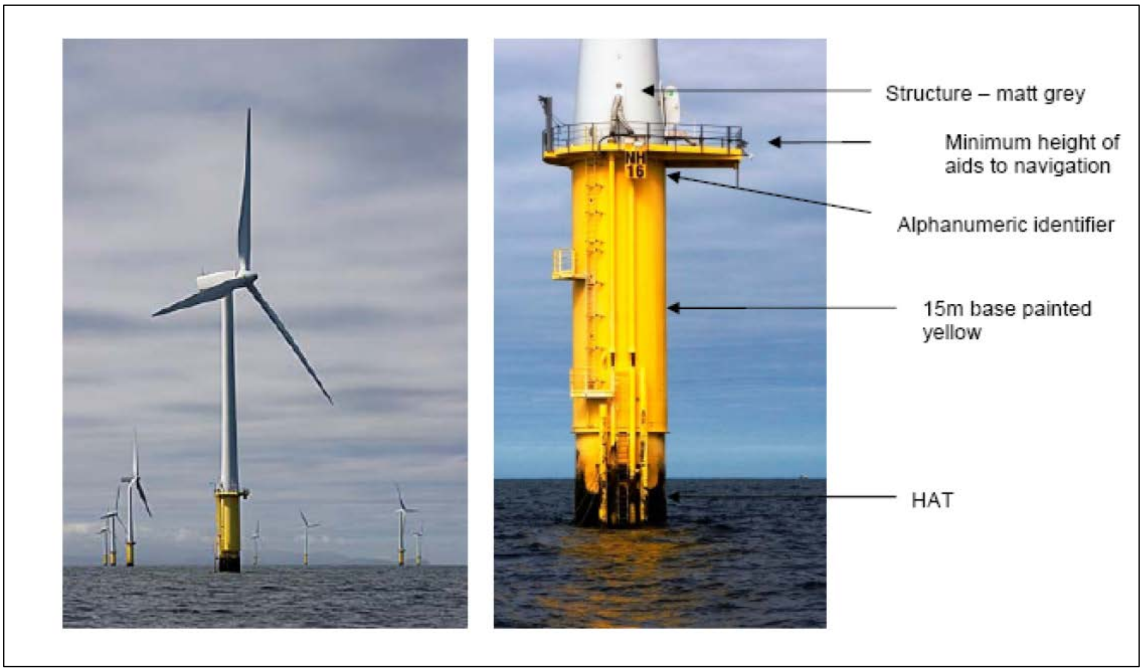

Figure 4: Example of marking a turbine structure[1]

An SPS is the "corner" or other significant point on the periphery of a wind farm. Each individual SPS should be fitted with lights visible from all directions in the horizontal plane. The lights should be synchronised and display an IALA "special mark" characteristic i.e. flashing yellow, with a range of not less than five nautical miles (nm). As the distance between the SPS's will be greater than 3nm, selected WTGs in the middle of all sides of the wind farm other than SPS's should also be marked with flashing yellow lights, which are visible to the mariner from all directions in the horizontal plane. The lateral distance between such lit structures or the nearest SPS should not exceed 2nm.

2.3.2 Aviation Lighting

There are three types of lighting that should be fitted to some or all of the WTGs, and a fourth type that may be requested. The first three types are: medium intensity red lights, low intensity green lights, and low intensity red lights. The fourth type that may be requested is low intensity infrared (i.e., invisible to the eye) lighting.

The legal requirement for offshore wind turbine lighting is stipulated in "Article 220 of the Air Navigation Order 2009 (reproduced in CAP393 Air Navigation: The Order and the Regulations)", with other documents providing further policy information and guidance.

[1] Maritime and Coastguard Agency Marine Guidance Note 372 (M+F)

It is noted that the Air Navigation Order only requires lighting to be fitted to WTGs on the periphery of a group of WTGs (Article 220, Paragraph (2) – see Appendix 1); from this and Paragraph (12)(c). It is implicit that situating a light on the periphery every 3-4km should be adequate as a maximum separation.

Medium intensity red lights as specified in "Article 220 of the Air Navigation Order 2009" have a brightness of 2,000 candela (cd) – see CAA Policy Statement: "The Lighting of Wind Turbine Generators in United Kingdom Territorial Waters", dated 02 August 2010. These should be lit during the hours of darkness and in poor visibility (on a good visibility night, the brightness may be reduced).

Recently, more code red flashing "W" has been used to deconflict lighting requirements between aviation and maritime purposes.

2.3.3 Individual Structure Markings on the Perimeter and Within the Site

When in operation, all the WTGs will be marked with clearly visible unique identification characters, which will be visible from all sides of the wind turbine generators and comply with applicable requirements in MCA MGN 372 (M+F) "*OREI Guidance to Mariners Operating in the Vicinity of UK OREIs*".

The MCA has agreed that the blade and Nacelle markings should be in accordance with their consultation document: "*Offshore Renewable Energy Installations Search and Rescue and Emergency Response Guidance, Advice and Requirements*" (Draft) – 26.06.2015, the relevant extract of which is shown below in italics:

2.3.3.1 Wind Turbine Blade Hover-Reference Marking

"WTG blades need to be marked to provide a SAR helicopter pilot with a hover reference point when hovering over a nacelle during a rescue. This is necessary because SAR helicopters are large aircraft and the pilot (sitting on the right of the aircraft) may not be able to use objects or markings on the nacelle for reference because these are too far behind the pilot's location to be easily seen. The WTG blades are in the pilot's normal vision-arc and so are the best place for such markings.

Three marks are required on each blade - one each at the 10, 20 and 30m interval (starting from the hub end of the blade) and placed near the trailing edge of the blades so that, when they are feathered, and the blades are parked in the 'bunny ears' ('Y' position) or offset 'Y' (one blade angled forward into the wind), the marks lie upwards in view of the helicopter pilot. The blade tip should also be marked *in red (the amount of tip paint is dependent on the size of blade, but approximately 2% of the blade length should suffice).*

The marks should be painted in a contrasting shade to the turbines overall colour - red is considered to be most suitable. The diameter of the marks (which can either be dots or stripes) should be at least 600mm but may need to be larger according to the overall size and shape of the turbine and blades. The location of the dots/stripes to be confirmed with MCA Search and Rescue Operations branch to be as shown in **Figure 5**."

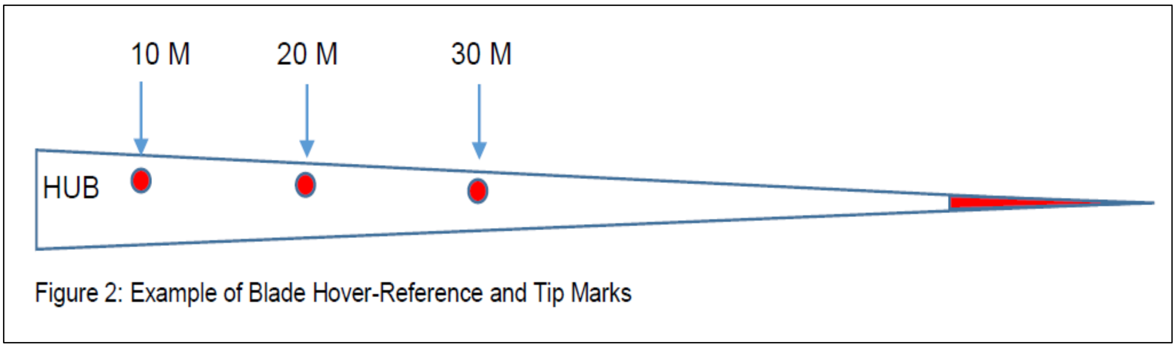

Figure 5: Example of Blade Hover Reference and Tip Marks.

2.3.3.2 Wind Turbine Tower and Nacelle-Roof ID Numbers

The requirement for the nacelle marking has been adopted by the MCA from the same document the relevant extract as described below in italics:

"Individual wind turbines are marked for safety of navigation and SAR situational awareness purposes with ID number plates, set at 120 degree intervals around the tower base usually somewhere above the entrance door area. These ID numbers must be clearly readable by an observer stationed 3m above sea level at a distance of at least 150m from the turbine. Each ID number plate shall be illuminated by a low intensity light visible from a vessel thus enabling the structure to be detected at a suitable distance to avoid a collision. It is recommended that lighting for this purpose be hooded or baffled so as to avoid unnecessary light pollution or confusion with navigation marks. Individual ID numbers are also to be painted on the nacelle roof so that SAR helicopters and/or other low flying aircraft (Search and Rescue, Counter Pollution, Fisheries patrol or Military) can locate and/or reference a particular turbine visually. These ID numbers should be recognisable from an aircraft flying 500 feet (152m) above the highest part of the structure, which for wind farms would be the blades at their vertical point. Advice from the CAA (October 2013), following discussion with the MCA, is that such numbers should be as large as practicable but not less than 1.5m in height and of proportionate width. This

implies that ID numbers should be more than 1.5m in height where there is space to achieve this. It is expected that developers will make ID numbers as large as can be sensibly fitted on a nacelle roof."

2.3.4 Foundation Identification

Agreement has been reached with MCA that the location of the three navigation lanterns proposed and the ID Boards positioned to give the capability to read from 360 degrees around the WTG, without shadowing the navigation lanterns, is acceptable

The foundation will be painted yellow up to the GBF/WTG interface at approximately 13.5m above HAT, with the ID Boards marked with the designation BLY B06 to BLY B10 (see **Figure 6**) – this can be done using a square or rectangular board as shown below and must be illuminated with low intensity lighting.

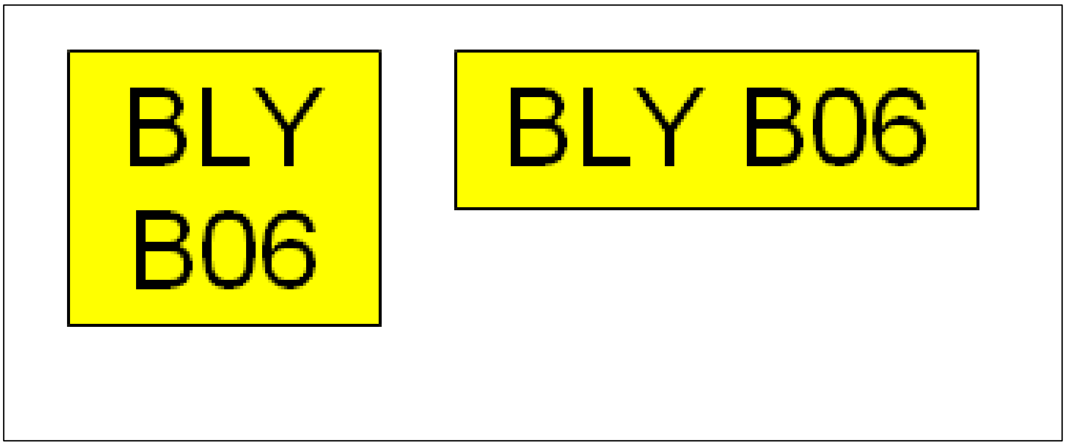

Figure 6: Foundation Identification Board Markings

2.4 CONSTRUCTION METHODOLOGY

2.4.1 Structures

Generally, WTGs are installed using the following process:

- WTG components are picked up from a port in the UK or elsewhere in Europe either by an installation vessel or transport barge. To date, installation vessels have typically been Jack-Up Vessels (JUVs) to ensure a stable platform for installation vessels when on site. Generally, blades, nacelles and towers for a number of WTGs are loaded separately onto the vessel;
- Typically, as much pre-assembly that can be carried out ahead of transit to site is completed to ease the installation process. The components will then transit to the wind farm array area and will be lifted onto the existing foundation or transition piece by the crane on the installation vessel. Each WTG will be assembled at site in this way

with technicians fastening components together as they are lifted into place. The exact methodology for the assembly is dependent on WTG type and installation contractor and will be defined in the pre-construction phase post-consent; and

- Alternatively, the WTG components may be loaded onto barges or dedicated transport vessels at port, and installed as above by an installation vessel that remains on site throughout the installation campaign.

A JUV would be assumed to have six legs each with footprint of up to 80m^2. The total duration of the installation for WTGs is expected to be a maximum of 6 months (including one-month downtime and assuming continuous working.

OSSs are generally installed in two phases, the first phase will be to install the foundation for the structure using an installation vessel as described in the foundations sections. Secondly, an installation vessel (same or different from the one installing the foundation) will be used to lift the topside from a transport barge/ vessel onto the pre-installed foundation structure. The foundation and topside may be transported by the installation vessel. Quadropod jackets are considered the most likely option, although a tripod would also be considered for the OSS foundation. For piling, a soft start procedure would be followed as with the WTG foundations. This would involve starting at a lower hammer energy (1500 kJ) compared to the maximum (2700 kJ) for one hour before ramping up to full power. The hammer blow rate would also be reduced by half (15 blows per minute compared to 30 blows per minute) during the soft start period.

2.4.2 Cables

The cables will be buried or protected wherever possible. The installation method and target burial depth will be defined post-consent in a Cable Burial Risk Assessment (CBRA) considering ground conditions as well as external aggressors to the cable such as trawling and vessel anchors. Possible installation methods include jetting, cutting and ploughing whereby the seabed is opened and the cable laid within the trench simultaneously using a tool towed behind the installation vessel. Alternatively, a number of these operations such as jetting or cutting may occur post-cable lay.

In some cases, where burial cannot be applied, or where the minimum burial depth cannot be achieved, it is necessary to use alternative methods such as rock placement, concrete mattresses, frond mattresses or Uraduct (or similar) for up to 25% of cable total length.

2.4.3 Vessel Movements

The total vessel numbers on-site at any one time are summarised in **Table 4** below. Note that many parts of the construction (e.g. foundation and WTG installation) are mutually exclusive and so the total vessels in this table is not reflective of the total number of vessels on-site at any one time.

Table 4: Maximum construction vessel quantities on-site at the same time (Volume 2, Chapter 1, Offshore PDS [6.2.1]).

Site capacity	Maximum vessel movements
Seabed preparation vessels	3
Foundation spreads per project	1
Number of vessels per foundation spread (includes tugs and feeders)	5
Transition piece installation vessels	2
Scour Installation Vessels	6
Number of vessels engaged in foundations	5
Wind turbine installation spreads	3
Max vessels per WTG installation spread	3
Total WTG installation vessels	6
Commissioning vessels	7
Accommodation vessels	1
Total IA cable vessels	4
Number of Export Cable spreads per Project	3
Number of vessels per Export Cable spread	2
Total export cable vessels	6
Landfall cable installation vessels	2
Substation/ collector IV	3
Other vessels	3
Total	48

2.5 OPERATION AND MAINTENANCE

The overall Offshore and Maintenance (O&M) strategy will be finalised once the technical specification is known, including WTG type and final project layout. O&M activities will take place from the existing hub in Ramsgate. Maintenance activities can be categorised into two levels: preventative and corrective maintenance. Preventative maintenance is according to scheduled services whereas corrective maintenance covers unexpected repairs, component replacements, retrofit campaigns and breakdowns.

The offshore O&M will be both preventative and corrective. The O&M strategy will include an onshore (harbour based) O&M base at the existing hub in Ramsgate. Due to the proximity of the wind farm to the shore, it is unlikely that a Special Operations Vessel (SOV) would perform the function of an offshore accommodation base.

The general O&M strategy may rely on Crew Transfer Vessels (CTVs), supply vessels, and helicopters for the O&M services that will be performed at the wind farm. The maximum vessel movements per year for the O&M activities can be found in **Table 5** below. A vessel movement is defined as a return trip from port to the site, and back to port.

Table 5: Maximum O&M vessel quantities per year (Volume 2, Chapter 1, Offshore PDS [6.2.1]).

Vessel activity	Maximum O&M quantities per year	Maximum O&M round trips per year, per vessel
CTV O&M vessels	2	150
Lift vessels	1	1
Cable maintenance vessel	1	1
Auxiliary vessels	1	3

2.6 DECOMMISSIONING

At the end of the operational lifetime of the offshore wind farm, it is anticipated that all structures above the seabed level will be completely removed. The decommissioning sequence will generally be the reverse of the construction sequence (reverse lay) and involve similar types and numbers of vessels and equipment. Closer to the time of decommissioning, it may be decided that removal would lead to greater environmental impacts than leaving components in situ, in which case certain components may be cut at or below the seabed (e.g. piles), or left buried (e.g. cables).

A decommissioning plan and programme would be required to be submitted prior to the construction of Thanet Extension. The decommissioning plan and programme would be updated during the lifespan of the wind farm to take account of changing best practice and new technology.

3 OVERVIEW OF THE BASELINE ENVIRONMENT

3.1 ADMIRALTY CHARTS

The project site is well charted and covered by the following navigational charts:

- 0002 – British Isles
- 0323 – Dover Strait Eastern Part
- 1183 – Thames Estuary
- 1406 - Dover and Calais to Orford Ness and Scheveningen
- 1607 – Thames Estuary Southern Part
- 1610 – Approaches to the Thames Estuary
- 1828 – Dover to North Foreland
- 2182A – North Sea Southern Sheet
- 2449 - Dover Strait to Westerschelde
- 4140 – North Sea

3.2 LOCAL PORTS AND HARBOURS

3.2.1 Port of London

The Port of London is the UK's second biggest port, with more than 10,000 port calls per year, handling 40 billion tonnes of cargo each year and employing more than 40,000 people. There are over 70 independently run terminals and wharves along the tidal Thames that serve a range of industries.

The Port of London Authority (PLA) operate both pilotage and Vessel Traffic Services (VTS) that covers much of the Thames Estuary (see **Section 3.4**).

3.2.2 Port of Ramsgate

The Port of Ramsgate is a local authority run harbour in the South East of England, serving mostly small craft. The port has an active fishing industry with more than 20 commercial vessels and more than 10,000 visitor nights for leisure users. Royal Temple Yacht Club in Ramsgate is an active yacht racing and cruising club.

The port also serves as the maintenance and operations base for the Thanet Wind Farm and London Array Wind farm.

3.2.3 Port of Medway

Peel Ports Medway, based at Sheerness, is the statutory harbour, pilotage and conservancy authority for the River Medway. The authority is also responsible for the Swale as far as Shell Ness. The Port of London is responsible for navigation in the Thames Estuary outside the Medway approach Area.

3.2.4 Margate Harbour

Margate is principally a seaside resort town. It has a small harbour which dries and which is used mainly recreational craft.

3.2.5 Broadstairs Harbour

Broadstairs is 1.25nm north of Ramsgate and has a small harbour which dries at half-tide. The harbour lies on the western side of a pier which extends 100m south from the shore and marked by a light.

3.3 METOCEAN CONDITIONS

3.3.1 Wind

The winds are predominantly from the south west, however there is a significant frequency of north easterlies, see **Figure 7**. The mean speed is approximately 10 knots but gales are fairly common.

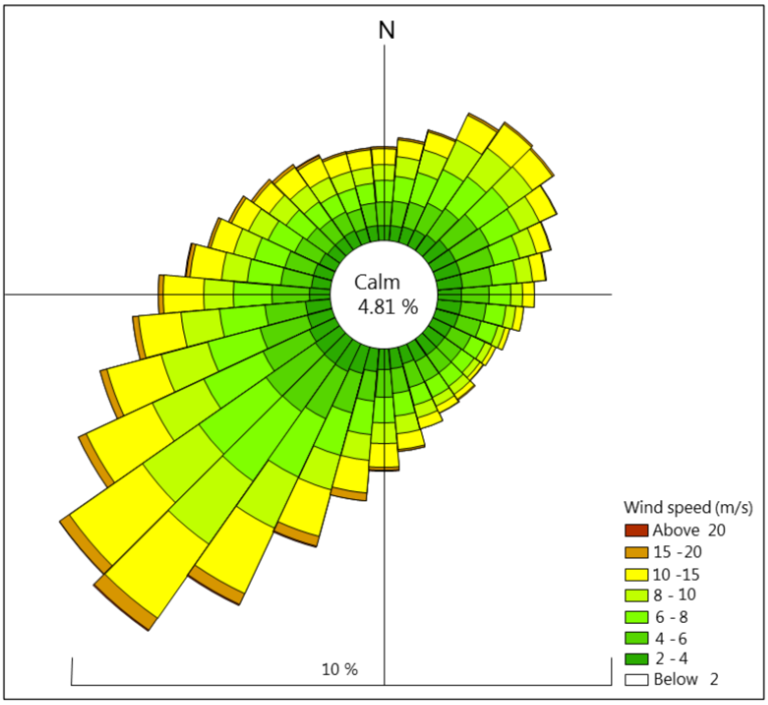

Figure 7: Wind direction and wind speed (source: Volume 2, Chapter 2, Physical Processes [6.2.4]).

3.3.2 Visibility

The Admiralty Dover Straits pilot states an average 37 days of fog at Manston Climate Station per year. January and December have the most days of fog on average, with 6 and 5 respectively.

3.3.3 Wave

Wave conditions across the site are shown in **Figure 8**. Dominant wave patterns are from the north east due to the large fetch lengths and from the south west due to the prevailing wind conditions.

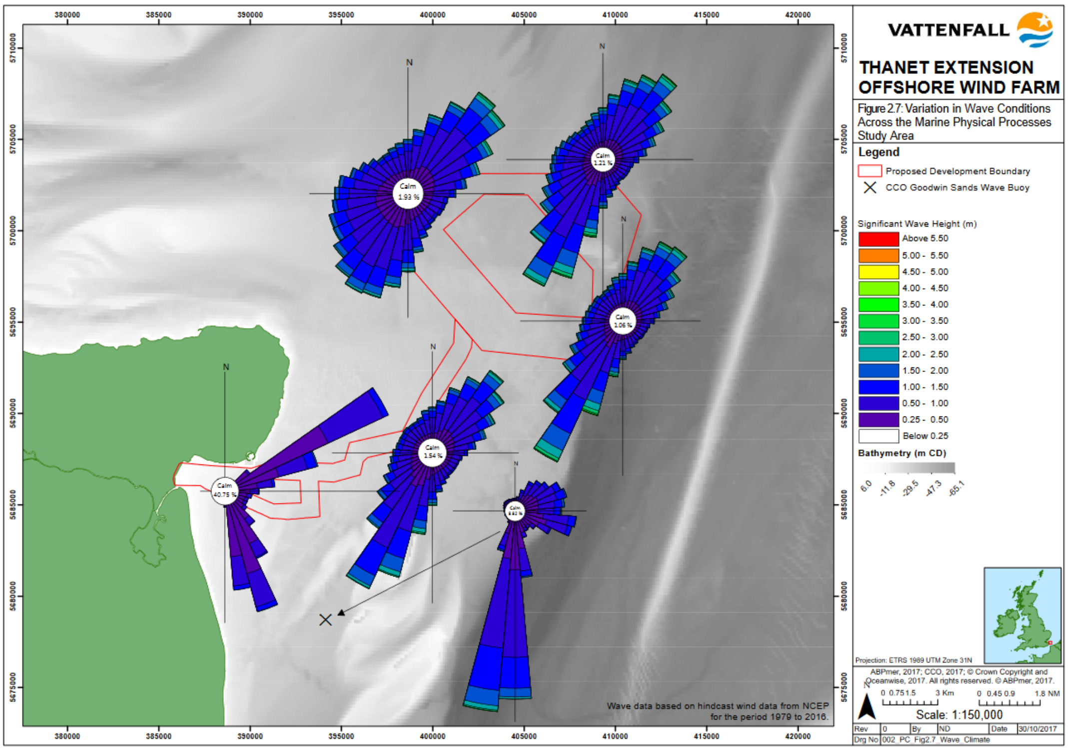

Figure 8: Wave conditions across project site (source: Volume 2, Chapter 2, Physical Processes [6.2.4]).

3.3.4 Tide

Table 6 gives the tidal diamond for the area around the wind farm. Tidal flows are in a SSW-NNE direction and are relatively low, reaching spring flow rates of up to 2 knots.

Table 6: Tidal diamond for project site (Admiralty Total Tide: 51°26.03'N 001°38.90'E)

HW Hour	Direction	Spring Rate kts	Neap Rate kts
-6	161	1.0	0.5
-5	171	1.5	0.8
-4	186	2.0	1.1
-3	198	1.6	0.9
-2	229	0.8	0.4
-1	320	0.8	0.5
HW	349	1.4	0.8
+1	002	1.6	0.9
+2	014	1.4	0.8
+3	024	1.0	0.6
+4	040	0.6	0.3
+5	090	0.3	0.2
+6	153	0.7	0.4

3.4 EXISTING VESSEL MANAGEMENT

3.4.1 Pilotage

The PLA, as the Competent Harbour Authority (CHA) within the meaning of the Pilotage Act 1987, have determined that the following vessels are subject to compulsory pilotage to the east of Sea Reach No.1 Buoy (PLA Pilotage Directions, 2013):

a) Vessels or Tugs and Tows of 90 metres or more in LOA;

b) Vessels or Tugs and Tows of 50 metres or more in LOA which are Specified Vessels, Passenger Vessels and vessels carrying Marine Pollutants in Bulk;

c) Vessels or Tugs and Tows of 50 metres and up to 90 metres in LOA with an Operating Draught of 6 metres or more; and

d) Vessels or Tugs and Tows of 50 metres and up to 90 metres in LOA with an Operating Draught of 4 metres or more when Restricted Visibility exists within that part of the London Pilotage District to the east of Sea Reach 1 Buoy where the vessel is planning to navigate.

Furthermore, pilots are normally boarded or landed at one of two locations (PLA Pilotage Directions, 2013):

a) At the North-East Spit Pilot Station by:
   i. All vessels entering from or leaving the London Pilotage District for the south or east, whose Operating Draught allows use of the Princes Channel, Fisherman's Gat or the Long Sand Head; and
   ii. All other vessels with an operating draught of less than 7.5 metres unless bound to or from ports in Essex or Suffolk.
b) At the Sunk Pilot Station by:
   i. Vessels of 7.5 metres draught and more entering from or leaving for ports to the north and north east of the Thames;
   ii. Vessels entering from or leaving for ports to the south and east of the Thames, which are unable to use the Princes Channel or Fisherman's Gate because their operating draught is too great;
   iii. Vessels less than 7.5 metres in draught, which agree to pay an additional pilotage charge for such service; and
   iv. Vessels entering from or leaving for ports in Essex or Suffolk.
c) At the Warp and Sea Reach No.1 Pilot Stations by vessels for which pilotage is compulsory only to the west of Sea Reach No. 1 Buoy;
d) At the Gravesend Pilot Station by vessels for which pilotage is compulsory to the west of the Margaretness Limit.

Some masters may be issued with a Pilotage Exemption Certificate (PEC) following completion of a number of qualifying trips and completion of exams. In 2016, a total of 153 PECs were issued (PLA Annual Report, 2017).

Estuary Services Ltd (ESL) is a private enterprise operating on behalf of the PLA from Ramsgate, servicing pilotage in the southern Thames Estuary. ESL operate 6 pilot vessels which are rotated between Ramsgate and Sheerness. The vessels are crewed by two coxswains and one Able Seaman who rotate with two on watch and one at rest. The pilot boats are variously capable of speeds of between 20 knots to 25 knots and so a planning operational speed of 20kts is assumed. There is normally only one pilot boat on duty at any one time.

A modernisation programme is currently underway to replace the pilot boats one by one with more modern and fuel-efficient equivalents.

Vessel traffic analysis of pilotage operations at North East (NE) Spit are contained in **Section 5.3.5**.

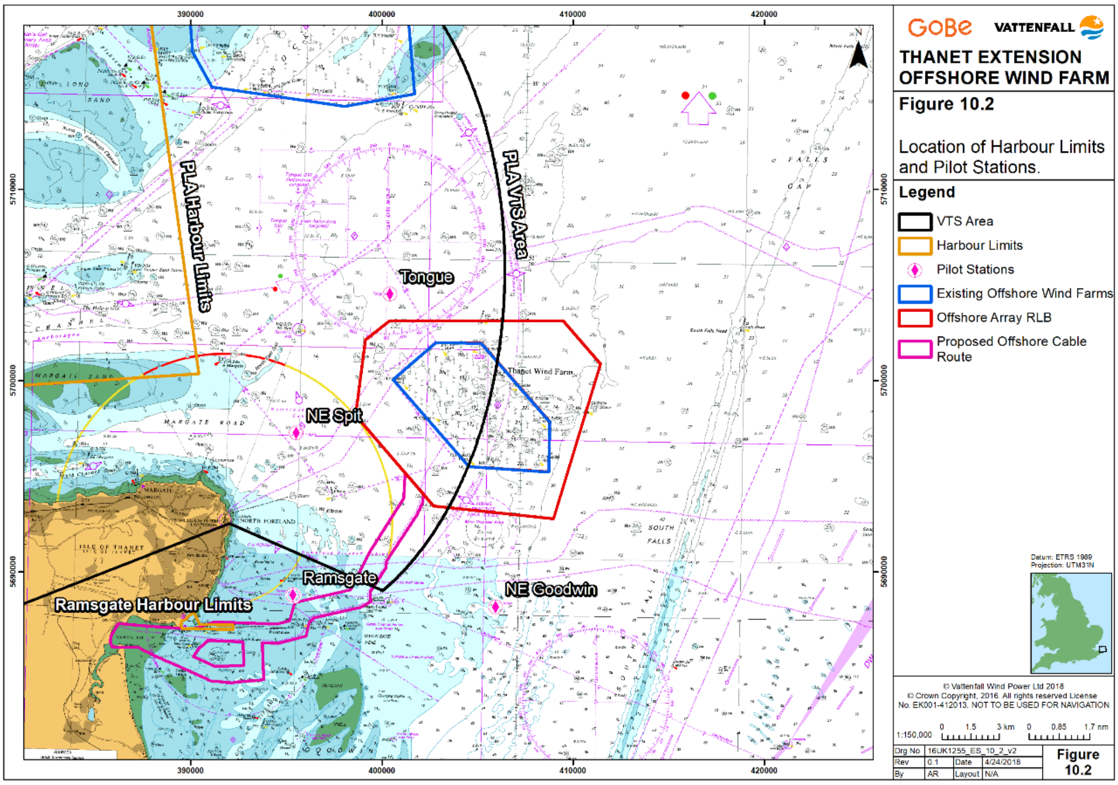

Figure 9: Location of pilot stations, VTS and harbour limits.

3.4.2 Vessel Traffic Services

The Thanet Wind Farm lies within the PLA's VTS area (see **Figure 9**). The aims and objectives of London VTS are to ensure safety of life at sea, safety and efficiency of navigation, and to protect the marine environment, adjacent shore areas, work sites and offshore installations from the possible adverse effects of maritime traffic. London VTS operates from two VTS Centres located at the Port Control Centre in Gravesend and at the Thames Barrier Navigation Centre in Woolwich. The VTS area is covered by radar and AIS coverage, as well as CCTV coverage inshore.

A team of 44 VTS personnel oversee the PLA VTS area on a 24/7 basis 365 days a year. Each VTS Centre is led by a VTS Supervisor with the delegated powers of the Harbour Master and is supported by a team of VTS Officers and Shipping Coordinators. All VTS personnel are fully trained to the International Association of Lighthouse Authorities (IALA) and Maritime and Coastguard Agency (MCA) standards using the PLA's in-house MCA accredited training programmes.

PLA's VTS provide all three of IALA's VTS levels, including Navigation Assistance Service (NAS). VTS operational information for calling vessels are available on the PLA website.[2]

3.4.3 Channel Navigation Information Service and CALDOVREP

The Channel Navigation Information Service (CNIS) helps vessels navigate safely and prevents collisions in the Dover Strait. The functions of CNIS are to:

- Keep the Dover Strait TSS under observation;
- Monitor the flow of traffic; and
- Detect and report vessels which contravene the COLREGs.

The service provides 24-hour radio and radar safety service, and is jointly operated by the Dover Maritime Rescue Co-ordination Centre (MRCC) in Dover and CROSS Gris Nez in France. CNIS broadcasts on VHF radio channel 11 every 60 minutes, or every 30 minutes if visibility drops below two miles, to give warnings of any navigational difficulties, weather conditions or useful traffic information in the TSS.

One of CNIS' functions is to manage the IMO Mandatory Reporting[3] area known as CALDOVREP. All vessels over 300 GT must report details of their passage to either Dover MRCC or CROSS Gris Nez depending on direction of travel. The reporting area for CALDOVREP is bounded to the east by a line between North Foreland to the border between France and Belgium, and is therefore to the west of Thanet Extension.

[2] https://www.pla.co.uk/assets/London_VTS_Operational_Information.pdf

[3] In accordance with SOLAS Convention 1974 Regulations 8-1 Chapter 5.

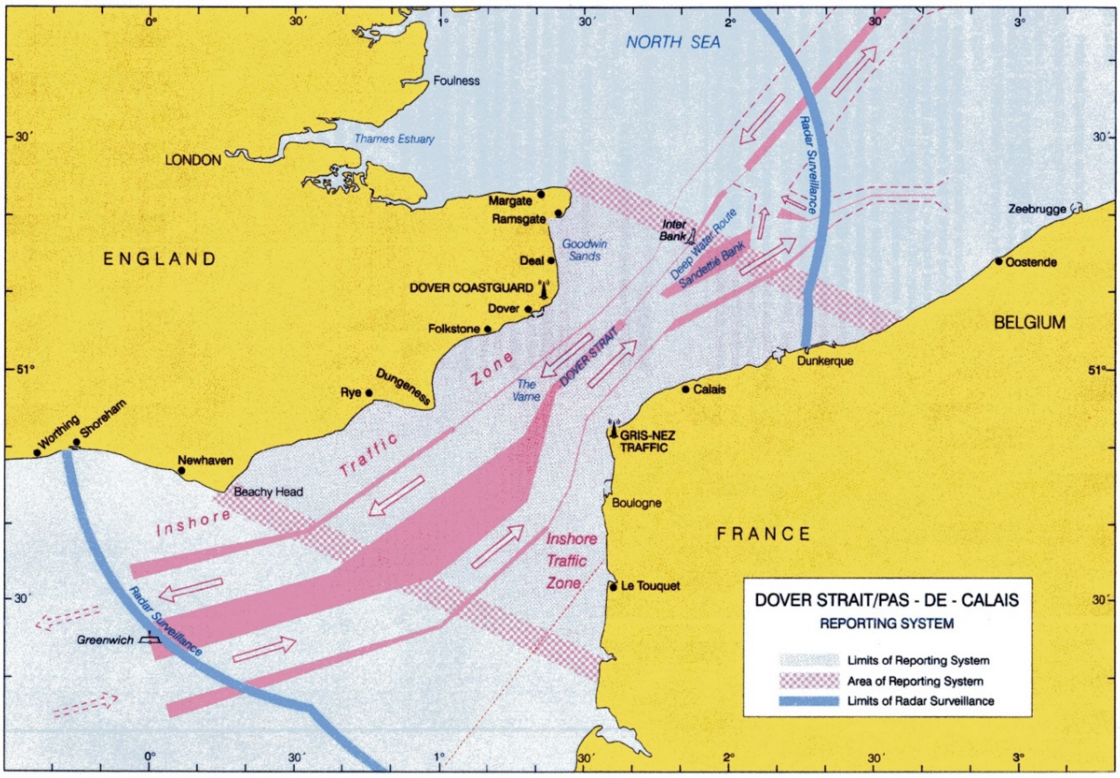

Figure 10: Limits of CALDOVREP (Source: MCA).

3.4.4 IMO Routeing Measures

Traffic Separation Schemes (TSS) are a form of ships routeing measures that separate vessel traffic by the direction of transit into lanes. The requirements and management of these schemes as well as the rules governing the transit of vessel are laid down in SOLAS Chapter V Regulation 10:1 and the COLREGS Rule 10 respectively.

Dover Straits TSS was one of the first traffic separation schemes introduced in the world, principally due to the volume of shipping and to reduce the frequency of collisions and groundings and the associated loss of life and pollution. Approximately 400 vessels each day transit through the scheme. The scheme is also monitored by CALDOVREP and Dover CNIS.

All vessels using the scheme are tracked by radar and AIS, and any vessels which do not appear to be navigating as per the Collision Regulations are challenged and reported to their flag state. Recordings of ‘rogue’ and ‘zombie’ vessels are made and, dependent on circumstances, details may be forwarded to MCA Enforcement Branch for further action, including prosecution through local courts.

The westbound approaches to the Dover Strait are located to the east of Thanet Extension. The inshore traffic zone commences off Dover and traffic joining or leaving this scheme will transit passed the extension.

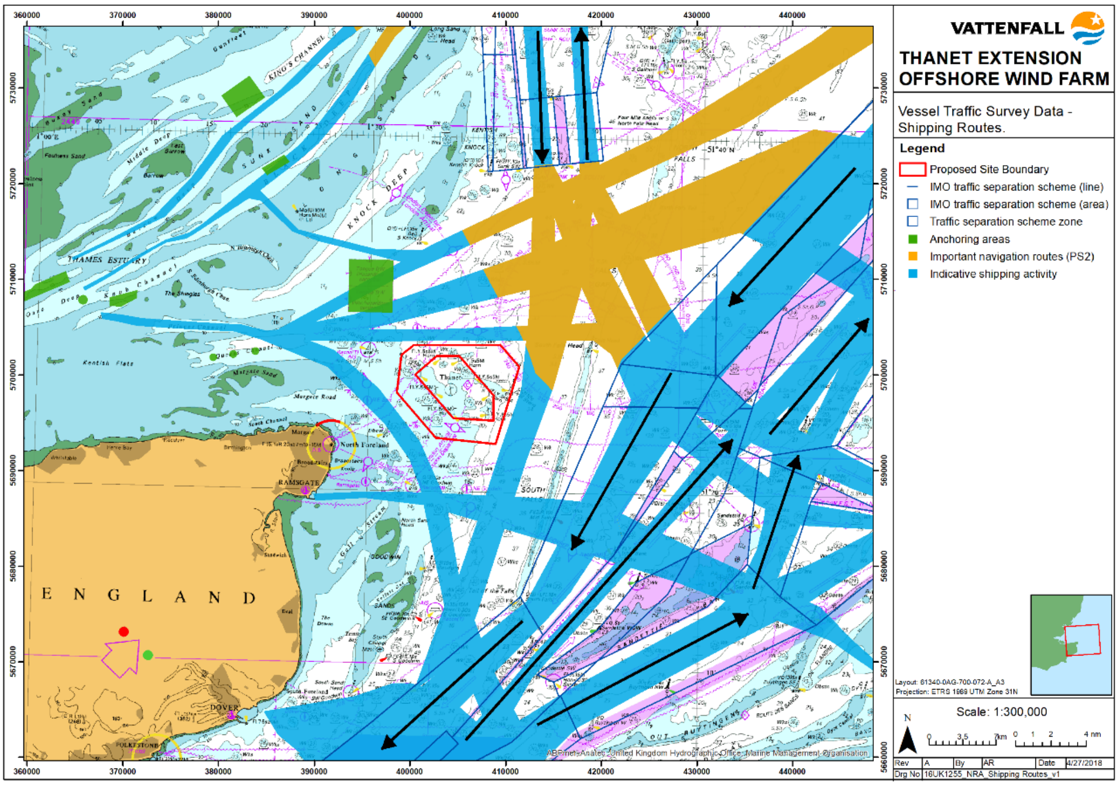

Figure 11: Key shipping routes near to development.

3.4.5 Aids to Navigation

The existing wind farm is marked by two Cardinal marks; Thanet North (to the north) and Drill Stone (to the east). Both of these marks keep vessel traffic at least one nautical mile from the boundary of the existing wind farm.

Marking the inshore route and the North Foreland shallows are three cardinal marks; NE Spit, Elbow and NE Goodwin, with a red lateral East Margate at the eastern limit of the Margate Sands.

3.5 SEARCH AND RESCUE

The primary role of the Coastguard service is the initiation and co-ordination of maritime Search and Rescue (SAR) within the UK search and rescue regions through a network of Coast Guard Operating Centres (CGOC). This role includes the mobilisation, organisation and tasking of adequate resources to respond to persons either in distress at sea, or to persons at risk of injury or death on the cliffs or UK shoreline.

In a maritime emergency the Coastguard Service calls on and co-ordinates the appropriate SAR assets such as helicopters, Royal National Lifeboat Institution (RNLI) lifeboats, Royal Navy and RAF ships and aircraft, as well as merchant ships and commercial aircraft.

The United Kingdom SAR service operates from 10 strategically located bases across the UK between latitudes 45°N and 61°N; and extending 30°W and to the east it is bounded by adjacent European SAR regions. The bases are positioned close to SAR hotspots so that the resources can be brought to bear as quickly and efficiently as possible. Seven new SAR bases have been built and three existing facilities will be used.

The UK SAR co-ordination in the vicinity of the wind farm is, at present, conducted by the MCA East of England Region Humber CGOC, which covers the sea area from the Anglo-Scottish Border to Haile Sand Fort (Humber). UK SAR response can be drawn from three levels of responder:

- Dedicated (e.g. RNLI, UK SAR helicopter);
- Declared (e.g. coastguard vessels, Royal Navy vessels, port launches, police boats); and
- Merchant shipping (e.g. vessels transiting in the area).

The RNLI provides a dedicated UK wide rescue service (commonly lifeboats) which is co-ordinated by local CGOC. There are a number of RNLI stations located in the Thames Estuary with both inshore and offshore capability (see **Table 7**).

Table 7: Lifeboat stations in the vicinity of Thanet.

Location	Lifeboat Type	Name	Length (metres)	Range (NM)	Speed (Kts)	Crew
Dover	Severn	City of London II	17	250	25	7
Margate	Mersey	Leonard Kent	11	240	17	6
	IB1	Tigger Three	5	3 hours	25	2/3
Ramsgate	Trent	Esme Anderson	14	250	25	6
	Atlantic 85	Claire and David Delves	8	3 hours	35	3/4
Walmer	Atlantic 85	Donald McLauchlan	8	3 hours	35	3/4
	IB1	Duggie Rodbard II	5	3 hours	25	2/3
Whitstable	Atlantic 85	Lewisco	8	3 hours	35	3/4

The WTGs are sufficiently spaced apart that they are unlikely to impinge on any UK SAR operations significantly. Effective monitoring by VHF radio, AIS radar as well as the implementation of proper procedures and training for emergency services and demonstrator site staff can ensure that any SAR operation is un-affected by the array's presence.

It is necessary that the developers in consultation with MCA, Royal National Lifeboat Institute (RNLI) and HM Coastguard produce a SAR plan for operations that occur within the wind farm site. This plan will incorporate the emergency response by both the emergency services and the actions of Vattenfall as well as the training required by all parties involved.

3.6 OTHER OFFSHORE ACTIVITIES

Figure 12 shows the locations of selected offshore infrastructure which could have a cumulative or in-combination impact on Thanet Extension.

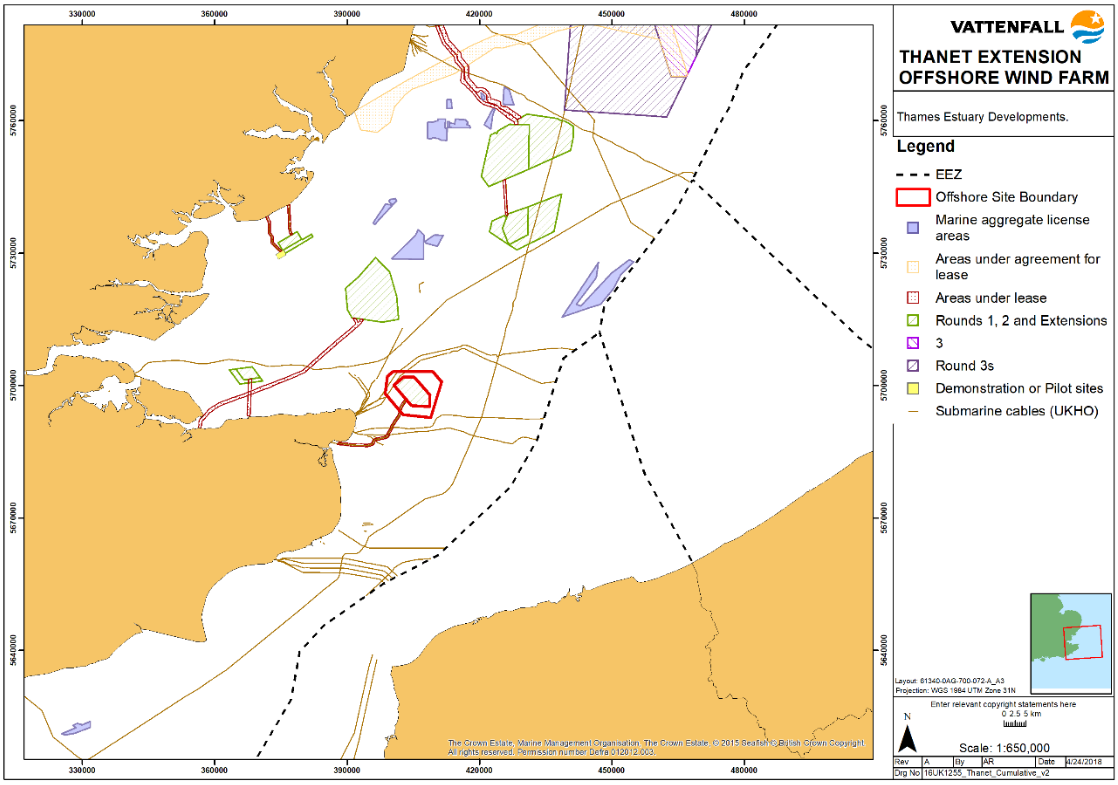

Figure 12: Location of other offshore activities in Thames Estuary.

3.6.1 Marine Aggregates

The nearest marine aggregate dredging sites are some distance, with Area 501 on the French-Belgium border and 509/3 to the north. It should be noted however that a number of aggregate dredgers operate from the Thames and transit passed the wind farm site (see **Section 5.3.5**).

3.6.2 Oil and Gas

There is no oil and gas infrastructure in the southern Thames Estuary.

3.6.3 Subsea Cables

Several cables pass the Thanet site, most of which make landfall around North Foreland to Pegwell Bay and are routed to the continent. The existing Thanet wind farm cables make landfall in Pegwell Bay.

The most recent subsea cable installed in the area is the Nemo Link interconnector between the UK and Belgium. The cable makes landfall in Pegwell Bay and was installed during 2017 and is not shown in **Figure 12**. Lessons learnt during the installation of this cable and the impact on navigation are discussed in **Section 7.6**.

3.6.4 Spoil Grounds

The cable corridor intersects several spoil grounds or disposal site. In particular, licensed spoil ground TH140, located to the south of Ramsgate, is used by the port to deposit dredged material extracted to ensure the port's ability to maintain safe depths.

3.6.5 Offshore Renewable Energy Installations

The Thames Estuary is one of the most productive areas for offshore wind farms in the country, including:

- Existing Thanet Wind Farm;
- Kentish Flats and its extension;
- London Array; and
- Gunfleet Sands.

Ramsgate serves as an O&M base for Thanet, London Array and Kentish Flats.

3.6.6 Anchorages

The Tongue deep water anchorage lies to the north of the extension and to the east of the Outer Tongue Light Buoy.

An anchorage for smaller vessels may be found in Margate Roads and is described by the Admiralty sailing directions as "*sheltered from southerly winds. Depths are between 10 and 12m. Vessels should anchor about 1 mile offshore and as far west as draught will permit.*" The use of Margate Roads is highly variable, with typically between 2 and 5 vessels at anchor, but in bad weather up to 20 vessels seek shelter here.

Figure 13 shows the distribution of anchorages within the study area, constructed as a heat map of where vessels have speeds of less than 0.2 knots (excluding WFSVs and pilot boats). Whilst the majority of vessels using Margate Roads do so well to the west of the wind farm, on occasion when the anchorage is busy, vessels extend up to 3nm from the boundary. The Tongue deep water anchorage is less frequently used in comparison.

