Norfolk Vanguard Offshore Wind Farm

Chapter 15

Shipping and Navigation

Environmental Statement

Volume 3 - Appendices

Applicant: Norfolk Vanguard Limited
Document Reference: 6.2.15
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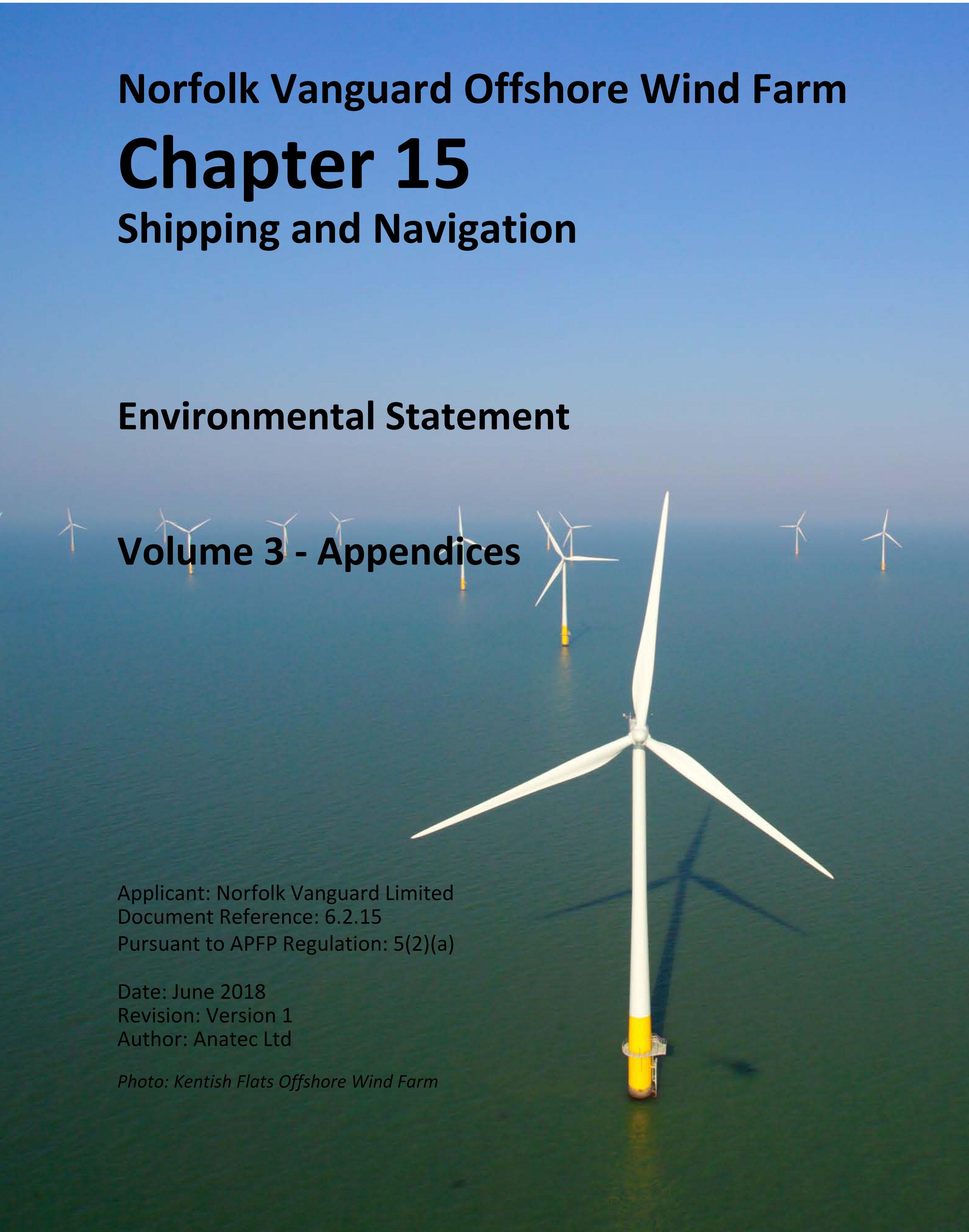

Photo: Kentish Flats Offshore Wind Farm

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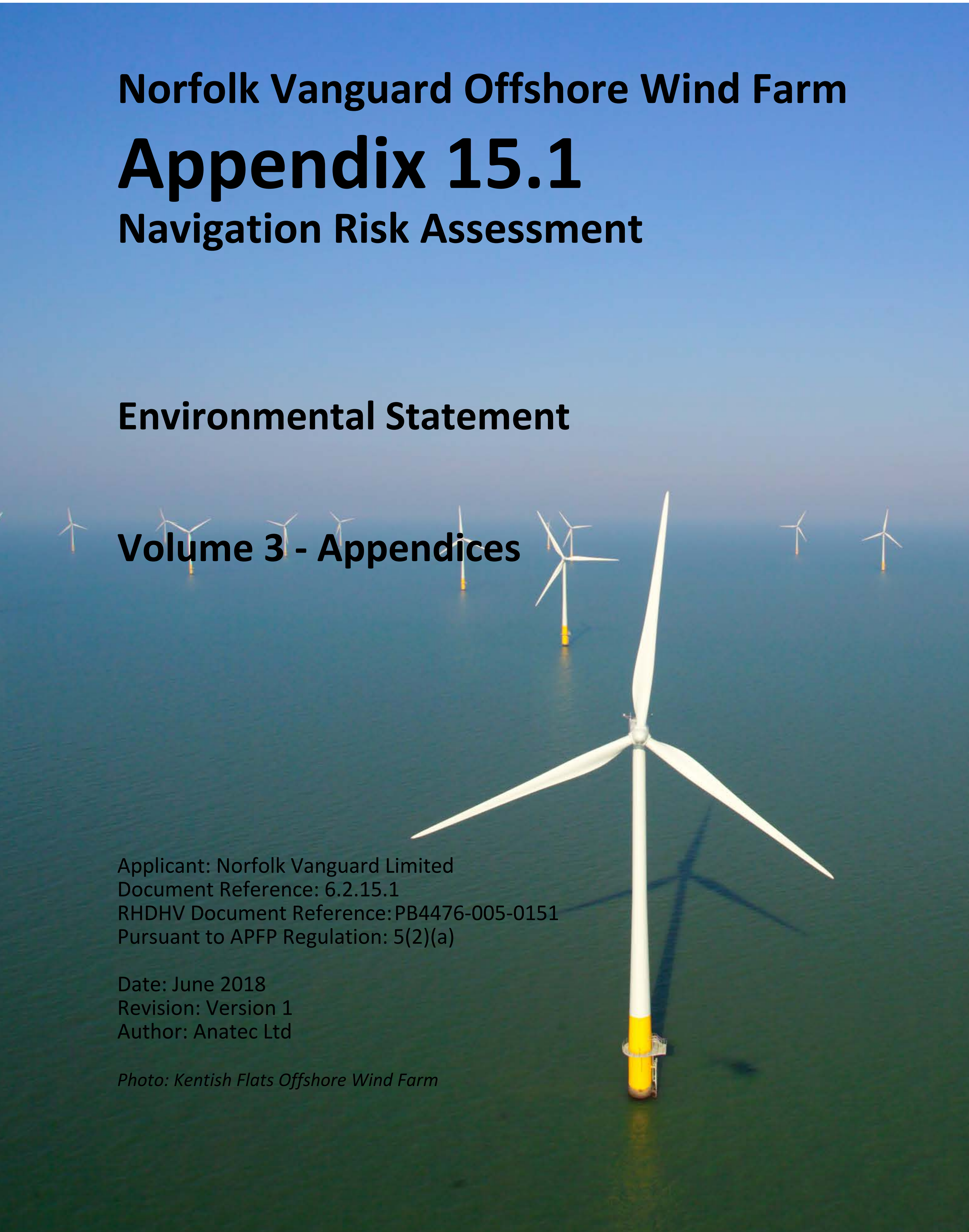
Norfolk Vanguard Offshore Wind Farm

Appendix 15.1

Navigation Risk Assessment



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For and on behalf of Norfolk Vanguard Limited
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Navigation Risk Assessment
Norfolk Vanguard
Offshore Wind Farm

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Date:	24/05/2018
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Abbreviations

ABP	Associated British Ports
AC	Alternating Current
AfL	Agreement For Lease
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
ALB	All Weather Lifeboat
AtoN	Aids to Navigation
AWAC	Acoustic Waves and Currents
BEIS	Department for Business, Energy and Industrial Strategy
BMAPA	British Marine Aggregates and Producers Association
CA	Cruising Association
CAA	Civil Aviation Authority
CGOC	Coastguard Operations Centre
CoS	Chamber of Shipping
CRO	Coastguard Rescue Officer
CRT	Coastguard Rescue Team
DfT	Department for Transport
DWR	Deep Water Route
E	East
EIA	Environmental Impact Assessment
ERCoP	Emergency Response and Cooperation Plan
ES	Environmental Statement
ESRI	Environmental Systems Research Institute
EU	European Union
FSA	Formal Safety Assessment
GBS	Gravity Base Structures
GIS	Geographic Information System
GMDSS	Global Maritime Distress and Safety System
GRP	Glass Reinforced Plastic
GRT	Gross Register Tonnage
HAT	Highest Astronomical Tide
HSE	Health and Safety Executive
IALA	International Association of Lighthouse Authorities
ILB	Inshore Lifeboats
IMO	International Maritime Organization
km	Kilometre
LAT	Lowest Astronomical Tide
m	Metre
MBS	Maritime Buoyage System
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
MCS	Maritime Safety Council

MEHRA	Marine Environmental High Risk Area
MetOcean	Meteorological Ocean
Met Mast	Meteorological Mast
MGN	Marine Guidance Note
MHWS	Mean High Water Springs
MoD	Ministry of Defence
MSC	Maritime Safety Council
MW	Megawatt
N	North
NFFO	National Federation of Fisherman's Organisations
nm	Nautical Mile
NMOC	National Maritime Operations Centre
NOREL	Nautical Offshore Renewable Energy Liaison
NRA	Navigational Risk Assessment
OREI	Offshore Renewable Energy Installation
OWF	Offshore Wind Farm
PEIR	Preliminary Environmental Information Report
PEXA	Practice and Exercise Area
PLL	Potential Loss of Life
QHSE	Quality, Health, Safety and Environment
REZ	Renewable Energy Zones
RNLI	Royal National Lifeboat Institution
RYA	Royal Yachting Association
SAR	Search and Rescue
SMS	Safety Management System
SNSOWF	Southern North Sea Offshore Wind Forum
SOLAS	Safety of Life at Sea
SPS	Significant Peripheral Structures
TH	Trinity House
TSS	Traffic Separation Scheme
UK	United Kingdom
UKHO	United Kingdom Hydrographic Office
VHF	Very High Frequency
VTS	Vessel Traffic Services
WTG	Wind Turbine Generator
ZAP	Zone Appraisal and Planning

Glossary

Term	Definition
Allision	The act of striking or collision of a moving vessel against a stationary object.
Area To Be Avoided (ABTA)	An area within defined limits in which either navigation is particularly hazardous or it is exceptionally important to avoid casualties and which should be avoided by all vessels, or by certain classes of vessels.
Automatic Identification System (AIS)	A system by which vessels automatically broadcast their identity, key statistics e.g. length, brief navigation details e.g. location, destination, speed and current status e.g. survey. Most commercial vessels and European Union (EU) fishing vessels over 15m are required to have AIS.
Base Case	The assessment of risk based on current shipping densities and traffic types as well as the marine environment.
Collision	The act or process of colliding (crashing) between two moving objects.
CollRisk	Anatec's Collision Risk Modelling Software.
Deep Water Route (DWR)	A route in a designated area within defined limits which has been accurately surveyed for clearance of sea bottom and submerged articles. They are of particular use to vessels restricted in their ability to manoeuvre due to their draught size.
Design Envelope	A description of the range of possible elements which make up the project design options under consideration, as set out in detail in the project description. This envelope is used to define the project for Environmental Impact Assessment purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Environmental Statement (ES)	A document reporting the findings of the EIA and produced in accordance with the EIA Directive as transposed into UK law by the EIA Regulations.
Formal Safety Assessment (FSA)	A structured and systematic process for assessing the risks and costs (if applicable) associated with shipping activity.
Future Case	An assessment of future traffic trends by assuming a set increase in vessel numbers on identified routeing within the area.
Hazard Log	Details the impacts upon shipping and navigation that may arise from the construction, operation, and decommissioning of Norfolk Vanguard.
In Isolation	Consideration of Norfolk Vanguard in isolation from other projects within the southern North Sea.
IMO Routeing	Predetermined shipping routes established by the International Maritime Organization.

Term	Definition
LiDAR	An instrument that detects the range and motion of atmospherics and weather phenomena using lasers.
Marine Environmental High Risk Area (MEHRA)	Areas in UK coastal waters where vessels' masters are advised of the need to exercise more caution than usual i.e. crossing areas of high environmental sensitivity where there is a risk of pollution from merchant shipping.
Meteorological Mast	A met mast or tower structure, on which meteorological observation and recording equipment is mounted.
Not Under Command (NUC)	A vessel not moored or anchored and not under control of its course or speed due to mechanical failure.
Offshore Cable Corridor	Corridor in which the section of cabling between the offshore substation and landfall will be routed.
Offshore Renewable Energy Infrastructure (OREI)	Offshore Renewable Energy Installations (OREIs) as defined by Guidance on UK Navigational Practice, Safety and Emergency Response Issues, MGN 543. For the purpose of this report and in keeping with the consistency of the Environmental Impact Assessment, OREI can mean offshore wind turbines and the associated infrastructures such as offshore accommodation platforms and sub station platforms.
Radar	Radio Detection And Ranging – an object-detection system which uses radio waves to determine the range, altitude, direction, or speed of objects.
Safety Zone	A marine zone outlined for the purposes of safety around a possibly hazardous installation or works / construction area under the Energy Act 2004.
Traffic Separation Scheme (TSS)	A TSS is a traffic-management route-system ruled by the International Maritime Organization. The traffic-lanes (or clearways) indicate the general direction of the vessels in that zone; vessels navigating within a TSS all sail in the same direction or they cross the lane in an angle as close to 90 degrees as possible.
Vessel Traffic Services (VTS)	A service implemented by a competent authority designed to improve the safety and efficiency of vessel traffic and to protect the environment. The service should have the capability to interact with the traffic and to respond to traffic situations developing in the VTS area.

1. Introduction

1.1 *Background*

1. Anatec were commissioned by Norfolk Vanguard Limited (the Applicant) to undertake a Navigational Risk Assessment (NRA) for the proposed Norfolk Vanguard Offshore Wind Farm (hereby referred to as Norfolk Vanguard). The report presents information on the proposed project relative to the existing and future case navigational activity and forms the technical appendix to the shipping and navigation chapter of the Environmental Statement (ES).

1.2 *Navigational Risk Assessment*

2. An EIA is a process which identifies the environmental effects of a project, both negative and positive, in accordance with European Union (EU) Directives. Impacts on shipping and navigation are informed by an NRA. Following the Maritime and Coastguard Agency (MCA) methodology (MCA, 2015) and Marine Guidance Note (MGN) 543 (MCA, 2016), the NRA includes:

- Overview of base case environment;
- Marine traffic survey;
- Implications of offshore wind farms including position of wind turbines;
- Assessment of navigational risk pre- and post development of Norfolk Vanguard;
- Formal Safety Assessment (FSA);
- Implications on marine navigation and communication equipment;
- Identification of mitigation measures;
- Emergency response; and
- Through life safety management.

3. The NRA has been reviewed by each phase of the proposed project, namely:

- Construction;
- Operation and maintenance; and
- Decommissioning.

2. Regulations and Guidance

2.1 *Primary Guidance*

4. The primary guidance documents used during the NRA are listed below:

- MCA MGN 543 (Merchant and Fishing) Safety of Navigation Offshore Renewable Energy Installations (OREIs) – Guidance on United Kingdom (UK) Navigational Practice, Safety and Emergency Response (MCA, 2016);
- MCA Methodology for Assessing Marine Navigational Safety Risks of Offshore Wind Farms (2015); and
- Guidelines for FSA – Maritime Safety Council (MSC)/Circular 1023/MEPC/Circular 392 (International Maritime Organization, 2002).

5. MGN 543 highlights issues that shall be taken into consideration when assessing the effect on navigational safety from offshore renewable energy developments, proposed UK internal waters, territorial sea or Renewable Energy Zones (REZ).

6. The MCA require that their methodology is used as a template for preparing navigational risk assessments. The methodology is centred on risk management and requires a submission that shows that sufficient controls are, or will be, in place for the assessed risk (base case and future case) to be judged as broadly acceptable or tolerable with mitigation. A checklist referencing the sections in this report which address all MCA requirements is presented in Appendix B: MGN 543 Checklist.

2.2 *Other Guidance*

7. Other guidance documents used during the NRA are listed below:

- MCA MGN 372 (merchant and fishing) Offshore Renewable Energy Installations (OREIs) Guidance to Mariners Operating in the Vicinity of UK OREIs (MCA, 2008);
- International Association of Marine Aids to Navigation (AtoN) and Lighthouse Authorities (IALA) Recommendation O-139 on The Marking of Man-Made Offshore Structures, Edition Two (IALA, 2013);
- Royal Yachting Association (RYA) – The RYA's Position on Offshore Renewable Energy Developments Paper One – Wind Energy (RYA, 2015); and
- Department for Business, Energy and Industrial Strategy (BEIS) Standard Marking Schedule for Offshore Installations (2011).

3. Navigational Risk Methodology Assessment

3.1 *Methodology for Assessing Norfolk Vanguard in Isolation*

8. The NRA is the technical document which informs the FSA process for Norfolk Vanguard in Chapter 15 Shipping and Navigation of the ES. The NRA uses a baseline assessment (established using the data sources listed in Section 6) to identify potential impacts relevant to shipping and navigation receptors that may arise as a result of the proposed project. Impacts are then reviewed and screened in to be carried forward to the ES based on the following additional aspects of the NRA:

- Scoping responses;
- Baseline data and assessment;
- Expert opinion;
- Level of stakeholder concern;
- Number of transits of specific vessel and / or vessel type;
- Effect of any vessel deviation;
- Outputs of modelling where undertaken; and
- Lessons learned from existing offshore projects including work undertaken as part of the former East Anglia zone.

9. The impacts evaluated within the NRA include required effects as detailed within MGN 543 (listed in Appendix B – MGN Checklist) and as required by the MCA.

10. Where an impact has been identified the overall severity of consequence to the receptor has been determined in the ES. As this process incorporates a degree of subjectivity, the assessment within the ES uses the various sources provided within the NRA (see list above) to inform the rankings assigned to each impact.

11. The definitions used within the assessment for identification of the severity of consequence and the frequency of occurrence are presented in Table 14.4 and 14.5 of Chapter 15 Shipping and Navigation.

12. The severity of consequence has been assessed against the frequency of occurrence to provide the level of tolerability of the impact. The tolerability matrix is shown in Table 15.6 of Chapter 15 Shipping and Navigation. The tolerability of the impact is then defined as per Table 3.1; if the risk of the impact is considered **Unacceptable** further mitigation or design change would be required to reduce the risk to **Tolerable** or **Broadly Acceptable.** The impact is then considered to be as low as reasonably practicable (ALARP) within tolerable and broadly acceptable parameters. However

unacceptable levels of tolerability will require further mitigation to reduce them to ALARP.

Table 3.1 Tolerability rankings

	Broadly Acceptable	Risk ALARP with no additional mitigations or monitoring required above embedded mitigations. Not significant under EIA.
	Tolerable	Risk acceptable but may require additional mitigation measures and monitoring in place to control and reduce to ALARP. Not significant under EIA.
	Unacceptable	Significant risk mitigation or design modification required to reduce to ALARP.

13. Further detail of the methodology is contained within section 14.3 of Chapter 15 Shipping and Navigation. The "in isolation" FSA assessment of potential impacts is contained within Section 14.6 of Chapter 15 Shipping and Navigation.

3.2 *Methodology of Assessing Cumulative Effects*

14. Cumulative impacts have been considered for shipping and navigation within this NRA; this includes impacts of other offshore developments, as well as activities associated with other marine operations. Fishing, recreation and marine aggregate dredging transits have been considered as part of the baseline assessment.

15. Cumulative effects of the zonal development plans for the round 3 development zones within the southern North Sea were assessed under the Southern North Sea Offshore Wind Forum (SNSOWF) in 2013 (SNSOWF 2013). It was recognised that due to the scale and location of these Round Three zones (Dogger Bank, the former Hornsea Zone and the former East Anglia zone) coordination was required between zones in order for the developers of these zones to successfully undertake their respective Zone Appraisal and Planning (ZAP) process. This work has been updated by the Applicant (Anatec, 2018) using up to date marine traffic data, with the results used within this NRA to predict cumulative routeing patterns in the vicinity of the proposed project (see Section 19.3).

16. Cumulative impacts are considered in Chapter 15 Shipping and Navigation.

3.3 *Methodology of Assessing Transboundary Effects*

17. Transboundary effects of offshore wind developments with regards to vessel routeing and international ports have also been assessed. Fishing, recreation and marine aggregate dredging impacts, although they have the potential to be internationally

owned or located, have been considered as part of the baseline assessment. Transboundary impacts are considered in Chapter 15 Shipping and Navigation.

3.4 Assumptions

18. The shipping and navigation baseline and impact assessment has been carried out based on the information available and responses received at the time of preparation. It is assumed that any notable changes will be re-assessed and re-modelled if and when required.

3.5 Study Areas

3.5.1 Offshore Wind Farm (OWF) Site Study Area

19. To ensure focus on the traffic relevant to Norfolk Vanguard is considered, marine traffic survey data within a ten nautical miles (nm) buffer of the two sites (hereby referred to as the "OWF sites study area"), as described in the following section, has been assessed. This encompassed all relevant shipping routes within the vicinity of the proposed project, including those associated with the IMO routeing measures passing both sites. In some cases, data sets have been considered beyond the 10nm extent if considered appropriate; in particular, cumulative routeing has been assessed over a wider geographical area as vessel displacement can impact routeing beyond 10nm.

3.5.2 Offshore Cable Corridor Study Area

20. In addition to the array areas, marine traffic data (Automatic Identification System (AIS) data only) has also been considered within a 5nm buffer of the offshore cable corridor (hereby referred to as the "offshore cable corridor study area").

3.5.3 Cumulative Study Area

21. Cumulative impacts have been considered within a 10nm buffer around Norfolk Vanguard but then extended where applicable to encompass vessel routeing (hereby referred to as the "cumulative study area"). This includes consideration of transboundary offshore windfarm projects and shipping routes. For a cumulative or transboundary windfarm to be considered in the cumulative routeing assessment, a vessel route needs to be impacted (route through or in proximity to) by both the screened windfarm and Norfolk Vanguard

22. The study areas for the Offshore Wind Farm (OWF) sites and for the cable corridor are presented in Figure 3.1.

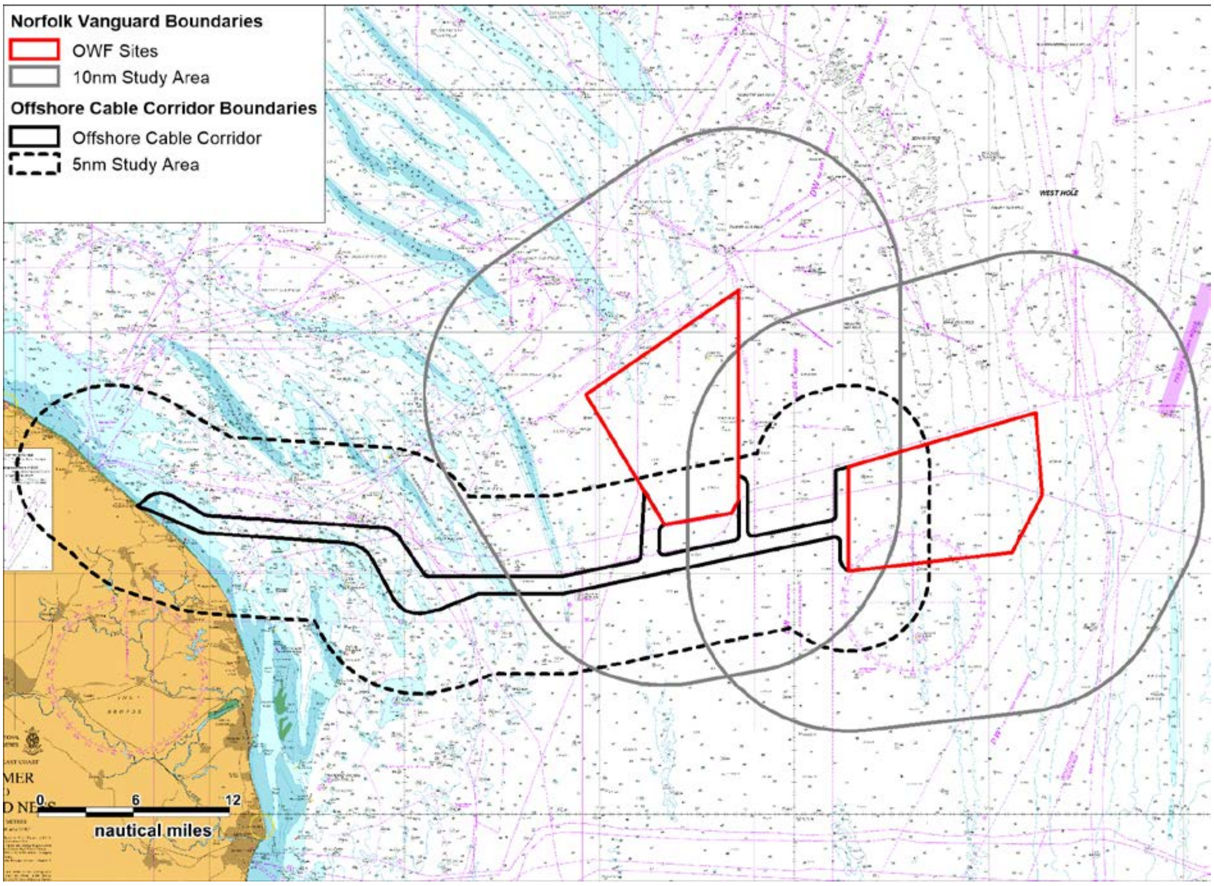

Figure 3.1 Navigation Risk Assessment Study Areas

4. Project Description

4.1 *Introduction*

23. This section presents details on Norfolk Vanguard, and the associated offshore electrical transmission works. The proposed project is located within the southern North Sea, 25.4nm from the east coast of the United Kingdom (UK) and is comprised of two project areas: Norfolk Vanguard East and Norfolk Vanguard West which together cover an area of approximately 173nm^2 (592 kilometres (km)^2).

4.2 *Norfolk Vanguard Boundaries*

24. The corner coordinates of Norfolk Vanguard East and Norfolk Vanguard West are presented in Table 4.1 and Table 4.2 respectively. Following this, the sites are shown graphically in Figure 4.1.

Table 4.1 Corner Co-ordinates of Norfolk Vanguard East

Norfolk Vanguard East		
Corner	**Latitude**	**Longitude**
North-East (C1)	52° 55' 0.42" North (N)	003° 04' 42.56" E
East (C2)	52° 49' 54.33" N	003° 05' 22.28" E
South-East (C3)	52° 46' 19.58" N	003° 02' 16.75" E
South-West (C4)	52° 45' 10.63" N	002° 45' 34.37" E
North-West (C5)	52° 51’ 41.91” N	002° 45’ 35.41” E

Table 4.2 Corner Co-ordinates of Norfolk Vanguard West

Norfolk Vanguard West		
Corner	**Latitude**	**Longitude**
North (C6)	53° 02' 36.77" N	002° 34' 16.27" E
South-East (C7)	52° 49' 38.83" N	002° 34' 15.81" E
South (C8)	52° 48' 47.69" N	002° 33' 28.45" E
South-West (C9)	52° 48' 3.51" N	002° 26' 37.41" E
West (C10)	52° 56' 8.88" N	002° 18' 33.86" E

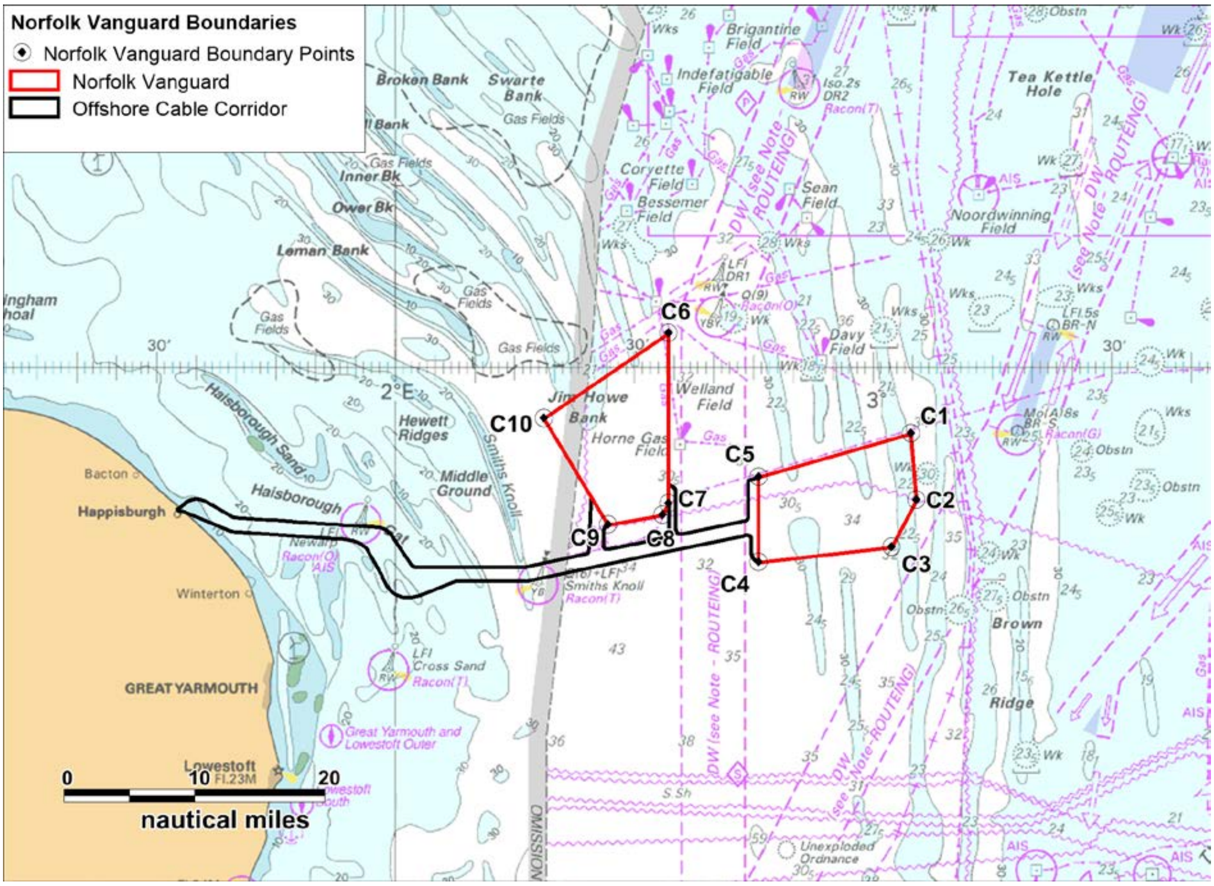

Figure 4.1 Chart Overview of Norfolk Vanguard

25. The proposed project can accommodate up to a total of 1,800 Megawatts (MW), split across the two OWF sites, with the following scenarios under consideration:

- 900MW in Norfolk Vanguard East, 900MW in Norfolk Vanguard West (+/- 100MW in either site); or
- 1,800MW in either Norfolk Vanguard East or Norfolk Vanguard West.

26. For shipping and navigation, the worst case has been identified as 900MW in both OWF sites, this gives the largest operation area with the maximum number of structures.

27. Following the Section 42 consultation, the Project Design Envelope used within this NRA represents a reduced number of wind turbines over that modelled as part of the Preliminary Environmental Impact Report (PEIR) process given that the minimum wind turbine size is now 9 MW (meaning the maximum number of wind turbines possible is 200 not 257). However, given that the worst case scenario for shipping and navigation is the maximum number of structures over the greatest development area (within both the OWF sites) the modelling is considered to represent worst case

results and any alternative configurations (or reduced wind turbine numbers) would return lower results. Therefore, any impacts assessed will be equal to or less than the residual ranking. The impact assessment in Chapter 15: Shipping and Navigation has considered the parameters as per Section 4 – Project Description.

28. Worst case parameters for identified impacts are identified in Chapter 15 Shipping and Navigation.

4.3 *Structure Details*

29. Details of the offshore surface structures under consideration for installation within the OWF sites are presented in this section, including the wind turbines, offshore electrical platforms, offshore accommodation platforms, and Meteorological Ocean (MetOcean) installations.

4.3.1 Wind Turbines

30. As a layout is not yet defined a number of different wind turbine size options are currently under consideration. Based on the 1,800MW generation, the maximum number of turbines for each wind turbine size is given in Table 4.3, which also includes estimated structure dimensions. The final layout may utilise more than one wind turbine size to reach the 1,800MW generation capacity

Table 4.3 Wind Turbine Numbers

Wind Turbine Size (MW)	Max Number of Wind Turbines	Indicative Rotor Diameter (m)	Max Hub Height above Highest Astronomical Tide (HAT) (m)	Max Tip Height above HAT (m)
9	200	170	132	217
15	120	230	162	277
17	106	250	172	297
20	90	300	198.5	350

31. Regardless of the wind turbine sizes used, there will a minimum rotor blade clearance (air draft over MHWS) of 22m, ensuring compliance with MGN543 (MCA 2016) and RYA policy statements (RYA, 2015). The wind turbines will maintain at least one line of orientation, with minimum spacing of four rotor diameters length (680m).

4.3.2 Wind Turbine Foundations

The following foundation types are under consideration for the wind turbines:

- Tension leg floating foundations;
- Monopiles;
- Jackets on pin piles (on three or four legs);
- Jackets on suction caissons (on three of four legs); and
- Gravity base structures (GBS).

32. It is noted that more than one foundation type may be used within the OWF sites, dependent on ground conditions, water depths, and the wind turbine models utilised. The worst case foundations considered within the modelling are tension leg floating foundations given the water line dimensions which present the greatest allision risk (see Section 20 for further information).

4.3.3 Platforms

33. The following additional platforms may also be constructed within the OWF sites, depending on the final layout and export scheme (HVDC):

- Up to two offshore electrical platforms; and
- Up to two offshore accommodation or helicopter platforms (one in each OWF site).

4.3.4 MetOcean Installations

34. The following MetOcean equipment may be installed if required within the OWF Sites:

- Up to two meteorological masts (Met Masts);
- LiDAR buoys (up to two, either floating anchors or monopiles); and
- Up to two wave buoys.

4.4 Cables

35. The offshore cable corridor is presented in Figure 4.2, relative to the OWF sites. Figure 4.3 presents a zoomed in plot of the corridor landfall site south of Happisburgh. Cable length to the landfall is approximately 75km (per cable) from the boundary of Norfolk Vanguard West, and 90km (per cable) from Norfolk Vanguard East. Cables will be protected either through burial or the use of surface protection (methods to be used will be based on a post consent cable burial risk assessment). Near shore the cable will be directionally drilled to make landfall.

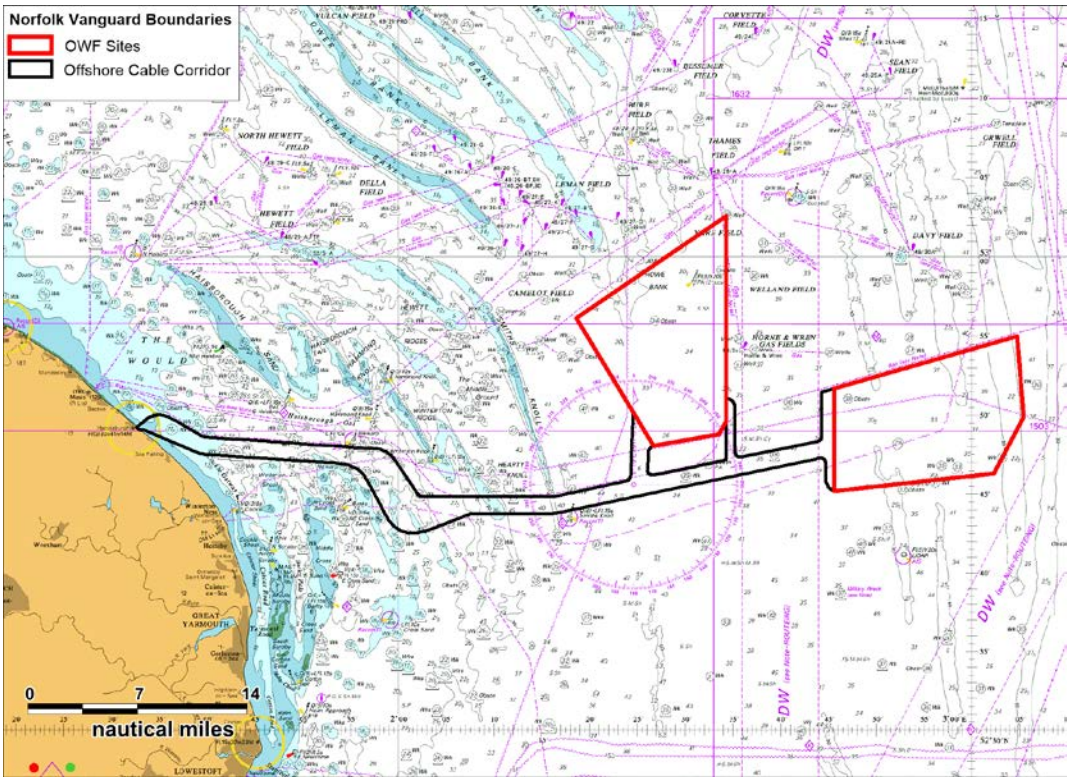

Figure 4.2 Offshore Cable Corridor

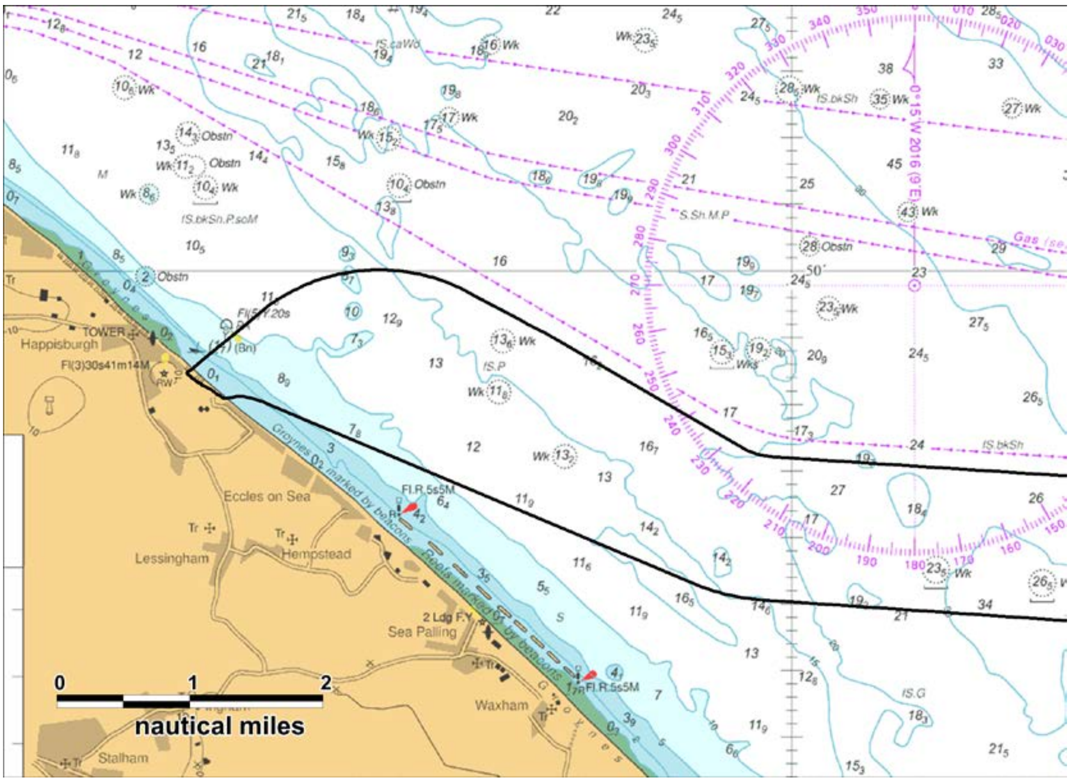

Figure 4.3 Offshore Cable Corridor Landfall Site

5. Consultation

5.1 *Introduction*

36. This section summarises the consultation relevant to shipping and navigation undertaken for Norfolk Vanguard to date, including the formal responses to the PEIR issued under Section 42 of the Planning Act 2008, and Regulation 11 of the Infrastructure Planning (EIA) Regulations 2009

5.2 *Stakeholders Consulted as Part of NRA Process*

37. Key marine and navigation stakeholders have been consulted as part of the NRA. The following stakeholders have been consulted:

- MCA;
- Trinity House (TH);
- Chamber of Shipping (CoS);
- RYA;
- Cruising Association (CA);
- British Marine Aggregates Producers Association (BMAPA);
- DfT;
- RNLI;
- Associated British Ports (ABP);
- P&O;
- Boston Putford Offshore Safety;
- Rotterdam Harbour Master;
- Royal Association of Netherlands Shipowners;
- Danish Shipowners Association;
- Rijkswaterstaat (Ministry of Infrastructure and the Environment for the Netherlands);
- VisNed (Coöperatie Kottervisserij Nederland U.A.);
- National Federation of Fisherman's Organisations (NFFO);
- Brown and May;
- Lowestoft Port Authority;
- Peel Ports;
- Perenco; and
- Shell.

5.3 *Regular Operators*

38. In addition to the stakeholders contacted above, a regular operator analysis was undertaken on the marine survey data collected within the OWF sites (see Section 12). This analysis identified operators with vessels regularly transiting the area. Any responses are included in Section 5.5.

5.4 *Hazard Log*

39. It is noted that additional consultation was also undertaken specifically for the hazard log prepared for Norfolk Vanguard. A summary of this process is presented in Section 24, with responses included in Table 5.1 below.

5.5 *Consultation Responses*

40. A summary of the key consultation responses received for Norfolk Vanguard is shown in Table 5.1, including where in this NRA, or other associated documentation, the response has been addressed.

Table 5.1 Consultation Responses

Consultee	Date /Document	Comment	Response / where addressed
MCA and TH	12 January 2016 Meeting with MCA and TH.	Overview of initial proposed project. MCA advised on guidance including the updated MGN 543. Boundaries between DWRs were discussed.	This NRA has been informed by the relevant guidance (including MGN 543) as shown in section 2. An assessment of the DWRs relative to Norfolk Vanguard is presented in section 17.
Secretary of State	Scoping Opinion	The environmental statement should assess the impacts on ports and harbours which could be affected by the development, such as increased traffic at the ports and changes to shipping times and durations as a result of routes being diverted around or through the development. The Secretary of State recommends consultation with the appropriate harbour Authorities.	An assessment of deviation of vessel routeing resulting from Norfolk Vanguard is presented in section 19. Harbour authorities were contacted during the consultation process (including Lowestoft, Great Yarmouth, and Rotterdam), with relevant responses included in this table. Allision and collision modelling (section 21) has been undertaken assuming a 10%

Consultee	Date /Document	Comment	Response / where addressed
			growth in traffic. At the request of the CoS, collision rates have also been modelled assuming a 20% growth in traffic.
Secretary of State	Scoping Opinion	As the layout of the array will not be fixed at the point of the application, the Environmental Statement (ES) should consider a worst case scenario in its navigation assessment. The ES should set out how such a worst case scenario has been determined.	A description of the worst case assessed, and the rationale by which it has been chosen is presented within Chapter 15 Shipping and Navigation.
Secretary of State	Scoping Opinion	The Secretary of State welcomes the proposed Navigational Risk Assessment (NRA) and directs the Applicant's attention to the comments of the Maritime and Coastguard Agency (MCA) and Trinity House (TH) (Appendix 3 of this Opinion) for their comments on the proposed assessment. The ES should provide details of the collision risk modelling used within the NRA.	The MCA and TH comments have been addressed, as summarised in this table. Results of the collision risk modelling are presented in section 21, with relevant impacts assessed within Chapter 15 Shipping and Navigation.
Secretary of State	Scoping Opinion	Paragraph 614 of the Scoping Report states that the NRA modelling will assume a 10% increase in future traffic. The ES should justify the 10% future case increase.	As traffic trends are difficult to predict, cases of 0%, 10%, and 20% increases in traffic have been assessed within the allision and collision modelling, the results of which are available in section 21. The 20% case was included at the request of the Chamber of Shipping (CoS).
Secretary of State	Scoping Opinion	This chapter of the ES should identify and consider within the assessment any necessary safety or buffer zones.	The application for safety zones is assumed to be embedded mitigation, and is discussed in section 26.
Norfolk County Council	Scoping Opinion	The Scoping Report (page 179, paragraph 659) refers to the potential cumulative impacts on shipping and navigation arising from other sites in	Section 19 presents an assessment of the cumulative impact on routes from southern North Sea wind farms, with

Consultee	Date /Document	Comment	Response / where addressed
		the former East Anglia Zone. This needs to be extended to the wider cumulative impacts arising from other operational, consented and proposed wind farms off the Norfolk Coast (i.e. taking into account wind farms consented under earlier consenting rounds / licencing regimes). The impacts need to be considered in terms of (a) commercial shipping; (b) fishing vessels and (c) recreational vessels. The County Council acknowledges that it will be a matter for the appropriate regulatory bodies to comment on the detailed matters relating to shipping and navigation, however, the County Council is keen to ensure that there will not be any demonstrable negative impact on Norfolk's ports as a consequence of the proposed offshore wind farms and any potential change in shipping and navigational routes.	relevant impacts assessed within Chapter 15 Shipping and Navigation. All impacts to commercial, fishing and recreational vessels were assessed as being within tolerable levels (with additional mitigation implemented where necessary).
Norfolk County Council	Scoping Opinion	The EIA should indicate that suitable navigation and shipping mitigation measures can be agreed with the appropriate regulatory bodies to ensure that Norfolk's Ports (King's Lynn and Wells) are not adversely affected by this proposal. The EIA will need to consider the wider cumulative impacts taking into account existing operational wind farm; those under construction; those consented and those in planning.	Embedded mitigation measures are listed in section 26. Where identified as necessary, proposed additional mitigation measures are discussed in Chapter 15 Shipping and Navigation. With additional mitigation in place, all impacts were assessed to be within tolerable levels. Cumulative impacts have been assessed in Chapter 15 Shipping and Navigation. Again, these were all within tolerable levels with additional mitigation in place where necessary.
MCA	Scoping Opinion	The ES should supply detail on the possible impacts on navigational issues for both commercial and recreational	An assessment of the relevant impacts to commercial and recreational vessels is provided in Chapter 15 Shipping and

Consultee	Date /Document	Comment	Response / where addressed
		craft: a) Collision risk; b) Navigational safety; c) Visual intrusion and noise; d) Risk Management and Emergency response; e) Marking and lighting of site and information to mariners; f) Effect on small craft navigational and communication equipment; g) The risk to drifting recreational craft in adverse weather or tidal conditions; and h) The likely squeeze of small craft into the routes of larger commercial vessels.	Navigation: a) Collision risk to both commercial vessels and recreational vessels has been assessed b) This NRA and Chapter 15: Shipping and Navigation have been authored for the purpose of ensuring navigational safety c) Visual intrusion and noise impact are covered in section 23 d) Chapter 15: Shipping and Navigation provides an assessment of the identified impacts. This assessment includes (where identified as necessary) additional risk management measures. An ERCoP will be created as per the embedded mitigation listed in section 26. e) Marking and lighting of the site and promulgation of information have been assumed to be embedded mitigation, and are listed in section 26 f) Effects on position fixing and communication equipment are assessed within section 23 g) Allision risks to recreational vessels is covered in Chapter 15: Shipping and Navigation h) Displacement impacts have been assessed within

Consultee	**Date /Document**	**Comment**	**Response / where addressed**
			Chapter 15: Shipping and Navigation
MCA	Scoping Opinion	An NRA will need to be submitted in accordance with MGN 543 (and MGN 372) and the MCA Methodology for Assessing the Marine Navigation Safety & Emergency Response Risks of Offshore Renewable Energy Installations (OREI). This NRA should be accompanied by a detailed MGN 543 Checklist which can be downloaded from the MCA website.	This NRA includes the completed MGN 543 checklist as an appendix.
MCA	Scoping Opinion	It is noted that traffic data had been collected between September 2012 and April 2014 and that a further 28 day traffic survey (AIS, Radar and visual observations) will be conducted to ensure data is up to date. MGN 543 Annex 2 requires that hydrographic surveys should fulfil the requirements of the International Hydrographic Organisation (IHO) Order 1a standard, with the final data supplied as a digital full density data set, and survey reports to the MCA Hydrography Manager. Failure to report the survey or conduct it to Order 1a might invalidate the NRA if it was deemed not fit for purpose.	Norfolk Vanguard will comply with the requirements of MGN 543 as per embedded mitigation – section 26. This includes the collection of 28 days of marine traffic survey data. The data collected has been analysed, the results of which are shown in section 12.
MCA	Scoping Opinion	Particular attention should be paid to cabling routes and where appropriate burial depth for which a Burial Protection Index study should be completed and, subject to the traffic volumes, an anchor penetration study may be necessary. If cable protection are required e.g. rock bags, concrete mattresses, the MCA would be willing to accept a 5% reduction in surrounding depths referenced to Chart Datum.	As described in section 26, a Cable Burial Risk Assessment will be undertaken post consent. This will include an assessment of expected cable burial depths, and a plan for other forms of protection where necessary.