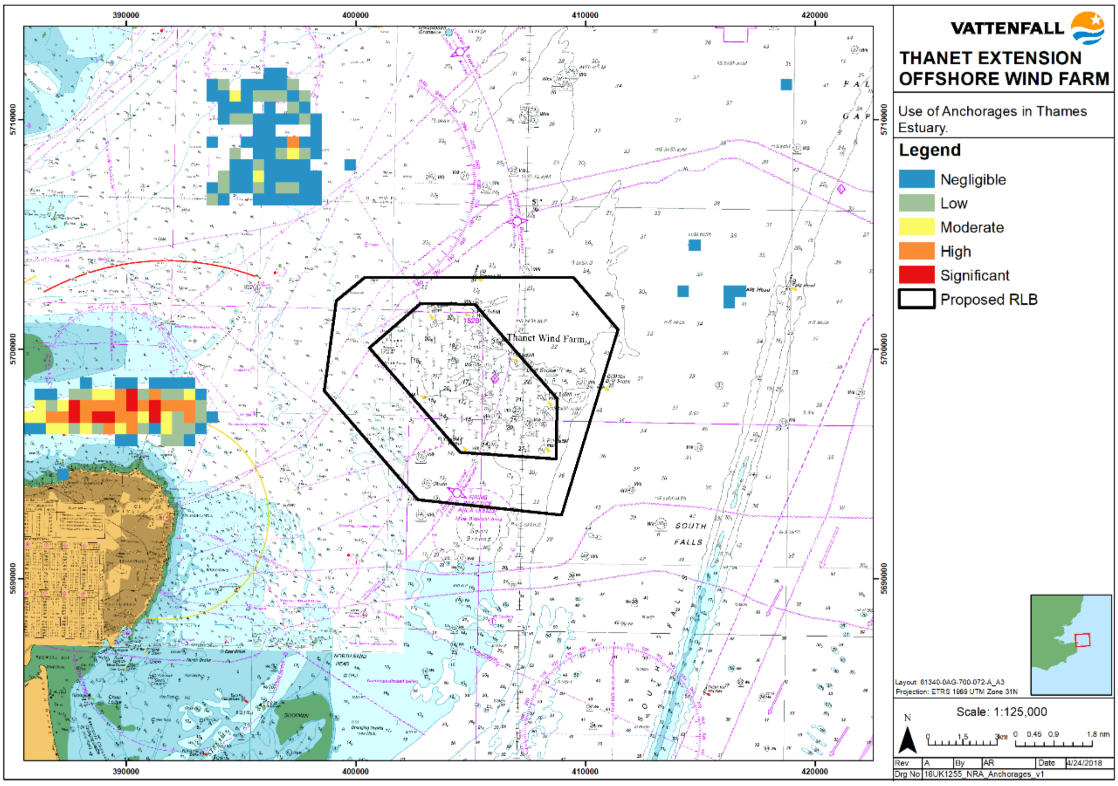

Figure 13: Use of Anchorages in Thames Estuary.

3.6.7 Military Exercise Areas

Thanet Extension intersects or is close to three Practice and Exercise Areas (PEXAs), namely:

- X5119 – Kentish Knock Mine Counter Measures;
- X5122 - Unnamed Mine Counter Measures; and
- X5123 – Mine Disposal.

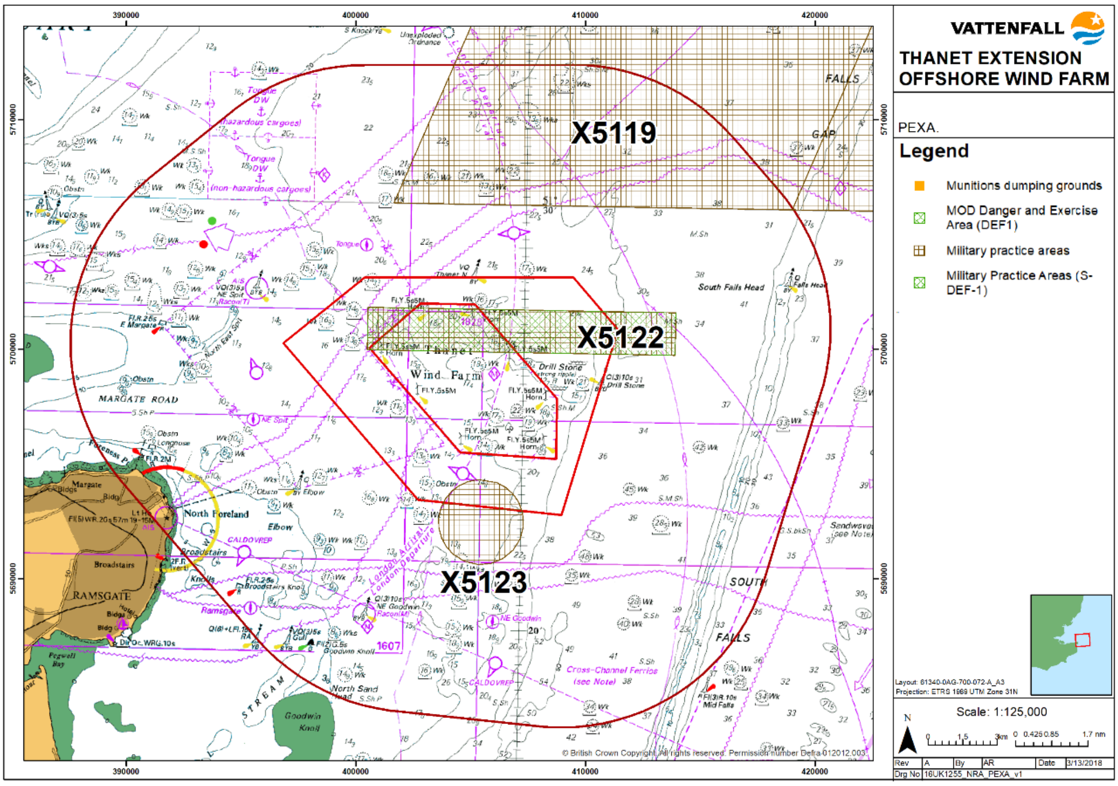

Figure 14: Proximity of project to PEXAs.

4 CONSULTATION

4.1.1 Consultation Meetings

Consultation was conducted with numerous stakeholders to better understand both the current activities of vessels in proximity of the TOWF and the possible impacts that would result from the extension. **Table 8** summarises the consultation held to support this NRA.

It should be noted that this consultation was undertaken prior to the reduction in the red line boundary described in **Section 1.1**.

4.1.2 Pilotage Simulation Workshop

During early consultation the PLA, ESL and pilots raised a concern related to pilotage transfers at the NE Spit pilot station, located to the west of the extension's footprint. In particular, the feasibility of undertaking pilot boarding and disembarkation in the reduced navigable corridor between the shallows off North Foreland and the wind farm boundary. In order to test this a pilotage study to review the current arrangements and a subsequent pilotage simulation workshop was conducted using full bridge simulation at the PLA's simulator in Gravesend, the results of which are given in **Section 7.2.2**.

The full pilotage study is contained in ES Volume 4, Annex 10.3, Document Ref: 6.4.10.3.

Table 8: Consultation Table.

Consultee	Engagement	Key issues raised	Action Taken	Section
MCA	January 2016 (Meeting) – Pre-Scoping January to December 2016 (Emails) – Pre-Scoping January 2017 - Scoping Response December 2017 (Meeting) – NRA January 2018 (Meeting) – NRA January 2018 – S42 Response February 2018 (Meeting) – Post-S42 March to April 2018 – Review of NRA	Requirement for NRA	MGN 543 Compliant NRA Produced	**1.3.1 / 8**
		Requirement for Early Engagement with PLA	Early meetings with PLA and ESL held to discuss pilotage	**4**
		Impact on Pilotage at North East Spit	Pilotage study and Pilotage Simulation Study conducted with PLA and ESL showing that pilotage is feasible. Reduction made to RLB to improve sea room.	**7.2 / 8.5**
		Alignment of WTG with Existing Thanet Wind Farm	Commitment to maintain line of orientation and symmetry.	**7.7 / 8.5**
		Impact on Anchorage at Margate	Analysis of anchorage footprint at Margate shows extent.	**3.6.6**
		Impact on Navigation Safety	MGN 543 Compliant NRA produced showing risks with ALARP.	**8**
		Impact on Vessel Routeing	Vessel routeing reviewed showing minimal impact.	**7.1**
		Cable Burial Depths	Cable burial depths would not exceed 5% UKC	**0**
		Impacts on AIS/Radar/VHF Coverage	Review of previous studies suggests no significant impact	**7.9**
		Reduction in Sea Room	Collision modelling and pilotage simulation showed an increase in risk but within ALARP. Reduction in RLB.	**7.2 / 7.3 / 8**
		Provision of Hydrography to MCA	Embedded risk control.	**8.5**
		Suitability of Risk Controls	Risk controls reviewed since PEIR	**8.5**

Consultee	Engagement	Key issues raised	Action Taken	Section
		Impact on SAR	Layout guidance reviewed and recommendations made on line of symmetry and orientation	**7.7 / 8.5**
		Requirement for ERCOP, Layout Plan and Lighting/Marking	Recommendation made	**8.5**
Trinity House	January 2016 (Meeting) – Pre-Scoping January to December 2016 (Emails) – Pre-Scoping January 2017 - Scoping Response January 2018 (Meeting) – NRA January 2018 – S42 Response February 2018 (Meeting) – Post-S42 March to April 2018 – Review of NRA	Requirement for NRA	MGN 543 Compliant NRA Produced	**1.3.1 / 8**
		Requirement for Early Engagement with PLA	Early meetings with PLA and ESL held to discuss pilotage	**4**
		Impact on Pilotage at North East Spit	Pilotage study and Pilotage Simulation Study conducted with PLA and ESL showing that pilotage is feasible. Reduction made to RLB to improve sea room.	**7.2 / 8.5**
		Impact on Anchorage at Margate	Analysis of anchorage footprint at Margate shows extent.	**3.6.6**
		Impact on Navigation Safety	MGN 543 Compliant NRA produced showing risks with ALARP.	**8**
		Impact on Vessel Routeing	Vessel routeing reviewed showing minimal impact.	**7.1**
		Impacts on AIS/Radar/VHF Coverage	Review of previous studies suggests no significant impact	**7.9**
		Reduction in Sea Room	Collision modelling and pilotage simulation showed an increase in risk but within ALARP. Reduction in RLB.	**7.2 / 7.3 / 8**
		Suitability of Risk Controls	Risk controls reviewed since PEIR	**8.5**
		Requirement for ERCOP, Layout Plan and Lighting/Marking	Recommendation made	**8.5**

Consultee	Engagement	Key issues raised	Action Taken	Section
Port of London Authority	January to January 2017 (Emails) – Pre-Scoping November 2016 (Meeting) – Pre-Scoping February 2017 - Scoping Response May 2017 (Meeting) – Pilotage Study July 2017 (Meeting) – Pilotage Study September 2017 (Meeting) – Pilotage Workshop December 2017 (Meeting) – NRA January 2018 – S42 Response	Requirement for NRA	MGN 543 Compliant NRA Produced	**1.3.1 / 8**
		Impact on Pilotage at North East Spit	Pilotage study and Pilotage Simulation Study conducted with PLA and ESL showing that pilotage is feasible. Reduction made to RLB to improve sea room.	**7.2 / 8.5**
		Relocation of Pilot Boarding Station	Relative merits of relocation of pilot boarding station reviewed but not recommended.	**7.2**
		Operational impact on pilotage	Wear and tear and manning requirements reviewed.	**7.2**
		Impact on Anchorage at Margate	Analysis of anchorage footprint at Margate shows extent.	**3.6.6**
		Impact on Navigation Safety	MGN 543 Compliant NRA produced showing risks with ALARP. Reduction in RLB.	**8**
		Impact on Vessel Routeing and increased transit time	Vessel routeing reviewed showing minimal impact.	**7.1**
		Impacts on AIS/Radar/VHF Coverage	Review of previous studies suggests no significant impact	**7.9**
		Reduction in Sea Room	Collision modelling and pilotage simulation showed an increase in risk but within ALARP. Reduction in RLB.	**7.2 / 7.3 / 8**
		Suitability of Risk Controls	Risk controls reviewed since PEIR	**8.5**
		Lighting and Buoyage Requirements	Recommendation made	**8.5**
ESL	August to October 2016 (Emails) – Pre-Scoping	Impact on Pilotage at North East Spit	Pilotage study and Pilotage Simulation Study conducted with PLA and ESL showing that pilotage is feasible. Reduction made to RLB to improve sea room.	**7.2 / 8.5**

Consultee	Engagement	Key issues raised	Action Taken	Section
	March 2017 (Meeting) - Scoping July 2017 (Meeting) – Pilotage Study September 2017 (Meeting) – Pilotage Workshop December 2017 (Meeting) – NRA January 2018 – S42 Response	Relocation of Pilot Boarding Station	Relative merits of relocation of pilot boarding station reviewed but not recommended.	**7.2**
		Operational impact on pilotage	Wear and tear and manning requirements reviewed.	**7.2**
		Impact on Anchorage at Margate	Analysis of anchorage footprint at Margate shows extent.	**3.6.6**
		Impact on Navigation Safety	MGN 543 Compliant NRA produced showing risks with ALARP.	**8**
		Impact on Vessel Routeing and increased transit time	Vessel routeing reviewed showing minimal impact.	**7.1**
		Requirement for Simulation	Pilotage simulation study conducted to test feasibility of pilotage, results suggest pilotage would remain feasible.	**7.2**
		Reduction in Sea Room	Collision modelling and pilotage simulation showed an increase in risk but within ALARP. RLB revision to increase sea room.	**7.2 / 7.3 / 8**
		Suitability of Risk Controls	Risk controls reviewed since PEIR	**8.5**
Port of Ramsgate / Thanet District Council	December 2017 (Meeting) – NRA January 2018 – S42 Response	Proximity of cable routeing close to Ramsgate	Cable exclusion area implemented in Ramsgate approach channel.	**0 / 7.6**
		Impacts during cable laying and maintenance	Cable exclusion area implemented in Ramsgate approach channel and commitment to cooperate with port during cable laying.	**0 / 7.6**
		Possible risk controls	Discussion of risk controls to minimise impact.	**8.5**
		Impact on pilotage operations	Pilotage simulation study conducted to test feasibility of pilotage, results suggest pilotage would remain feasible.	**7.2**

Consultee	Engagement	Key issues raised	Action Taken	Section
Royal Temple Yacht Club	December 2017 (Meeting) - NRA	Proximity of cable routeing close to Ramsgate	Cable exclusion area implemented in Ramsgate approach channel.	**0 / 7.6**
		Impacts during cable laying and maintenance	Cable exclusion area implemented in Ramsgate approach channel and commitment to cooperate with port during cable laying.	**0 / 7.6**
Thanet Fishermen Association	December 2017 (Meeting) – NRA January 2018 – S42 Response	Disruption during construction.	Cooperation plan with fishing groups to be put in place.	**8.5**
		Impact of cable laying and disruption	Cooperation plan with fishing groups to be put in place.	**0 / 7.6**
		Offset of shipping into fishing areas	Collision risk modelling and risk assessment undertaken, risks assessed to be within ALARP. Revision of RLB to improve sea room.	**7.2 / 7.3 / 8**
		Navigational Marking Requirements	Recommendation made	**8.5**
		Practicality of Risk Controls	Risk controls reviewed since PEIR	**8.5**
RYA	December 2017 (Meeting) - NRA	Offset of shipping into recreational traffic.	Collision risk modelling and risk assessment undertaken, risks assessed to be within ALARP. Revision of RLB to improve sea room.	**7.2 / 7.3 / 8**
		Impact of cable protection and UKC	Cable burial depths would not exceed 5% UKC	**0**
Chamber of Shipping	December 2017 (Meeting) - NRA	Reduction in sea room to west	Collision modelling and pilotage simulation showed an increase in risk but within ALARP. Reduction in RLB.	**7.2 / 7.3 / 8**
		Impact on Pilotage Operations.	Pilotage study and Pilotage Simulation Study conducted with PLA and ESL showing that pilotage is feasible. Reduction made to RLB to improve sea room.	**7.2 / 8.5**

Consultee	Engagement	Key issues raised	Action Taken	Section
		Impact to Navigational Aids, Radar and Communications.	Review of previous studies suggests no significant impact	**7.9**
French Government	January 2018 - S42 Response	Impact to Vessel Routeing	Project site clear of international shipping lanes.	**3.4.4**
		Impact to Navigational Aids, Radar and Communications.	Review of previous studies suggests no significant impact	**7.9**
Port of Sheerness	January 2018 - S42 Response	Impact on Pilotage at North East Spit	Pilotage study and Pilotage Simulation Study conducted with PLA and ESL showing that pilotage is feasible. Reduction made to RLB to improve sea room.	**7.2 / 8.5**
		Reduction in Sea Room	Collision modelling and pilotage simulation showed an increase in risk but within ALARP. Reduction in RLB.	**7.2 / 7.3 / 8**
		Impact on Vessel Routeing and increased transit time	Vessel routeing reviewed showing minimal impact.	**7.1**
		Impact to Navigational Aids, Radar and Communications.	Review of previous studies suggests no significant impact	**7.9**

Consultee	Engagement	Key issues raised	Action Taken	Section
UK Marine Pilots Association	January 2018 – S42 Response	Impacts to Pilotage	Pilotage study and Pilotage Simulation Study conducted with PLA and ESL showing that pilotage is feasible. Reduction made to RLB to improve sea room.	**7.2 / 8.5**
		Validity and Limitations of Pilotage Simulation Workshop	The pilotage simulation workshop was designed in consultation with the PLA and ESL to determine the parameters, runs and conditions of each trial. Whilst any simulation is not a true reflection of reality and there are inevitably limitations, it was agreed by the participants that the results of assessment were valid and that pilotage would remain feasible, albeit with a reduced margin for error.	**N/A**
		Impact on Navigational Safety	Collision modelling and pilotage simulation showed an increase in risk but within ALARP. An MGN 534 compliant NRA produced. Reduction in RLB undertaken to improve traffic flow.	**7.2 / 7.3 / 8**
Marine Management Organisation	January 2018 - S42 Responses	NRA	MGN 543 Compliant NRA Produced	**1.3.1 / 8**
		Safety zones	Safety zone distance stipulated as 500m during construction	**8.5**
		Aids to Navigation Plan	Required as part of marine license.	**8.5**
		Cable risks	Ongoing monitoring of cable risks to be undertaken	**8.5**
		Thanet Cable Replacement	Scoped into in-combination assessment	**7.10**

5 EXISTING VESSEL TRAFFIC AND RISK PROFILE

5.1 DATA SOURCE

To provide an accurate baseline of vessel traffic near to the development site and to meet the requirements of MGN 543, two x 14-day traffic surveys were conducted during representative summer and winter periods of 2017. Both surveys were conducted from a dedicated survey vessel (**Figure 15**) that was on station within the western extent of the development area. The survey vessel recorded all marine craft using radar, AIS and visual means and the results recorded into a database for later analysis. In addition, a three-month AIS dataset from December 2016 to February 2017 was collected from Ramsgate for use in the pilotage and modelling studies. Where appropriate this has been supplemented with other datasets from secondary sources, such as VMS and RYA data, which is referred to in the relevant sections.

The two survey dates were as follows:

- Winter survey: 7th February to 25th February 2017:
    - Due to adverse weather conditions the survey vessel was off station at several stages and maintained an AIS only survey from the shore. A 14-day duration of radar data was, however, achieved in fragments during this period.
- Summer survey: 15th June to 29th June 2017

Figure 15: Survey Vessel: Seiont A.

5.2 OVERALL TRAFFIC PROFILE

The tracks of all vessels recorded by both radar and AIS during the winter and summer survey periods are shown in **Figure 16** and **Figure 17** respectively. Both plots show similar traffic patterns, with several traffic routes bowing around the existing wind farm and a significant inshore route. There is relatively higher activity recorded within the Thanet Wind Farm site during the summer survey as opposed to the winter survey.

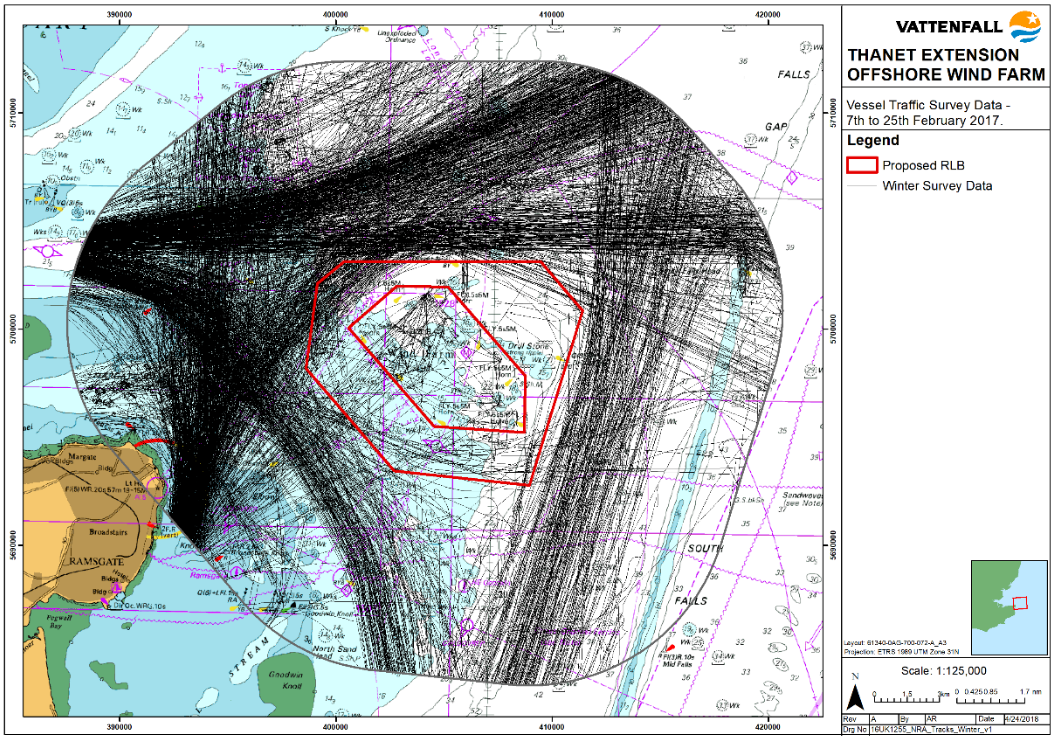

Figure 16: Vessel tracks during winter survey.

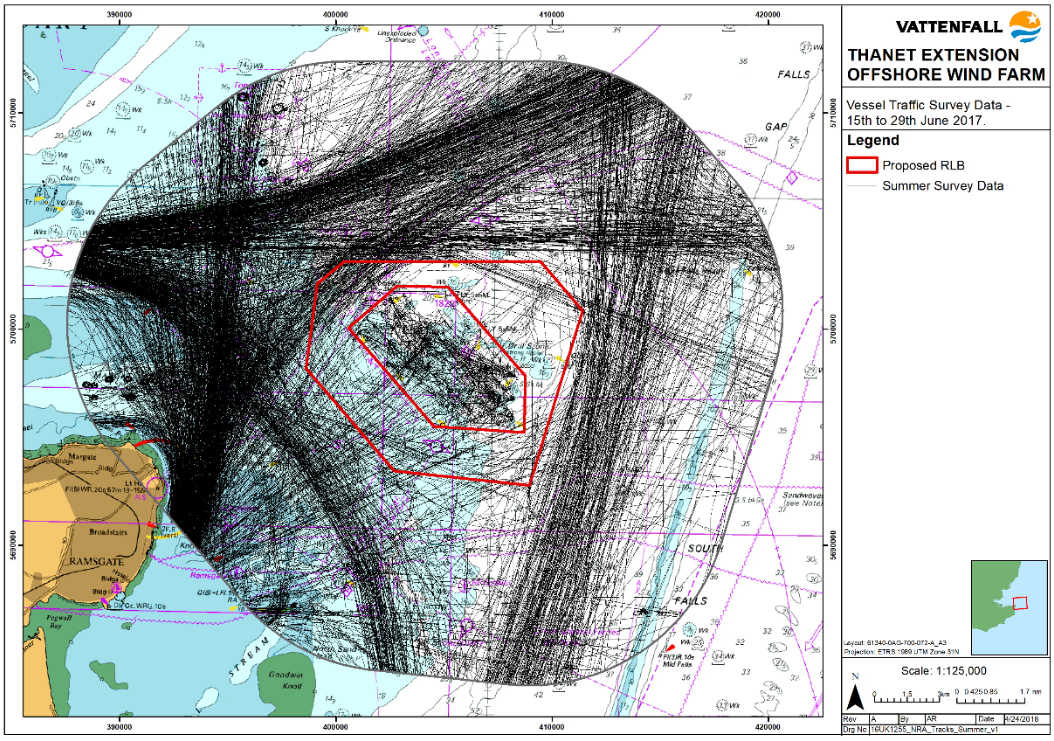

Figure 17: Vessel tracks during summer survey.

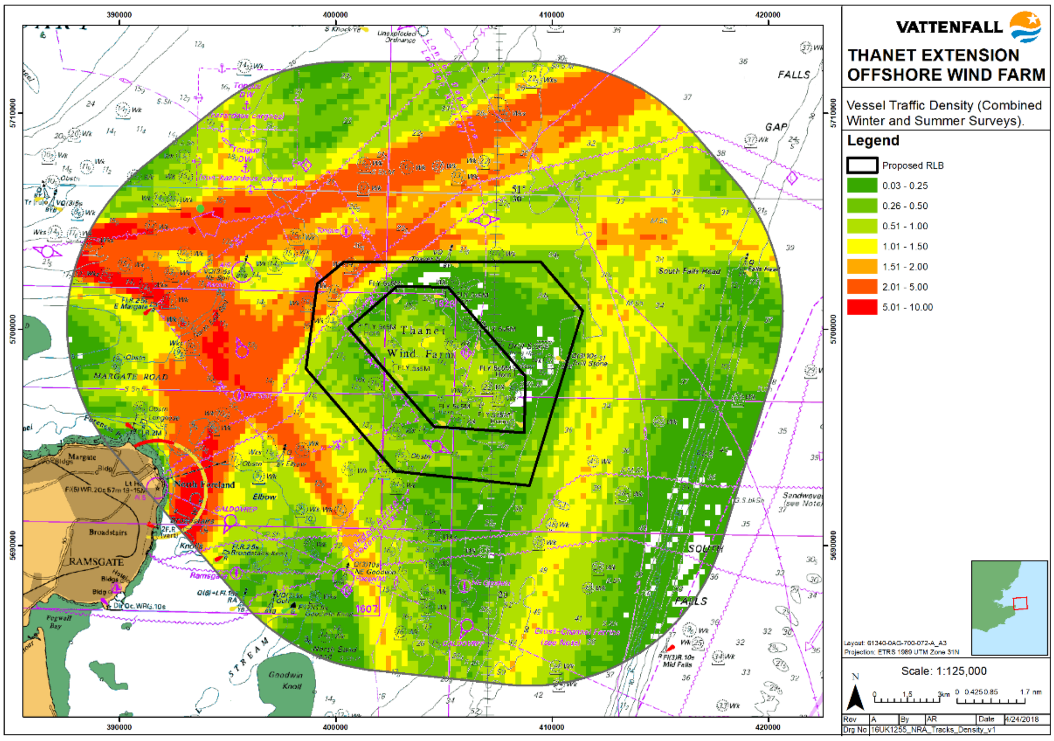

Figure 18: Vessel transit density during both surveys.

5.3 VESSEL TRAFFIC BY TYPE

5.3.1 Commercial Shipping

The tracks of cargo vessels and tankers recorded during the combined surveys are shown below in **Figure 19** and **Figure 20**. It can be seen whilst both vessel types commonly transit passed the wind farm, there are generally more cargo transits than tanker ones. Coblefret, a regular runner carrying bulk and Ro-Ro, pass to the north of the extension.

Several key routes can be identified from these transits and they are described in **Figure 46** and **Table 10**.

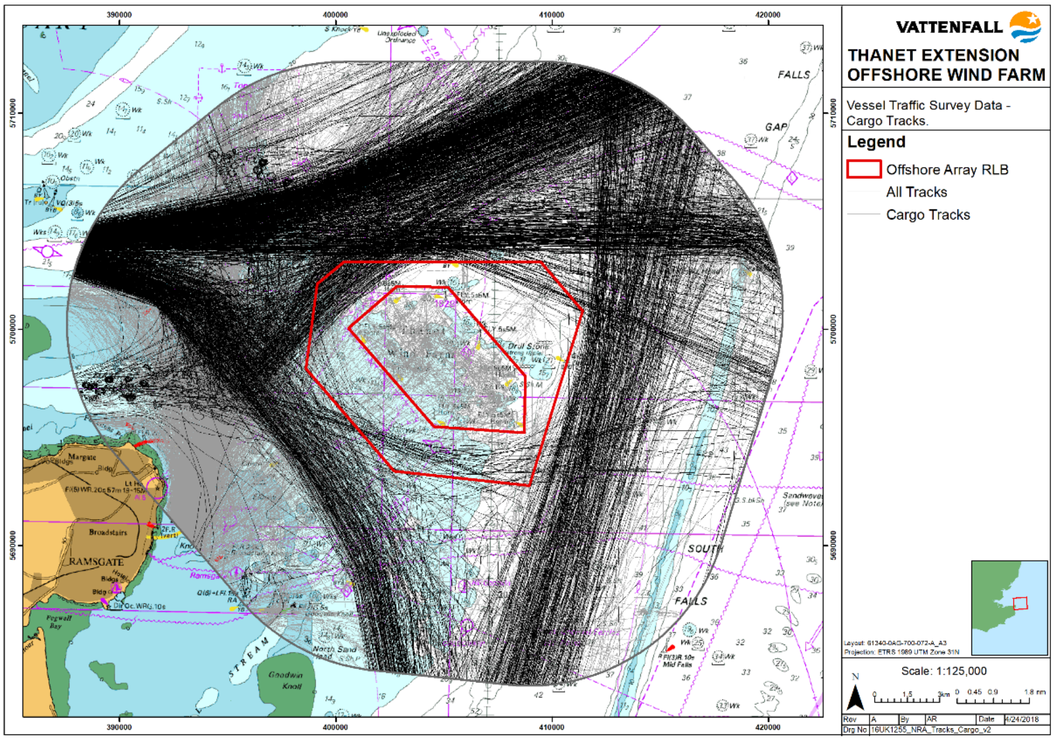

Figure 19: Cargo vessel tracks during combined surveys.

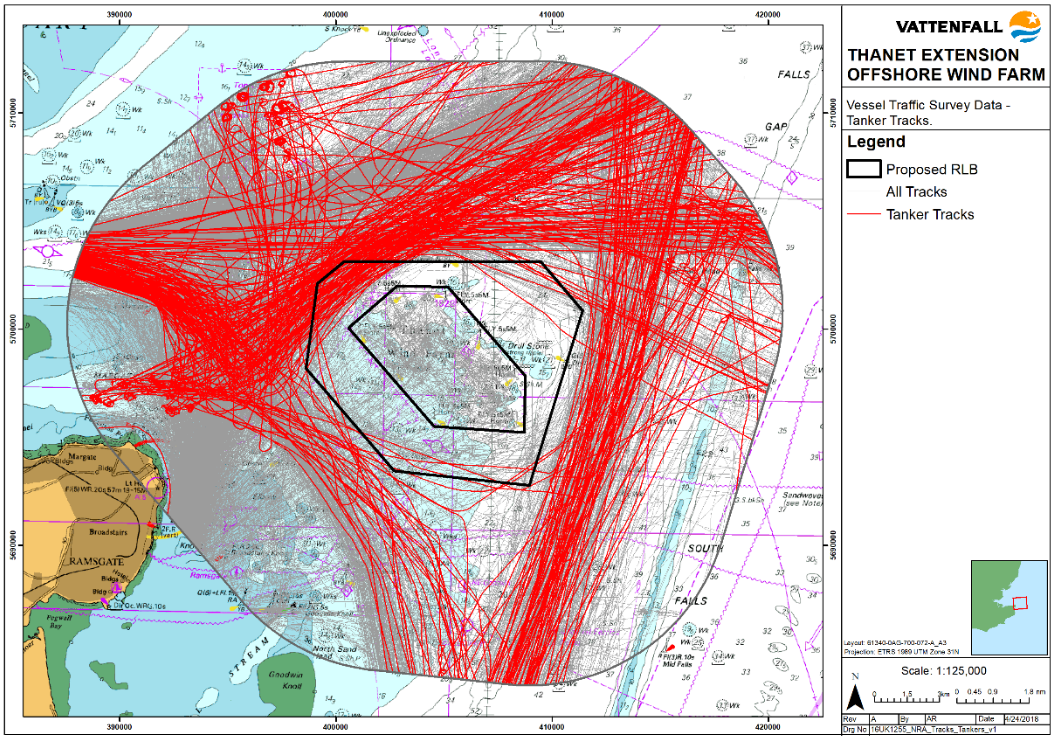

Figure 20: Tanker vessel tracks during combined surveys.

5.3.2 Passenger Vessels

No ferry routes or frequently used passenger routes were identified during consultation or in the AIS data presented in **Figure 21**. Those passenger vessels that transited through the red line boundary area of the extension were cruise ships using the NE Spit pilot station. These include the *Aegean Odyssey*, *Columbus, Silver Wind*, *Viking Sky* and *Viking Star* all between 140m and 245m during the summer period. Three passenger vessels transited approximately five nautical miles to the east and therefore well clear of extension.

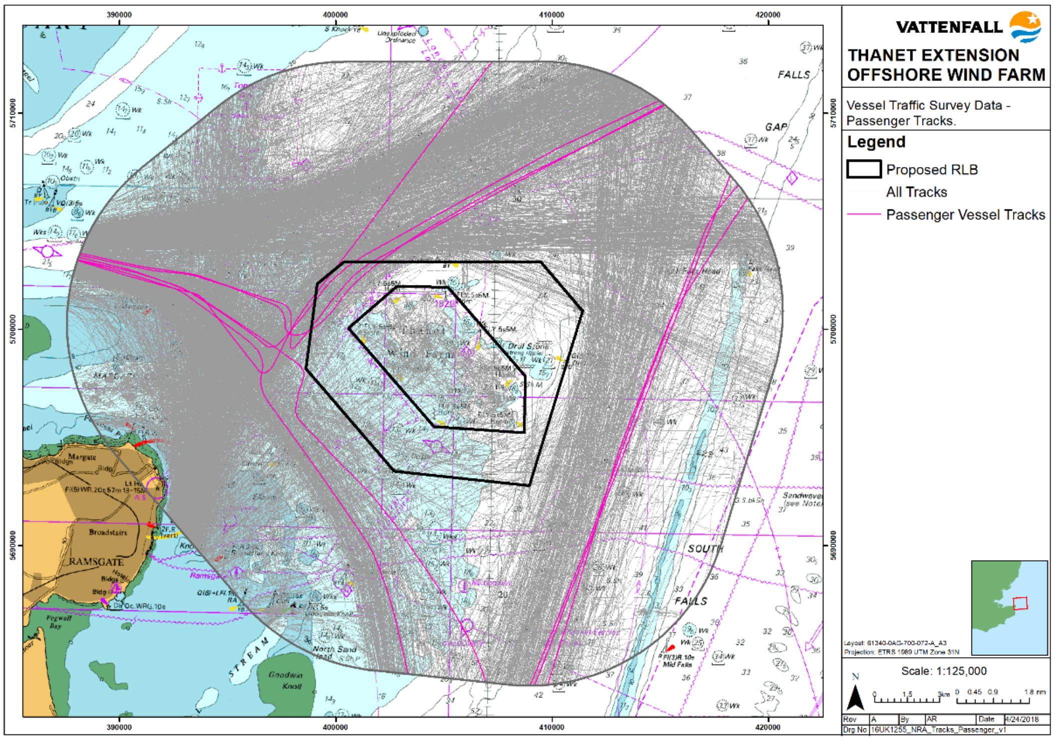

Figure 21: Passenger vessel tracks during survey periods.

5.3.3 Fishing Vessels

Figure 22 shows the tracks of fishing vessels recorded during the surveys. It can be seen from the orientation of the tracks that the majority of fishing vessels transiting or fishing in the area are based in Ramsgate. There is a large amount of activity to the north-east, of which the vessels are larger. Consultation with the Thanet Fishermen's Association (TFA) revealed that there are approximately 20 vessels based in Ramsgate, generally day boats less than 15m LOA, with 50% of the fleet out fishing at any one time. The main catches around the wind farm are Dover Sole, cod, sea bass, skate, whelks and lobster/crab potting. A number of the fishermen fish within the existing wind farm, and in the area of the proposed extension.

Figure 23 shows the intensity of fishing activity as recorded by the MMO using the Vessel Monitoring System (VMS), required on vessels greater than 15m LOA. During consultation, it was identified that VMS was only fitted on one fishing boat operating from Ramsgate and therefore the plot mostly shows the larger offshore European vessels, particularly Dutch trawlers to the north-east. For those vessels recorded, few are active near to the proposed wind farm extension.

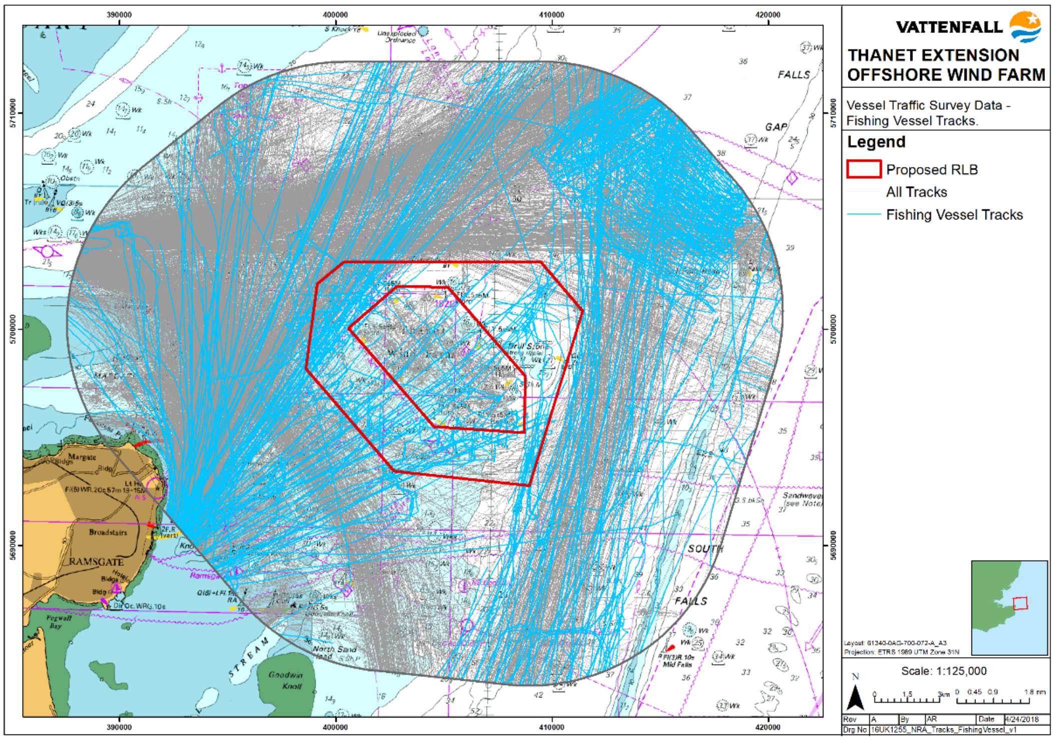

Figure 22: Fishing vessel tracks during survey periods.

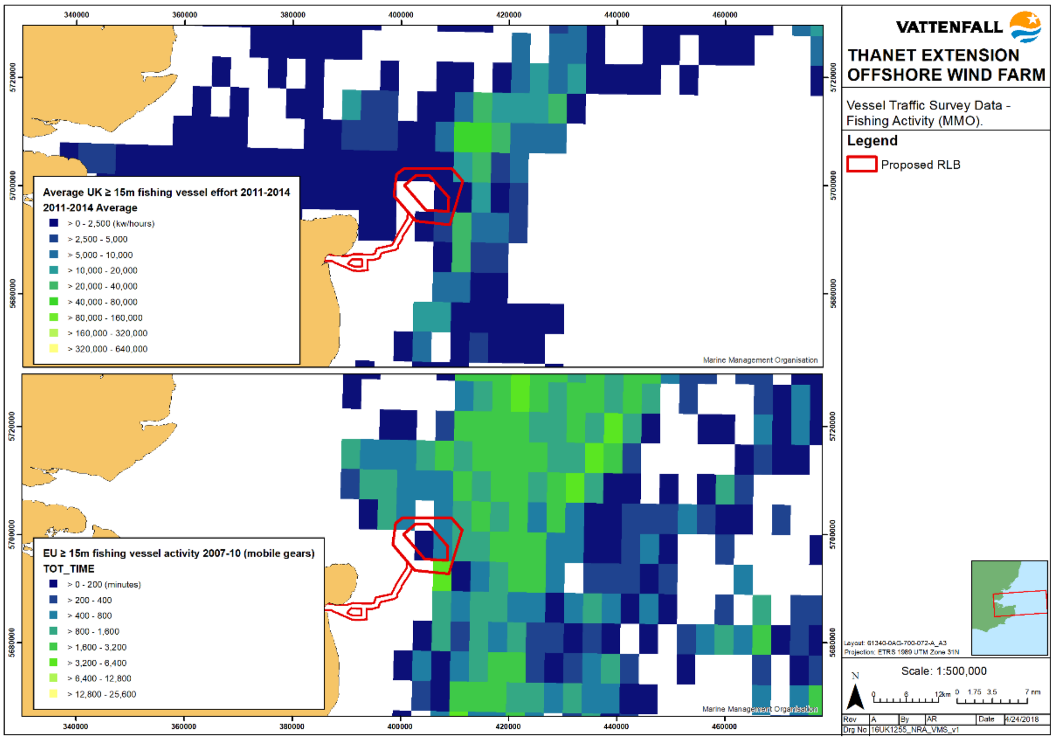

Figure 23: VMS Data 2011-2014.

5.3.4 Recreational Vessels

The tracks of recreational vessels (yachts and pleasure boats) collected during the winter and summer surveys are presented below in **Figure 24**. It can be seen that the majority of tracks are concentrated inshore, with vessels passing around North Foreland. Some tracks were identified around the wind farm, but only a single recreational craft transited through the existing Thanet site (a 13m yacht).

Consultation with Royal Temple Yacht Club and the RYA identified that much of the activity is inshore and to the southwest of the wind farm. Few recreational users pass through the Thanet site, principally because the footprint does not intersect any major cruising routes with routes to the continent passing either side of the wind farm and routes north and south, generally inshore. Due to the tidal conditions and harbour characteristics, with the exception of Ramsgate there are few marinas near to the project where recreational users are active from.

Figure 25 shows the RYA's AIS based boating intensity maps around the wind farm and supports the activity suggested in the radar and AIS plots.

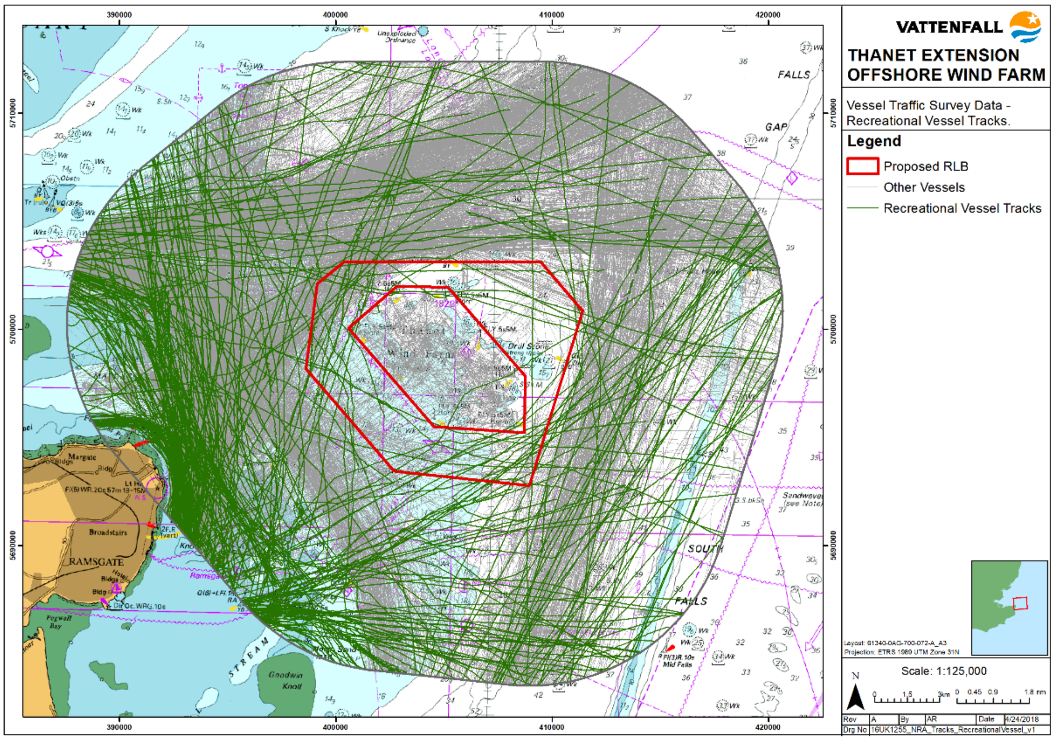

Figure 24: Recreational vessel tracks during survey periods.

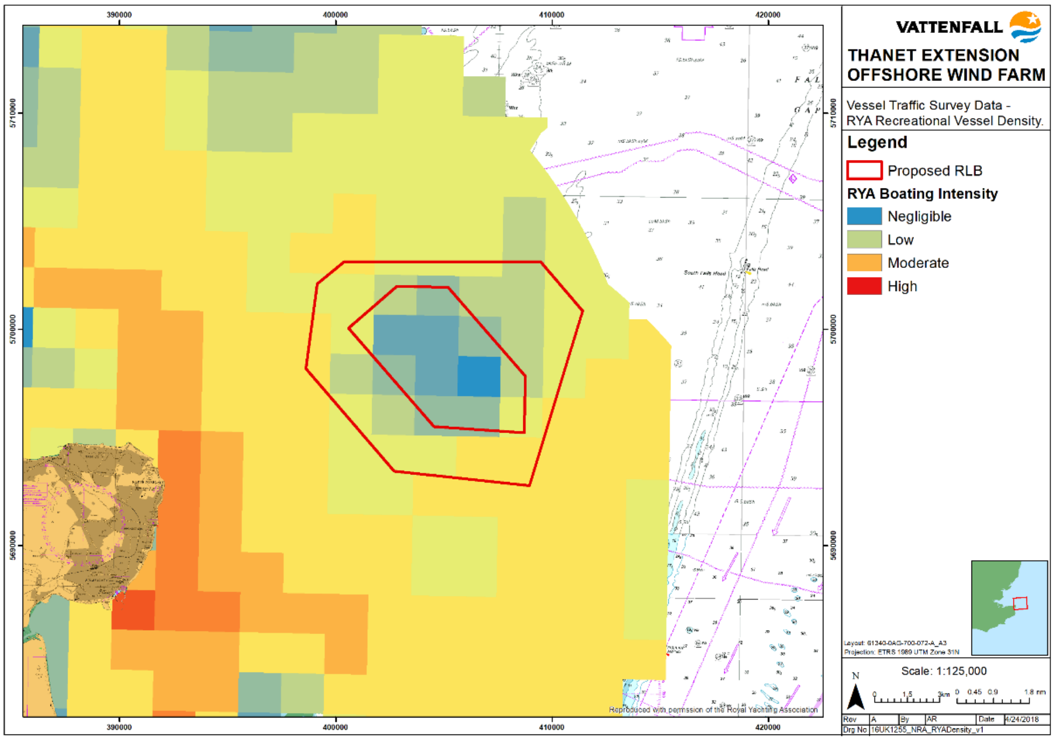

Figure 25: RYA boating intensity.

5.3.5 Service Craft

Figure 26 to **Figure 30** show an assortment of other vessel types which are active near the project.

Figure 26 shows the tracks of WFSVs operating to and from Ramsgate to Thanet, London Array and Kentish Flats. Each project has between two and four designated WFSVs operating on a daily basis. WFSV's therefore, constitutes one of the principal vessel types operating within the area.

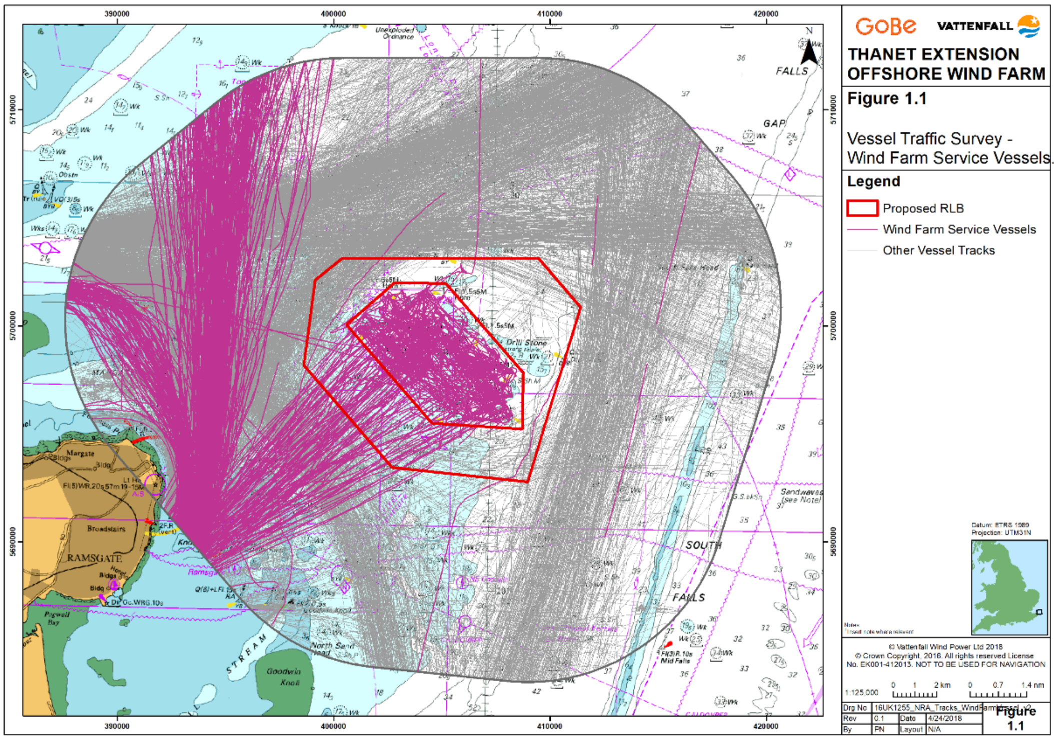

Figure 26: WFSVs tracks during survey periods.