Consultee	Date /Document	Comment	Response / where addressed
MCA	Scoping Opinion	The Radar effects of a wind farm on ships' Radars are an important issue and the effects, particularly with respect to adjacent wind farms on either side of a route, will need to be assessed on a site specific basis taking into consideration previous reports on the subject available on the MCA website.	Effects on marine Radar are assessed within section 23. The assessment includes discussion of previous radar trials undertaken with MCA involvement.
MCA	Scoping Opinion	The development area carries a significant amount of through traffic and liner routes. Attention needs to be paid to routeing, particularly in heavy weather ensuring shipping can continue to make safe passage without significant large scale deviations.	Impacts on vessel routeing are considered within the impact assessment in Chapter 15 Shipping and Navigation. This includes an assessment of routeing during adverse weather (section 16).
MCA	Scoping Opinion	Particular consideration will need to be given to the implications of the site size and location of SAR resources and Emergency Response Cooperation Plans (ERCoP). Attention should be paid to the level of Radar surveillance, AIS and shore-based Very High Frequency (VHF) radio coverage and give due consideration for appropriate mitigation such as Radar, AIS receivers and in-field, Marine Band VHF radio communications aerial(s) (VHF voice with Digital Selective Calling (DSC)) that can cover the entire wind farm sites and their surrounding areas.	Norfolk Vanguard will comply with the requirements of MGN 543 as per embedded mitigation – section 26. Existing SAR resources relative to Norfolk Vanguard are summarised in section 10. As listed in section 26, an ERCoP will be created post consent.
TH	Scoping Opinion	The NRA should include: • Comprehensive vessel traffic analysis in accordance with MGN 543; and • Assessment of the possible cumulative and in-combination effects on shipping routes and patterns. Any proposed layouts should conform with MGN 543; however, should some	An MGN 543 checklist has been completed as part of this NRA. Up to date marine traffic survey data has been used to assess current shipping levels and patterns within the vicinity of Norfolk Vanguard. The results of the analysis are available in section 12. Vessel routeing has been

Consultee	Date /Document	Comment	Response / where addressed
		structures such as OSPs lie outwith the actual wind farm turbine layout, then additional risk assessment should be undertaken.	considered on a cumulative basis in section 19. Associated impacts have been assessed in the impact assessment in Chapter 15 Shipping and Navigation.
TH	Scoping Opinion	We consider that the wind farm(s) will need to be marked with marine aids to navigation by the developer/operator in accordance with the general principles outlined in International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) Recommendation O 139 on the Marking of Man-Made Offshore Structures as a risk mitigation measure. In addition to the marking of the structures themselves, it should be borne in mind that additional aids to navigation such as buoys may be necessary to mitigate the risk posed to the mariner, particularly during the construction phase. All marine navigational marking, which will be required to be provided and thereafter maintained by the developer, will need to be addressed and agreed with TH. This will include the necessity for the aids to navigation to meet the internationally recognised standards of availability.	Norfolk Vanguard will comply with the requirements of IALA O-139 as per embedded mitigation – section 26. All lighting and marking will be agreed with TH prior to implementation.
		Appropriate buffer zones surrounding the two IMO Deep Water Routes (DWRs) should be fully considered.	This NRA includes an assessment of the cumulative impact (including buffer zones) on routes from southern North Sea wind farms (section 19.3). Spacing between the OWF sites and the DWRs has been agreed with the MCA.

Consultee	Date /Document	Comment	Response / where addressed
		Any possible national trans-boundary issues should be assessed, through consultation with the Dutch authorities.	Consultation was undertaken with the Dutch Authorities through Rijkswaterstaat (Ministry of Infrastructure and the Environment), as shown in this table. Transboundary issues are discussed in Chapter 15: Shipping and Navigation.
		A Decommissioning Plan, which includes a scenario where upon decommissioning and upon completion of removal operations an obstruction is left on site (attributable to the wind farm) which is considered to be a danger to navigation and which it has not proved possible to remove, should be considered. Such an obstruction may require to be marked until such time as it is either removed or no longer considered a danger to navigation, the continuing cost of which would need to be met by the developer/operator.	A Decommissioning Plan will be created post consent. Impacts associated with the decommissioning of Norfolk Vanguard are considered in the impact assessment in Chapter 15 Shipping and Navigation.

Consultee	Date /Document	Comment	Response / where addressed
		The possible requirement for navigational marking of the export cables and the vessels laying them. If it is necessary for the cables to be protected by rock armour, concrete mattresses or similar protection which lies clear of the surrounding seabed, the impact on navigation and the requirement for appropriate risk mitigation measures needs to be assessed.	As described in section 26, a Cable Burial Risk Assessment will be undertaken post consent. This will include identification of any sections of cable requiring protection other than burial. Any associated risks will be assessed within the Cable Burial Risk Assessment.
MCA and TH	24 May 2016 Meeting with MCA and TH.	Agreement was reached on the survey methodology proposed by Norfolk Vanguard including dates and time period.	The marine traffic survey is summarised in section 12.
MCA	17 March 2017 Minutes from meeting held with TH and MCA.	Indicative position of substations or other platforms had not yet been agreed; MCA noted that the platforms should be in rows with wind turbines.	As shown in Chapter 5 Project Description, platforms have been kept in a grid format with the wind turbines.
MCA	17 March 2017 Minutes from meeting held with TH and MCA.	MCA require two lines of orientation but would be content to see a safety case for one line of orientation.	Regular grid layouts have been assessed within the NRA; if a single line of orientation is considered post consent it will be supported by a relevant safety case.
MCA	17 March 2017 Minutes from meeting held with TH and MCA.	Both marine and aviation lighting was discussed. MCA noted that synchronisation between East Anglia three, Norfolk Vanguard East and Norfolk Boreas was important especially for aviation lighting.	Lighting and marking of the Offshore Wind Farm (OWF) sites is discussed in section 26.1. All lighting and marking will be agreed in consultation with TH, the MCA, and the Civil Aviation Authority (CAA).

Consultee	Date /Document	Comment	Response / where addressed
TH	17 March 2017 Minutes from meeting held with TH and MCA.	TH noted that they preferred straight edges and no isolated turbines.	Norfolk Vanguard Ltd will work with MCA and TH post consent to agree edges and peripheral turbine locations.
CoS	11 April 2017 Email correspondence	What is most important is that stakeholders get the opportunity to feed in concerns and issues.	This table summarises all relevant consultation received to date, and indicates where the points raised have been addressed.
CoS	8 May 2017 Minutes from consultation meeting with CoS.	The CoS want to see the impact on the affected (deviated) routes entirety and not just within 10 nautical miles (nm) i.e., a holistic review of the overall route from port to port to assess deviations.	The purpose of the NRA (and the EIA) is to assess the impact of Norfolk Vanguard primarily in isolation. However, section 19.3 includes cumulative main routes.
CoS	8 May 2017 Minutes from consultation meeting with CoS.	Access points will be needed for wind farm service vessels in the area, and it will need to be known where they are likely to be crossing the Deep Water Route (DWR). It should be ensured that the impact of wind farm construction and operational traffic is considered in the NRA.	Entry and exit points for wind farm construction, operation and maintenance and decommissioning vessels will be agreed as mitigation post consent and has been considered additional mitigation
CoS	8 May 2017 Minutes from consultation meeting with CoS.	Transboundary issues should be considered and the Dutch authorities/stakeholders consulted.	Chapter 15 Shipping and Navigation includes consideration for Transboundary issues. The Dutch authorities have been consulted with, as summarised in this table.
BP Shipping	7 April 2017 Email correspondence	BP Shipping would appreciate if the impact of the proposed wind farms could be reviewed with specific focus upon shipping density in the region – the loss of navigational space and the impact upon the shipping which will be navigating in and or around the DWRs.	Section 19.3 includes cumulative main routes. A review of navigation through the DWRs post installation of Norfolk Vanguard is included in section 17. Up to date marine traffic survey

Consultee	**Date /Document**	**Comment**	**Response / where addressed**
		The loss of sea-room remains a concern for BP Shipping and we would appreciate visibility of the existing review of regional vessels Automatic Identification System (AIS) tracks within this area and the considered opinion of the regulator upon traffic densities within this region when adjusted for regional growth within the major ports and the impact on maritime trade of the UK's withdrawal from the European Union (EU). We would suggest port growth which should be reviewed are: • Rotterdam / Europort including Mass flack 1 and 2; • Hamburg / Willhelmshaven; and • London gateway terminal including Thames estuary.	data (including AIS) is assessed in section 12. This data was used to assess baseline vessel routeing within the vicinity of Norfolk Vanguard. Allision and collision modelling has been undertaken assuming a 10% growth in traffic. At the request of the CoS, collision rates have also been modelled assuming a 20% growth in traffic.
BP Shipping	15 May 2017 Minutes from consultation meeting with BP.	Transboundary issues should be considered and the Dutch authorities and relevant Dutch stakeholders should be consulted.	Chapter 15 Shipping and Navigation includes consideration of cumulative impact and transboundary elements. The Dutch authorities have been consulted with, as summarised in this table.
BP Shipping	15 May 2017 Minutes from consultation meeting with BP.	BP expressed concerns with respect to oil spill risk in the area increasing with the wind farms and emergency response in the event of a drifting vessel and a potential oil spill clean-up operation in the southern North Sea.	Chapter 15 Shipping and Navigation consider the impacts and cumulative impacts of the proposed project including analysis of the impact upon emergency response arising from the proposed project. Emergency response plans will be laid out in full within the Emergency Response Plan (ERP) and ERCoP post consent.

Consultee	Date /Document	Comment	Response / where addressed
Boston Putford	8 May 2017 Email correspondence	When the fields are established extra time will need to be given in order for our vessels to meet the required relief times. Consideration will need to be given for vessels returning to port from the mentioned locations. It really is a time factor we have to deal with here taking into consideration: • Weather conditions for the vessels concerned; • Extra distances involved by avoiding the proposed fields; • Vessels arriving on location in time for platforms manning up; and • Vessels arriving on time to relieve any vessel that is returning to port for cargo or crew change. With the above stated It will be down to operations and logistics to consult with vessel Masters in order to get an accurate ETA for any requirements when transiting these areas.	Sections 18 and 19 provide an assessment of vessel routeing, both pre- and post-wind farm. This includes the identified oil and gas routes, based on a review of marine traffic survey data. Adverse weather routeing is considered in section 16. Changes in route lengths are assessed in section 19. Impacts associated with deviations to vessel routes are assessed in Chapter 15 Shipping and Navigation.
Royal Yachting Association (RYA)	8 May 2017 Minutes from consultation meeting with RYA.	One of the main issues for the RYA would be the cable landfall, and any resultant reduction in water depths in this area.	A Cable Burial Risk Assessment will be undertaken prior to installation; this will include consideration of under keel clearance.
Cruising Association (CA)	8 May 2017 Minutes from consultation meeting with CA.	The key concern is the cumulative impact of all the projects in the former East Anglia Zone as opposed to just that from the Norfolk Vanguard and Norfolk Boreas sites.	A cumulative assessment of routes is presented within section 19.3.
CA	8 May 2017 Minutes from consultation	Two lines of orientation and any convertor stations/accommodation platforms etc. in line with the turbines.	Grid layouts have been assessed within this NRA; if a single line of orientation is considered post consent it will be supported by

Consultee	Date /Document	Comment	Response / where addressed
	meeting with CA.		a relevant safety case. Norfolk Vanguard Ltd will work with MCA and TH post consent to agree edges and peripheral turbine locations.
CA	8 May 2017 Minutes from consultation meeting with CA.	It was raised that the "area has a high proportion of bad visibility (i.e. mist and fog)." It was suggested the latest pilot book was reviewed for visibility information.	Various sources of visibility data have been assessed and considered as part of the NRA, as summarised in section 9. This included the Pilot Book.
Peel Ports – Great Yarmouth	11 May 2017 Response to hazard log.	No comments to add.	n/a
Rijkswaterstaat (Ministry of Infrastructure and the Environment)	19 May 2017 Written response to initial correspondence	Norfolk Vanguard is situated within a nautically important area, close to IMO DWRs. One of the main concerns for the Dutch government is the safety of shipping in these routes. We would ask you to take these guidelines (IMO, 2016) into consideration when designing the layout of the wind farm.	As priority the development will consider MCA guidance; however, consideration will be given to the importance of IMO routeing measures and thus the IMO guidelines. An assessment of Norfolk Vanguard relative to the DWRs against the IMO guidance is presented in section 17.
ABP Humber	25 May 2015 Response to hazard log.	No foreseeable impacts on the port of Humber.	n/a
P&O Ferries	1 June 2017 Response to hazard log.	A possible additional risk is "allision caused by deliberate act". Additional scenario is a vessel that has been hijacked by persons and to increase to the impact of their act they take the vessel through a wind farm. Highly unlikely but the type of incident we are preparing for.	Impact included within the updated hazard log within this NRA to include deliberate act of allision.
Rijkswaterstaat (Ministry of	15 June 2017	We appreciate the systematic approach with regard to the content and the stakeholder process very much and	Section 17 demonstrates compliance of Norfolk Vanguard with the referenced

Consultee	Date /Document	Comment	Response / where addressed
Infrastructure and the Environment)		would like to stay in touch on a regular basis in the remainder of the process. Regarding the nautical safety aspects of Norfolk Vanguard we would like to refer to the documents as presented in our letter dated 19th May 2017 in which the design criteria for safe distances between shipping lanes and OWFs are attached.	documents. It is noted that the buffers between the OWF sites and the DWRs were agreed as part of the former East Anglia Zone process.
VISNED (Coöperatie Kottervisserij Nederland U.A.)	9 June 2017 Response to hazard log.	"The displacement will be influenced by how big the turbines will turn out to be. Fishermen I talk to aren't really happy about the prospects of fishing inside an array. The spacing between the turbines will have a major impact on a skipper's decision to trawl there. The smaller the spacing between turbines, the smaller the chances are of skippers taking the risks. Correct me if I'm wrong but when opting for the 7 MW turbines the spacing would be about 900 meters between. Most fishermen won't take their chances with such a small area to manoeuvre. In that case the most likely consequence will be the same as the worst case scenario: loss of fishing grounds and a major impact on businesses, especially when the cumulative effects of other arrays are taken into effect. This last point bothers us quite a bit since the effects of large wind arrays on fishing are always presented individually and never accumulated as they should be in our view. We think the largest turbines (15 MW) with the biggest spacing will be the best options for having the least impact on our members and their activities."	Issues in relation to displacement of fishing activity are covered within the ES in Chapter 14 Commercial Fisheries.

5.6 *Responses to PEIR*

The PEIR was submitted to relevant consultees to obtain marine stakeholder opinion, as required under Section 42 of the Planning Act 2008, and Regulation 11 of the Infrastructure Planning (EIA) Regulations 2009. The responses received are presented in Table 5.2, which includes a reference as to where the points raised have been addressed within this NRA, or within the ES (Chapter 15: Shipping and Navigation).

Table 5.2 PEIR Consultation Response

Consultee	Date	Comment	Response/where addressed in the NRA for Norfolk Vanguard
RYA	15 Nov 2017	"The most up to date RYA position on offshore renewable wind energy developments (paper 1 of 4) is dated September 2015" "Otherwise the PEIR reflects the RYA concerns and observations arising from our discussions on 8 May 2017."	Section 2 (Legislation and Guidance) references the most up to date RYA guidance as required.
CA	7 Dec 2017	"We note that between 90 and 257 turbines are proposed. Each will be an obstruction to navigation and potential danger to small vessels so we therefore urge selection of the largest generators possible giving the fewest obstructions. From the point of view of navigation safety all should be located within Norfolk Vanguard East rather than Norfolk Vanguard West area as suggested so that when considered in combination with the proposed Boreas site a smaller east-west obstruction is presented."	Allision and collision modelling has been undertaken assuming the worst case parameters from a shipping and navigation perspective. The final layout will be agreed with the MCA post consent. It is noted that maximum number of turbines at the time of writing is now 200.
CA	7 Dec 2017	"We note that proposed spacing between turbines will be a minimum of 616m. This is just adequate but our experience is that spacing of 1,000m or greater is required for problem free navigation of small craft and urge selection of generator size large enough to require this."	Worst case (minimum) spacing has been increased to 680m. The final layout will be agreed with the MCA post consent.
CA	7 Dec 2017	"We have no views on the type of foundations proposed except to ensure a minimum navigable depth at all times of at least 3m round the visible part of the towers even if a Safety Zone of 50m is provided round each tower."	Navigable depth will be maintained in line with MCA guidance. See embedded mitigations, Section 26.
CA	7 Dec 2017	"Our layout preference is strongly towards turbine patterns in straight rows and lines in	The final layout will be considered in line

Consultee	Date	Comment	Response/where addressed in the NRA for Norfolk Vanguard
		order to preserve the essential 'see-through' characteristic required for easiest navigation through from all directions and to assist SAR operations. We are pleased therefore to note that you will adopt at least a single line of orientation and to note that all ancillary structures (accommodation platforms, electrical stations, etc) will be in line with rows and lines to preserve sightlines through the tower field. We strongly support straight edges with no isolated structures."	with MGN 543 and a safety case will be submitted as required to demonstrate that it is within As Low As reasonably Practicable Parameters.
CA	7 Dec 2017	"Whichever port is finally chosen it is likely that the Vanguard projects, and Boreas to come, will generate high traffic between it and the offshore sites and that much of this will be specialised construction or support vessels and RAM vessels. While the Collision Regulations can deal with most situations our experience is that heavy work traffic can greatly increase the risks to small vessels particularly in or near harbour exits. Consideration should therefore be given to defined and publicised routing of working vessels which can become known in advance."	Promulgation of information will be undertaken, as per Section 26 (Embedded Mitigation). The RYA request a minimum of 4m under keel clearance and the Norfolk Vanguard OWF sites are expected to achieve this
CA	7 Dec 2017	"We can confirm the recreational craft routing given in the PEIR but have cause to doubt the low frequency of yachts recorded." "While we cannot offer survey data we suggest that an average of 10-30 yachts per day may be expected to cross the corridor at maximum in the summer season." "Our doubt concerning the number of yachts captured in the surveys does not affect the overall assessment."	Marine traffic analysis within the Offshore Cable Corridor was AIS only. Given that the RYA Coastal Atlas (RYA, 2016) has also been considered, the available data is considered to provide a good indication of the levels and locations of recreational activity.
TH	8 Dec 2017	"At this stage Trinity House would like to advise that the layout of Norfolk Vanguard East must align with adjoining wind farm projects, such as the East Anglia Three OWF. Therefore, continuous dialogue with such projects is imperative throughout the consenting process of the Norfolk Vanguard OWF."	Continuous dialogue is ongoing with the developers of East Anglia Three.
CAA	11 Dec 2017	"The CAA has no comment to make on this proposal".	n/a

Consultee	Date	Comment	Response/where addressed in the NRA for Norfolk Vanguard
MCA	11 Dec 2017	"We note that the development area carries a significant amount of through traffic, and attention needs to be paid to routeing, particularly in heavy weather ensuring shipping can continue to make safe passage without significant large scale deviations."	Vessel routeing is assessed in Sections 18 (base case) and 19 (future case). Adverse weather is discussed in Section 16.
MCA	11 Dec 2017	"The possible cumulative and in combination effects on shipping routes should be considered taking into account the proximity to other windfarm developments; Norfolk Vanguard East, Norfolk Vanguard West, Norfolk Boreas, the alignment with East Anglia 3 and other operations throughout the Southern North Sea."	An assessment of likely cumulative routeing is presented in Section 19.3, which takes the wind farms mentioned within the MCA response into account. Collision has been assessed on a cumulative basis in Section 22.
MCA	11 Dec 2017	"MGN 543 Annex 2 Paragraph 6 requires that hydrographic surveys should fulfil the requirements of the International Hydrographic Organisation (IHO) Order 1a standard, with the final data supplied as a digital full density data set, and survey report to the MCA Hydrography Manager. This information will need to be submitted, ideally at the EIA stage."	As per Entry 6) of the MGN543 Checklist (Appendix B), the Applicant will supply hydrographic data compliant with MGN543 requirements.
MCA	11 Dec 2017	"Export cable routes, cable burial protection index and cable protections are issues that are yet to be fully developed. However due cognisance needs to address cable burial and protection, particularly close to shore where impacts on navigable water depth may become significant. Any consented cable protection works must ensure existing and future safe navigation is not compromised. The MCA would accept a maximum of 5% reduction in surrounding depth referenced to Chart Datum. Existing charted anchorage areas should be avoided. Where burial depths are not achieved consultation will need to take place with MCA regarding the locations, impact and potential risk mitigation measures."	As per the embedded mitigation listed in Section 26, a Cable Burial Risk Assessment will be undertaken post consent, which will present in detail the intended cable protection to be implemented. The approach taken for cable sections where protection may reduce water depths by more than 5% will be agreed with the MCA.
MCA	11 Dec 2017	"The turbine layout design will require MCA approval prior to construction to minimise the risks to surface vessels, including rescue boats, and Search and Rescue aircraft operating within the site. As	The final layout will be agreed with the MCA post consent.

Consultee	Date	Comment	Response/where addressed in the NRA for Norfolk Vanguard
		such, MCA will seek to ensure all structures are aligned in straight rows and columns, including any platforms. Any additional navigation safety and/or Search and Rescue requirements, as per MGN 543 Annex 5, will be agreed at the approval stage. The layout design should take into account East Anglia 3 and should align, ideally with information sharing agreements in place with the associated developers."	
MCA	11 Dec 2017	Safety zones during the construction, maintenance and decommissioning phases are supported, however it should be noted that operational safety zones may have a maximum 50m radius from the individual turbines. A detailed justification would be required for a 50m operational safety zone, with significant evidence from the construction phase in addition to the baseline NRA required supporting the case.	As per the embedded mitigation listed in Section 26, standard safety zones will be applied for during construction, major maintenance, and decommissioning. There is the potential for the safety zone application to include provision for operational safety zones around permanently manned accommodation platforms to protect the personnel onboard. Further consultation will be undertaken prior to submission of the safety zone application.
MCA	11 Dec 2017	"An Emergency Response Cooperation Plan is required to meet the requirements of MCA guidance. The template is available on the MCA website at www.gov.uk. An approved ERCOP will need to be in place prior to construction. The ERCoP is an active operational document and must remain current at all stages of the project including during construction, operations & maintenance and decommissioning. A SAR checklist will be discussed post consent to track all requirements detailed in MGN 543 Annex 5. The checklist will be adapted to suit Norfolk Vanguard."	As per the embedded mitigation listed in Section 26, an ERCoP will be produced post consent using the MCA template. The new MCA SAR checklist will be discussed with the MCA post consent.
MCA	11 Dec 2017	"The boundary turbines, where they are more than 900m apart, must be lit with a single 2000 candela, red aviation light,	Lighting and marking of the OWF sites will be agreed with TH,

Consultee	Date	Comment	Response/where addressed in the NRA for Norfolk Vanguard
		flashing Morse 'W' in unison with all other boundary turbines. All other turbines must be fitted with a fixed single red 200 candela aviation light, visible through 360°, for SAR purposes. Further consultation with the CAA and MCA should be sought by the applicant where additional mitigation may be identified. We would expect consistency with lighting across East Anglia 3, Norfolk Vanguard East and West and Norfolk Boreas."	MCA, Ministry of Defence (MOD) and the CAA, and will be in line with IALA-O139.
Rijkswaterstaat	11 Dec 2017	"I am happy to note that you comply with the arrangements for East Anglia as commented by Rijkswaterstaat (distance between shipping route and wind park) with reference in Appendix 15.1 section 17.3.2 to the IMO advice."	The assessment referenced is available in Section 17.3.2. A meeting was offered with Rijkswaterstaat which they declined.

5.7 *Former East Anglia Four Consultation*

41. It is noted that consultation was undertaken for the former East Anglia Four wind farm (now Norfolk Vanguard East) between 2012 and 2014. The relevant consultation responses are provided in Table 5.3 below for reference. See section 24 for further detail on the hazard log process which includes consultation originally undertaken for East Anglia Four site.

Table 5.3 Consultation undertaken for the former East Anglia Four

Consultee	Date /Document	Comment	Response/where addressed in the NRA for Norfolk Vanguard
Scoping opinion (for the former East Anglia Four)			
TH	December 2012	The possible cumulative effects on shipping routes and patterns should be fully assessed.	A cumulative assessment of vessel routeing is provided in section 19.3 of this NRA.
MCA	December 2012	Particular consideration will need to be given to the implications of the site size and location on SAR resources and emergency Response & Co-operation Plans (ERCoP) and Guard Vessel provisions.	The impact upon SAR resources has been considered within Chapter 15 Shipping and Navigation of the PEIR. The creation of ERCoP and the use of guard vessels are included in the assumed embedded mitigation listed in section 26 of this NRA.
Consultation with relevant stakeholders (for the former East Anglia Four)			

Consultee	Date /Document	Comment	Response/where addressed in the NRA for Norfolk Vanguard
DFDS Ferries and P&O Ferries	February 2014 (Hazard Workshop)	Vessel collision / allision with a windfarm structure were identified as greatest concern. However, the four engine configuration of most ferries minimised the likelihood of a ferry drifting and alliding with a windfarm structure. Indicated a preference for inclusion of electronic aids to navigation to mark windfarm. Stated that adverse weather routeing is crucial for this area and loss of adverse weather routes could be problematic. Raised concerns over the impact of ancillary windfarm support craft on normal ferry operations i.e. the need for a passing ferry to respond to an incident involving a windfarm support vessel.	DFDS and P&O were provided with the tracks recorded from their vessels collected during the marine traffic surveys undertaken in 2016 and 2017 as part of the regular operator consultation discussed in section 5.3. The marine traffic survey data used to inform this NRA was collected in 2016 and 2017, and will therefore account for changes in fuel regulations introduced in 2015. Vessel collision and allision has been assessed in section 21. Lighting and marking is discussed in section 26.1. Final lighting and marking of Norfolk Vanguard will be agreed with the MCA and TH. Adverse weather is discussed in section 16 of this NRA.
Hanson Marine Aggregates	February 2014 (Hazard Workshop)	No concerns regarding the potential impact of East Anglia Four on current active dredge areas. Forecasts that dredging activity in the area will be operational for up to 25 years and due to increasing demand for coarse material, has significant potential to increase and therefore future vessel routeing should be considered. Satisfied that the zonal scenario shown at the Hazard Workshop (East Anglia ONE, East Anglia Three and East Anglia Four) was satisfactory and did not significantly impact upon dredge operations, including routeing. However, the loss of adverse weather routes and future cumulative impacts, following further zonal development, were of concern.	This is assumed to remain the case for Norfolk Vanguard East based on the baseline assessment of dredging activity provided in section 8.7. Future case vessel routeing (both for in isolation and cumulative cases) is assessed in section 19. Future case vessel routeing (both for in isolation and cumulative cases) is assessed in section 19, and discussion of adverse weather is discussed in section 16.
Royal National Lifeboat Institute (RNLI)	February 2014 (Hazard Workshop)	Adequate marking of wind turbines (coding and lettering) was identified to be of high importance. Main concern was the creation of 'choke points' on the landward side of East Anglia Four due to increases in	Lighting and marking is discussed in section 26.1. Final lighting and marking of Norfolk Vanguard will be agreed with the MCA and TH. The impact of construction upon

Consultee	Date /Document	Comment	Response/where addressed in the NRA for Norfolk Vanguard
		construction traffic.	passing traffic has been assessed within Chapter 15 Shipping and Navigation.
Rederscentrale (Belgian Fisheries)	February 2014 (Hazard Workshop)	Stated that the likelihood of vessel-to-vessel collisions occurring within the windfarm was low. Stated that larger spacing between wind turbines would lower the risk.	Vessel to vessel collisions involving fishing vessels are accounted for within the assessment of consequences provided in section 21.4.
VisNed (Netherlands Fisheries)	February 2014 (Hazard Workshop)	Highlighted the need for adequate cable burial or protection given the stochastic nature of the seabed and typical penetration depths (20cm) of beam trawling. Highlighted usefulness of providing input data (locations of windfarm structures and cables) for fishing vessel 'plotters' as potential mitigation. If deemed necessary, use of 50m safety zones during operational phase were supported. Stated that the likelihood of vessel-to-vessel collisions occurring within the windfarm was low with fishermen likely to be more alert whilst fishing within the windfarm.	The cable protection methods utilised will be decided in a Cable Burial Management Plan undertaken post consent (section 26). As per section 26, provision of data for fishing vessel plotters included in embedded mitigation. Safety zones surrounding active construction or maintenance work and 50m safety zones are included as embedded mitigation (section 26), however it is noted that permanent operational safety zones are unlikely to be applied for. Vessel to vessel collisions involving fishing vessels are accounted for within the assessment of consequences provided in section 21.4.
Cruising Association	February 2014 (Hazard Workshop)	Raised concerns on the potential for increased vessel-to-vessel encounters following construction of the windfarm, including potential consequences of a large vessel encountering recreational craft and the risk of a recreational vessel-to-vessel collision occurring within the windfarm. However, it was agreed that the likelihood of such an event was low. Stated that current mitigation measures were sufficient to adequately reduce the risk to recreational craft.	Vessel to vessel collisions involving recreational vessels are accounted for within the assessment of consequences summarised in section 21.4. Mitigation levels of Norfolk Vanguard are in line with those proposed for East Anglia Four.

6. Data Sources

42. This section summarises the main data sources used in assessing the existing environment and shipping activities relative to Norfolk Vanguard. The main data sources used in this assessment are listed below:

- Historic Marine traffic survey data collected for the former East Anglia Four (AIS, visual and Radar);
- Marine traffic survey – AIS, visual and Radio Detecting and Ranging (Radar) survey data for both OWF sites (28 days throughout September 2016 and 28 days throughout January and February 2017) collected from two survey vessels. Further details are provided in section 12;
- AIS survey data – AIS survey data for the offshore cable corridor study area (period coinciding with that of marine traffic survey for the OWF sites) collected from onshore coastal receivers. Further details are provided in section 15;
- Maritime incident data from the MAIB (2005 to 2014);
- Maritime incident data from the RNLI (2005 to 2014);
- Marine aggregate dredging data (licence areas and active areas) and transit routes from The Crown Estate and BMAPA (2016);
- The Crown Estate UK offshore wind farm boundaries (2017);
- Admiralty Sailing Direction – North Sea (West) Pilot NP 54 United Kingdom Hydrographic Office (UKHO), 2016);
- UKHO Admiralty Charts 106, 1408, 1503, 1504, 1631 and 2182a;
- RYA UK Coastal Atlas of Recreational Boating (2009) and Geographic Information System (GIS) Shape Files (2016); and
- MetOcean data –
  - Wind direction data recorded from the Northern Met Mast (2013 to 2016);
  - Significant wave height data recorded within Norfolk Vanguard East (2012 to 2013)
  - Visibility data recorded from the Ijmuiden Met Mast (2011 to 2016).

43. The marine traffic survey data used within this NRA is compliant with the relevant requirements of MGN 543, and is summarised in Section 12. The approach to marine traffic data collection was also agreed in advance of the NRA being undertaken by the MCA and TH following submission of marine traffic survey methodologies in 2016.

7. Lessons Learned

44. There is considerable benefit to developers in the sharing of lessons learned within the offshore industry. The NRA and in particular the hazard assessment, includes general consideration for lessons learned and expert opinion from previous offshore wind farm projects and other sea users.

45. Lessons learned data sources include:

- Anatec (2012). Navigation Risk Assessment: East Anglia ONE Offshore Windfarm;
- Anatec (2015). Navigation Risk Assessment: East Anglia THREE Offshore Windfarm;
- DfT (2004) Results of the electromagnetic investigations 2nd edition, Southampton, MCA and QinetiQ;
- MCA (2005) Offshore Wind Farm Helicopter Search and Rescue – Trials Undertaken at the North Hoyle Wind Farm Report of helicopter Search and Rescue (SAR) trials undertaken with Royal Air Force Valley C Flight 22 Squadron on March 22nd 2005, Southampton, MCA;
- Nautical Offshore Renewable Energy Liaison (NOREL Group) (unknown) A Report compiled by the Port of London Authority based on experience of the Kentish Flats Wind Farm Development, NOREL Work Paper, WP4 (2nd NOREL);
- Renewables UK (2014 issue 2) Guidelines for Health and Safety in the Wind Energy Industry;
- RYA and CA (2004) Sharing the Wind – Identification of recreational boating interests in the Thames Estuary, Greater Wash and North West (Liverpool Bay), Southampton, RYA;
- The Crown Estate (2012) Strategic Assessment of Impacts on Navigation of Shipping and Related Effects on Other Marine Activities Arising from the Development of Offshore Wind Farms in the UK REZ;
- Scottish Power and Vattenfall (2012). East Anglia ONE Offshore Windfarm Environmental Statement Volume 2 Offshore, Chapter 15 – Shipping and Navigation; and
- Scottish Power and Vattenfall (2015). East Anglia THREE Environmental Statement Volume 1 Chapter 15 Shipping and Navigation.

8. Existing Environment

8.1 *Introduction*

46. This section presents the navigational baseline assumed within this NRA which has been established based on the data sources outlined in Section 6.

47. Figure 8.1 presents an overview of the navigational features in proximity to the offshore project area. Each of these features is discussed in the following subsections.

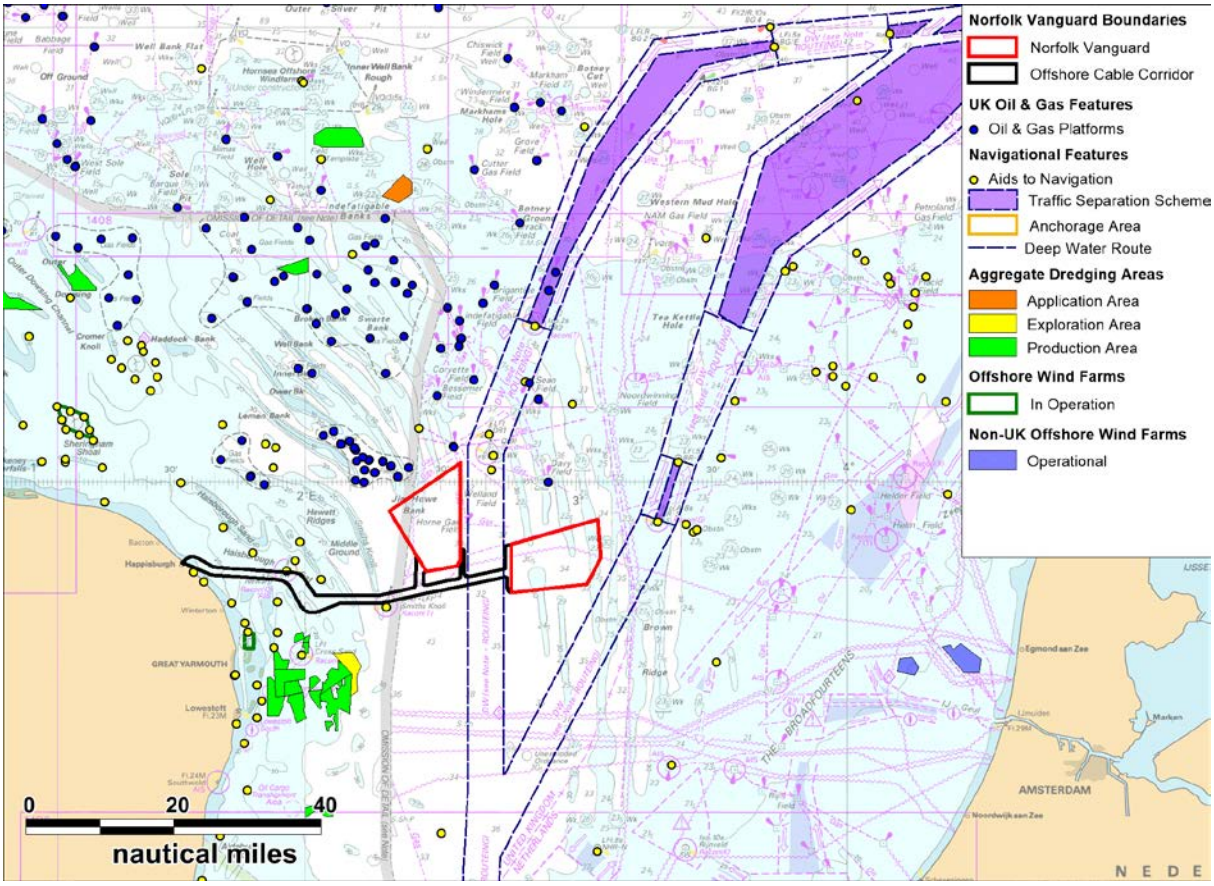

Figure 8.1 Navigational Features Overview - IMO Routeing Measures

48. The key navigational features in the immediate vicinity of Norfolk Vanguard are the IMO routeing measures, most notably the DR1 LightBuoy Deep Water Route (DWR), and the West Friesland DWR, as shown in Figure 8.2. These routeing measures form part of the overall traffic management system implemented within the southern North Sea.

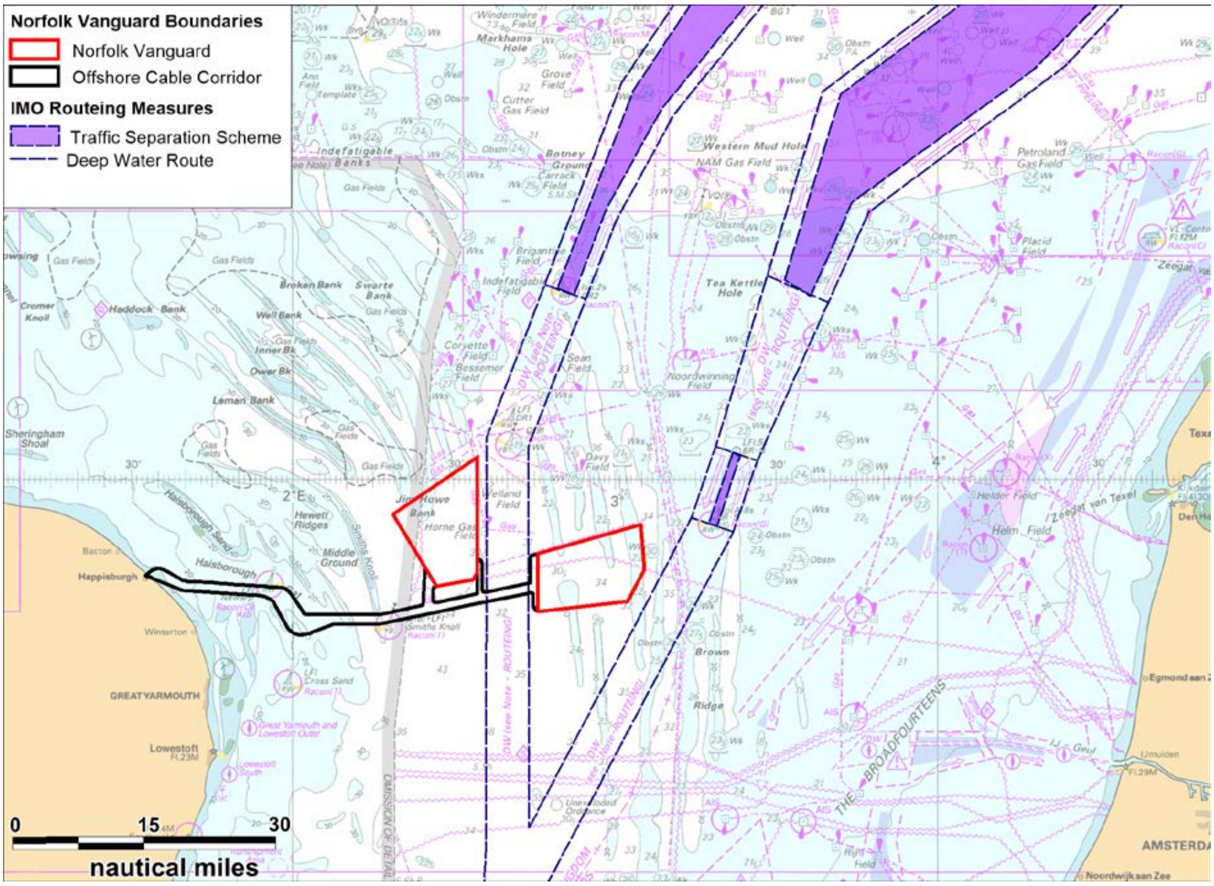

Figure 8.2 IMO Routeing Measures

49. The DR1 LightBuoy DWR passes between Norfolk Vanguard East and Norfolk Vanguard West (1nm buffer from both OWF sites), and connects to the Off Botney Ground Traffic Separation Scheme (TSS), located approximately 20 to 25nm north of the OWF sites. As shown in Figure 8.2, this DWR intersects the offshore cable corridor. The West Friesland DWR passes approximately 2nm to the east of Norfolk Vanguard East, and links to the Off Brown Ridge TSS. The two DWRs join approximately 25nm south of the OWF sites. Impacts on the IMO routeing measures are considered further within Chapter 15 Shipping and Navigation – both in isolation and cumulatively.

8.2 *Navigational Aids*

50. There are a number of existing Aids to Navigation (AtoN) located in proximity to the offshore project area, as presented in Figure 8.3. Positions and details of the presented AtoNs have been taken from UKHO Admiralty Charts. No impacts on shipping and navigation receptors have been identified.

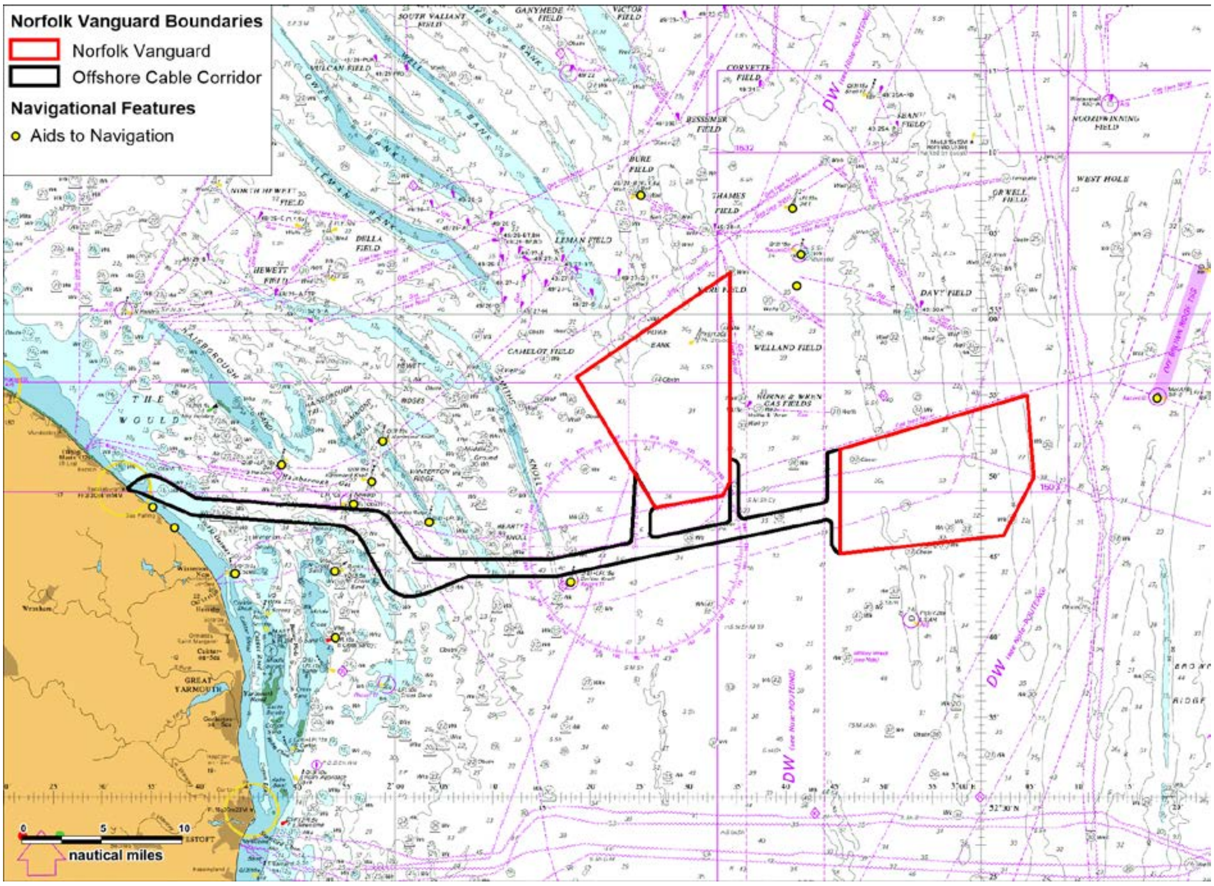

Figure 8.3 Navigational Aids Relative to Norfolk Vanguard

8.3 *Anchorage Areas*

51. There are no charted or designated anchorage areas within the vicinity of the proposed project. However, it is noted that the Pilot Book (UKHO 2016) states that anchorage can be obtained in the following areas:

- The Would, between Bacton and Winterton Ness;
- Caister and Yarmouth Roads in depths of 10 to 24m over sand; and
- Gorleston Road, south-east of entrance to Great Yarmouth, in depths of 10 to 20m over sand.

52. The charted positions of the locations mentioned above are presented in Figure 8.4. It is emphasised that these represent preferred anchorage areas, rather than designated charted anchorages.

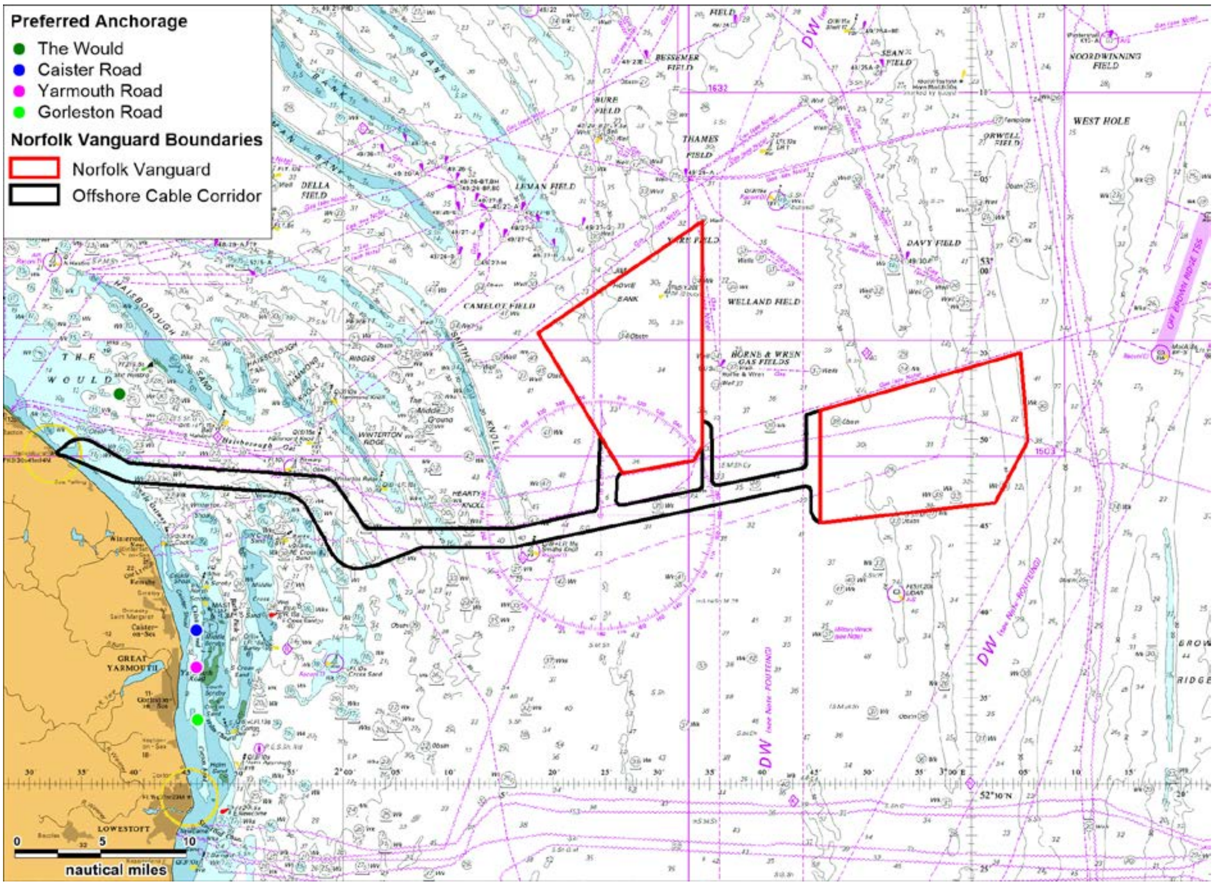

Figure 8.4 Preferred Anchorage Areas

53. Impacts on anchoring for shipping and navigation receptors are considered within Chapter 15 Shipping and Navigation.

8.4 *Ports*

54. Notable ports in the vicinity of Norfolk Vanguard and the offshore cable corridor are presented in Figure 8.5; however, there are also a number of small marinas on the Norfolk coastline that serve small recreational and fishing vessels only.

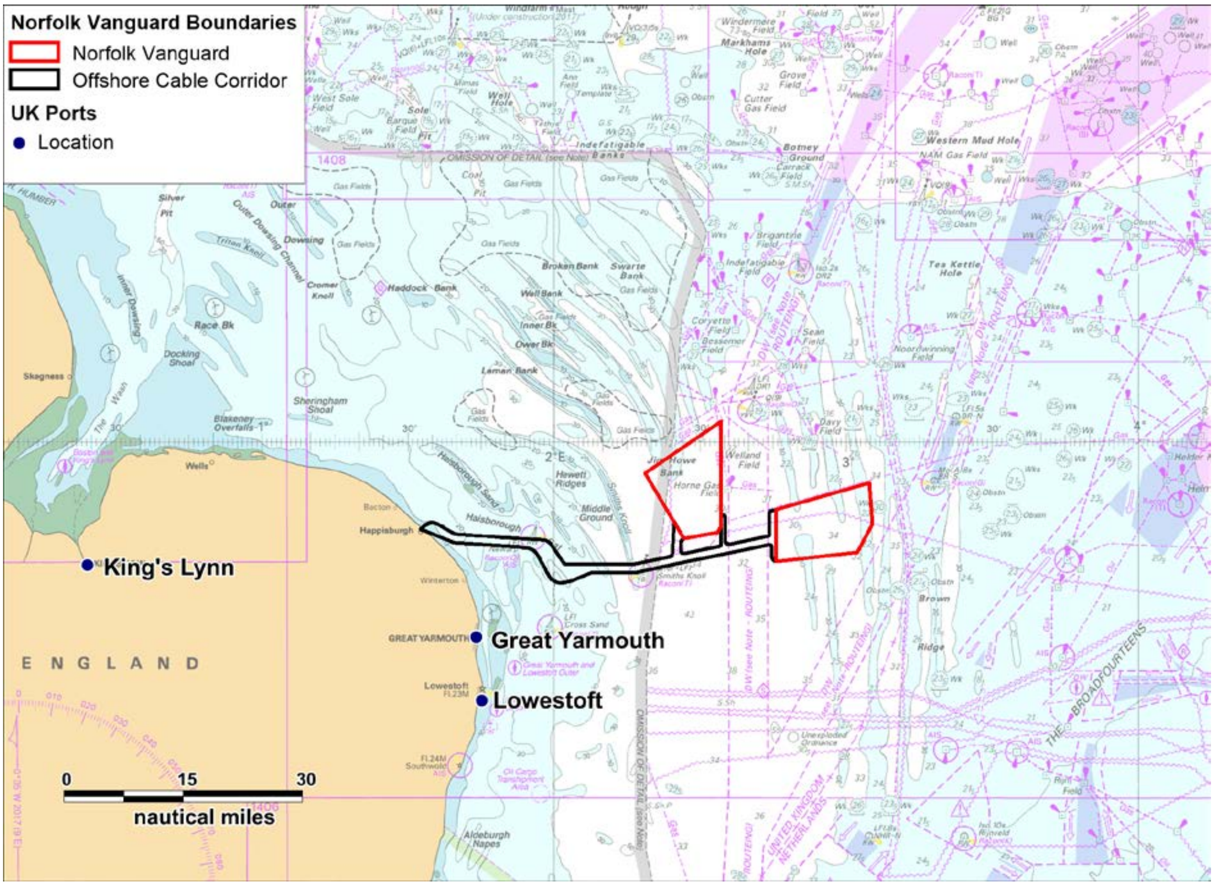

Figure 8.5 Principal Ports Relative to Norfolk Vanguard

55. There are three main commercial ports in the vicinity of Norfolk Vanguard. The closest commercial port to Norfolk Vanguard is Great Yarmouth, located 11.7nm south-west of the offshore cable corridor.

56. The number of vessel arrivals at these ports is presented in Figure 8.6.

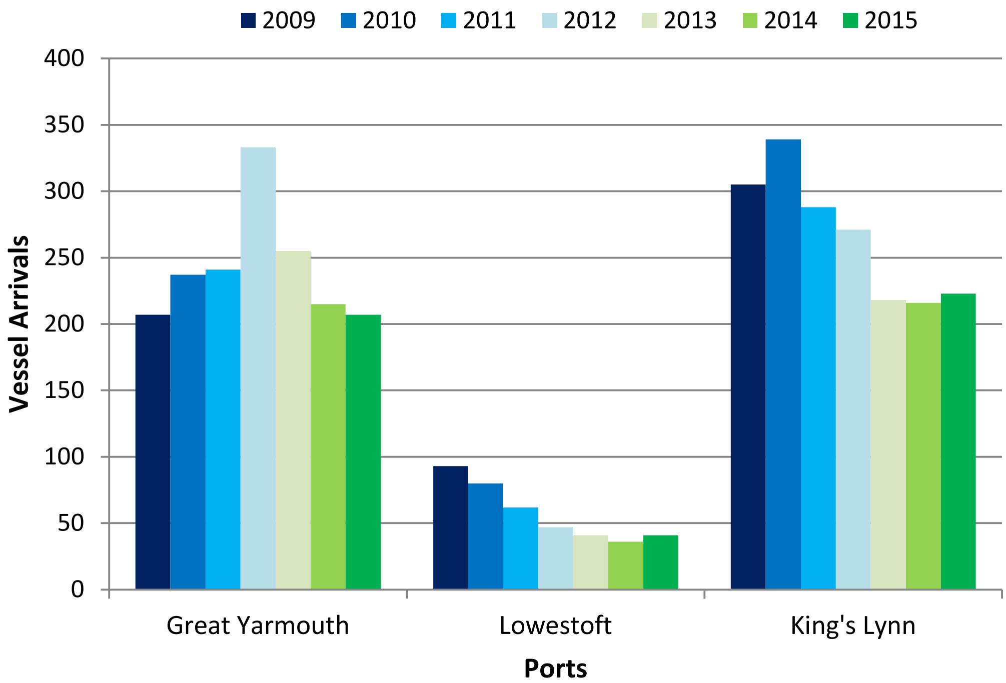

Figure 8.6 Vessel Arrivals to Principal Ports Relative to Norfolk Vanguard

57. In 2015, King's Lynn had the most vessel arrivals, closely followed by Great Yarmouth. Lowestoft consistently had significantly fewer arrivals than the other two major ports. King Lynn is primarily a cargo port (specifically dry bulk, agricultural products, and metals), with Lowestoft and Great Yarmouth mostly serving the offshore support industry. Great Yarmouth and Lowestoft are being considered as ports (along with berths within the River Humber) for construction and operational vessels.

58. Given the distance from the coastline and thus port activity there are no notable impacts associated within shipping and navigation receptors.

8.5 *Ministry of Defence (MoD) Practice and Exercise Areas (PEXAs)*

59. There are no MOD practice and exercise areas (PEXAs) in the vicinity of the offshore project area. The nearest PEXA is a naval exercise area located 55nm (102km) north of Norfolk Vanguard.

60. No consultation responses with regards to shipping and navigation were received from the MOD. There are no anticipated impacts on shipping and navigation receptors associated with MOD PEXAs given there are no surface installations, however military vessel traffic is considered as part of the baseline in Section 12.

8.6 *Oil and Gas Infrastructure*

61. Figure 8.7 presents an overview of the nearby oil and gas infrastructure in the vicinity of the proposed project area. There are no oil & gas surface platforms located within the offshore project area itself, with infrastructure concentrated to the north of the OWF sites. The Horne and Wren gas platform, located 1.01nm from Norfolk Vanguard West within the corridor between the OWF sites, has been decommissioned, with its topside removed. However, at the time of writing, subsea conductor stubs and pipeline ends remain within a 10m radius of the original platform and the location remains charted with a safety zone in situ.

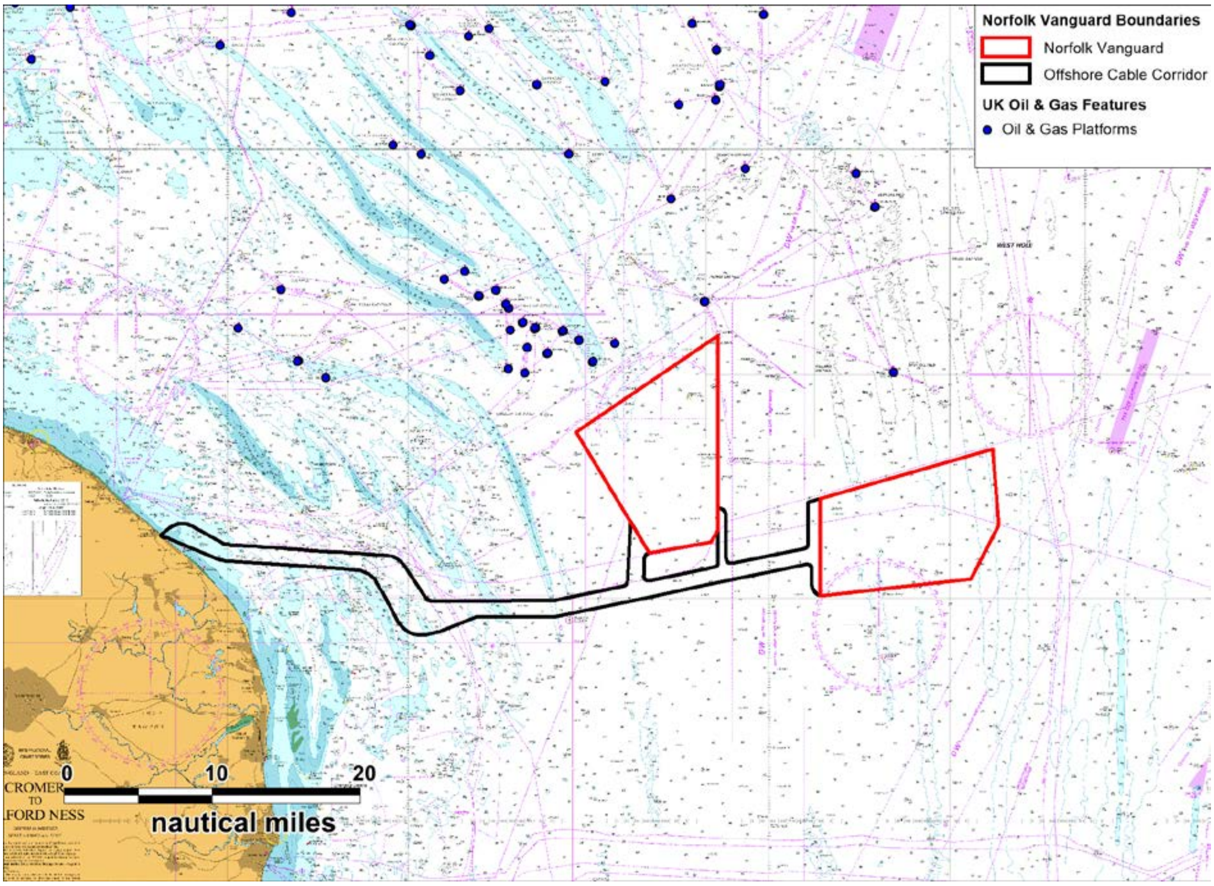

Figure 8.7 Oil and Gas Platforms and Relative to Norfolk Vanguard

62. Details of the nearest existing surface installations are detailed in the following table. It is noted that each installation listed in the table is a gas platform, as are the surrounding installations in the southern North Sea.

Table 8.1 Nearest Existing Offshore Surface Installations to Norfolk Vanguard

Offshore Surface Installation	Approximate Distance From Norfolk Vanguard (nm)	Nearest Norfolk Vanguard Boundary
Thames AR Platform	2.54	North (Norfolk Vanguard West)
Thames A Platform	2.58	North (Norfolk Vanguard West)
Leman DD Platform	3.37	North (Norfolk Vanguard West)
Leman DP Platform	3.38	North (Norfolk Vanguard West)
Leman G Platform	3.54	North (Norfolk Vanguard West)

63. The landfall site is located in close proximity to the Bacton Gas Terminal and its associated pipelines. As shown in Figure 8.8, none of these pipelines are within the offshore cable corridor at the landfall site itself; however, two pipelines do cross the corridor further offshore and no effects on shipping and navigation have been identified.

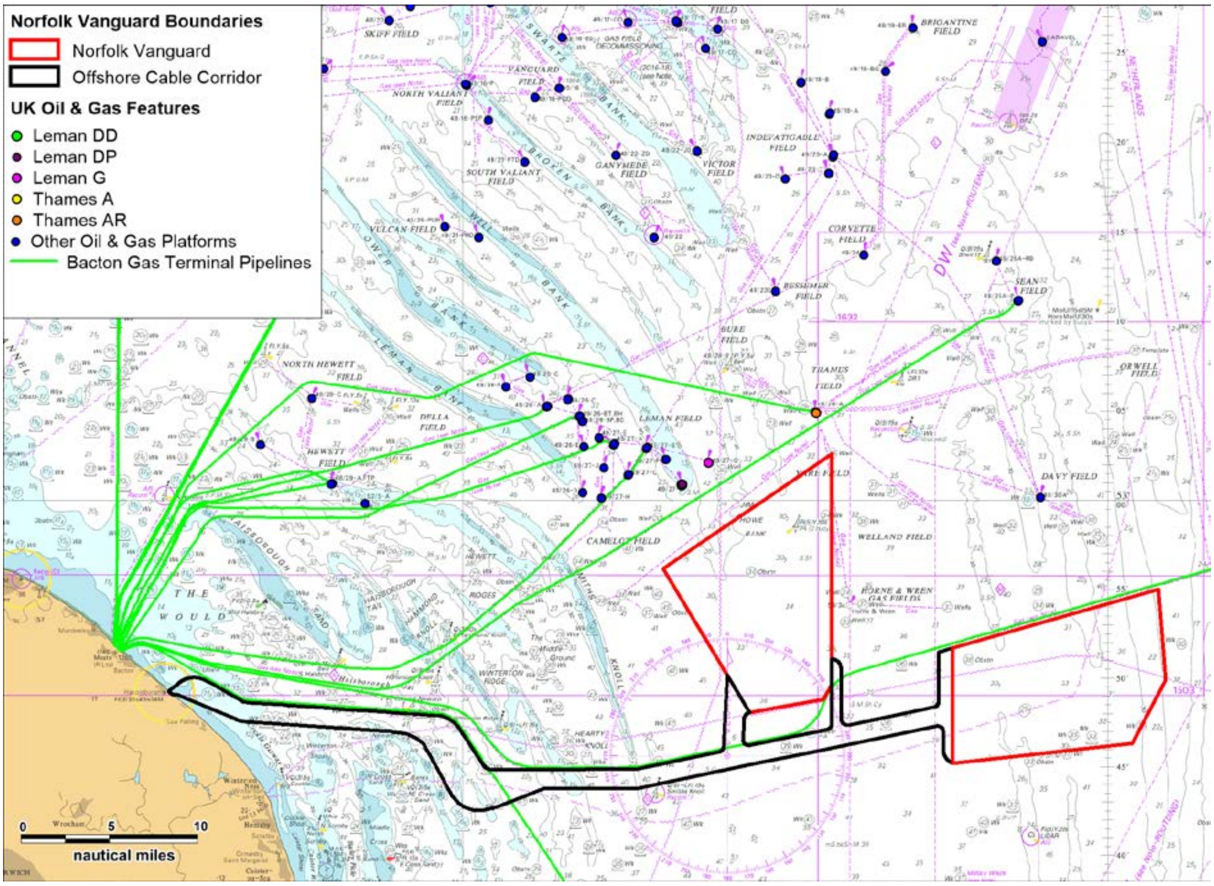

Figure 8.8 Bacton Gas Terminal Pipelines in Relation to Norfolk Vanguard

8.7 *Marine Aggregate Dredging Areas*

64. Marine aggregate dredging areas in the vicinity of Norfolk Vanguard and the offshore cable corridor are presented in Figure 8.9.

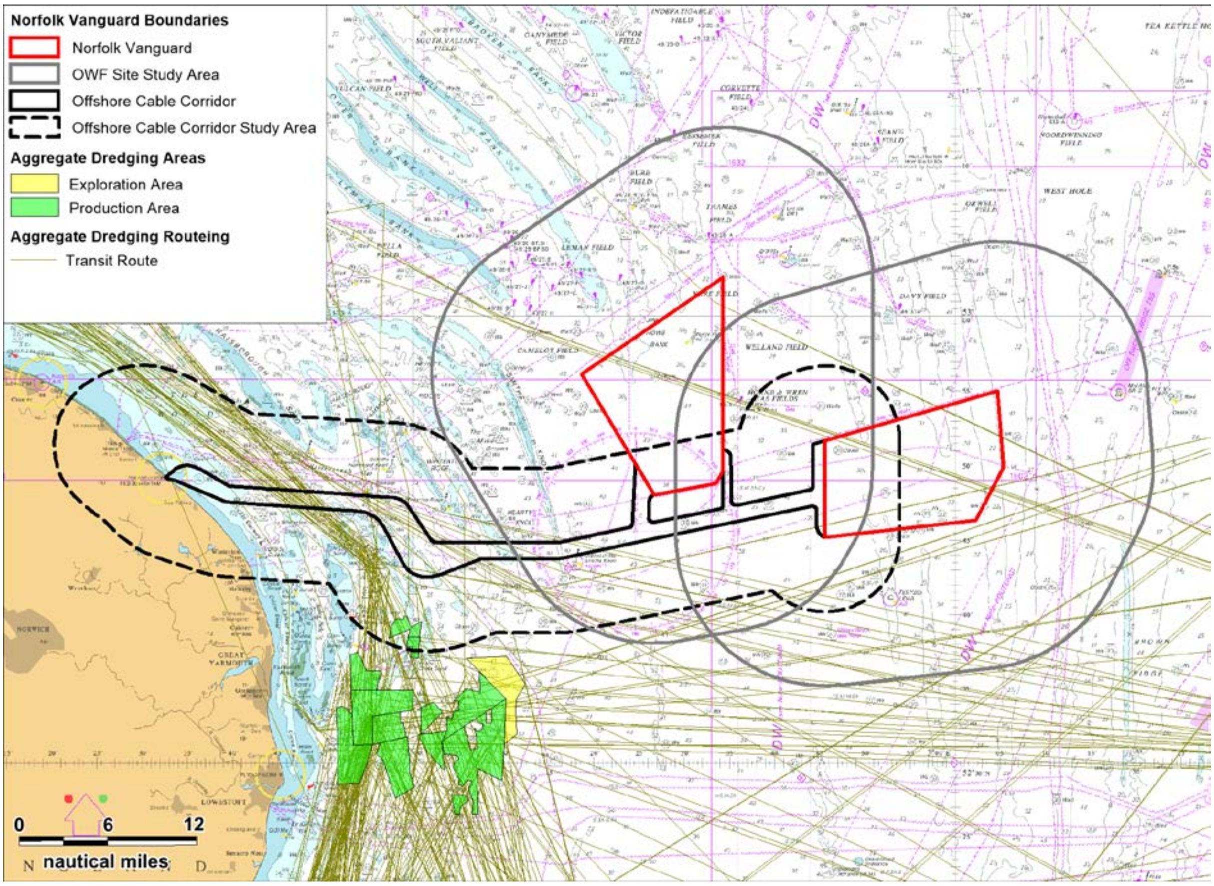

Figure 8.9 Marine Aggregate Dredging Areas and Transit Routes

65. There are three marine aggregate dredging areas located approximately 3.14nm south of the offshore cable corridor. Area 494 is an option area owned by Tarmac Marine Ltd. Areas 212 and 496 are both production areas operated by Hanson Aggregates Marine Ltd and Tarmac Marine Ltd respectively. Outside the offshore cable corridor study area there are ten further production areas and one exploration area, all located in the same region as the three areas within the offshore cable corridor study area.

66. BMAPA routes show potential activity, of marine aggregate dredgers, within the southern North Sea. There is no significant activity within the OWF sites and therefore there are not anticipated to impacts on marine aggregate dredgers engaged in dredging or any perceptible impacts on supply route. Marine aggregate dredgers are

therefore considered within the impact assessment under general commercial shipping.

8.8 *Other Offshore Wind Farm Projects*

67. Other offshore wind farm developments in the vicinity of Norfolk Vanguard are presented in Figure 8.10.

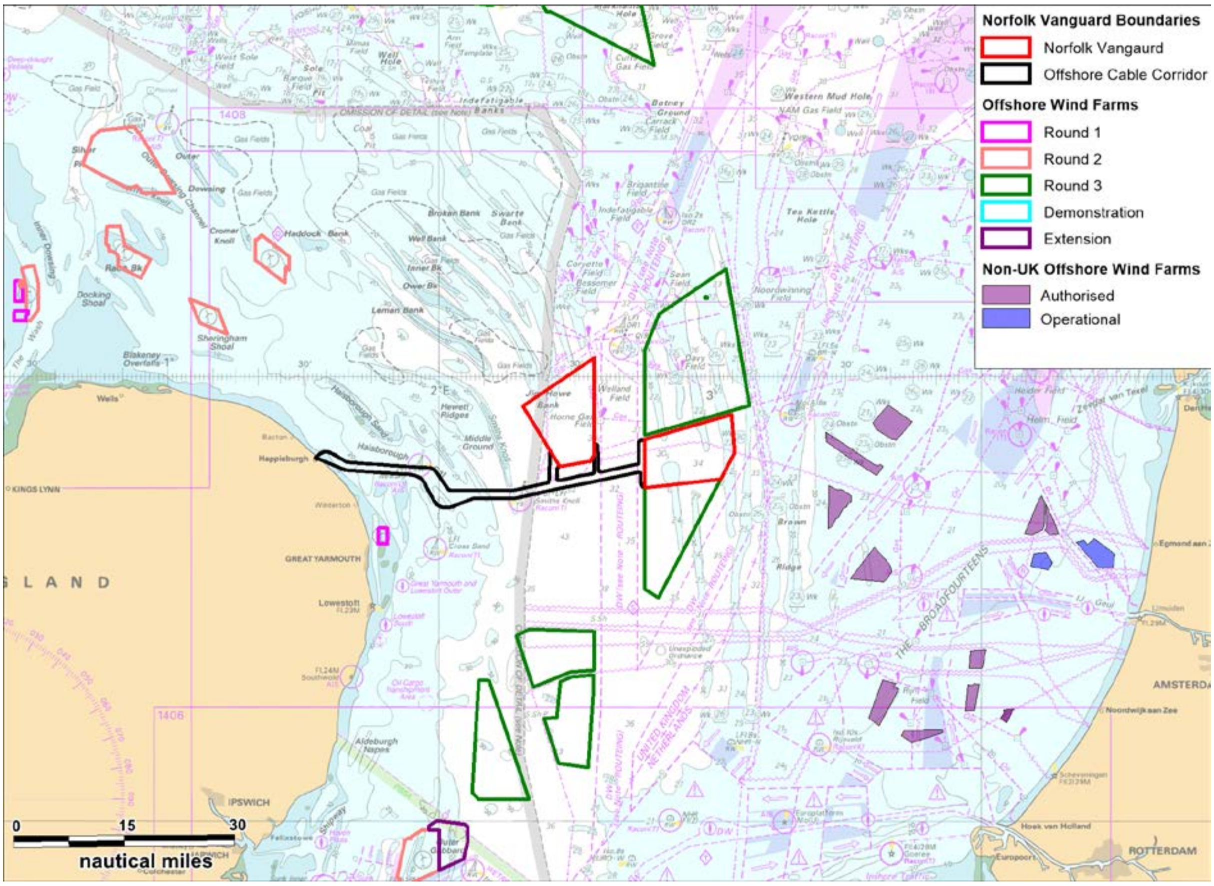

Figure 8.10 Other Wind Farm Projects Relative to Norfolk Vanguard

68. The closest operational wind farm project relative to Norfolk Vanguard is the Scroby Sands Offshore Wind Farm, located 7.3nm south-west of the offshore cable corridor. It is noted that Norfolk Boreas (planning) and East Anglia Three (consented) border the north and south borders of Norfolk Vanguard East respectively. A full assessment of other windfarm developments (consented through to decommissioning) has been undertaken in section 25 – cumulative impacts.

8.9 *Submarine Cables*

69. The submarine cables in the vicinity of Norfolk Vanguard and the offshore cable corridor are presented in Figure 8.11. It can be seen that there are three submarine cables intersecting the OWF sites, with each also intersecting the offshore cable corridor. These are an active telecommunication cable from Winterton to Egmond (Netherlands), an inactive telecommunication cable from the Winterton to Norddiech (Germany) and an active North Sea telecommunications cable from Lowestoft to the Sleipner Gas Field. No impacts on shipping and navigation receptors have been identified.

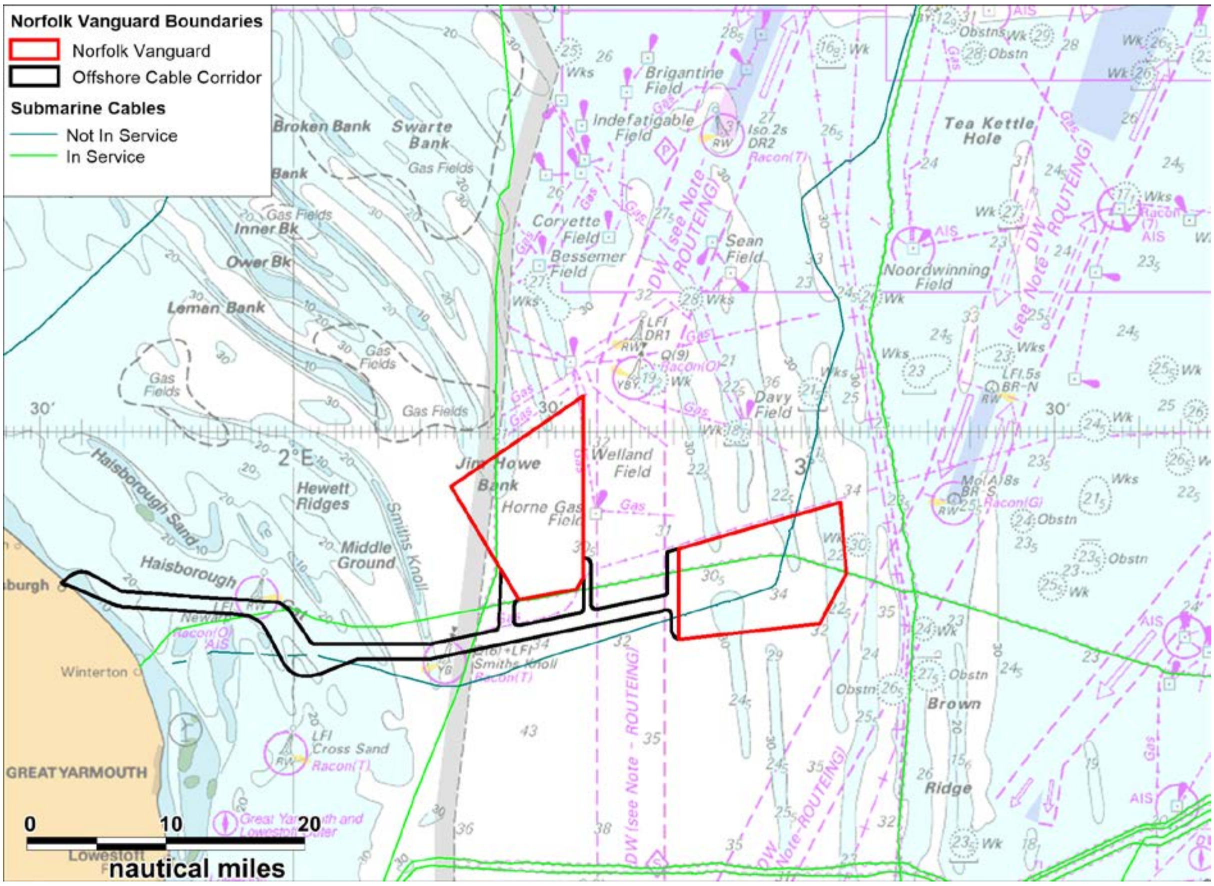

Figure 8.11 Submarine Cables Relative to Norfolk Vanguard

8.10 *Marine Environmental High Risk Areas (MEHRAS)*

70. There are no Marine Environment High Risk Areas (MEHRAs) in the vicinity of the offshore project area, with the nearest being the Harwich and Felixstowe MEHRAs located approximately 49nm (91km) from the offshore cable corridor and 62nm (115km) to the south-west of the OWF sites respectively.

8.11 *Wrecks*

71. Based on information given on UKHO Admiralty Charts covering the region, the locations of wrecks in the vicinity of the offshore project area are presented in Figure 8.12. None of the charted wrecks have any impact on surface navigation.

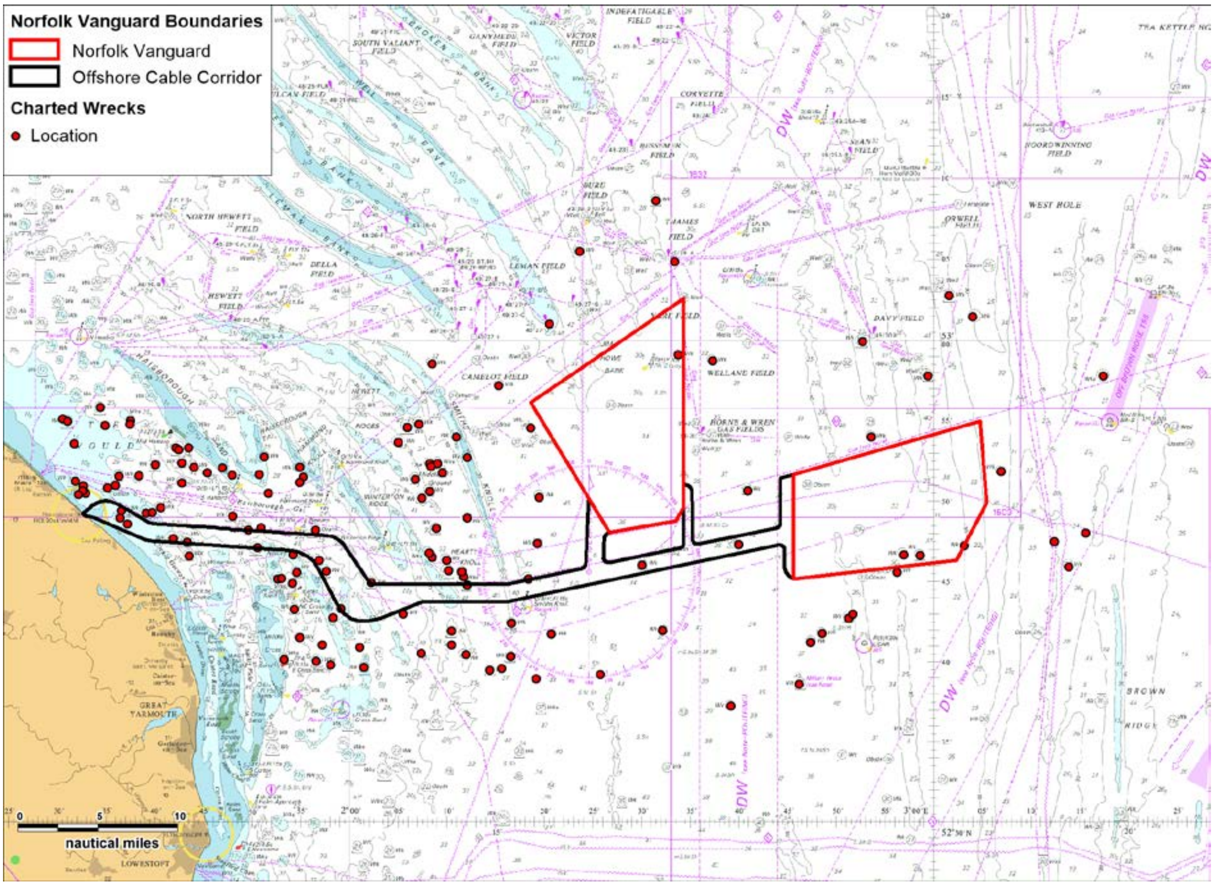

Figure 8.12 Charted Wrecks Relative to Norfolk Vanguard

9. MetOcean Data

9.1 *Introduction*

72. This section presents nearby meteorological and oceanographic statistics for Norfolk Vanguard. Analysis of various data sources have been collated, and used to estimate the MetOcean conditions within the vicinity of Norfolk Vanguard for use as input to the risk assessment.

73. The following MetOcean sources have been assessed, and validated against Anatec's in-house data.

- Wind direction data recorded from the Northern Met Mast;
- Significant wave height data recorded within Norfolk Vanguard East;
- Visibility data recorded from the Ijmuiden Met Mast;
- Visibility data from North Sea (West) Pilot NP 54 (UKHO, 2016); and
- Tidal data from UKHO Admiralty Chart 1408.

74. This data has then been used within modelling assessment undertaken within this NRA.

9.2 *Wind*

75. Wind direction data was available from the Northern Met Mast over a three year period from September 2013 to September 2016. This has been validated against two of Anatec's in-house MetOcean data sources within the same region, with the locations of all three data sources are presented in Figure 9.1. Following this, Figure 9.2 presents the annual wind direction distribution of all three data sources.

76. This data was used to estimate the wind direction probabilities as shown in Figure 9.2. The results have been compared with Anatec's in house MetOcean data for validation purposes. This data has then been used within modelling assessment undertaken within this NRA.

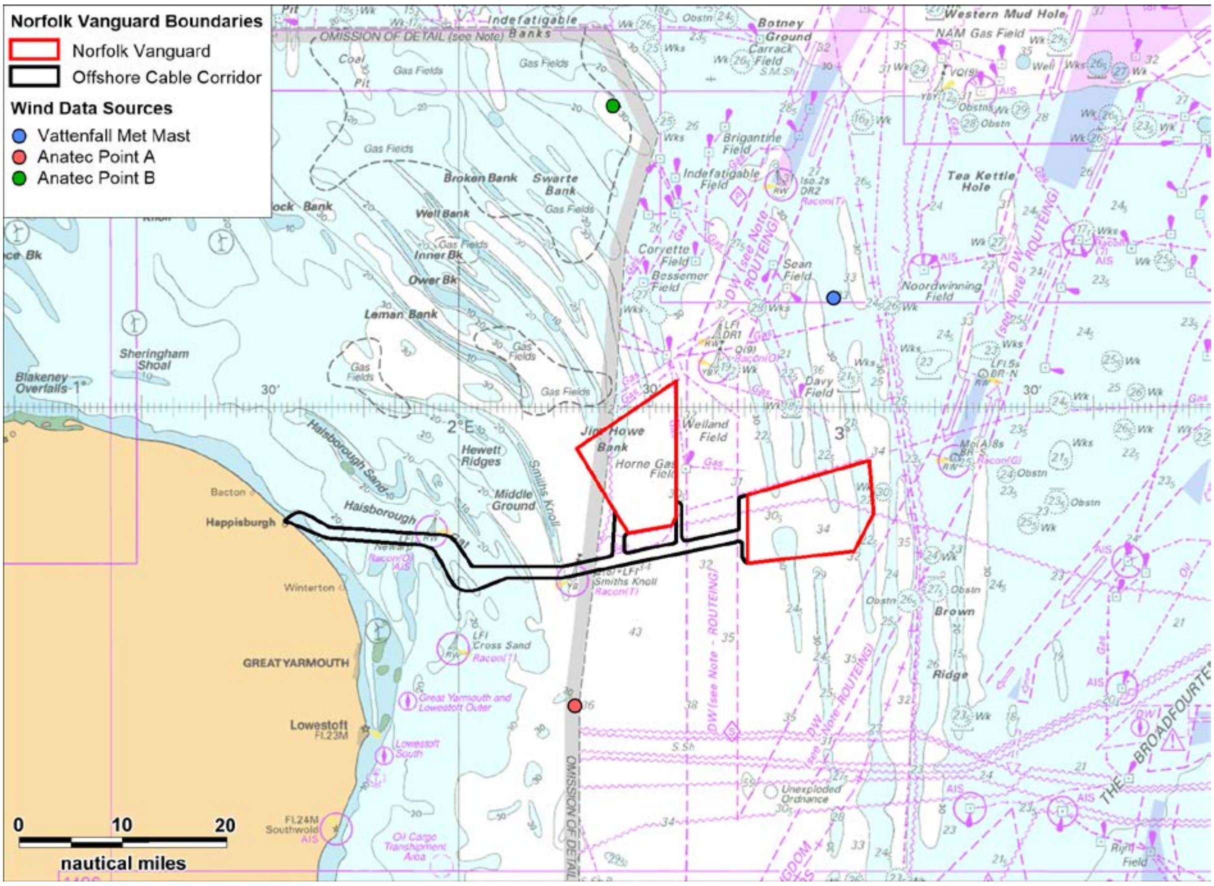

Figure 9.1 Wind Direction Data Source Locations

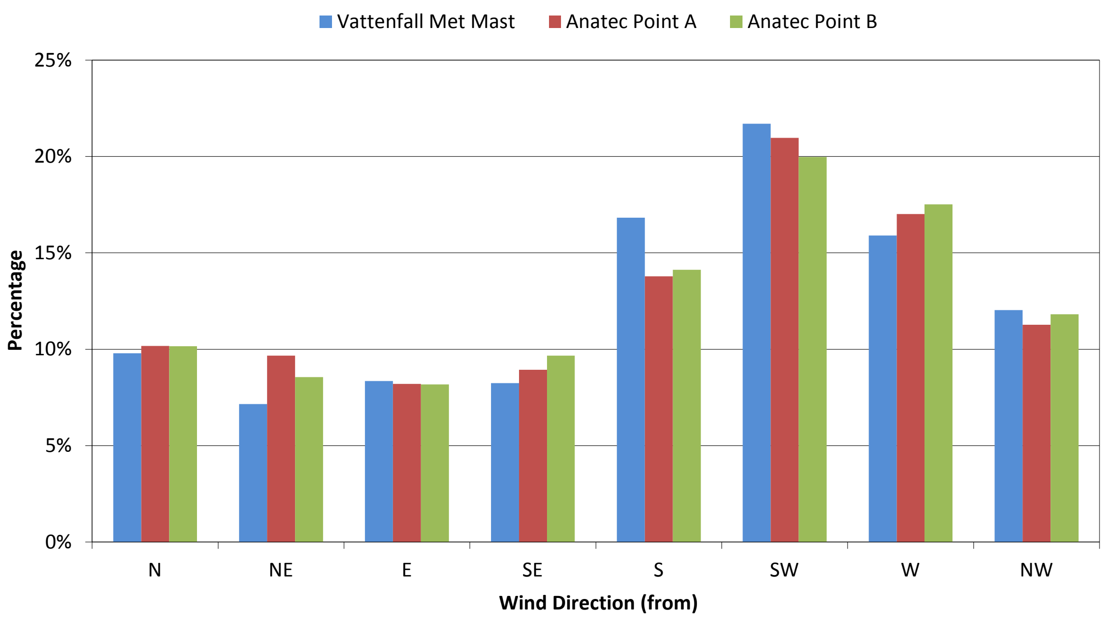

Figure 9.2 Annual Wind Direction Distribution

77. It is observed that overall there is good correlation between the data collected by Vattenfall and Anatec's in house data, with the predominant wind direction from the south-west. The Vattenfall data has been used as input to the modelling (see Section 20).

9.3 *Wave*

78. Significant wave height data was available from an Acoustic Waves and Currents (AWAC) sensor located within the Norfolk Vanguard East site over a 12 month period from December 2012 to December 2013. The significant wave height exceedance curve produced by this data is presented in Figure 9.3 along with the equivalent data from the same two Anatec in-house MetOcean data sources introduced in section 9.2.

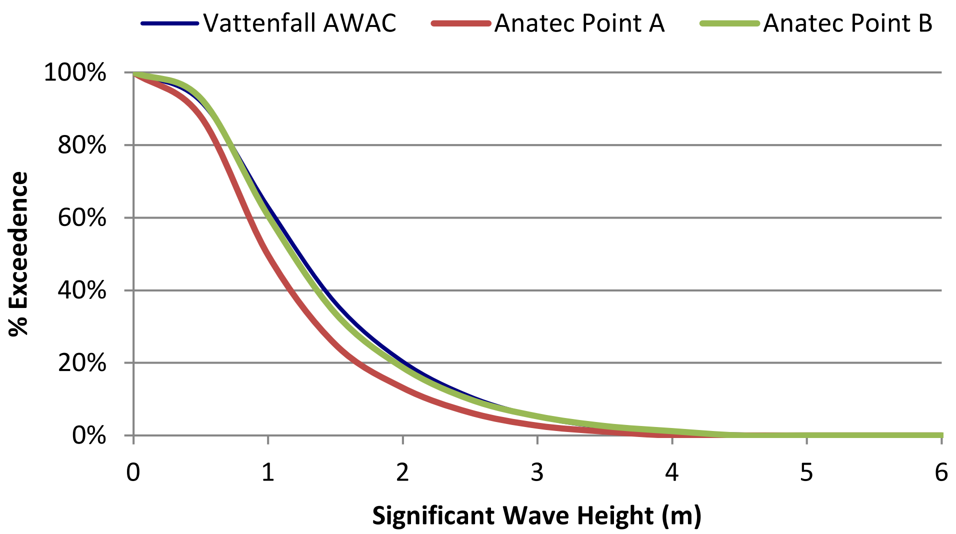

Figure 9.3 Significant Wave Height Exceedance Curve

79. It is observed that overall there is again good correlation between the data collected by Vattenfall and Anatec's in house data, with the proportion of the significant wave height exceeding 5m (defined as a severe sea state) only 0.09%. The Vattenfall data has been used as input to the modelling (see Section 20).

9.4 *Visibility*

80. Historically, visibility has been shown to have a major influence on the risk of vessel collision. The annual average probability of bad visibility (defined as less than 1km) for the UK North Sea is approximately 0.03, i.e., an average of 3.0% of the year. The

North Sea (West) Pilot NP 54 (UKHO 2016) gives approximate values for visibility in the area, as shown in Table 9.1.

Table 9.1 Average Incidence of Fog (UKHO 2016)

Month	Incidence of Fog
February	3 to 4%
May	3 to 4%
August	1 to 2%
November	0 to 1%

81. For validation purposes, an assessment of visibility data recorded from a Met Mast installed at Ijmuiden was also undertaken. The data indicated that incidence of poor visibility (< 1km) was approximately 2%.

82. For the purposes of the modelling, and based upon the available information, the probability of poor visibility has been assumed to be in line with the UK North Sea average, namely 3%.

9.5 *Tide*

83. Tidal current data has been taken from UKHO Admiralty Chart 1408. The positions of the diamonds considered are presented in Figure 9.4. Following this, the table showing the corresponding tidal stream details (taken directly from the chart) is presented in Figure 9.5.

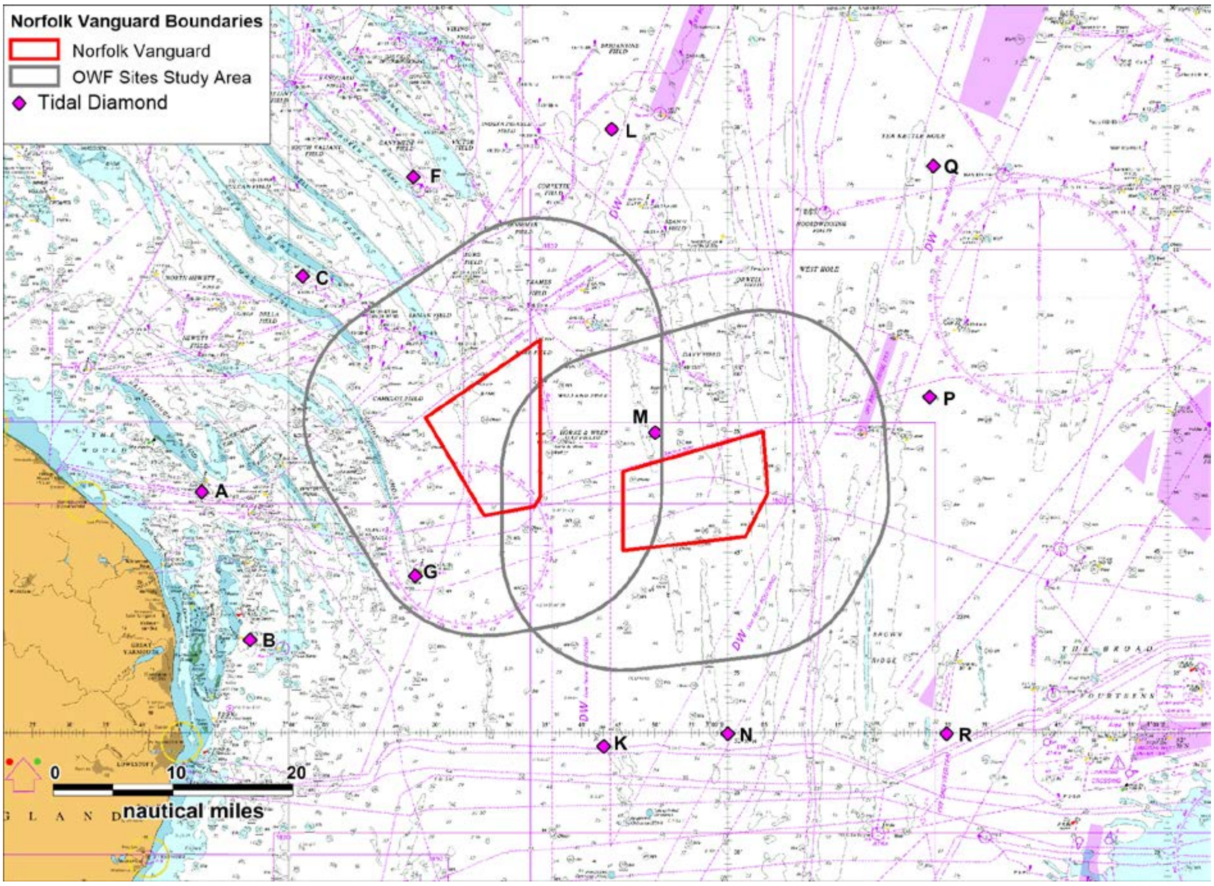

Figure 9.4 UKHO Admiralty Chart 1408 Considered Tidal Diamond Locations

Tidal Streams referred to HW at DOVER

	A 52°50'0N 1 47·9E		B 52°38'0N 1 54·4E		C 53°08'0N 2 01·9E		D 51°59'0N 2 05·9E		E 52°15'5N 2 11·6E		F 53°16'5N 2 16·9E		G 52°43'0N 2 16·9E		H 51°51'0N 2 29·4E		J 52°01'0N 2 40·0E		K 52°29'0N 2 43·0E		
−6	141	0·6 0·4	004	0·2 0·0	134	0·7 0·3	073	0·6 0·4	005	0·5 0·3	049	0·4 0·2	014	1·0 0·5	337	0·3 0·2	328	0·6 0·4	053	0·6 0·5	−6
−5	141	1·9 1·1	178	1·8 1·2	138	1·7 1·1	198	0·8 0·3	196	0·9 0·5	131	1·1 0·5	139	0·5 0·3	224	0·6 0·4	324	0·7 0·3	180	0·3 0·3	−5
−4	141	2·6 1·5	179	2·9 1·9	141	2·2 1·4	202	1·8 0·8	195	1·9 1·1	139	2·1 1·0	169	1·7 0·8	209	1·5 1·0	208	1·5 0·7	190	1·0 0·5	−4
−3	141	2·5 1·5	179	3·5 2·2	141	1·9 1·4	203	2·1 1·3	197	2·4 1·3	146	2·1 1·1	175	2·2 1·1	209	1·9 1·3	207	1·8 1·2	192	1·4 0·9	−3
−2	141	1·9 1·1	179	2·9 2·1	143	1·2 0·9	205	2·2 1·4	201	2·3 1·3	152	1·7 0·9	180	2·0 1·0	206	1·6 1·0	208	1·8 1·2	195	1·5 1·1	−2
−1	141	0·9 0·5	179	1·8 1·4	154	0·3 0·2	204	1·8 1·1	202	1·8 1·0	167	0·9 0·5	185	1·7 0·8	199	1·0 0·7	204	1·5 0·9	195	1·3 0·9	−1
0	321	0·2 0·1	180	0·4 0·2	300	0·6 0·2	196	0·8 0·5	208	0·7 0·4	267	0·5 0·2	190	1·0 0·5	176	0·4 0·3	187	0·7 0·5	191	0·9 0·6	0
+1	321	1·4 0·8	357	1·2 0·9	318	1·2 0·8	063	0·6 0·3	018	0·7 0·4	312	0·9 0·5	306	0·3 0·1	051	0·5 0·3	078	0·7 0·4	077	0·3 0·2	+1
+2	321	2·3 1·3	359	2·7 1·8	321	1·7 1·2	032	1·6 0·8	024	1·9 1·0	320	1·5 0·7	348	1·2 0·6	036	1·3 0·9	039	1·4 0·8	027	0·9 0·5	+2
+3	321	2·7 1·5	359	3·3 2·3	321	1·9 1·3	027	2·1 1·2	022	2·4 1·3	325	2·0 1·0	354	1·9 1·0	022	1·6 1·1	031	1·8 1·1	018	1·4 0·9	+3
+4	321	2·4 1·3	359	3·1 2·1	321	1·6 1·1	026	2·1 1·2	019	2·4 1·3	329	2·0 1·0	356	2·1 1·1	027	1·6 1·1	026	1·8 1·1	014	1·7 1·0	+4
+5	321	1·4 0·7	359	2·2 1·6	324	0·8 0·6	026	1·6 0·9	016	1·9 1·1	331	1·3 0·6	359	1·9 0·9	021	1·0 0·7	018	1·5 0·8	009	1·4 0·9	+5
+6		0·0 0·0	000	1·0 0·7	122	0·2 0·1	024	0·8 0·6	009	1·0 0·5	002	0·6 0·3	009	1·2 0·6	357	0·4 0·3	004	0·8 0·5	005	0·9 0·6	+6

	L 53°20'0N 2 44·0E		M 52°55'0N 2 50·0E		N 52°30'0N 2 59·9E		P 52°58'0N 3 27·5E		Q 53°17'0N 3 28·0E		R 52°30'0N 3 30·0E		S 51°52'5N 3 38·8E		T 52°56'0N 4 20·0E		U 53°14'0N 4 25·0E		V 53°27'0N 4 47·0E		
−6	078	0·7 0·5	062	0·6 0·4	353	0·6 0·3	039	0·8 0·4	057	0·8 0·6	018	0·6 0·4	312	0·5 0·4	020	1·0 0·8	038	1·1 0·9	054	1·3 1·0	−6
−5	120	0·9 0·4	131	0·7 0·3	152	0·4 0·2	118	0·5 0·3	094	0·7 0·5	150	0·1 0·1	237	0·9 0·6	059	0·5 0·4	051	0·8 0·6	060	1·1 0·8	−5
−4	147	1·0 0·6	166	1·1 0·6	165	1·0 0·5	159	0·6 0·3	138	0·7 0·4	190	0·9 0·6	223	1·4 0·9	158	0·4 0·2	097	0·4 0·3	069	0·8 0·5	−4
−3	161	1·1 0·8	177	1·4 0·9	186	1·4 0·7	172	1·2 0·8	169	0·9 0·6	203	1·4 1·0	222	1·5 1·1	191	0·9 0·8	180	0·4 0·5	100	0·3 0·2	−3
−2	173	1·0 0·8	187	1·4 1·0	205	1·5 0·7	195	1·2 0·8	189	0·9 0·8	204	1·6 1·1	222	1·5 1·1	197	1·2 1·0	204	0·8 0·8	203	0·5 0·5	−2
−1	194	0·8 0·6	198	1·1 0·8	201	1·1 0·5	206	1·0 0·8	205	0·8 0·7	201	1·1 0·8	218	1·2 0·8	199	1·2 1·0	211	1·0 0·9	229	0·8 0·8	−1
0	233	0·5 0·4	214	0·8 0·5	217	0·6 0·3	211	0·8 0·6	222	0·7 0·6	198	0·6 0·3	196	0·6 0·4	200	1·0 0·8	215	1·0 0·9	233	1·0 0·9	0
+1	282	0·6 0·4	284	0·4 0·2	291	0·1 0·0	256	0·6 0·4	249	0·6 0·4	224	0·2 0·1	087	0·9 0·6	203	0·8 0·5	221	0·9 0·7	238	1·1 0·9	+1
+2	323	0·8 0·5	347	0·9 0·5	006	0·7 0·4	326	0·3 0·1	296	0·5 0·3	006	1·0 0·7	051	1·6 1·0	207	0·3 0·1	230	0·6 0·4	242	1·0 0·6	+2
+3	347	1·1 0·7	005	1·3 0·9	016	1·3 0·6	358	1·1 0·6	357	0·8 0·5	013	1·3 0·9	043	1·7 1·2	000	0·8 0·7	350	0·3 0·4	242	0·7 0·3	+3
+4	001	1·0 0·8	010	1·5 1·0	017	1·5 0·7	005	1·3 0·8	016	1·0 0·8	013	1·5 1·0	039	1·4 1·0	017	1·4 1·1	025	1·0 0·8	022	0·5 0·5	+4
+5	017	0·7 0·7	014	1·2 0·9	010	1·3 0·6	012	1·3 0·8	026	1·0 0·8	014	1·3 0·8	029	1·0 0·7	016	1·4 1·1	030	1·3 1·1	047	1·1 0·9	+5
+6	059	0·6 0·5	036	0·7 0·6	356	0·9 0·4	017	1·0 0·6	045	0·8 0·7	014	0·8 0·6	345	0·5 0·4	018	1·1 0·9	035	1·2 1·0	051	1·3 1·0	+6

Figure 9.5 UKHO Admiralty Chart 1408 Tidal Stream Data

10. Emergency Response

84. This section summarises the existing search and rescue (SAR) resources in proximity to Norfolk Vanguard. It is noted that given the distance offshore of Norfolk Vanguard, the Applicant will be required to consider self-help capabilities for its own personnel and vessels.