The tracks of dredgers are depicted in **Figure 27** and shows that whilst there are a number of transits to and from sites, no aggregate extraction takes place within the study area. Many of the dredgers are based in London at Charlton and Cliffe and therefore account for a large proportion of the transits.

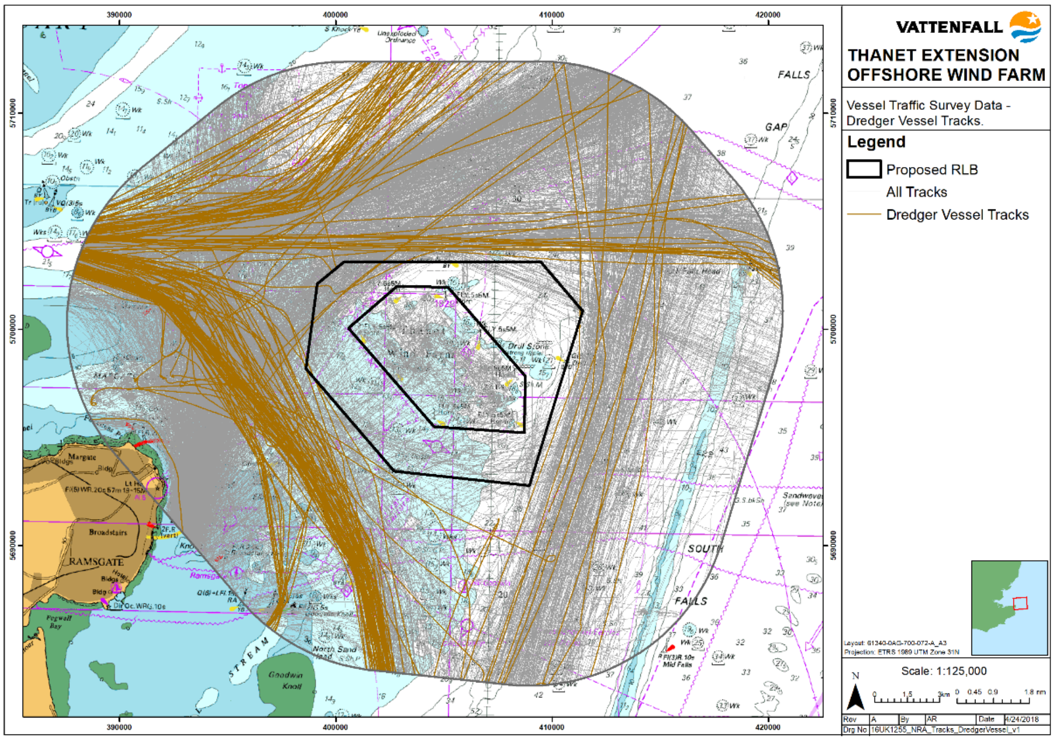

Figure 27: Dredger vessel tracks during survey periods.

Figure 28 gives the extent to which pilot vessels operate to conduct transfers at the pilot stations at NE Spit, Tongue and NE Goodwin. The majority of these transfers take place in and around NE Spit **Figure 29** shows the frequency of pilot transfers conducted from Ramsgate per month with between 460 and 640 typical depending on conditions and demand. An analysis of pilotage movements undertaken as part of the Pilotage Study showed that the average round trip length (from Ramsgate to Ramsgate) is between 35 minutes and an hour and 10 minutes.

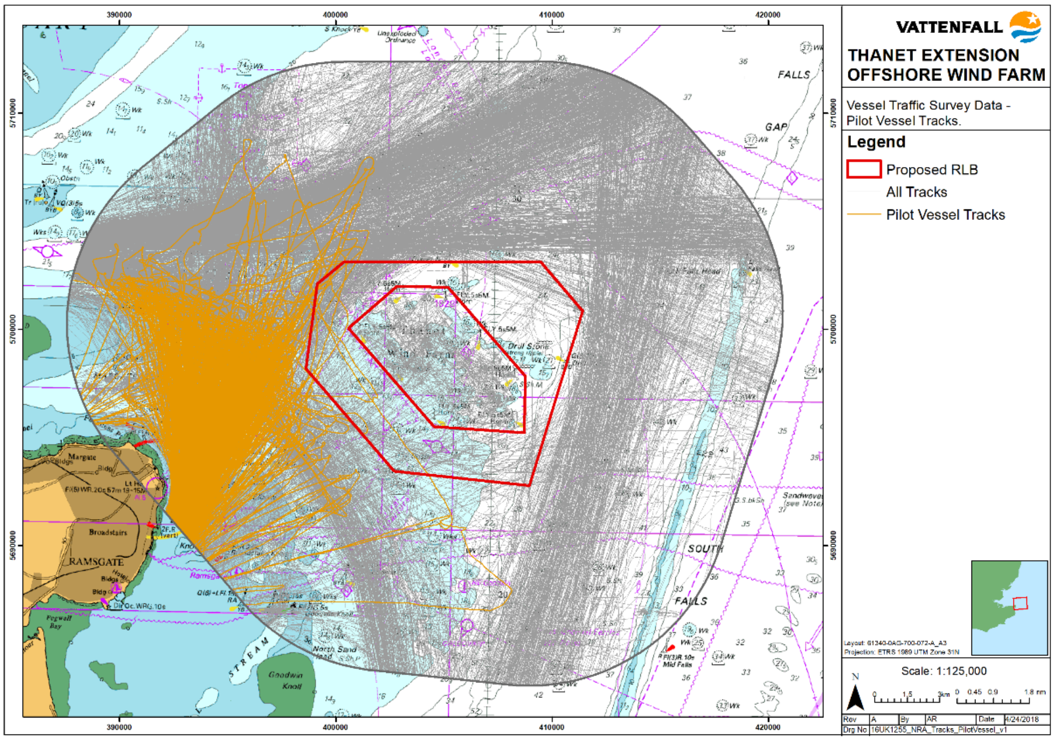

Figure 28: Pilot vessel tracks during survey periods.

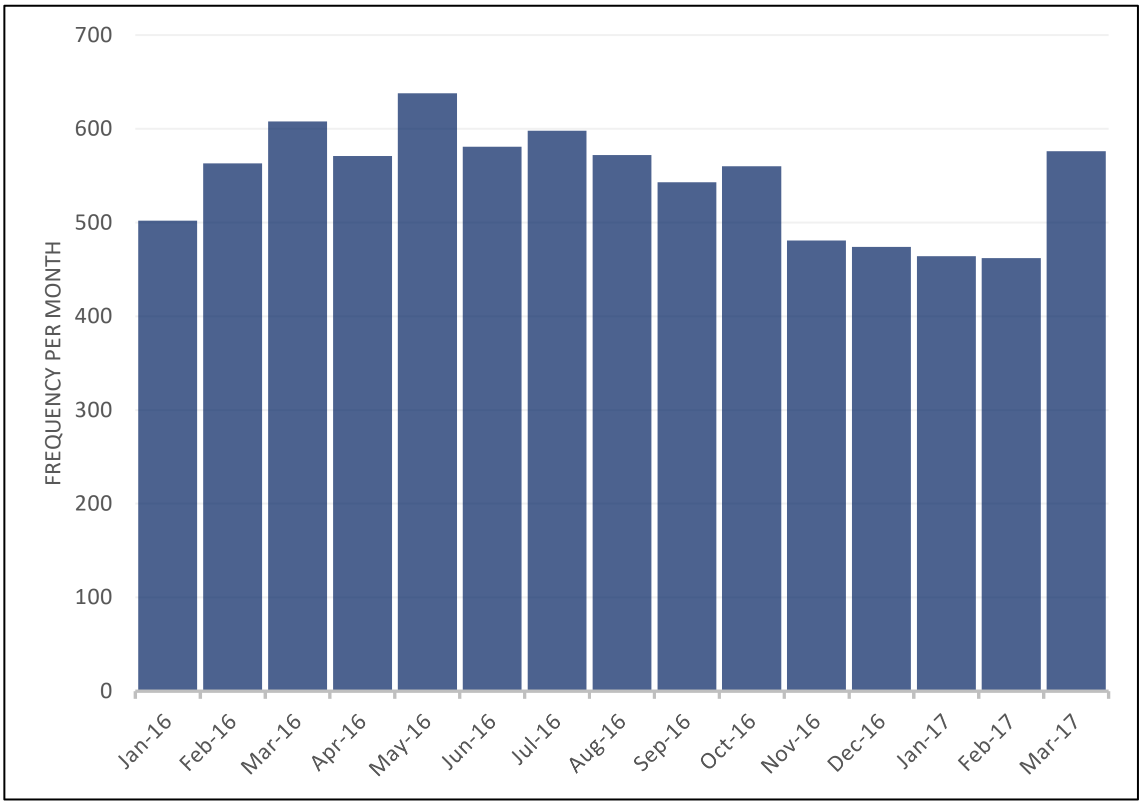

Figure 29: Pilot Transfers per month (source: PLA).

The few naval transits which were recorded during the surveys are shown below in **Figure 30**. It should be noted that military vessels may or may not broadcast AIS data, as discussed in **Section 3.6.7** and therefore, may be under-represented in the analysis.

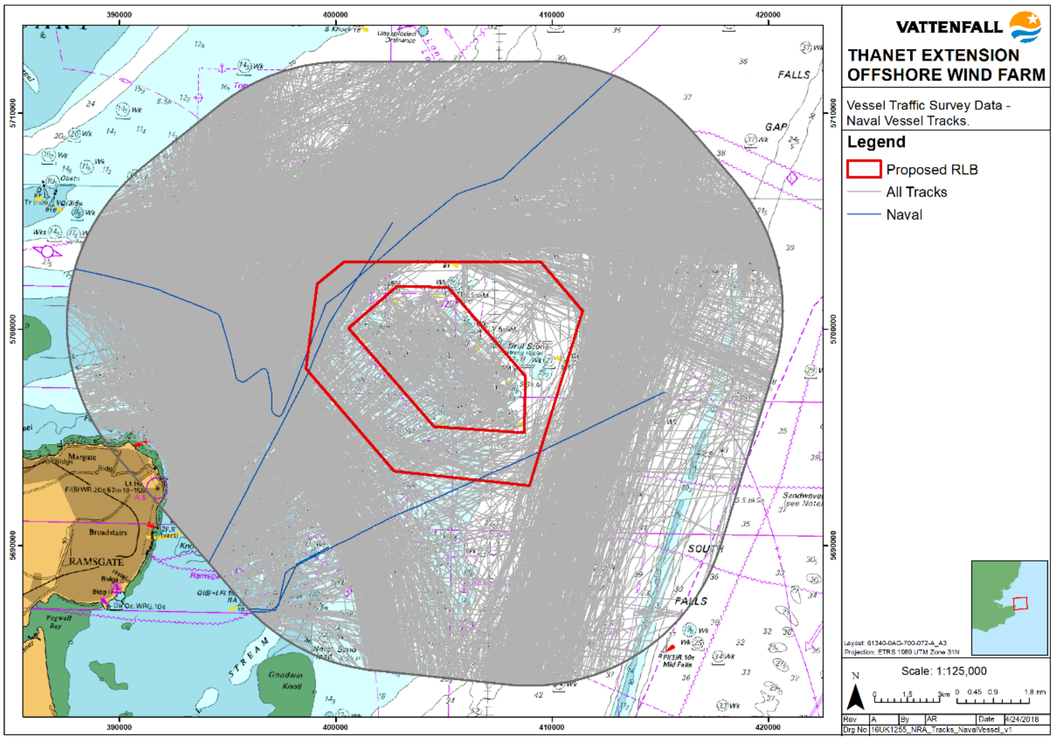

Figure 30: Naval vessel tracks during survey periods.

5.4 VESSEL TRAFFIC BY SIZE

Figure 31 and **Figure 32** show the tracks of vessels by their length and draught respectively. The largest vessels in the study area all pass to the east of the wind farm and include Ultra Large Container Vessels (ULCV), some of the largest in the world: 399m and 400m container vessels operated by CMA CGM and Maersk which draw up to 15m. The destinations of these vessels in the UK are principally Felixstowe and London Gateway with vessels therefore, using Sunk rather than the Princes Channel.

During the four-week survey period, only three transits were made by vessels greater than 250m LOA inshore of the wind farm, with an additional vessel "dipping down" to use the NE Spit Pilot Station. Six vessels of this size were seen to use the Princes Channel.

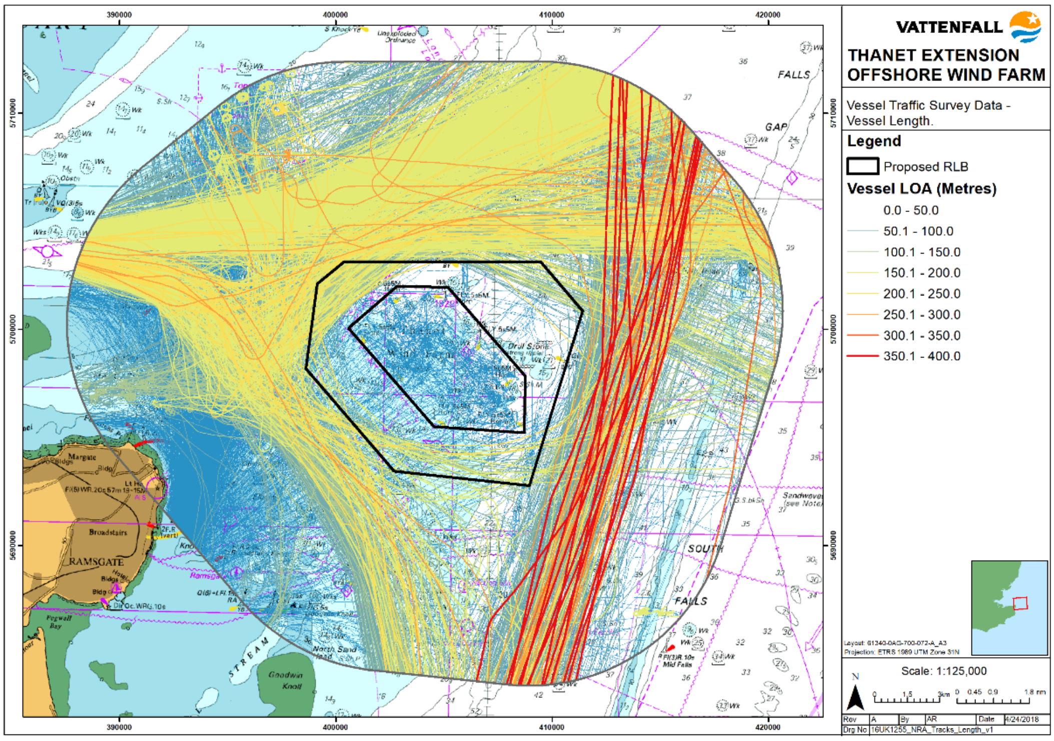

Figure 31: Vessel tracks by length from winter and summer surveys.

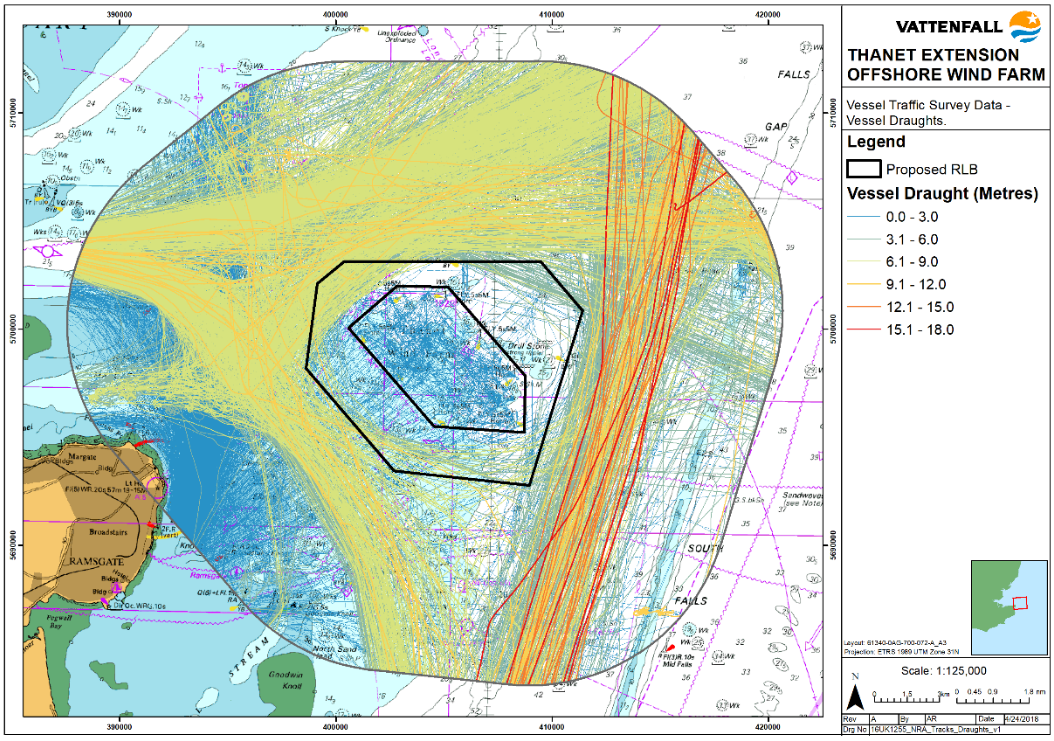

Figure 32: Vessel tracks by draught from winter and summer surveys.

5.5 GATE ANALYSIS

In order to quantify the frequency and types of transit passing the TOWF, a series of gates were constructed. A gate is a linear cross-section of a traffic flow that measures the frequency and distribution of traffic flow by their direction.

Five gates were constructed; A, B, C and E are orientated at various points around the wind farm whilst gate D measures the traffic flow to and from Ramsgate and the wind farm. The plots of these gates are shown in **Figure 33** and **Figure 34** as constructed from December 2016 to February 2017 AIS data.

Gates A and E show the inshore traffic route of the existing wind farm. Much of the traffic in Gate A is clear of the extension, whilst a greater proportion of Gate E traffic passes through the western boundary. The difference in total number of vessels passing through Gate A and E highlights the number of vessels dipping down to NE Spit Pilot station and Margate Roads anchorage without passing to the south west of the wind farm. There is also a strong concentration of traffic to the far west of Gate E, likely reducing the distance travelled to Margate Roads anchorage.

Gate B shows a route between the wind farm and South Falls, with no dominant distribution in traffic. Much of the traffic in this gate is clear of the extension. Gate C gives the distribution of the east-west route, to the north of the wind farm. There are two general routes of traffic converging here, but the presence of the Cardinal mark is keeping vessel traffic clear of the extension footprint.

Gate D, shown in **Figure 34**, is mostly the routes of wind farm service vessels and pilot boats from Ramsgate.

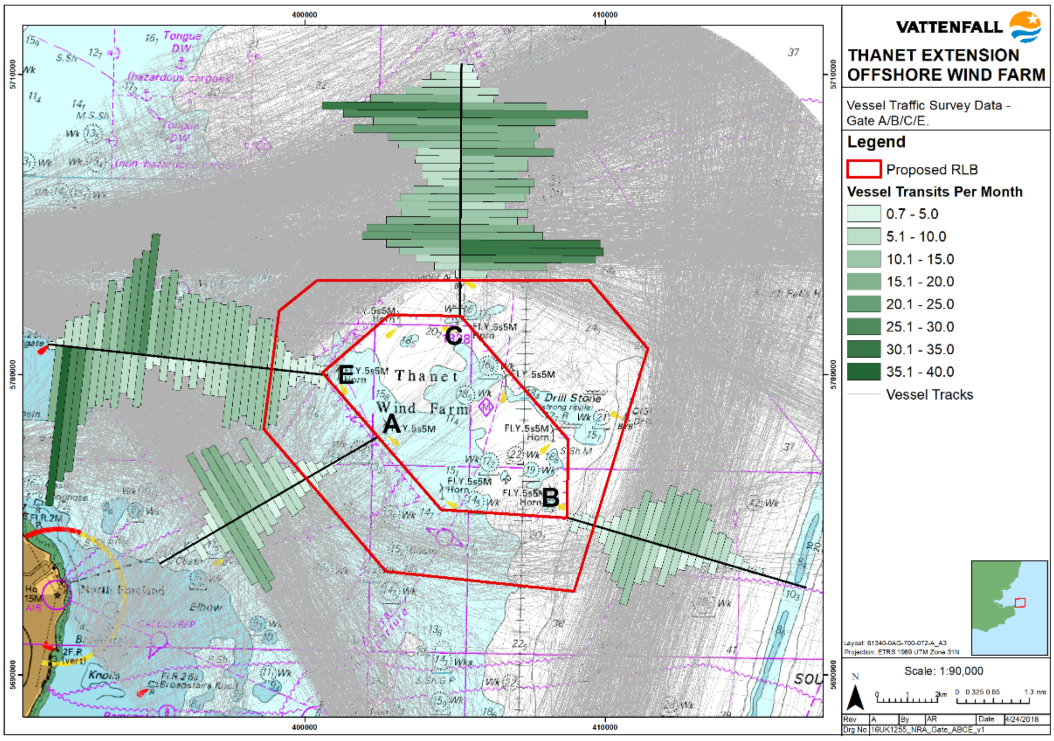

Figure 33: Gate Analysis for A, B, C and E.

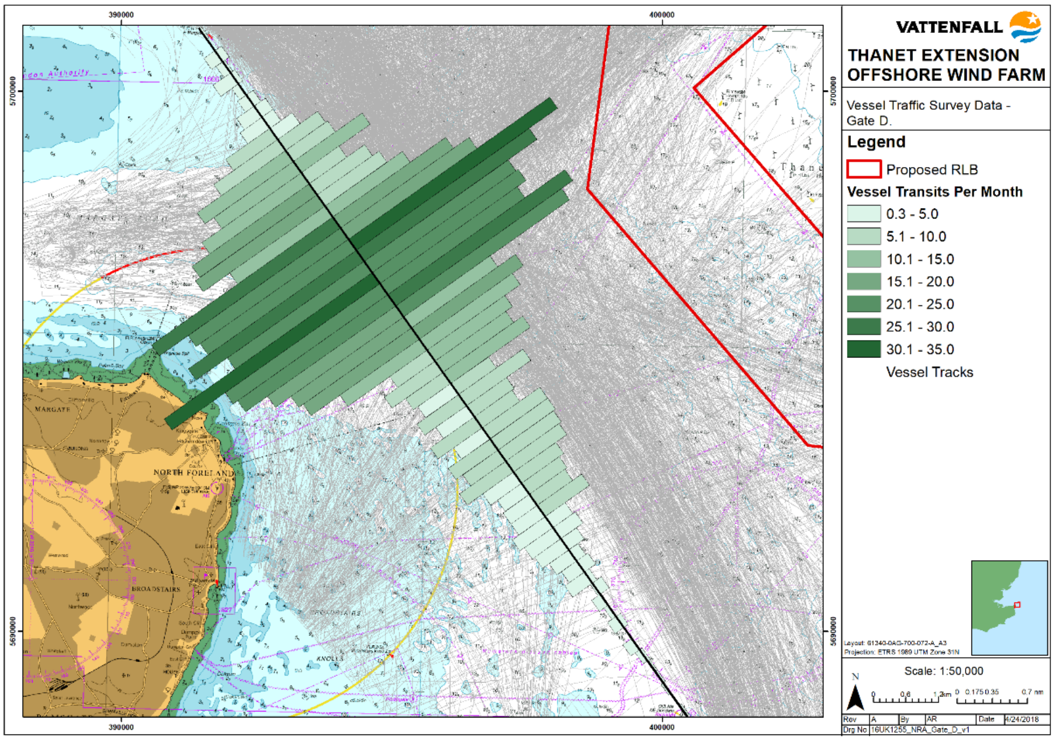

Figure 34: Gate Analysis for Gate D.

To better understand the types of vessels captured in these gates, some descriptive analysis has been undertaken. **Figure 35** gives the distribution of transits per day by vessel type through each gate. Gates A and B have approximately 10 transits per day, whilst Gates C, D and E are busier and have between 25 and 30. Cargo vessels make up the largest proportion of transits for all gates, with the exception of Gate D which captures the flow of pilot boats and wind farm service vessels from Ramsgate.

Figure 36 and **Figure 37** reflect this same trend with Gate D having proportionally faster transits (at 24 knots) and of smaller vessels than the other gates. The transits of other vessels through the gate is approximately 12 knots and they are between 75 and 150m LOA.

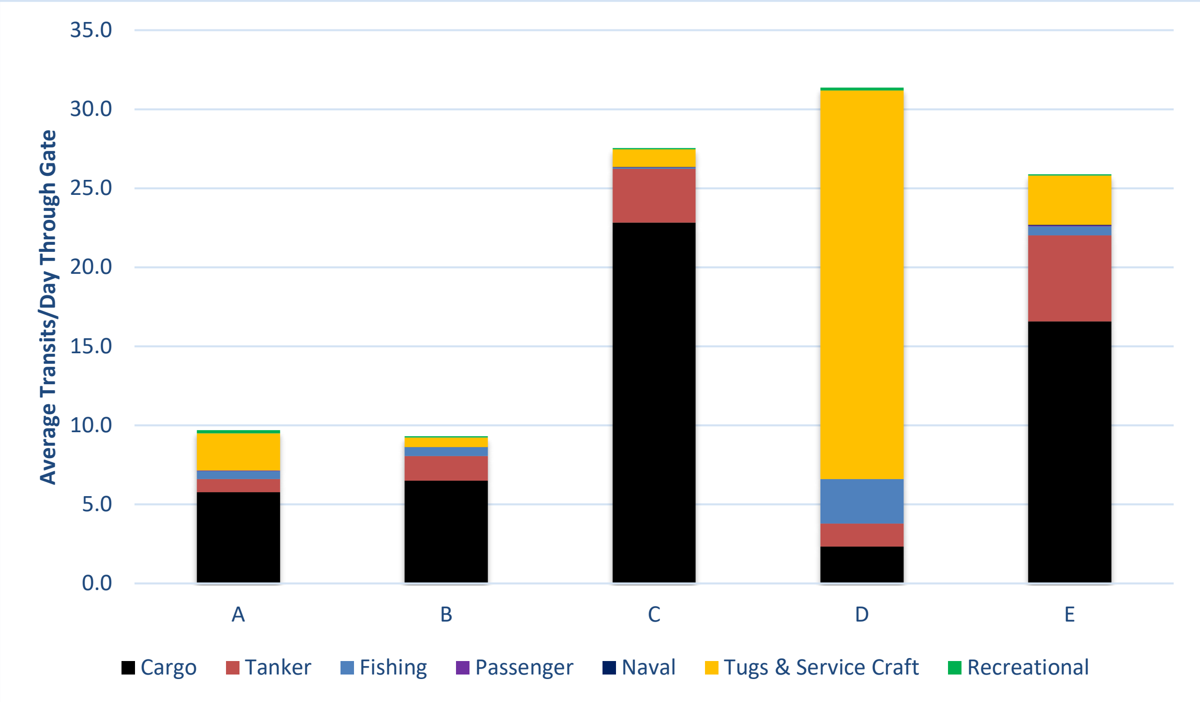

Figure 35: Transits of vessels by type through Gates.

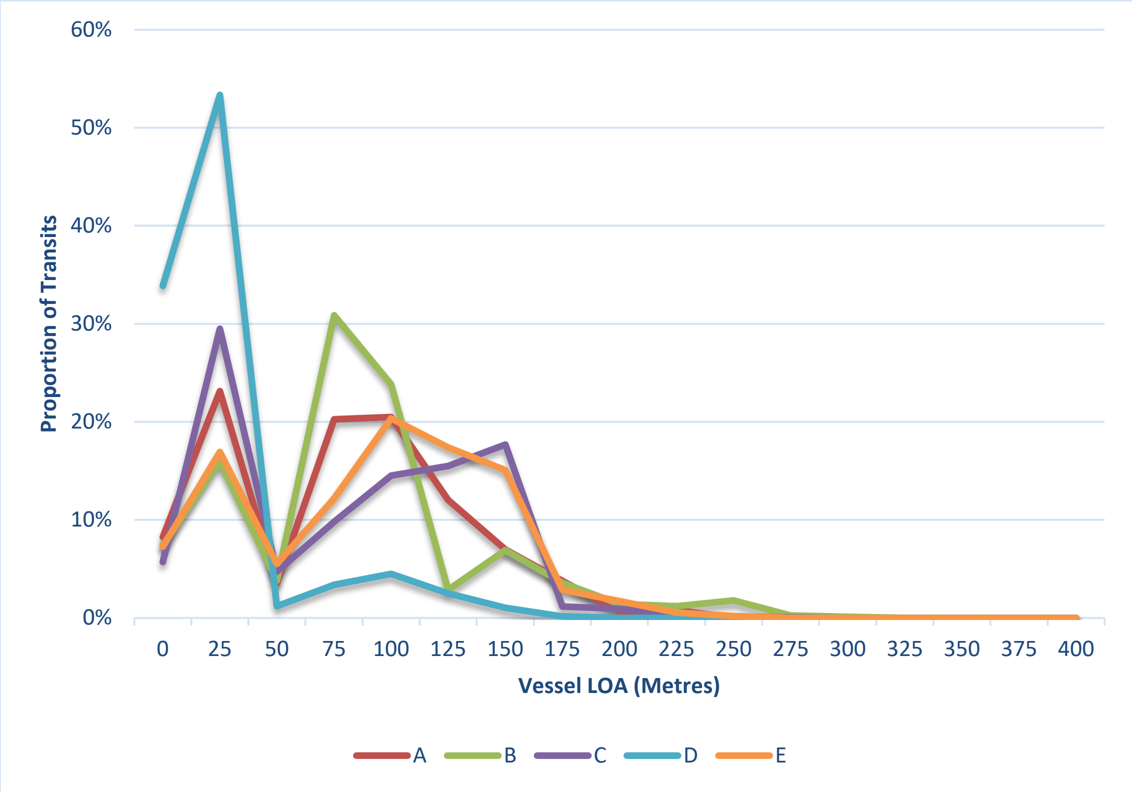

Figure 36: Vessel transits by size through each Gate.

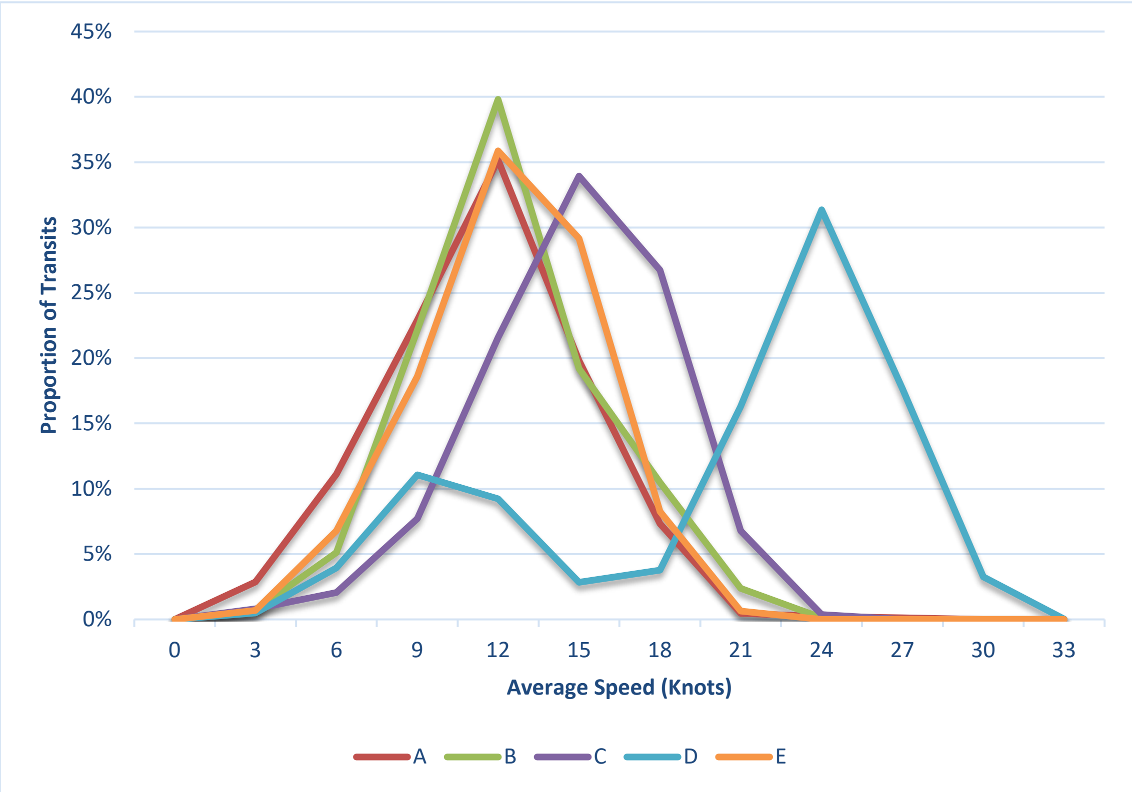

Figure 37: Vessel transits by speed through each Gate.

5.6 SEASONALITY

The number of transits from the winter and summer vessel traffic surveys, through each of the analysis gates, are compared in **Figure 38**. There are consistently more transits in summer than winter, however the difference varies significantly by gate. The greatest differences are evident between the inshore gates (D and E) with more fishing and recreational craft, who are not draught restricted, active during this season. There are also significantly more maintenance vessels active between Ramsgate and the wind farms during this period (Gate D). Offshore routes (A/B/C) have a relatively steady number of transits, with commercial vessels less affected by seasonality.

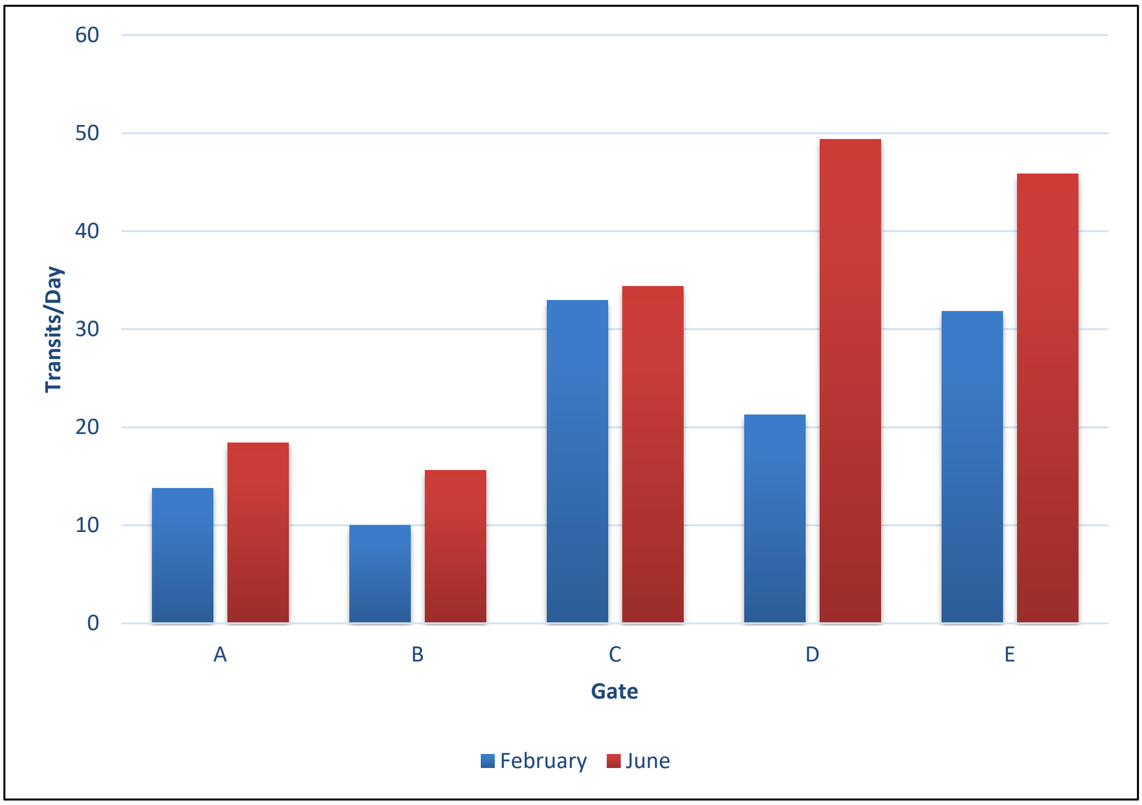

Figure 38: Seasonality of transits through Gates.

5.7 HISTORICAL INCIDENTS

5.7.1 MAIB Dataset

An analysis of historical marine incidents within 5nm of Thanet Extension is shown in **Figure 39**. The majority of incidents in close proximity to the TOWF are near misses, mechanical failures and accidents to persons.

Figure 40 shows the frequency of incidents per year within 5nm of the wind farm. The principal incident type is mechanical failures on board ships and hazardous incidents (near misses). There are few navigational incidents (collisions, contacts and groundings) during the 18 years of incident data, with approximately one of these incidents every 2 years on average. Three collisions were recorded in the dataset one involving two tankers and two collisions involving fishing vessels and yachts, neither of which resulted in injuries. This gives a collision return period across all vessel types of one collision every 6 years.

A notable near miss occurred in 2009 when the *Maersk Nottingham* lost all power, including to her anchors, just to the north of the Thanet construction site. Tugs used for the construction of the wind farm were required to assist the vessel before it contacted with the WTGs.

Several incidents were described anecdotally during consultation which are not contained in the MAIB dataset. This includes two contacts between navigating fishing vessels and WTGs at the Thanet site, both of which resulted in only a glancing blow.

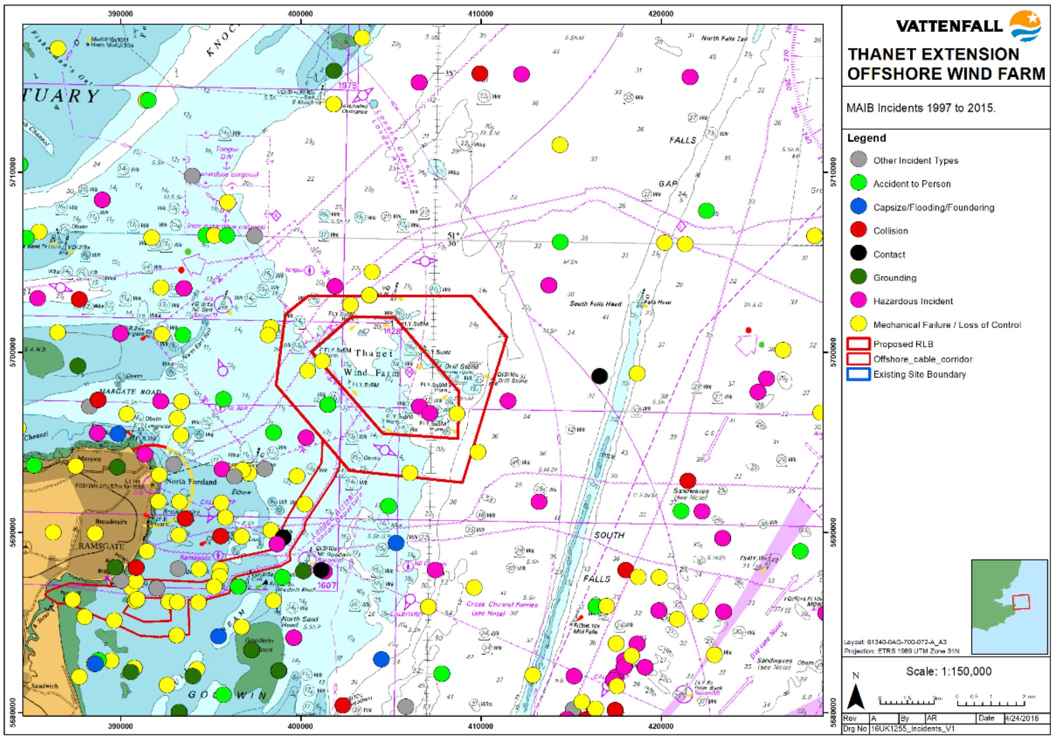

Figure 39: Location of MAIB reported navigational incidents, 1997-2015.

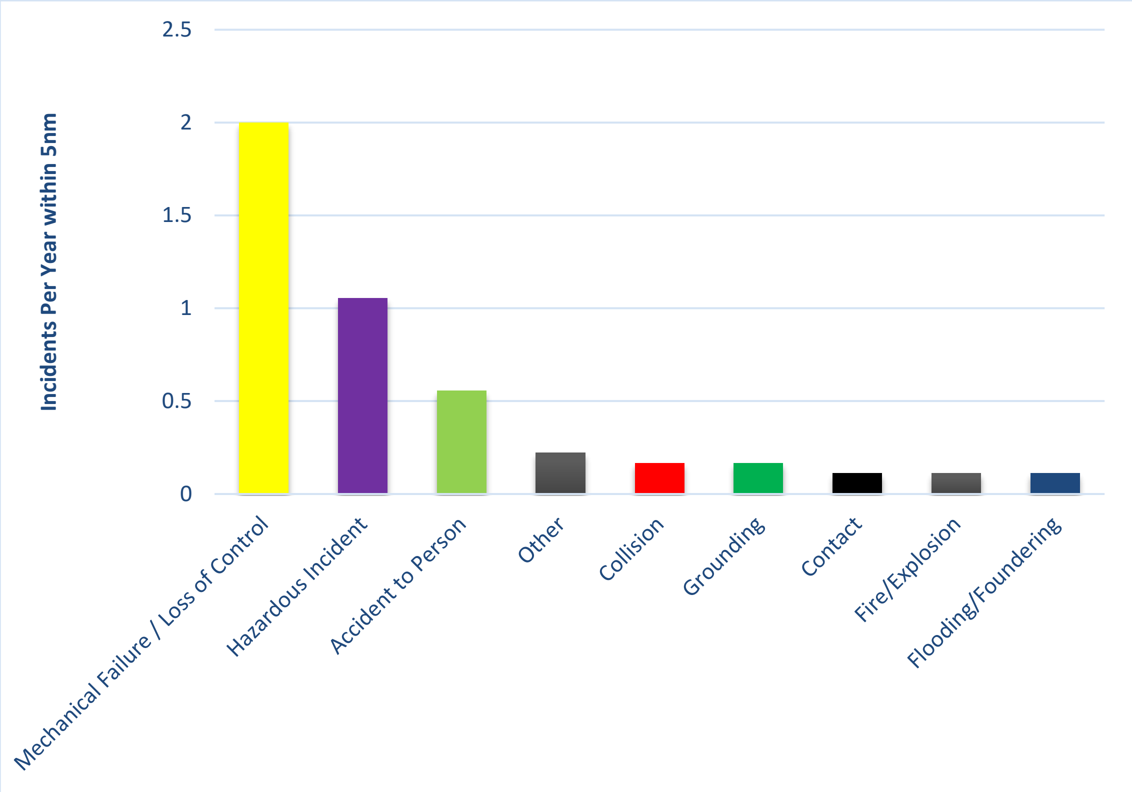

Figure 40: Incidents by incident type.

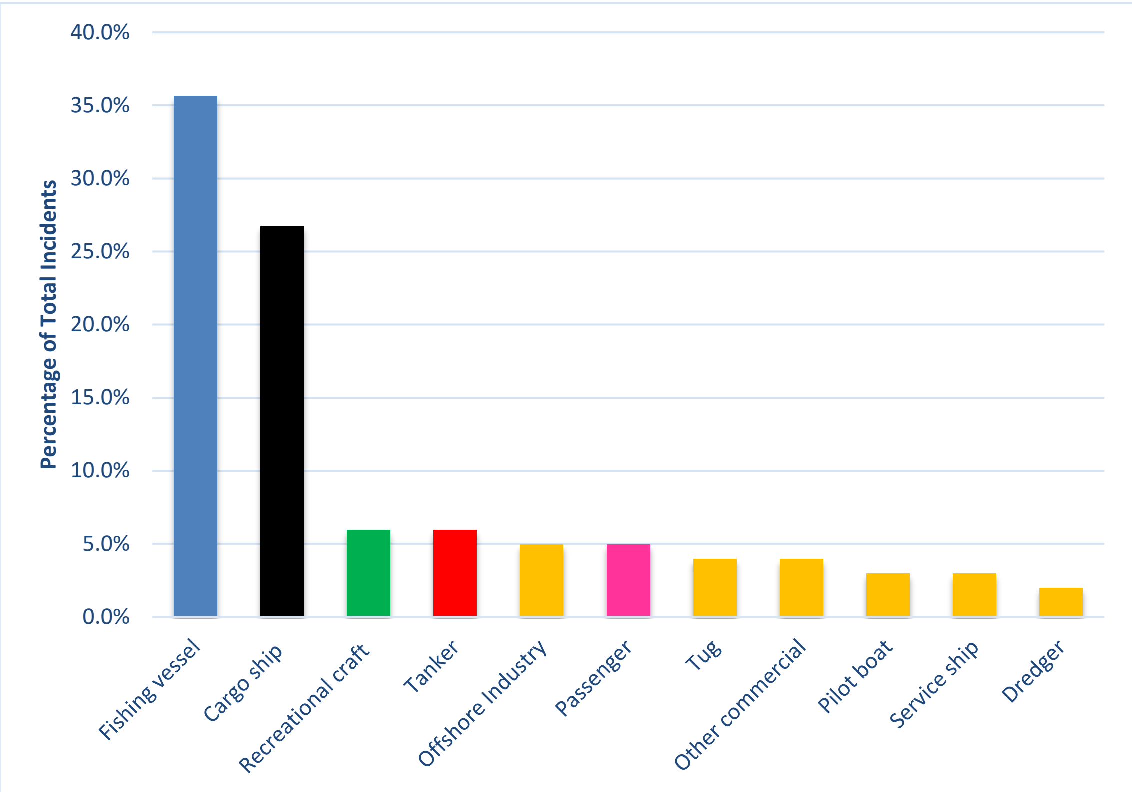

Figure 41: Incidents by vessel type.

Figure 42 shows the seasonal distribution of incidents, with no discernible seasonal pattern.

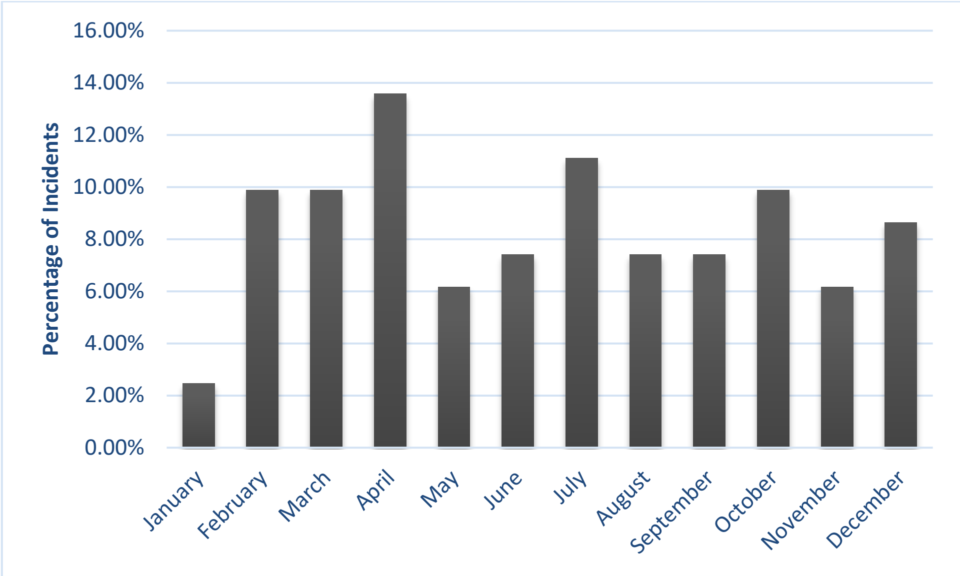

Figure 42: Incidents by month.