10.1 *Search and Rescue Helicopters*

85. In March 2013, the Bristow Group were awarded the contract by the MCA (as an executive agency of Department for Transport (DfT)) to provide helicopter SAR operations in the UK over a ten year period. Bristow have now been operating the service since April 2015. There will be ten base locations for the SAR helicopter service, the final one of these is expected to go live in July 2017. The nearest SAR helicopter base to the offshore cable corridor is a new purpose built base located in Humberside which is approximately 118nm from the centre of Norfolk Vanguard (see Figure 10.1), and has been in operation since April 2015. This base operates two Sikorsky S-92 aircraft.

10.2 *RNLI*

86. The Royal National lifeboat Institution (RNLI) is organised into six divisions, with the relevant regions for Norfolk Vanguard being North and East. Based out of more than 230 stations, there are more than 350 lifeboats across the RNLI fleet, including both all-weather lifeboats (ALBs) and inshore lifeboats (ILBs). Based on the offshore position of Norfolk Vanguard it is likely that all weather lifeboat (ALBs) from Happisburgh and Great Yarmouth & Gorleston would respond to an incident in proximity to Norfolk Vanguard given they generally operate within a 100nm limit (due to endurance and transit time). Locations of RNLI lifeboat stations along the east coast of England are presented in Figure 10.1 and details of the types of lifeboats operating out of these stations are given in Table 10.1. At each station, crew, ALBs and ILBs are available on a 24-hour basis throughout the year.

Table 10.1 UK Lifeboats Operated from southern North Sea RNLI Stations

Station	Lifeboats	ALB Class	ILB Class	Approximate Distance to Central Point between OWF Sites (nm)
Great Yarmouth & Gorleston	ALB & ILB	Trent	B Class	38

Station	Lifeboats	ALB Class	ILB Class	Approximate Distance to Central Point between OWF Sites (nm)
Happisburgh	ILB (x2)	–	B & D Class	40
Lowestoft	ALB	Shannon	–	42
Cromer	ALB & ILB	Tamar	D Class	49
Southwold	ILB	–	B Class	50
Sheringham	ILB	–	B Class	52
Wells	ALB & ILB	Mersey	D Class	65
Hunstanton	ILB & Hovercraft	–	B Class	78
Skegness	ALB & ILB	Mersey	D Class	85
Mablethorpe	ILB (x2)	–	B & D Class	90
Humber	ALB	Severn	–	100
Cleethorpes	ILB	–	D Class	104
Withernsea	ILB	–	D Class	107

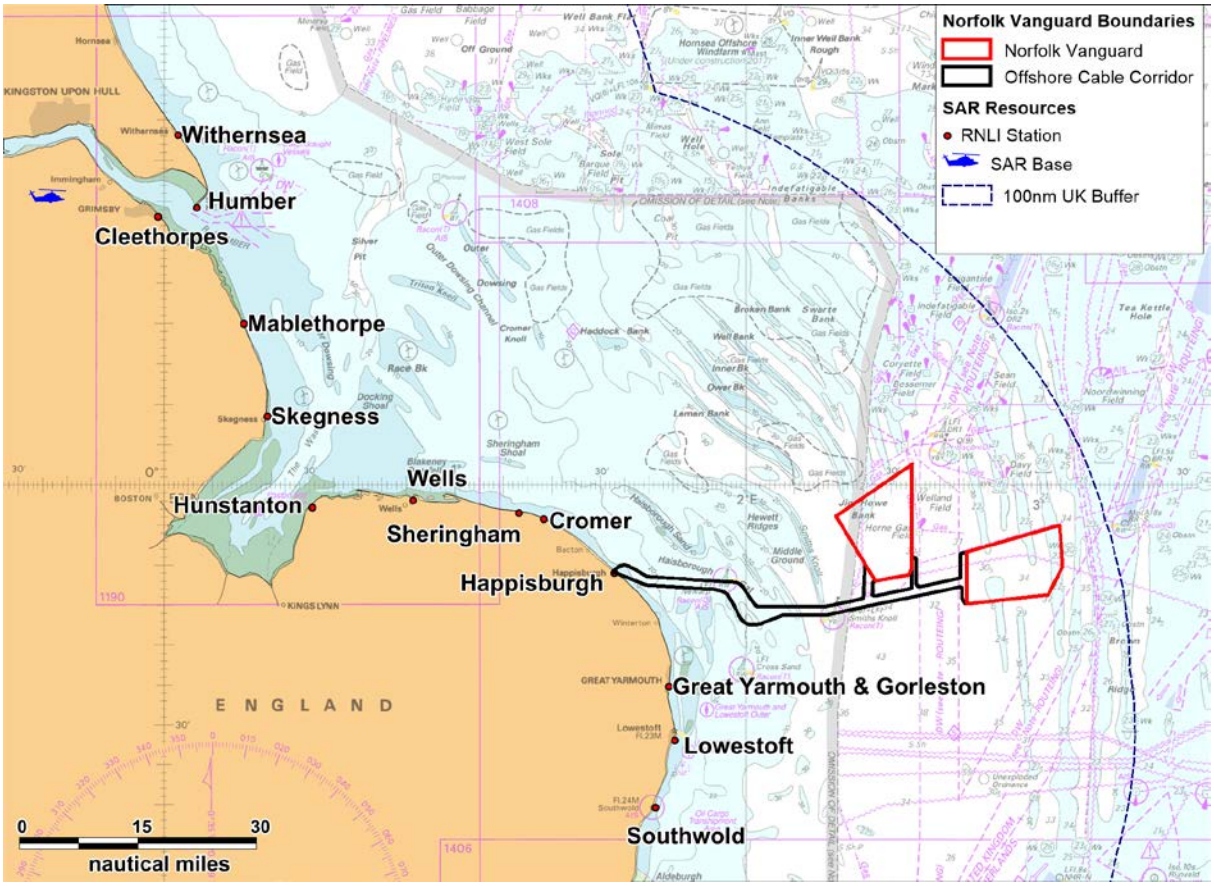

Figure 10.1 SAR Resources in Proximity to Norfolk Vanguard

10.3 *HM Coastguard Stations*

87. HM Coastguard, a division of the MCA, is responsible for requesting and tasking SAR resources made available to other authorities and for co-ordinating the subsequent SAR operations (unless they fall with military jurisdiction).

88. The HM Coastguard co-ordinates SAR through a network of 11 Coastguard Operations Centres (CGOC), including a National Maritime Operations Centre (NMOC) based in Hampshire. A corps of over 3,500 volunteer Coastguard Rescue Officers (CROs) around the UK form over 352 local Coastguard Rescue Teams (CRT) involved in coastal rescue, searches and surveillance.

89. All of the MCA's operations, including SAR, are divided into three geographical regions. The East of England Region covers the east and south coasts of England from the Scottish border down to the Dorset and Devon border, and therefore covers the area around Norfolk Vanguard.

90. Each region is divided into six districts with its own CGOC, which coordinates the SAR response for maritime and coastal emergencies within its district boundaries (East of England includes an additional station, London Coastguard, for co-coordinating SAR on the River Thames). The nearest rescue co-ordination centre to Norfolk Vanguard is the Humber CGOC based in Bridlington, East Yorkshire, located approximately 125nm (232km) from Norfolk Vanguard.

10.4 *Third Party Assistance*

91. Companies operating offshore typically have resources of vessels, helicopters and other equipment available for normal operations that can assist with emergencies offshore. Alongside that all vessels under IMO obligations set out in the International Convention for the Safety of Life at Sea (SOLAS) (IMO, 1974) as amended, are required to render assistance to any person or vessel in distress if safety able to do so.

11. Maritime Incidents

11.1 *Introduction*

92. This section reviews maritime incidents that have occurred in the vicinity of Norfolk Vanguard throughout the ten year period between 2005 and 2014.

93. The analysis is intended to provide a general indication as to whether the area of the proposed project is currently low or high risk in terms of maritime incidents. If it was found to be a particularly high risk area for incidents, this may indicate that the project could exacerbate the existing maritime safety risks in the area.

94. Data from the following sources have been analysed:

- Marine Accident Investigation Branch (MAIB); and
- RNLI.

95. It is noted that the same incident may be recorded by both sources.

11.2 *MAIB Incident Data*

96. All UK commercial vessels are required to report accidents to the MAIB. Non-UK vessels do not have to report unless they are in a UK port or within 12nm territorial waters and carrying passengers to a UK port. There are also no requirements for non-commercial recreational craft to report accidents to the MAIB.

11.2.1 OWF Sites

97. The locations of accidents, injuries and hazardous incidents reported to the MAIB within the OWF sites study area for the ten year period between January 2005 and December 2014 are presented in Figure 11.1 and are colour-coded by incident type. It should be noted that the MAIB aim for 97% accuracy in reporting locations of incidents.

98. A total of nine unique incidents were reported within the OWF sites study area, corresponding to an average of approximately one incident per year. None of the incidents occurred within the proposed OWF sites.

99. The most frequently recorded incident type was “Accident to Person”, representing three of the nine incidents. The “Flooding / Foundering” incident involved a standby vessel which after taking on water headed back to port.

100. Figure 11.2 presents the same set of incidents colour-coded by vessel type. The most frequently recorded vessel type was Oil & Gas associated vessels, accounting for three of the nine incidents throughout the ten year period analysed.

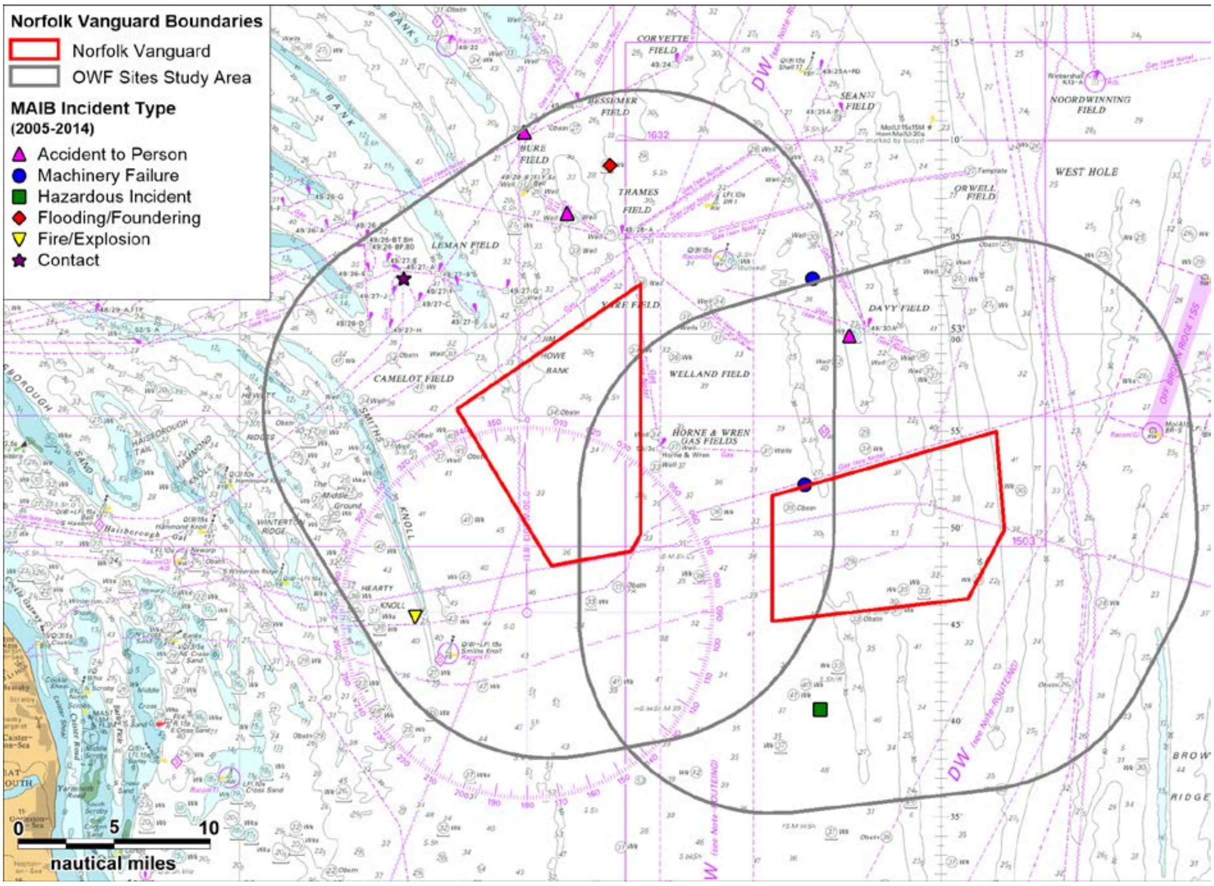

Figure 11.1 MAIB Incident Locations by Incident Type within OWF Sites Study Area (2005 – 2014)

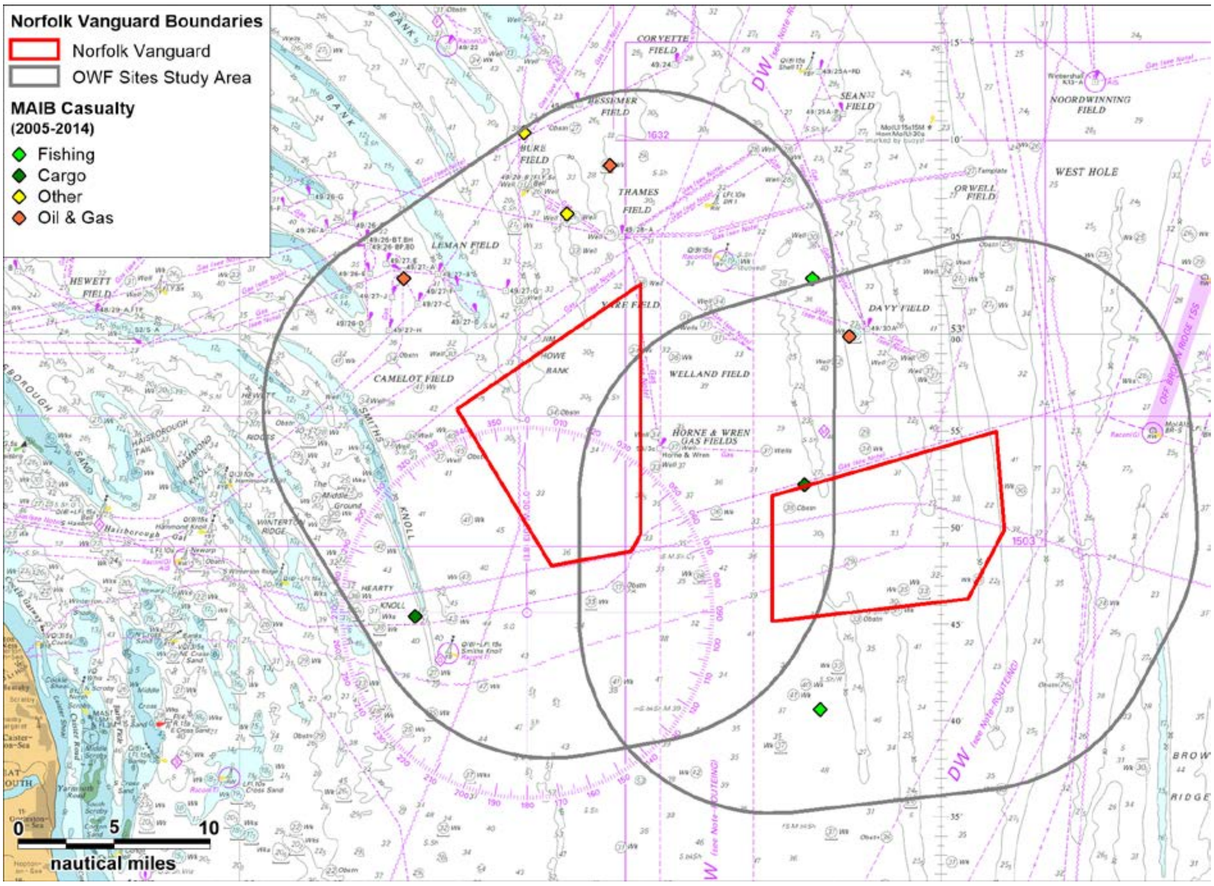

Figure 11.2 MAIB Incident Locations by Casualty Type within OWF Sites Study Area (2005 – 2014)

11.2.2 Cable Corridor

101. The locations of accidents, injuries and hazardous incidents reported to the MAIB within the offshore cable corridor study area for the ten year period between January 2005 and December 2014 are presented in Figure 11.3 and are colour-coded by incident type.

102. A total of 83 unique incidents were reported within the offshore cable corridor study area, involving 96 vessels. This corresponds to an average of eight to nine incidents per year, with the majority of incidents reported occurring in the vicinity of the UK east coast. Of the incidents reported within the offshore cable corridor study area, approximately 15% occurred within the offshore cable corridor itself.

103. The most frequently recorded incident type was “Machinery Failure”, representing 36% of the incidents throughout the ten year period analysed.

104. Figure 11.4 presents the same set of incidents colour-coded by vessel type. The most frequently recorded vessel type was fishing vessels, accounting for 30% of the incidents throughout the ten year period analysed.

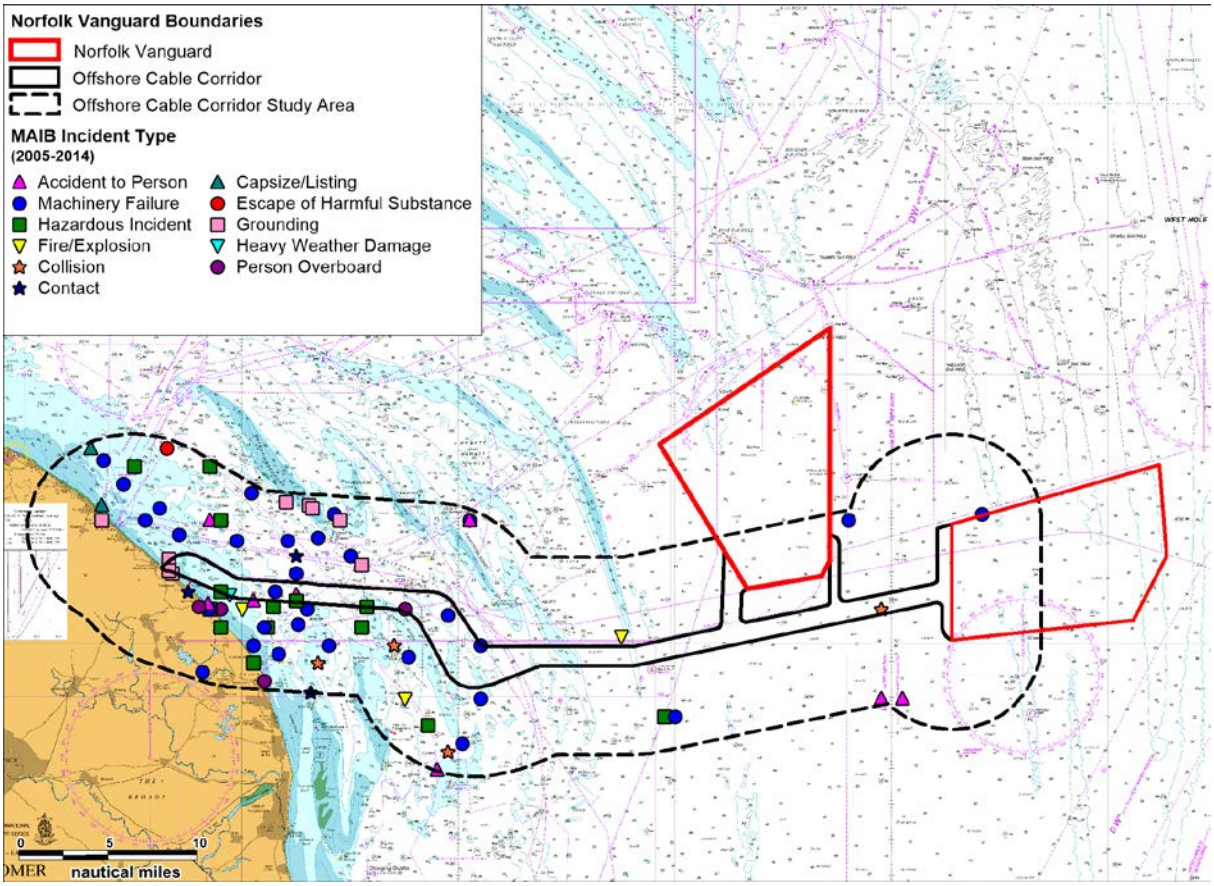

Figure 11.3 MAIB Incident Locations by Incident Type within Cable Corridor Study Area (2005 – 2014)

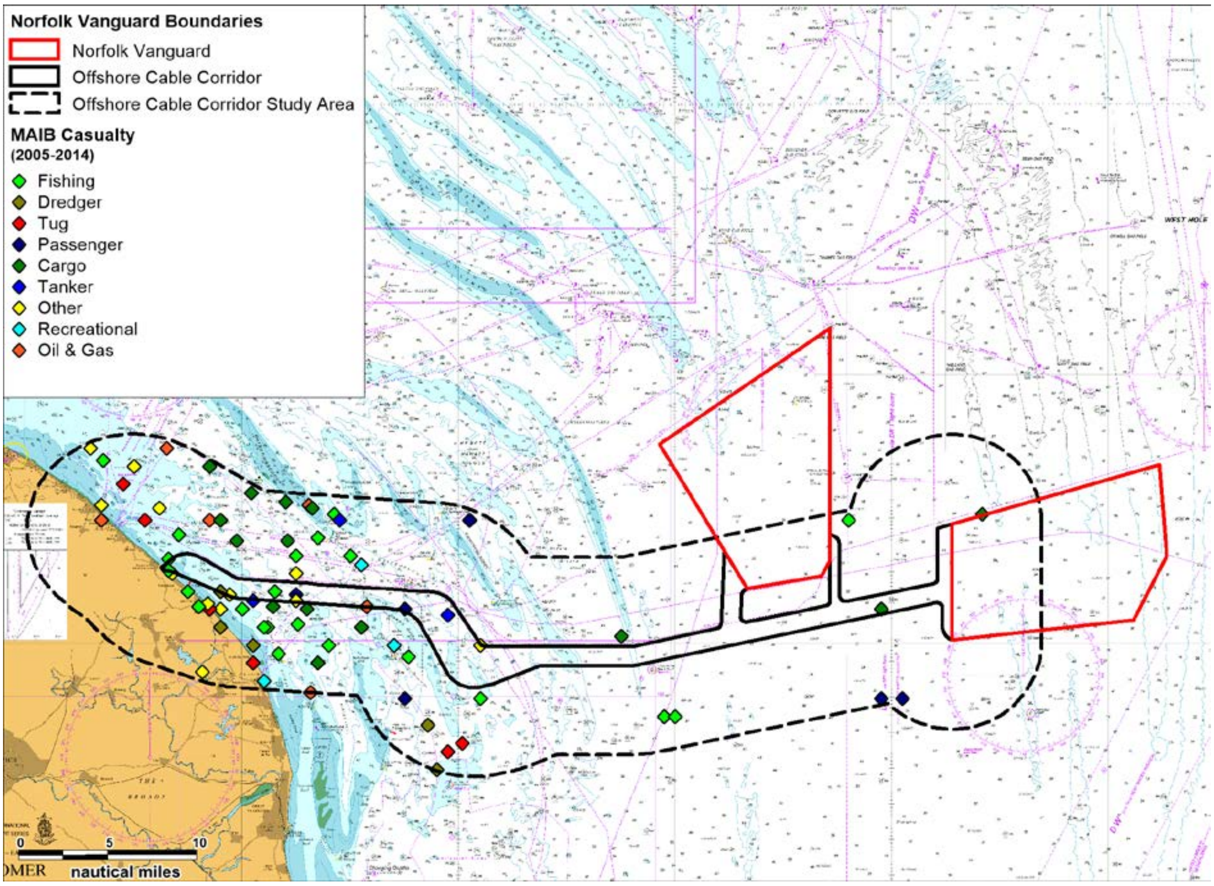

Figure 11.4 MAIB Incident Locations by Casualty Type within Cable Corridor Study Area (2005 – 2014)

11.3 *RNLI Incident Data*

105. Data on RNLI lifeboat responses within the OWF sites and offshore cable corridor study areas for the ten year period between 2005 and 2014 were analysed, with cases of a hoax or false alarm excluded.

11.3.1 OWF Sites

106. The locations of incidents responded to by the RNLI (excluding hoaxes and false alarms) within the OWF sites study area for the ten year period between January 2005 and December 2014 are presented in Figure 11.5 and are colour-coded by incident type.

107. A total of 11 launches were reported within the OWF sites study area, corresponding to an average of approximately one incident every year. One of the launches was to a

location within the Norfolk Vanguard West site, with this being a large fishing vessel which experienced flooding.

108. "Person In Danger" and "Machinery Failure" were the most frequently recorded incident types, each representing 36% of the total number of incidents.

109. Figure 11.6 presents the same set of launch locations colour-coded by vessel type. Recreational vessels were the most frequently recorded casualty types, representing 45% of the total number of incidents throughout the ten year period analysed.

110. The majority of reported RNLI incidents within the OWF sites study area were responded to by the Great Yarmouth & Gorleston station. One incident was responded to by the Lowestoft station.

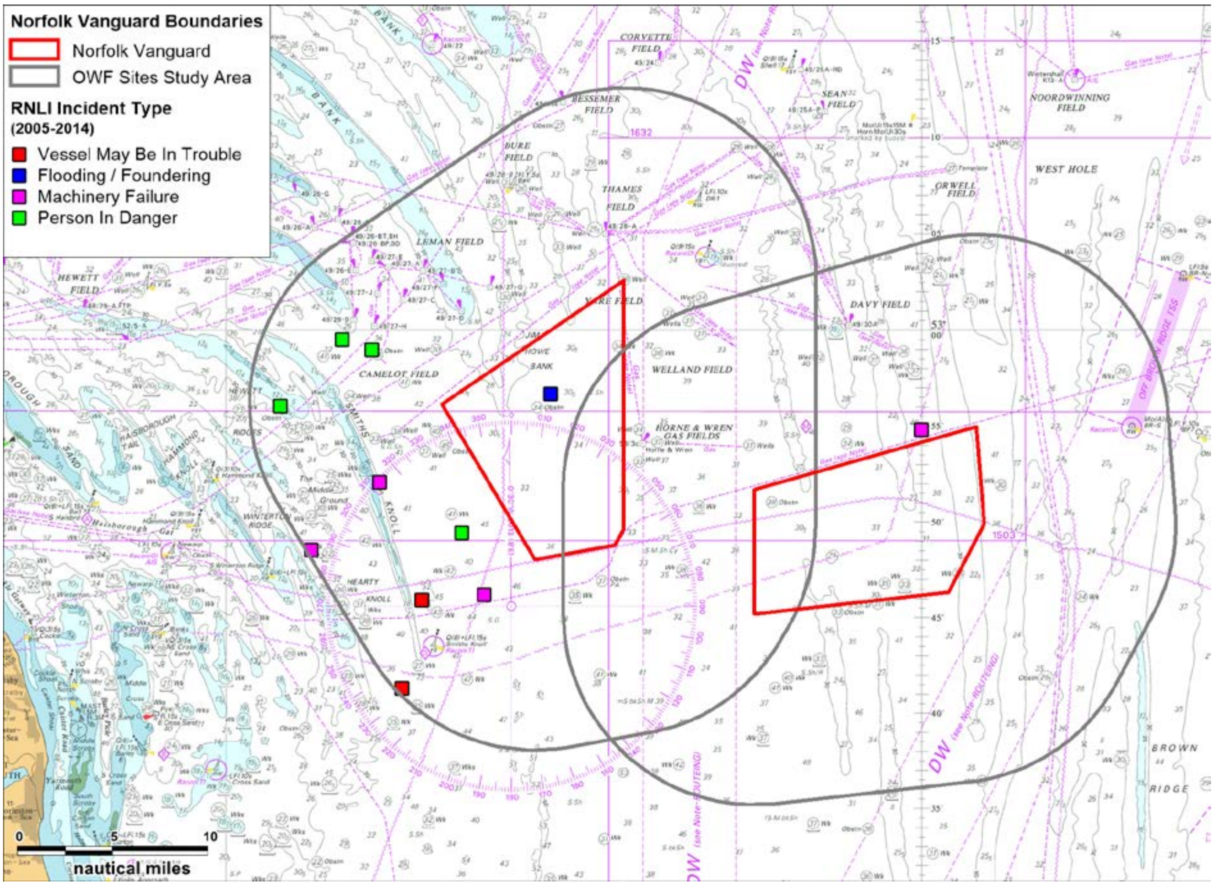

Figure 11.5 RNLI Incident Locations by Incident Type within OWF Sites Study Area (2005 – 2014)

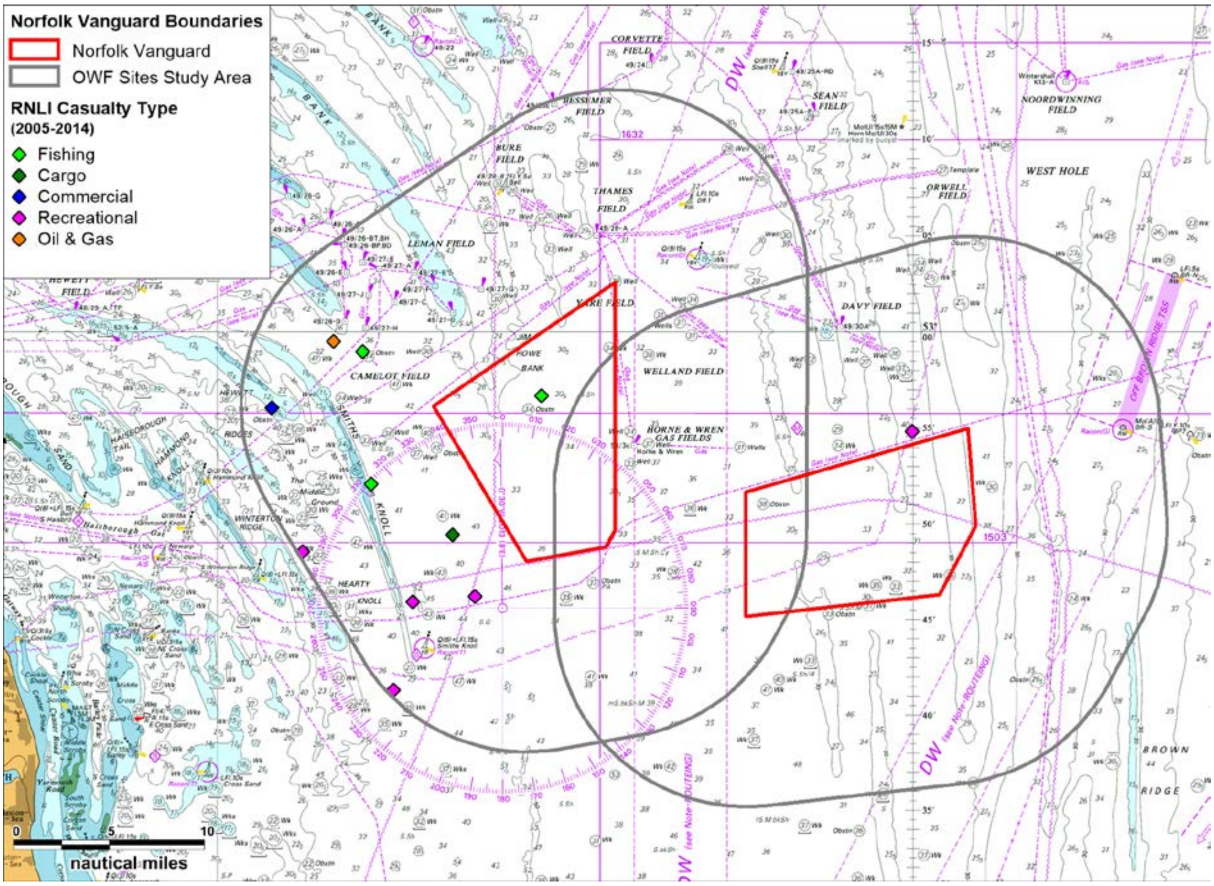

Figure 11.6 RNLI Incident Locations by Casualty Type within OWF Sites Study Area (2005 – 2014)

11.3.2 Cable Corridor

111. The locations of incidents responded to by the RNLI (excluding hoaxes and false alarms) within the offshore cable corridor study area for the ten year period between January 2005 and December 2014 are presented in Figure 11.7 and are colour-coded by incident type.

112. A total of 102 launches were reported within the offshore cable corridor study area, This corresponds to an average of approximately ten incident responses every year, with the majority of incidents reported occurring in the nearshore area. Of the incidents reported within the offshore cable corridor study area, approximately 10% occurred within the offshore cable corridor, although only 3% of all incidents occurring within the offshore cable corridor were located outside of the nearshore area.

113. "Person In Danger" was the most frequently recorded incident type, representing 42% of the total number of incidents, followed by "Machinery Failure" with 32%.

114. Figure 11.8 presents the same set of launch locations colour-coded by vessel type. Recreational vessels were the most frequently recorded casualty types, representing 45% of the total number of incidents throughout the ten year period analysed. It is noted that 34% of incidents did not involve a vessel.

115. The majority of reported RNLI incidents within the offshore cable corridor study area were responded to by the Happisburgh station, with the Great Yarmouth & Gorleston and Cromer stations also responded to a number of incidents.

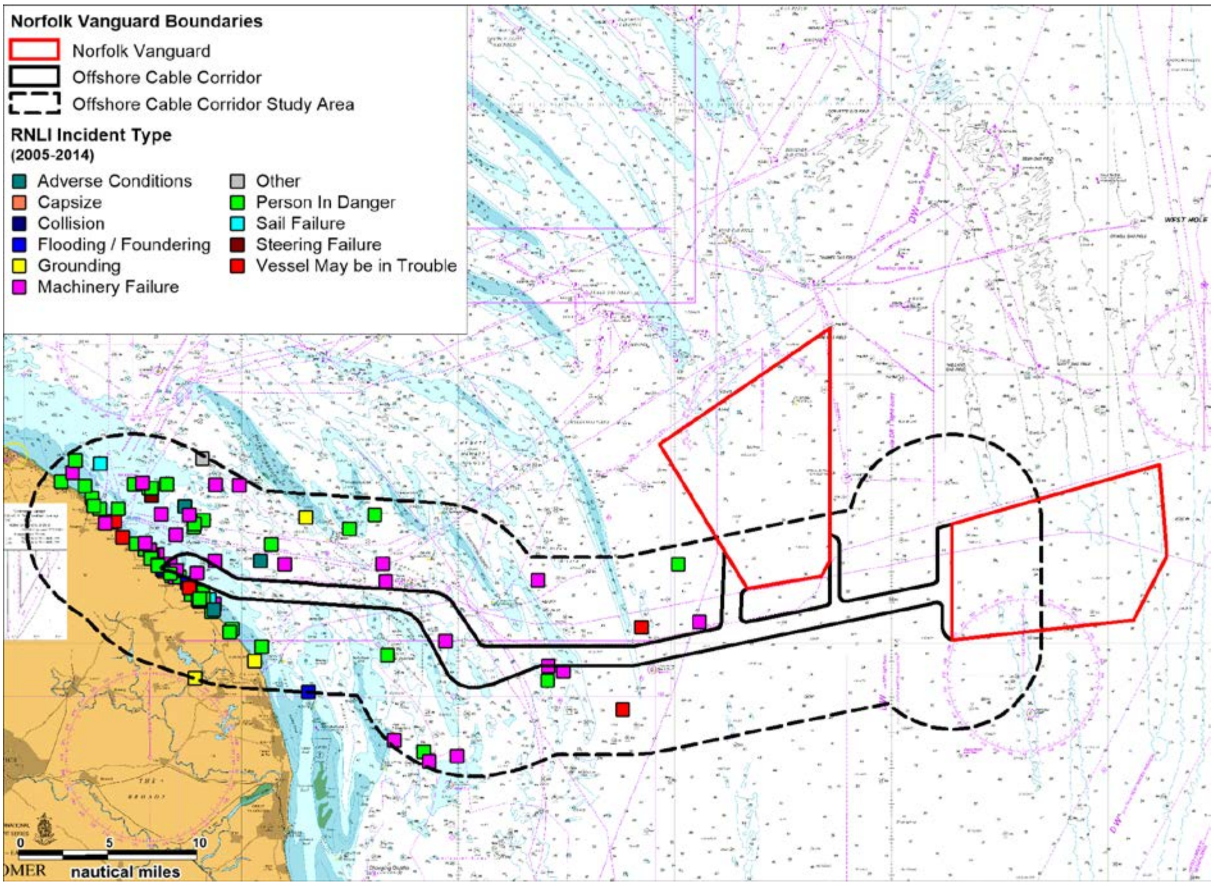

Figure 11.7 RNLI Incident Locations by Incident Type within Cable Corridor Study Area (2005 – 2014)

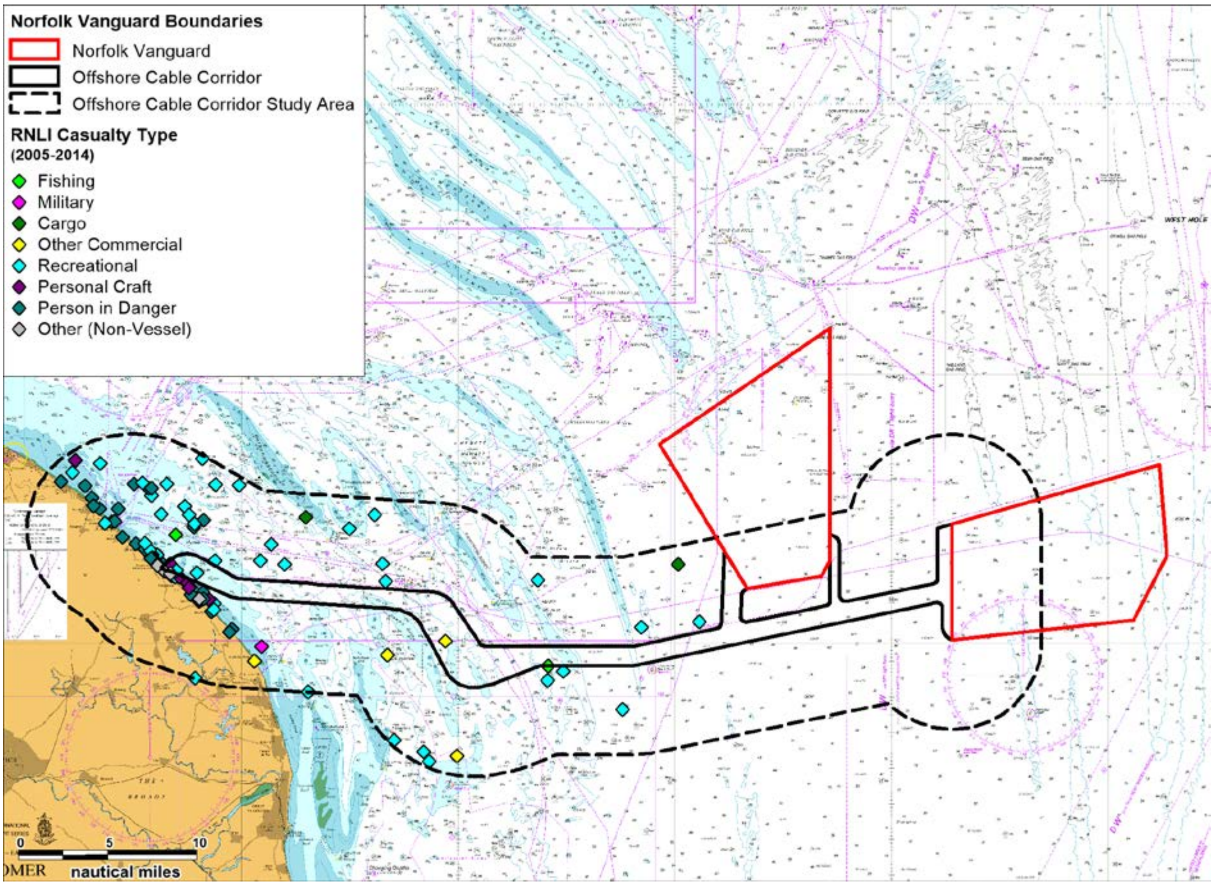

Figure 11.8 RNLI Incident Locations by Casualty Type within Cable Corridor Study Area (2005 – 2014)

11.4 *Historical Offshore Wind Farm Incidents*

116. Table 11.1 presents historical collision and allision incidents involving wind farm sites and the resulting damage to the vessel involved and / or injury to the people involved.

117. During 2005 to 2016 there were 14 incidents involving a renewable energy installation and / or a wind farm vessel. Of these 14 only two were collision incidents, with the other 12 allision incidents.

118. Of the two collisions one was a wind farm support vessel with a third party vessel whilst manoeuvring within a harbour area and the second was between two wind farm support vessels. To date there have been no third party to wind farm vessel or third party to third party vessel incidents at or near a wind farm site.