5.7.2 National Incidents

A summary of serious historical incidents, that resulted in either reportable damage or injuries, involving offshore wind farms was undertaken as part of the NRA for Hornsea 3 (Dong Energy, 2017). The review found 13 incidents, two collisions and 11 contacts, involving wind farm support vessels or WTGs over 11 years of data. The collisions involved a project guard boat in Ramsgate and a third-party catamaran, and a wind farm vessel and a floating hotel. All of the contacts involved a support vessel and a turbine with the exception of one incident involving a fishing vessel and a turbine.

There has been approximately 150 years of operational activity across all UK wind farms (as measured since their commissioning) since 2005[4]. This gives a serious collision rate of one collision per 75 operational years and a serious contact rate of once per 13.6 operational years.

[4] For example, a single wind farm operational between 2005 and 2015 has had 10 years of operation. Two wind farms operational for the same period have a total of 20 years of operation.

6 FUTURE TRAFFIC PROFILE

To understand how the vessel traffic profile may change during the life cycle of the project, an analysis of the national and local shipping statistics was conducted.

6.1 NATIONAL TRADE STATISTICS

Figure 43 shows the freight moved through the UK's major ports between 2000 and 2016. The data shows a general decrease from approximately 550 million tonnes in 2000 to 480,000 tonnes in 2016, albeit with the sharpest decline in the years 2007-2009. This downturn is the result of numerous factors, including the economic recession and the decline of the UK manufacturing industry. Concurrently, there is a shift towards ever larger vessels operating to take advantages of economies of scale, which reduces the number of vessels calling at ports given the same freight throughput.

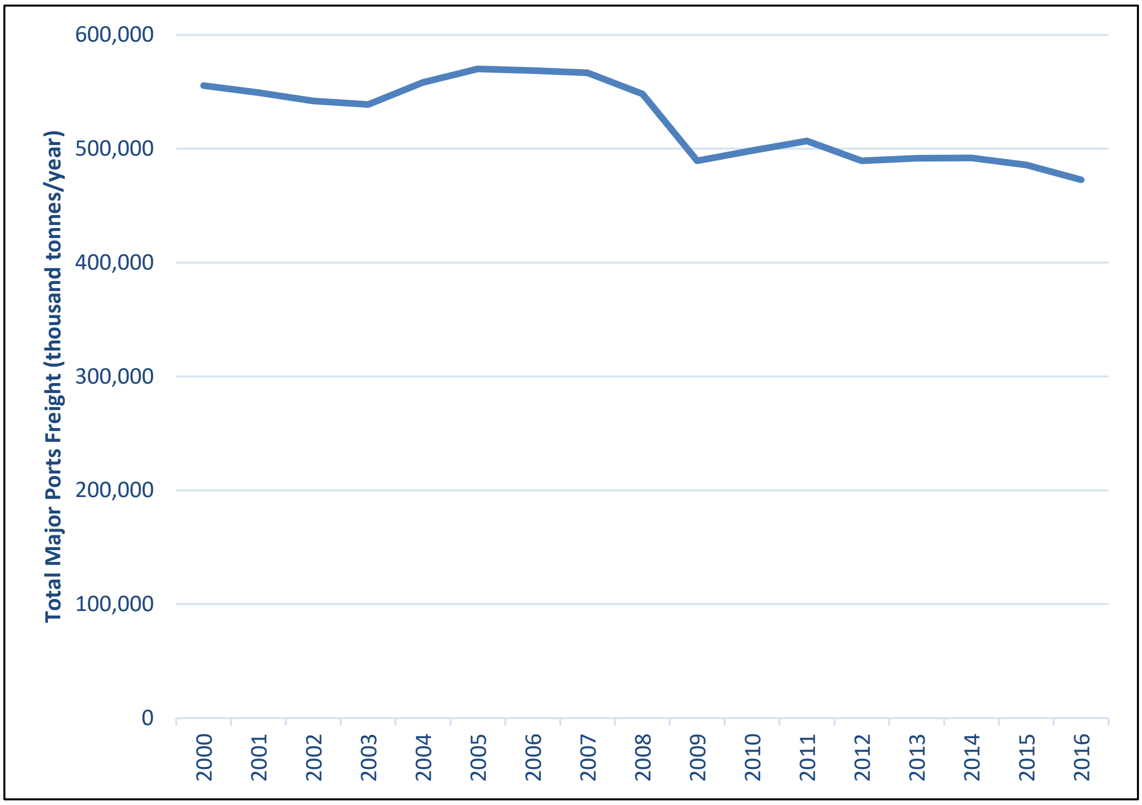

Figure 43: Freight movements in Major Ports between 2000 and 2016.

6.2 LOCAL STATISTICS

Figure 44 shows the total freight moved through the Ports of London, Ramsgate and Medway. Whilst the ports all show a decline prior to 2010 during the economic downturn, there is a notable upturn in the Port of London in recent years. The PLA's Thames Vision project (PLA, 2015) forecast trade growth until 2035 and concluded that during the life of the project, inter-port trade will increase from 45 million tonnes to between 56 and 93 million tonnes per year. The PLA set a 20-year target to increase trade to between 60-80 million tonnes per year and have identified a strategy to achieve this; including increasing private investment, and improving navigational and terrestrial access to the port

The growth target set by the PLA, coupled with the trend towards larger vessels, may result in fewer vessels using the inshore passage to the south west of the TOWF. Given the draught restrictions from the relatively shallow depth of water around Margate, much of the increased trade may be required to pass to the north of the existing wind farm or through the Sunk TSS.

Ramsgate has experienced a significant decline in commercial movements, with the suspension of the Ro-Ro ferry in 2013. The port has since specialised in the offshore renewables industry with smaller vessel movements such as crew transfer vessels markedly increasing the number of small traffic movements in and out of the port. During consultation, it was identified that a master plan for Ramsgate is being developed that would increase the number of commercial vessel movements during the life cycle of the wind farm. It is likely that this would not coincide with the construction phase of the extension and furthermore traffic will not be bound to the north, passing instead clear of the extension.

The global and national downturn in shipping is also reflected in the movement numbers through the Dover Straits. Analysis by Dover Coastguard identified that between 2009 and 2013, the number of reporting vessel transits through the south-west traffic lane declined from 39,096 to 35,551 (MAIB, 2014).

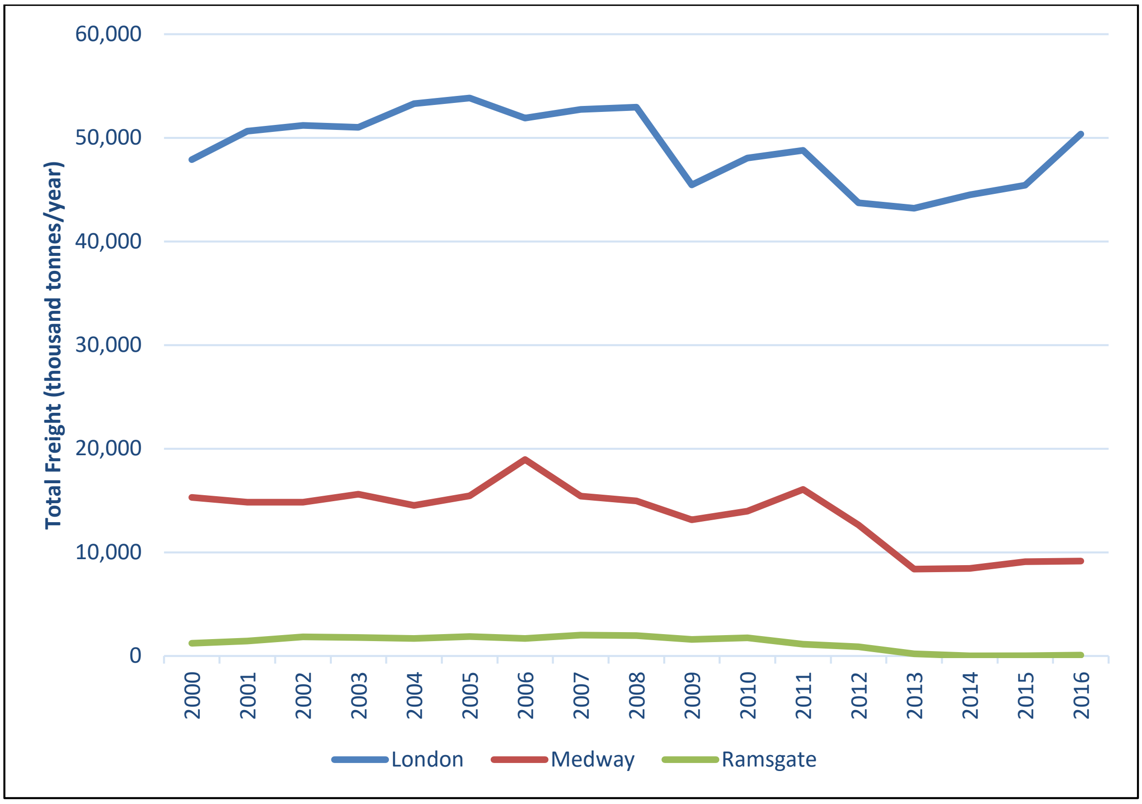

Figure 44: Freight movements in Thames Estuary between 2000 and 2016.

6.3 SUMMARY

An analysis of the national and local statistics of vessel movements shows that there has been a recent downturn in the shipping industry across all metrics. Predicting trade patterns over a 20-year period involves much uncertainty, however based on the data analysed it is concluded that whilst there may be a reduction nationally in maritime trade, this will be offset by a localised increase at the Port of London, albeit with fewer but larger vessels. For the purposes of this assessment, it has been included to assess against a predicted 10% increase in commercial vessel activity and a steady increase in the number of fishing and recreational vessels activity.

7 IMPACT OF THANET EXTENSION

The following impacts have been raised by stakeholders, which due to their significance, have been discussed in detail.

Table 9: Impact Assessment.

Section	Impact	Raised by
7.1	Impact on Vessel Traffic Routeing	MCA, PLA, THLS
7.2	Impact on pilotage operations	MCA, THLS, PLA, ESL
7.3	Impact on collision risk	MCA, PLA, THLS
7.4	Impact on contact/grounding risk	MCA, PLA
0	Impact on risk to inter-array and export cable risk	MCA, TFA
7.6	Impact on navigation during cable laying	Port of Ramsgate, RTYC, TFA
7.7	Impact on SAR	MCA
7.8	Impact on visual navigation and collision avoidance	MCA, THLS
7.9	Impact on communications, radar and positioning equipment	MCA
7.10	Cumulative and In-Combination Impacts	MCA

7.1 IMPACT ON VESSEL TRAFFIC ROUTEING

The proposed extension would require a change to the routeing required by vessels in the southern Thames Estuary and this was highlighted as a concern during consultation.

7.1.1 Impact of Existing Thanet Wind Farm

To better understand how the extension may influence vessel traffic routeing, a comparative analysis was undertaken of historical data collected prior to the existing TOWF. This formed part of research on the impact of wind farms on vessel traffic presented at the “International Workshop on Nautical Traffic Models” in 2015 and published in an academic journal (Rawson and Rogers, 2015).

Figure 45 shows the tracks of vessels prior to the construction of the original TOWF. The most notable change is the Ramsgate ferry route which ceased operation, however the plot demonstrates how vessel traffic has adapted to the presence of the existing wind farm. When compared to **Figure 46**, which shows the key routes used by commercial traffic in the study area, many of the routes have not been altered significantly. For example, the inshore route to the west (4), offshore route to the east (2) and parallel route to the north (1/3) have not significantly altered. Two key differences are that traffic passing north-south through the wind farm would have been offset to the east, through the introduction of the Drill Stone Cardinal, and that vessels using the NE Spit Pilot Station are no longer able to transit through the wind farm and must divert around it.

The research also considered how far vessels choose to pass from a wind farm using historical analysis and a literature review. In summary, the evidence suggests that a 0.5nm buffer is the minimum safe distance considered acceptable by ships masters to pass a wind farm, to allow sufficient time and space to manoeuvre safely and deal with an emergency.

7.1.2 Impact of Thanet Extension

Using the evidence from the Thanet wind farm and previous research at other locations, vessel traffic routes were realistically diverted around the extension. **Table 10** shows the approximate distance travelled per route before and after the proposed extension within 5nm, excluding those vessels taking a pilot or choosing to anchor. The results suggest that whilst the proposed extension would offset vessel traffic routes, the increase in distance travelled would be minimal. If the master of a vessel was uncomfortable with the available sea-room to the west of the development (route 4), then a vessel coming from the Dover Straits to the Princes Channel and having to pass to the east and then north, as opposed to the shorter route, would increase their transit distance from 14nm to 25nm, an increase of 78%. However, the impact on vessel routeing distance of the proposed extension would be minimal compared to the total length of the route taken by the vessel, from origin to destination.

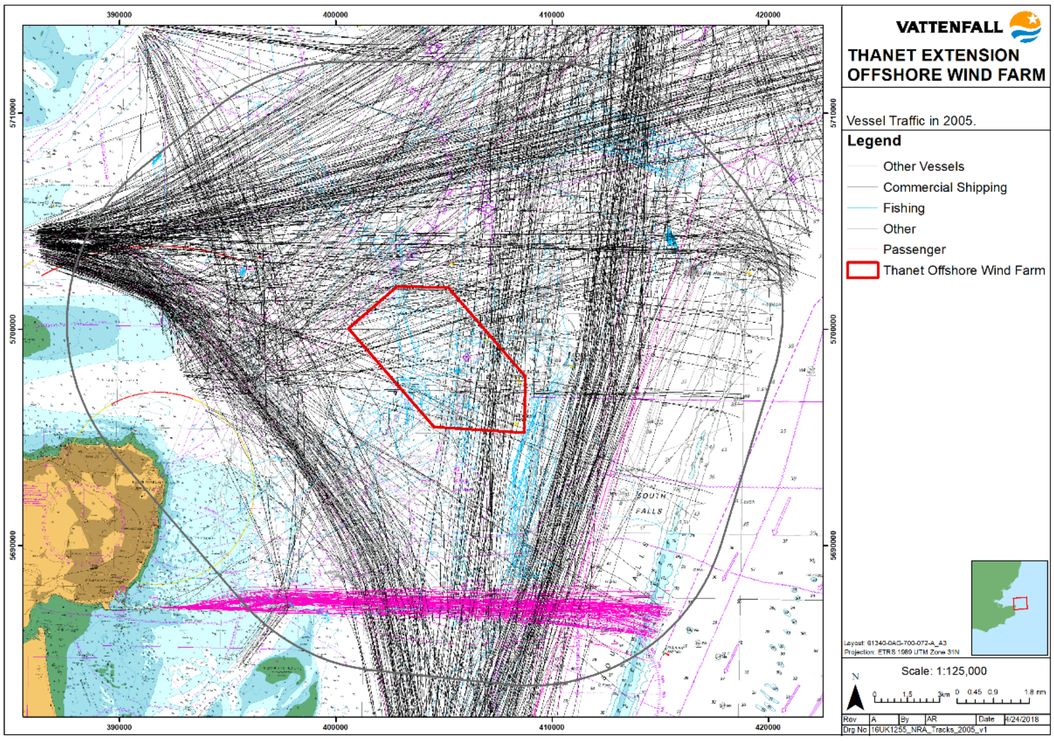

Figure 45: Vessel traffic in 2005.

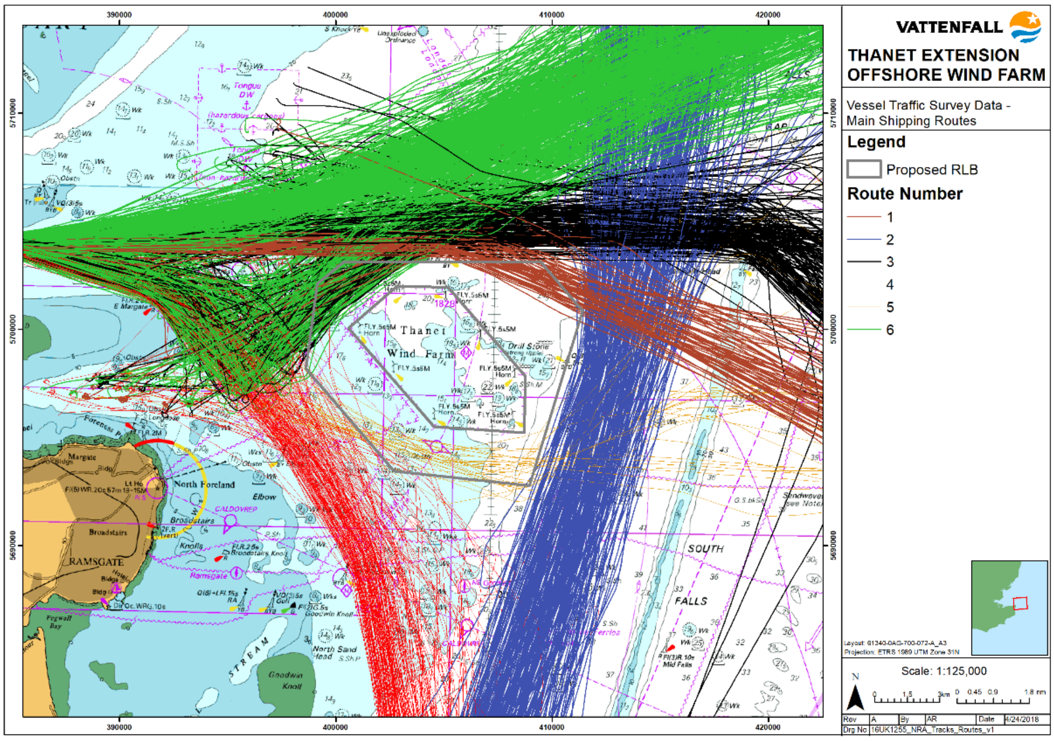

Figure 46: Key commercial shipping routes identified (2017).

Table 10: Description of key shipping routes and distance travelled within 5nm of the extension.

Route	Description	Transits/ Year	Distance of Current Transit (nm)	Distance of Predicted Transit (nm)	Change (nm)	Total Increase Distance for all Vessels
1	Princes Channel to Belgium/Netherlands (north of Thanet)	1,200	18	18	+ 0	0
2	North/South route to east of Thanet	3,600	15	15	+ 0	0
3	Princes Channel to Belgium/Netherlands (north of Thanet)	2,760	17	18	+ 1	2,760 (5.9%)
4	Princes Channel to English Channel	3,840	14	15	+ 1	3,840 (7.1%)
5	Princes Channel to Belgium/Netherlands (south of Thanet)	600	18	21	+ 3	1,800 (16%)
6	Princes Channel to North Sea	6,360	14	14	+ 0	0

A further impact on vessel routeing which is not related to distance is bad weather routeing taken by ships. The MetOcean analysis in **Section 3.3** shows the propensity for gales, particularly south westerlies and therefore vessels may pass close inshore near North Foreland to provide good shelter. During bad weather, smaller vessels may take shelter in the Margate Roads anchorage where there can be up to 20 vessels anchored. Vessels may choose to pass inshore of the wind farm during bad weather to take advantage of the lee, however the draught limitations will prevent the largest vessels from doing so. This may result in some temporary increases in smaller commercial vessels in this area, and therefore the increase in distance travelled, at this time, however the largest vessels that call at London are unlikely to be affected.

The Dover Straits Inshore Traffic Zone exists to the south west of the project area. Vessels joining or leaving the scheme will feed into the traffic flow in routes 2/4 above. As such, the extension will not restrict access to the scheme.

In summary, the wind farm may require vessels to alter their routes but the increased distance travelled would not be significant.

7.1.3 Transits of Tidally Constrained Vessels

During consultation, it was identified that the route inshore of the Extension is limited by depth and therefore the activities of vessels might be concentrated at and around high water. This would mean that the congestion and risk to navigational safety at these times would be much greater than if the transits were spread out across the day, and would therefore have a bearing on the risk assessment.

To test this, analysis was undertaken to compare the proportion of concurrent transits with the height of tide. The transits through Gate C (see **Section 5.5**) were extracted and filtered by hour to identify how many transits of cargo and tanker transits took place each hour. **Figure 47** shows the frequency distribution of the results across the study period. For nearly half of the hours in this period, no cargo or tanker transited and for 34% of time only a single vessel was recorded. For the remaining 20% of the time, the likelihood of concurrent transits gets less and less common, with on four occasions five vessels transiting at the same time.

To understand whether this relationship is as a result of the height of tide, the height per hour for this period was extracted from Admiralty Total Tide. The average height of tide per one, two etc. concurrent transits was calculated. The results show that between none and three concurrent transits, the average height of tide changes very little. On the six occasions in December 2016 when there were four or more concurrent transits, the height of tide was shown to be much greater however given that this accounts for less than 1% of the month its impact is not considered significant.

To some degree vessels are scheduled into similar time periods to allow for pilot transfers to take place on more than one vessel per trip but the numbers of vessels and the frequency of occurrence shown in this analysis is not significant.

Figure 47: Concurrent Transits per Hour of Cargo/Tanker vessels.

7.2 IMPACT ON PILOTAGE OPERATIONS

A key impact described by a number of consultees is that of the feasibility of conducting pilot transfers at NE Spit. A more detailed review of this impact has been considered in the following two documents and therefore only a summary is provided below:

- Thanet Extension: Pilotage Study Technical Note (PEIR Volume Annex 10-1); and
- Thanet Extension Offshore Wind Farm: Pilotage Simulation Study Technical Note (ES Volume 4, Annex 10.3, Document Ref: 6.4.10.3).

These studies were produced against the previous RLB proposal and the results reflect the greater loss of sea room than that being proposed for the development (see **Section 1.1**).

Section 3.4.1 gives a description of the requirements and activities of pilot vessels and **Section 5.3.5** shows the tracks of pilot vessels operating from Ramsgate. As has been described, for vessels inbound to or outbound from the Princes Channel, NE Spit is the principle pilot station and is used on average 16 times per day. A deep-water pilot station at Tongue to the north is available but is rarely utilised.

Given the variability in conditions and circumstances that dictate where pilot transfers would take place, analysis was undertaken to identify the spatial extent of pilot transfers at NE Spit and is shown in **Figure 48**. The vast majority are undertaken around the pilot station, with a small number extending into the boundary of the wind farm extension. The lateral space for pilot transfers at NE Spit is approximately 4.5nm at present, which would reduce by approximately a quarter to 3.3nm with the extension in place.

Therefore, with the reduction in sea room, there are two possible impacts which could result following the extension:

- Either NE Spit continues operating with a reduced sea room; or
- NE Spit is no longer practicable and alternative pilotage arrangements are required.

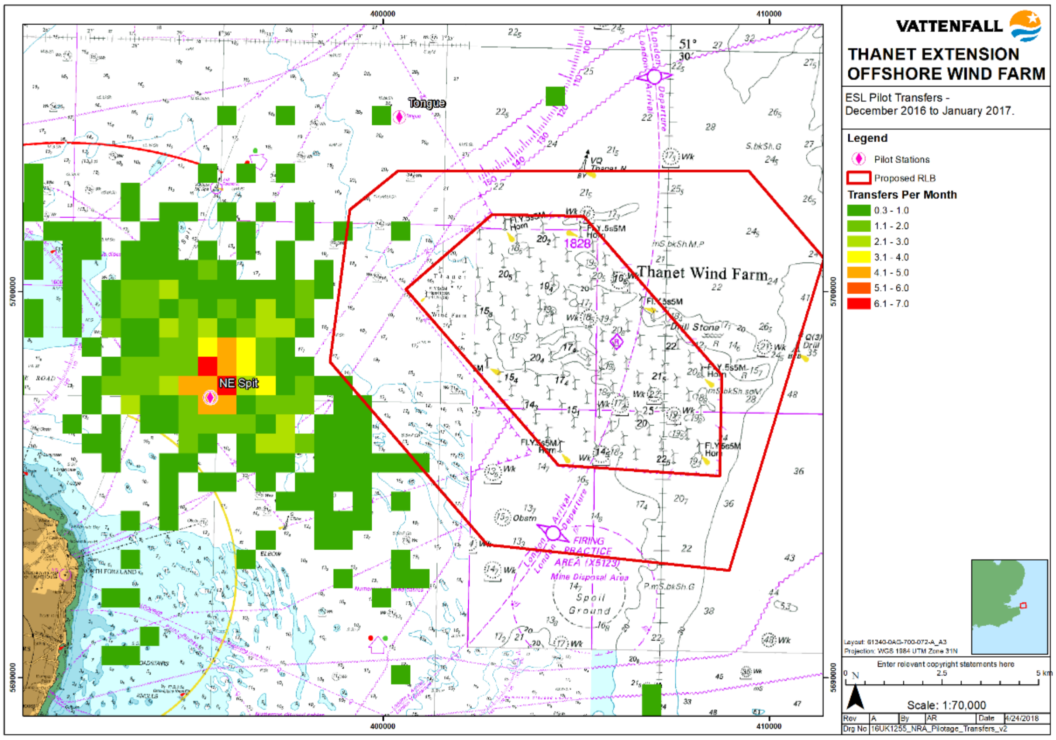

Figure 48: Location of Pilotage Operations at NE Spit.

7.2.1 Previous Relocation of NE Spit

During discussion with stakeholders, it was asserted that to accommodate the original TOWF (proposed in 2005, commissioned in 2010), the NE pilot station was moved to its current location and positioned so as to best maximise navigable space, being approximately 2nm from all hazards. **Figure 49** and **Figure 50** show two extracts from Admiralty charts taken from 2000 and 2005 respectively, when compared to the latest charts referenced in this report, it can be seen that NE Spit pilot station has remained relatively static relative to its position east / west to the cardinal marks at Margate sands.

Figure 49: Extract from MAIB Report 35/2000.

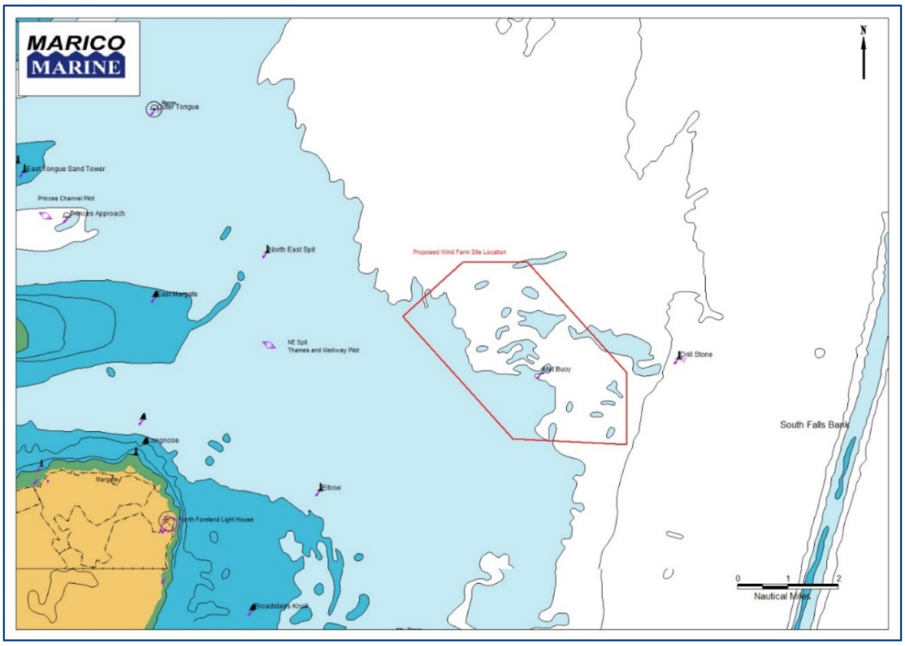

Figure 50: Extract from Thanet Wind Farm NRA (2005).

7.2.2 Continued Operation of NE Spit

As discussed, the Extension would reduce the available sea room for pilotage, however there would still be at least 3nm of space. At an early stage, it was identified that pilotage operations are conducted around the world, and within the UK, with similar or less space than would result at NE Spit, albeit under different operational conditions and environments.

Therefore, to test whether pilotage could still be safely conducted at NE Spit with the extension in place, a simulation study was conducted with the PLA and ESL. An overview of this study has been described in **Section 4.1.2**. This study was conducted with the full RLB layout, prior to the reduction to the west, and therefore is conservative in nature.

A setup day on the 15th September 2017 was used to define scenarios to be tested, including environmental conditions and vessel types. Two days of simulation runs was held on the 20th to the 21st September at the PLA's simulator in Gravesend. The simulation was attended by four PLA pilots and ship masters as well as two ESL pilot launch coxswains. For each scenario, a briefing was held on the conditions, and the PLA pilot and ESL coxswain located in two simulator bridge rooms, communicated their proposed plan for pilotage transfer. The vessel was directed onto the required course and speed and the pilot launch manoeuvred alongside with approximately two minutes for transfer. Each simulation was considered complete when the ship had recovered its inward or outward-bound heading and a debrief held. The scenario was graded as either successful, marginal or a failure against agreed criteria, such as distance to wind farm boundary or shallow waters, proximity to other vessels (background traffic was modelled in each scenario) or loss of control.

14 scenarios were tested across five vessel types between 35m and 240m (including Ro-Ros, container vessels, dredgers and tugs and tows). 13 of the 14 runs were successful with one judged as marginal due to the completed manoeuvre putting the vessel within 1000 yards of an anchored vessel in Margaret Roads. It was concluded that the reduction in sea room, as a result of the extension, did not compromise the feasibility of pilot transfers at NE Spit, however the reduction in sea-room changed the risk profile thereby reducing the margin for error. It was noted that the participants naturally undertook transfers further south in the simulation than is currently the case, maximising the space available.

Recognising the reduction in sea room and associated increase in risk it was agreed that additional measures may be necessary so as not to compromise navigational safety. Measures identified included improved coordination and situational awareness, training and a review of the regulatory measures at that pilotage station be conducted. These measures are discussed in more detail in

Section 8.5. However, with the reduction in the RLB proposed on that which was assessed (see **Section 1.1**), these risk controls have not been taken forward as recommendations given the significant operational cost on operators.

7.2.3 Possible Alternative Pilotage Options and Impacts

If it is deemed necessary to relocate the pilot station, there are two alternatives. These are:

1. Board pilots to the south of the wind farm, between Ramsgate and North-East Goodwin;
2. Board pilots near to NE Spit east cardinal, to the west of the wind farm and the Tongue pilot station.

Table 11 gives the increase in transit time to or from the pilot station options. When combined with the trip duration time analysis within **Section 5.3.5.**

Table 11: Comparison of distances and times between pilot stations from Ramsgate Breakwater.

Option	Name	Distance	Time (20kts)	Increase
Existing	North East Spit	6.5nm	19.5 mins	0%
1	North East Goodwin	6.5nm	19.5 mins	0%
2	Tongue	9.4nm	28.2 mins	45%

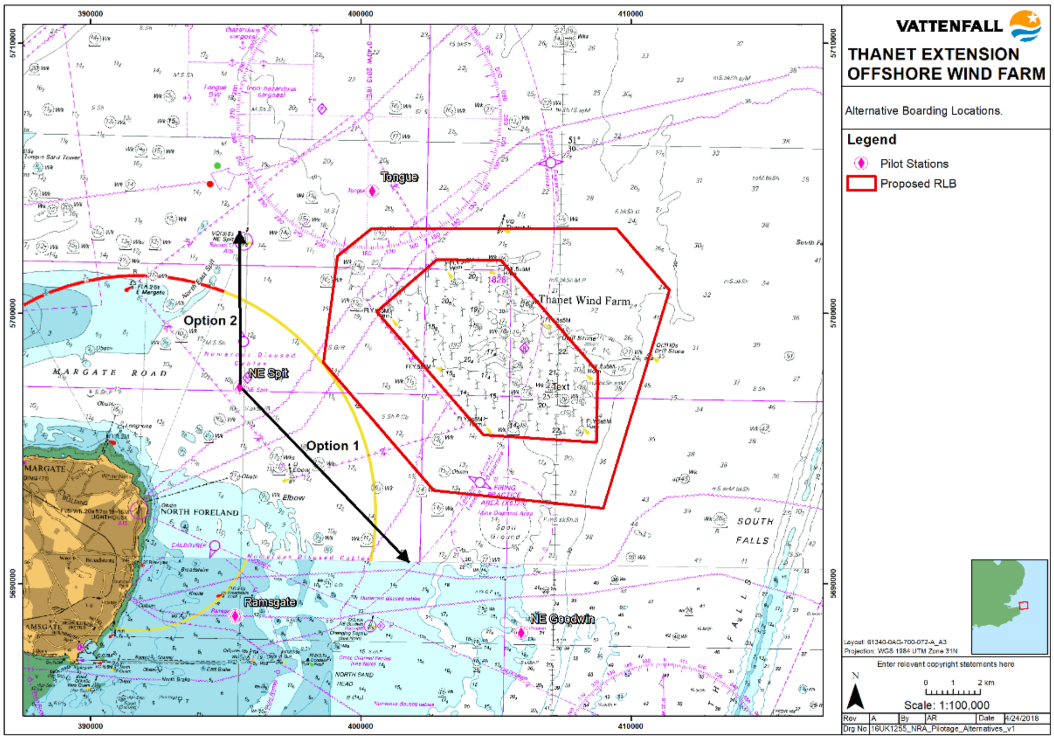

Figure 51: Alternative pilot stations.

Whilst Option 1 (south) results in no increase in transit distance or time for pilot vessels, it would increase the trip duration of a pilot once on board a vessel by 5nm in each direction (total of 30 mins per pilotage move) which may impact upon hours of rest and rostering. Furthermore, vessels approaching from the north east would be re-routed either through the Sunk or transiting to the east and then south of the wind farm as opposed to currently passing to the north and dipping into the pilot station. Option 1 is also located in less sheltered waters from the south west and this may make pilot transfers more hazardous, increase the proportion of time that it is off station or increase wear and tear on the pilot vessels. This however would have the advantage that vessels transiting inshore of the wind farm would be under pilotage, reducing the likelihood of an incident in this more confined waterway.

Option 2, located to the north west of the site is further from Ramsgate thereby increasing transit time and distance for pilots and pilot vessels. This may have hours of rest and maintenance implications for the pilots and pilot vessels respectively. Furthermore, it is possible that the increased distance and an increase in the vessel traffic profile may make pilotage operations with a single vessel untenable. A two pilot boat service may therefore be required.

Furthermore, as the boarding point at Option 2 is closer to the Princes Channel, there would be less time to conduct a master-pilot exchange. A further impact would be requiring vessels to pass the now constrained fairway, between the extended wind farm boundary and East Margate red lateral mark, without a pilot, having possible navigational safety implications. The proximity of this relocated station and the Tongue pilot station and anchorage is not considered significant given the greater available sea room than is currently the case with the existing wind farm.

Both alternative arrangements have the additional advantage that they are moved clear of this increasingly constrained fairway and allows for transfers to be taken away from the main passage of vessel traffic, which could hinder transfers in terms of both congestion and increased wash. However, there would be a significant administrative burden for several parties to obtaining the consents and undertaking due process for relocating the pilot station and it has not therefore been recommended as part of this study.

7.2.4 Summary of Impacts on Pilotage Operations

In summary, the analysis and simulation has shown that pilotage operations would be feasible with the extension in place, albeit this would increase the risk of an incident by reducing the margin for error. This increase in risk would however remain within the ALARP range. Risk control options have been identified to reduce this risk, many of which should be considered with or without Thanet

Extension. Whilst this assessment has shown that pilotage would still be feasible with the extension in place, several stakeholders remain concerned about the risk of these operations, pilot transfers could be transferred to alternative locations or management practices changed but this would incur significant operational impacts and so have not been taken forward as recommendations. To mitigate this impact, the project has reduced the RLB of the development to open up the available sea room in the western corner both for pilotage transfers and transits.

7.3 MODELLING OF IMPACT ON COLLISION RISK

A key concern raised by stakeholders was how the extension would impact upon collision risk, particularly where vessel traffic was funnelled between North Foreland and the western corner. To investigate this, collision risk modelling was undertaken through the development of a traffic simulation using the principles of domain analysis.

Figure 52 gives a schematic of the reduction in sea room the extension would impose between the wind farm and NE Spit shallows. At present, there is 4.3nm of available water between the limits of the wind farm and the most westerly transit of a vessel greater than 200m LOA in the dataset. If it is assumed that no vessel will transit within 0.5nm of the wind farm this gives 3.8nm of sea room between the wind farm and the furthest westerly transit. The original proposal for the extension would increase the footprint of the wind farm by 2nm, which with a 0.5nm buffer, gives a new sea room distance of 1.8nm, a reduction of 53%. With the revised Red Line Boundary, this increase is 1nm, giving a new sea room of 2.8nm, a reduction in total width of 26%. For a vessel bound for the Port of London, the most constrained aspect of that route is the Princes Channel at 0.5nm wide, albeit well marked and under pilotage.

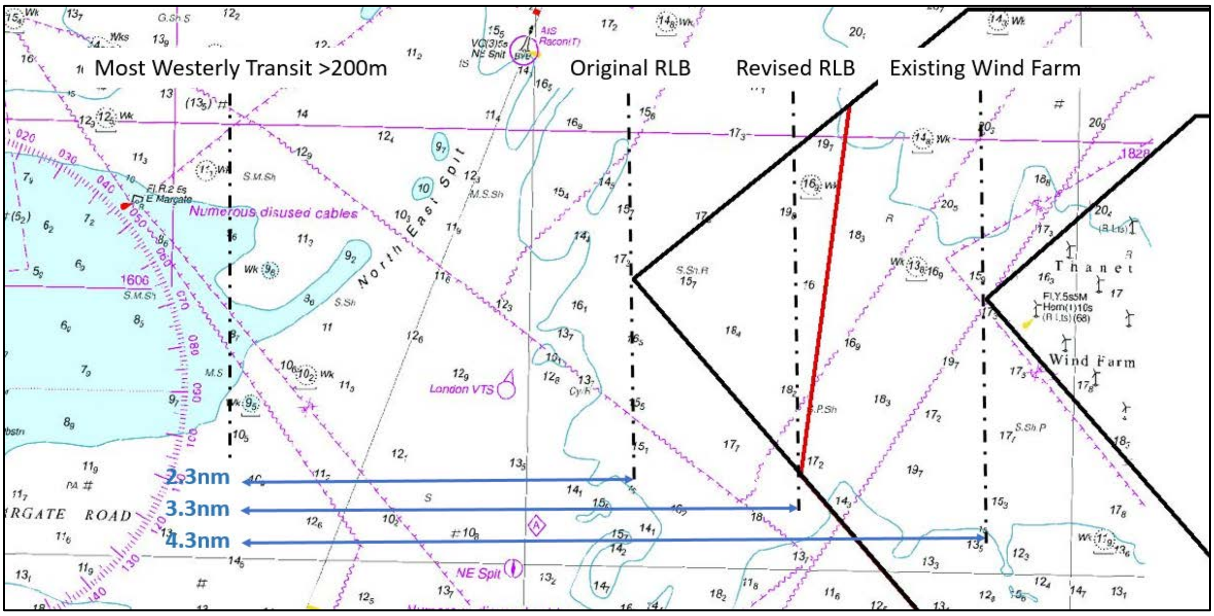

Figure 52: Schematic of sea room between extension and North-East Spit.

7.3.1 Methodology

Domain analysis reflects that all navigating vessels are attempting to keep clear of one another, in compliance with the collision regulations, and therefore have a comfort area around each vessel which they try to keep clear. This approach is widely used and discussed in the academic literature with Goodwin (1975) describing a vessel domain as "*the surrounding effective waters which the navigator of a ship wants to keep clear of other ships or fixed objects*" with the contravention of the respective domains between two vessels representing a threat to navigational safety (Pietrzykowski and Uriasz, 2009). Therefore, by running simulations of vessel traffic over long periods of time and looking at the frequency and locations of encounters between vessels, a measure of collision risk can be given. This model is an extension of the Thames Traffic Model developed to test collision risk for the Port of London (Rawson et al. 2014).

Whilst there is no objective definition of a domain, a suitable domain was constructed by consulting the academic literature and reviewing the passing distances vessels are typically taking in the study area as observed from AIS data. **Figure 53** shows a schematic of the domain used in this assessment. It consists of a two-minute vector of the vessels track multiplied by a manoeuvrability factor scaled by the vessel size with 200m as the baseline. Therefore, a 400m vessel would have a four-minute vector and a 100m vessel would have a 1 minute domain. A minimum distance of 30 seconds travel was set for the smallest vessels. Finally, the vector and vessel was buffered by twice the vessel length.

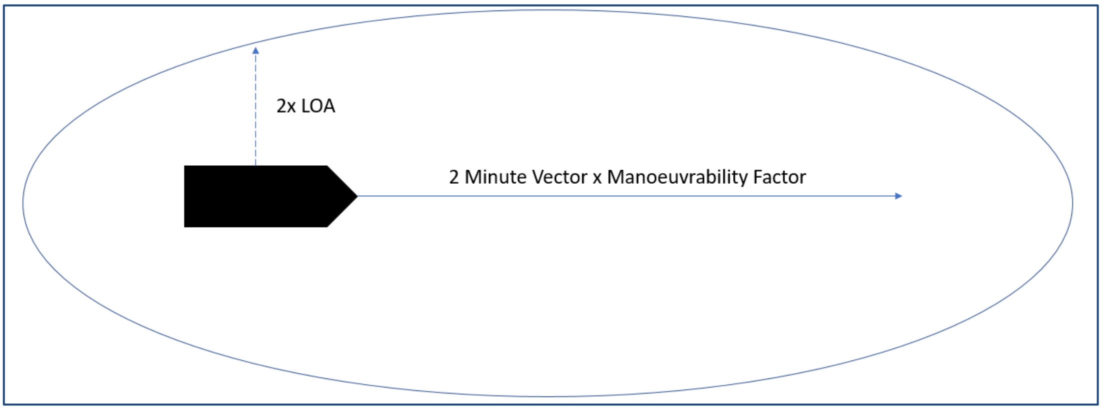

Figure 53: Domain Outline.

To test collision risk with Thanet Extension, a simulation was constructed at one minute intervals and domain analysis undertaken for a full month of AIS data (December 2016) and then again simulating how traffic would behave with the extension in place. The route characteristics and frequency of transit in **Section 7.1** were extracted and modified to pass clear of the proposed extension with a similar passing distance. The model was then run again to test how the number and location of encounters had changed, this is referred to as Scenario 1. A further scenario was tested in which vessels no longer used NE Spit unless they were transiting inshore of the wind farm, therefore assuming that NE Goodwin or Tongue pilot stations were more commonly used (Scenario 2). Once the RLB was revised to reduce the size of the western corner, the results were updated as Scenario 3.

Figure 54 shows a snapshot of the model underway with the red areas representing the vessel domains and the vessels to scale visible within them. Where two of these red areas intersect, an encounter was recorded. It should be noted that during the modelling process, vessels are not given intelligence to avoid one another and therefore some of the encounters which result would not occur in reality and are introduced purely as part of the modelling process. To account for this, a comparison was made of the difference in the baseline results and the modelled results in areas away from the extension to gauge what proportion of encounters are affected by this. The results suggest that approximately a third of encounters occur as a result of this and a correction factor of 0.33 is therefore applied to the modelled results.

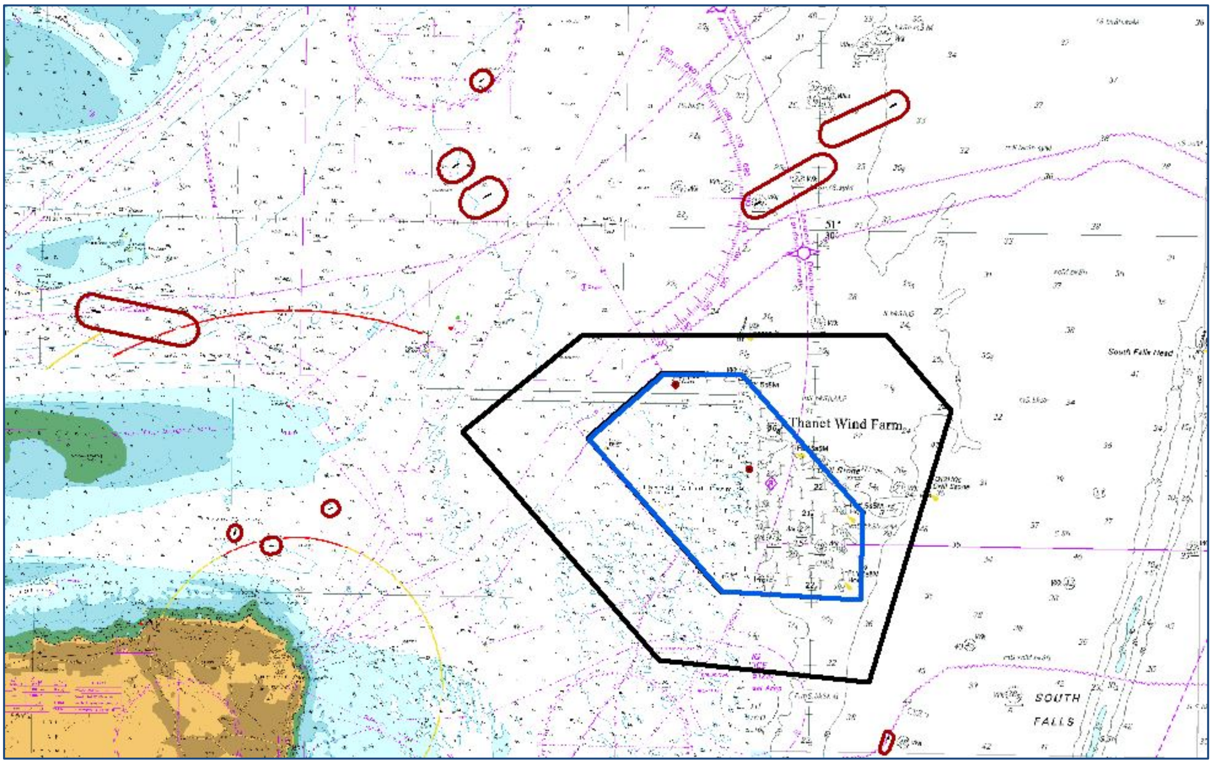

Figure 54: Snapshot of encounter model with original RLB.

7.3.2 Results

The results of the assessment are displayed in **Table 12** and **Figure 55**. The results suggest that the proposed extension of the wind farm with the revised RLB, without any additional traffic management or risk controls, would increase the collision risk within 5nm by 54%. This would increase a further 9% with the additional WFSVs operating to and from Ramsgate and the extension.

Scenario 2 tested the effectiveness of introducing a control on traffic flow around the site. In this case the increased use of Tongue as a pilot station rather than vessels diverting to NE Spit. This control was effective and reduced the risk by 23%.

The historical incident record suggests that one collision occurs every six years in 10nm of the development (**Section 5.7**). A 54% increase in likelihood would increase this rate to one collision every four years without risk controls in place.

Sensitivity testing was undertaken on the results by re-modelling the scenarios with a 5-minute vector rather than a 2-minute vector. The number of encounters increased, as expected with larger domains, however the ratio between the 2-minute and 5-minute results between the baseline and modelled scenarios was relatively consistent at 1.4 and 1.5 respectively. This indicates that the relative change in collision risk of the results is not sensitive to the size of the domain.

Table 12: Encounter results.

Scenario	Name	Encounters
Baseline	Present Day	246
S1	With Full RLB Extension as part of PEIR	403
S1b	With Full RLB + doubling WFSVs	440
S2	With Full RLB but Increased use of NE Goodwin and Tongue.	310
S3	With Revised RLB as part EIA	379

Figure 55 shows the location of where the encounters were recorded between the baseline scenario and modelled scenario 1, with the PEIR full RLB. An increase is evident, particularly to the north of the western extent and in the inshore route where the navigable width of vessel traffic has decreased. An increase, although less significant one, is also seen to the north east of the site.

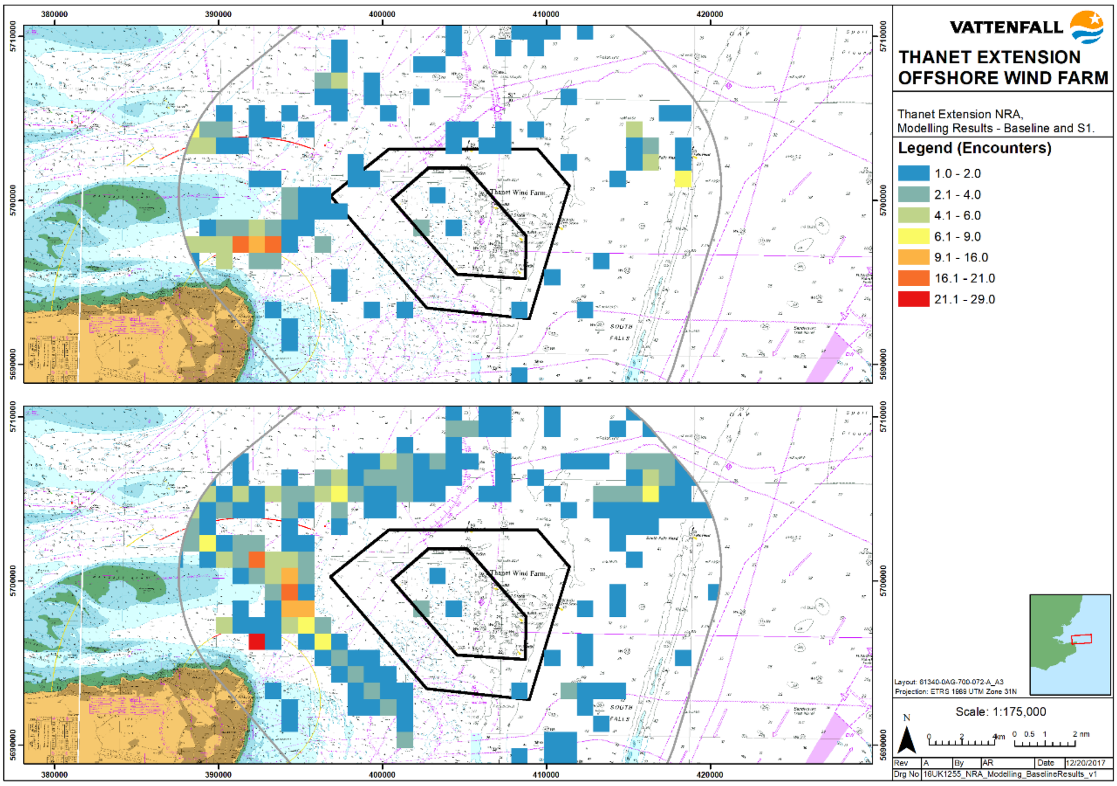

Figure 55: Location of encounters between baseline and Scenario 1 with Full RLB.

7.4 MODELLING OF IMPACT ON CONTACT (ALLISION)

Figure 56 gives the impact to the available fairway for vessel traffic once the extension has been constructed. As has been discussed previously, the width of the inshore route for vessel traffic has been reduced, and vessel transit routes to the north and east of the wind farm are closer. Whilst vessel traffic will attempt to keep a safe distance from the wind farm, the extension will likely bring vessel traffic closer and therefore increase the risk of a contact. To test this, contact risk modelling was undertaken.

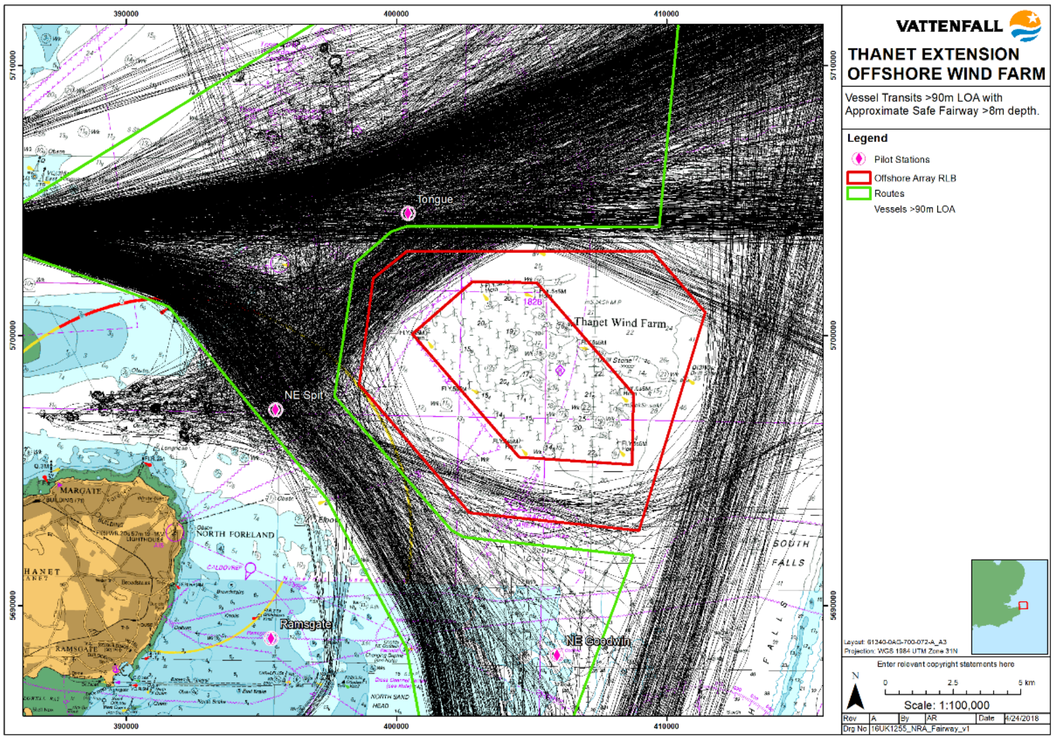

Figure 56: Approximate fairway with >8m chart datum and avoiding anchorages, vessel tracks for >90m LOA excluding dredgers.

A simple geometric model of vessel traffic was used to test how the extension would alter traffic flow and the relative risk of a contact with a turbine. A commercial vessel may collide with a turbine for many reasons, principally human error or mechanical failure. The presence of the extension won't increase the relatively likelihood that these two causes occur, however the relative risk is increased if vessel traffic must necessarily transit closer, providing less room to correct an error should it occur.

Figure 57 describes this model, a vessel traffic flow with a known distribution and frequency passes an obstruction. Using distribution curves, it is possible to estimate the number of vessels which transit at a given distance from the route centreline, and therefore the proportion of transits which intersect the wind farm. However, the bridge team of a vessel take corrective action to prevent this and based on previous research, the proportion of critical navigational decisions which are compromised due to human error or mechanical failure are given (1.1 x 10^{-4}). Finally, it is possible that a vessel transits through a wind farm without colliding with a turbine and therefore this also needs to be accounted for (a 0.5 modifier). By modelling the flows of traffic before and after the extension (see **Section 7.1**), a comparative risk analysis can be undertaken.

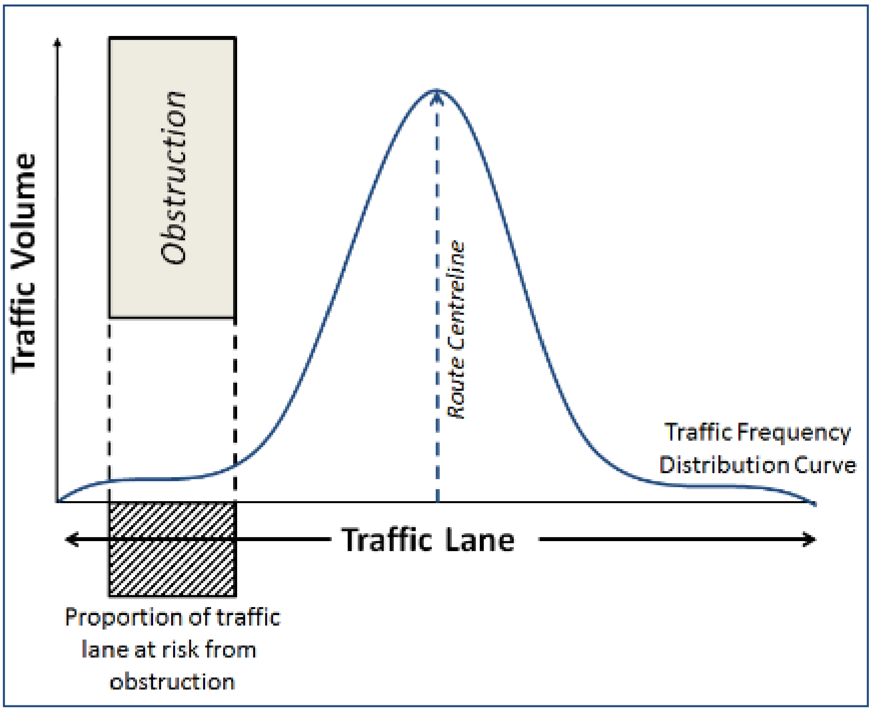

Figure 57: Contact Risk Model.

The results of this assessment are displayed below in **Table 13**. The results suggest that without mitigation, the likelihood of a passing vessel contacting a turbine increases from once every 85 years to once every 36 years, a 137% increase. This increase is mostly the result of the compression of the inshore traffic route between Thanet and North Foreland. Whilst the other routes exhibit some degree of increase, the likelihoods modelled are relatively modest at less than once in 100 years. The residual likelihood of a contact between a passing vessel and a turbine, whilst increased, remains unlikely and this is reflected in the risk assessment in **Section 8**.

Table 13: Vessel contact risk.

Route	Number of Movements	Baseline Geometric Risk	Modelling Geometric Risk	Baseline Likelihood (years)	Modelled Likelihood (years)	Increase
1	1,200	0.17%	0.28%	8,849	5,452	62%
2	3,500	1.98%	3.36%	258	152	70%
3	2,700	1.89%	2.46%	353	272	30%
4	3,800	1.11%	6.38%	425	74	473%
5	600	6.20%	7.25%	489	418	17%
6	6,300	0.16%	0.45%	1,759	643	173%
Total	**18,250**	**N/A**	**N/A**	**85**	**36**	**137%**

7.5 INTER-ARRAY AND EXPORT CABLE RISK

Inter-array and export cables are vital to the continued operation of a wind farm and can at times be exposed to the risks of vessel anchors and fishing gear which could damage the cables or the vessel. **Figure 58** shows the route of the cable route and vessel traffic in the vicinity. The study area is used by commercial vessels, recreational vessels and fishing vessels, all of which have the potential to damage the cables.

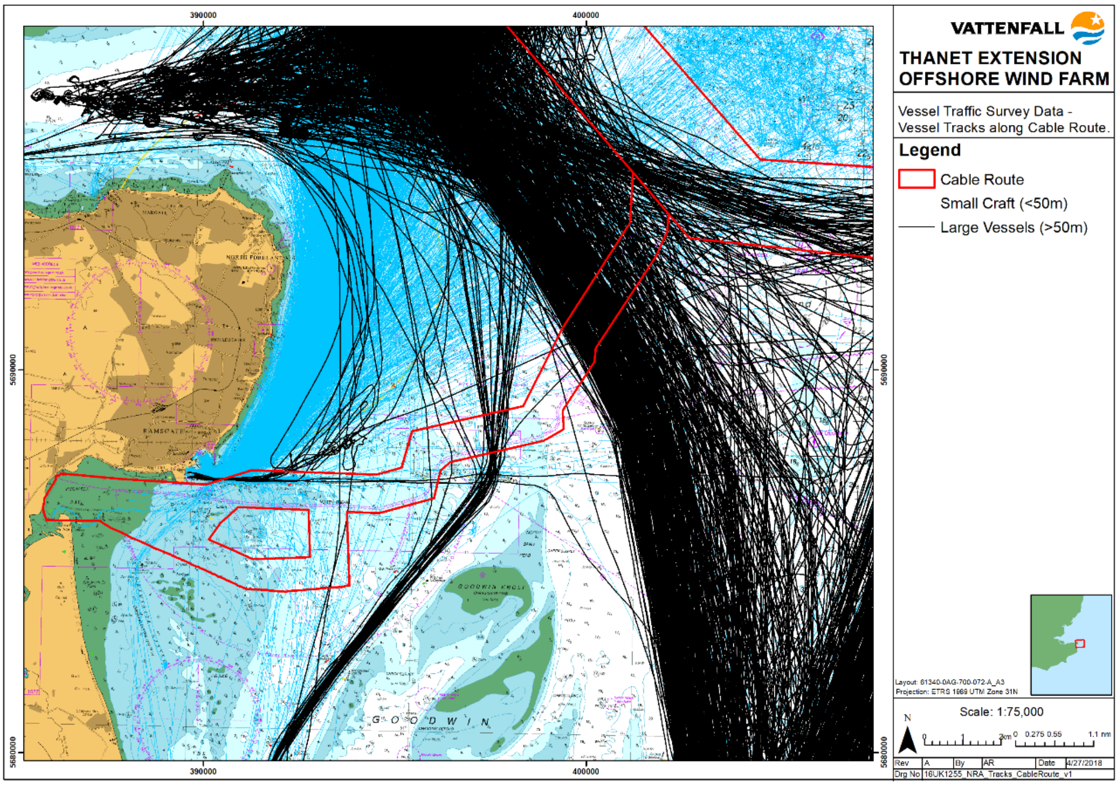

Figure 58: Vessel traffic along the cable route.

7.5.1 Commercial Vessel Anchors

The anchors carried by commercial vessels can be of a significant size and therefore have a great penetration depth into the seabed, posing a significant hazard to cables. There are a number of reasons as to why a vessel would deploy its anchor:

- Firstly, a vessel may anchor in an anchorage to hold position for an extended period of time;
- Secondly, an anchor may be deployed in an emergency to prevent an incident such as a collision or a grounding when a vessel is disabled;

- Thirdly, anchors can be used to aid turning, particularly in confined waterways and whilst berthing; and
- Finally, anchors may be released accidently or through equipment failure on a transiting vessel.

The penetration depth of an anchor, and therefore the potential for damage to a cable, is dependent upon a number of factors such as the size and the type of the anchor (particularly the size of the fluke length) as well as ground conditions. The size of a ships anchor is dependent upon a number of factors, including the ships design and classification society requirements. Typical anchor carriage on commercial shipping and their associated fluke lengths is shown below in **Table 14**. Large anchor penetration depths are shown below in **Figure 59**.

***Table 14: Typical anchor carriage on commercial shipping*[5]**

Vessel Size	Estimated Anchor Size (kg)	Anticipated fluke length (m)
5,000 DWT	1,740	1.24
10,000 DWT	4,000	1.3
50,000 DWT	8,000	1.6
75,000 DWT	13,000	2
100,000 DWT	15,000	2.1
150,000 DWT	17,500	2.2
200,000 DWT (Suezman / VLCC)	22,500	2.5
300,000 DWT (Q Max)	>26,000	3

Tennet (2014) have conducted real world trials of anchor penetration depths for 11.7t and 8.4t anchors at test sites at different soil densities. Their results were:

- **Site 1**: Loose layered fine sand in 35m water:
  - Hall 11.7t: 0.70 to 0.88m, average of 0.79m; and
  - AC14 8.4t: 0.65 to 0.69m, average of 0.67m.
- **Site 2**: medium dense to dense sand with silt in 28m water:
  - Hall 11.7t: 0.26 to 0.28m, average of 0.27m; and
  - AC14 8.4t: 0.28 to 0.34m, average of 0.31.
- **Site 3**: dense sand underplayed with stiff clays in 25m water:
  - Hall 11.7t: 0.34m to 0.67m, average of 0.45m; and
  - AC14 8.4t: 0.19 to 0.67m, average of 0.40m.

[5] Anchor carriage requirements estimated by authors utilising literature review of classification society requirements, manufacturers' specifications and expert judgement. See for example Sharples 2011.

The analysis shows that anchor penetration depth was less than 1m for both anchor types. The authors suggested that fluke tip to shank distance was a useful measure to estimate penetration depth of a particular anchor.

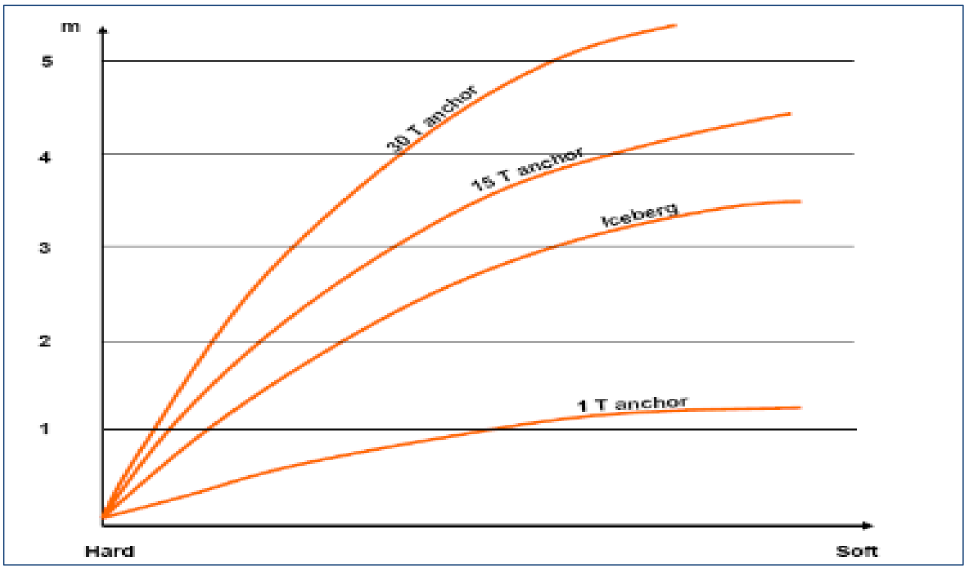

Figure 59: Large anchor penetration depths.[6]

There are two anchorages in proximity to the cable route. The Margate Roads anchorage to the west and the Tongue anchorage to the north. Both of which are several miles from the cable corridor and it is therefore unlikely that a vessel would anchor along the cable route. Furthermore, a charted no anchoring zone exists to the west of the wind farm. In exceptional circumstances, a vessel's anchor may drag in adverse weather conditions towards the cable and cause damage, but the shelter from prevailing south westerlies and separation distance makes this unlikely.

Emergency anchoring is unlikely to occur for much of the cable route given the significant sea room available to avoid other vessels and obstacles. In the event of a blackout on a vessel, a prudent master would deploy his anchor after consulting charts to be clear of charted obstacles. Emergency anchoring may occur in the approach channel to Ramsgate where vessels are in close proximity and manoeuvring in confined waters. It would therefore be advantageous to route the cable clear of the main approach channel to Ramsgate to avoid this hazard and the project has committed to designating this a cable exclusion area to mitigate this impact.

Accidental release of anchors is a rare occurrence and is therefore not a significant threat to the export or inter-array cables at Thanet. The full MAIB database does not differentiate anchoring incidents; however, in an MAIB investigation report into the "*MV Young Lady*" (MAIB, 2008) it was noted that

[6] CIGRE, 2009. Third-Party Damage to Underground and Submarine Cables.

between 1997 and 2006, eight incidents were recorded of an anchor cable running free. The MAIB identified the causes of these incidents as a combination of brake reliability, human error and windlass power failure. In several of these incidents the vessel was already at anchor before the uncontrolled release of the cable (MAIB, 2008). The probability of this occurring in the study area is negligible.

The anchors of construction or maintenance vessels may be the most hazardous to the cables for Thanet Extension given their close operating proximity. This hazard could be mitigated through the training and awareness of the masters of these vessels.

7.5.2 Fishing Gear and Recreational Anchors

In general, fishing activity is the principal cause of cable faults globally accounting for 44% of all incidents between 1959 and 2006 (ICPC, 2009)[7]. The majority of recorded incidents occur through bottom demersal trawling by both beam and otter boards over an exposed or uncovered cable. Other instances include shellfish dredging and scallop dredging that invasively penetrate the seabed.

Little research has been undertaken that definitively provides fishing gear penetration depths (Allan et al, 2001) see **Figure 60**. Evidence of historical fishing gear snagging interactions since the 1950s shows that increased burial depth has significantly reduced the number of interactions (Shapiro et al. 1997).

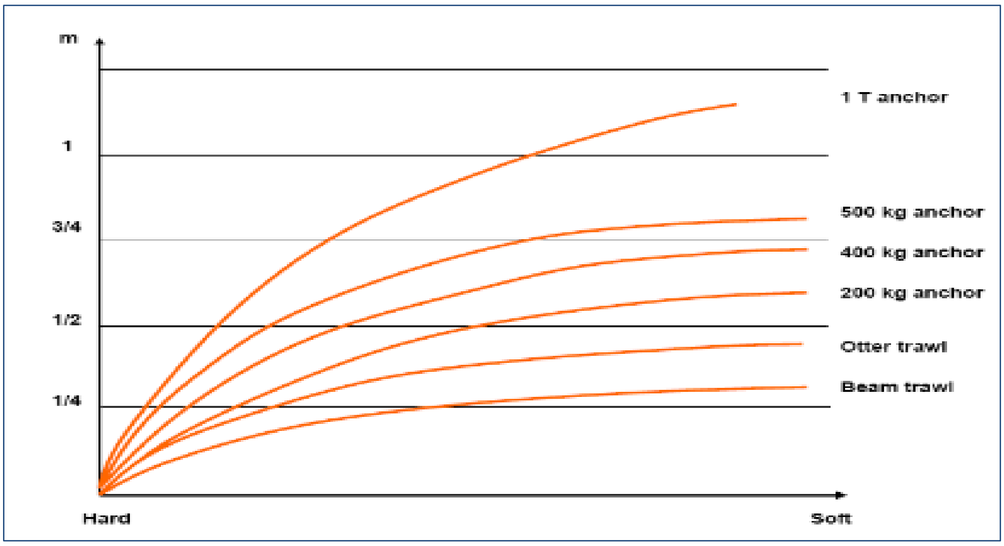

Figure 60: Small anchor and fishing gear penetration depth[8].

[7] Result of analysis of a database of 2,162 incidents between 1959 and 2006 undertaken by Tyco Telecommunications (US) Inc.

[8] CIGRE, 2009. Third-Party Damage to Underground and Submarine Cables

Estimations of trawl boards, beam trawls and scallop dredgers penetration depths are shown below in **Table 15**.

Table 15: Penetration of fishing gear in various soil types (Sharples, 2011).

Gear	Fine Sand	Firm Clay	Course Sand	Very Soft Clay
Trawl boards, Beam trawls and Scallop dredgers	<0.4m	<0.4m	0.5m	>0.85m

Research has shown that the probability of snagging occurring is low, this is due to design considerations in the trawl equipment to pass clear of underwater obstructions. More than 90% of crossings of fishing gear over cables result in no cable damage (cited in ICPC, 2009).

Snagging on cables (or any underwater object) either when fishing or with anchors could be hazardous to vessels. It can lead to cable damage and can in principle, in extreme cases, lead to capsize and loss of life (International Cable Protection Committee (ICPC) 2009[9]). There is also a risk of electrocution from damage cables.

In light of these risks, and because of the additional risk of damage to cables and associated costs, a system for reporting potential snagging events and compensating fishermen for loss of gear is in place. Under the Submarine Telegraph Act 1885, it is a punishable offence to break or injure any submarine cable; wilfully or by culpable negligence. However, cable owners are obliged to compensate the owners of vessels if those owners can prove that they have sacrificed an anchor, net or other fishing gear in order to avoid damaging a submarine cable.

Kingfisher Information Services Cable Awareness (KISCA) charts are freely available, which identify all in-service cables and the associated cable maintenance company.

Fishing around the site of the proposed extension is significant (**Section 5.3.3**) and fishermen are known to operate both along the cable route and between the WTGs of the existing wind farm. Cable protection may be considered to reduce the impacts to the cable but some can pose greater hazards to snagging fishing gear (concrete mattresses/rock dumping).

For recreational craft, the depth of water for much of the cable route is well in excess of their normal anchoring conditions. Where the cable makes landfall at Pegwell Bay, where small vessels may anchor, and routes close to the small craft holding area outside of Ramsgate, the risk increases. Increased burial or protection may therefore be required in these locations and will be determined as part of the cable burial risk assessment.

[9] https://www.iscpc.org/

7.5.3 Cable Protection

Once the cable route and the method of protection is determined, a cable burial risk assessment is recommended to investigate the safety and impacts to navigating vessels.

The MCA, with support from the RYA, have both indicated during consultation that they would typically accept only up to a 5% loss of Under Keel Clearance (UKC) as a result of cable protection. For much of the cable route this would be achievable but should be considered where the cable makes landfall or needs to cross existing cables. This will likely be most critical where the cable makes landfall at Pegwell Bay and therefore would impede the access to the River Stour for leisure users if significant cable protection compromised UKC.

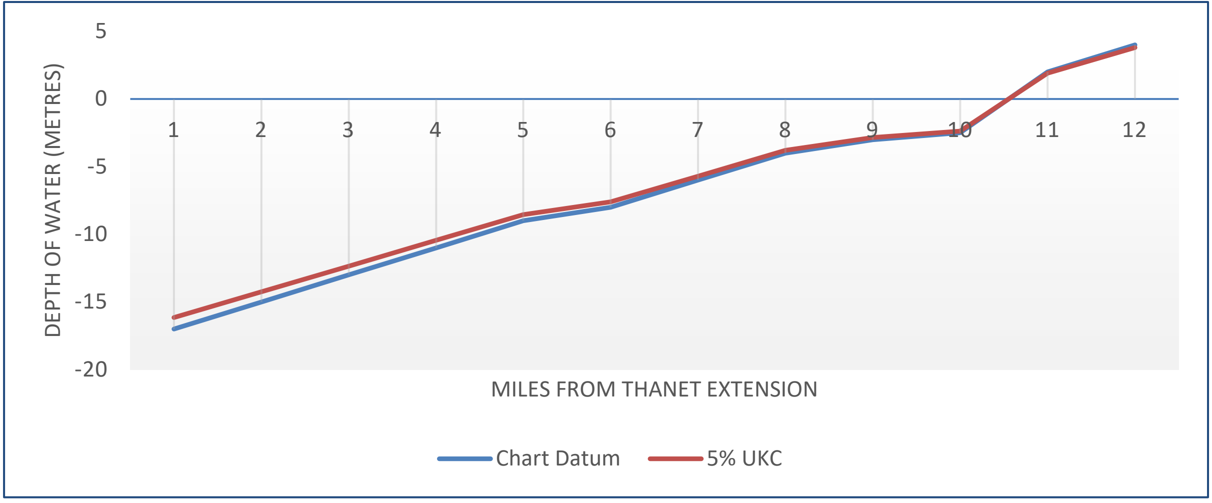

Figure 61: Impact on UKC of cable protection.

Post-burial surveys will be required to determine where target burial depth has not been achieved and where additional cable protection may be required.

7.5.4 Cable Exclusion Area

Recognising that the installation of a subsea cable across the approach channel into Ramsgate would have risks associated with anchor strikes and would cause disruption to both vessels and dredging requirements, the project has committed to a cable exclusion area for the length of the approach channel (see **Figure 62**). The cable route will avoid this cable exclusion area; however it may be necessary that temporary disruption would occur associated with anchor spreads during cable installation or maintenance.

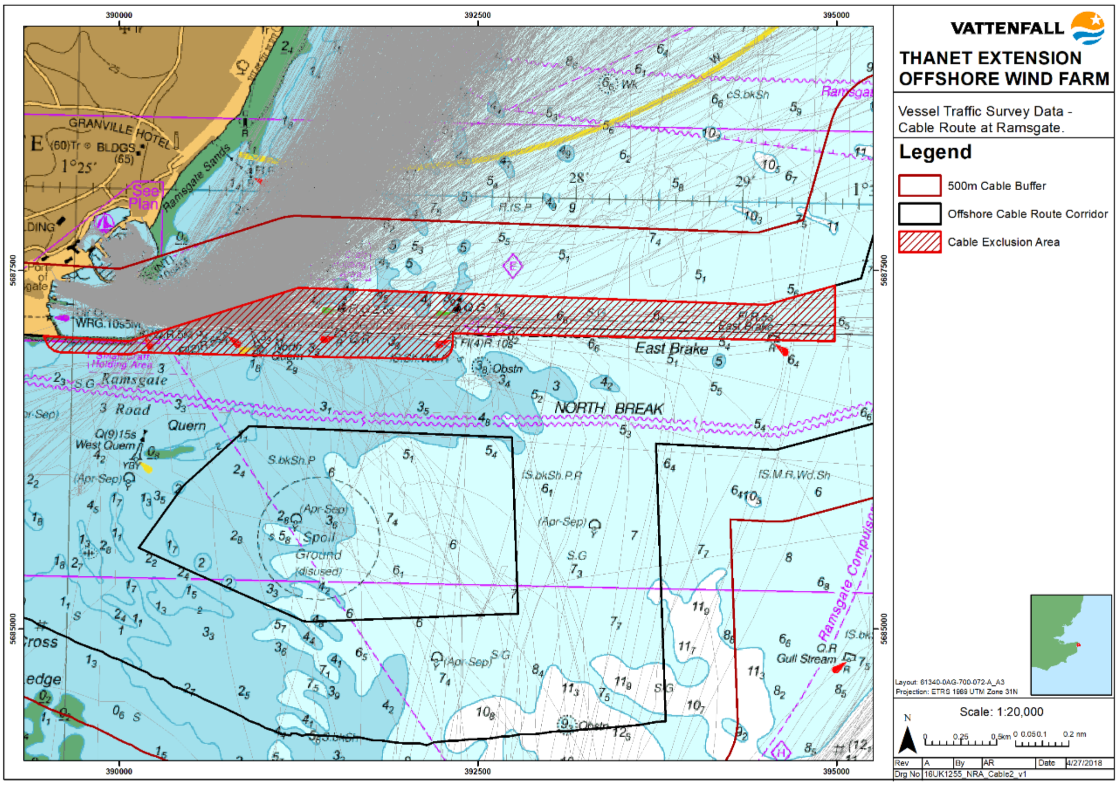

Figure 62: Vessel tracks in proximity to Ramsgate and 500m buffer.

7.6 IMPACT ON NAVIGATION OF CABLE LAYING

In 2017, the Nemo Interconnector was laid between Pegwell Bay and Belgium. During consultation for this NRA it was identified that the laying of the cable was disruptive to a number of users, particularly around Ramsgate. Therefore, a review of the impacts which could be expected from the laying of the proposed Thanet Extension cable has been undertaken.

Figure 62 shows the project's cable corridor as it passes Ramsgate along with vessel traffic collected through AIS. The majority of traffic entering and exiting Ramsgate comes from the northerly direction and therefore passes north of the cable route. The corridor does however include the marked approach channel into the Port of Ramsgate which is used by deep draught vessels. As discussed in **Section 7.5**, the presence of the cable itself is unlikely to cause any significant adverse impacts, however, the laying of the cable can be disruptive if not effectively managed.

During the laying of Nemo, a 500m safety zone was enforced around the cable route as it was being laid. As shown in **Figure 62**, a 500m safety zone would obstruct the entrance into Ramsgate, and any fishing or recreational activities to the south.

It is recommended that during the laying of Thanet Extension cable, liaison is held with Ramsgate user groups (including the harbour authority, recreational and fishing users) to provide updates on progress and to minimise the overlap with their activities. In addition, a 500m safety zone should only apply around the cable laying vessel, rather than across the whole route and the position of the vessel should be effectively communicated to interested parties.

To reduce the level of impact of the cable installation, the project has committed to a cable exclusion area that prevents the cable from crossing the navigational approach channel to Ramsgate (see **Figure 62**).

7.7 IMPACT ON SEARCH AND RESCUE

The existing wind farm complies with the MCA's requirements for SAR compatibility and it is necessary to ensure that the proposed extension of the wind farm also meets these requirements. The general arrangement of the extension is not yet known and therefore only general guidance and impacts on SAR are considered here. It is recommended that the developer engages with the MCA post-submission to ensure the layout taken forward is compatible with SAR objectives.

The MCA's SAR guidance is given in "*Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue and Emergency Response*". The following list is given as vital aspects to an OREIs impact on SAR which must be considered:

- **Emergency Response Cooperation Plans (ERCOP)** – MCA requires that such a plan is drafted in collaboration with SAR authorities for the construction, operation and decommissioning phases of a project. The plans provide contact details and procedures for use in an emergency;
- **Offshore SAR Management Courses** – MCA provides training to staff working on OREIs on the correct procedures and processes to be followed in SAR situations;
- **Layouts** – Layouts should follow the guidance in MGN 543 and have multiple lines of orientation and symmetry to allow SAR assets to safely transit amongst the WTGs. Furthermore, production of a layout plan for MCA that can be used to carefully consider the layout's impact on SAR. This may include computer generated models or visualisations and to scale drawings;
- **Marking and Lighting** – Clear and unique identification markings visible to surface craft and aircraft. Hover reference marking on wind turbine blades. Aviation Hazard and aviation SAR lighting of WTGs;
- **Monitoring** – Provision of in-field AIS, VHF DSC, weather systems for use by HM Coastguard;

- **Rapid Control and Shutdown capability** – if a rescue by air is required, the SAR mission co-ordinator will need to know how a WTG is shut down, feathered and orientated to allow access; and
- **Equipment and Capability of wind farm vessels** – capability of wind farm assets to undertake SAR.

The guidance document recognises that OREIs may provide valuable contribution to SAR. This includes availability of OREI support vessels for rescue response, the use of OREI communications equipment (such as VHF/AIS/Radar) and assistance in the drafting of offshore emergency response documentation.

A key aspect to be considered for the extension will be the integration of the layout for the TOWF with that of the proposed extension to ensure lines of orientation are consistent and a logical form of marking. The different size of WTGs and necessary spacing between WTGs would vary and this poses challenges to SAR compliance. It is expected that all other aspects of SAR requirements can be adapted from the existing wind farm to be compliant with the extension.

7.8 IMPACT ON VISUAL NAVIGATION AND COLLISION AVOIDANCE

7.8.1 Hindering the View of Other Vessels Under Way

The layout of the site has significant spacing between each of the WTGs to ensure that vessels will not lose sight of each other in the array. Furthermore, prudent mariners will leave sufficient sea-room when close to the WTGs to navigate safely. It is anticipated that commercial vessels will pass more than 0.5nm from boundary of the wind farm, giving sufficient time to take avoiding action should small craft be obscured when in very close proximity to a turbine. The significant size of the WTGs proposed for Thanet Extension and therefore the large distances between them would increase the level of visibility through the wind farm than is currently experienced at Thanet.

7.8.2 Hindering the View of Any Navigational Feature or Aids to Navigation

The proximity of the WTGs to the shoreline will result in a possible increase in background lights. Excessive brightness of markings of the arrays may diminish the effectiveness of the major navigational lights adjacent to the site. Furthermore, consultation discussed the issues associated with identifying navigational lights around Thanet against the significant shore lights from around the Thames Estuary, particularly when approaching from the east. The extension of the wind farm will contribute to the challenge of navigating in the Thames Estuary. Any additional lighting on the turbines should be turned so far as possible downwards to avoid dazzle and obscuring the lights of other vessels during darkness. This should be considered as part of the marking and lighting plan for the wind farm.

Care should therefore be taken to ensure that the lights associated with the development are well publicised and mariners are made aware of the changes. Aids to Navigation in the vicinity of Thanet are discussed in **Section 3.4.5**.

Offshore wind farms provide landmarks for vessels and are used as part of the general navigation toolkit. Whilst it would no longer be possible to identify individual lights through the wind farm, the vessel would necessarily need to pass clear of the obstacle first.

7.9 IMPACT ON COMMUNICATIONS, RADAR AND POSITIONING SYSTEMS

The effect of WTGs on navigation technology has been previously examined in other projects with regard to maritime[10] and aviation[11] applications. Further trials were carried out to assess the impact on SAR in conjunction with a helicopter.[12] There is a general consensus that the impact of WTGs on technology routinely used in maritime navigation is benign, with one exception, that being radar.

Offshore structures carry the potential to impact the navigation systems and communications equipment essential to safe navigation and must therefore be carefully considered. Consistent and effective radio communications are required to ensure safety at sea. For example, mariners are reliant on radio for:

- Navigation – using electronic charts and similar satellite-based technologies;
- Distress or safety communications; and
- Communications relating to commercial operations.

Furthermore, emergency services such as SAR helicopters require dependable radio communications to rapidly detect and react to maritime casualties. In addition, radio communications are increasingly essential to coastal zone management. This includes enforcement of environmental controls implemented to minimise marine pollution and the protection of essential maritime resources such as fisheries.

[10] Results of the electromagnetic investigations and assessments of marine radar, communications and positioning systems undertaken at the North Hoyle wind farm by QinteQ and the Marine and Coastguard Agency – 22 November 2004

[11] Feasibility of mitigating the effects of wind farms on primary radar. ETSU W/14/00623/REP DTI PUB URN No. 03/976

[12] Offshore Wind Farm Helicopter Search and Rescue Trials Undertaken at the North Hoyle Wind Farm by the Marine and Coastguard Agency May 2005.

As with other large structures, WTGs have the capacity to interfere with radio signals by blocking or otherwise disrupting the propagation of electromagnetic energy. Any disruption to radio communication by a proposed wind farm has the potential to reduce the effectiveness of the services outlined above.

7.9.1 Previous Studies

There has been extensive study into the effects that turbine arrays have on marine radar. Furthermore, Marico Marine has undertaken ship based studies of the specific effects of turbine arrays on marine radar onboard Marico's survey vessel *FPV Morven,* and on other ship bridges, while navigating in proximity to the Kentish Flats Wind Farm (see **Section 7.9.1.2**) and more recent trials at Thornton Bank (see **Section 7.9.1.3**).

7.9.1.1 North Hoyle Impact Assessment (2004)

The UK Maritime and Coastguard Agency with QinetiQ, conducted trials at the North Hoyle wind farm, a 30 x 2 MW wind turbine array, off the North Wales coast. The trials, undertaken in 2004 determined the impact of operational WTGs upon the performance of marine communication and navigation systems and the results were used to compare the theoretical results of an earlier study which had been designed to predict the impact on marine radio systems. Furthermore, where any degradation of the performance of those systems was ascertained effective solutions were recommended.

The North Hoyle wind farm research tried to obtain scientific and practical operational data on the performance of various navigation and communications systems within and in the vicinity of offshore wind farms.

The trial's outcome intended to be used to inform mariners, the shipping and ports industry, lighthouse authorities and wind farm developers on the extent of any system limitations as well as informing the consents process of offshore wind farm applications.

The research focused on how the performance of practical communications systems used for maritime navigation and communications, including shipborne and shore-based radar, satellite and hyperbolic position fixing systems, and the Automatic Identification System (AIS) would be adversely affected, with recommended cost-effective solutions. The tests also included basic navigational equipment such as magnetic compasses.

Four different trials were designed to test the validity of the results from the theoretical study and indicated that there is minimal impact on:

- VHF radio;
- GPS receivers;
- Cellular telephones; and
- Automated Identification Systems.

Ultra-high frequency and other microwave systems suffered from the normal masking effect when WTGs were in the line of the transmissions.

In conclusion, the effects on the majority of systems tested by the MCA were found not to be significant enough to affect navigational efficiency or safety. It should be noted however that this study was conducted more than 14 years ago, and the degree to which AIS and other technological advances have developed over this period may render some of these results out of date.

7.9.1.2 Kentish Flats Study (2006-2007)

In 2006-2007, Marico Marine on behalf of the British Wind Energy Association (BWEA) conducted an investigation in to the technical and operational effects on marine radar close to the Kentish Flats Offshore Wind Farm comprising 30 x 3MW WTGs, with a combined capacity of 90MW. The study built on earlier work at North Hoyle (MCA and QinetiQ) to become an industry standard reference document. Firstly, radar screens were recorded from a variety of vessels (53 in total) transiting near and through the wind farm and secondly, trials conducted by attempting to track Marico's survey vessel *FPV Morven,* whilst navigating between the WTGs.

Figure 63: Kentish Flats Radar Study (Marico Marine).

The study found that:

- A number of effects were seen by mariners, they were not significant enough to either raise concern for navigational safety nor inhibit vessels tracking one another;
- Navigators were able to effectively track other vessels from both within and behind the area of the wind farm;
- A number of the impacts were the result of the ship structures and fittings combined with the reflectivity of the WTGs;
- Small craft operating within the wind farm were detectable except when in very close proximity to a turbine; and
- No impact to AIS was discernible whatsoever.

7.9.1.3 Thornton Bank Radar Trials (2014)

In December 2014 Marico Marine conducted radar trials for vessels transiting close to the Thornton Bank offshore wind farm. The aim of the radar trials study was to update the analysis and conclusions obtained from the Kentish Flats Offshore Wind Farm, assessing the impacts that WTGs produce on the radars of vessels, however focusing specifically on the impacts of larger 6MW WTGs. Through this analysis, reliable data can be provided to assess the impacts that the proposed 8.3MW WTGs would have upon marine radar systems.

On the 10th and 11th December 2014, a Marico Marine Master Mariner collected radar observations from the bridge of passenger ferry the *Pride of York* on passage to and from Hull and Zeebrugge. Data was collected by recording footage of the radar display through a video camera at various points of the vessel's passage. Furthermore, Marine Rescue Coordination Centre (MRCC) Ostend and Vessel Traffic Services (VTS) at Zeebrugge were also visited to discern any impacts on shore based marine radar systems.

The analysis largely supported the results of the Kentish Flats study, however several phenomena were observed to be different from the 2006-2007 study. In general, a field of 6MW WTGs produces fewer effects than one of 3MW WTGs, principally a result of the increased spacing between the structures required for larger WTGs. The results of this study are summarised below:

- The 6MW WTGs were more clearly visible than the 3MW WTGs;
- Distortion of targets was less when the spacing between WTGs was greater in the 6MW array;
- The intensity of the WTGs in the 6MW field was less than the 3MW fields, due to the greater distance between the WTGs preventing in-field reflections from increasing the signal returns;

- Both studies demonstrated that small vessels could be tracked between the WTGs except in very close proximity to the tower. The greater space between the towers increases visibility; and
- The 6MW WTGs presented no spurious vectors on shore-based radar systems whereas the 3MW WTGs in the same view did. Further research is required to understand the cause of this phenomenon.

7.9.2 Summary of Impacts on Radar from WTGs

From both the wider literature and Marico's own extensive studies the following conclusions can be drawn:

- Many vessels, experience some unwanted interference on radar screens when passing in close proximity to turbine arrays;
- This can in many cases be kept to a minimum by proper placement of the radar units clear of the mast or of reflective surfaces;
- There is strong evidence that shows that the presence of turbine arrays does not significantly diminish the echoes of vessels navigating either among the WTGs or those detected on the other side of the site;
- Experienced navigators and masters are quickly learning how to interpret radar signals received in the proximity of turbine arrays;
- Furthermore, the training of new mariners and navigators now incorporates the study of radar interference from OREIs; and
- It is considered that Thanet Extension WTGs are sufficiently spaced apart that they will have little effect on marine radar, and any interference can be mitigated by maintaining a proper lookout.

It is therefore not considered that the extension of the Thanet wind farm will adversely affect the use of radar for collision avoidance. Furthermore, the existence of other wind farms in the Thames Estuary means that vessel operators are already familiar with the effects that WTGs have on radar and can mitigate it accordingly.

7.9.3 Shipboard Systems

The following section briefly describes the possible impacts on other marine radio communication and positioning systems commonly used onboard vessels.

7.9.3.1 Very High Frequency (VHF)

VHF communications are the most common form of marine communications for ship-shore and ship-ship. As part of the North Hoyle 2004 assessment by the MCA and QinetiQ, tests were made on the quality of VHF transmissions when made in close proximity to WTGs. This assessment concluded that there were no discernible impacts on VHF communications, a conclusion which was supported by further tests by the MCA on SAR capabilities in wind farms in 2005.

Therefore, it is not considered that the extension will have any negative impact upon VHF communications.

7.9.3.2 Global Maritime Distress and Safety System (GMDSS)

The Global Maritime Distress and Safety System (GMDSS) is an international system which uses terrestrial and satellite technology and ship-board radio-systems to ensure rapid, automated, alerting of shore-based communication and rescue authorities, in addition to ships in the immediate vicinity, in the event of a marine distress.

Under the GMDSS, all ocean-going passenger ships and cargo ships of 300 gross tonnage and upwards engaged on international voyages must be equipped with radio equipment that conforms to international standards as set out in the system. The basic concept is that search and rescue authorities ashore, as well as shipping in the immediate vicinity of the ship in distress, will be rapidly alerted through satellite and terrestrial communication techniques so that they can assist in a coordinated search and rescue operation with the minimum of delay.

Under the International Convention for the Safety of Life at Sea (SOLAS), every ship, while at sea, must have the facilities for essential communications, namely:

- Transmitting ship-to-shore distress alerts by at least two separate and independent means;
- Receiving shore-to-ship distress alerts;
- Transmitting and receiving ship-to-ship distress alerts;
- Transmitting and receiving search and rescue co-ordinating communications;
- Transmitting and receiving on-scene communications;
- Transmitting and (as required) receiving signals for locating;
- Transmitting and receiving maritime safety information;
- Transmitting and receiving general radio communications to and from shore-based radio systems or networks; and
- Transmitting and receiving bridge-to-bridge communications.

Specific equipment requirements for ships vary according to the sea area (or areas) in which the ship operates. The GMDSS combines various sub-systems - which all have different limitations with respect to coverage - into one overall system, and the oceans are divided into four sea areas as designated by the IMO:

- **Area A1**: Within range of VHF coast stations with continuous DSC alerting available (about 20-30 miles);
- **Area A2**: Beyond area A1, but within range of Medium Frequency (MF) coastal stations with continuous DSC alerting available (about 100 miles);
- **Area A3**: Beyond the first two areas, but within coverage of geostationary maritime communication satellites (in practice this means INMARSAT). This covers the area between roughly 70˚N and 70˚S; and
- **Area A4**: The remaining sea areas. The most important of these is the sea around the North Pole (the area around the South Pole is mostly land). Geostationary satellites, which are positioned above the equator, cannot reach this far.

The proposed wind farm is within an area designated by IMO as “Area A1” that is, within range of VHF coast radio stations. Therefore, VHF radio communications operating between 156 and 162.025 MHz fulfils all the GMDSS functions outlined above other than receiving Marine Safety Information (MSI) and SAR homing. For these functions, respectively, IMO requires MF NAVTEX and a radar Search and Rescue Transponder (SART). However, in practice this technology is not widely used by non-SOLAS vessels (e.g. fishing vessels > 15 m) and for SOLAS vessels, it is judged to be obsolescent with acceptable equivalents widely used, for example the Automatic Identification System SART.

Ships which do go beyond area A1 have to carry MF equipment as well as VHF - or INMARSAT satellite equipment. Ships which operate beyond MF range have to carry INMARSAT satellite equipment in addition to VHF and MF. Ships which operate in area A4 have to carry HF, MF and VHF equipment.

It should be noted that marine VHF radio communications is also increasingly used for essential communications relating to safe navigation and environmental protection.

Presently, most fishing vessels (<15m) and recreational boaters are not required to participate in the GMDSS, however they will find many of the services available useful and may want to acquire equipment such as EPIRBs, which must be registered with the appropriate authorities.

Small vessels are also recommended to fit Digital Selective Calling (DSC) equipment, since once the GMDSS is fully implemented, vessels without DSC will have difficulty contacting ships which are monitoring the DSC calling channel only.

Most fishermen and recreational boaters will carry VHF marine radios; however, they are not generally DSC compatible.

Within the site area it is considered that VHF is their primary tool for communicating with vessels in both emergency and non-emergency situations.

7.9.3.3 Satellite Communications

Satellite communications are extensively used in the maritime sector, even where a vessel is operating in range of VHF services. The principal provider of these services remains the International Maritime Satellite Service or INMARSAT, which currently uses a geo-stationary satellite network. A geo-stationary satellite remains in an approximately stationary position in the sky relative to the land-based observer.

Other satellite service providers are also active in the maritime sector including those using low-earth orbiting satellites; for example, IRIDIUM; a low-earth orbiting satellite continuously moves across the sky as far as the land-based observer is concerned.

There is no known impact from WTGs on satellite communications.

7.9.3.4 Global Navigation Satellite Systems (GNSS)

Global Navigation Satellite Systems (GNSS) use a constellation of low-earth orbiting satellites whose transmitted radio signals may be used to determine, with great accuracy, location in three dimensions. For optimum accuracy, a minimum of four satellites must be in view at all times.

GNSS provides critical capabilities to ships and other maritime stakeholders, notably for safe navigation and coastal zone management.

There are a number of GNSS in service or under development. These are:

- The United States military controlled Global Positioning System (GPS);
- The Russian Federation military controlled GNSS;
- The Chinese military controlled BeiDou Navigation Satellite System (BEIDOU); and
- The European civilian controlled satellite navigation system (GALILEO).

Of the above, the United States and Russian systems are fully operational. However, in practice all but a tiny minority of the GNSS receivers in service use GPS.

The Chinese and European systems are at various stages of development. BEIDOU is more advanced but is seen as primarily serving the South-East Asia market. GALILEO has commenced launching satellites, although there is no indication when, or if, the system will come into operation.

GPS trials undertaken at the North Hoyle wind farm found no adverse effects, even in very close proximity to the towers. It is not therefore anticipated that Thanet Extension would degrade positional accuracy of GPS navigation for vessels in the vicinity.

7.9.3.5 Differential GNSS (DGNSS)

Differential GNSS (DGNSS) is an enhancement to GNSS that may be used to improve location accuracy and repeatability. It operates through the transmission of a separate signal containing information relating to the errors within the GNSS and the correction thereof.