Table 11.1 Summary of Historical Collision and Allision Incidents within UK Waters

Project or third Party	Incident type	Date	Description of incident	Damage to vessel	Injury to person	Source
Project	ALLISION - Service Vessel with WTG	7 August 2005	A vessel involved with the installation of offshore wind turbines, underestimated the effect of the current and made contact with the base of a wind turbine while manoeuvring alongside it. Minor damage was sustained to a gangway on the vessel, the wind turbine and a wind turbine blade.	Minor damage to gangway on the vessel.	No injury	MAIB
Project	ALLISION - Service Vessel with WTG	29 September 2006	When approaching an offshore wind turbine, to conduct servicing operations, an offshore support vessel was struck by the tip of a wind turbine blade. The accident occurred because the blade was not secured in a fixed position, and was rotating as the vessel approached.	No damage to vessel.	No Injury	MAIB
Project	ALLISION - Service Vessel with Disused Pile	8 February 2010	An 18m work boat was servicing a wind farm. Directly astern of the vessel was a test pile (now disused and no longer required), the position of which was well marked and known to skipper. While vessel was manoeuvring within about three metres of this pile, the skippers hand slipped on the throttle controls, pulling the port throttle to full astern. The skipper realised there was a problem, and quickly tried to stop the vessel from moving astern, but as the pile was so close, there was not time or room to do so. The vessel struck the pile, causing minor damage to the stern fenders and deck plating. The impact caused a passenger, who was moving around the interior to be thrown off his feet, and to fall against furniture and injure himself. The passenger injuries did not seem to be very serious at the time and he mounted the wind turbine to work as usual, but later reported sick and was taken to hospital where back injuries were diagnosed. Once the vessel was safely clear of the pile and the situation stabilised, the skipper checked around for further damage but no serious damage was found. No water ingressed.	Minor damage to vessel	Injury	MAIB
Third Party and Project in Harbour	COLLISION - Service Vessel Collision with Vessel	23 April 2011	Third party catamaran was hit by a project guard boat. The collision took place in Ramsgate harbour.	Moderate damage to vessel	No injury	Web Search

Project or third Party	Incident type	Date	Description of incident	Damage to vessel	Injury to person	Source
Project	ALLISION - Service Vessel with WTG	18 November 2011	A cable laying vessel suffered two hull breaches in way of a fresh tank and damage to the steel rubbing strake after it struck the foundations of a partially completed wind turbine. The subsequent company investigation found that the Officer of the Watch (OOW) had fallen asleep while on watch and woke to find the vessel inside the wind farm. He attempted to take the vessel out of the farm on autopilot but the settings were such that the vessel did not turn quickly enough and the vessel made contact with the partially built structure. Nobody on the vessel felt the impact and the second officer deleted the passage on the electronic chart system to avoid detection. However, when the crew woke the next morning, the mate found that the vessel had lost 90 tonnes of fresh water and there was further cause for concern when the vessel's potable water supply tasted salty. The electronic chart system track was recovered and the second officer challenged. He eventually admitted what had happened and following the investigation, was dismissed from the vessel.	Major damage to vessel	No injury	MAIB
Projects	COLLISION - Service Vessel Collision with Service Vessel	2 June 2012	Nine wind farm workers were safely evacuated from their personnel transfer vessel into a life raft after their vessel became lodged under the boat landing equipment of the floating hotel. The workers were returning to their accommodation on the "flotel" after their shift installing and commissioning turbines when the incident occurred. A section of the flotels boat landing equipment detached and the bow of the personnel transfer vessel was lodged underneath just as workers were preparing to transfer on-board. The life raft was deployed and all passengers were safely evacuated and transferred to a nearby vessel before being brought in to port.	Moderate damage to vessel	No Injury	Web Search
Project	ALLISION - Service Vessel Collision with OWT Structure	20 October 2012	A wind farm service vessel caused minor damage when the officers of the watch misjudged its distance from the monopile and made contact with the vessel's stern at a wind farm site.	Minor damage to vessel	No Injury	MAIB

Project or third Party	Incident type	Date	Description of incident	Damage to vessel	Injury to person	Source
Project	ALLISION - Service Vessel with WTG	21 November 2012	Wind farm passenger transfer catamaran struck a floating target at a speed of 23.5 knots, whilst supporting operations at wind farm. During the incident, the 15 member crew were forced to abandon the work boat and the vessel was towed into harbour. The port hull was holed, causing extensive flooding, but there were no injuries. The investigation found that the master did not hold the correct qualifications and that navigation practices, including passage planning and monitoring, use of lookouts and knowledge of the navigation equipment were weak. In addition, the company's crew assessment procedures were not followed and the master had not been formally assessed to determine his suitability for his role. It was also noted that best practice guidance for managers and crew of offshore renewable energy passenger transfer vessels was limited and disparate, and there was no integrated method of promulgating lessons learned to the industry.	Major damage to vessel	No Injury	MAIB
Project	ALLISION - Service Vessel with WTG	21 November 2012	A work boat allided head on with the unlit transition piece of wind turbine in an offshore wind farm, at a speed of 12 knots. The impact caused the five persons on board to be forced out of their seats and sustain various injuries. A doctor was transferred to the vessel by lifeboat to treat the injured personnel. The structure immediately aft of the vessels bow fender crumpled as a result of the impact but no water ingress occurred. The investigation determined that the accident occurred because the master had relied too heavily on visual cues and had made insufficient use of the lookout and navigation equipment available. There was insufficient training, particularly in regard to navigation equipment, and no formal assessment of new masters, allowing the possibility of ingrained poor working practices being passed on. Although the wind turbine transition piece had been reported as unlit, the system for reporting defects had failed to result in a navigation warning being promulgated. Although not formal aids to navigation, it was inevitable that the lights would be utilised as such.	Moderate damage to vessel	Injury	MAIB

Project or third Party	Incident type	Date	Description of incident	Damage to vessel	Injury to person	Source
Project	ALLISION - Service Vessel with WTG	16 February 2013	A shipping accident occurred at the offshore wind farm. An offshore service and supply vessel collided with one of the wind farm's turbine foundations, causing serious damage to the bow fender of the twin hulled vessel.	Minor damage to vessel	No Injury	Web Search
Third Party	ALLISION - Passing Vessel with OREI	9 June 2013	Incident occurred where a yacht in Strangford Lough struck the surface piercing machine. A lifeboat attended the incident.	Minor damage to vessel	No Injury	Web Search
Project	ALLISION - Service Vessel with WTG	July 2013	A wind farm service vessel collided with a wind turbines foundation, after failure of the vessel jet drive. The incident occurred after the vessel had disembarked passengers at the sub-station and had reversed away to drift, whilst standing by for the next assignment. The jets were disengaged and engines left running, as was common practice. Under the influence of currents, the vessel drifted towards another wind turbine foundation and when approximately 30 m away, the vessel coxswain / skipper attempted to engage the jets. At this moment it was found that neither jet would engage. Several minutes were spent fault finding to no avail, after which the vessel coxswain / skipper assisted the deckhand with fenders. The vessel collided with the foundation, causing a buckled frame and bent plate in the port quarter bulwark, but no damage to the foundation. It was found that there was no guidance from the wind farm operator on a minimum distance of approach to offshore structures while drifting. At the speed the wind farm vessel was drifting, 30 m was not sufficient distance to allow enough time to restart the jets or to anchor.	Minor damage to vessel	No injury	International Marine Contractors Association (IMCA) Safety Flash
Project	ALLISION - Service Vessel with WTG	14 August 2014	An accident occurred at an offshore wind farm when a standby safety vessel collided with a wind turbines pile. The accident caused the vessel to leak marine gas oil and a surface sheen, 5-10m wide and around 0.7nm in length trailed from the vessel. The standby vessel moved under its own power to a location outside the Port Authority limits, away from environmentally sensitive areas until the leak was stopped.	Minor damage to vessel and pollution	No Injury	Web Search

Project or third Party	Incident type	Date	Description of incident	Damage to vessel	Injury to person	Source
Third Party	ALLISION – Fishing Vessel with WTG	26 May 2016	A fishing vessel collided with a wind turbine at an offshore wind farm. The incident occurred after a crew member left the vessel on auto-pilot. A lifeboat attended the incident. The vessel had been travelling to Ravenglass at the time of the incident. Vessel Master prosecuted.	Moderate damage to vessel	Injury	Web Search

119. Overall 13 incidents were recorded over an 11 year periods. Figure 11.9 presents a breakdown of the damage to vessels involved in wind farm related incidents.

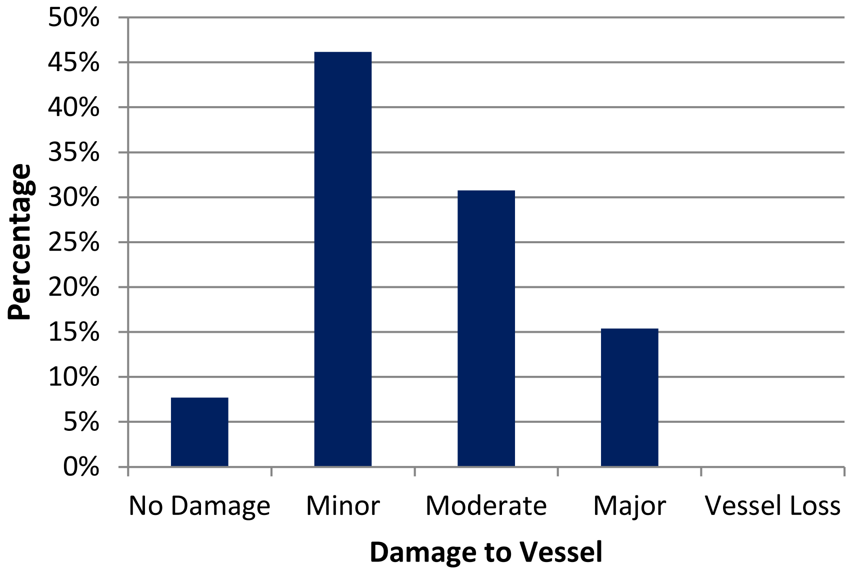

Figure 11.9 Breakdown of Damage to Vessels Involved in Wind Farm Incidents

120. Minor damage to vessels involved in the incidents was the most frequent degree of damage (46%), followed by moderate damage (30%). No incidents resulted in vessel loss and in some cases no damage was sustained to the vessel involved (8%). Major damage was reported in approximately 15% of incidents. The majority of incidents involved wind farm vessels.

121. Figure 11.10 presents a breakdown of the injuries sustained as a result of wind farm related incidents.

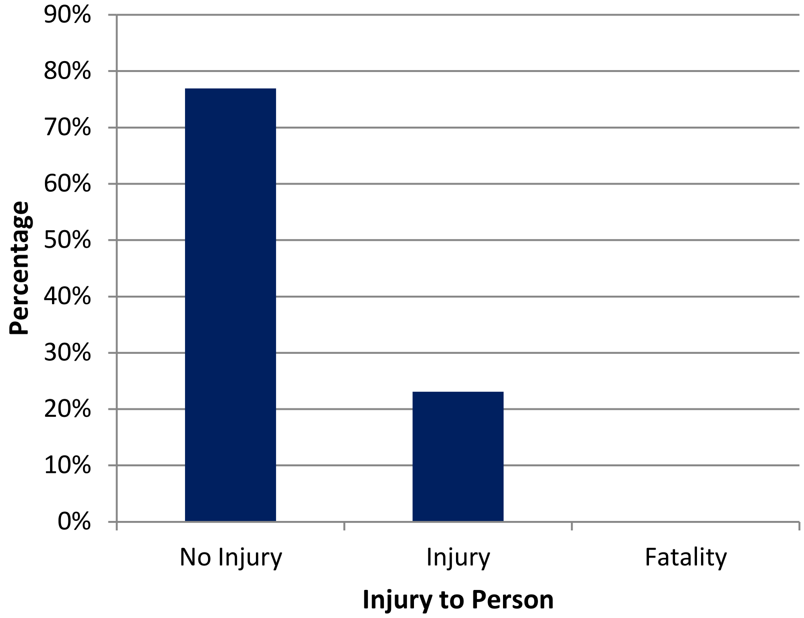

Figure 11.10 Breakdown of Injuries as a Result of Wind Farm Incidents

122. The majority of incidents resulted in no injury (77%). Although injuries were reported in the remaining 23% of incidents, there were no fatalities reported.

12. OWF Sites Marine Traffic Surveys

12.1 *Introduction*

123. This section presents the results of the marine traffic surveys carried out by vessels stationed within the OWF sites. Four surveys were undertaken in total (two in each OWF site), with periods chosen to account for seasonal variations. The survey periods are as follows:

- 13 to 28 September 2016 (summer period at Norfolk Vanguard East);
- 24 January to 7 February 2017 (winter period at Norfolk Vanguard East);
- 8 to 21 September 2016 (summer period at Norfolk Vanguard West); and
- 7 to 21 February 2017 (winter period at Norfolk Vanguard West).

124. As the OWF sites were surveyed individually, the results of the analysis are presented in two separate sections.

125. Throughout both marine traffic surveys, the majority of vessels were recorded via AIS. AIS is now fitted on all commercial vessels operating in UK waters over 300 Gross Register Tonnage (GRT) engaged on international voyages, over 500GRT on domestic voyages, passenger vessels irrespective of size built on or after 1 July 2002 and fishing vessels over 15m. Vessels not broadcasting via AIS were captured by Radar and visual observation wherever possible.

12.2 *Norfolk Vanguard East Survey Analysis*

126. The Norfolk Vanguard East marine traffic survey consists of 28 days AIS and Radar data recorded during surveys between 13 and 28 September 2016 (14 days summer) and 24 January and 7 February 2017 (14 days winter).

127. Both surveys were carried out by the *RV Aora*. Figure 12.1 presents the tracks for the survey vessel *RV Aora* for both the summer and winter survey periods.

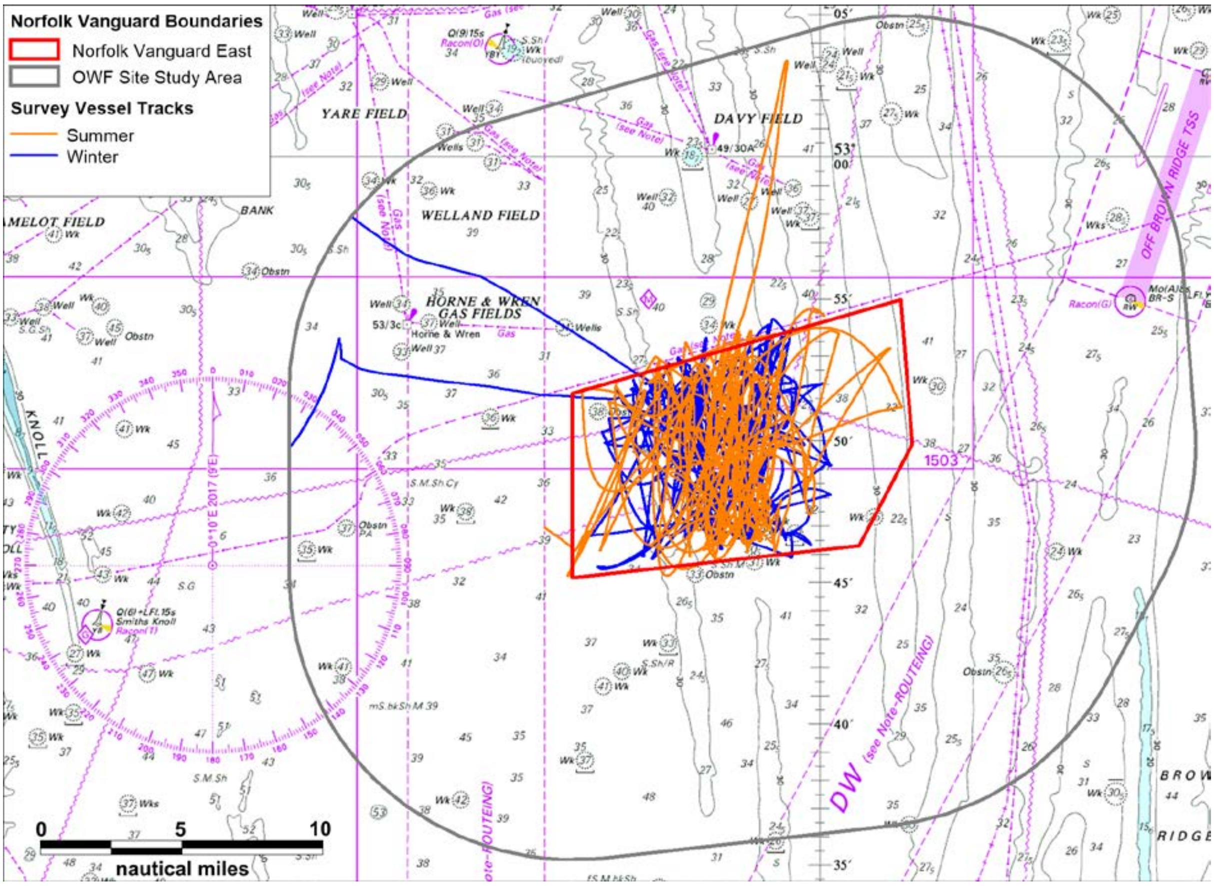

Figure 12.1 Overview of Survey Vessel Tracks within Norfolk Vanguard East (14 Days Summer 2016 and 14 Days Winter 2017)

128. A number of tracks recorded during the survey were classified as temporary (non-routine), such as the tracks of the survey vessels and traffic associated with temporary drilling rigs. These have therefore been excluded from further analysis. Oil and gas affiliated vessels supporting permanent installations were retained in the analysis.

129. Plots of vessel tracks recorded within the Norfolk Vanguard East study area during each respective period, colour-coded by vessel type and excluding temporary traffic (as defined above), are presented in Figure 12.2 and Figure 12.3 respectively, with the corresponding vessel density grids presented in Figure 12.4 and Figure 12.5 respectively. The same density ranges have been used in both density grids to allow direct comparison.

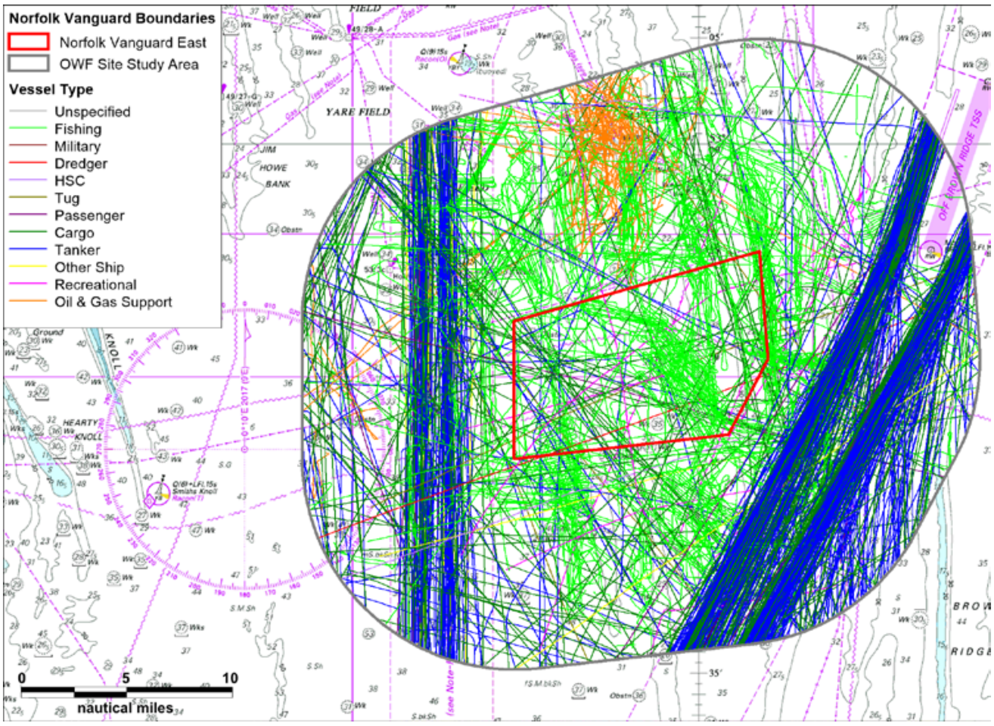

Figure 12.2 Overview of AIS and Radar Data within Norfolk Vanguard East Study Area Excluding Temporary Tracks (14 Days Summer 2016)

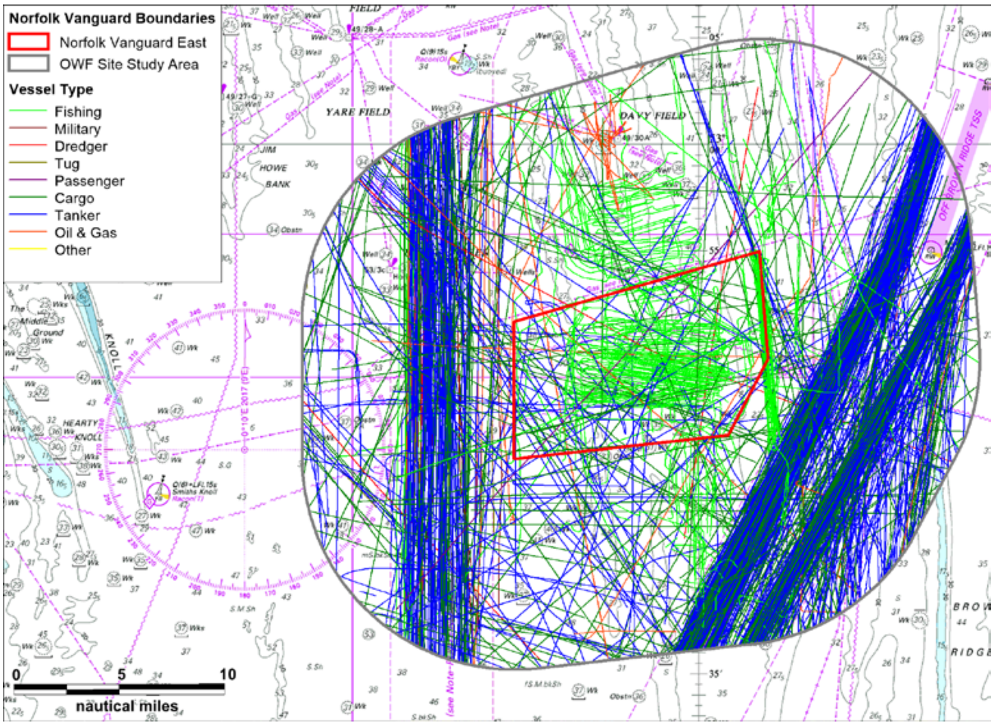

Figure 12.3 Overview of AIS and Radar Data within Norfolk Vanguard East Study Area Excluding Temporary Tracks (14 Days Winter 2017)

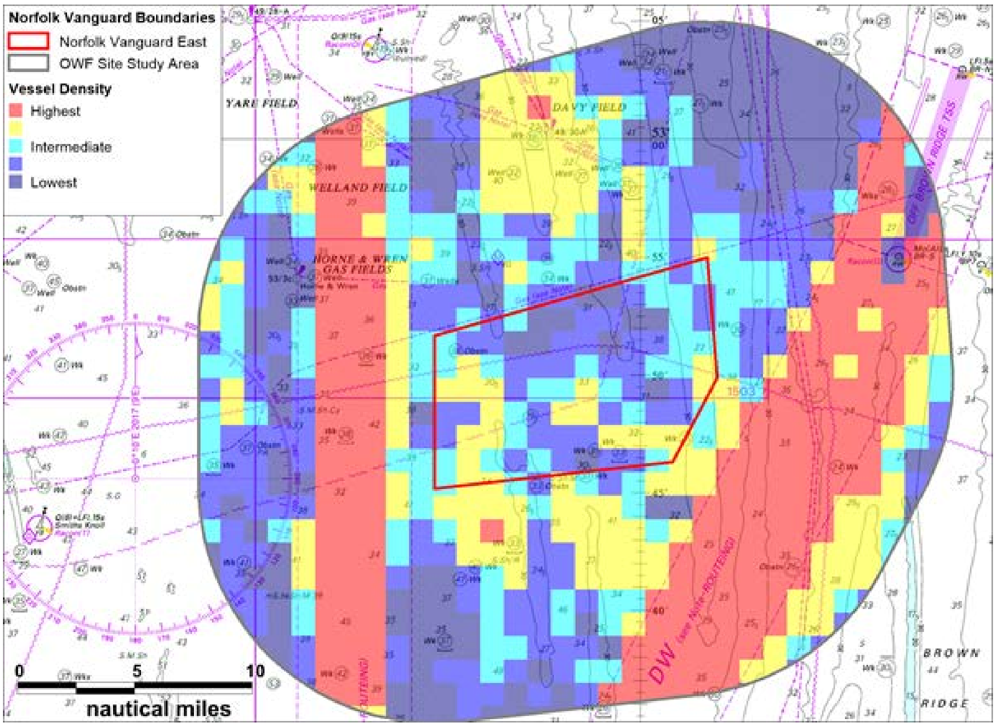

Figure 12.4 Vessel Density from AIS and Radar within Norfolk Vanguard East Study Area (14 Days Summer 2016)

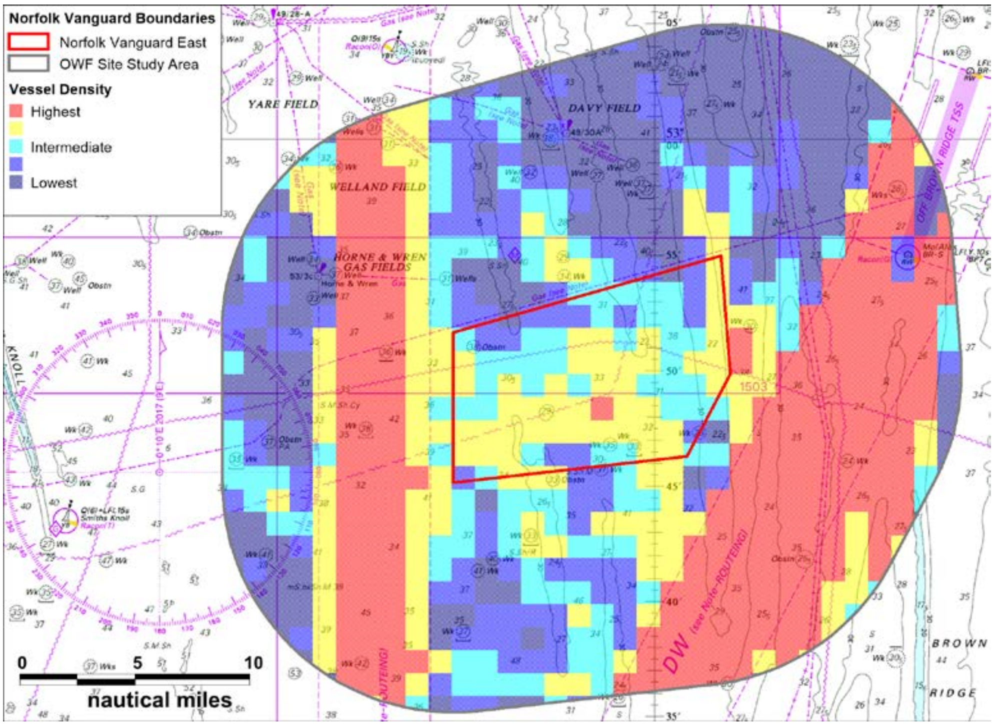

Figure 12.5 Vessel Density from AIS and Radar within Norfolk Vanguard East Study Area (14 Days Winter 2017)

130. During both survey periods, the highest vessel density areas were observed to correspond to the busy commercial shipping routes along the two DWRs passing west and south-east of Norfolk Vanguard East respectively.

131. The vessel density within Norfolk Vanguard East was observed to be lower during summer than in winter. This was largely due to fishing activity recorded during the winter period which was not reflected during the summer period.

12.2.1 Summer Vessel Counts

132. For the 14 days analysed in summer 2016, there was an average of 69 unique vessels per day passing within the Norfolk Vanguard East study area, recorded on AIS and Radar. In terms of vessels intersecting Norfolk Vanguard East, there was an average of eight unique vessels per day.

133. Figure 12.6 presents the daily number of unique vessels passing through the Norfolk Vanguard East study area during summer 2016.

134. The busiest day recorded throughout the summer survey period was 22 September 2016 when 84 unique vessels were recorded within the Norfolk Vanguard East study area.

135. The quietest day recorded throughout the summer survey period was 24 September 2016 when 56 unique vessels were recorded within the Norfolk Vanguard East study area.

136. Throughout the summer survey period, 9% of traffic recorded within the Norfolk Vanguard East study area intersected Norfolk Vanguard East.

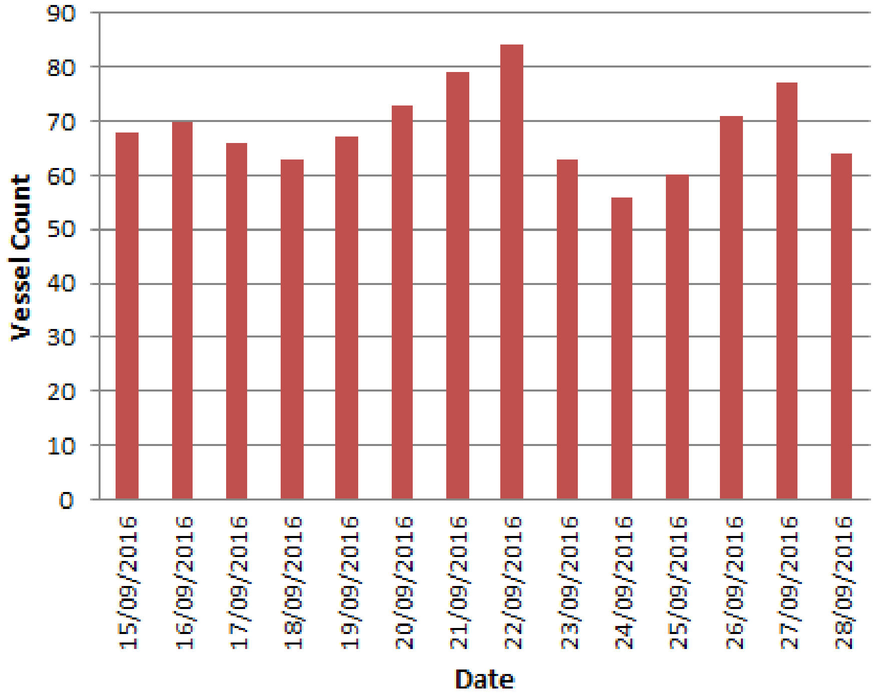

Figure 12.6 Unique Vessels per Day from AIS and Radar within Norfolk Vanguard East Study Area (14 Days Summer 2016)

12.2.2 Winter Vessel Counts

137. For the 14 days analysed in winter 2017, there was an average of 63 unique vessels per day passing within the Norfolk Vanguard East study area, recorded on AIS and Radar. In terms of vessels intersecting Norfolk Vanguard East, there was an average of six unique vessels per day.

138. Figure 12.7 presents the daily number of unique vessels passing through the Norfolk Vanguard East study area during winter 2017.

139. The busiest day recorded throughout the winter survey period was 25 January 2017 when 91 unique vessels were recorded within the Norfolk Vanguard East study area.

140. The quietest day recorded throughout the winter survey period was 1 February 2017 when 51 unique vessels were recorded within the Norfolk Vanguard East study area.

141. Throughout the winter survey period, 10% of traffic recorded within the Norfolk Vanguard East study area intersected Norfolk Vanguard East.

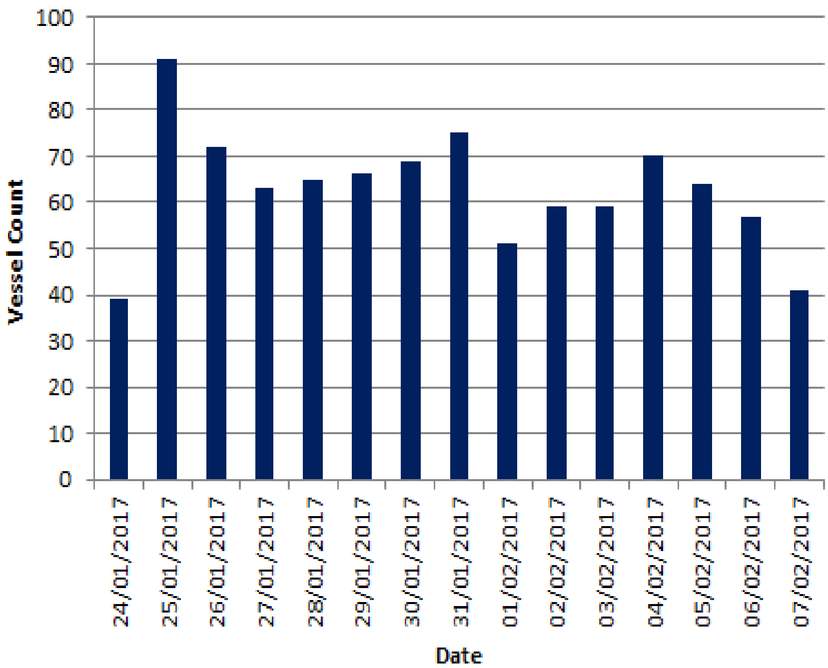

Figure 12.7 Unique Vessels per Day from AIS and Radar within Norfolk Vanguard East Study Area (14 Days Winter 2017)

12.2.3 Vessel Types

142. Analysis of the vessel types recorded passing within the Norfolk Vanguard East study area and Norfolk Vanguard East throughout both survey periods are presented in Figure 12.8. The category of "other" vessels includes those that are not large enough in quantities to be categorised separately, such as anchor handling vessels, dive support vessels, pipe layer vessels and research / survey vessels.

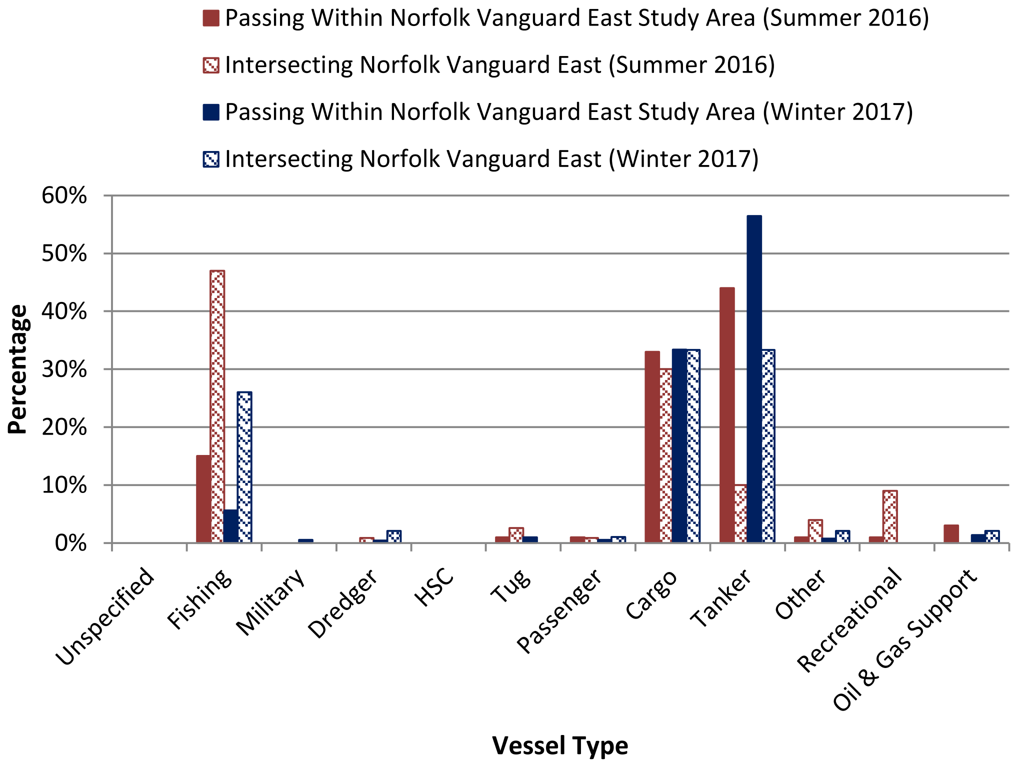

Figure 12.8 Distribution of Vessel Types within Norfolk Vanguard East Study Area from AIS and Radar (28 Days Summer 2016 and Winter 2017)

143. Throughout the summer period, the majority of tracks recorded on AIS and Radar were tankers (44% within the Norfolk Vanguard East study area) and cargo vessels (33%). Throughout the winter period the majority of tracks were tankers (56% in the Norfolk Vanguard East study area) and cargo vessels (33%). It should be noted that the cargo vessel category does not include commercial ferries (e.g. DFDS Seaways) operating in the Norfolk Vanguard East study area. Details specific to commercial ferries are presented in section 12.2.4.

144. Less than 0.1% of tracks recorded on AIS and Radar throughout the survey periods were unspecified vessels.

145. Figure 12.9 presents a plot of tankers recorded within the Norfolk Vanguard East study area throughout the survey periods. Equivalent plots of cargo vessels and oil and gas associated vessels are presented in Figure 12.10 and Figure 12.11 respectively.

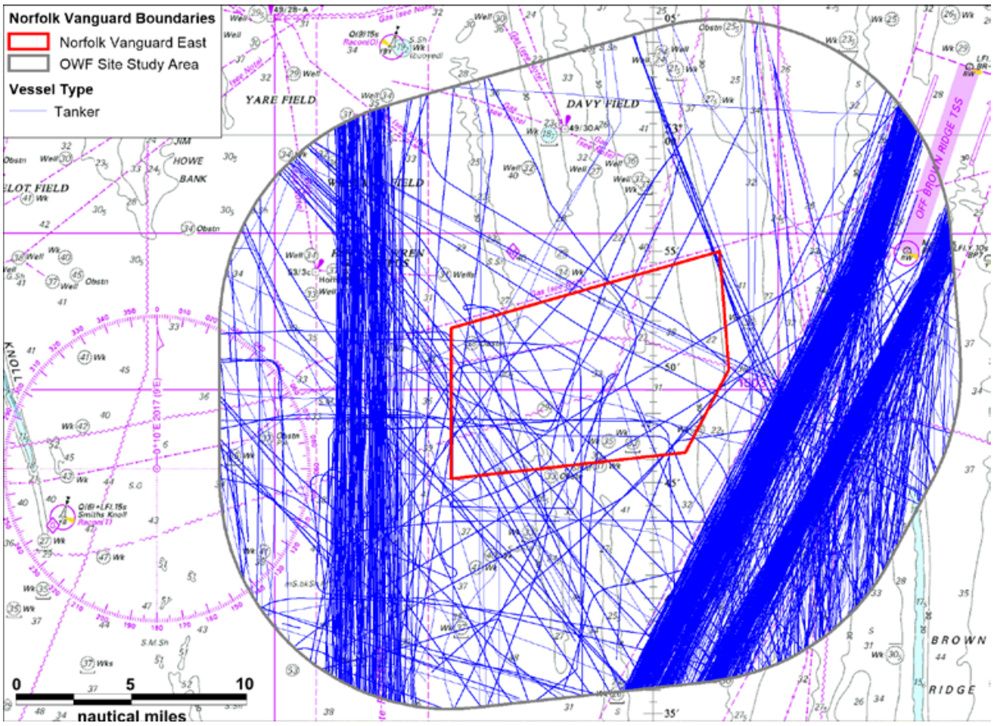

Figure 12.9 AIS and Radar Tankers within Norfolk Vanguard East Study Area (28 Days Summer 2016 and Winter 2017)

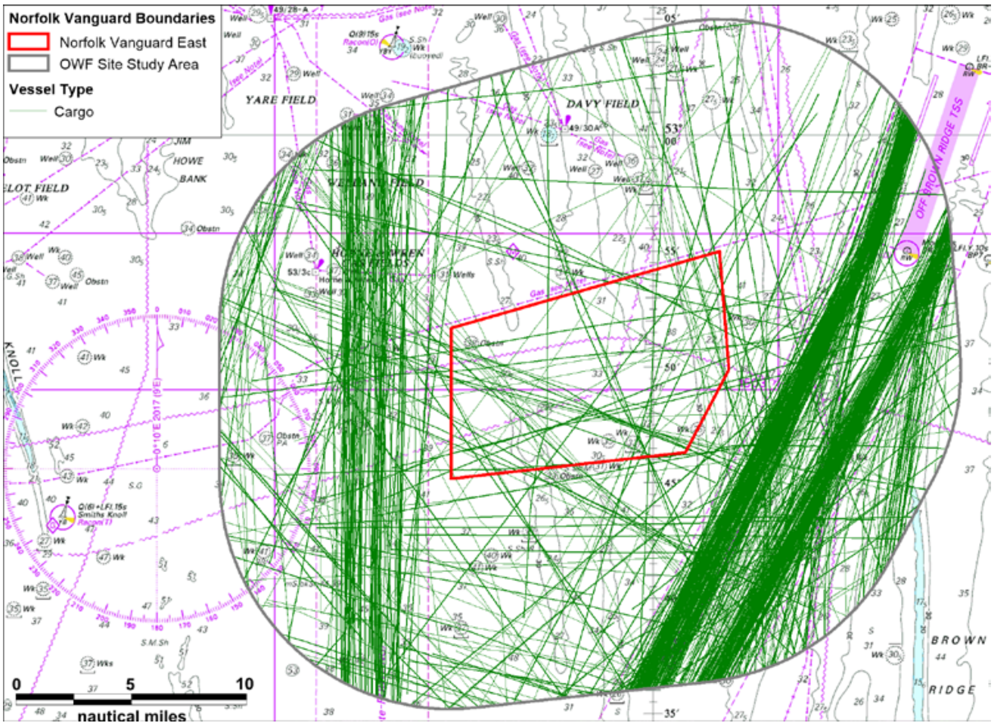

Figure 12.10 AIS and Radar Cargo Vessels within Norfolk Vanguard East Study Area (28 Days Summer 2016 and Winter 2017)

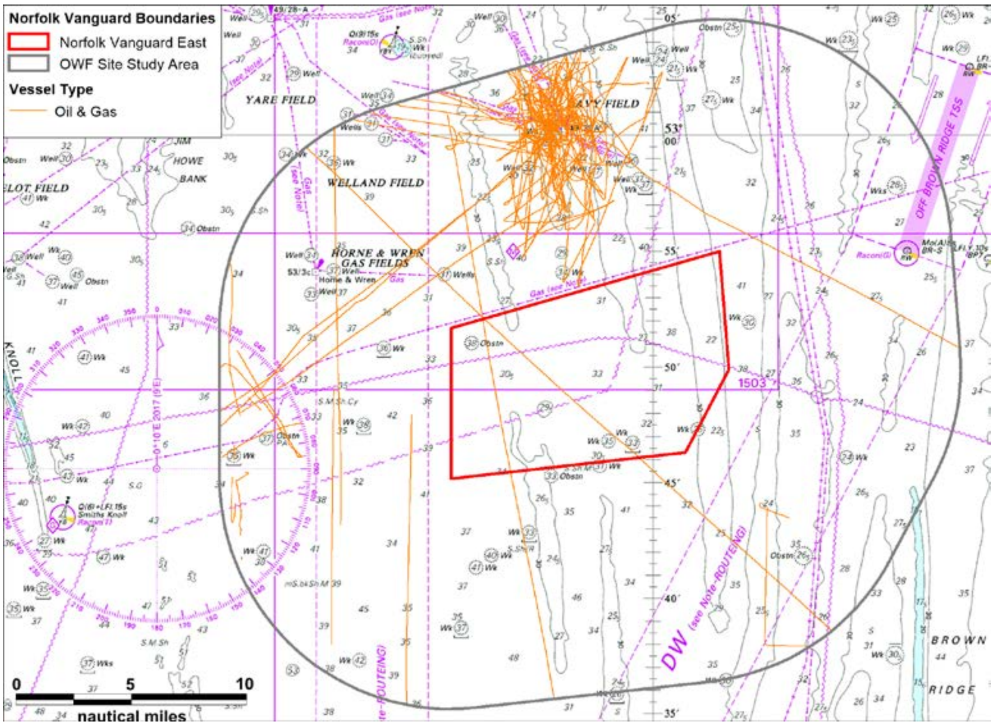

Figure 12.11 AIS and Radar Oil and Gas Support Vessels within Norfolk Vanguard East Study Area (28 Days Summer 2016 and Winter 2017)

146. Throughout the combined summer and winter survey period, an average of 85 unique tankers per day and 66 unique cargo vessels per day passed within the Norfolk Vanguard East study area.

147. It can be seen that the majority of tankers and cargo vessels were transiting the DR1 LightBuoy DWR and West Friesland DWR (see section 8.1). The main destinations of tankers and cargo vessels using the DR1 Light Buoy DWR and West Friesland DWR throughout the combined survey periods are presented in Table 12.1.

Table 12.1 Main Destinations of Tankers and Cargo Vessels Relative to Norfolk Vanguard East

	Main Destinations	Percentage Traffic
DR1Light Buoy DWR		
Cargo Vessels	Immingham	10%
	Rotterdam	8%
	Newcastle	5%
	Jelsa	4%
	Zeebrugge	4%
Tankers	Rotterdam	20%
	Antwerp	9%
	Immingham	8%

	Main Destinations	Percentage Traffic
	Teesport	6%
West Friesland DWR		
Cargo Vessels	Hamburg	4%
	Gdansk	3%
	Tilbury	3%
	Klaipeda	3%
Tankers	Rotterdam	16%
	Antwerp	7%
	Amsterdam	5%
	Primorsk	3%

148. Throughout the survey periods, an average of two unique offshore associated vessels per day passed within the Norfolk Vanguard East study area. The majority of these vessels were on passage to / from the Davy Gas Field located to the north of the Norfolk Vanguard East study area.

12.2.4 Passenger Vessel Activity

149. This section reviews the passenger vessel activity within the Norfolk Vanguard East study area based upon the marine traffic surveys.

150. Figure 12.3 presents a plot of passenger vessels recorded within the study area on AIS and Radar throughout both the summer and winter survey periods. Passenger vessels include commercial passenger ferries, cruise operators and Roll on Roll off (Ro Ro) vessels.

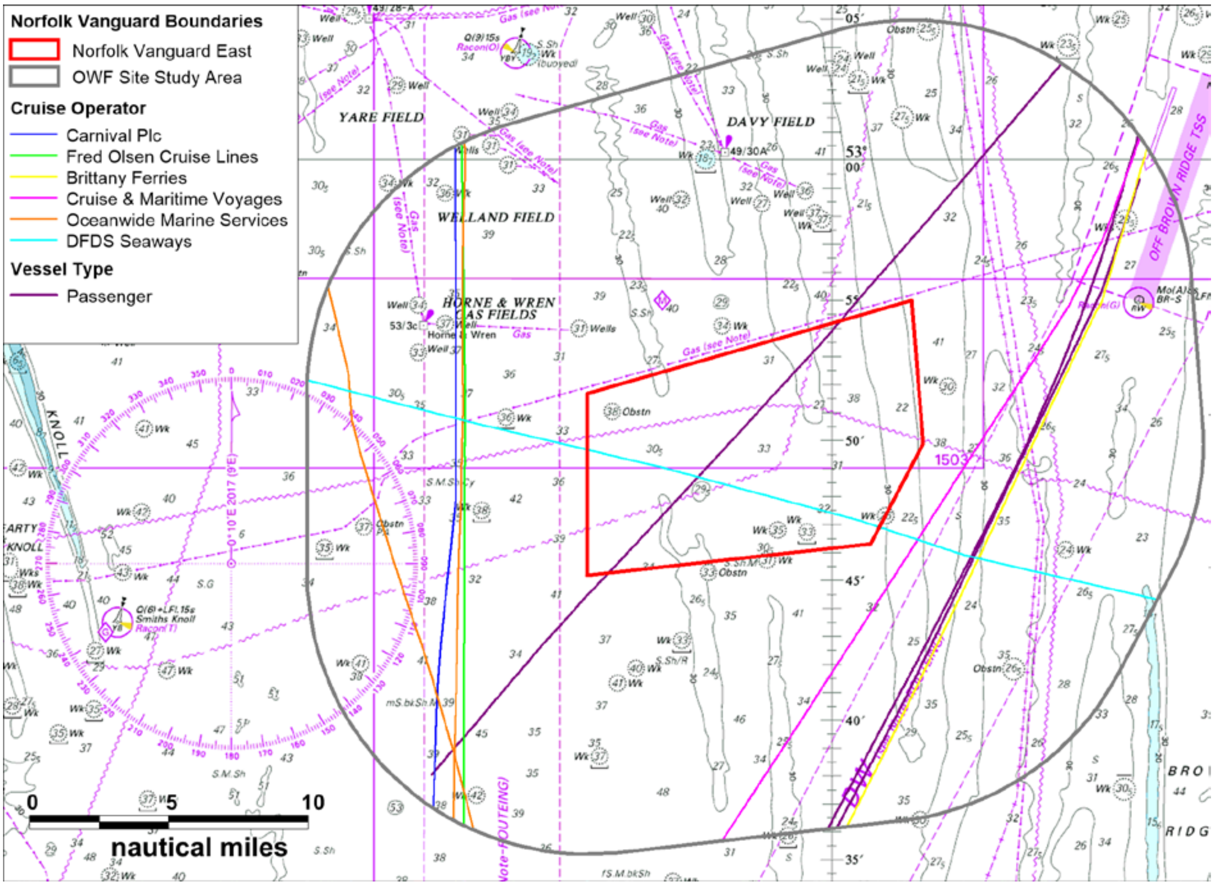

Figure 12.12 AIS and Radar Passenger Vessels within the Norfolk Vanguard East Study Area (28 Days Summer 2016 and Winter 2017)

151. The passenger vessel operating the Amsterdam (Netherlands) to Newcastle (UK) route for DFDS normally passes further north of Norfolk Vanguard East. In this case, the *Princess Seaways* has undertaken an adverse weather route directly through Norfolk Vanguard, transiting closer to the UK coast to be protected from south-west winds.

152. The DFDS operated *Britannia Seaways* transited north from Felixstowe (UK) through Norfolk Vanguard East towards Gdansk (Poland). It should be noted that DFDS has no regular route for Gdansk therefore this was likely to be a one off journey likely for dry docking.

153. The majority of passenger vessels transited past Norfolk Vanguard East along the DWRs and consisted of single transits.

154. In addition to DFDS, other operators with passenger vessels passing within the study area include Tallink, P&O Ferries, Brittany Ferries, Fred Olsen Cruise Lines, Carnival Plc, Cruise & Maritime Voyages and Oceanwide Marine Services BV.

12.3 *Norfolk Vanguard West Survey Analysis*

155. The Norfolk Vanguard West marine traffic survey consists of 28 days AIS and Radar data recorded during surveys between 8 and 21 September 2016 (14 days summer) and 7 and 21 February 2017 (14 days winter). It is noted that only AIS data is analysed for the winter survey period since there was no data recorded via Radar.

156. The summer survey was carried out by the *Fugro Pioneer* and the winter survey was carried out by the *RV Aora*. Figure 12.13 presents the tracks of the survey vessels.