There are a number of DGNSS, summarised as follows:

- Systems conforming to IALA standards;
- Commercial systems tailored to specific users; and
- Satellite-based systems, commercial and non-commercial.

"IALA Standard" DGNSS is established at lighthouses located on or near to the coast. It uses radio frequencies previously allocated to marine radio direction finding service, typically at around 310 kHz (low medium frequency). Consequently, "IALA DGNSS" offers marginal benefit with few vessels reported to be still using the service, particularly in the non-SOLAS sector. There is also a general acceptance that the technology is obsolete and requires replacement, notably as part of the move to E-Navigation.

Commercial DGNSS is used to nominally improve DGNSS accuracy to around 10cm. Such accuracy is required for hydrographic and other forms of surveying but has no material additional benefit to safety of navigation. Commercial DGNSS may operate on a range of frequencies, typically in the VHF or UHF bands. However, industry best practice recommends no single radio communication-based system is relied upon for positioning and, given the nature of operations; the service provider may reasonably be assumed to be well versed in any issues of potential interference.

Satellite-based DGNSS operates on a similar principle to terrestrial systems with the exception that the correction signal is transmitted from a geo-stationary satellite network such as INMARSAT. The potential impact of a wind farm development on satellite DGNSS is that for satellite communications systems, and therefore not deemed significant.

7.9.3.6 Automatic Identification System (AIS)

In 2000, IMO adopted a new requirement (as part of a revised Chapter V of SOLAS) for ships to be fitted with Automatic Identification System (AIS). AIS was developed primarily as an aid for collision avoidance between vessels. Vessels that carry an AIS transponder broadcast at regular intervals to all AIS receivers within VHF range key information such as identity, name, type, speed, course, etc. AIS exists in two forms, Class A and Class B: the former in all those vessels mandated by IMO to carry AIS; the latter on a voluntary basis by non-SOLAS vessels such as recreational craft.

Regulation 19 of Safety of Life at Sea (SOLAS) Chapter V - sets out the navigational equipment to be carried on board ships according to ship type AIS is required to be carried on:

- All ships of 300 gross tonnage and upwards related to international voyages;
- Cargo ships of 500 gross tonnage and upwards not engaged on international voyages; and
- All passenger vessels irrespective of size.

There is currently no requirement for small commercial vessels or cruising yachts to carry AIS, however should they choose to do so they should be fitted with an AIS B transponder or receiver. In 2007, the new Class B AIS standard was introduced which enabled a new generation of economical AIS transceivers. In 2010, most commercial vessels operating on the EU inland waterways were mandated to fit an inland-waterway-modified and approved AIS Class A device. As required under EU directive 2009/17/EC the entire EU fishing fleet over 15m has been required to carry AIS as an additional aid to collision avoidance, although the majority of smaller fishing vessels operating in the study area do not carry AIS voluntarily.

Studies undertaken at North Hoyle in 2004 found no discernible impact upon AIS and therefore it is not anticipated that Thanet Extension would adversely impact the use of AIS in the Thames Estuary.

7.9.3.7 Long Range Identification and Tracking (LRIT)

The Long-Range Identification and Tracking (LRIT) system provides for the global identification and tracking of ships. LRIT utilises satellite communications, typically INMARSAT-C.

LRIT has no specific benefit in the assessment area noting that it replicates information transmitted by AIS. Furthermore, no adverse impact is anticipated.

7.9.3.8 Ship Security Alerting Systems (SSAS)

The Ship Security Alerting System (SSAS) is part of the International Ship Port Security Facility Code (ISPS Code) and is a marine communication system that contributes to the IMO’s efforts to strengthen maritime security and suppress acts of terrorism and piracy against shipping. In case of attempted piracy or terrorism the vessel SSAS beacon can be activated and appropriate law enforcement or military forces dispatched. The primary way for alerts to be transmitted is via existing satellite communications such as INMARSAT or Cospas/Sarsat which is a satellite-based search and rescue distress alert detection and information distribution system.

The ISPS Code is a comprehensive set of measures to enhance the security of ships and port facilities, developed in response to the perceived threats to ships and port facilities in the wake of the 9/11 attacks in the United States.

SSAS has no specific benefit or use in the assessment area and is therefore omitted from the assessment.

7.9.3.9 E-Navigation

E-Navigation is defined by IMO as follows:

"*E-Navigation is the harmonised collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment*".

Although IMO has committed itself to the development of e-navigation, progress in system development is reported to be slow with a number of fundamental legal issues - for example, resolution of liability for data integrity - and technical issues, including the identification of suitable technology and radio frequencies to adopt, all yet to be resolved. Early indications suggest consideration is given to the use of the now-redundant medium frequency band around 500kHz.

Given the uncertainty in how E-Navigation will be implemented, it is not possible to assess the possible impacts as a result of WTGs.

7.9.3.10 Mobile Telephones

Although mobile phones are not a mandatory carriage requirement for any vessels they are now carried onboard virtually all vessels as a matter of course. They are very often the primary means of undertaking commercial ship to shore communications when vessels are transiting close inshore. For smaller vessels, not covered by the GMDSS, most coastal authorities do not recommend mobile telephones as a substitute for the marine radio distress and safety systems in the VHF maritime radio band. A VHF radio is more advantageous in that it can also help ensure that storm warning and other urgent marine information broadcasts are received.

The North Hoyle assessment found no adverse impacts upon mobile telephony and therefore no adverse impact is anticipated as a result of Thanet Extension.

7.9.4 Sound

Any sound that may be generated by the WTGs, when operating, is not expected to mask any vessel sound signals used for navigational and safety purposes.

7.9.5 Electromagnetic Interference from cables

The preceding section has considered how the turbine structures could interfere with marine navigation and communication systems. Export and inter-array cables can have impacts as a result of electromagnetic interference, particular on the accuracy of a compass which is essential to good navigation.

All compasses are impacted by the proximity of certain materials and strong magnetic forces which could cause the compass to falsely indicate a direction and potentially disorientate a vessel's navigator. The degree of deviation as a result of subsea cables is related to the water and burial depth of the cable, the type of current carried, and the spacing and geometry of the cable (Crown Estate, 2012). Whilst some degree of deviation could be expected, it is likely minimal given the depth of water for much of the route, with a full assessment necessary following the selection of the final layout and configuration of the route.

7.9.6 Summary

A review of previous studies undertaken and discussions with stakeholders on the impacts of the existing wind farm have not identified any significant adverse impacts which may increase the risk of an accident to shore based or ship board communications, radar or positioning systems.

7.10 CUMULATIVE AND IN-COMBINATION IMPACTS

The cumulative and in combination effects as a result of Thanet Extension have been reviewed and assessed. **Section 3.6** identifies a number of other activities that are taking place in the Thames Estuary which may be impacted by the extension. These projects together, in combination with one another, have impacts on shipping and navigation greater than each in isolation.

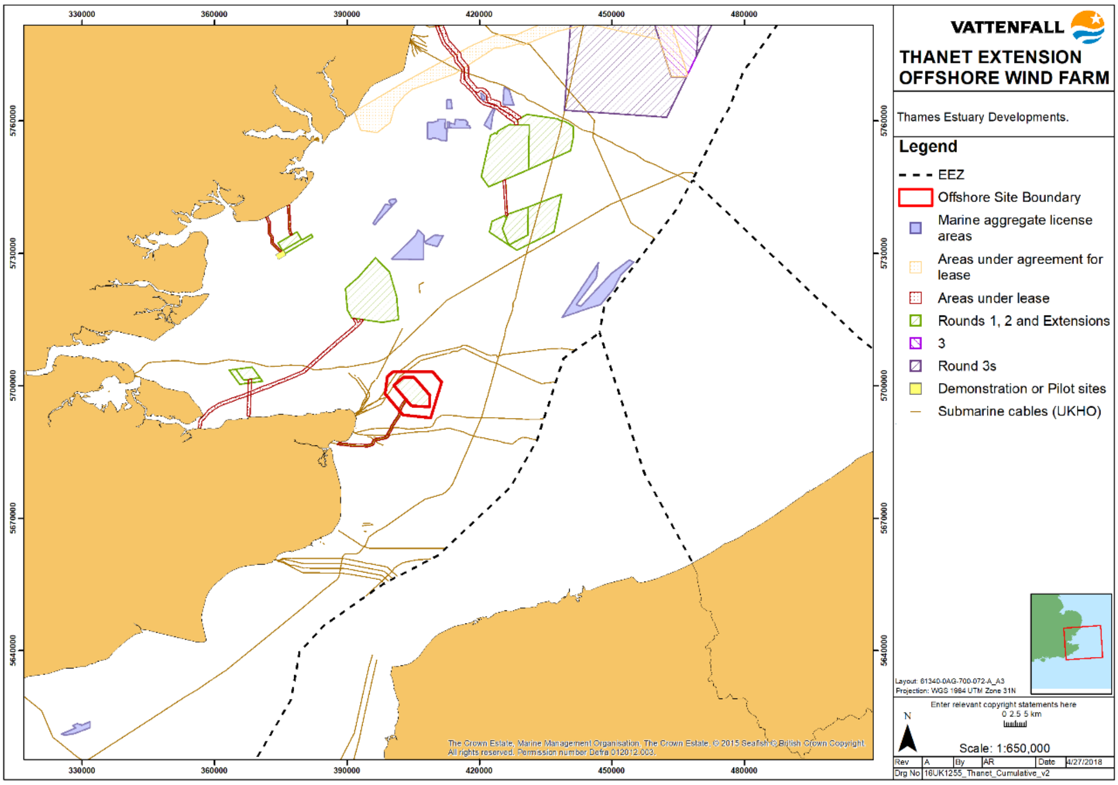

Figure 64: Location of other developments in the Thames Estuary.

Table 16 lists a variety of different projects by type and size that also impact upon navigation of vessels in the Thames Estuary. The Thames Estuary is host to several offshore wind farms, aggregate extraction areas and cables. The nearest wind farms (with the exception of the existing Thanet) are the London Array and Kentish Flats wind farms, both of which are serviced from Ramsgate. Both are however located in shallow waters outside of shipping lanes, which limits their cumulative impact. Similarly there are no aggregate extraction sites in close proximity to the extension footprint. The most significant cumulative impact may therefore be cables, and where cable crossings are required.

Table 16: Projects related to shipping and navigation for cumulative assessment.

Development type	Project	Status
OWF	Thanet	Operational
OWF	Gunfleet Sands	Operational
OWF	Kentish Flats	Operational
OWF	Kentish Flats Extension	Operational
OWF	London Array	Operational
Cable	Thanet Export Cable	Operational
Cable	Nemo Interconnector	Operational
Marine Aggregate and Disposal	Nemo Disposal	Operational
Marine Aggregate and Disposal	Pegwell Bay	Operational
Marine Aggregate and Disposal	Ramsgate Harbour	Operational
Marine Aggregate and Disposal	Area 524, 509/3, 510/1, 108/3, 510/2, 508, 509/2, 446, 509/1, 447, 501/2	Operational

Three broad themes of cumulative and in combination impacts are shown in **Table 17**.

Table 17: Cumulative Rochdale Envelope.

Impact	Scenario	Justification
Cumulative Impact due to Increased Vessel Activity	Multiple offshore developments require construction and maintenance vessels. The numerous projects that are active in the Thames Estuary would likely increase vessel activity as they transit to and from their bases of operation.	Potential increases in collision risk and possible congestion issues.
Cumulative Impact on Vessel Routeing	Commercial shipping, fishing boats and recreational craft must all operate to avoid these developments and any works taking place. This reduces the available sea room available, concentrating them in smaller areas, potentially bringing them into conflict.	Change in vessel routeing across multiple sites due to multiple developments.

Impact	Scenario	Justification
Cumulative Impact from Cable Routes	Multiple cable routes that cross over one another will reduce the navigable depth of water in these locations.	Reduction in depth and increased maintenance works vessels.

7.10.1 Cumulative Impact due to Increased Vessel Activity

Thanet Extension and London Array wind farm service vessels are likely to interact with one another, increasing risk along the route and possibly resulting in congestion at Ramsgate Harbour, with Kentish Flats, Thanet and London Array all serviced from here. The increased number of vessels will be relatively high in the local area to TOWF, particularly during the construction period of the extension. The interaction between operators will therefore need to be carefully managed.

7.10.2 Cumulative Impact on Vessel Routeing

Several wind farms and other developments are located in the Thames Estuary which act as obstacles for the flow of vessel traffic. Due to engineering requirements, the majority of these are already located in areas of shallow water outside of the main shipping lanes. The cumulative impact of these developments will result in a slight loss of sea room around Thanet Extension which may be rerouted into other lanes, increasing the risk elsewhere.

This rerouting may impact other activities such as aggregate dredgers and maintenance vessels. For example, vessels servicing London Array would have to transit through or around Thanet Extension, causing disruption to their operations.

For large commercial shipping, the combination of multiple other projects, given their relative distance to Thanet, is not considered to result in any material alteration of activities.

7.10.3 Cumulative Impact from Cable Routes

Multiple cable routes are located inshore of Thanet Extension which may cross one another. Where these cables cross it would likely result in a decrease in the navigable depth of water. Given the depth of water and the likely protection at the point of crossing, this percentage is small and will not pose a hazard to shipping (see **Section 7.5**). The exception to this maybe near to where the cable makes landfall in Pegwell Bay, particularly so as not to prevent access to the River Stour.

8 NAVIGATION RISK ASSESSMENT

8.1 INTRODUCTION AND METHODOLOGY

This NRA was commissioned to assess the impact on navigation potentially caused by each of the three phases of the wind farm project, namely: construction, operation and decommissioning. The NRA is limited to identifying and quantifying any additional or increased navigational risk resulting from the project. It subsequently identifies possible mitigation measures where appropriate and makes recommendations.

The process starts with the identification of all potential hazards. It then assesses the likelihood (frequency) of a hazard causing an incident and considers the possible consequences of that incident. It does so in respect of two scenarios, namely the “most likely” and the “worst credible”. The quantified values of frequency and consequence are then combined using the Marico HAZMAN ll software to produce a risk score for each hazard. These are collated into a “Ranked Hazard List” from which the need for possible additional mitigation may be reviewed.

The hazards were scored using the collective experience of the project team and consultees, with traffic analysis, incident analysis and other available information to support the assessment. For a description of the risk assessment methodology see **Annex B**.

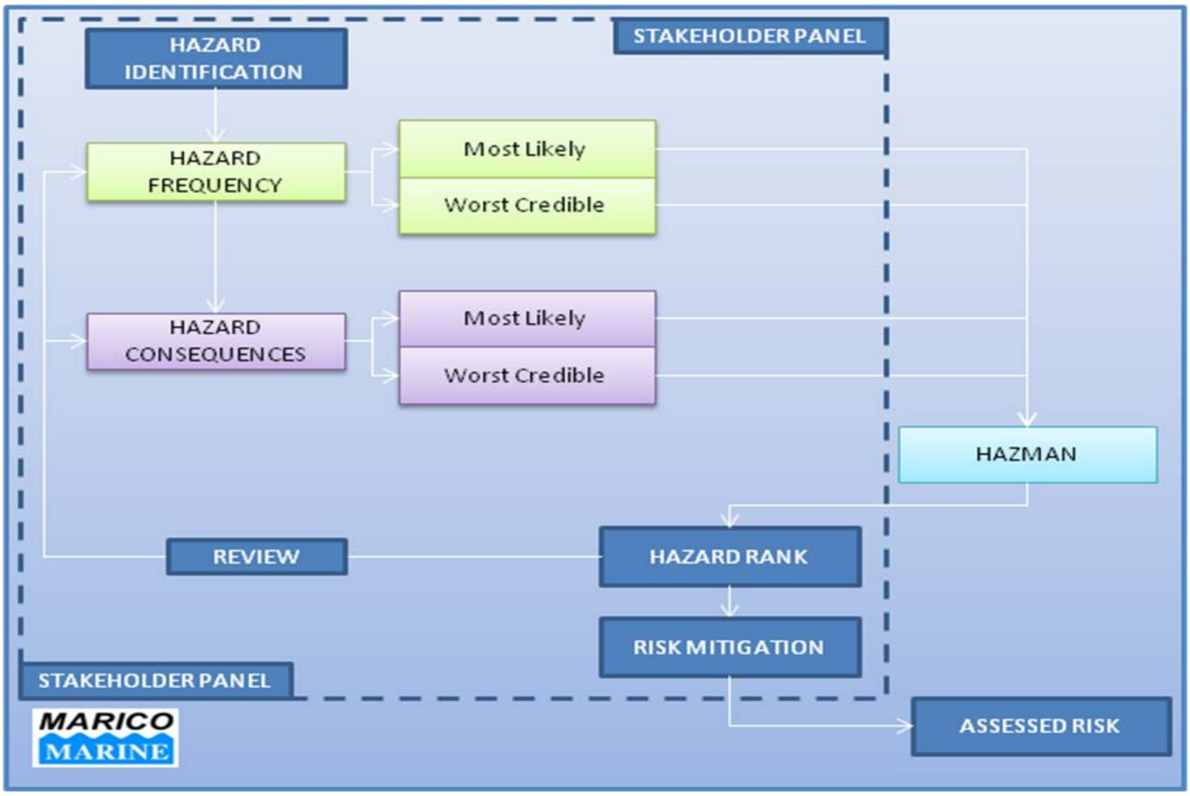

Figure 65: Marico Marine Risk Assessment Methodology

8.2 HAZARD IDENTIFICATION

Hazard identification is the first and fundamental step in the risk assessment process. It was undertaken for this project by Marico Marine navigation specialists and with important input derived from discussions with local stakeholders. To ensure that the process was both structured and comprehensive, potential hazards were reviewed under the following headings:

- Project phase;
- Incident category; and
- Vessel type.

The three project phases (construction, operation and decommissioning) have been assessed, however following a review of the relative impacts of each, it was decided that the construction and decommissioning phase will be assessed together as they have similar activities. By way of example the frequency and consequences of collision during the construction/decommissioning phase will differ significantly due to the many movements of larger specialist vessels associated with the construction/decommissioning as opposed to the operational phase. The five incident categories identified as being relevant to this study are:

- Collision;
- Contact;
- Grounding;
- Obstruction; and
- Swamping/Capsize.

Whilst there is a great variety of vessel types operational in the Thames Estuary, most of which have been studied and assessed in this NRA, for the purposes of the risk assessment they have been grouped into distinct categories. Grouping vessel categories into groups with similar characteristics, causes and consequences provides a more intuitive risk assessment with fewer distinct hazards but still reflects the cumulative risk of each vessel type. This is particularly relevant for collision hazards, where increasing the number of vessel types results in many more hazards, which increases the uncertainty of assessment and results in lower risk scores given the less likely it is that any specific pair of vessel types has an incident. The vessel groups assessed are given below:

- **Large Construction Vessels** – major construction vessels used for the installation of the foundations, WTGs and cable. Includes cable laying vessels, heavy lift and crane barges around 100m LOA;
- **Small Construction Vessels / O&M vessels** – smaller and more regular maintenance vessels, such as wind farm support vessels and crew transfer vessels. May be high

speed craft and typically around 10m LOA. Vessels are active throughout the lifecycle of the project;

- **Large Commercial** – large commercial shipping greater than 75m LOA, including cargo vessels, tankers and passenger ships navigating in the vicinity of the wind farm;
- **Small Commercial** – All other commercial vessels such as pilot boats, survey boats and tugs;
- **Fishing Vessels** – Vessels engaged in fishing or trawling; and
- **Recreational** –Recreational craft operating in and around the wind farm.

To demonstrate how the risk profile would change over the lifecycle of the development and the effectiveness of the risk control options the risk assessment has been scored in three different stages:

- **Baseline** – Present day risk profile with the existing TOWF in place. Risk profile identified through analysis and historical incident record and is therefore the same for both construction/operational risk assessments, albeit those hazards which relate to the introduction of new vessel types (such as large construction vessels);
- I**nherent** – Risk profile with the full Thanet Extension in place, the future traffic profile and embedded risk controls (**Section 8.5.1**); and
- **Residual** – Risk profile with full Thanet Extension in place, the future traffic profile and both embedded and possible additional risk controls that could be implemented to manage the risks of the project (**Section 8.5.2**).

8.3 HAZARD SCORING

For a description of the risk assessment methodology see **Annex B**. The likelihood of each hazard occurring was assessed using the criteria described in **Figure 20**. Using the assessed notional frequency for the "most likely" and "worst credible" scenarios for each hazard, the probable consequences associated with each were assessed in terms of damage to:

- People - Personal injury, fatality etc.;
- Property – Wind farm site and third party;
- Environment - Oil pollution etc.; and
- Business - Reputation, financial loss, public relations etc.

The magnitude of each was then assessed using the consequence categories given below. These have been set such that the consequences in respect of property, environment and business have similar monetary outcomes.

Table 18: Frequency criteria.

Scale	Description	Definition	Operational Interpretation
F5	Frequent	An event occurring in the range once a week to once an operating year.	One or more times in 1 year
F4	Likely	An event occurring in the range once a year to once every 10 operating years.	One or more times in 10 years 1 - 9 years
F3	Possible	An event occurring in the range once every 10 operating years to once in 100 operating years.	One or more times in 100 years 10 – 99 years
F2	Unlikely	An event occurring in the range less than once in 100 operating years.	One or more times in 1,000 years 100 – 999 years
F1	Remote	Considered to occur less than once in 1,000 operating years (e.g. it may have occurred at a similar site, elsewhere in the world).	Less than once in 1,000 years >1,000 years

Table 19: Consequence categories and criteria.

Cat.	People	Property	Environment	Business
C1	**Negligible** Possible very minor injury (e.g. bruising)	**Negligible** Costs <£10k	**Negligible** No effect of note. Tier1 may be declared but criteria not necessarily met. Costs <£10k	**Negligible** Costs <£10k
C2	**Minor** (single minor injury)	**Minor** Minor damage Costs £10k – £100k	**Minor** Tier 1 – Tier 2 criteria reached. Small operational (oil) spill with little effect on environmental amenity Costs £10K–£100k	**Minor** Bad local publicity and/or short-term loss of revenue Costs £10k – £100k
C3	**Moderate** Multiple minor or single major injury	**Moderate** Moderate damage Costs £100k - £1M	**Moderate** Tier 2 spill criteria reached but capable of being limited to immediate area within site Costs £100k -£1M	**Moderate** Bad widespread publicity Temporary suspension of operations or prolonged restrictions at wind farm Costs £100k - £1M
C4	**Major** Multiple major injuries or single fatality	**Major** Major damage Costs £1M -£10M	**Major** Tier 3 criteria reached with pollution requiring national support. Chemical spillage or small gas release Costs £1M - £10M	**Major** National publicity, Temporary closure or prolonged restrictions on wind farm operations Costs £1M -£10M
C5	**Catastrophic** Multiple fatalities	**Catastrophic** Catastrophic damage Costs >£10M	**Catastrophic** Tier 3 oil spill criteria reached. International support required. Widespread shoreline contamination. Serious chemical or gas release. Significant threat to environmental amenity. Costs >£10M	**Catastrophic** International media publicity. wind farm site closes. Operations and revenue seriously disrupted for more than two days. Ensuing loss of revenue. Costs >£10M

8.3.1 Benchmarking

In order to provide realistic scorings of the frequency and consequence of each hazard in its most likely and worst credible states, benchmarking was taken with national incident statistics (see **Section 5.7**). The consequences of a hazard occurring are unlikely to change significantly as a result of the construction of the wind farm, with the key impact on how likely an incident is to occur. Therefore, the historic incident rate was used to inform the baseline risk assessment and the results of modelling and analysis used to gauge the increase in frequency as a result of the construction.

A key uncertainty of risk scoring is the relationship between the high frequency and low consequence events which account for the majority of the incident data, and the far less frequent but more catastrophic events that result in fatalities and major damage or pollution. To assess this, analysis was conducted of the MAIB database to understand how often collisions result in fatalities. Between 1997 and 2015, 1,304 collisions were recorded across all vessel types. Of these, 20 (1.5%) resulted in a fatality, and 5 (0.4%) of these resulted in more than 1 fatality. It can therefore be concluded that only 1 in 100 collisions result in a fatality, therefore the ratio between most likely frequencies for collisions and worst credible collisions (which result in fatalities) should be approximately 100 times less likely. Furthermore, for large commercial shipping, multiple fatalities as a result of a collision is possible but remote.

8.4 RISK ASSESSMENT

8.4.1 Large Construction Vessels

During the construction / decommissioning phase of Thanet Extension, there would likely be a significant increase in the number of vessel movements within the project site (**Section 2.4.3**), which would increase the risk of collision. In particular, the introduction of large construction vessels, with low manoeuvrability, and more numerous smaller service / crew transfer type vessels. Furthermore, the reduction in sea room to the west of the development would increase the traffic density likely leading to more encounters between vessels.

A collision involving a large construction/decommissioning vessel, such as cable layer or heavy lift barge is a new hazard introduced by the extension, and whilst possible, it is generally unlikely. Firstly, there will be a limited number of these vessels which makes the likelihood that they will be involved in a collision, particularly with each other, low. Secondly, except for the cable laying vessel, the vessels will be stationary which both reduces the likelihood and the consequence of a collision. Furthermore, they will be positioned near to the existing TOWF and therefore clear of the main shipping routes. The cable laying vessel will be slow moving and closer to Ramsgate, having a higher likelihood of being involved in an incident with a fishing or recreational craft, but additional mitigation would be put in place to protect it.

The most likely collision involving the construction vessels would be between a large construction vessel and a smaller crew transfer vessel, given the relative close proximity in which they operate.

Given the close proximity within which the large construction vessels would necessarily be operating to the WTGs, a contact/allusion is probable. Whilst the most likely outcome is some minor damage, the turbine structure could be seriously damaged, causing some injuries, damage to the construction vessel and significant delays to the project.

The grounding of a large construction vessel is unlikely within the wind farm, given the depth of water but more likely along the cable route, particularly near landfall.

Similarly, the construction vessel could snag and damage the export cable for the project, either through problems during laying or with the vessel's anchors, causing serious damage to the cable but little damage to the vessel.

During the operational phase, there may be occasions when larger maintenance vessels are required and these should be risk assessed on a case by case basis.

8.4.2 Small Construction and O&M Vessels

There would be a significant increase in the numbers of small maintenance vessels operating between Ramsgate and the site of the extension during construction (**Section 2.4.3**), with fewer during the O&M phase (**Section 2.5**). Therefore, in general, the likelihood of an incident involving these vessels has been scored higher for the construction phase than the O&M phase. These small vessels transit at high speed and carry numerous passengers and therefore the consequences of an incident can be significant.

The greatest risk of collision would be between themselves and with other small craft (fishing and recreational) in the approaches or within Ramsgate Harbour. During construction, the increased number of crews required for these vessels would not be familiar with the area and the customs and practices of the vessels operating here, when compared to the regular crews during the operational phase.

When transiting to and from Ramsgate to the project site, they would be required to cross the inshore route that commercial traffic use through NE Spit and into the Thames Estuary. The number of commercial shipping transits through this route is modest at approximately 10 per day (**Section 5.5**) and the likelihood of an encounter is low. The collision risk modelling suggested that doubling the number of O&M vessels would increase the risk of collision by 10% in the area, without additional risk controls.

Crew transfer vessels are considered the most likely vessel type to have a serious contact with a WTG both during construction and operation, given the nature of their operations. An example investigated by the MAIB was the contact of a wind farms service craft with an unlit turbine in the Sheringham Shoal wind farm in November 2012 causing multiple injuries and some vessel damage.[13] Furthermore a contact by a construction vessel at Walney Offshore Wind Farm in August 2014 resulted in light fuel oil being spilt as well as vessel damage.[14]

Finally, whilst it is possible that a small construction or maintenance vessel runs aground, given the depth of water it is not considered likely.

8.4.3 Large Commercial Shipping

The proposed extension is bounded by a number of commercial shipping routes (**Section 5.2**) which would be impacted by the development. At present, approximately 10 commercial vessels pass inshore of the wind farm, a further 10 passes to the west and 25 passes to the north each day (**Section 5.5**). Whilst there may be significant numbers of smaller vessels inshore during the summer months, the general density of large commercial shipping is less significant than in other constrained waterways. This is supported by the relatively low incident rate involving commercial shipping in the area, with only one collision involving a commercial ship in the last 20 years in the area, and no incidents involving the Thanet wind farm, which has been in place since 2010 (**Section 5.7**).

The proposed Thanet Extension would potentially increase the risk of collision for larger commercial vessels in two ways:

- Firstly, the reduction in sea room on the inshore route between North Foreland and the wind farm and the NE Spit pilot station, and less significantly to the east of the extension; and

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[13] http://www.maib.gov.uk/publications/investigation_reports/2013/windcat_9_and_island_panther_combined_report.cfm

[14] http://www.nwemail.co.uk/home/barrow-lifeboat-called-out-after-vessel-collides-with-wind-turbine-off-walney-coast-1.1155234

- Secondly, an increase in the amount of crossing project traffic during the construction, operation and decommissioning activities at the extension.

The reduction in sea room has been investigated through modelling (**Section 7.3**) and pilotage simulation (**Section 7.2**). The results suggest that the reduction in sea room would increase the risk of collision and make pilotage operations, whilst still feasible, more challenging with less margin for error inshore of the extension.

The probability of a commercial ship contacting with a wind turbine was also modelled (**Section 7.4**). The results suggested that the probability is low with the current layout but that the likelihood would increase as more WTGs are added and the inshore route is constricted. Drift groundings would also increase in likelihood as there are more WTGs which are closer to the main shipping routes, potentially resulting in more incidents similar to the *Maersk Nottingham* near miss (see **Section 5.7**). The consequence of a grounding was considered to be less significant than the collision hazards. The likelihood of a grounding was also scored in a similar fashion.

Damage to the export cable from a vessel's anchor was considered to be unlikely, given the distance form key anchorages and the low probability of accidental releases (**Section 7.5**).

8.4.4 Small Commercial Vessels

Small commercial vessels, such as tugs and pilot vessels, are principally impacted by the reduction in sea room associated with the development, with the risks of contact and grounding not deemed likely to change. As the navigable width to the west of the wind farm decreases, the probability of two vessels being brought into conflict increases, particularly with the reduced margin for error for pilot transfers (**Section 7.2**).

8.4.5 Fishing Vessels

A large number of small fishing vessels operate form Ramsgate (**Section 5.3.3**) and operate within and around the project site. Furthermore, larger trawlers from the continent can be found to the north west. During the construction stage, vessels may be temporarily excluded from the project site and along the cable corridor. Following construction, the vessels are likely to continue operating within the wind farm. It has anecdotally been revealed that there have been at least two contacts between a fishing vessel and a turbine structure in the existing TOWF.

The key hazards associated with fishing vessels are collisions with other navigating vessels, contact with the turbine structures and the snagging of cables. As the numbers of maintenance vessels, WTGs and cables increases, these risks would increase and the availability of fishing grounds would diminish.

This in turn may bring fishing vessels into greater conflict with commercial vessels that have also had their available fairway reduced (**Section 7.3**).

8.4.6 Recreational Craft

Ramsgate Harbour is a focal point of recreational traffic in the South-East and hosts an active yacht club. Much of the recreational activity takes place clear of the project site (**Section 5.3.4**) and as such is not directly impacted by the construction/operation, with the exception of heightened collision risk with project vessels to and from Ramsgate. Furthermore, no key recreational offshore routes intersect the project site.

There may be some indirect impacts where larger commercial vessels are offset from the extension and closer to the shore, bringing them into greater conflict with recreational craft. However, given the depth of water restriction and significant sea room, this impact is not deemed significant.

The turbine structures will have an air clearance of at least 22m above MHWS (**Section 2**) and as such most yacht mast heights would be clear.

8.5 RISK CONTROL OPTIONS

8.5.1 Embedded Risk Controls

A number of risk controls have been proposed embedded in the project, these are listed below in **Table 20**.

Table 20: Embedded risk controls – those assumed to be in place for the risk assessment.

ID	Risk Control
1.	Promulgation of information and warnings through notice to mariners and other appropriate Maritime Safety Information (MSI) dissemination methods.
2.	Planning and coordination between developer and operators.
3.	All construction, operational and maintenance vessels are to be fully compliant with legislation, guidance and best practice.
4.	All those involved in construction, operational and maintenance operations are to be trained and competent persons, using appropriate PPE.
5.	Incidents and near misses are reported and investigated by developer and operators.
6.	ERCOP to be drafted in conjunction with MCA/HMCG and other stakeholders.

ID	Risk Control
7.	Continuous watch of site by radar, AIS, VHF, DSC and CCTV during construction by project's Marine Coordinator.
8.	Inter-array / export cables to be buried to the depth agreed, or suitably protected, which provides sufficient protection without compromising UKC.
9.	Aids to Navigation management plan (Marking and Lighting) to be submitted to MCA/TH for approval prior to construction.
10.	Blade Clearance of at least 22m above MHWS.
11.	Layout Plan to be submitted to MCA for approval prior to construction. The layout plan should include the proposed location and foundation types of all structures, the height and clearances of blades and length and arrangement of cables.
12.	Cable Burial Risk Assessment and periodic cable inspections to be conducted and protection so not to exceed 5% UKC.
13.	Update navigational charts to show wind farm layout and cable route
14.	Revision of Red Line Boundary - Several stakeholders raised concerns about the restriction of sea room to the west of the extension during the process of this assessment. In order to mitigate these concerns and reduce the level of impact, the project took the decision to reduce the red line boundary of the extension in this area (see **Section 1.1**).
15.	A cable exclusion area should be implemented that covers the port limits, approach channel and dredged channel of the Port of Ramsgate. Within this area no cables will be installed associated with this project. During cable laying and or maintenance, it may be necessary for anchor spreads or moorings to be temporarily placed within this area to assist with the installation, however this will be conducted as per risk control 3.

8.5.2 Additional Risk Controls to Reduce the Risks to ALARP

Through consultation with stakeholders and a review of the impacts of the project, the following list of additional risk controls could be considered to reduce the impacts and risks associated with the extension. Where the risk assessment considers these to be required they are detailed within the relevant section, and within the recommendations section of this report.

Table 21: Additional risk controls recommended to reduce the risks to ALARP

ID	Risk Control
1.	**500m safety zones around WTGs and around a construction vessel** It is recommended that the developer applies for 500m safety zones during construction/decommissioning under Section 95 of the Energy Act 2004. These will be fixed during construction around the WTGs and other offshore structures. A rolling safety zone should be considered around the cable laying vessel to minimise disruption to stakeholders. There should also be appropriate means for the operator to notify, and provide evidence of, the infringement of any safety zones.
2.	**Guard Vessels** It is recommended that guard vessels should be considered during the construction operations (including the cable laying) to enforce the 500m safety zones and advise any passing vessels of the works being conducted.
3.	**Cooperation during Cable Laying with Port of Ramsgate** A number of stakeholders voiced concerns over the impacts that cable laying and the required safety zones would have on navigation to/from Ramsgate, particularly whilst the cable is installed close to the channel. This impact should be minimised by liaising with the port to time installation in this critical section with off-peak seasons / times of day to minimise disruption to the port and its users.
4.	**Construction Coordination with Port of London VTS** The project should have a regular and formalised means to coordinate with PLA VTS during construction and maintenance to ensure that the PLA, VTSOs and pilots are aware of the hazards, operations and movements at the site on a day to day basis. This information can then be provided to vessels to aid their safe passage. Liaison should be between the project and both the Harbour Master (Lower) and Duty Port Control. The following information should be provided: • A schedule of activities, timescales and construction methodology; • Details of construction vessels including name, size, MMSI, telephone numbers etc. • Any restrictions in place, such as safety zones; • Contact details for project's Marine Coordinator; • Regular charts of installed infrastructure e.g. turbines/cables – overlaid on navigational chart to show progress; • Notification of any navigational incidents which occur or any hazards to navigation (e.g. dropped objects) which may compromise navigable depths;

ID	Risk Control
	• A copy of the project's ERCOP and Layout Plan. This information would allow the PLA to do the following: • Issue PLA notice to mariners; • Include any significant activities or vessel moves in routine traffic broadcasts; • Provide timely information to pilots of expected activities. In addition, the project should attend River User Consultative Forum (Lower & Estuary) to share information on the project and planned works and listen to feedback from stakeholders.
5.	**Communication between project, sub-contractors and fishermen/leisure groups** It is important to maintain a dialogue between the developers and fishing and leisure stakeholder groups, particularly during construction and cable-laying. This would enable a transfer of information and experiences, such as planned maintenance or any adverse impacts on their operations. This builds upon an existing promulgation strategy of Vattenfall. A fisheries liaison officer would be in place for the project to liaise with the local fishing organisations, inform them of ongoing works and discuss any concerns. In addition, Vattenfall would continue to attend monthly harbour user meetings in Ramsgate to discuss the state of the project with wider stakeholders and consider any impacts. Vattenfall should also engage with the committee at Royal Temple Yacht Club, particularly during cable laying or cable maintenance to make sure targeted information on these impacts can be passed to recreational sailors. Project status updates should also be passed to the RYA for publishing in their monthly magazine and on their website to engage with a wider recreational audience.
6.	**Maintaining line of orientation and symmetry in the wind farm** In order to aid both SAR and general navigation within the wind farm, a line of orientation and symmetry should be maintained in line with MGN 543. This would require integration between the turbine spacing of the TOWF and the proposed extension, given the different sizes of WTG. Turbine numbering should also be logical and consistent. The outcome of this should be included within the layout plan and submitted to the MCA for review.
7.	**Relocation of Buoyage** The existing wind farm is marked by two Cardinal marks; Thanet North (to the north) and Drill Stone (to the east). Both marks keep vessel traffic at least one nautical mile from the boundary of the existing wind farm and would require relocation or removal. The relocation of these would be determined following the finalisation of the WTG positions and the development of the layout plan and in consultation with the MCA and Trinity House.

8.5.3 Additional Risk Controls Identified but Not Recommended

In addition to the risk controls identified above, further risk controls were identified which although would reduce the impact or risks of the project, would either be disproportionate in terms of cost or operational impact or not be necessary to reduce the risks to ALARP.

Table 22: Possible additional risk controls which have not been recommended.

ID	Risk Control
1.	**Construction and Post-Construction Monitoring** To validate the assumptions and analysis in the NRA, the developer could continue to collect vessel traffic data (through AIS) around the proposed extension in order to gauge the degree of impact that it has on navigation in comparison to this NRA. Periodic review of this data would identify whether unexpected impacts were occurring that may warrant additional mitigation measures. This process should be conducted in collaboration with the MCA. Furthermore, a process of continuous risk assessment should be conducted across the project site.
	Reason not adopted: This risk control improves monitoring of the risks but would not necessary prevent an incident. Real time monitoring is already recommended in other adopted risk controls.
2.	**Relocation of Pilot Boarding Station** Through this assessment it was identified that the sea room surrounding the NE Spit Pilot boarding station would be reduced. Simulation trials identified that it was still feasible to conduct pilot transfers in this area, albeit with reduced margin for error, therefore with some increase in risk. Consideration could be given to relocating the pilot boarding station. Activities could be split between NE Goodwin, to the south of wind farm, and Tongue, to the north. Vessels passing inshore of the wind farm could take a pilot at NE Goodwin, providing safe passage through the more constrained waters to the west of the wind farm. Vessels passing north of the extension could utilise the greater space available around Tongue and reduce collision risk at NE Spit by removing the practice of vessels dipping down to NE Spit to collect a pilot.
	Reason not adopted: The alteration of pilotage arrangements would incur additional costs, both in terms of pilot hours and wear and tear on the pilot vessels. Furthermore, it may not be feasible to continue operation our of Ramsgate with only one pilot boat given the increased distance travelled and number of trips. A two-vessel pilot system may therefore be required. There would also be impacts to availability of the pilot station during bad weather conditions, as both of these stations are less sheltered.

ID	Risk Control
	The degree of impact is considered disproportionate to the level of impact with the pilotage simulation study showing that pilotage was still feasible under the full RLB and subsequent reductions of the RLB in the western corner.
3.	**Increased Co-Ordination and Situational Awareness of Movements and Pilotage at NE Spit** The improvement of overall situational awareness and more active prior co-ordination of arriving and departing traffic at the NE Spit station could be considered for the more constrained waters after the construction of the wind farm. Early sequencing and prior organisation of the transfers would assist in reducing the onboard workload of an already busy Launch crew and especially the coxswain. This will require: • Early and refined planning, supported by enhanced shore support, to reduce pressurised decision making afloat; and • Improved situational awareness at ESL and on board the pilot vessels through the provision of higher definition and longer range presentation of vessel traffic data. This could be achieved by: • Enhancing the role of London VTS to provide early guidance, organisation or formalising the sequencing of arrivals and departures. This could take the form of “slots” at the Pilot Station published in advance in the form of a shipping list; • Strategically co-ordinating the arrival and departure of vessels estuary wide including traffic to and from the Medway. It is suggested that as a precursor to gaining improved situational awareness estuary wide visibility of the ETA and ETD aspects of POLARIS as a planning tool would significantly aid the subsequent co-ordination of traffic; • Formalising the method by which the transfer courses and vessel positioning at the pilot station is decided, communicated and executed; at present, this is achieved using a transfer course planning diamond that is refined by the Coxswain afloat and only communicated to the ship immediately prior to transfer. Early promulgation of a likely transfer course and a rendezvous position might help maximise the sea room available for transfer. Aided by weather forecasting, it ought to be possible to plan transfers up to 6 -12 hours in advance and inform the ship when they make initial VHF contact 2 hours prior to transfer. For example; for a North-East wind, an Inbound vessel could be informed to arrive 2 miles to the south east of the pilot station ready for a port ladder transfer on a course of 330. This could be published earlier in advance by email, SMS or other means to VTS, Pilots and the ship itself; • ESL could consider re-instating the role of “Station Officer” (a role removed in circa 2010) to provide a centralised and senior point of contact for planning and a real-time co-ordination of traffic and transfers outlined above. The scope of this role might include:

<table>
<tr><th>ID</th><th>Risk Control</th></tr>
<tr><td rowspan="2"></td><td>

Interaction with VTS / ships agents and using POLARIS to coordinate transfers of 6-12 hours in advance ahead.
Planning individual Launch trips and the likely order and geometry of the transfers.
Operational support to the Coxswain.

It was suggested that a re-examination of the authority of the PLA / ESL to direct and co-ordinate vessel arrival and departure timings and traffic in the area is conducted.
</td></tr>
<tr><td>Reason not adopted:
The degree of impact is considered disproportionate to the level of impact with the pilotage simulation study showing that pilotage was still feasible under the full RLB and subsequent reductions of the RLB in the western corner.</td></tr>
<tr><td rowspan="2">4.</td><td>Improved Training and Integration of Pilots, ESL and PLA VTS

Consideration could be given to enhancing and broadening the scope of training for ESL coxswains specifically regarding VTS, traffic management and awareness of themes that will be concerning a pilot or ships master before, during and after transfer;
The role of the pilot as a source of advice and guidance for the coxswain when present on the launch should also be explored. The authority and responsibility of the coxswain with regard to the conduct of the transfers would not be changed but discussion and the provision of real time advice by the pilots on board the launch should be actively encouraged;
Increase integration and training exposure between pilots, ESL and VTS. Two days interaction in the simulator between two pilots and two coxswains yielded a range of unanticipated benefits with regard to improved mutual understanding and comprehension of the challenges faced by each group. Notwithstanding the acknowledged difficulties of operational rotas, the benefits of further integration or exposure between the two groups could only aid cross fertilisation of procedures, planning and mutual understanding. The inclusion of VTS officers in this process is also strongly encouraged.
</td></tr>
<tr><td>Reason not adopted:
The degree of impact is considered disproportionate to the level of impact with the pilotage simulation study showing that pilotage was still feasible under the full RLB and subsequent reductions of the RLB in the western corner.</td></tr>
</table>

8.6 RESULTS

8.6.1 Construction / Decommissioning

Table 23 shows the top 10 hazards identified during the construction or decommissioning phase. Hazard ID 23/35/7 are all project risks relating solely to construction activities and the greater frequency of movements and close proximity of activities. The most significant hazards relating to other mariners involve large commercial shipping and are shown to increase as a result of the reduced sea room and greater number of project vessel movements. These hazards can be mitigated to some degree with additional risk controls, however the residual risks remain heightened above current levels. All hazards, do however, fall within ALARP and below the threshold of intolerable.

8.6.2 Operational

The top 10 hazards identified during the operational phase are shown in **Table 24**. The risk is generally lower than during the construction phase due to the lower number of project vessel movements. These hazards can be mitigated to some degree with additional risk controls, however the residual risks remain heightened above current levels. As above, all hazards fall within ALARP and below the threshold of intolerable.

Table 23: Top 10 Hazards in Construction/Decommissioning Phase.

Hazard ID	Category	Hazard Title	Baseline Risk	Inherent Risk	Residual risk
23	Contact	Contact - Small Construction/O&M Vessel in Contact with WTG	4.04	5.24	5.24
12	Collision	Collision - Large Commercial ICW Large Commercial	4.59	5.05	4.93
15	Collision	Collision - Large Commercial ICW Recreational Craft	4.16	4.78	4.55
26	Contact	Contact - Fishing Craft in Contact with WTG	4.39	4.74	4.55
35	Obstruction	Obstruction - Large Construction Vessel Fouls Cables	N/A	4.67	4.67
21	Collision	Collision - Recreational ICW Recreational	4.66	4.66	4.66
24	Contact	Contact - Large Commercial Shipping in Contact with WTG	4.28	4.66	4.46
7	Collision	Collision - Small Construction/O&M ICW Small Construction/O&M	3.68	4.48	4.48
30	Grounding	Grounding of Commercial Shipping	4.09	4.47	4.47
32	Grounding	Grounding of Fishing Vessel	4.31	4.31	4.31

Table 24: Top 10 Hazards in Operational Phase.

Hazard ID	Category	Hazard Title	Baseline Risk	Inherent Risk	Residual risk
6	Collision	Collision - Large Commercial ICW Large Commercial	4.59	5.05	5.05
9	Collision	Collision - Large Commercial ICW Recreational Craft	4.16	4.78	4.78
19	Contact	Contact - Fishing Craft in Contact with WTG	4.39	4.74	4.55
15	Collision	Collision - Recreational ICW Recreational	4.66	4.66	4.66
17	Contact	Contact - Large Commercial Shipping in Contact with WTG	4.28	4.66	4.56
16	Contact	Contact - O&M Vessel in Contact with WTG	4.04	4.48	4.48
22	Grounding	Grounding of Commercial Shipping	4.09	4.47	4.47
24	Grounding	Grounding of Fishing Vessel	4.31	4.31	4.31
26	Obstruction	Obstruction - Small vessel (O&M/small commercial/non-commercial) Fouls Cables	3.84	4.19	4.19
23	Grounding	Grounding of Small Commercial	4.09	4.09	4.09

8.6.3 Acceptability of Risk

No defined threshold exists for what constitutes an acceptable level of risk in the maritime domain or for wind farm developments. The risk scoring methodology (see **Annex B**) is common throughout the industry and a significant amount of evidence has been collected, such as through simulation and collision risk modelling, to support the assessments of the likelihood of an incident occurring before and after the development.

Considerations of what is deemed as an acceptable risk have been discussed by the IMO (see MSC 72/16) and HSE (see HSE 1999 - Reducing Risks, Protecting People) when the risk relates to the loss of life. Typical values are given for the threshold of acceptability to individuals as 1 x 10^{-3}, approximately a 1 in 1000 chance per year per crew person and 1 x 10^{-4} for members of the public.

To gauge the level of acceptability of the risk assessment shown above, the likelihood of a fatality per year per hazard was calculated. A conservative estimate was then made of how many individuals would be exposed to the risk of a fatality for that hazard by vessel type (for example a collision between a fishing vessel and a commercial ship would pose a threat to the fishing boats crew only), assumptions are shown below:

- Large Construction Vessel – 20 crew – 50 individuals over a year;
- Small construction/O&M Vessel – 15 crew – 200 individuals over a year;
- Large commercial shipping – 20 crew – 10,000 individuals over a year;
- Small commercial – 10 crew – 1000 individuals over a year;
- Fishing – 5 crew – 50 individuals over a year;
- Recreational – 5 crew – 500 individuals over a year.

For example, if a hazard has a 1 in 100 years return rate across the study area and may cause a fatality, the risk is 1% per year. If there are 100 people exposed to that hazard, i.e. working or operating in that area, the risk per an individual is 0.01%.

The total risk for all hazards relating to each vessel type was summed and is shown below **in Figure 66**. The results suggest that all hazards fall well below the 1 x 10^{-3} threshold even under the inherent case. The risk to fishermen is shown to be most significant, but this reflects the hazardous nature of that industry which is well known and supported by this assessment. The majority of other vessel types also fall below the 1 x 10^{-4} threshold, a 1 in 10,000 chance per individual per year. The figures do however demonstrate that the risk does increase above the baseline scenario as a result of the development across most vessel types.