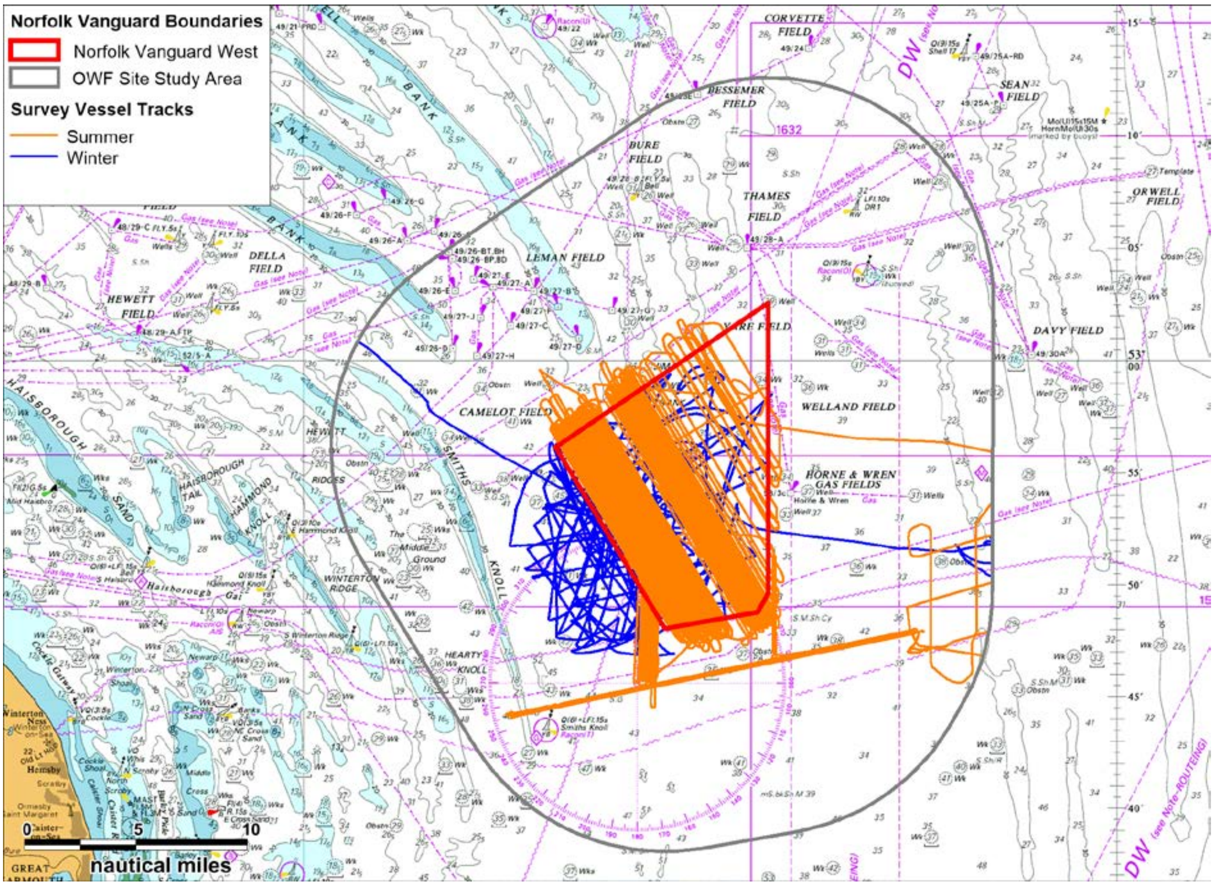

Figure 12.13 Overview of Survey Vessel Tracks within Norfolk Vanguard West (14 Days Summer 2016 and 14 Days Winter 2017)

157. As with the Norfolk Vanguard East survey, a number of tracks recorded during the survey were classified as temporary (non-routine), such as the tracks of the survey vessels and traffic associated with temporary drilling rigs. These have therefore been

excluded from further analysis. Oil and gas affiliated vessels supporting permanent installations were retained in the analysis.

158. Plots of vessel tracks recorded within the Norfolk Vanguard West study area during each respective period, colour-coded by vessel type and excluding temporary traffic (as defined above), are presented in Figure 12.14 and Figure 12.15 respectively, with the corresponding vessel density grids presented in Figure 12.16 and Figure 12.17 respectively. The same density ranges have been used in both density grids to allow direct comparison.

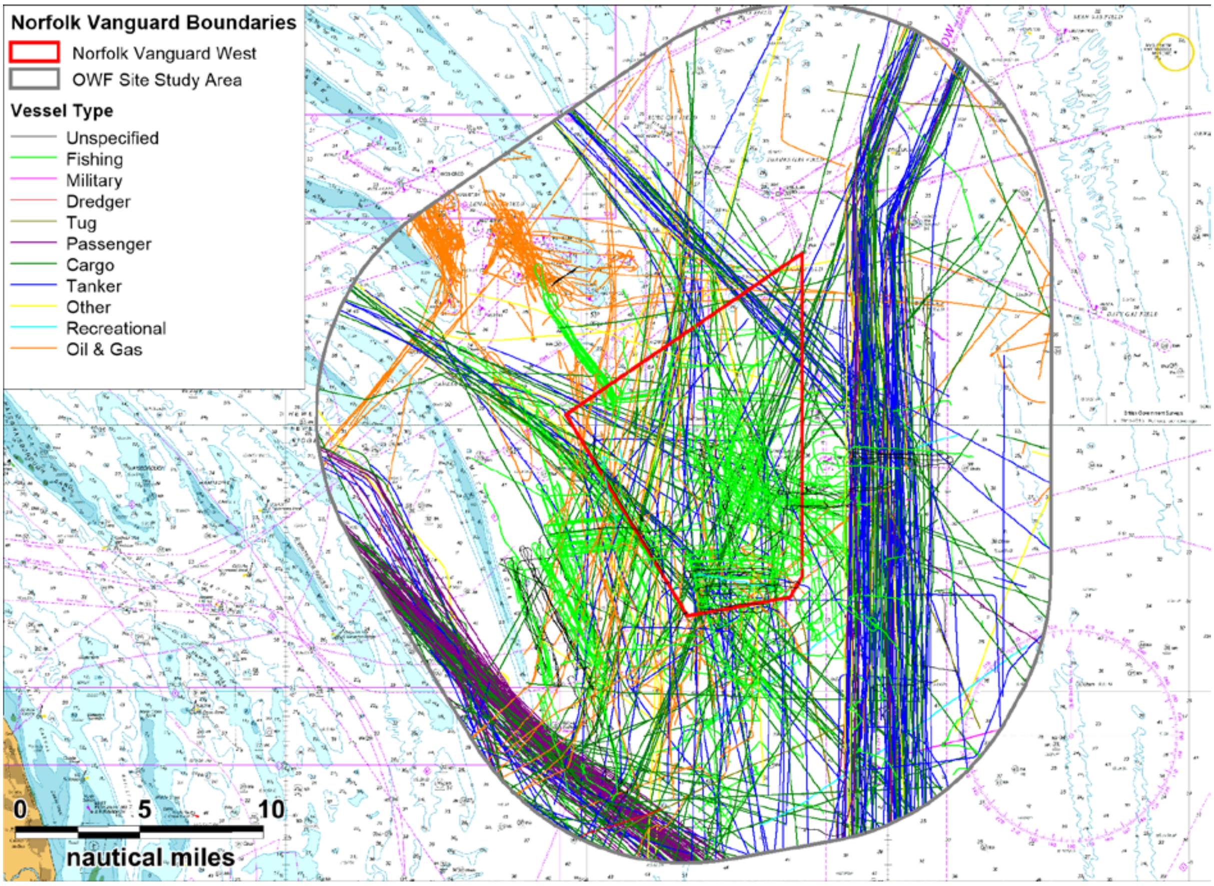

Figure 12.14 Overview of AIS and Radar Data within Norfolk Vanguard West Excluding Temporary Tracks (14 Days Summer 2016)

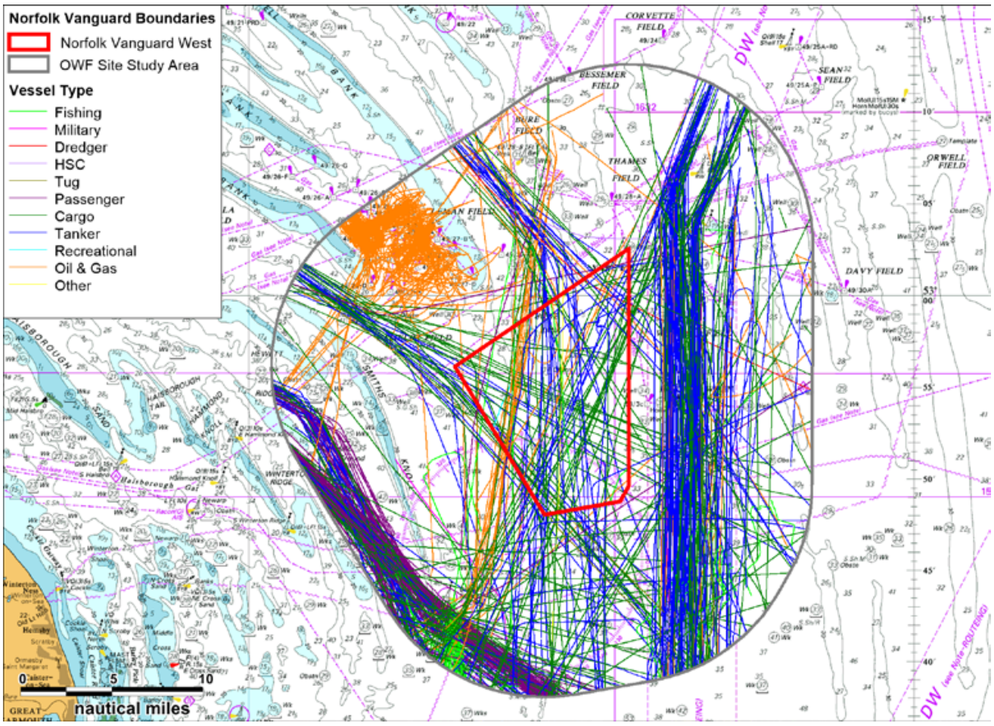

Figure 12.15 Overview of AIS and Radar Data within Norfolk Vanguard West Excluding Temporary Tracks (14 Days Winter 2017)

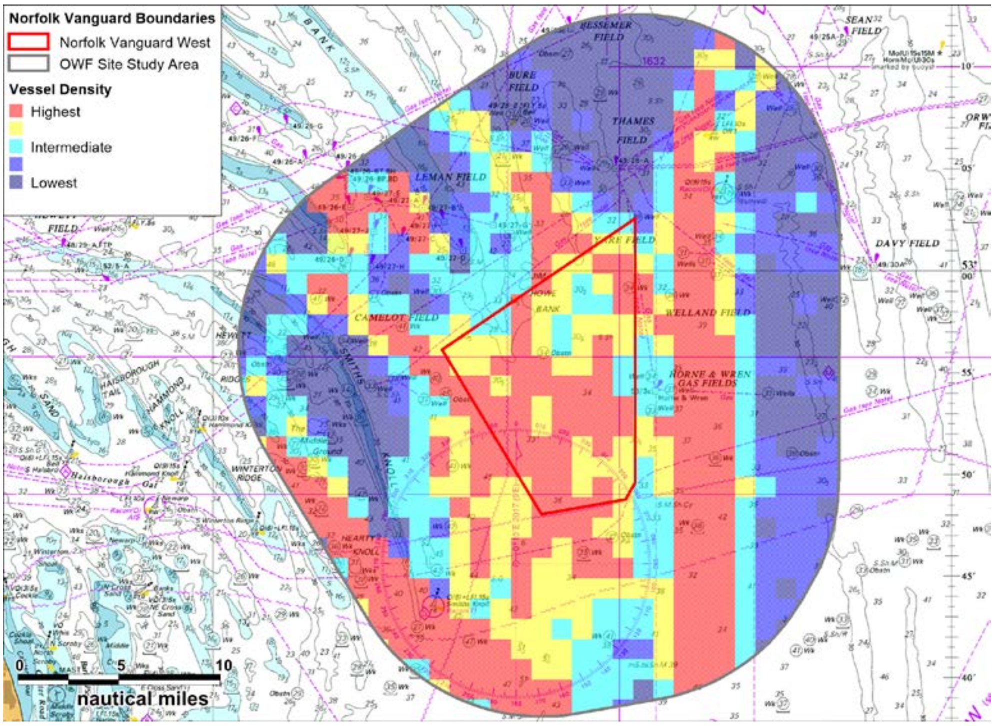

Figure 12.16 Vessel Density from AIS and Radar within Norfolk Vanguard West Study Area (14 Days Summer 2016)

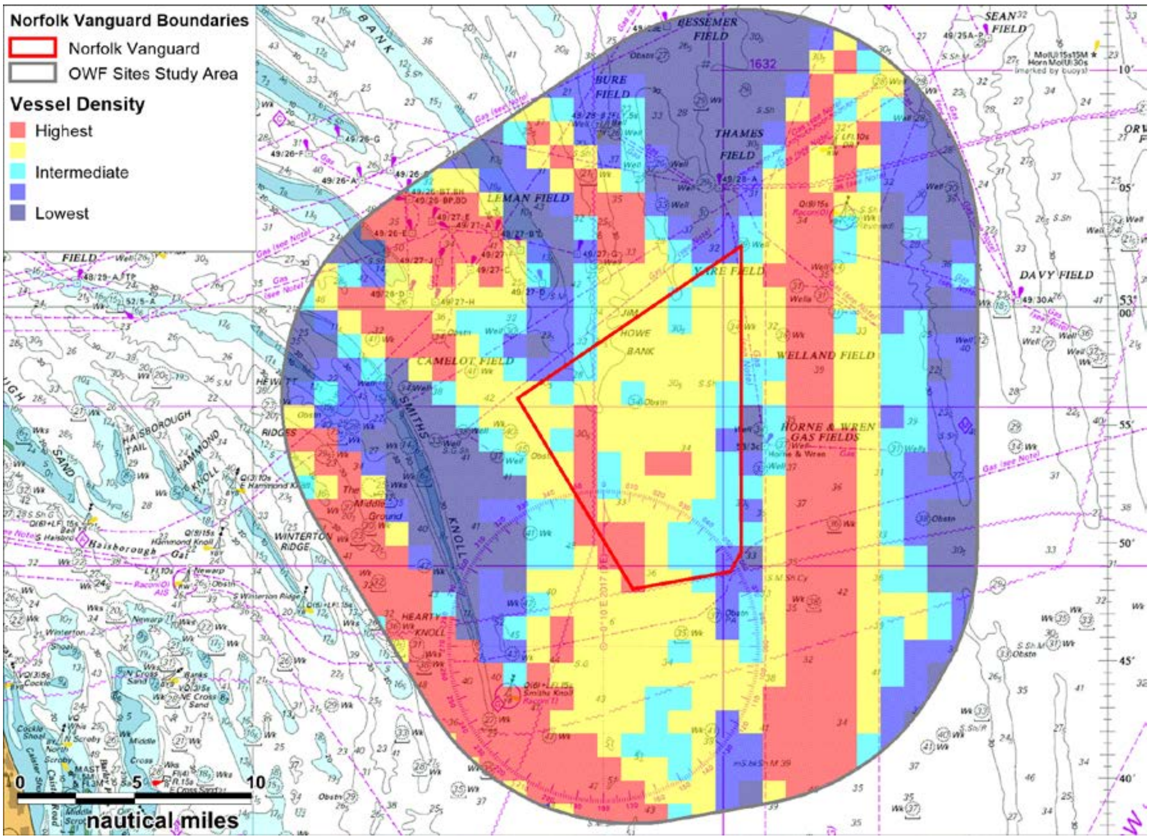

Figure 12.17 Vessel Density from AIS and Radar within Norfolk Vanguard West Study Area (14 Days Winter 2017)

159. During both survey periods, the highest vessel density areas were observed to correspond to the busy commercial shipping routes along the DR1 Lightbuoy DWR and the passenger ferry route passing east and south-west of Norfolk Vanguard East respectively.

160. Similarly, to the Norfolk Vanguard East survey, the vessel density within Norfolk Vanguard West was observed to be lower during summer than in winter. This was largely due to fishing activity recorded during the winter period which was not reflected during the summer period.

12.3.1 Summer Vessel Counts

161. For the 14 days analysed in summer 2016, there was an average of 43 unique vessels per day passing within the Norfolk Vanguard West study area, recorded on AIS and Radar. In terms of vessels intersecting Norfolk Vanguard West, there was an average of 14 unique vessels per day.

162. Figure 12.18 illustrates the daily number of unique vessels passing through the Norfolk Vanguard West study area during summer 2016.

163. The busiest day recorded throughout the survey period was 14 September 2016 when 55 unique vessels were recorded within the study area.

164. The quietest day recorded throughout the survey period was the 11 September 2016 when 29 unique vessels were recorded within the study area.

165. Throughout the survey period, 31% of traffic recorded within the Norfolk Vanguard West study area intersected Norfolk Vanguard West.

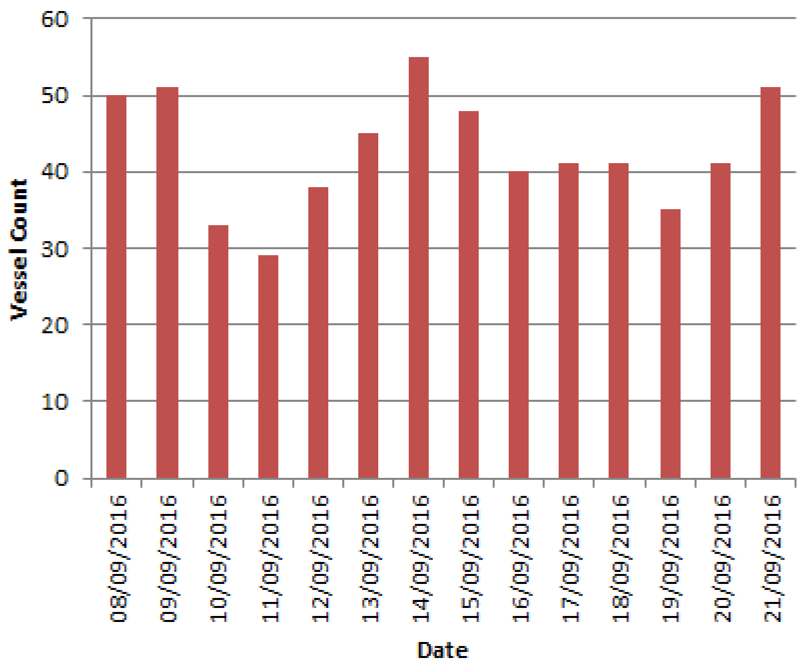

Figure 12.18 Unique Vessels per Day from AIS and Radar within Norfolk Vanguard West Study Area (14 Days Summer 2016)

12.3.2 Winter Vessel Counts

166. For the 14 days analysed in winter 2017, there was an average of 39 unique vessels per day passing within the Norfolk Vanguard West study area, all recorded on AIS. In terms of vessels intersecting Norfolk Vanguard West, there was an average of eight unique vessels per day.

167. As stated previously, no Radar data was recorded for the winter survey period.

168. Figure 12.19 illustrates the daily number of unique vessels passing through the Norfolk Vanguard West study area during winter 2017.

169. The busiest day recorded throughout the winter survey period was the 17 February 2017 when 58 unique vessels were recorded within the Norfolk Vanguard West study area.

170. The quietest day recorded throughout the winter survey period was the 12 February 2017 when 28 unique vessels were recorded within the Norfolk Vanguard West study area.

171. Throughout the winter survey period, 16% of traffic recorded within the Norfolk Vanguard West study area intersected Norfolk Vanguard West.

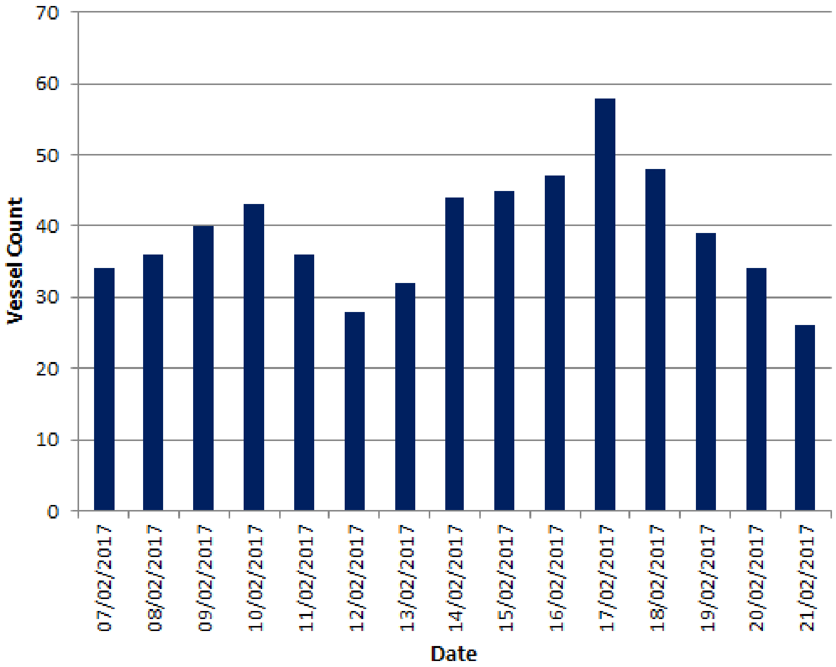

Figure 12.19 Unique Vessels per Day from AIS and Radar within Norfolk Vanguard West Study Area (14 Days Winter 2017)

12.3.3 Vessel Types – Combined Summer Winter Data Sets

172. Analysis of the vessel types recorded passing within the Norfolk Vanguard West study area and Norfolk Vanguard West throughout both survey periods are presented in Figure 12.20. The category of "other" vessels includes those that are not large enough in quantities to be categorised separately, such as anchor handling vessels, dive support vessels, pipe layer vessels and research / survey vessels.

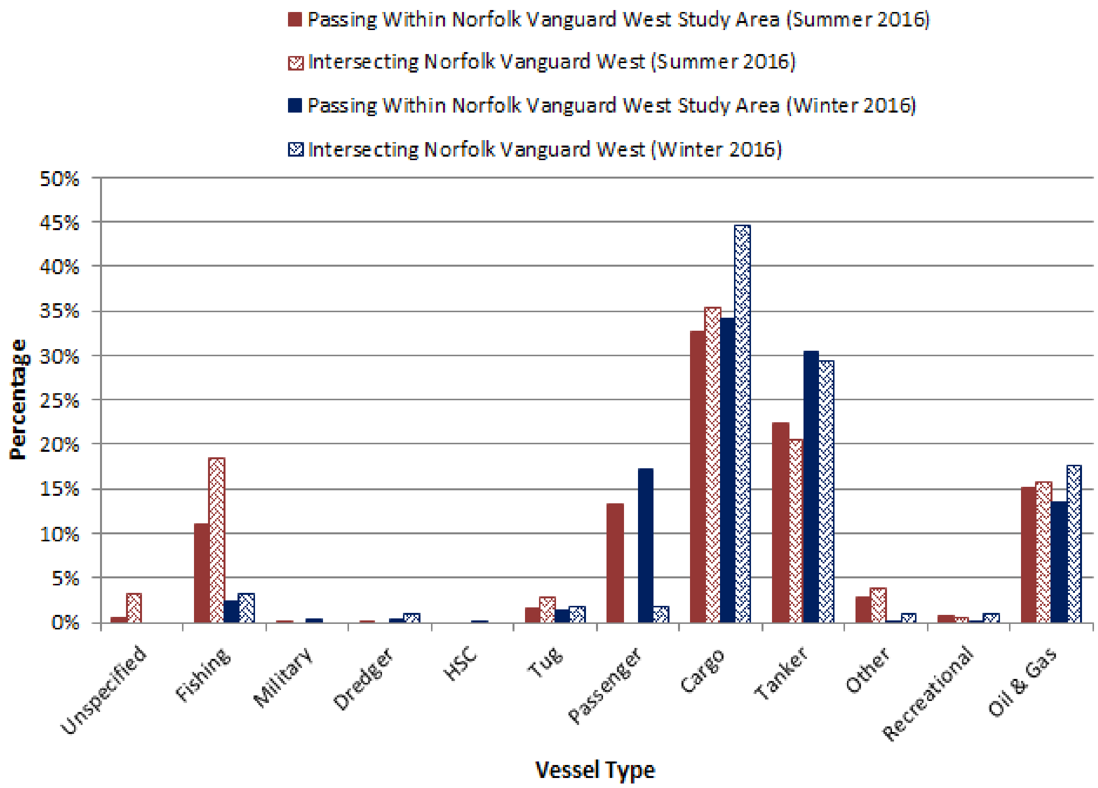

Figure 12.20 Distribution of Vessel Types within Norfolk Vanguard West Study Area from AIS and Radar (28 Days Summer 2016 and Winter 2017)

173. Throughout the summer period, the majority of tracks recorded on AIS and Radar were cargo vessels (32% within the Norfolk Vanguard West study area) and tankers (22%). Throughout the winter period the majority of tracks recorded were cargo vessels (34% in the Norfolk Vanguard West study area) and tankers (30%). As with the analysis for the Norfolk Vanguard East survey, it should be noted that the cargo vessel category does not include commercial ferries (e.g. DFDS Seaways) operating in the Norfolk Vanguard West study area who generally broadcast their vessel types on AIS as cargo. Details specific to commercial ferries are presented in Section 12.3.4.

174. Approximately 1% of tracks recorded on AIS and Radar throughout the survey periods were unspecified vessels.

175. Figure 12.21 presents a plot of cargo vessels, recorded within the Norfolk Vanguard West study area throughout the survey periods. Equivalent plots of tankers and oil and gas associated vessels are presented in Figure 12.22 and Figure 12.23 respectively.

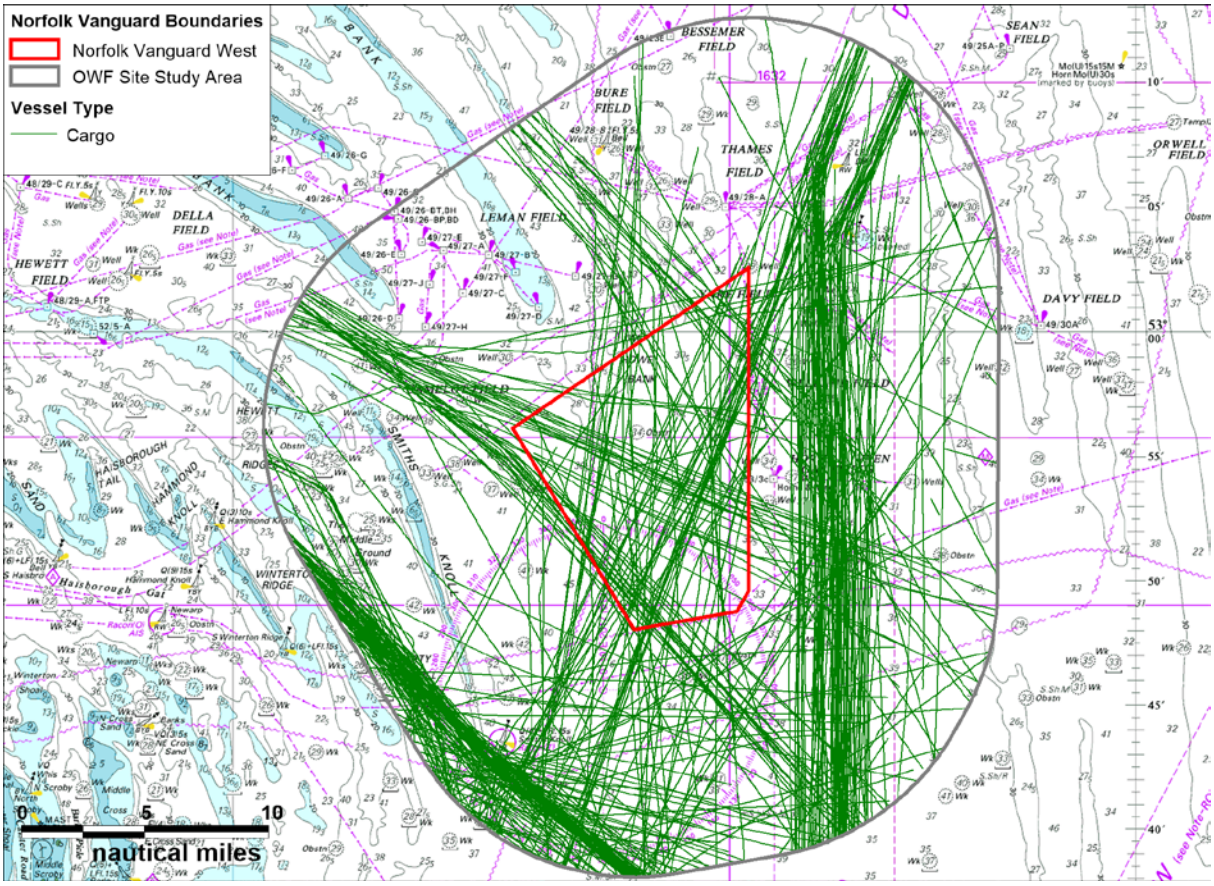

Figure 12.21 AIS and Radar Cargo Vessels within the Norfolk Vanguard West Study Area (28 Days Summer 2016 and Winter 2017)

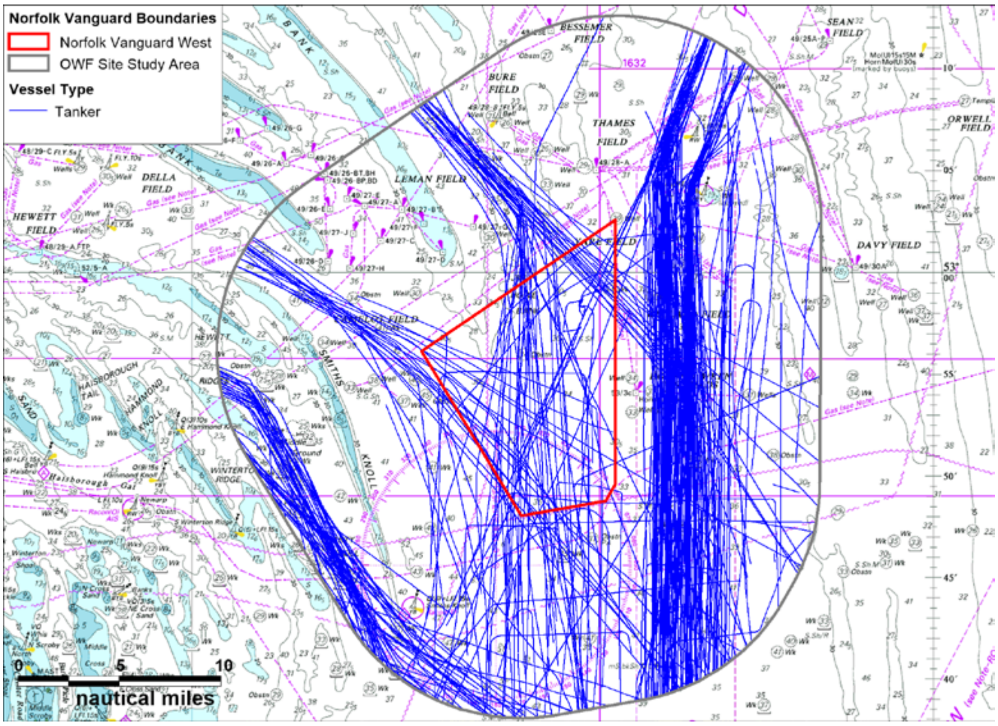

Figure 12.22 AIS and Radar Tankers within the Norfolk Vanguard West Study Area (28 Days 2016 and Winter 2017)

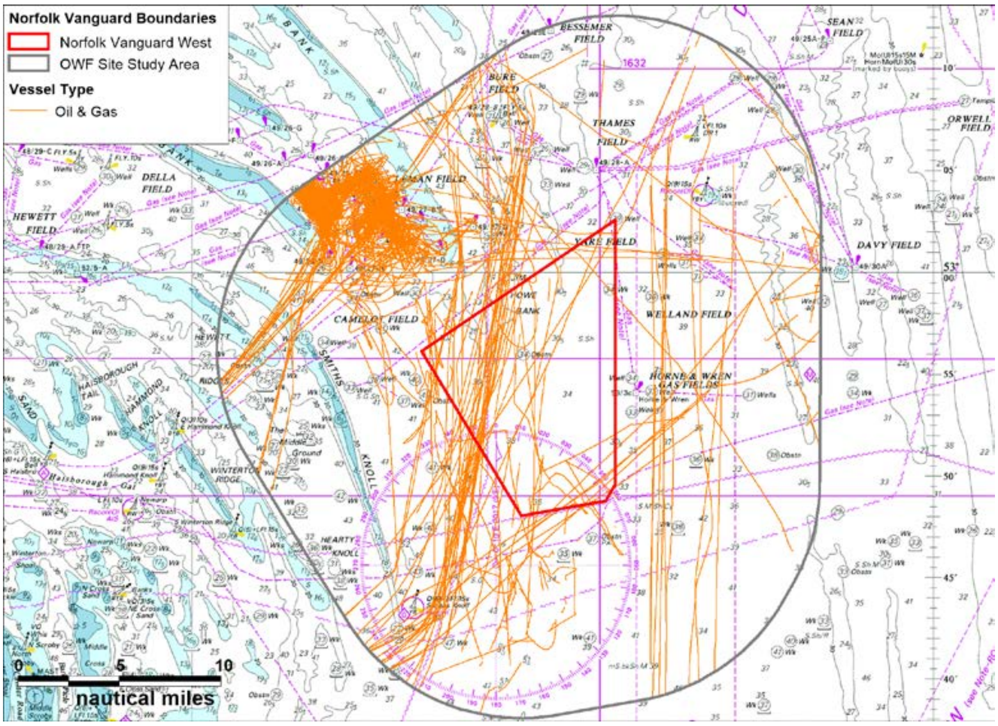

Figure 12.23 AIS and Radar Oil and Gas Associated Vessels within the Norfolk Vanguard West Study Area (28 Days Summer 2016 and Winter 2017)

176. Two tankers were identified as carrying out a vessel to vessel manoeuvre within Norfolk Vanguard West on 9 February 2017; the crude oil tanker *New Success* and the chemical tanker *Atlantic*. This manoeuvre may have been a refuelling, or lightening operation. Figure 12.24 presents the tracks of these vessels.

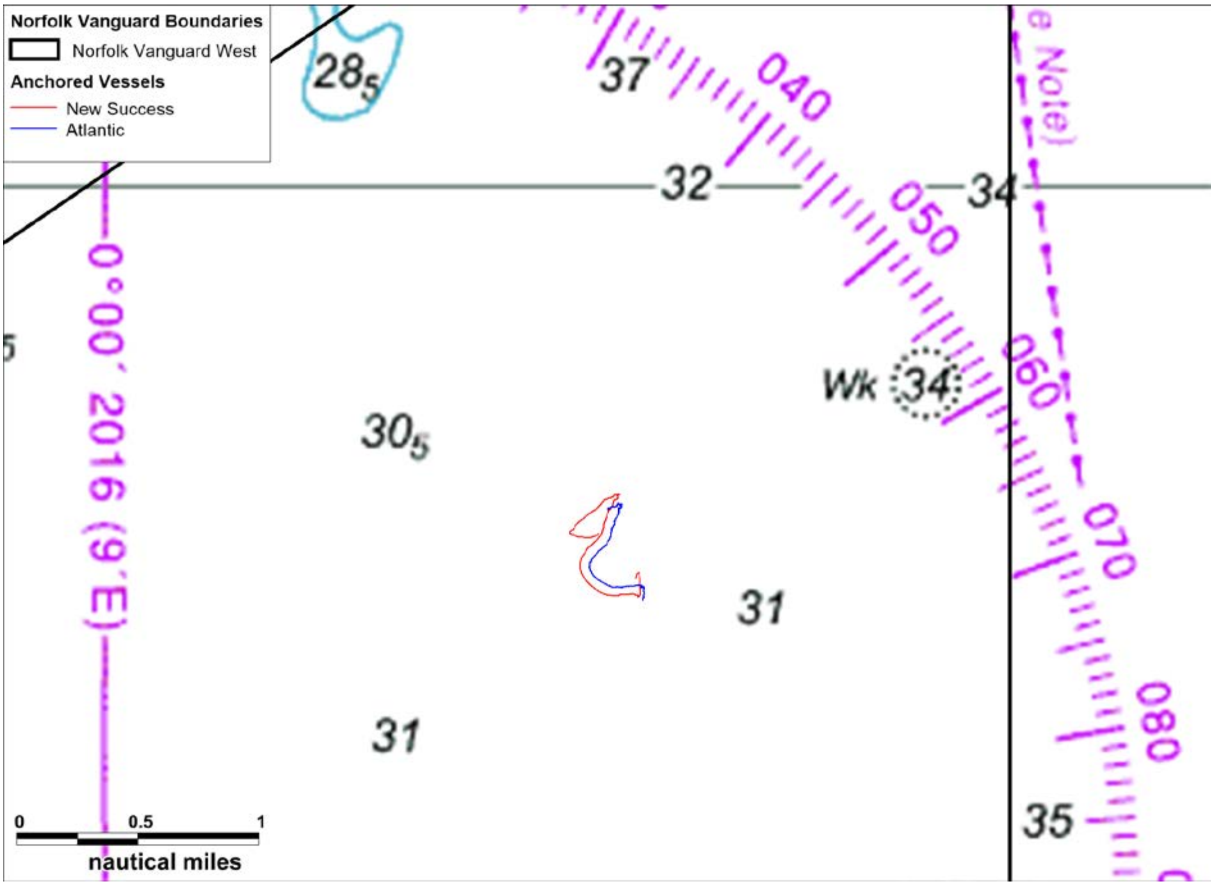

Figure 12.24 Activity of *New Success* and *Atlantic* Tankers

177. Throughout the combined summer and winter survey period, an average of 19 unique cargo vessels per day and 11 unique tankers passed within the Norfolk Vanguard West study area.

178. It can be seen that the majority of cargo vessels and tankers were transiting the DR1 Lightbuoy DWR or utilising the busy passenger vessel route to the south-west of Norfolk Vanguard West (see section 12.3.4). The main destinations of cargo vessels and tankers using the DR1 Lightbuoy DWR and the passenger vessel route throughout the combined survey periods are presented in Table 12.2.

Table 12.2 Main Destinations of Tankers and Commercial Vessels Relative to Norfolk Vanguard West

	Main Destinations	Percentage Traffic
DR1 LightBuoy DWR		
Cargo Vessels	Immingham	18%
	Newcastle	7%
	Rotterdam	6%
	Rochester	3%
Tankers	Rotterdam	16%
	Antwerp	10%
	Teesport	9%
	Immingham	8%
Passenger Vessel Route		
Cargo Vessels	Teesport	28%
	Rotterdam	24%
	Immingham	12%
Tankers	Immingham	17%
	Rotterdam	17%
	Antwerp	16%
	Teesport	16%

179. Throughout the combined survey periods, an average of four unique oil & gas associated vessels per day passed within the Norfolk Vanguard West study area.

12.3.4 Passenger Vessel Activity

180. This section reviews the passenger vessel activity within the Norfolk Vanguard West study area based upon the marine traffic surveys. Passenger vessels include commercial ferries, cruise operators, commercial sailing vessels and Ro Ro vessels.

181. Figure 12.25 presents a plot of passenger vessels recorded within the study area on AIS and Radar throughout both the summer and winter survey periods.

182. Throughout the combined summer and winter survey period, the most frequent passenger vessel routes were the DFDS freight route between Immingham and Rotterdam and the Stena Line route between Killingholme and the Hook of Holland.

183. The passenger transited within the south-west corner of the OWF site study area and the DWR within the study area.

184. In addition to DFDS and Stena Line, other operators with passenger vessels passing within the OWF site study area include Cobelfret Ferries, P&O Ferries, Carnival Plc,

Fred Olsen Cruise Lines, Pullmantur Ship Management, Oceania Cruises, Classic Sailing Voyages and Princess Cruise Lines.

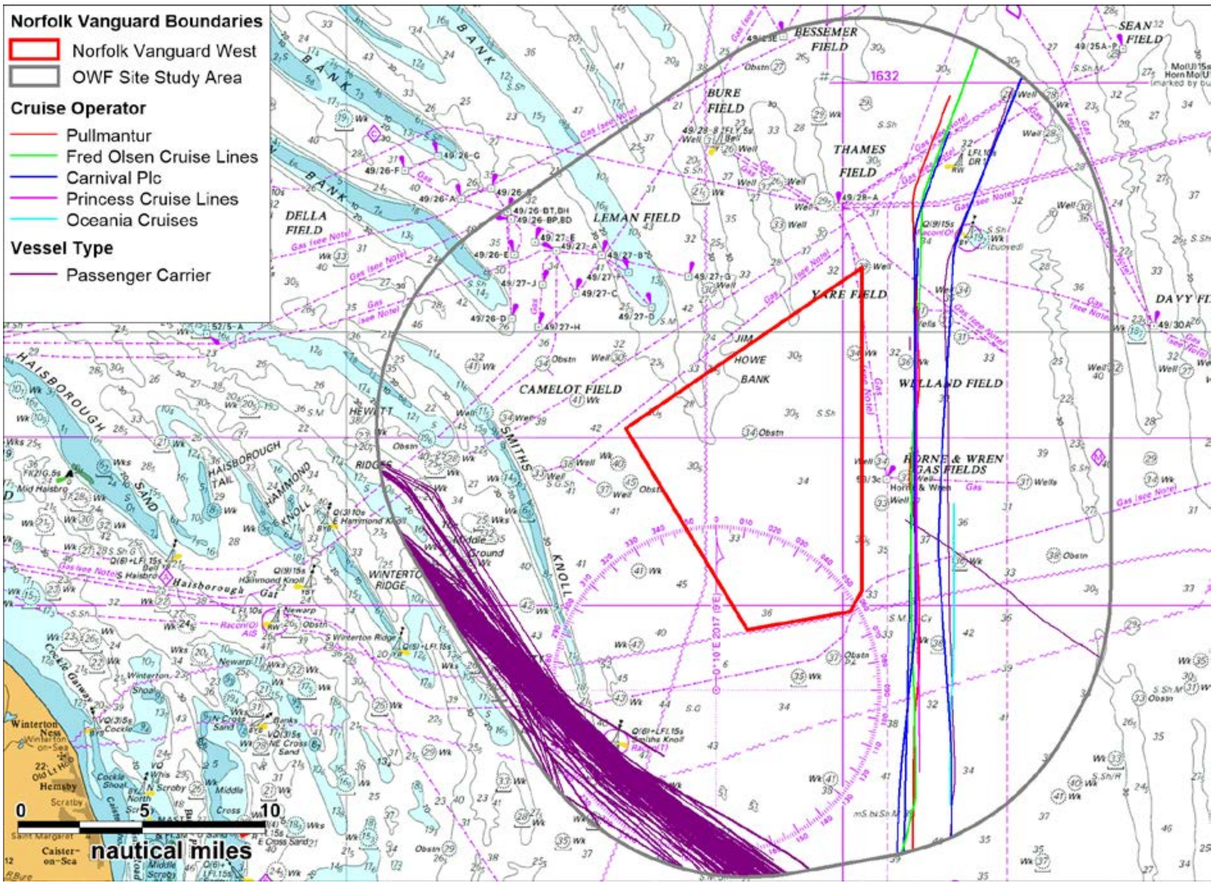

Figure 12.25 AIS and Radar Passenger Vessels within the Norfolk Vanguard West Study Area (28 Days Summer and Winter 2017)

185. Given the low level of activity within the OWF sites, passenger vessels have been considered as general commercial vessels within Chapter 15 Shipping and Navigation.

12.4 *Anchoring*

186. With the exception of the tanker manoeuvre described in section 12.3.3, no vessels transmitted a navigation status of "At Anchor" within the OWF sites study areas (excluding cases where vessels transmitted such a status, but a visual check showed the vessel was clearly not at anchor). Additionally, a speed analysis was undertaken to identify any vessels transmitting a status other than "At Anchor", but exhibited behaviour suggesting they were anchored at the time. No such vessels were identified. Within the OWF sites there are not expected to be any impacts on anchoring.

13. OWF Sites Fishing Vessel Activity

13.1 *Norfolk Vanguard East*

187. Fishing vessel activity recorded within the Norfolk Vanguard East study area during the AIS and Radar marine traffic surveys is presented in Figure 13.1. It can be seen that fishing vessel activity recorded within Norfolk Vanguard East and the Norfolk Vanguard East study area included vessels both transiting through the study area as well as actively engaged in fishing.

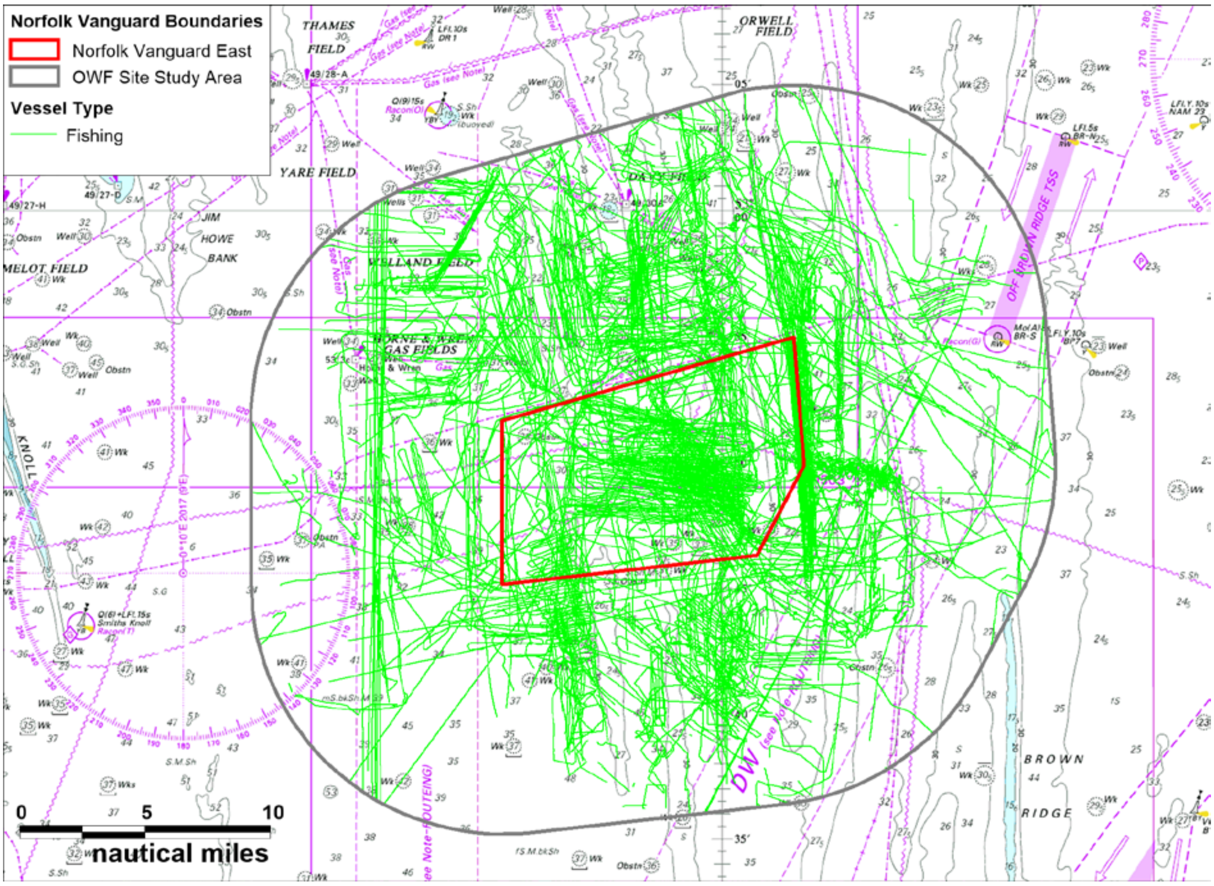

Figure 13.1 AIS and Radar Fishing Vessels within Norfolk Vanguard East Study Area (28 Days Summer 2016 and Winter 2017)

188. Throughout the combined summer and winter survey period, an average of eight unique fishing vessels per day passed within the Norfolk Vanguard East study area.

189. Flag state (nationality) information was available for approximately 96% of fishing vessels recorded on within the Norfolk Vanguard East study area, with the 4% of

unspecified nationalities corresponding to Radar tracks. Of the nationalities identified, the most common was the Netherlands (80%).

190. Fishing method information was available for 90% of fishing vessels recorded within the Norfolk Vanguard East study area. Of the fishing methods identified, the most common were beam trawlers (75%). Other fishing methods recorded included demersal trawlers (6%), seiners (4%) and pelagic trawlers (3%). Unspecified fishing types accounted for 10%. Active fishing was recorded within Norfolk Vanguard East, most notably from beam trawlers, with demersal trawling and seiner activity also recorded.

13.2 *Norfolk Vanguard West*

191. Fishing vessel activity recorded within the Norfolk Vanguard East study area during the AIS and Radar marine traffic surveys is presented in Figure 13.2. Based upon vessel speed and behaviour, the majority of fishing vessels were actively engaged in fishing rather than transiting on passage. There were no fishing vessels recorded via Radar throughout the survey periods.