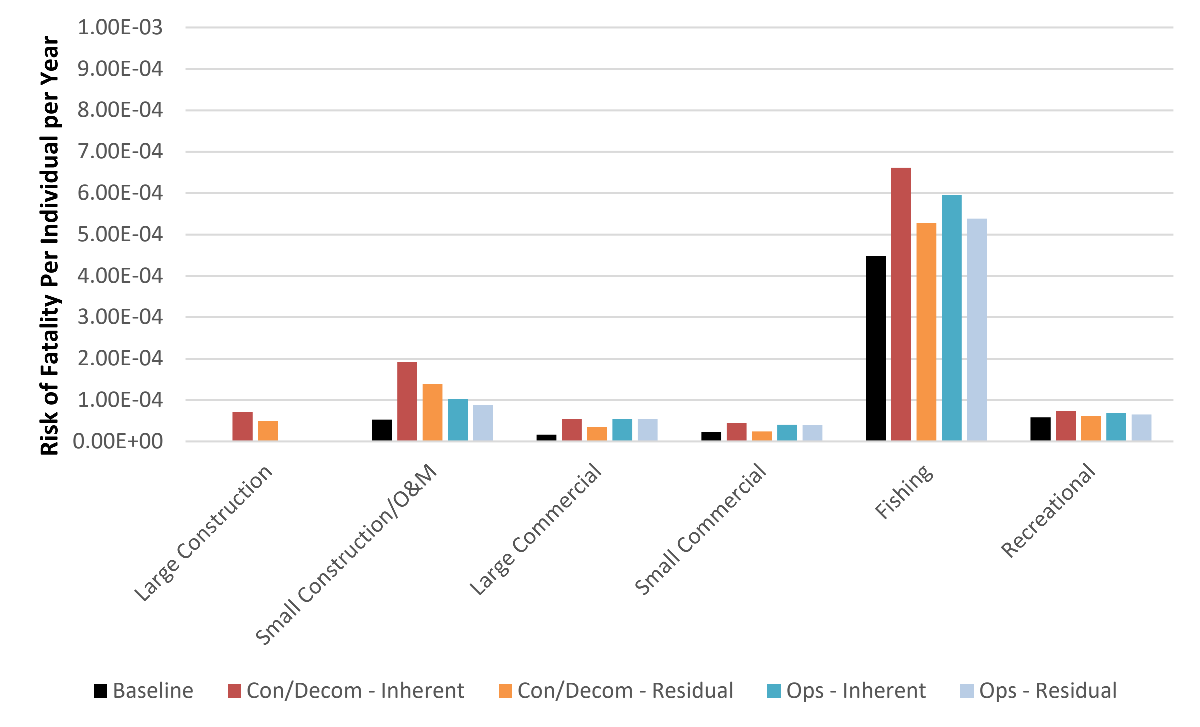

Figure 66: Risk of a fatality per individual per year.

8.7 SUMMARY

The risk assessment has demonstrated that the proposed Thanet Extension would increase the navigational risk for vessels near to the development. This increase is however not considered to be intolerable, with all hazards falling within ALARP with additional risk controls put in place. In general, the construction / decommissioning phase was considered more hazardous than the operational phase, due to the increased activities and movements of vessels.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

This assessment has considered the activities of vessels around the TOWF and the possible impacts of the development of the extension. The following conclusions have been reached:

1. The development would result in an increase in capacity by up to 340 MW with up to an additional 34 WTGs and an export cable route to Pegwell Bay. The construction and maintenance base would be in Ramsgate.
2. The extension lies partially within the VTS area for the Port of London, and adjacent to pilot boarding points into the Thames Estuary. Vessel traffic passing the development services several ports and harbours in the southern Thames Estuary.
3. With the exception of the existing Thanet Wind Farm, no other renewables, aggregate or oil and gas developments lie within 10nm. Vessel traffic supporting these services does however transit passed the extension footprint.
4. Consultees identified a range of concerns relating to shipping and the safety of navigation, particularly related to the reduction in sea room to the west, the impact on pilotage operations at NE Spit and the impacts to navigation during the cable installation.

Vessel Traffic

5. The vessel traffic survey identified a range of activities near to the development including commercial shipping, fishing and recreational users.
6. Several commercial shipping routes exist adjacent to the site. An inshore route exists between the Thanet Wind Farm and North Foreland of which there are 10 movements a day, a route to the east with a further 10 movements per day and a route to the north of up to 30 movements per day. A practice of "dipping down" was identified whereby commercial shipping that would typically pass to the north of the development would come south to NE Spit to embark or disembark a pilot before turning north back to their route.
7. Fishing in the area is significant with approximately 20 small vessels operating from Ramsgate and larger vessels active to the north-east of the site.
8. Recreational activity is generally further inshore than the development, centred around Ramsgate.
9. Analysis of the historical incident record suggests a background collision rate of once in six years, a contact rate of once in nine years and once in six years for grounding. It is noted that

there is underreporting of incidents with collisions and contacts anecdotally reported but not included in the MAIB dataset.

10. A review of the macro-economic and local drivers of shipping activity suggests that vessel movements are unlikely to increase significantly near to the development during the life cycle of the project. There are however aspirations to increase trade in the Port of London, Ramsgate and Medway.

Impact Assessment

11. The impact on vessel routeing was considered and a comparison made between existing routes and those with the extension in place. A small increase in transit time was identified as the likely impact but this was not considered significant to make commercial operations of local ports unviable.
12. The impact on pilotage operations was considered, particularly the reduction in sea room at NE Spit. A simulation workshop conducted with PLA pilots and ESL coxswains tested the feasibility of the continued operation with the extension in place and concluded that even under critical MetOcean conditions and vessel types, pilotage operations were feasible. It was noted however that the reduced margin for error would increase the risk of an incident. Additional risk control measures were discussed in the simulation workshop to manage the safety of pilotage operations, with or without the extension, however there would be significant operational impacts and they have not been taken forward in this assessment.
13. The reduction in sea room to the west of the development was modelled to understand how this would increase the collision risk for navigating vessels. Collision risk modelling compared the before and after change in encounters between vessels, suggesting a 54% increase in collision risk without additional controls. This would increase the historical incident rate of one collision per six years to one collision per four years within 10nm of the extension.
14. The risk of contact with a turbine by a passing commercial vessel was also modelled, and whilst the risk was identified to increase due to the reduced passing distance and increased number of WTGs, the resulting likelihood and consequence was relatively low.
15. The impact to navigation of the cable and its laying were considered, with effective management of the process essential to minimising impact to stakeholders. UKC should not be compromised near to landfall to maintain access to the River Stour.
16. Whilst the final design of the wind farm is unknown, attention is drawn to the key principles of Search and Rescue in wind farms so that there are no adverse impacts.
17. The positioning of the wind farm is not considered to have a significant effect on visual navigation and collision avoidance, given the spacing of the WTGs.

18. A review of research on the impacts of WTGs on communications, radar and positioning systems was undertaken and applied to Thanet Extension. Whilst there would be some impacts, these could be effectively managed and would not increase the risk of collision as a result.
19. The cumulative and in-combination impacts were reviewed, and whilst the footprints of the developments would not cause an adverse impact, the extension would impact the routeing and navigational safety of supporting vessels.

Navigation Risk Assessment

20. A Navigation Risk Assessment was undertaken in line with the Formal Safety Assessment and MGN 543 for the construction/decommissioning phase and the operational phase, for which 38 and 29 distinct hazards were identified respectively.
21. Of the hazards identified, all fall into or below the category of As Low as Reasonably Practicable, however several would increase as a result of the extension even with additional risk controls in place. The most significant hazards relate to the risks of collision involving vessels to the west of the development and contact risks between navigating or construction/maintenance vessels and the WTGs.
22. A suite of embedded and additional risk controls have been identified which could be implemented to reduce the risks further. Additional controls have been discussed to further manage the safety of navigation, but whilst undoubtedly effective, would introduce significant operational challenges to the project, vessels or local port authorities and may not be cost-effective. These have not therefore been recommended.
23. In order to address the concerns of stakeholders, the project has revised the Red Line Boundary to increase the available sea room to the west of the extension. Furthermore, a cable exclusion area has been created to maintain clearance of the cable route from the approach channel to Ramsgate.

9.2 RECOMMENDATIONS

In order to reduce the risks to those hazards which would increase as a result of the extension to As Low as Reasonably Practicable or less, it is recommended that a suite of additional risk controls are implemented by the project in addition to the embedded risk controls described above:

1. The developer to apply to the Secretary of State for 500m Safety Zones during the construction of the wind farm and 50m during operation.
2. Guard vessels should be in place to manage vessel traffic during construction of the site and installation of the cable.
3. Coordination during cable laying with the Port of Ramsgate and local user groups to minimise disruption.
4. A means of coordination and information provision between the developer and the Port of London VTS should be in place for construction and maintenance activities.
5. Communication between project, sub-contractors and fishermen/leisure groups should be maintained.
6. Line of orientation and symmetry should be maintained in the wind farm layout to aid Search and Rescue.
7. Existing buoyage should be relocated or removed as appropriate.

9.3 SUMMARY

This assessment has considered a variety of impacts and hazards associated with Thanet Extension, drawing upon evidence presented from analysis and stakeholders. The assessment concludes that the extension would heighten the risks to navigation in the southern Thames Estuary. These risks, whilst heightened, are considered to fall within “As Low as Reasonably Practicable”. Additional risk controls could be implemented to manage them further, several of which would introduce operational challenges to the project, vessels or local port authorities and may not be cost-effective and have therefore not been recommended within this NRA. In particular, pilotage operations at NE Spit will become more operationally challenging, albeit still feasible; additional management of activities in this area were discussed but have not been considered necessary.

Several stakeholders raised concerns about the restriction of sea room to the west of the extension during the process of this assessment. In order to mitigate these concerns and reduce the level of impact, the project took the decision to reduce the red line boundary of the extension in this area.

In summary, this study has outlined the methodology, evidence base and results that demonstrate that the impacts to navigational safety of the proposed extension, would be heightened but can be managed to ALARP using proposed risk control measures.

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Annex A MGN 543 Checklist

MGN 543 (M+F) Safety of Navigation: Offshore Renewable Energy Installations –

Guidance on UK Navigational Practice, Safety and Emergency Response

Issue: OREI Response	Yes/No	Comments
Annex 1 : Considerations on Site Position, Structures and Safety Zones		
1. Site and Installation Co-ordinates: Developers are responsible for ensuring that formally agreed co-ordinates and subsequent variations of site perimeters and individual OREI structures are made available, on request, to interested parties at relevant project stages, including application for consent, development, array variation, operation and decommissioning. This should be supplied as authoritative Geographical Information System (GIS) data, preferably in Environmental Systems Research Institute (ESRI) format. Metadata should facilitate the identification of the data creator, its date and purpose, and the geodetic datum used. For mariners' use, appropriate data should also be provided with latitude and longitude coordinates in WGS84 (ETRS89) datum.		
Traffic Survey – includes:		
All vessel types	✓	**Section 5**
At least 28 days duration, within either 12 or 24 months prior to submission of the Environmental Statement	✓	**Section 5**
Multiple data sources	✓	**Section 5**
Seasonal variations	✓	**Section 5.6**
MCA consultation	✓	**Section 4** and **Annex C**
General Lighthouse Authority consultation	✓	**Section 4** and **Annex C**
Chamber of Shipping consultation	✓	**Section 4** and **Annex C**
Recreational and fishing vessel organisations consultation.	✓	**Section 4** and **Annex C**
Port and navigation authorities consultation, as appropriate	✓	**Section 4** and **Annex C**
Assessment of the cumulative and individual effects of (as appropriate):		
i. Proposed OREI site relative to areas used by any type of marine craft.	✓	**Section 5**
ii. Numbers, types and sizes of vessels presently using such areas	✓	**Section 5**

iii. Non-transit uses of the areas, e.g. fishing, day cruising of leisure craft, racing, aggregate dredging, etc.	✓	**Section 5**
iv. Whether these areas contain transit routes used by coastal or deep-draught vessels on passage.	✓	**Section 5**
v. Alignment and proximity of the site relative to adjacent shipping lanes	✓	**Section 3.4.4**
vi. Whether the nearby area contains prescribed routeing schemes or precautionary areas	✓	**Section 3.4.4**
vii. Whether the site lies on or near a prescribed or conventionally accepted separation zone between two opposing routes	✓	**Section 3.4.4**
viii. Proximity of the site to areas used for anchorage, safe haven, port approaches and pilot boarding or landing areas.	✓	**Section 3.4**
ix. Whether the site lies within the jurisdiction of a port and/or navigation authority.	✓	**Section 3.2**
x. Proximity of the site to existing fishing grounds, or to routes used by fishing vessels to such grounds.	✓	**Section 5.3.3**
xi. Proximity of the site to offshore firing/bombing ranges and areas used for any marine military purposes.	✓	**Section 3.6.7**
xii. Proximity of the site to existing or proposed offshore oil / gas platform, marine aggregate dredging, marine archaeological sites or wrecks, Marine Protected Area or other exploration/exploitation sites.	✓	**Section 3.6**
xiii. Proximity of the site to existing or proposed OREI developments, in co-operation with other relevant developers, within each round of lease awards.	✓	**Section 3.6.5**
xiv. Proximity of the site relative to any designated areas for the disposal of dredging spoil or other dumping ground	✓	**Section 3.6**

xv. Proximity of the site to aids to navigation and/or Vessel Traffic Services (VTS) in or adjacent to the area and any impact thereon.	✓	**Section 3.4**
xvi. Researched opinion using computer simulation techniques with respect to the displacement of traffic and, in particular, the creation of 'choke points' in areas of high traffic density and nearby or consented OREI sites not yet constructed.	✓	**Section 7.1** and **Section 7.3**
xvii. With reference to xvi. above, the number and type of incidents to vessels which have taken place in or near to the proposed site of the OREI to assess the likelihood of such events in the future and the potential impact of such a situation.	✓	**Section 5.6**
3. OREI Structures – the following should be determined:		
a. Whether any feature of the OREI, including auxiliary platforms outside the main generator site, mooring and anchoring systems, inter-device and export cabling could pose any type of difficulty or danger to vessels underway, performing normal operations, including fishing, anchoring and emergency response.	✓	**Section 7.4 and Section 8**
b. Clearances of wind turbine blades above the sea surface are *not less than 22 metres* above MHWS.	✓	**Section 2**
c. Underwater devices i. changes to charted depth ii. maximum height above seabed iii. Under Keel Clearance	✓	**Section 2, Section 7.5 and 7.6**
d. The burial depth of cabling and changes to charted depths associated with any protection measures.	✓	**Section 2, Section 7.5 and 7.6**

4. Assessment of Access to and Navigation Within, or Close to, an OREI **To determine the extent to which navigation would be feasible within the OREI site itself by assessing whether:**		
a. Navigation within or close to the site would be safe:		
i. by all vessels, or ii. by specified vessel types, operations and/or sizes. iii. in all directions or areas, or iv. in specified directions or areas. **v.** in specified tidal, weather or other conditions	✓	**Section 7.3, Section 7.4, Section 7.8** and **Section 8**
b. Navigation in and/or near the site should be:		
i. prohibited by specified vessels types, operations and/or sizes. ii. prohibited in respect of specific activities, iii. prohibited in all areas or directions, or iv. prohibited in specified areas or directions, or v. prohibited in specified tidal or weather conditions, or simply **vi.** recommended to be avoided.	✓ ✓ ✓ ✓ ✓	**Section 8.5**
c. Exclusion from the site could cause navigational, safety or routeing problems for vessels operating in the area e.g. by preventing vessels from responding to calls for assistance from persons in distress.	✓	**Section 7.1, Section 7.3** and **Section 7.7**
Relevant information concerning a decision to seek a safety zone for a particular site during any point in its construction, extension, operation or decommissioning should be specified in the Environmental Statement accompanying the development application	✓	**Section 8.5**
Annex 2 : Navigation, collision avoidance and communications		
The Effect of Tides and Tidal Streams : It should be determined whether:		
a. Current maritime traffic flows and operations in the general area are affected by the depth of water in which the proposed installation is situated at various states of the tide i.e. whether the installation could pose problems at high	✓	**Section 3.4.1**

water which do not exist at low water conditions, and vice versa.		
b. The set and rate of the tidal stream, at any state of the tide, has a significant effect on vessels in the area of the OREI site.	✓	**Section 3.3.4**
c. The maximum rate tidal stream runs parallel to the major axis of the proposed site layout, and, if so, its effect.	✓	**Section 3.3.4**
d. The set is across the major axis of the layout at any time, and, if so, at what rate.		**Section 3.3.4**
e. In general, whether engine failure or other circumstance could cause vessels to be set into danger by the tidal stream.	✓	**Section 3.3.4, Section 7.4** and **Section 8**
f. The structures themselves could cause changes in the set and rate of the tidal stream.	✓	**Section 8**
g. The structures in the tidal stream could be such as to produce siltation, deposition of sediment or scouring, affecting navigable water depths in the wind farm area or adjacent to the area	✓	**Section 8**
2. Weather: It should be determined whether:		
a. The site, in normal, bad weather, or restricted visibility conditions, could present difficulties or dangers to craft, including sailing vessels, which might pass in close proximity to it.	✓	**Section 3.3**
b. The structures could create problems in the area for vessels under sail, such as wind masking, turbulence or sheer.	✓	**Section 8**
c. In general, taking into account the prevailing winds for the area, whether engine failure or other circumstances could cause vessels to drift into danger, particularly if in conjunction with a tidal set such as referred to above.	✓	**Section 8**Risk Control Options

3. Collision Avoidance and Visual Navigation: It should be determined whether:		
a. The layout design will allow safe transit through the OREI by SAR helicopters and vessels.	✓	**Section 7.7**
b. The MCA's Navigation Safety Branch and Maritime Operations branch will be consulted on the layout design and agreement will be sought.	✓	**Section 4** and **Section 7.7**
c. The layout design has been or will be determined with due regard to safety of navigation and Search and Rescue.	✓	**Section 4** and **Section 7.7**
d.i. The structures could block or hinder the view of other vessels under way on any route.	✓	**Section 7.8**
d.ii. The structures could block or hinder the view of the coastline or of any other navigational feature such as aids to navigation, landmarks, promontories, etc.	✓	**Section 7.8**
4. Communications, Radar and Positioning Systems - To provide researched opinion of a generic and, where appropriate, site specific nature concerning whether:		
a. The structures could produce radio interference such as shadowing, reflections or phase changes, and emissions with respect to any frequencies used for marine positioning, navigation and timing (PNT) or communications, including GMDSS and AIS, whether ship borne, ashore or fitted to any of the proposed structures, to: i. Vessels operating at a safe navigational distance ii. Vessels by the nature of their work necessarily operating at less than the safe navigational distance to the OREI, e.g. support vessels, survey vessels, SAR assets. iii. Vessels by the nature of their work necessarily operating within the OREI.	✓ ✓ ✓ ✓	**Section 7.9**
b. The structures could produce radar reflections, blind spots, shadow areas or other adverse effects: i. Vessel to vessel;	✓ ✓	**Section 7.9**

ii. Vessel to shore; iii. VTS radar to vessel; iv. Racon to/from vessel.	✓ ✓ ✓	
c. The structures and generators might produce sonar interference affecting fishing, industrial or military systems used in the area.		**Section 7.9**
d. The site might produce acoustic noise which could mask prescribed sound signals.	✓	**Section 7.9**
e. Generators and the seabed cabling within the site and onshore might produce electro-magnetic fields affecting compasses and other navigation systems.	✓	**Section 7.9**
5. Marine Navigational Marking: It should be determined:		
a. How the overall site would be marked by day and by night throughout construction, operation and decommissioning phases, taking into account that there may be an ongoing requirement for marking on completion of decommissioning, depending on individual circumstances.	✓	**Section 2.3**
b. How individual structures on the perimeter of and within the site, both above and below the sea surface, would be marked by day and by night.	✓	**Section 2.3**
c. If the specific OREI structure would be inherently radar conspicuous from all seaward directions (and for SAR and maritime surveillance aviation purposes) or would require passive enhancers.	✓	**Section 7.9**
d. If the site would be marked by additional electronic means e.g. Racons	✓	**Section 2.3** and **Section 8.5**
e. If the site would be marked by an AIS transceiver, and if so, the data it would transmit.	✓	**Section 2.3** and **Section 8.5**
f. If the site would be fitted with audible hazard warning in accordance with IALA recommendations	✓	**Section 2.3** and **Section 8.5**

g. If the structure(s) would be fitted with aviation lighting, and if so, how these would be screened from mariners or guarded against potential confusion with other navigational marks and lights.	✓	**Section 2.3** and **Section 8.5**
h. Whether the proposed site and/or its individual generators complies in general with markings for such structures, as required by the relevant GLA in consideration of IALA guidelines and recommendations.	✓	**Section 2.3** and **Section 8.5**
i. The aids to navigation specified by the GLAs are being maintained such that the 'availability criteria', as laid down and applied by the GLAs, is met at all times.	✓	**Section 2.3** and **Section 8.5**
j. The procedures that need to be put in place to respond to casualties to the aids to navigation specified by the GLA, within the timescales laid down and specified by the GLA.	✓	**Section 2.3** and **Section 8.5**
k. The ID marking will conform to a spreadsheet layout, sequential, aligned with SAR lanes and avoid the letters O and I.	✓	**Section 2.3** and **Section 8.5**
l. Working lights will not interfere with AtoN or create confusion for the Mariner navigating in or near the OREI.	✓	**Section 2.3** and **Section 8.5**
6. Hydrography - In order to establish a baseline, confirm the safe navigable depth, monitor seabed mobility and to identify underwater hazards, detailed and accurate hydrographic surveys are included or acknowledged for the following stages and to MCA specifications:		
i. Pre-consent: The site and its immediate environs extending to 500m outside of the development area shall be undertaken as part of the licence and/or consent application. The survey shall include all proposed cable route(s).	✓	**Section 8.5**
ii. Post-construction: Cable route(s)	✓	**Section 8.5**
iii. Post-decommissioning of all or part of the development: Cable route(s) and the area extending to 500m from the installed generating assets area.	✓	**Section 8.5**

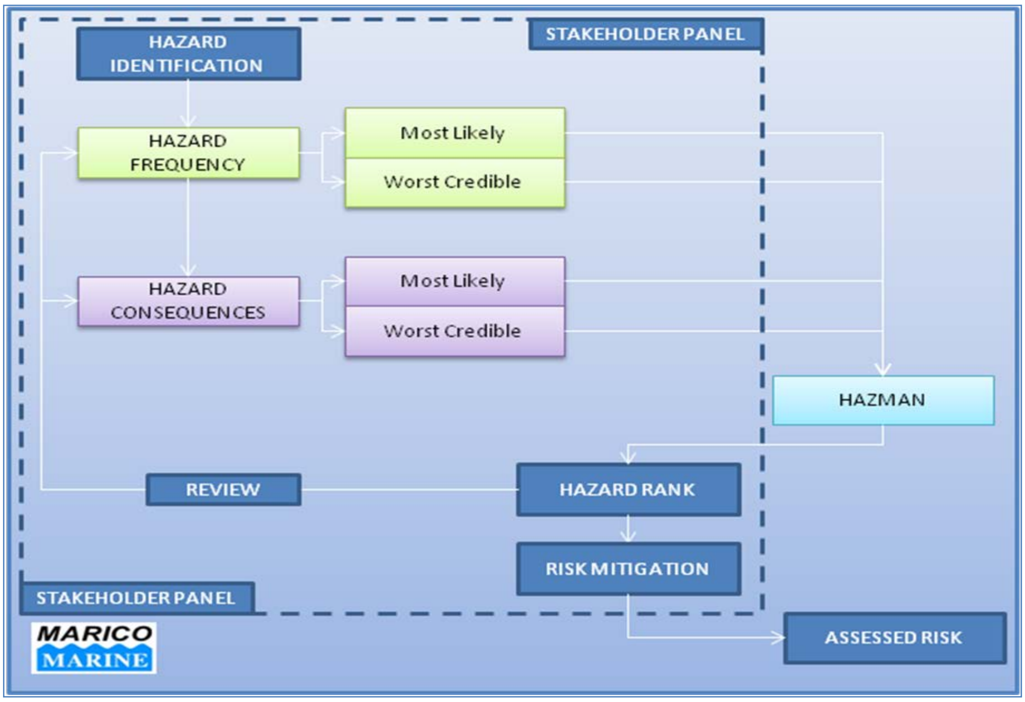
Annex 3: MCA template for assessing distances between wind farm boundaries and shipping routes		
"Shipping Route" template and Interactive Boundaries – where appropriate, the following should be determined:		
a. The safe distance between a shipping route and turbine boundaries.	✓	**Section 5.5** and **Section 7.1**
b. The width of a corridor between sites or OREIs to allow safe passage of shipping.	✓	**Section 7.10**
Annex 4: Safety and mitigation measures recommended for OREI during construction, operation and decommissioning.		
Mitigation and safety measures will be applied to the OREI development appropriate to the level and type of risk determined during the EIA. The specific measures to be employed will be selected in consultation with the Maritime and Coastguard Agency and will be listed in the developer's Environmental Statement (ES). These will be consistent with international standards contained in, for example, the SOLAS Convention - Chapter V, IMO Resolution A.572 (14)[3] and Resolution A.671(16)[4] and **could include any or all** of the following:	✓	**Section 8.5**
i. Promulgation of information and warnings through notices to mariners and other appropriate maritime safety information (MSI) dissemination methods.	✓	**Section 8.5**
ii. Continuous watch by multi-channel VHF, including Digital Selective Calling (DSC).		
iii. Safety zones of appropriate configuration, extent and application to specified vessels[15]		

iv. Designation of the site as an area to be avoided (ATBA).	✓	**Section 8.5**
v. Provision of AtoN as determined by the GLA	✓	**Section 8.5**
vi. Implementation of routeing measures within or near to the development.	✓	**Section 8.5**
vii. Monitoring by radar, AIS, CCTV or other agreed means	✓	**Section 8.5**
viii. Appropriate means for OREI operators to notify, and provide evidence of, the infringement of safety zones.	✓	**Section 8.5**
ix. Creation of an Emergency Response Cooperation Plan with the MCA's Search and Rescue Branch for the construction phase onwards.	✓	**Section 7.7** and **Section 8.5**
x. Use of guard vessels, where appropriate	✓	**Section 8.5**
xi. Any other measures and procedures considered appropriate in consultation with other stakeholders.	✓	**Section 8.5**
Annex 5: Standards, procedures and operational requirements in the event of search and rescue, maritime assistance service counter pollution or salvage incident in or around an OREI, including generator/installation control and shutdown.		
The MCA, through HM Coastguard, is required to provide SAR and emergency response within the sea area occupied by all offshore renewable energy installations in UK waters. To ensure that such operations can be safely and effectively conducted, certain requirements must be met by developers and operators.		
a. An ERCoP will be developed for the construction, operation and decommissioning phases of the OREI.	✓	**Section 7.7** and **Section 8.5**
b. The MCA's guidance document *Offshore Renewable Energy Installation: Requirements, Advice and Guidance for Search and Rescue and Emergency Response* for the design, equipment and operation requirements will be followed.	✓	**Section 8.5**

Annex B NRA Methodology

Methodology

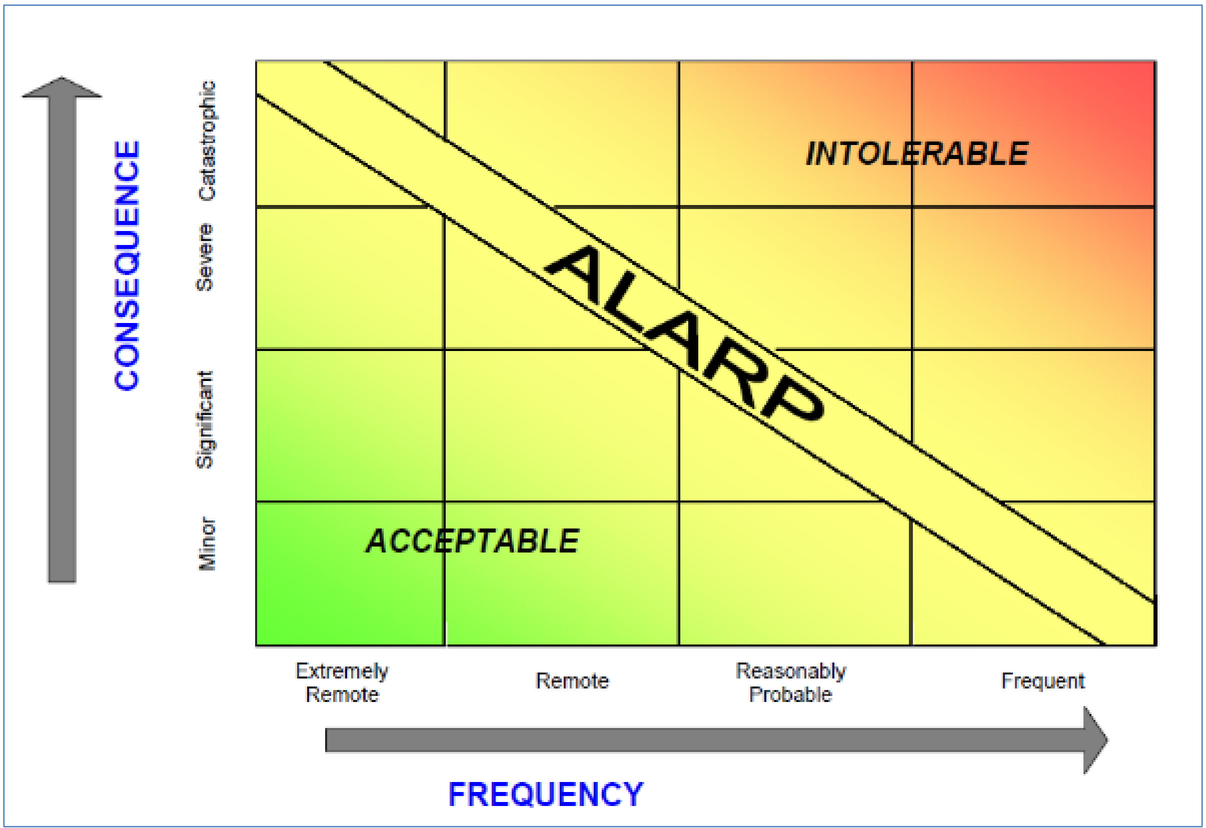
This Navigation Risk Assessment (NRA) was commissioned to assess the impact on navigation potentially caused by each of the three phases of the proposed wind farm project, namely: construction, operation and decommissioning. The NRA is limited to identifying and quantifying any additional or increased navigational risk resulting from the project. It subsequently identifies possible mitigation measures where appropriate and makes recommendations. The process starts with the identification of all potential hazards. It then assesses the likelihood (frequency) of a hazard causing an incident and considers the possible consequences of that incident. It does so in respect of two scenarios, namely the "most likely" and the "worst credible". The quantified values of frequency and consequence are then combined using the Marico HAZMAN software to produce a Risk Score for each hazard. These are collated into a "Ranked Hazard List" from which the need for possible additional mitigation may be reviewed.



Marico Marine Risk Assessment Methodology.

Criteria for Navigational Risk Assessment

Risk is the product of a combination of consequence of an event and the frequency with which it might be expected to occur. In order to determine navigational risk a Formal Safety Assessment (FSA) approach to risk management is used. International Maritime Organisation (IMO) Guidelines define a hazard as "something with the potential to cause harm, loss or injury", the realisation of which results in an accident. The potential for a hazard to be realised can be combined with an estimated or known consequence of outcome. This combination is termed "risk". Risk is therefore a measure of the frequency and consequence of a particular hazard.



General risk matrix.

The combination of consequence and frequency of occurrence of a hazard is combined using a risk matrix which enables hazards to be ranked and a risk score assigned. The resulting scale can be divided into three general categories:

- Acceptable;
- As Low as Reasonable Practicable (ALARP); and
- Intolerable.

At the low end of the scale, frequency is extremely remote and consequence minor, and as such the risk can be said to be "acceptable", whilst at the high end of the matrix, where hazards are defined as frequent and the consequence catastrophic, then risk is termed "intolerable". Every effort should be made to mitigate all risks such that they lie in the "acceptable" range. Where this is not possible, they should be reduced to the level where further reduction is not practicable. This region, at the centre of the matrix is described as the ALARP region. It is possible that some risks will lie in the "intolerable" region, but can be mitigated by measures, which reduce their risk score and move them into the ALARP region, where they can be tolerated, albeit efforts should continue to be made when opportunity presents itself to further reduce their risk score.

The FSA methodology used in this NRA, determines where to prioritise risk control options for the navigational aspects of an offshore wind farm site. The outcome of this risk assessment process should then act as the basis for a Navigation Safety Management System, which can be used to manage navigational risk.

Hazard Identification

Hazard identification is the first and fundamental step in the risk assessment process. It was undertaken for this project by three Marico Marine specialists using the results of the analysis and feedback from local stakeholders. In order to ensure that the process was both structured and comprehensive, potential hazards were reviewed under the following headings;

- Project phase;
- Incident category;
- Geographical area; and
- Vessel type.

The three project phases (construction, operation and decommissioning) have been assessed individually due to their different navigational risk exposure and magnitude, i.e. the different nature of the operations, the vessels involved, and the potential cost of any consequences. By way of example the frequency and consequences of collision during the construction phase will differ significantly due to the many movements of larger specialist vessels associated with the construction. It was determined that the uncertainty of the decommissioning phase and the likely activities were similar to the construction phase and therefore these two have been combined. The five incident categories identified as being relevant to this study are:

- Collision;
- Contact;
- Obstruction;
- Grounding; and
- Swamping/Capsize.

It the content of this study, foundering, defined as “filling from above the waterline and sinking” and pollution have been treated as possible consequences of the above accident categories. The geographical areas used for the study were:

- Within the perimeter of the proposed site;
- In the vicinity of proposed site;
- Along the export cable route; and

- Transiting between base port and the proposed site.

The vessel types considered were:

- **Large Construction Vessels** – major construction vessels used for the installation of the foundations, WTGs and cable. Includes cable laying vessels, heavy lift and crane barges around 100m LOA.
- **Small Construction Vessels/ O&M vessels** – smaller and more regular maintenance vessels, such as wind farm support vessels and crew transfer vessels. May be high speed craft and typically around 10m LOA. Vessels are active throughout the lifecycle of the project.
- **Large Commercial** – large commercial shipping greater than 75m LOA, including cargo vessels, tankers and passenger ships navigating in the vicinity of the wind farm.
- **Small Commercial** – All other commercial vessels such as pilot boats, survey boats and tugs.
- **Fishing Vessels** – Vessels engaged in fishing or trawling.
- **Recreational** –Recreational craft operating in and around the wind farm.

Risk Matrix Criteria

As indicated earlier, frequency of occurrence and likely consequence were both assessed for the "most likely" and "worst credible" scenario. Frequencies were assessed according to the levels set out below.

Frequency criteria.

Scale	Description	Definition	Operational Interpretation
F5	Frequent	An event occurring in the range once a week to once an operating year.	One or more times in 1 year
F4	Likely	An event occurring in the range once a year to once every 10 operating years.	One or more times in 10 years 1 - 9 years
F3	Possible	An event occurring in the range once every 10 operating years to once in 100 operating years.	One or more times in 100 years 10 – 99 years
F2	Unlikely	An event occurring in the range less than once in 100 operating years.	One or more times in 1,000 years 100 – 999 years
F1	Remote	Considered to occur less than once in 1,000 operating years (e.g. it may have occurred at a similar site, elsewhere in the world).	Less than once in 1,000 years >1,000 years

Using the assessed notional frequency for the "most likely" and "worst credible" scenarios for each hazard, the probable consequences associated with each were assessed in terms of damage to:

- People - Personal injury, fatality etc.;
- Property – Wind farm site and third party;
- Environment - Oil pollution etc.; and
- Business - Reputation, financial loss, public relations etc.

The magnitude of each was then assessed using the consequence categories given below. These have been set such that the consequences in respect of property, environment and business have similar monetary outcomes.

Consequence categories and criteria.

Cat.	People	Property	Environment	Business
C1	**Negligible** Possible very minor injury (e.g. bruising)	**Negligible** Costs <£10k	**Negligible** No effect of note. Tier1 <u>may</u> be declared but criteria not necessarily met. Costs <£10k	**Negligible** Costs <£10k
C2	**Minor** (single minor injury)	**Minor** Minor damage Costs £10k – £100k	**Minor** Tier 1 – Tier 2 criteria reached. Small operational (oil) spill with little effect on environmental amenity Costs £10K–£100k	**Minor** Bad local publicity and/or short-term loss of revenue Costs £10k – £100k
C3	**Moderate** Multiple minor or single major injury	**Moderate** Moderate damage Costs £100k - £1M	**Moderate** Tier 2 spill criteria reached but capable of being limited to immediate area within site Costs £100k -£1M	**Moderate** Bad widespread publicity Temporary suspension of operations or prolonged restrictions at wind farm Costs £100k - £1M
C4	**Major** Multiple major injuries or single fatality	**Major** Major damage Costs £1M -£10M	**Major** Tier 3 criteria reached with pollution requiring national support. Chemical spillage or small gas release Costs £1M - £10M	**Major** National publicity, Temporary closure or prolonged restrictions on wind farm operations Costs £1M -£10M
C5	**Catastrophic** Multiple fatalities	**Catastrophic** Catastrophic damage Costs >£10M	**Catastrophic** Tier 3 oil spill criteria reached. International support required. Widespread shoreline contamination. Serious chemical or gas release. Significant threat to environmental amenity. Costs >£10M	**Catastrophic** International media publicity. wind farm site closes. Operations and revenue seriously disrupted for more than two days. Ensuing loss of revenue. Costs >£10M

Hazard Data Review Process

Frequency and consequence data was assessed for each hazard drawing initially on the knowledge and expertise of the Marico Marine specialists. This was subsequently influenced by the views and experience of the many stakeholders, whose contribution was greatly appreciated, as well as historic incident where available. It should be noted that the hazards were scored on the basis of the "status quo" i.e. with all existing mitigation measures taken into consideration. The outcome of this process was then checked for consistency against the assessments made in previous and similar risk assessments.

Having decided in respect of each hazard which frequency and consequence criteria are appropriate for the four consequence categories in both the "most likely" and "worst credible" scenarios, eight risk scores were obtained using the following matrix.

Risk factor matrix used for hazard assessment.

Consequences	Cat 5	5	6	7	8	10
	Cat 4	4	5	6	7	9
	Cat 3	3	3	4	6	8
	Cat 2	1	2	2	3	6
	Cat 1	0	0	0	0	0
	Frequency	**>1,000 years**	**100-1,000 years**	**10-100 years**	**1 to 10 years**	**Yearly**

Where:

Risk Number	*Risk*
0 to 1.9	*Negligible*
2 to 3.9	*Low Risk*
4 to 6.9	*As Low as Reasonably Practical*
7 to 8.9	*Significant Risk*
9 to 10.0	*High Risk*

It should be noted that occasionally, a "most likely" scenario will generate a higher risk score than the equivalent "worst credible" scenario; this is due to the increased frequency often associated with a "most likely" event. For example, in the case of a large number of small contact events, the total damage might be of greater significance than a single heavy contact at a much lesser frequency.

Hazard Ranking

The risk scores obtained from the above process were then analysed further to obtain four indices for each hazard as follows:

- The average risk score of the four categories in the "most likely" set;
- The average risk score of the four categories in the "worst credible" set;
- The maximum risk score of the four categories in the "most likely" set; and
- The maximum risk score of the four categories in the "worst credible" set.

These scores were then combined in Marico Marine's hazard management software "HAZMAN" to produce a single numeric value representing each of the four indices. The hazard list was then sorted in order of the aggregate of the four indices to produce a "Ranked Hazard List" with the highest risk hazards prioritised at the top.

Mitigation

Mitigation measures that could be employed to reduce the likelihood or consequence of the hazards occurring are then identified.

Annex C Consultation Minutes (on Previous Red Line Boundary)

Minutes of Meeting held on 05-December 2017

Client:	GoBe Consultants	
Project:	16UK1255 Thanet Extension Offshore Wind Farm (Thanet Extension)	
Venue:	Maritime & Coastguard Agency, Spring Place, Southampton	
Date of Meeting:	05-Dec-17 0900 – 1100	
Present:	MCA	Helen Croxson (HC)
	Marico Marine	Andrew Rawson (AR)
	Marico Marine	Paul Fuller (PF)

Item	Action item / Notes for the record	Action
1	**Introduction**	
1.1	Introductions of those present.	
1.2	AR gave an overview of the project and the work done to date and consultation/NRA process following MGN 543.	
2	**Discussion of key navigational themes raised by MCA during scoping**	
2.1	Impact on Vessel Routeing – HC raised issue of impact on traffic to the three major ports, ensuring Thanet Extension F does not adversely affect traffic navigating in the Thames Estuary, and the impact on the pilot boarding area Marico to quantify increase in transit distance of traffic following development.	AR
2.2	Sea Room – MCA concerned on constriction of traffic inshore (west and south west) of extension and the resultant increase in collision risk. Marico undertaking collision risk modelling to gauge the change in encounters before and after the proposed development.	
2.3	Pilotage – AR described the simulation exercises undertaken with PLA Pilots/ESL and the conclusions that pilotage transfers would be feasible albeit with less available sea room.	
2.4	NRA Methodology – AR described NRA methodology which follow MCA guidelines as part of MGN 543. HC advised that the monitoring and mitigation measures need to be able to reduce the risks to navigation safety to ALARP.	
2.5	Cable Burial UKC – HC explained the MCA guidance on accepting a maximum of 5% reduction in surrounding chart datum for cable burial protection.	
2.6	Safety Zones – Discussion on 500m safety zone during construction. NRA to determine level of restriction, if any, during operational phase.	
2.7	SAR – HC advised that MCA officer Peter Lowson would comment on the ERCOP once produced. PF identified that an ERCOP already exists at Thanet, therefore the ERCOP should be reviewed to account for the Extension.	
3	**Next steps**	
3.1	AR to arrange navigation risk workshop hosted by MCA at Spring Place, including MCA/Trinity House/Vattenfall/Marico in early January.	AR
3.2	HC to review PEIR documentation and comment accordingly.	HC

Minutes of Meeting held with PLA on 05-December 2017

Client:	GoBe Consultants		
Project:	16UK1255 Thanet Extension Offshore Wind Farm (Thanet Extension)		
Venue:	Port of London Authority (PLA), London River House, Gravesend		
Date of Meeting:	05-Dec-17 1400 – 1530		
Present:	PLA	Cathryn Spain (CS)	
	Marico Marine	Andrew Rawson (AR)	
	Marico Marine	Paul Fuller (PF)	

Item	Action item / Notes for the record	Action
1	**Introduction**	
1.1	Introductions of those present and outline meeting agenda.	
1.2	AR described work conducted to date and outlined the NRA process.	
2	**Discussion of key navigational themes raised by PLA**	
2.1	Impact on Vessel Routeing – AR presented vessel traffic analysis conducted around the wind farm. PF/CS discussed the density of traffic around the wind farm, particularly the concentration of traffic around NE Spit. CS commented that the number of large vessels entering London is increasing and they are considering the feasibility of using Princes Channel for these vessels, and thereby the Tongue Pilot Station. The largest vessels will go outside of the wind farm because they wouldn't have enough water, but if they are light enough draught to use the Princes Channel they would opt to go inside if possible, as this saves time and fuel. An extension may well force them outside due to the reduced sea room.	
2.2	Sea Room – PLA concerned on constriction of traffic inshore of extension and the resultant increase in collision risk. Marico undertaking collision risk modelling to gauge the change in encounters before and after the proposed development. PF questioned whether there had been any incidents involving vessels approaching Thanet other than those reported to the MAIB. CS explained how PLA collect incident data and have started collected "VTS Positive Intervention" data, detailing where VTS has stepped in to prevent a possible accident.	
2.3	Pilotage – AR described the simulation exercises undertaken with PLA Pilots/ESL and the conclusions that pilotage transfers would be feasible albeit with less available sea room. CS identified that the simulation would not be able to accurately reflect all outcomes and included experienced mariners, familiar with the Thames Estuary, and therefore did not entirely reflect the relative inexperience of masters inbound to London, in a challenging environment.	
2.4	Marine Navigation and Communication Systems – CS reiterated the need to investigate the possible effects of the extension on radar and electronic aids to navigation, including PLA's shore based VTS. AR/PF gave an overview of the findings of previous research at other wind farms.	
3	**Discussion of possible risk controls**	
3.1	PF tabled whether the PLA could identify any additional mitigation measures in order to reduce the risk of the extension. CS described how the PLA had adapted their	

	procedures and practices to ensure that the risks of the original Thanet Wind Farm were acceptable, and that it would be difficult to identify anything further which could be implemented.	
3.2	PF/CS discussed the relative merits of additional buoyage and concluded that it was not practical and would present an additional hazard to navigation.	
3.3	CS outlined how moving the pilot station would be costly, both in terms of wear and tear on pilot vessels and/or rostering of pilots and hours of work.	
3.4	CS concluded that without substantial mitigation implemented to reduce the impact on pilotage and sea room, the PLA would likely object to the development on navigational safety grounds.	

Minutes of Meeting held with Port of Ramsgate on 06-December 2017

Client:	GoBe Consultants	
Project:	16UK1255 Thanet Extension Offshore Wind Farm (Thanet Extension)	
Venue:	Harbour Office, Ramsgate	
Date of Meeting:	06-Dec-17 1000 – 1200	
Present:	Port of Ramsgate	Captain Robert Brown (RB) – HM
	Port of Ramsgate	Simon Bown (SB) - DHM
	Port of Ramsgate	Colin Winbush (CB) - Pilot
	Marico Marine	Andrew Rawson (AR)
	Marico Marine	Paul Fuller (PF)

Item	Action item / Notes for the record	Action
1	**Introduction**	
1.1	Introductions of those present and outline meeting agenda.	
1.2	AR/PF described work done to date and NRA methodology.	
2	**Overview of the Port of Ramsgate**	
2.1	RB described the commercial, leisure and fishing user groups at the port.	
2.2	The port's commercial RoRo stopped operating in 2013, currently it is principally aggregate vessels with 30/40 movements per year. Vessels typically less than 90m LOA and the berths could be NABSA. Compulsory pilotage for vessels >80m. ESL provide pilot boat services for port.	
2.3	The leisure sector is a significant part of the Port operations: • 10,000 visitor nights between April and October; • 700 berths, 200 of which are visitor berths; • Small craft holding areas outside of the port which are clear of the main channel; • Recommended small craft channel marked on charts; and • Marina owned and operated by the Port.	
2.4	PF asked about any recent incidents or near misses. RB raised concern on the experience and certification standard of WFSV operators, but believed that it was only a significant issue during construction – those WFSV active during the O&M phase are much more experienced. There was an incident in 2011 where one WFV contacted the breakwater and a catamaran which resulted in some damage. There were some groundings associated with the London Array project. There was anecdotal evidence of serious near misses between WFSV and commercial vessels. During construction of the cable it was believed that the construction vessel had snagged the cable with their own anchor.	
2.5	RB described the importance of the wind farm industry to Ramsgate, with more than 500 people directly employed. During construction periods there were more than 60 boats operating from Ramsgate.	
2.6	RB gave an overview of the Port's future expansion plans to redevelop the harbour and introduce new commercial services from the Ro-Ro Berths. Secondly, plans for	

	a new southern breakwater with a research and development college and wind farm engineering facility were presented. Vessel sizes would increase up to 120m.	
3	**Discussion of Impacts of** Thanet Extension	
3.1	RB concluded that the Port was generally supportive of the project and that there were no impacts associated with the development itself. RB highlighted the navigational impacts associated with the western portion of the extension but considered that they did not directly impact the port.	
3.2	The Port was principally concerned with the cable route and its construction. Recent laying of the Nemo interconnector and the original Thanet cable had resulted in adverse impacts to the port and its users. The cable corridor for Thanet passes close to the buoyed channel into the port and would have 2 impacts: 1. Blocking approach to the port during construction/maintenance; 2. Present a risk of collision with port users	
3.3	PF raised if there had been any issues raised with regards to radar returns at the wind farms and no one present had noticed or heard about an existing issue at Thanet.	
3.4	RB believed that the risk of collision was greatest during the construction phase with the increased vessel movements with inexperienced skippers.	
3.5	RB identified issues at cable landfall, particularly with recreational users coming out of Sandwich Bay. There had previously been a contact between a yacht and an anchor marker.	
4	**Risk Controls**	
4.1	RB considered that the cable route should be as clear as possible from the buoyed channel to reduce the impact during construction/maintenance. Furthermore, the cable should not cross the buoyed channel and should be routed to the south.	
4.2	The developer should liaise with the port to prevent the construction vessel blocking the channel when commercial vessels wished to enter/exit the port	
4.3	PF raised emergency plans for Thanet. RB described the exercises regularly conducted, including the Guardex exercise, where a passenger vessel was assumed to have hit the wind farm.	
4.4	PF asked how NtMs were circulated. The Port issues their own which is posted in reception, Vattenfall circulate NtM to all user groups.	