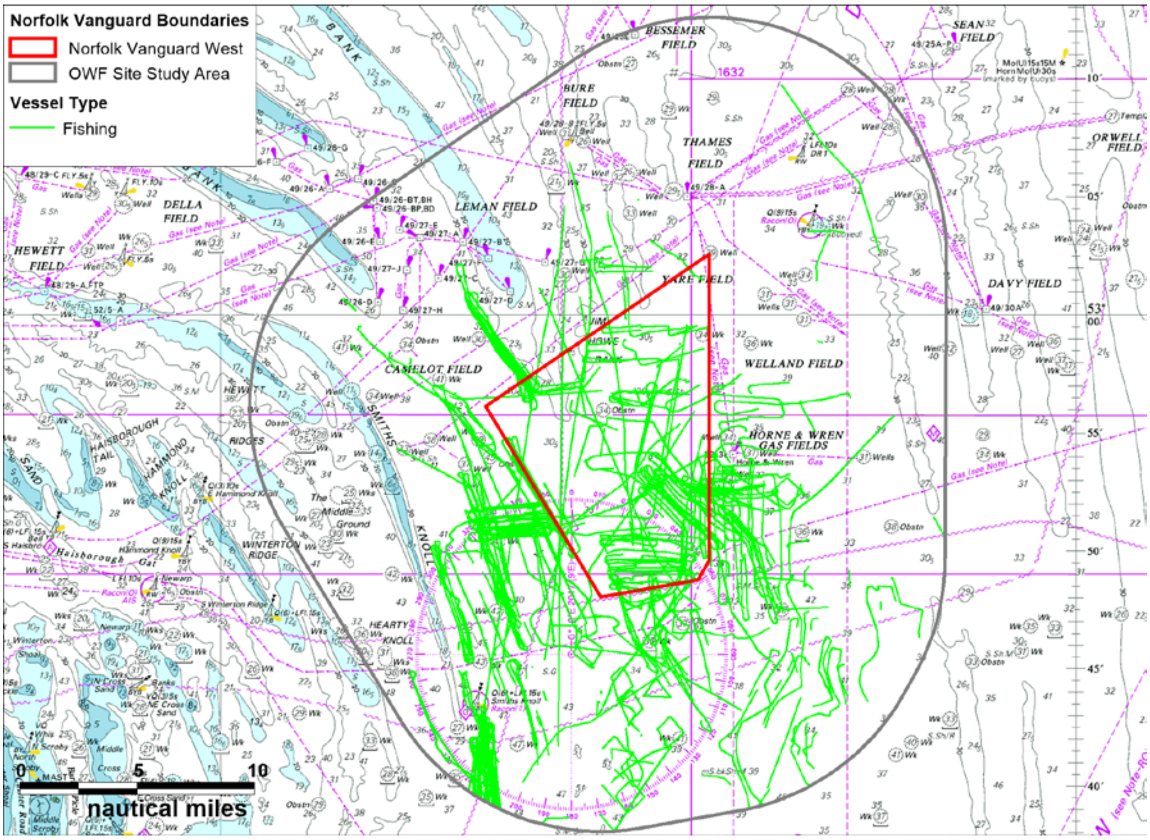

Figure 13.2 AIS Fishing Vessels within the Norfolk Vanguard West Study Area (28 Days Summer 2016 and Winter 2017)

192. Throughout the combined summer and winter survey period, an average of three unique fishing vessels per day passed within the Norfolk Vanguard West study area.

193. Flag state (nationality) information was available for 100% of fishing vessels recorded within the Norfolk Vanguard West study area. Of the nationalities identified, the most common was the Netherlands (87%).

194. Fishing method information was available for 100% of fishing vessels recorded within the Norfolk Vanguard East study area. Of the fishing methods identified, the most common were beam trawlers (83%). Seiner fishing vessels were also common (12%) while demersal trawlers and pelagic trawlers accounted for approximately 3% each.

13.2.1 Effects on Commercial Fishing Vessels

195. Further information on commercial fishing vessel activity can be found in Chapter 14 Commercial Fishing. Impacts on the safe navigation of fishing vessels are considered within Chapter 15 Shipping and Navigation.

14. OWF Sites Recreational Vessel Activity

14.1 *Introduction*

196. This section presents analysis of the recreational vessel activity in the vicinity of the offshore project area using the recreational tracks recorded during the marine traffic surveys, and the RYA Coastal Atlas. As per Recreational Craft Regulations 2004 (Directives 94/25/EC and 2003/44/EC), sailing vessels and motor craft recorded as between 2.5 and 24m in length have been classed as recreational vessels.

14.2 *Norfolk Vanguard East*

197. Recreational vessel activity recorded within the Norfolk Vanguard East study area during the AIS and Radar marine traffic surveys is presented in Figure 14.1.

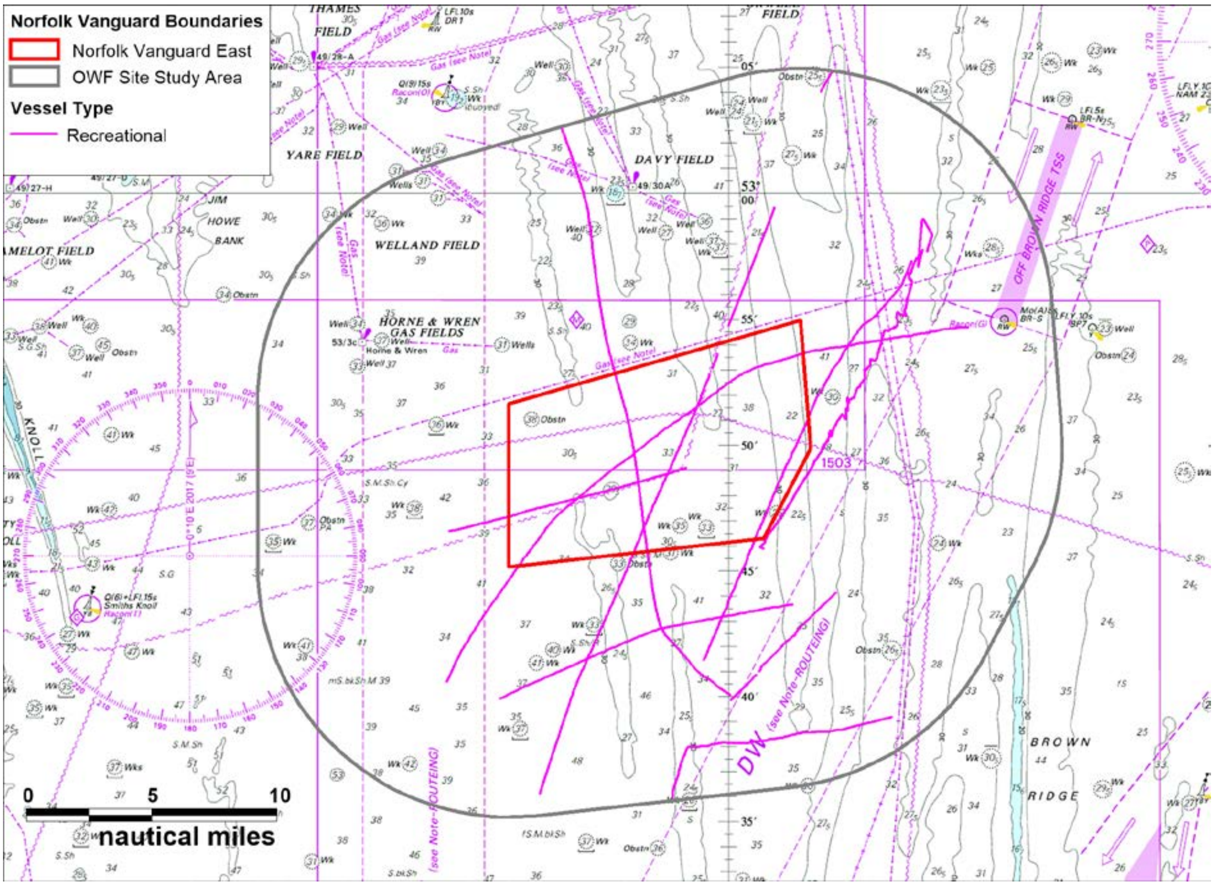

Figure 14.1 AIS and Radar Recreational Vessels within the Norfolk Vanguard East Study Area (28 Days Summer 2016 and Winter 2017)

198. Eight unique recreational vessel transits were recorded within the Norfolk Vanguard East study area during summer, with none being recorded in winter. Six of the eight recreational vessels were identified as sailing vessels with the type of the remaining two undefined. Lengths ranged from 9m to 20m. It is noted that five of the eight recreational vessels were recorded within Norfolk Vanguard East.

199. It is noted that 96% of recreational craft recorded throughout the combined summer and winter survey period were recorded on AIS, with only 4% recorded on Radar.

14.3 *Norfolk Vanguard West*

200. Recreational vessel activity recorded within the Norfolk Vanguard West study area during the AIS and Radar marine traffic surveys is presented in Figure 14.2.

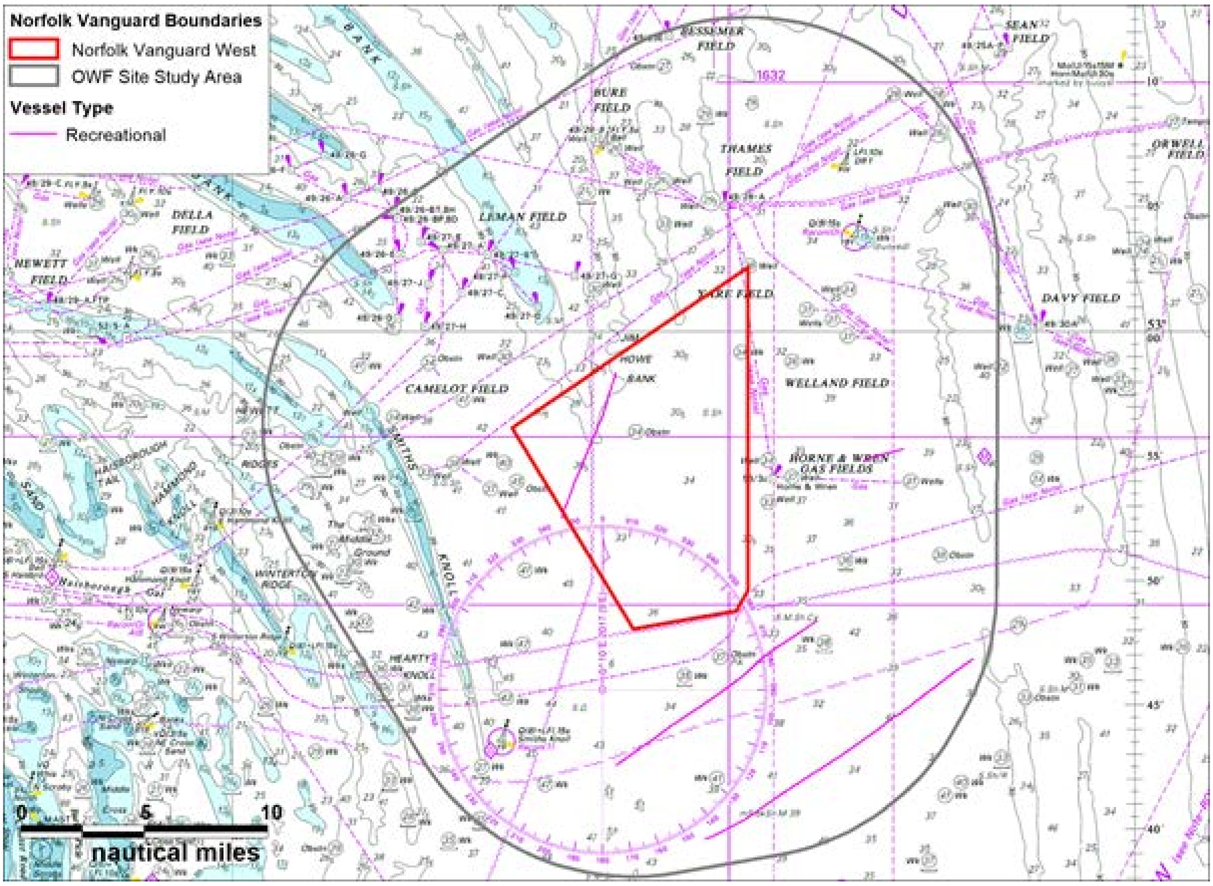

Figure 14.2 AIS Recreational Vessels within the Norfolk Vanguard West Study Area (28 Days Summer 2016 and Winter 2017)

201. Four unique recreational vessel transits were recorded within the Norfolk Vanguard West study area; three during the summer period and one during the winter period.

The recreational vessel recorded during the winter period was also recorded within Norfolk Vanguard West. Lengths ranged from 12m to 22m, and each recreational vessel was identified a sailing vessel.

202. As stated previously, the winter survey period did not contain any vessels recorded via Radar. Moreover, all recreational vessels recorded during the summer survey period were recorded via AIS rather than Radar.

14.4 *RYA Coastal Atlas*

203. In 2004 the RYA, supported by the Cruising Association (CA), started to identify recreational cruising routes, general sailing and racing areas. This work was based on extensive consultation and qualitative data collection from RYA and Cruising Association members, through the organisations' specialist and regional committees and through the RYA affiliated clubs. The consultation was also sent to berth holder associations and marinas.

204. The results of this work were initially published in Sharing the Wind (RYA, 2004) and updated in the UK Coastal Atlas of Recreational Boating (RYA, 2016).

205. A summary plot of the recreational sailing activity and facilities off the Norfolk coast is presented in Figure 14.3, relative to Norfolk Vanguard. This is based on the latest RYA Coastal Atlas data (RYA, 2016). Areas of high density recreational activity were observed to be largely coastal, however an offshore route mark indicates recreational routeing to the south of the OWF sites. There is also a general boating area noted approximately 5nm to the north west of the offshore cable corridor landfall.

206. For reference, historic offshore cruising routes (RYA, 2009) are also included in Figure 14.3, however the 2016 dataset is the stakeholder required primary assessment tool. No cruising routes were observed to intersect the OWF sites, however four intersected the offshore cable corridor.

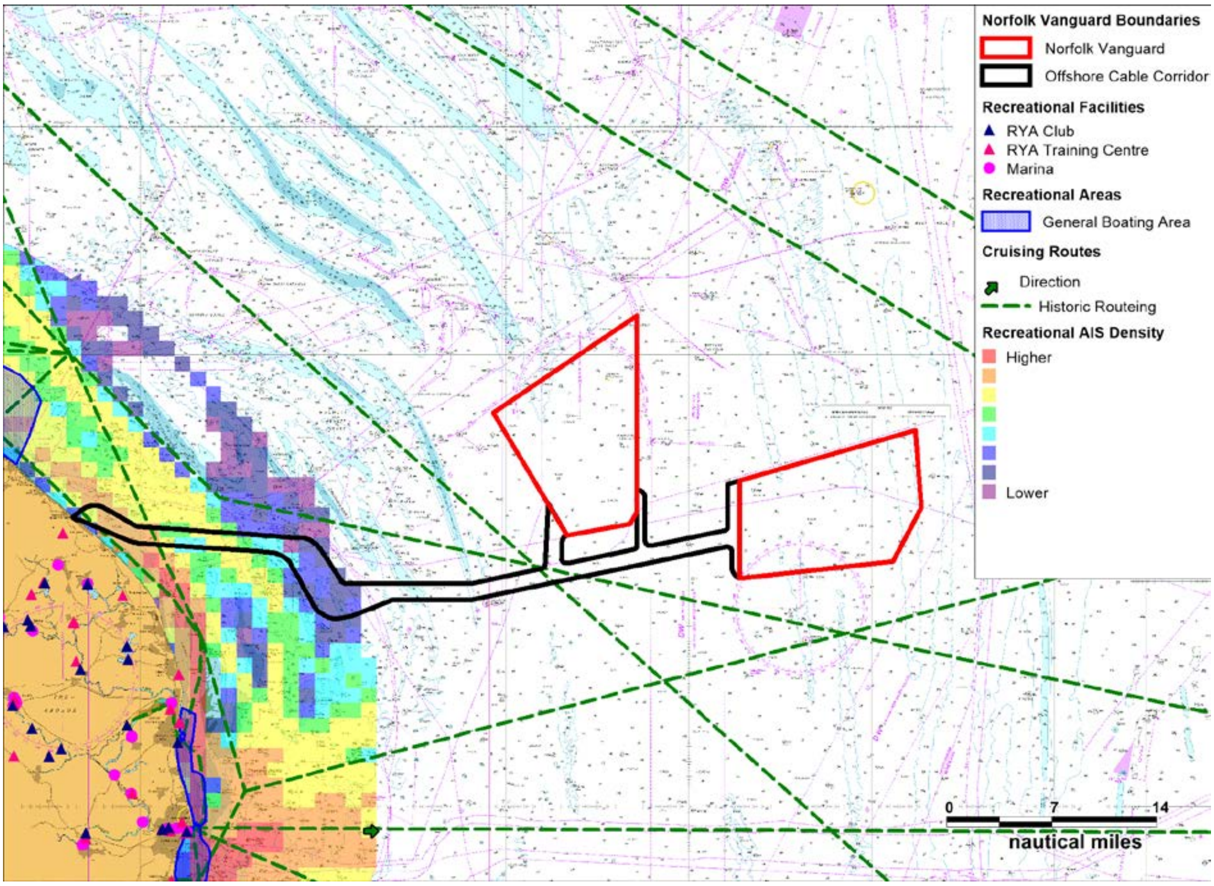

Figure 14.3 RYA Coastal Atlas

14.5 *Effects on Recreational Vessels*

207. Effects on recreational vessels are considered within Chapter 15 Shipping and Navigation.

14.6 *Effects of Structures on Wind Masking/Turbulence or Shear*

208. The offshore wind turbines have the potential to affect vessels under sail when passing through the OWF sites from effects such as wind shear, masking and turbulence.

209. From previous studies of offshore wind farms, it was concluded that wind turbines do reduce wind velocity by the order of 10% downwind of a wind turbine. The temporary effect is not considered as being significant and similar to that experienced passing a large vessel or close to other large structures (e.g. bridges) or the coastline. In addition, practical experience to date from RYA members taking vessels into other sites indicates that this is not likely to be an issue. A number of OWFs are operational within UK waters and no effects have been reported by recreational users.

14.7 *Recreational Vessel Blade and Mast Allision*

210. The RYA considers the largest risk to recreational craft from offshore wind developments to be the risk of rotor blade allision and under keel allision associated with scour protection, cable protection or floating foundation moorings which reduces the keel clearance. An allision between a wind turbine blade and the mast of a yacht or damage to the keel could result in the structural failure and foundering of the yacht.

14.7.1 Air Clearance

211. In order to mitigate the risk of blade allision, the proposed project would adhere to guidance on the construction of windfarms including ensuring that the minimum rotor blade clearance (air draught) for the wind turbines is at least 22m above MHWS. This is the clearance when the blade is in its lowest (six o'clock) position. The actual clearance at a given time would depend upon the prevailing tide and wave conditions, i.e., lower clearance at high water and rough seas, greater clearance at low water and calm seas.

212. To determine the extent to which yacht masts could interact with the rotor blades, details on the air draughts of the IRC fleet are provided in Figure 14.4 based on a fleet size of over 3,000 vessels (study undertaken in 2002 however values are not expected to have significantly changed). IRC is a rating used worldwide which allows boats of different sizes and designs to race on equal terms. The UK IRC fleet, although numerically only a small proportion of the total number of sailing yachts in the UK, is considered representative of the range of modern sailing boats in general use in UK waters.

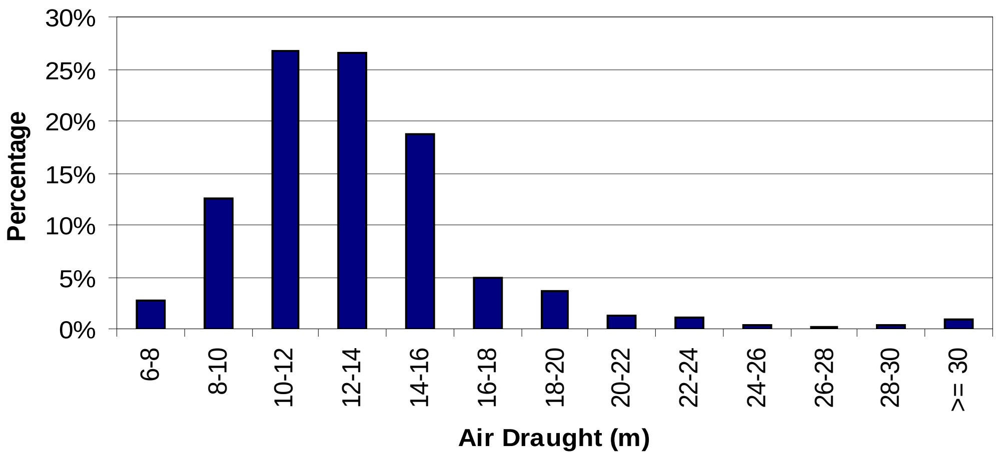

Figure 14.4 Air Draught Data – IRC Fleet (2002)

213. From this data, just fewer than 4% of boats have air draughts exceeding 22m. Therefore, only a fraction of vessels could potentially be at risk of dismasting if they were directly under a rotating blade in the worst-case conditions. It is further noted that the windfarm would be designed and constructed to satisfy the requirements of the MCA in respect to control functions and safety features, as specified in the MGN 543 (MCA 2016).

214. These measures mean that whilst the blade allision risk cannot be completely eliminated it would be reduced to a level as low as reasonably practicable. In terms of consequences, most allisions with the wind turbines should be relatively low speed and hence low energy. If the seaworthiness of the recreational craft was threatened by the impact, the wind turbines would be equipped with access ladders for use in emergency, placed in the optimum position taking into account the prevailing wind, wave and tidal conditions, as required by the MCA. This should provide a place of safety / refuge until such time as the rescue services arrive.

14.7.2 Under Keel Clearance and Allision Risk

215. Given the water depths there are not expected to be any impacts associated with scour protection affecting under keel clearance.

216. Under keel clearance associated within mooring lines and cable protection (within the near shore area) is considered within Chapter 15 Shipping and Navigation. However, it is noted that a cable burial risk assessment will be undertaken post consent to ensure that under keel clearance of transiting vessels is considered when selecting cable burial methods.

15. Offshore Cable Corridor Marine Traffic Survey

15.1 *Introduction*

217. This section presents analysis of marine traffic survey data recorded within the study area of the cable corridor. It is noted that the study area, and therefore the analysis, is based on a 5nm buffer of the most up to date iteration of the offshore cable corridor available to Anatec at the time of the commencement of the analysis. The offshore cable corridor presented in the below figures represents an update to that used to create the study area, however the changes are considered to be insignificant in terms of the traffic analysis.

218. The marine traffic survey data set used for the analysis was created by supplementing the 28 days of AIS data recorded for Norfolk Vanguard West (see Section 12.3) with AIS data recorded from onshore coastal receivers. Multiple onshore receivers were utilised for this purpose, ensuring downtime was minimal (approximately 1%).

219. As only AIS data has been considered for the offshore cable corridor, vessels not required to broadcast via AIS may be underrepresented in the following analysis, including all recreational vessels and fishing vessels of less than 15m.

15.2 *Traffic Filtering*

220. A plot of the vessel tracks recorded within the study area during the 14 day survey period from 8 to the 21 September 2016 (summer) and a plot of all the vessel tracks recorded within the study area during the 14 day survey period from 7 to the 21 February 2017 (winter) is presented in Figure 15.1 and Figure 15.2.

221. A number of tracks recorded during the summer and winter surveys were classified as temporary (non-routine), such as the tracks of survey vessels and traffic associated with temporary offshore construction. These have therefore been excluded from the analysis. Oil and gas affiliated vessels and wind farm vessels supporting permanent installations were retained in the analysis.

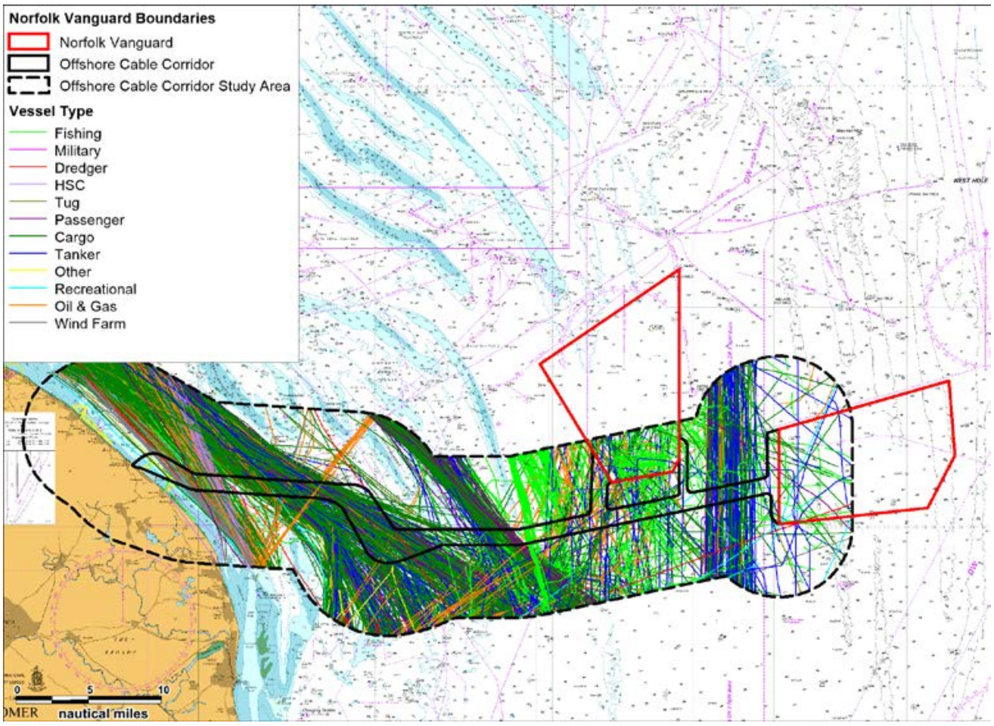

Figure 15.1 Overview of AIS Data Excluding Temporary Tracks (14 Days Summer 2016)

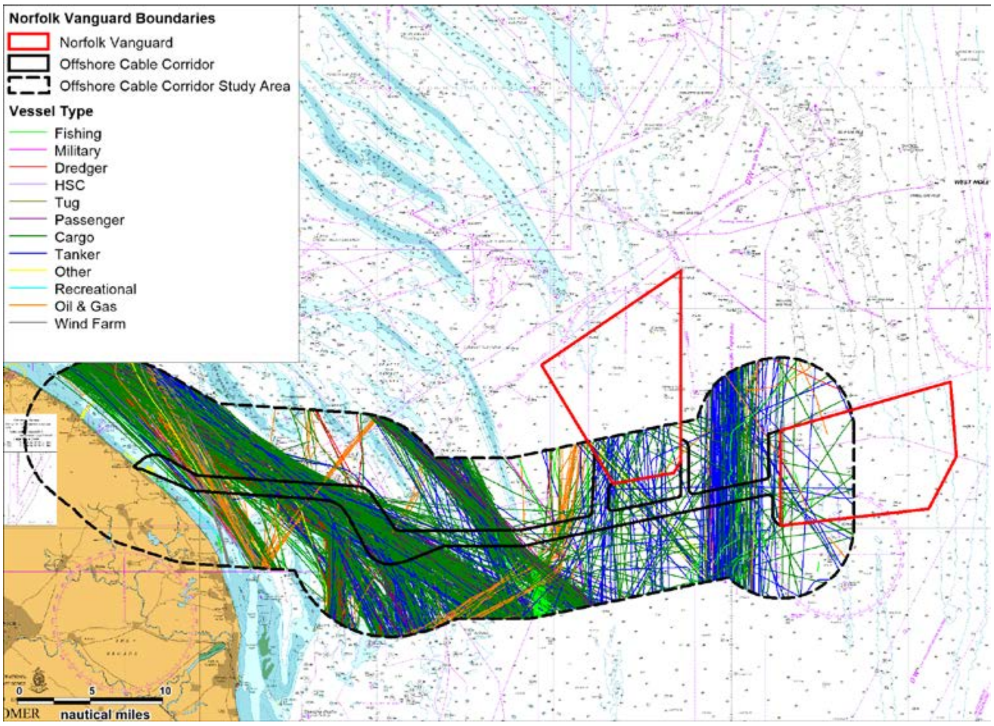

Figure 15.2 Overview of AIS Data Excluding Temporary Tracks (14 Days Winter 2016)

15.3 *Summer Vessel Counts*

222. For the 14 days analysed in summer 2016, there was an average of 96 unique vessels per day passing within the offshore cable corridor study area, recorded on AIS. In terms of vessels intersecting the offshore cable corridor, there was an average of 83 unique vessels per day.

223. Figure 15.3 illustrates the daily number of unique vessels passing through the offshore cable corridor study area during the summer survey period.

224. The busiest day recorded was the 14 September 2016 when 115 unique vessels were recorded. The quietest day recorded was the 18 September 2016 when 80 unique vessels were recorded.

225. Throughout the summer survey period, 80% of traffic recorded within the offshore cable corridor study area intersected the offshore cable corridor.

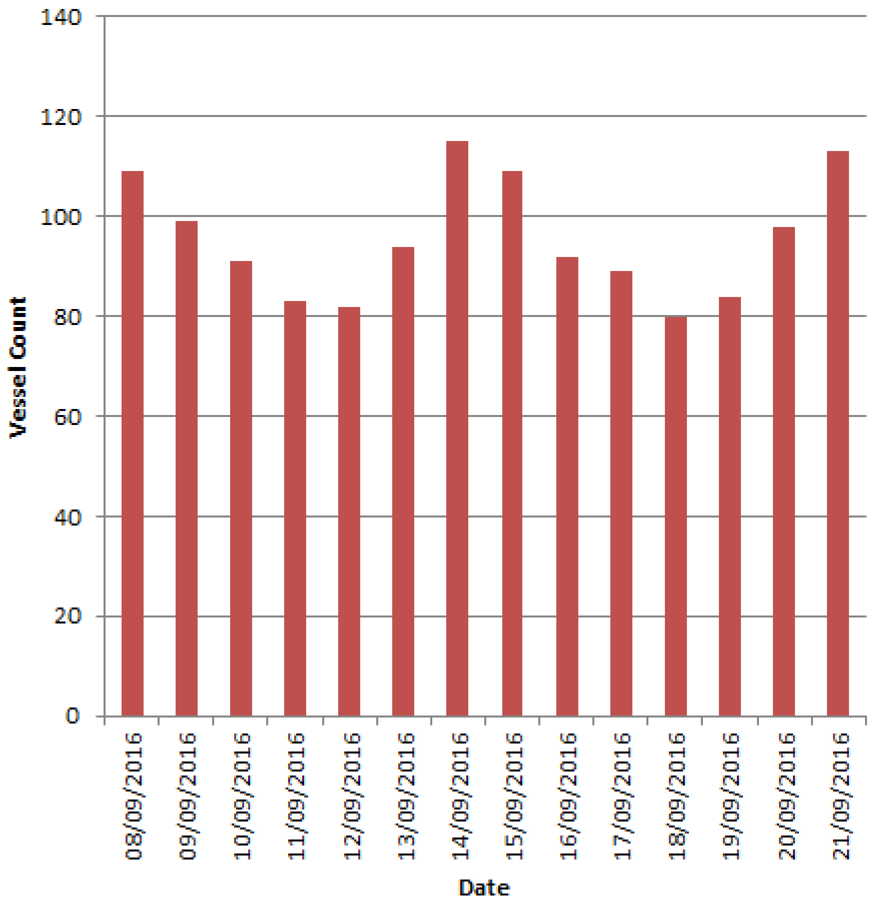

Figure 15.3 Unique Vessels per Day within Offshore Cable Corridor Study Area (14 Days AIS Summer 2016)

15.4 *Winter Vessel Counts*

226. For the 14 days analysed in winter 2017, there was an average of 92 unique vessels per day passing within the offshore cable corridor study area, recorded on AIS. In terms of vessels intersecting the offshore cable corridor, there was an average of 82 unique vessels per day.

227. Figure 15.4 illustrates the daily number of unique vessels passing through the offshore cable corridor study area during the winter survey period.

228. The busiest day recorded was the 16 February 2017 when 122 unique vessels were recorded. The quietest day recorded was the 12 February 2017 when 61 unique vessels were recorded.

229. Throughout the winter survey period, 73% of traffic recorded within the offshore cable corridor study area intersected the offshore cable corridor.

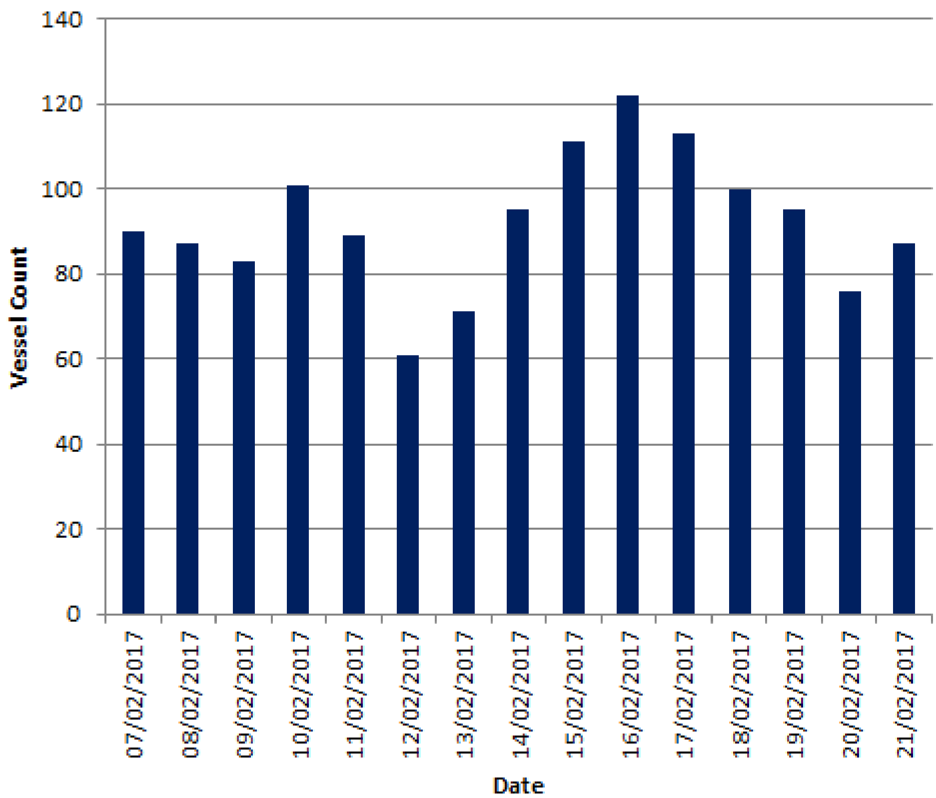

Figure 15.4 Vessel Count – Offshore Cable Corridor – Winter

15.5 *Vessel Types*

230. Analysis of the vessel types recorded passing within the offshore cable corridor study area throughout both survey periods are presented in Figure 15.5. The category of "other" vessels includes those that are not large enough in quantities to mention on their own. This includes training vessels, lifeboat vessels, buoy-laying vessels, search and rescue (SAR) vessels, work vessels and pontoons.

231. There were no unspecified vessels recorded throughout the survey periods.

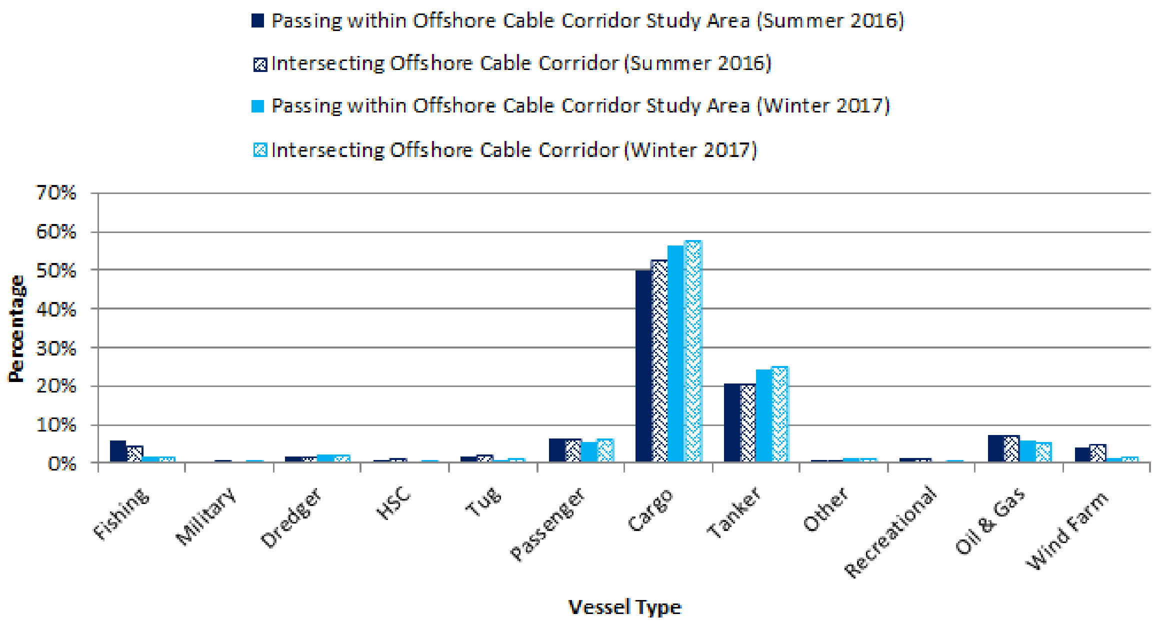

Figure 15.5 Vessel Type Distribution – Offshore Cable Corridor

232. Throughout the summer period, the majority of tracks were cargo vessels (50% within the offshore cable corridor study area) and tankers (21%). Throughout the winter period the majority of tracks were also cargo vessels (56% within the offshore cable corridor study area) and tankers (24%).

233. It should be noted that the cargo vessel category includes commercial Ro Ro cargo vessels (e.g. DFDS Seaways) broadcasting their vessel type as cargo vessel. Details specific to commercial Ro Ro cargo vessels are presented in Section 15.6.

234. Figure 15.6 presents a plot of cargo vessels and tankers, recorded within the offshore cable corridor study area on AIS throughout both the summer and winter survey periods.

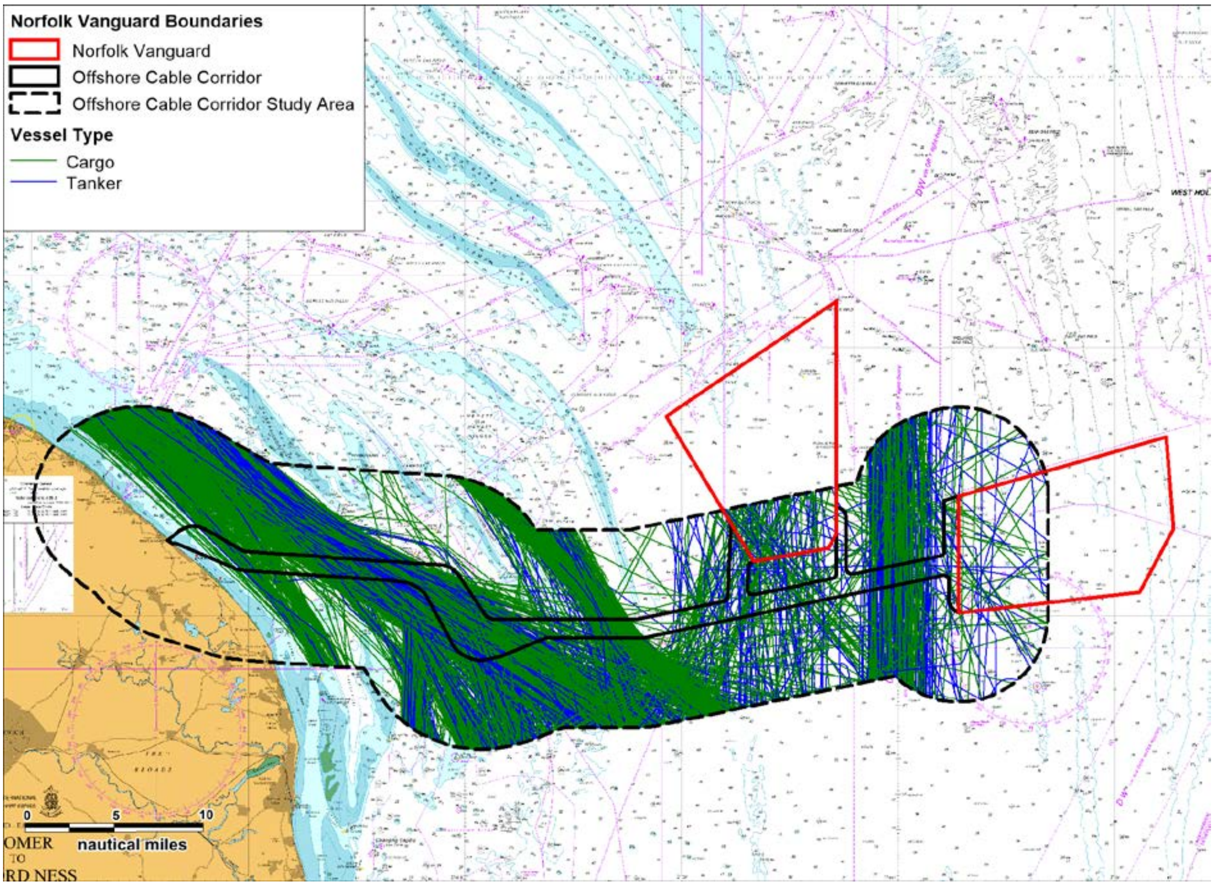

Figure 15.6 Commercial Vessels within the Offshore Cable Corridor Study Area

235. Throughout the combined summer and winter survey period, an average of 50 unique cargo vessels per day passed within the offshore cable corridor study area.

236. Throughout the combined summer and winter survey period, an average of 21 unique tankers per day passed within the offshore cable corridor study area.

237. The AIS data within the offshore cable corridor study area was used as input to Anatec's ShipDensity software. The results are presented in Figure 15.7 and Figure 15.8 for summer and winter respectively. The same density ranges have been used in both figures to allow direct comparison.

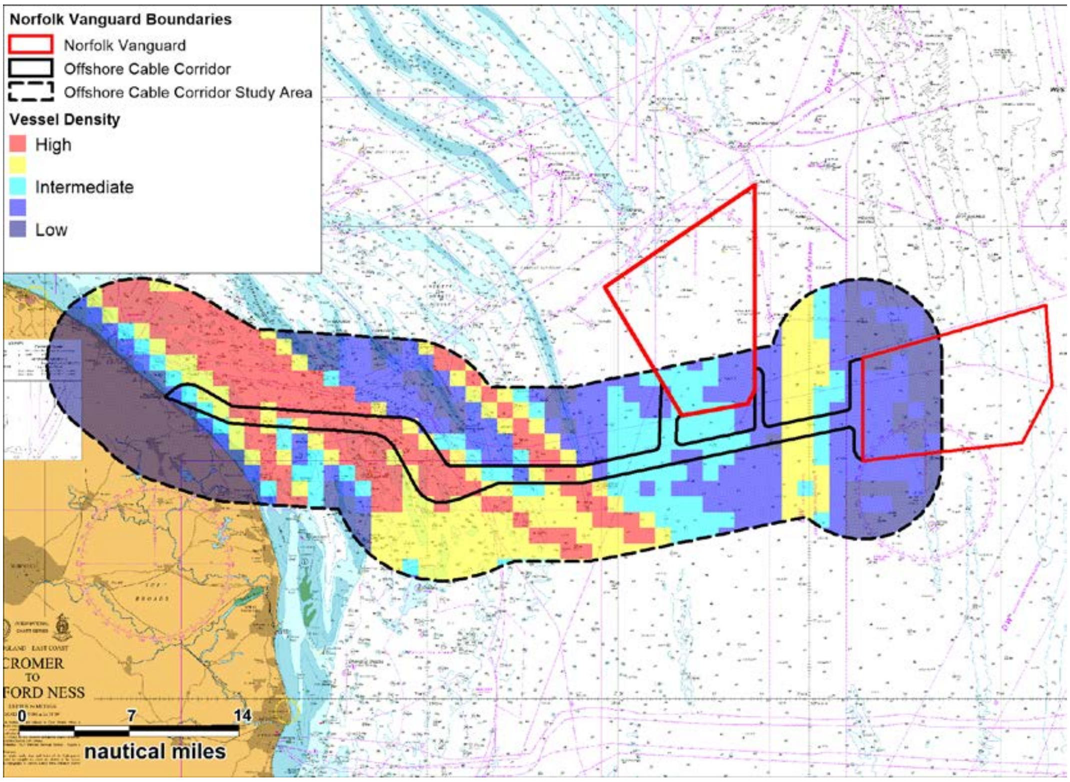

Figure 15.7 Vessel Density – Offshore Cable Corridor - Summer

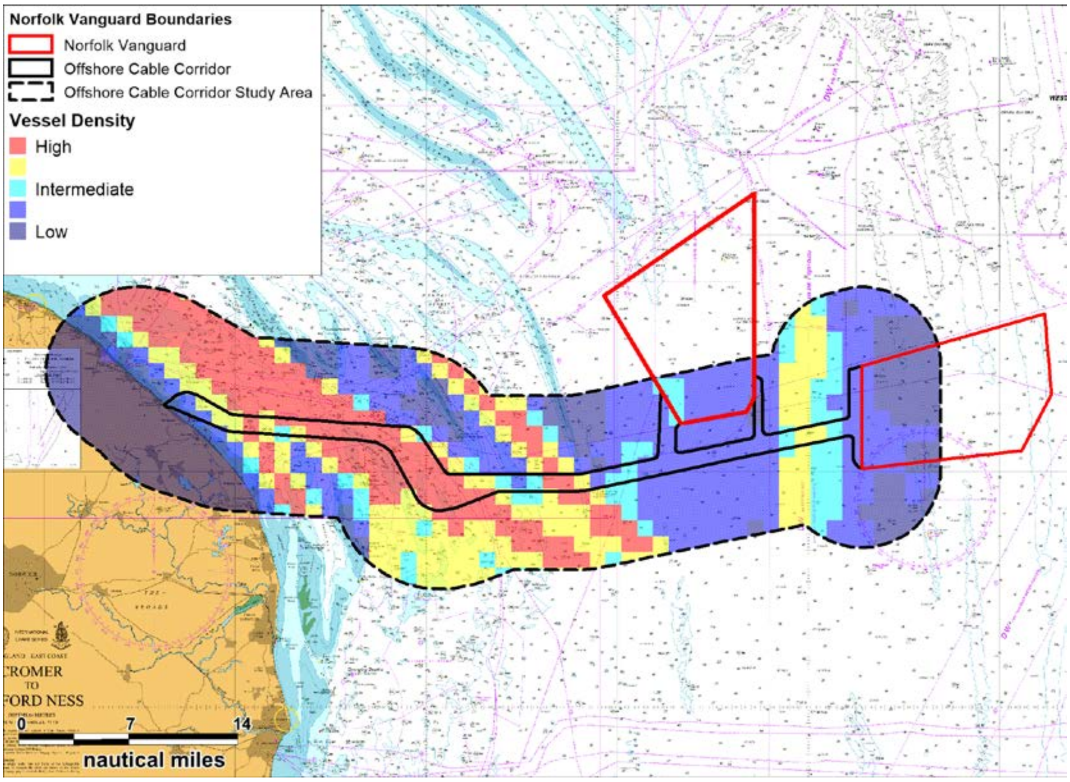

Figure 15.8 Vessel Density – Offshore Cable Corridor – Winter

238. During both summer and winter, the highest density areas were observed to correspond to the busy commercial shipping routes passing west of the OWF sites (see Figure 15.6). These routes produced higher density than that estimated within the DR1 LightBuoy DWR.

239. Density within the area of the offshore cable corridor study area within the vicinity of Norfolk Vanguard West was observed to lower during winter than in summer. This was largely due to fishing activity recorded within summer that was not reflected during the winter period.

15.6 *Ro Ro Vessels*

240. Figure 15.9 presents the commercial Ro Ro vessel tracks colour-coded by route recorded during the marine traffic survey.