Minutes of Meeting held with Royal Temple Yacht Club on 06-December 17

Minutes of Meeting held with Royal Temple Yacht Club on 06-December 17

Client:	GoBe Consultants	
Project:	16UK1255 Thanet Extension Offshore Wind Farm (Thanet Extension)	
Venue:	Royal Temple Yacht Club, Ramsgate	
Date of Meeting:	06-Dec-17 1200 – 1400	
Present:	RTYC	Matt Green (MG) – Rear Commodore Racing
	RTYC	Stan Jacob (SJ) – Rear Commodore Cruising
	RTYC	Stuart Carter (SC) – Race Officer
	Marico Marine	Andrew Rawson (AR)
	Marico Marine	Paul Fuller (PF)

Item	Action item / Notes for the record	Action
1	**Introduction**	
1.1	Introductions of those present and outline meeting agenda.	
1.2	AR/PF presented work done to date and NRA process.	
2	**Activities at RTYC**	
2.1	MG gave an overview of RTYC's racing programme, with racing year-round on Sunday and a Wednesday evening series in the summer. Typically, of the 30 regulars there are about 15 boats racing on any given day. There are several major events hosted by RTYC, e.g. • Euro Regatta, 70-80 boats race across to Europe and around the marks on Ascension weekend; and • Ramsgate Week Regatta – Up to 100 boats.	
2.2	Discussion on RTYC racing area and racing marks, which are principally located adjacent and to the south of Ramsgate (between Deal Bank and Elbow).	
2.3	There are no other substantial all tide marinas between Queensborough and Dover. [There is Margate YC, Minnis Bay SC, Herne Bay SC, Whitstable YC].	
3	**Impacts of** Thanet Extension **Project**	
3.1	Generally, few issues with the wind farms and associated vessels. Good working relationship, one of the companies lays the clubs seasonal marks and several have towed in a broken-down yacht.	
3.2	There were problems during the cable installation, and with the Nemo interconnector. During construction the vessels and their anchor spread, are an obstacle particularly if it passes close to the main channel which the yachts use both for transit and as racing marks. Survey work is also problematic due to the long tow, slow speeds and inability to manoeuvre. The guard vessels have been known to exclude the vessels from the other, plus a substantial safety buffer. Many occasions when the vessel has not been where the yacht was told it would be but they were still told to stay clear. There was generally felt to be poor communication during the actual construction process of Nemo.	

3.3	Few yachts go through the wind farm, principally because it is not on a main cruising route to anywhere. Yachts on passage north would pass to the west of the extension, on passage east to Europe would pass south of it. Some members had passed through wind farms, although they generally motor and if under sail would pass around it.	

Minutes of Meeting held with ESL on 06-December 2017

Client:	GoBe Consultants	
Project:	16UK1255 Thanet Extension Offshore Wind Farm (Thanet Extension)	
Venue:	Estuary Services Ltd, Ramsgate	
Date of Meeting:	06-Dec-17 1400 – 1600	
Present:	ESL	Ian Lord (IL) – General Manager
	ESL/PLA	Peter Steen (PS) - Director
	Marico Marine	Andrew Rawson (AR)
	Marico Marine	Paul Fuller (PF)

Item	Action item / Notes for the record	Action
1	**Introduction**	
1.1	Introductions of those present and outline meeting agenda.	
1.2	AR/PF presented work undertaken to date and NRA process.	
2	**Discussion on impacts of Thanet and other projects**	
2.1	IL described how the NE Spit station had been moved to its current location and was previously inside the Thanet wind farm. ESL are relatively untroubled in transiting to and from the pilot station, but the area is busier in summer.	
2.2	Tongue was put in place for those vessels uncomfortable with passing inshore of the wind farm. However, Tongue is more in the path of the main traffic stream into London and therefore the collision risk here is higher. It also involves a greater steaming time out to the station and is less sheltered.	
2.3	IL had previously had concerns about the lack of experience of WFSVs operating out of Ramsgate and their competence to keep a good look out, albeit this had got better over time. Pilot vessel crews have had occasion to report near misses with the crew boats. London Array project had involved a collision between a crew boat and a ship at Margate Roads.	
2.4	Nemo interconnector had not caused any significant issues for ESL's operations.	
3	**Discussion on possible impacts of Extension**	
3.1	All reviewed the previous consultation comments from ESL and PLA and agreed that the same issues and concerns still stood, i.e. reduction in sea room to undertake pilot boarding's safely. PS questioned whether the traffic profile would be different at high/low tide – AR agreed to investigate.	AR
3.2	PF questioned the impacts of relocating the pilot station. It was felt by ESL that once Thanet was consented, the PLA spent considerable time to determine the most optimal position for its relocation. Moving it again would therefore be sub-optimal and impact their commercial operations and/or navigational safety. PS believed it was placed where it is because it is 2nm from all hazards and therefore makes maximum use of the space. It would not be possible to move it much further inshore as there is significant ground swell around North Foreland.	
3.3	PF questioned impact on pilot rostering, PS/IL explained how the boat crew and pilot hours are managed. The PLA have agreed with the pilots that they should not spend	

	more than one hour on the pilot boats per trip. It is not uncommon for up to 4 pilots per trip to be carried. Increasing the distance of the pilot station may require a second boat system and associated crew/pilots, such as in the place in Harwich.	

Minutes of Meeting held with Thanet Fisherman's Assoc. on 06-December-17

Client:	GoBe Consultants	
Project:	16UK1255 Thanet Extension Offshore Wind Farm (Thanet Extension)	
Venue:	Vattenfall Offices, Ramsgate	
Date of Meeting:	06-Dec-17 1600 – 1800	
Present:	Thanet Fisherman's Association & Vattenfall Fishing Liaison Officer	Merlin Jackson (MJ)
	Marico Marine	Andrew Rawson (AR)
	Marico Marine	Paul Fuller (PF)

Item	Action item / Notes for the record	Action
1	**Introduction**	
1.1	Introductions of those present and outline meeting agenda.	
1.2	AR/PF described the work conducted to date and the NRA process.	
1.3	PF emphasised that Marico's interest is with the safety of navigation of the fishing vessels and not the commercial implications on loss of fishing grounds.	
2	**Discussion on current Fishing Activities**	
2.1	AR presented the Radar, AIS and VMS plots for discussion and the associated limitations of each. MJ stated that of the Thanet fleet, only one vessel is greater than 15m and therefore is represented by VMS.	
2.2	MJ described main catches as Dover Sole, cod (in decline), sea bass, skate and whelks, lobster/crab pots. There are 20-24 vessels based in Ramsgate who are members of the Thanet Fishermen's Association, with only 2 unaffiliated (one of which has recently requested to join). Approximately 50% of the fleet is out fishing at any one time, and are generally day-boats although can fish at night. Most of the vessels are flexible in design, capable of multiple fishing methods to deal with quota issues. MJ gave an overview of the findings of the fisheries section of the PEIR. Whitstable fishermen also attend Ramsgate fishing meetings and vice versa.	
2.3	Much of the Lobster potting is seasonal (late-May to August) and is concentrated in the North western and north-eastern extents of the extension.	
2.4	MJ described how Dutch Pulse Beamers operate to the north east of the site outside of UK limits.	
2.5	MJ explained marking requirements for fishing pots. IFCA have an office and vessel based in Ramsgate and therefore undertake regular gear inspections around the site.	
2.6	PF questioned whether fishing takes place inside the wind farm. MJ described how there is some trawling in the wind farm and that there has been international interest from France and the USA and how this has been achievable. This had however resulted in some gear loss. Some anchored netting and potting also takes place within the wind farm. There is also potting, trawling and static netting along the cable route. Many do fish 50m from a turbine, outside the safety zone.	
2.7	WFSV pass clear of the general gear sites now when transiting to or from Ramsgate, however several instances during construction where a WFSV took out many pots/ near misses in poor visibility/ passing too close. Wake/swell issues were also raised	

	as they transited to and from Ramsgate near to shore, danger of swamping the smaller fishing boats. Speed limits and distance from shore (1 NM) were applied during construction. Now WFSV typically pass 1 mile from the shore before heading off.	
2.8	MJ state how there had been 2 collisions between fishermen and WTGs at Thanet at night. Both collisions were glancing blows. MJ raised that the WTGs not being lit at platform level is a problem as Fishing vessels use them for navigating through the site. Following a review this was identified as being common with up to a third of platform lights not being lit. A number of TFA vessels operate single handed.	
3	**Discussion on possible impacts of Extension.**	
3.1	MJ described how during construction of Thanet, TFA members had an exemption allowing them to transit through the wind farm construction site as long as 500m exclusion around work vessels was observed. It is unknown if this would be granted during the Extension project. There were also some anecdotal near misses involving WFSVs and fishing boats.	
3.2	MJ described issues associated with the Nemo interconnector and how a 500m exclusion zone was enforced along the whole cable corridor by the guard vessels. This led to significant disruption to the fishermen. PF/MJ discussed the possible use of a 500m moveable exclusion around the actual construction vessel during the extension project to reduce the impact to fishermen.	
3.3	MJ believed that fishermen will object to the project through the TFA due to: • Principal issue is loss of fishing grounds; • Secondly, construction vessel/cable laying disruption; and • Thirdly, navigation issues. Particularly how the extension would force fishermen away from the current site and closer to the busy shipping lanes – resulting in a risk of collision.	

Minutes of Meeting held with Royal Yachting Association and Chamber of Shipping on 11-December-17

Client:	GoBe Consultants	
Project:	16UK1255 Thanet Extension Offshore Wind Farm (Thanet Extension)	
Venue:	RYA House, Hamble	
Date of Meeting:	11-Dec-17 1400 – 1600	
Present:	RYA	Stuart Carruthers (SC)
	Chamber of Shipping	Adrian Mundin (AM)
	Marico Marine	Andrew Rawson (AR)
	Marico Marine	Paul Fuller (PF)

Item	Action item / Notes for the record	Action
1	**Introduction**	
1.1	Introductions of those present and outline meeting agenda.	
1.2	AR/PF gave an overview of the project, work conducted to date and key issues identified by consultees. AR presented the vessel traffic analysis.	
2	**Impacts to Recreational Users**	
2.1	AR/PF gave an overview of the previous consultation with Royal Temple Yacht Club and the issues raised. Issues raised by port users' regarding safety zones and communication during the Project Nemo cable laying operation undertaken during the summer were discussed.	
2.2	SC described how the RYA were concerned with the squeezing of commercial shipping inshore of the proposed wind farm extension in what is already a busy area, which would increase the density and encounter rate with recreational users and the associated collision risk.	
2.3	SC stated that the RYA's interest on cable routes was principally with chart datum <10m. The MCA have a position of not compromising 5% UKC. SC pointed out problems with cable crossings and increased protection that reduces depth. This and cable laying operations in Pegwell Bay may impact recreational users on the River Stour up to Sandwich were there were a number of recreational clubs.	
2.4	PF questioned risk controls, SC highlighted RYA's opposition to any operational safety zones during the operational phase of a project.	
3	**Impacts to Commercial Shipping**	
3.1	AM considered there was sufficient sea room to the north and east of the wind farm but had grave concerns with the western section of the extension. This would lead to a significant reduction in sea-room for both transit and pilotage operations with vessels forced to manoeuvre in close proximity to each other and the western edge of the proposed wind farm extension.	
3.2	General discussion on possible relocation of pilot stations and the operational/commercial impacts that would result. AM/SC both considered the removal of the western section of the wind farm the most effective risk control.	
4	**Impacts to Navigational Aids and Communication Equipment**	

4.1	PF raised impacts of wind farms to navigational aids. SC described his experiences in both transiting through a wind farm and previous research the RYA has been involved in e.g. North Hoyle QinetiQ study. Issue principally the result of echoes on radar which requires users to reduce gain, thereby losing smaller targets (i.e. small boats) and possibly increasing collision risk. All agreed that there was little evidence of impact from WTGs/cables on other navigational aids e.g. compasses/VHF.	

Meeting Agenda - 10-Jan-18

Client:	GoBe Consultants
Project:	16UK1255 Thanet Extension Offshore Wind Farm (Thanet Extension)
Venue:	Maritime and Coastguard Agency, Spring Place, Southampton
Date of Meeting:	10-Jan-18 1300 – 1500

Invited:	MCA	Helen Croxson (HC)
	MCA	David Turner (DT)
	MCA	Peter Lowson (PL)
	Trinity House	Stephen Vanstone (SV)
	Trinity House	Trevor Harris (TH)
	Vattenfall Wind Power Limited	Mike Vanstone (MV)
	Marico Marine	Andrew Rawson (AR)
	Marico Marine	Paul Fuller (PF)

Item	Action item / Notes for the record	
1	**Introductions**	
2	**Project overview: Thanet Extension Offshore Windfarm (**Thanet Extension**)**	
2.1	AR gave an overview of Thanet Extension project and the current stage of the application process. The NRA would assess the red-line boundary of the maximum extent which would likely be greater than the actual area of the WTGs, which would be determined following EIA.	
3	**Summary of Work Undertaken to Date**	
3.1	AR gave an overview of work undertaken to date: • Vessel traffic surveys using AIS, radar and visual (boat based) for winter/summer 2017. • Pilotage Study into issues at NE Spit, desk based analysis with consultation. • Pilotage Simulation Study using PLA pilots and ESL coxswains. Critical navigational scenarios were tested to test feasibility of pilotage transfers at NE Spit with extension in place. • PEIR – Desk based review of key navigational impacts prior to consultation/risk assessment/analysis. • NRA – ongoing process which includes modelling, consultation and risk assessment.	
4	**Discussion of Key Impacts Raised by Stakeholders**	
4.1	AR gave an outline of the key impacts raised by stakeholders which were discussed in turn. HC/DT/PL raised key points in MCA's response to PEIR and SV/TH discussed their concerns with each.	
4.2	**Impacts to Pilotage**	

	HC had not seen the Pilotage Simulation report and questioned how the simulation was conducted and planned. AR explained the involvement of PLA/ESL in defining the scenarios and how each scenario was determined and its success/failure tested. Simulation showed that pilot transfers would be feasible albeit with a reduction in the margin for error. AR also emphasized that the simulation was conducted after the submission of the PEIR and the feedback is not represented in the PEIR document. TH noted how simulation is artificial and the limitations of using trained and experienced pilots rather than actual masters. PF emphasized that simulation is the best tool in the absence of real world trials and can be used to test the feasibility of an operation.	
4.3	**Reduction in Sea Room** HC/DT concerned over the reduction in sea room at the western extent. AR described the modelling results which showed that, whilst the baseline risk is relatively low, without mitigation the collision risk could increase by approx. 50%. This could be mitigated through changing traffic routes and pilot boarding arrangements. AR described the key traffic routes in the area – with on average only 10 vessels passing inshore of the wind farm per day, and they are therefore had a low probability of meeting each other. Practice of “dipping down” of E/W bound vessels to NE Spit to board a pilot was discussed and the reasons for this. The cost/operational impacts of changing this arrangement were raised. DT questioned why the western WTGs could not be relocated elsewhere – MV explained the other constraints on turbine placement which would feed into the layout plan.	
4.4	**Cumulative Impacts** HC questioned how the cumulative assessment was done. AR described the interaction between the Wind Farm Service Vessels operating out of Ramsgate to the various wind farms. Other wind farms are clear of the major shipping routes and so the interaction between them is minimal.	
4.5	**Cables** Discussion on the cable route and landfall was held, however no major concerns were raised. PF/AR described the experiences of local stakeholders with NEMO, MV stated that Vattenfall were committed to a less impactful cable laying methodology. A rolling safety area around the cable laying vessel was considered the most sensible mitigation measure.	
4.6	**Aids to Navigation** AR raised impact to cardinal marks surrounding Thanet. SV/TH stated that North Thanet cardinal was a Vattenfall mark and Drill Stone was Trinity House. North Thanet was lined up to allow the approach of vessels to the Princes Channel. Drill Stone may require moving but would be considered further down the application process with a Layout Plan in place. The relative merits of the cardinals were discussed when compared to a parallel line of marked WTGs as an aid to navigation. The removal of these marks may be considered. NE Spit East Cardinal may need to be relocated following the extension, however this would require further review.	
4.7	**Impact on Radar/Comms** PF gave an overview of the work conducted to date on the impacts of WTGs on radar (QinetiQ, Marico studies). TH described the impacts of shadowing etc. No known major issues reported at other wind farms. DT referred to MGN 372 as a guidance note on the impacts of WTGs on radar.	
4.8	**Lighting/Marking**	

	AR questioned TH/SV on marking/lighting arrangements for Thanet Extension. Consensus was that all Lights would be extinguished for Thanet and the new boundary of WTGs relit for both navigational and aviation marking. DT/PL raised numbering of WTGs in any proposed layout and that they should follow a logical sequence in conjunction with the existing wind farm (i.e. avoid 1,2,3,4 adjacent to 54,55,56). This would be determined with the layout plan.	
4.9	**Mitigation Options** HC/DT/TH questioned the practicality of some of the mitigation measures proposed in the PEIR (e.g. MCC/IMO routeing). AR described how the consultation and NRA had refined the mitigation measures to a more practicable list. Some of these were discussed, including increased coordination and training. The impacts on operations and costs were also raised for some of the measures, such as relocation of the pilot boarding station, if required.	
5	**Discussion of Impacts on SAR**	
	PL emphasized the importance of maintaining lines of orientation between Thanet and Thanet Extension. MV stated that this requirement would be adhered to by Vattenfall. MV/PL discussed the merits of Wind Farm Service Vessels as SAR assets. PL was not aware of any major SAR exercises at Thanet, with GuardX conducted at London Array in 2012. An ERCOP and Layout Plan would be produced for agreement with the MCA/TH following consent.	
6	**Actions / Further Work/ AOB**	
6.1	AR described the planned consenting process and the next steps in the NRA. NRA likely issued for comment in March / April 2018.	

Annex D Construction/Decommissioning Hazard Logs

Hazard ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence							Worst Credible Consequence							Baseline Risk	Inherent Risk	Residual risk	Key Embedded Risk Controls	Possible Additional Risk Controls
							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
1	Collision	Collision - Large Construction Vessel ICW Large Construction Vessel	Collision between two large construction vessels working in the Thames Estuary	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 3 pollution; Major Operational Downtime;	2	2	1	2	N/A	3.0	3.0	4	5	4	4	N/A	1.0	1.0	N/A	3.42	3.42	Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	
2	Collision	Collision - Large Construction Vessel ICW Large Commercial	Collision between a large construction vessel and a large commercial vessel (cargo/tankers/passenger)	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 3 pollution; Major Operational Downtime;	2	2	1	2	N/A	3.3	3.2	4	5	4	4	N/A	2.0	1.8	N/A	3.93	3.80	Promulgation/NtM; Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	Safety Zones; Coordination with PLA VTS; Guard Vessels; Cooperation with Port of Ramsgate;
3	Collision	Collision - Large Construction Vessel ICW Small Commercial	Collision between a large construction vessel and small commercial craft such as a pilot boat or tug	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 2 pollution; Major Operational Downtime;	2	2	1	2	N/A	4.0	3.6	4	4	3	4	N/A	2.0	1.6	N/A	3.87	3.48	Promulgation/NtM; Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	Safety Zones; Coordination with PLA VTS; Guard Vessels; Cooperation with Port of Ramsgate;
4	Collision	Collision - Large Construction Vessel ICW Fishing Vessel	Collision between a large construction vessel and small commercial craft such as a pilot boat, fishing or tug	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 2 pollution; Major Operational Downtime;	2	2	1	2	N/A	4.0	3.6	4	3	2	4	N/A	2.0	1.6	N/A	3.68	3.30	Promulgation/NtM; Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	Safety Zones; Cooperation with Port of Ramsgate; Coordination with Leisure/Fishing; Guard Vessels;
5	Collision	Collision - Large Construction Vessel ICW Recreational	Collision between a large construction vessel and a recreational craft	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	N/A	4.0	3.6	4	3	2	4	N/A	2.0	1.6	N/A	3.68	3.30	Promulgation/NtM; Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	Safety Zones; Cooperation with Port of Ramsgate; Coordination with Leisure/Fishing; Guard Vessels;

							Most Likely Consequence							Worst Credible Consequence											
Hazard ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	Baseline Risk	Inherent Risk	Residual risk	Key Embedded Risk Controls	Possible Additional Risk Controls
6	Collision	Collision - Large Construction ICW Small Construction/O&M	Collision between a large construction vessel and a small construction/O&M vessel working in the Thames Estuary	Increased Traffic volume; Increased Traffic Density; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	N/A	4.0	4.0	4	4	2	4	N/A	2.0	2.0	N/A	3.77	3.77	Promulgation/NtM; Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	
7	Collision	Collision - Small Construction/O&M ICW Small Construction/O&M	Collision between two small construction/O&M vessels working in the Thames Estuary	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	4.0	4.6	4.6	4	3	2	4	2.0	2.6	2.6	3.68	4.48	4.48	Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	
8	Collision	Collision - Small Construction/O&M ICW Large Commercial	Collision between a small construction/O&M vessel and a large commercial vessel (cargo/tankers/passenger)	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	3.0	3.6	3.5	4	3	2	4	2.0	2.6	2.5	3.22	3.73	3.64	Promulgation/NtM; Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	Safety Zones; Coordination with PLA VTS; Guard Vessels;
9	Collision	Collision - Small Construction/O&M ICW Small Commercial	Collision between a small construction/O&M Vessel and small commercial craft such as a pilot boat or tug	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Operational Downtime;	2	2	1	2	3.3	3.6	3.3	4	3	2	3	2.3	2.6	2.3	3.37	3.64	3.37	Promulgation/NtM; Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	Safety Zones; Coordination with PLA VTS; Guard Vessels; Coordination with Leisure/Fishing;
10	Collision	Collision - Small Construction/O&M ICW Fishing	Collision between a small construction/O&M Vessel and a fishing vessel	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Operational Downtime;	2	2	1	2	3.6	4.0	3.8	4	3	2	3	2.0	2.6	2.3	3.37	3.87	3.60	Promulgation/NtM; Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	Safety Zones; Coordination with PLA VTS; Guard Vessels; Coordination with Leisure/Fishing; Cooperation with Port of Ramsgate;
11	Collision	Collision - Small Construction/O&M ICW Recreational	Collision between a small construction/O&M Vessel and a recreational craft	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Operational Downtime;	2	2	1	1	4	4.6	4.3	4	3	2	3	2.0	2.6	2.3	3.38	4.09	3.70	Promulgation/NtM; Construction Planning/Coordination; Training; Continuous Monitoring; ERCOP;	Safety Zones; Cooperation with Leisure/Fishing; Guard Vessels; Cooperation with Port of Ramsgate;

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							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
12	Collision	Collision - Large Commercial ICW Large Commercial	Collision between two large commercial vessels (cargo/tanker/passenger) navigating in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Moderate damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 3 pollution; Major Adverse Publicity;	2	3	1	2	3.6	4.0	3.9	4	5	4	4	1.6	2.0	1.9	4.59	5.05	4.93	Promulgation/NtM; Reduction in RLB;	Coordination with PLA VTS;
13	Collision	Collision - Large Commercial ICW Small Commercial	Collision between a large commercial vessel (cargo/tanker/passenger) and a small commercial vessel (tug/pilot boat etc.) in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 3 pollution; Major Adverse Publicity;	2	2	1	2	3.6	3.8	3.7	4	4	4	4	1.6	2.0	1.9	3.56	3.83	3.74	Promulgation/NtM; Reduction in RLB;	Coordination with PLA VTS;
14	Collision	Collision - Large Commercial ICW Fishing	Collision between a large commercial vessel (cargo/tanker/passenger) and a fishing vessel in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Pollution; Major Adverse Publicity;	2	2	1	2	3.3	4.0	3.8	4	3	2	4	1.6	2.0	1.8	3.17	3.68	3.48	Promulgation/NtM; Reduction in RLB;	Coordination with PLA VTS;
15	Collision	Collision - Large Commercial ICW Recreational Craft	Collision between a large commercial vessel (cargo/tanker/passenger) and a recreational craft in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Multiple Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Fatalities; Loss of Vessel; Minor Pollution; Major Adverse Publicity;	3	2	1	2	3.3	4.0	3.8	5	3	2	4	1.6	2.0	1.8	4.16	4.78	4.55	Promulgation/NtM;	Coordination with PLA VTS; Coordination with Leisure/Fishing;
16	Collision	Collision - Small Commercial ICW Small Commercial	Collision between two small commercial vessels (tug/pilot boat etc.) in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Adverse Publicity;	2	2	1	2	3.3	3.6	3.5	4	4	2	4	1.6	2.0	1.8	3.25	3.54	3.41	Promulgation/NtM; Reduction in RLB;	Coordination with PLA VTS;
17	Collision	Collision - Small Commercial vs Fishing	Collision between a small commercial vessel (tug/pilot boat etc.) and a fishing vessel in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Adverse Publicity;	2	2	1	2	3.3	3.6	3.3	4	3	2	3	1.6	2.0	1.6	3.09	3.37	3.09	Promulgation/NtM;	Coordination with PLA VTS; Coordination with Leisure/Fishing;

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							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
18	Collision	Collision - Small Commercial vs Recreational	Collision between a small commercial vessel (tug/pilot boat etc.) and a recreational craft in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Adverse Publicity;	2	2	1	2	3.3	3.6	3.3	4	3	2	3	1.6	2.0	1.6	3.09	3.37	3.09	Promulgation/NtM;	Coordination with PLA VTS; Coordination with Leisure/Fishing;
19	Collision	Collision -Fishing ICW Recreational	Collision between a fishing vessel and a recreational craft in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Adverse Publicity;	2	2	1	2	4.0	4.0	4.0	4	3	2	3	2.0	2.0	2.0	3.60	3.60	3.60	Promulgation/NtM;	
20	Collision	Collision - Fishing ICW Fishing	Collision between two recreational vessels in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Adverse Publicity;	2	2	1	2	4.0	4.0	4.0	4	3	2	3	2.0	2.0	2.0	3.60	3.60	3.60	Promulgation/NtM;	
21	Collision	Collision - Recreational ICW Recreational	Collision between two recreational vessels in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Adverse Publicity;	2	2	1	2	5.0	5.0	5.0	4	3	2	3	2.0	2.0	2.0	4.66	4.66	4.66	Promulgation/NtM;	
22	Contact	Contact - Large Construction Vessel in Contact with WTG	A large construction vessel comes into contact with a WTG or other structure during construction	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Minor Injuries; Major Damage to Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	N/A	4.0	4.0	3	3	2	4	N/A	2.6	2.6	N/A	3.87	3.87	Aids to Navigation Plan; Continuous Monitoring; ERCOP; Blade Clearance;	

Hazard ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence							Worst Credible Consequence							Baseline Risk	Inherent Risk	Residual risk	Key Embedded Risk Controls	Possible Additional Risk Controls
							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
23	Contact	Contact - Small Construction/O&M Vessel in Contact with WTG	A small construction/O&M vessel comes into contact with a WTG or other structure during construction	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	4.3	5.0	5.0	4	3	2	4	2.3	3.0	3.0	4.04	5.24	5.24	Aids to Navigation Plan; Training; Continuous Monitoring; ERCOP: Blade Clearance;	Maintain Lines of Orientation/Symmetry;
24	Contact	Contact - Large Commercial Shipping in Contact with WTG	Construction activities and the constriction of shipping routes results in a commercial vessel coming into contact with a WTG or other structure	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Moderate Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 3 Pollution; Loss of WTG;	2	2	1	3	3.2	3.6	3.4	4	5	4	5	1.2	1.6	1.4	4.28	4.66	4.46	Promulgation/NtM; Aids to Navigation Plan; Continuous Monitoring; ERCOP; Blade Clearance; Reduction in RLB;	Safety Zones; Guard Vessel; Coordination with PLA VTS; Relocation of Buoyage;
25	Contact	Contact - Small Commercial Vessel in Contact with WTG	Construction activities and the constriction of shipping routes results in a small commercial vessel coming into contact with a WTG or other structure	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	3.8	4.2	4.0	4	4	2	3	1.8	2.2	2.0	3.48	3.91	3.68	Promulgation/NtM; Aids to Navigation Plan; Continuous Monitoring; ERCOP; Blade Clearance;	Safety Zones; Guard Vessel; Coordination with PLA VTS; Relocation of Buoyage; Maintain Lines of Orientation/Symmetry;
26	Contact	Contact - Fishing Craft in Contact with WTG	Construction activities and the constriction of shipping routes results in a fishing vessel coming into contact with a WTG or other structure	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	4.6	4.8	4.7	4	3	2	3	2.6	2.8	2.7	4.39	4.74	4.55	Promulgation/NtM; Aids to Navigation Plan; Continuous Monitoring; ERCOP; Blade Clearance;	Safety Zones; Guard Vessel; Coordination with Leisure/Fishing; Relocation of Buoyage; Maintain Lines of Orientation/Symmetry;
27	Contact	Contact - Recreational Craft in Contact with WTG	Construction activities and the constriction of shipping routes results in a recreational vessel coming into contact with a WTG or other structure	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	4.0	4.2	4.0	4	3	2	3	2.0	2.2	2.0	3.60	3.83	3.60	Promulgation/NtM; Aids to Navigation Plan; Continuous Monitoring; ERCOP; Blade Clearance; Reduction in RLB;	Safety Zones; Guard Vessel; Coordination with Leisure/Fishing; Relocation of Buoyage; Maintain Lines of Orientation/Symmetry;
28	Grounding	Grounding of Large Construction Vessel	Construction activities results in a large construction vessel running aground	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Offset of Vessel Traffic towards shallows; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Minor Injuries; Major Damage to Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	N/A	4.0	4.0	3	4	2	4	N/A	2.0	2.0	N/A	3.68	3.68	Promulgation/NtM; Training;	

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							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
29	Grounding	Grounding of Small Construction/O&M Vessel	Construction activities and personnel transfer results in a small construction/O&M vessel running aground	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Offset of Vessel Traffic towards shallows; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Minor Injuries; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	3.0	4.0	4.0	3	3	2	4	2.0	2.3	2.3	3.13	3.73	3.73	Promulgation/NtM; Training;	
30	Grounding	Grounding of Commercial Shipping	Displacement or constriction of shipping routes and the loss of depth along cable route results in a commercial vessel running aground.	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Offset of Vessel Traffic towards shallows; Equipment or Mechanical Failure; Adverse Environmental Conditions;	No Injuries; Minor damage; No Pollution; Minor adverse publicity;	Multiple Minor Injuries; Major Damage to Vessel; Tier 2 Pollution; Major adverse publicity;	1	2	1	2	4.0	4.3	4.3	3	4	3	4	3.0	3.3	3.3	4.09	4.47	4.47	Promulgation/NtM; Reduction in RLB;	
31	Grounding	Grounding of Small Commercial	Displacement or constriction of shipping routes and the loss of depth along cable route results in a small commercial vessel running aground.	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor adverse publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major adverse publicity;	2	2	1	2	4.0	4.0	4.0	4	3	2	3	3.0	3.0	3.0	4.09	4.09	4.09	Promulgation/NtM; Reduction in RLB;	
32	Grounding	Grounding of Fishing Vessel	Displacement or constriction of shipping routes and the loss of depth along cable route results in a fishing vessel running aground.	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor adverse publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate adverse publicity;	2	2	1	2	4.3	4.3	4.3	4	3	2	3	3.0	3.0	3.0	4.31	4.31	4.31	Promulgation/NtM; Sufficient Cable Burial/Protection;	
33	Grounding	Grounding of Recreational Craft	Displacement or constriction of shipping routes and the loss of depth along cable route results in a recreational craft running aground.	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor adverse publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate adverse publicity;	2	2	1	2	4.3	4.3	4.3	4	3	2	3	2.3	2.3	2.3	3.95	3.95	3.95	Promulgation/NtM; Sufficient Cable Burial/Protection;	
34	Obstruction	Obstruction - Small vessel (O&M/fishing/recreational) Fouls Cables	A small vessel (particularly fishing or recreational) fouls cable route through anchoring, dragging anchor or trawling	Incorrectly marked cable; Human error; Equipment Failure; Adverse Environmental Conditions;	Negligible Injuries; Negligible damage; No Pollution; Minor impact to project;	Multiple major injuries or Fatality; Loss of Vessel; Minor Pollution; Major impact to project;	1	1	1	2	4.0	4.3	4.0	4	4	2	4	3.0	3.3	3.0	3.84	4.19	3.84	Promulgation/NtM; Sufficient Cable Burial/Protection; Cable Exclusion Area;	Coordination with Fishing/Leisure; Guard Vessel;

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							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
35	Obstruction	Obstruction - Large Construction Vessel Fouls Cables	A large construction vessel fouls cable route	Incorrectly marked cable; Human error; Equipment Failure; Adverse Environmental Conditions;	Negligible Injuries; Negligible damage; No Pollution; Moderate impact to project;	Negligible injuries; Minor damage; No Pollution; Major impact to project;	1	1	1	3.3	N/A	4.3	4.3	1	2	1	5	N/A	3.3	3.3	N/A	4.67	4.67	Promulgation/NtM; Sufficient Cable Burial/Protection;	
36	Obstruction	Obstruction - Large Commercial Vessel Fouls Cables	A large vessel (particularly commercial shipping) fouls cable route through anchoring or anchor dragging	Incorrectly marked cable; Human error; Equipment Failure; Adverse Environmental Conditions;	Negligible Injuries; Negligible damage; No Pollution; Moderate impact to project;	Negligible injuries; Minor damage; No Pollution; Major impact to project;	1	1	1	3	3.0	3.3	3.0	1	2	1	5	2.0	2.3	2.0	3.35	3.57	3.35	Promulgation/NtM; Sufficient Cable Burial/Protection; Cable Exclusion Area;	Guard Vessel; Safety Zones; Coordination with PLA VTS;
37	Obstruction	Obstruction - Construction Vessel Encounters Unexploded Ordnance	Construction vessel encounters unexploded ordnance whilst operating at the wind farm	Incomplete UXO survey;	Negligible Injuries; Negligible damage; No Pollution; Minor impact to project;	Moderate injuries; Moderate damage; Minor Pollution; Moderate impact to project;	1	1	1	2	3.0	4.0	4.0	3	4	2	3	2.0	2.0	2.0	2.83	3.16	3.16	Training;	
38	Capsize/ Swamping	Small vessel capsizes or swamps due to movement of project vessels	Small vessel capsizes or swamps due to movement of project vessels	Increased vessel movements; Poor seamanship; Adverse Environmental Conditions;	Negligible Injuries; Negligible damage; No Pollution; Negligible adverse publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Adverse publicity;	1	1	1	1	3.3	4.3	4.3	4	3	2	3	2.0	2.3	2.3	2.07	2.20	2.20	Training;	Coordination with Fishing/Leisure;

Annex E: Operational Phase Hazard Log

							Most Likely Consequence							Worst Credible Consequence											
Hazard ID	**Category**	**Hazard Title**	**Hazard Detail**	**Possible Causes**	**Most Likely Outcome**	**Worst Credible Outcome**	**People**	**Property**	**Environment**	**Stakeholders**	**Baseline Freq**	**Inherent Freq**	**Residual Freq**	**People**	**Property**	**Environment**	**Stakeholders**	**Baseline Freq**	**Inherent Freq**	**Residual Freq**	**Baseline Risk**	**Inherent Risk**	**Residual risk**	**Embedded Risk Controls**	**Possible Additional Risk Controls**
1	Collision	Collision - O&M ICW O&M	Collision between two O&M vessels working in the Thames Estuary	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	4.0	4.3	4.3	4	3	2	4	2.0	2.3	2.3	3.68	4.04	4.04	Training; ERCOP;	
2	Collision	Collision - O&M ICW Large Commercial	Collision between an O&M vessel and a large commercial vessel (cargo/tankers/passenger)	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	3.0	3.3	3.3	4	3	2	4	2.0	2.3	2.3	3.22	3.46	3.46	Training; ERCOP;	
3	Collision	Collision - O&M ICW Small Commercial	Collision between an O&M Vessel and small commercial craft such as a pilot boat or tug	**Minor Damage to device and its moorings;** **Minor Damage to Vessel;** **No Injuries;** **No Pollution;** **Minor operational Downtime;**	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Operational Downtime;	2	2	1	2	3.3	3.4	3.4	4	3	2	3	2.3	2.4	2.4	3.37	3.45	3.45	Training; ERCOP;	
4	Collision	Collision - O&M ICW Fishing Vessel	Collision between an O&M Vessel and a fishing vessel	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Operational Downtime;	2	2	1	2	3.6	4.0	3.8	4	3	2	3	2.0	2.3	2.2	3.37	3.73	3.56	Training; ERCOP;	Coordination with Leisure/Fishing;
5	Collision	Collision - O&M ICW Recreational Craft	Collision between an O&M Vessel and recreational craft	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Operational Downtime;	2	2	1	1	4.0	4.3	4.1	4	3	2	3	2.0	2.3	2.1	3.38	3.70	3.48	Training; ERCOP;	Coordination with Leisure/Fishing;
6	Collision	Collision - Large Commercial ICW Large Commercial	Collision between two large commercial vessels (cargo/tanker/passenger) navigating in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Moderate damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 3 pollution; Major Adverse Publicity;	2	3	1	2	3.6	4.0	4.0	4	5	4	4	1.6	2.0	2.0	4.59	5.05	5.05	Promulgation/NtM; Reduction in RLB;	

Hazard ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence							Worst Credible Consequence							Baseline Risk	Inherent Risk	Residual risk	Embedded Risk Controls	Possible Additional Risk Controls
							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
7	Collision	Collision - Large Commercial ICW Small Commercial	Collision between a large commercial vessel (cargo/tanker/passenger) and a small commercial craft such as a pilot boat or tug in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 3 pollution; Major Adverse Publicity;	2	2	1	2	3.6	3.8	3.8	4	4	4	4	1.6	2.0	2.0	3.56	3.83	3.83	Promulgation/NtM; Reduction in RLB;	
8	Collision	Collision - Large Commercial ICW Fishing	Collision between a large commercial vessel (cargo/tanker/passenger) and a fishing vessel in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Pollution; Major Adverse Publicity;	2	2	1	2	3.3	4.0	4.0	4	3	2	4	1.6	2.0	2.0	3.17	3.68	3.68	Promulgation/NtM; Reduction in RLB;	
9	Collision	Collision - Large Commercial ICW Recreational Craft	Collision between a large commercial vessel (cargo/tanker/passenger) and a recreational craft in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Multiple Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Fatalities; Loss of Vessel; Minor Pollution; Major Adverse Publicity;	3	2	1	2	3.3	4.0	4.0	5	3	2	4	1.6	2.0	2.0	4.16	4.78	4.78	Promulgation/NtM; Reduction in RLB;	
10	Collision	Collision - Small Commercial ICW Small Commercial	Collision between two small commercial vessels (tug/pilot boat etc.) in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Adverse Publicity;	2	2	1	2	3.3	3.6	3.6	4	4	2	4	1.6	2.0	2.0	3.25	3.54	3.54	Promulgation/NtM; Reduction in RLB;	
11	Collision	Collision - Small Commercial vs Fishing	Collision between a small commercial vessel (tug/pilot boat etc.) and a fishing vessel in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Adverse Publicity;	2	2	1	2	3.3	3.6	3.6	4	3	2	3	1.6	2.0	2.0	3.09	3.37	3.37	Promulgation/NtM;	
12	Collision	Collision - Small Commercial ICW Recreational	Collision between a small commercial vessel (tug/pilot boat etc.) and a recreational vessel in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Adverse Publicity;	2	2	1	2	3.3	3.6	3.6	4	3	2	3	1.6	2.0	2.0	3.09	3.37	3.37	Promulgation/NtM;	

Hazard ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence							Worst Credible Consequence							Baseline Risk	Inherent Risk	Residual risk	Embedded Risk Controls	Possible Additional Risk Controls
							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
13	Collision	Collision -Fishing ICW Recreational	Collision between a fishing vessel and a recreational craft in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Adverse Publicity;	2	2	1	2	4.0	4.0	4.0	4	3	2	3	2.0	2.0	2.0	3.60	3.60	3.60	Promulgation/NtM;	
14	Collision	Collision - Fishing ICW Fishing	Collision between two recreational vessels in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Adverse Publicity;	2	2	1	2	4.0	4.0	4.0	4	3	2	3	2.0	2.0	2.0	3.60	3.60	3.60	Promulgation/NtM;	
15	Collision	Collision - Recreational ICW Recreational	Collision between two recreational craft in the vicinity of the wind farm	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Human Error; Low Manoeuvrability of Vessels; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Adverse Publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Adverse Publicity;	2	2	1	2	5.0	5.0	5.0	4	3	2	3	2.0	2.0	2.0	4.66	4.66	4.66	Promulgation/NtM;	
16	Contact	Contact - O&M Vessel in Contact with WTG	O&M activities within the wind farm results in an O&M vessel coming into contact with a WTG or other structure	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	4.3	4.6	4.6	4	3	2	4	2.3	2.6	2.6	4.04	4.48	4.48	Training; ERCOP; Aids to Navigation Plan; Blade Clearance;	Maintain Lines of Orientation/ Symmetry;
17	Contact	Contact - Large Commercial Shipping in Contact with WTG	O&M activities and the constriction of shipping routes results in a commercial vessel coming into contact with a WTG or other structure	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Moderate Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Tier 3 Pollution; Loss of WTG;	2	2	1	3	3.2	3.6	3.5	4	5	4	5	1.2	1.6	1.5	4.28	4.66	4.56	ERCOP; Aids to Navigation Plan; Blade Clearance; Reduction in RLB;	Relocation of Buoyage;
18	Contact	Contact - Small Commercial Vessel in Contact with WTG	O&M activities and the constriction of shipping routes results in a small commercial vessel coming into contact with a WTG or other structure	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Operational Downtime;	2	2	1	2	3.8	4.2	4.1	4	4	2	3	1.8	2.2	2.1	3.48	3.91	3.79	ERCOP; Aids to Navigation Plan; Blade Clearance; Reduction in RLB;	Maintain Lines of Orientation/ Symmetry; Relocation of Buoyage;

Hazard ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence							Worst Credible Consequence							Baseline Risk	Inherent Risk	Residual risk	Embedded Risk Controls	Possible Additional Risk Controls
							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
				Adverse Environmental Conditions;																					
19	Contact	Contact - Fishing Craft in Contact with WTG	Construction activities and the constriction of shipping routes results in a fishing vessel coming into contact with a WTG or other structure	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	4.6	4.8	4.7	4	3	2	3	2.6	2.8	2.7	4.39	4.74	4.55	Promulgation/NtM; Aids to Navigation Plan; Continuous Monitoring; ERCOP; Blade Clearance; Reduction in RLB;	Coordination with Leisure/Fishing; Relocation of Buoyage; Maintain Lines of Orientation/ Symmetry;
20	Contact	Contact - Recreational Vessel in Contact with WTG	O&M activities and the constriction of shipping routes results in a recreational vessel coming into contact with a WTG or other structure	Increased Traffic volume; Increased Traffic Density; Constriction of Shipping Routes; Unmarked WTGs; Human Error; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate Operational Downtime;	2	2	1	2	4.0	4.2	4.0	4	3	2	3	2.0	2.2	2.0	3.60	3.83	3.60	ERCOP; Aids to Navigation Plan; Blade Clearance; Reduction in RLB;	Coordination with Leisure/Fishing; Maintain Lines of Orientation/ Symmetry;
21	Grounding	Grounding of O&M Vessel	O&M activities and personnel transfer results in an O&M vessel running aground	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Offset of Vessel Traffic towards shallows; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor Operational Downtime;	Multiple Minor Injuries; Loss of Vessel; Minor Pollution; Major Operational Downtime;	2	2	1	2	3.0	3.0	3.0	3	3	2	4	2.0	2.0	2.0	3.13	3.13	3.13	ERCOP;	
22	Grounding	Grounding of Commercial Shipping	Displacement or constriction of shipping routes and the loss of depth along cable route results in a commercial vessel running aground.	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Offset of Vessel Traffic towards shallows; Equipment or Mechanical Failure; Adverse Environmental Conditions;	No Injuries; Minor damage; No Pollution; Minor adverse publicity;	Multiple Minor Injuries; Major Damage to Vessel; Tier 2 Pollution; Major adverse publicity;	1	2	1	2	4.0	4.3	4.3	3	4	3	4	3.0	3.3	3.3	4.09	4.47	4.47	Promulgation/NtM; Reduction in RLB;	
23	Grounding	Grounding of Small Commercial	Displacement or constriction of shipping routes and the loss of depth along cable route results in a small commercial vessel running aground.	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor adverse publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate adverse publicity;	2	2	1	2	4.0	4.0	4.0	4	3	2	3	3.0	3.0	3.0	4.09	4.09	4.09	Promulgation/NtM; Reduction in RLB;	

Hazard ID	Category	Hazard Title	Hazard Detail	Possible Causes	Most Likely Outcome	Worst Credible Outcome	Most Likely Consequence							Worst Credible Consequence							Baseline Risk	Inherent Risk	Residual risk	Embedded Risk Controls	Possible Additional Risk Controls
							People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq	People	Property	Environment	Stakeholders	Baseline Freq	Inherent Freq	Residual Freq					
24	Grounding	Grounding of Fishing Vessel	Displacement or constriction of shipping routes and the loss of depth along cable route results in a fishing vessel running aground.	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor adverse publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate adverse publicity;	2	2	1	2	4.3	4.3	4.3	4	3	2	3	3.0	3.0	3.0	4.31	4.31	4.31	Promulgation/NtM; Sufficient Cable Burial/Protection;	
25	Grounding	Grounding of Recreational	Displacement or constriction of shipping routes and the loss of depth along cable route results in a recreational craft running aground.	Increased Traffic volume; Loss of UKC along cable route; Constriction of Shipping Routes; Equipment or Mechanical Failure; Adverse Environmental Conditions;	Minor Injuries; Minor damage; No Pollution; Minor adverse publicity;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Moderate adverse publicity;	2	2	1	2	4.3	4.3	4.3	4	3	2	3	2.3	2.3	2.3	3.95	3.95	3.95	Promulgation/NtM; Sufficient Cable Burial/Protection;	
26	Obstruction	Obstruction - Small vessel (O&M/small commercial/non-commercial) Fouls Cables	A small vessel (particularly fishing or recreational) fouls cable route through anchoring, dragging anchor or trawling	Incorrectly marked cable; Human error; Equipment Failure; Adverse Environmental Conditions;	Negligible Injuries; Negligible damage; No Pollution; Minor impact to project;	Multiple major injuries or Fatality; Loss of Vessel; Minor Pollution; Major impact to project;	1	1	1	2	4.0	4.3	4.3	4	4	2	4	3.0	3.3	3.3	3.84	4.19	4.19	Promulgation/NtM; Training; Sufficient Cable Burial/Protection; Cable Exclusion Area;	Coordination with Fishing/Leisure;
27	Obstruction	Obstruction - Large Commercial Vessel Fouls Cables	A large vessel (particularly commercial shipping) fouls cable route through anchoring or anchor dragging	Incorrectly marked cable; Human error; Equipment Failure; Adverse Environmental Conditions;	Negligible Injuries; Negligible damage; No Pollution; Moderate impact to project;	Negligible injuries; Minor damage; No Pollution; Major impact to project;	1	1	1	3	3.0	3.3	3.3	1	2	1	5	2.0	2.3	2.3	3.35	3.57	3.57	Promulgation/NtM; Training; Sufficient Cable Burial/Protection; Cable Exclusion Area;	
28	Obstruction	Obstruction - O&M Vessel Encounters Unexploded Ordnance	O&M vessel encounters unexploded ordnance whilst operating at the wind farm	Incomplete UXO survey;	Negligible Injuries; Negligible damage; No Pollution; Minor impact to project;	Moderate injuries; Moderate damage; Minor Pollution; Moderate impact to project;	1	1	1	2	3.0	3.0	3.0	3	4	2	3	2.0	2.0	2.0	2.83	2.83	2.83	Training;	
29	Capsize/ Swamping	Small vessel capsizes or swamps due to movement of project vessels	Small vessel capsizes or swamps due to movement of project vessels	Increased vessel movements; Poor seamanship; Adverse Environmental Conditions;	Negligible Injuries; Negligible damage; No Pollution; Negligible impact to project;	Multiple Major Injuries or Fatality; Loss of Vessel; Minor Pollution; Adverse publicity;	1	1	1	1	3.3	4.0	4.0	4	3	2	3	2.0	2.3	2.3	2.07	2.20	2.20	Training;	Coordination with Fishing/Leisure;