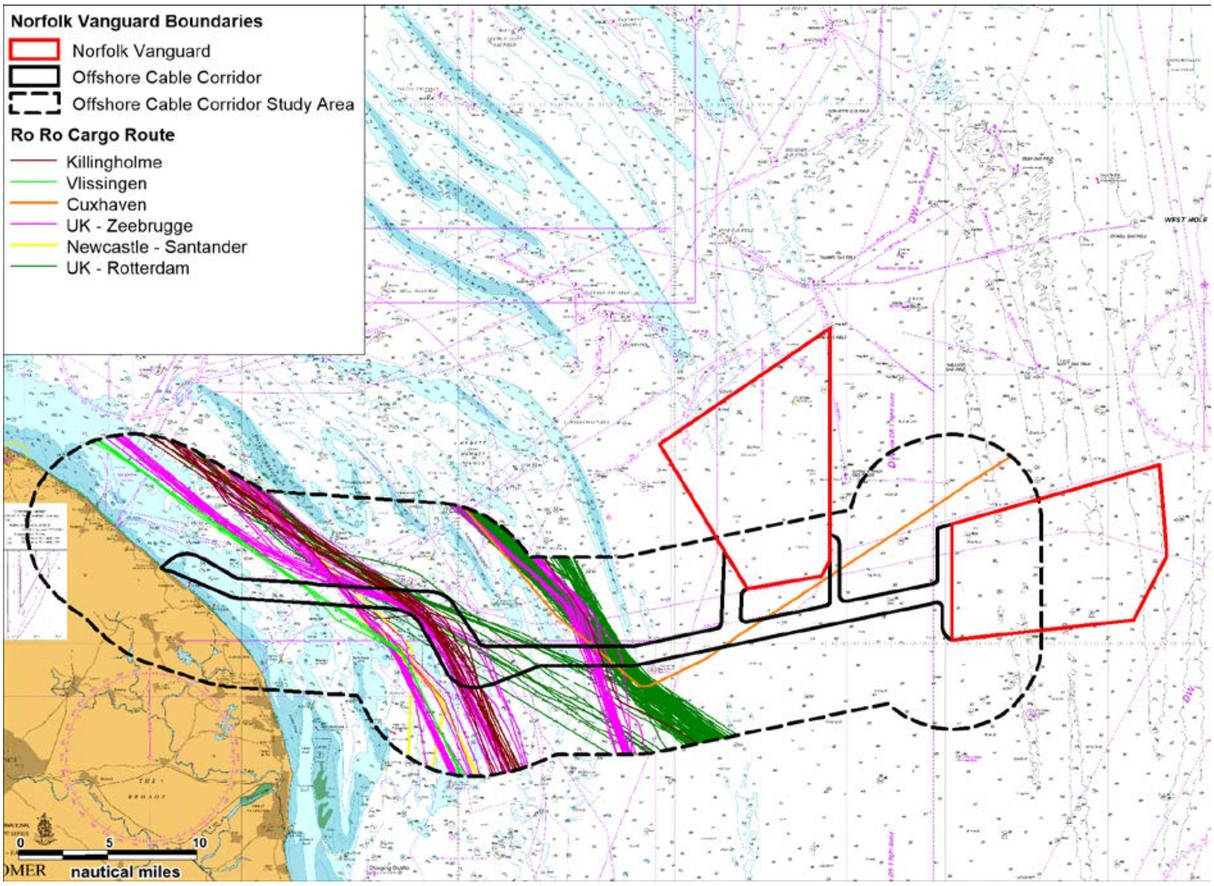

Figure 15.9 AIS Ro Ro Cargo Vessels within the Offshore Cable Corridor Study Area 28 Days Summer 2016 and Winter 2017

241. The UK to Zeebrugge and UK to Rotterdam routes were the busiest routes recorded during the combined summer and winter period. One vessel, the 188 m vehicles carrier, *Jutlandia Seaways* was recorded transiting to Cuxhaven on the 12th February 2017. It is noted there was no adverse weather on this day.

242. Throughout the combined summer and winter survey period, an average of seven unique Ro Ro cargo vessels per day passed within the offshore cable corridor study area.

15.7 *Recreational Activity*

243. Figure 15.10 presents the recreational tracks recorded during the marine traffic survey. As per Recreational Craft Regulations 2004 (Directives 94/25/EC and 2003/44/EC), sailing vessels and motor craft recorded as between 2.5 and 24m in length have been classed as recreational vessels.

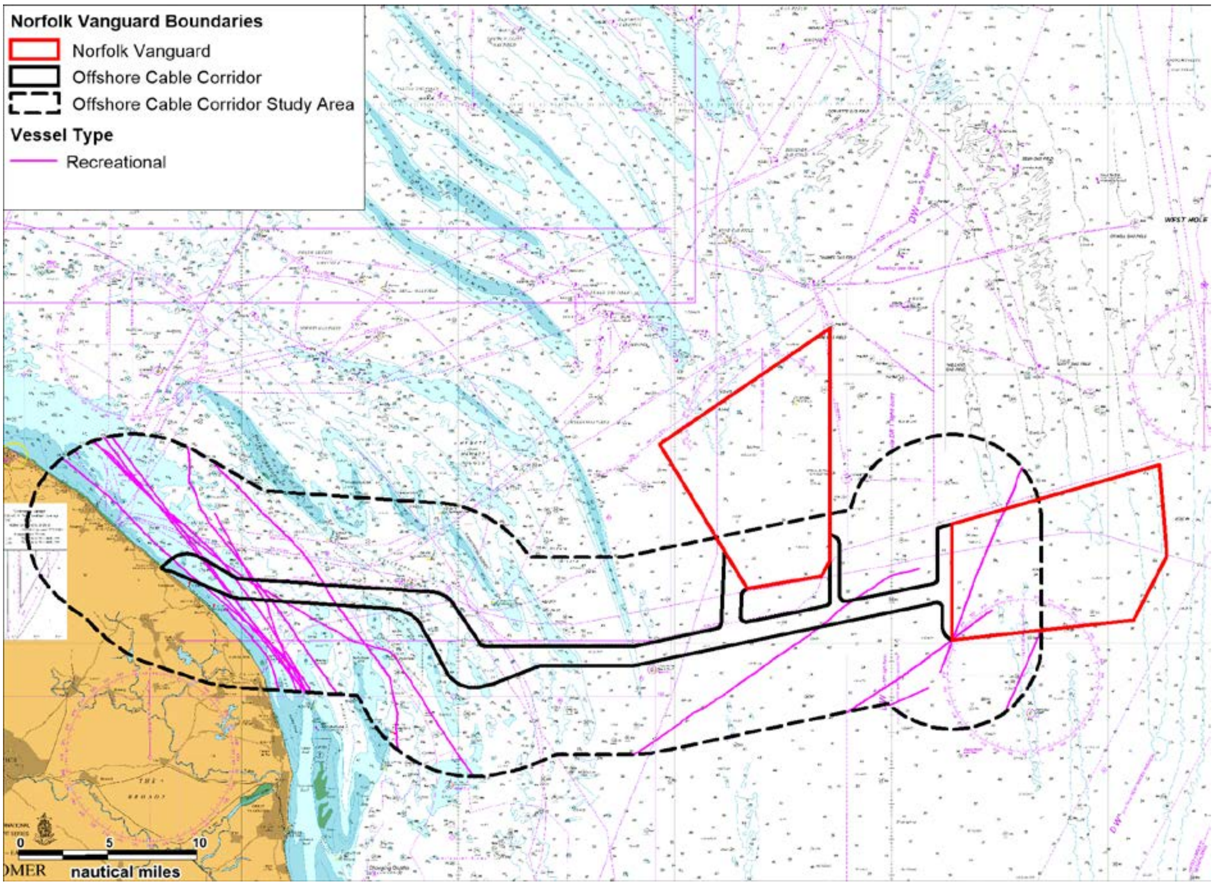

Figure 15.10 AIS Recreational Vessels within the Offshore Cable Corridor Study Area 28 Days Summer 2016 and Winter 2017)

244. Throughout the summer survey period, an average of one unique recreational craft per day passed within the offshore cable corridor study area. Only two unique recreational craft were recorded throughout the winter survey period. There were therefore significantly more recreational craft during the summer survey period than the winter survey period.

245. A zoomed in plot of the recreational activity relative to the landfall site is presented in Figure 15.11.

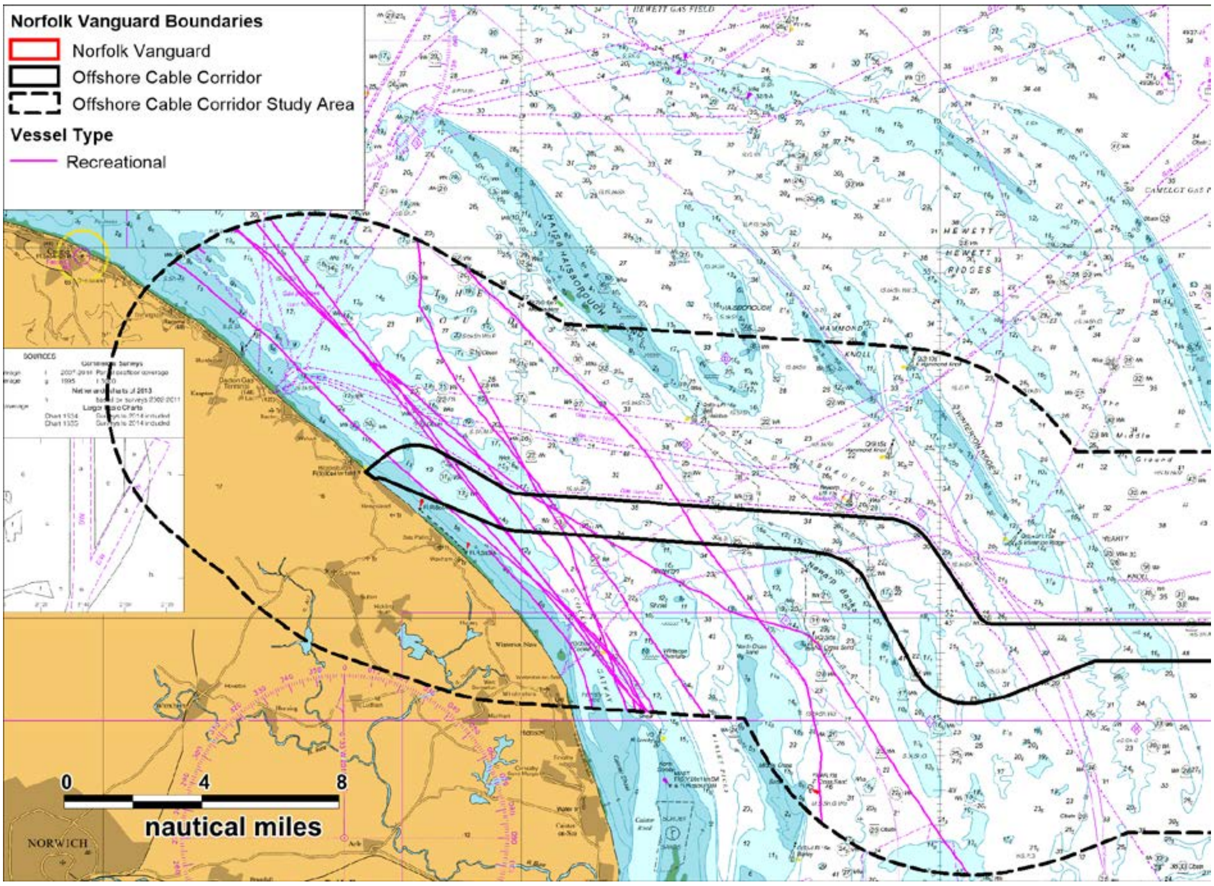

Figure 15.11 Recreational Activity – Landfall Site

15.8 *Fishing Activity*

246. Fishing vessel activity recorded during the AIS traffic surveys colour-coded by gear type is presented in Figure 15.12.

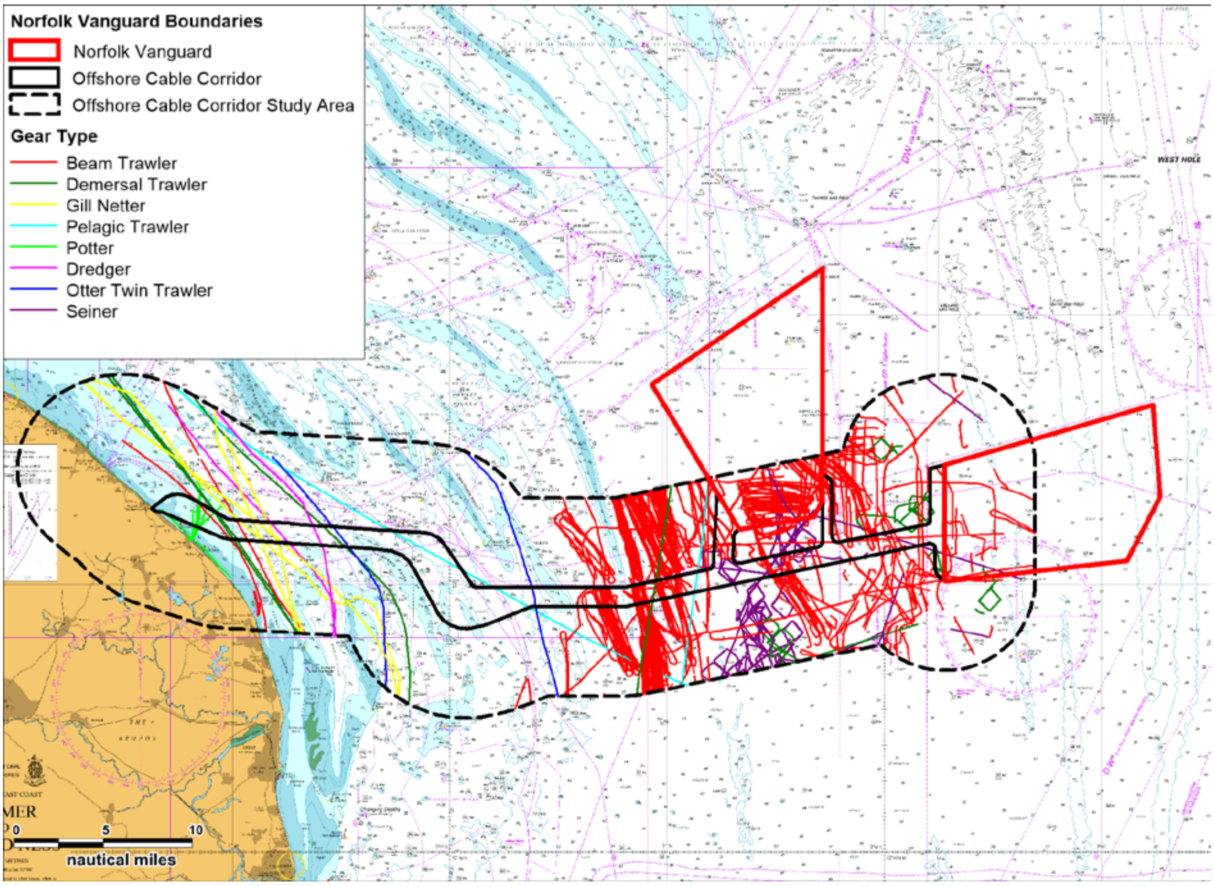

Figure 15.12 Fishing Vessels within Offshore Cable Corridor

247. The majority of fishing vessels recorded were beam trawlers (73%). Seiner fishing vessels were also common (12%). There were no vessels whose gear type was unable to be identified.

248. Significant beam trawling was recorded within the offshore cable corridor in the vicinity of the OWF sites. Active demersal trawling and seiner activity was also recorded in this area. Coastally, vessels tended to be on passage, rather than engaged in active fishing, however potting activity associated with vessels from Sea Palling was recorded near the cable landfall site.

249. Throughout the combined summer and winter survey period, an average of three to four unique fishing vessels per day were recorded within the offshore cable corridor study area. Of the fishing vessels recorded, the most common nationality identified was the Netherlands (66%) followed by the UK (20%). Other nationalities identified included Belgium (7%), France (5%) and Denmark (1%).

250. A zoomed in plot of the fishing vessel activity relative to the landfall site is presented in Figure 15.13.

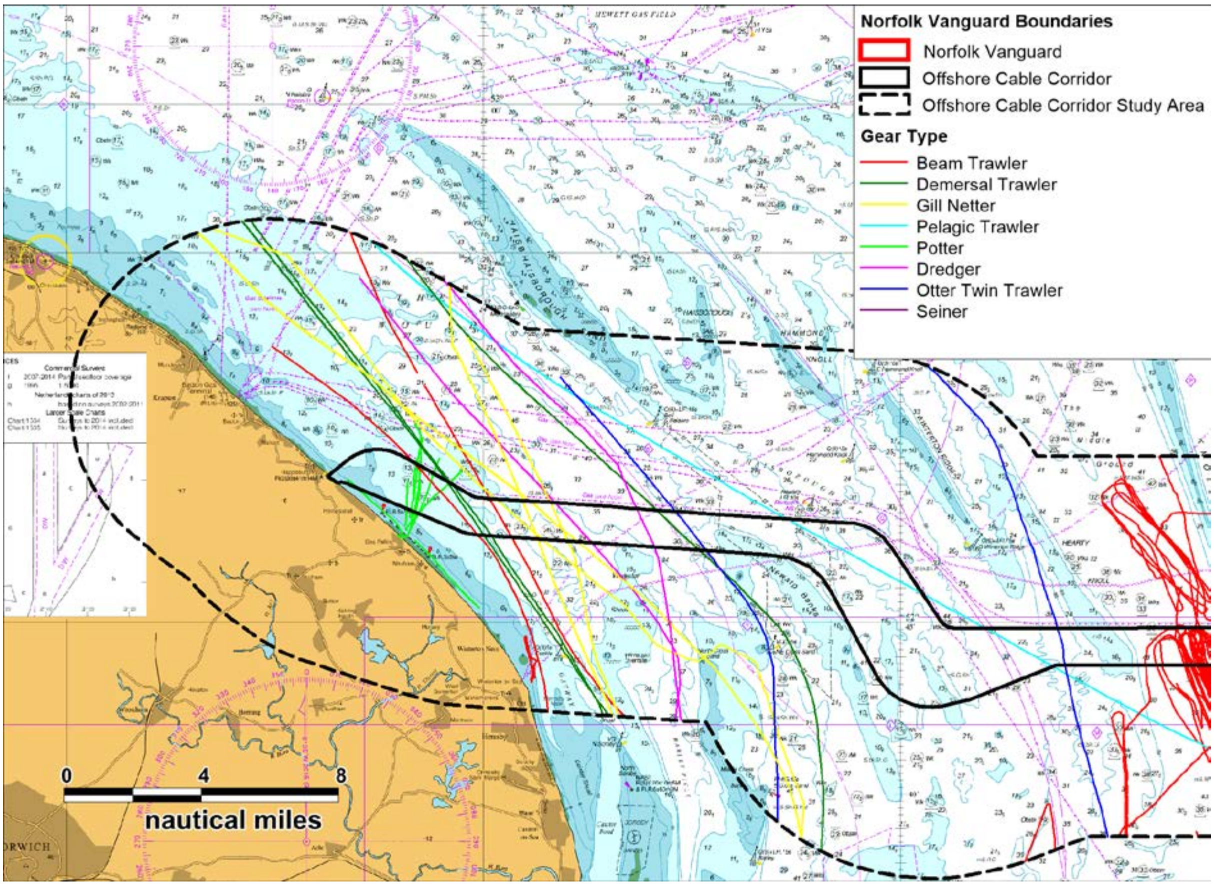

Figure 15.13 Fishing Vessel Activity – Landfall Site

15.9 *Anchoring Activity*

251. Over the 28 day period studied, two vessels were recorded at anchor within the study area surrounding the cable corridor, both during the winter period. The positions of these vessels while at anchor are presented in Figure 15.14.

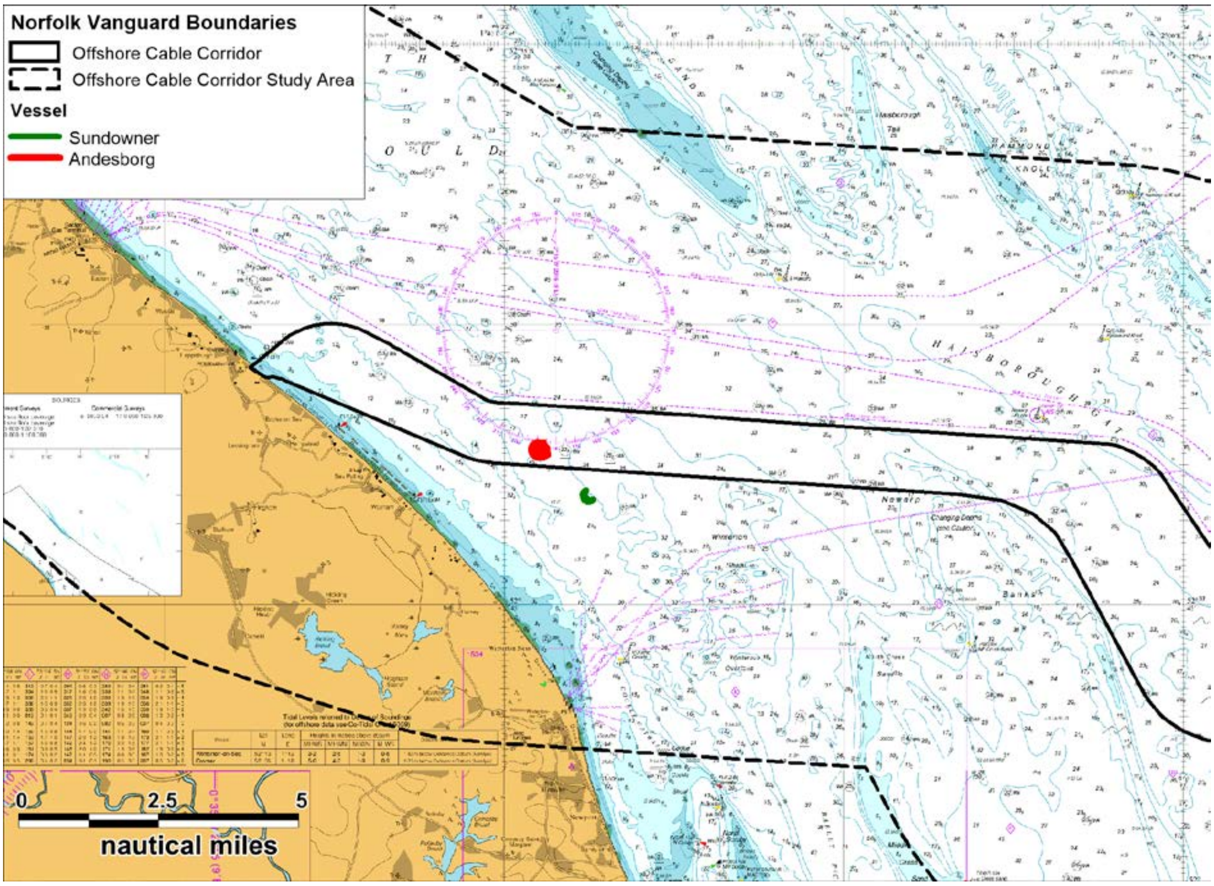

Figure 15.14 Anchored Vessels within Cable Corridor

252. The *Andesborg*, a 142m cargo vessel was recorded at anchor within the cable corridor, approximately six nautical miles from the landfall site. The vessel anchored for approximately a week awaiting orders, before departing eastbound for Hamburg.

253. The *Sundowner*, an 87m tanker, was recorded anchoring approximately 0.3nm south of the cable corridor. The vessel anchored for approximately 24 hours, before departing northbound for Immingham. It is noted that this vessel was recorded multiple times in the area during both the summer and winter periods, running between Immingham, and mainland European ports (Antwerp, Rotterdam, and Terneuzen).

254. It is noted that anchoring activity from non-AIS vessels will not be reflected in the above figure. As discussed in Section 8.3, the Pilot Book (UKHO 2016) states that anchorage is available in the Would off the coast between Bacton and Winterton Ness, and there is therefore the potential that recreational or fishing vessels may anchor within the area.

16. Adverse Weather

255. Adverse weather includes wind, wave and tidal conditions as well as reduced visibility due to fog that can hinder a vessel's normal route and / or speed of navigation. Adverse weather routes are assessed to be significant course adjustments to mitigate vessel movement in adverse weather conditions. When transiting in adverse weather conditions, a vessel is likely to encounter various kinds of weather and tidal phenomena, which may lead to severe roll motions, potentially causing damage to cargo, equipment and / or danger to persons on board. The sensitivity of a vessel to these phenomena will depend on the actual stability parameters, hull geometry, vessel type, vessel size and speed.

256. The probability of occurrence in a particular sea state may differ for each vessel. Adverse weather is considered most significant for passenger vessels, due to the potential health and safety risks (as well as the effect on passenger comfort) to people on board (such as sea sickness and difficulty moving around the vessel). This can also have implications for regular timetabled vessels, due to increases in journey time and potential cancellations. Mitigations for vessels include adjusting their heading to position themselves 45° the wind, altering or delaying sailing times, reducing speed and potentially cancelling journeys.

257. One vessel, the *Princess Seaways*, was recorded adverse routeing through the OWF sites on 27 September 2016 – see Figure 16.1. The *Princess Seaways* was recorded transiting closer to the UK coast and then crossing the North Sea at a more southerly point than her usual route so as to be protected from the south westerly winds. It is noted that on the 27 September the sea state was reported to be moderate and the wind speed was at its highest during the survey period (five to six on the Beaufort wind force scale).

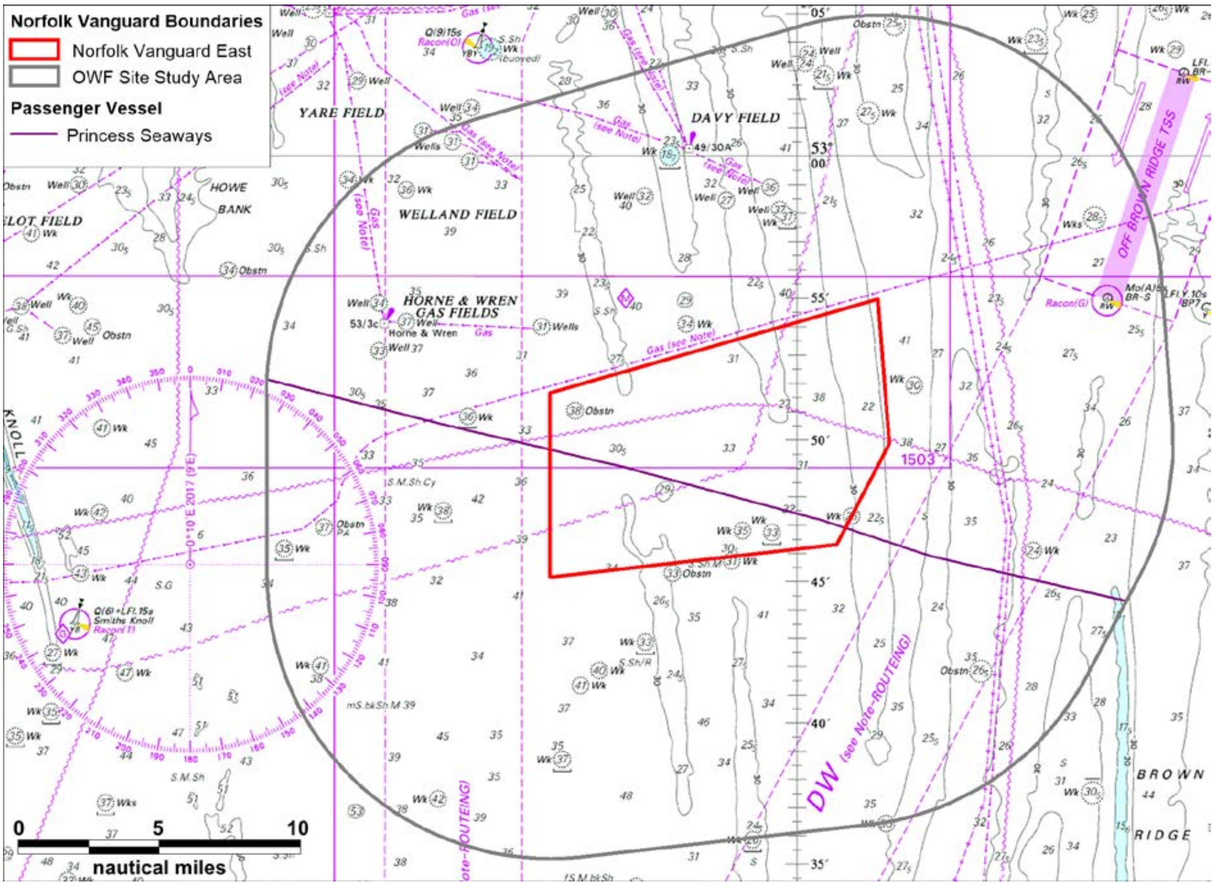

Figure 16.1 Princess Seaways Adverse Weather Route on the 27 September 2016.

17. DWR Analysis

17.1 *Introduction*

258. As highlighted during consultation undertaken for this NRA (see section 5), a thorough understanding of the current traffic volumes and routeing patterns within the DWRs is imperative to predicting the future case. This section presents an analysis of vessel numbers within the DWRs, and compares the separation distances between the OWF sites and the DWRs against the relevant MCA guidance. It is noted that during consultation, Rijkwaterstaat (2014) provided guidance on recommended safe separation distances between wind farms and shipping traffic lanes. As the proposed project is within UK waters, the MCA guidance remains the primary source, however the Rijkwaterstaat guidance has also been considered within this section.

17.2 *DWR Numbers*

259. Long term AIS data collected during 2016 from the northern Met Mast was used to estimate vessel numbers within the DWR. The estimated results are compared with the corresponding numbers using the marine traffic survey data in Table 17.1. It is noted that the numbers have been factored up to account for downtime observed in the Met Mast data, and that months during 2016 with significant downtime have not been included in the analysis.

Table 17.1 Estimated DWR Vessels Numbers

Deep Water Route		Estimated Vessels per Day	
		Met Mast	**NRA Marine Traffic Survey**
DR1 Lightbuoy	Northbound	4 to 5	5 to 6
	Southbound	5	5 to 6
West Friesland	Northbound	12	11 to 12
	Southbound	16	17

17.3 *DWR and Wind Farm Separation Distances*

17.3.1 MCA Guidance

260. Annex 3 of MGN 543 (MCA 2016) provides a template from which the required width of shipping lanes located in a corridor between two or more wind farm sites can be calculated. Where such a lane exists, the MCA require that there is room within the corridor between the wind farms for a vessel to deviate up to 20°. The DR1 Lightbuoy

DWR passes between the OWF sites, and it was therefore necessary to check the DWR against the guidance.

261. To ensure compliance cumulatively, an analysis of the required route width when Norfolk Boreas and East Anglia Three were included has been undertaken (noting that Norfolk Boreas has not yet been submitted for applications and East Anglia Three is awaiting consent). When multiple wind farms are considered, there is some difficulty in defining where the shipping corridor between the sites begins and ends. For this reason, it has simply been assumed that the cumulative corridor extends from the northernmost point of Norfolk Vanguard to its most southerly point, totalling 17.1nm in length, as shown in Figure 17.1. This ensured there were always wind turbines on at least one side of the defined corridor. It is noted that this leaves an excess section of corridor to the south of Norfolk Vanguard West where wind turbines are only present to the east of the corridor, however this was considered the best approach, as it adds conservatism to the analysis, and ensures Norfolk Vanguard remains the focus of the cumulative assessment.

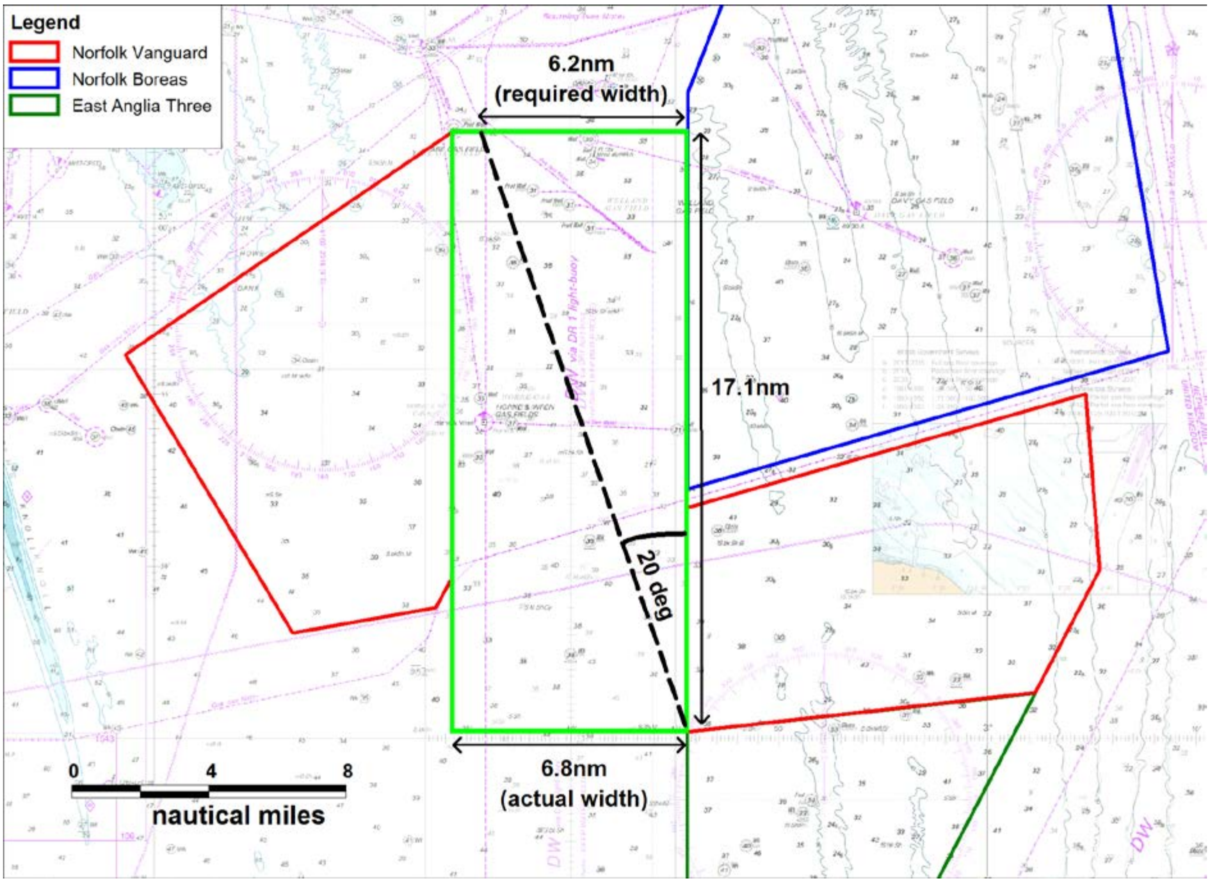

Figure 17.1 Cumulative Assessment of Norfolk Vanguard Corridor Width

262. Based on the corridor length of 17.1nm, and the required deviation angle of 20°, the required corridor width was estimated at 6.2nm. As shown in Figure 17.1, the actual width between the OWF sites is 6.8nm, and the corridor is therefore compliant with the MCA requirements.

17.3.2 Rijkwaterstaat Guidance

263. During consultation, Rijkwatersaat provided Anatec with guidance relating to recommended separation distances between wind farms and passing traffic (Rijkwaterstaat, 2014). Norfolk Vanguard is within UK waters and is therefore subject to MCA requirements. It is also noted that separation distances between the OWF sites and the DWRs have been agreed with both TH and the MCA. However, to ensure transboundary issues are addressed, the proposed project has been compared with the Dutch guidance in this section.

264. The recommended separation distances between offshore wind farms and passing vessels given within the Dutch IMO guidance are presented in Table 17.2.

Table 17.2 Separation Distances between Wind Farms and Passing Traffic

Vessel Length	Port (nm)	Starboard (nm)
400m	1.57	1.87
300m	1.24	1.54

265. The greatest recommended separation distance is 1.87nm, for a 400m vessel on its starboard side. An analysis of the vessels using the West Friesland DWR showed that the largest vessel recorded during 2016 from the Met Mast data (see Section 17.2) was 400m in length, and it is considered unlikely that larger vessels would be a regular occurrence. Therefore, as the 2nm spacing between the DWR and Norfolk Vanguard East exceeds the 1.87nm requirement (illustrated in Figure 17.2), the spacing is considered compliant with the Dutch IMO guidance.

266. As spacing between the DR1 Lightbuoy DWR and the OWF sites was 1nm, further analysis was necessary to demonstrate compliance with the Dutch IMO Guidance. Figure 17.2 presents the boundaries of the OWF sites relative to a 1.87nm separation distance within the corridor defined in Section 17.3.1.

267. It can be seen that when applied, the larger separation distance recommended for a 400m vessel (1.87nm to starboard) still leaves a clear space of 3.1nm on the port side within the DWR. As the largest vessel recorded within the DWR by the Met Mast during 2016 was 396m, the corridor is considered compliant with the Rijkwaterstaat Guidance (2014).

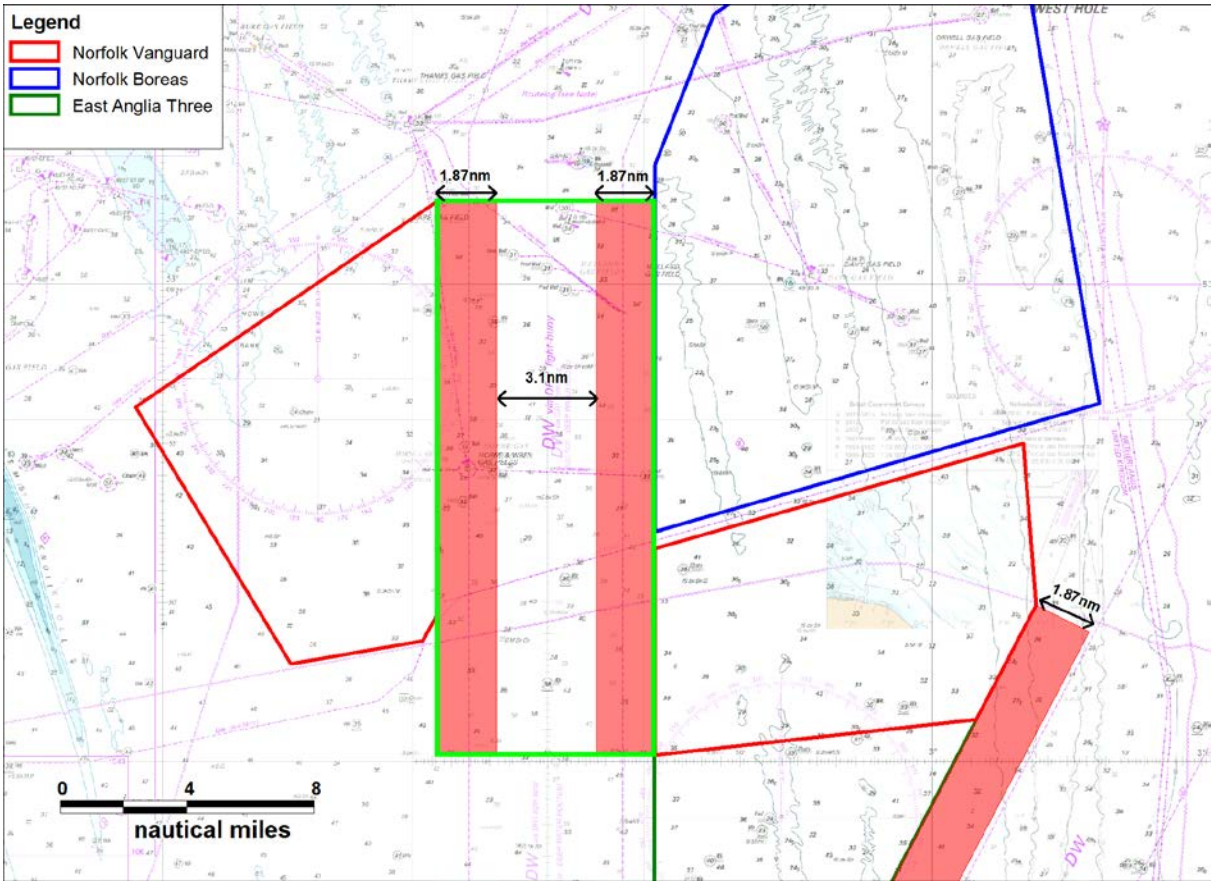

Figure 17.2 Norfolk Vanguard and DR1 Lightbuoy DWR – 1.87nm Separation Distance

17.4 *Structure Alignment on DWR Boundaries*

268. It will be ensured that structure alignment on the boundaries facing the DWRs will be consistent with East Anglia One and East Anglia Three. As per the request of TH (see section 5), lighting of the OWF sites should include consideration of lighting at East Anglia Three, including within the DWR.

269. It will also be ensured that mooring buoys within the OWF sites will not be placed on boundaries facing the DWRs.

270. Impacts associated within the development on Norfolk Vanguard and other cumulative projects are assessed further within Chapter 15 Shipping and Navigation.

18. Base Case Routeing Analysis

18.1 *Introduction*

271. The marine traffic survey data shown in section 12 was used to identify the main vessel routes within 10nm of the OWF sites. The information transmitted via AIS was used to estimate the types and sizes of vessels using each route, and the origin / terminus ports. Anatec's internal UK-wide route database and the charted IMO Routeing measures were then used to validate the findings, and to extend the routes beyond the 10nm threshold of the AIS data.

272. As described in Section 17, additional validation of the vessel numbers within the DWRs has also been undertaken.

273. In addition to being the basis for the 90^{th} percentile analysis provided below, the final routes were also used as input to the collision and allision risk modelling for the proposed project, as summarised in Section 20.

18.2 *Main Routes*

274. The main routes identified are presented in Figure 18.1, with a summary of each route then presented in Table 18.1. It is noted that the origin and destination ports for each route shown represent the most common destinations transmitted via AIS by vessels using those routes within the study area. Actual destinations and origin ports may vary per route.

18.3 *Main Route 90th Percentiles*

275. The AIS and Radar data and Anatec's internal ship routes database were used to estimate the 90^{th} percentiles within the study area surrounding the OWF sites. The 90^{th} percentiles are presented in Figure 18.2.

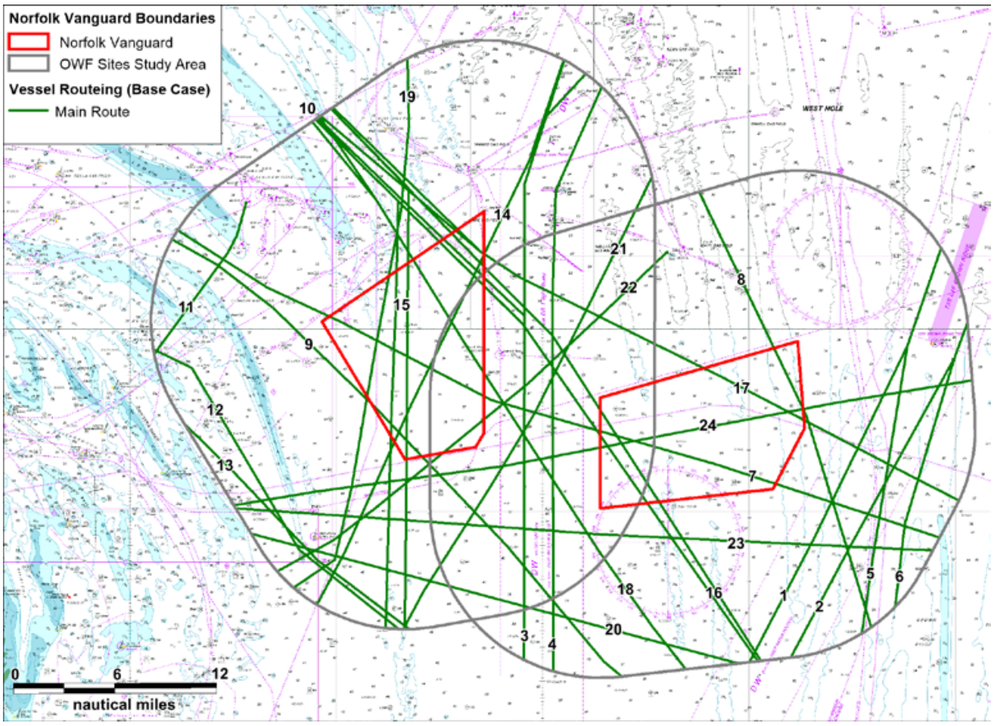

Figure 18.1 Main Traffic Routes within 10nm of Norfolk Vanguard

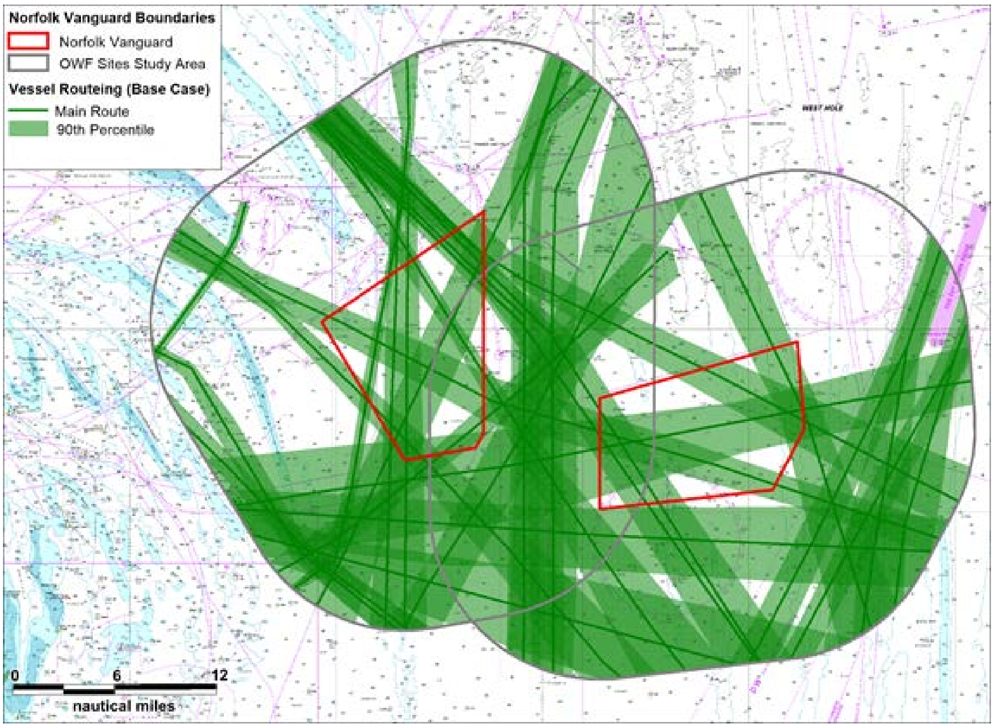

Figure 18.2 Main Traffic Route 90th Percentiles

Table 18.1 Route Summary

Route	Main Origin / Terminus	Vessels per Day	Intersects Norfolk Vanguard West	Intersects Norfolk Vanguard East	Comments
1	Off Brown Ridge TSS / Rotterdam	17	No	No	Southbound traffic leaving the Off Brown Ridge TSS and transiting the DWR.
2	Rotterdam / Off Brown Ridge TSS	11	No	No	Northbound traffic in the West Friesland DWR, bound for the TSS.
3	Off Botney TSS / Rotterdam	4	No	No	Southbound traffic in the DR1 Lightbuoy DWR, originating from the Off Botney TSS.
4	Rotterdam / Off Botney TSS	5	No	No	Northbound traffic in the DR1 Lightbuoy DWR, bound for the Off Botney TSS.
5	Off Brown Ridge TSS / Rotterdam	4	No	No	Southbound traffic leaving the Off Brown Ridge TSS, but then exiting the DWR.
6	Rotterdam / Off Brown Ridge TSS	3	No	No	Northbound traffic joining the West Friesland DWR at the access point to the northbound lane of the TSS.
7	Amsterdam – Immingham	< 1	Yes	Yes	Commercial traffic route which crosses both DWRs and intersects both OWF sites.
8	Rotterdam – Tees	< 1	No	Yes	Commercial traffic route which intersects Norfolk Vanguard East and crosses the West Friesland DWR.
9	Rotterdam – Immingham	1	Yes	No	Commercial traffic route which intersects Norfolk Vanguard West and crosses the DR1 Lightbuoy DWR.
10	Antwerp – Immingham	< 1	Yes	No	Commercial traffic route utilising the DR1 Lightbuoy DWR. Route intersects Norfolk Vanguard West.

Route	Main Origin / Terminus	Vessels per Day	Intersects Norfolk Vanguard West	Intersects Norfolk Vanguard East	Comments
11	Great Yarmouth – Leman Field	< 1	No	No	Oil and gas route associated with the Leman field.
12	Killingholme – Rotterdam	2	No	No	Commercial traffic route. Includes commercial ferry traffic between the UK and mainland Europe (DFDS and P&O).
13	Immingham – Rotterdam	7 to 8	No	No	Commercial traffic route. Includes commercial ferry traffic between the UK and mainland Europe (DFDS and P&O).
14	Northfleet – Jelsa	1	Yes	No	Commercial traffic route intersecting Norfolk Vanguard West. Route adjoins DR1 Lightbuoy DWR.
15	Grangemouth – Antwerp	< 1	Yes	No	Commercial traffic route intersecting the Norfolk Vanguard West site.
16	Rotterdam – Tees	< 1	Yes	Yes	Commercial traffic route intersecting both OWF sites and crossing both DWRs.
17	Grangemouth – Amsterdam	< 1	Yes	Yes	Commercial traffic route intersecting both OWF sites and crossing both DWRs.
18	Grangemouth – Rotterdam	< 1	Yes	No	Commercial traffic route intersecting Norfolk Vanguard West and crossing both DWRs.
19	Great Yarmouth – Victor Field	< 1	Yes	No	Oil and gas route mainly associated with the Victor field. Route intersects Norfolk Vanguard West.
20	Immingham – Amsterdam	1	No	No	Commercial traffic route passing south of the OWF sites and crossing both DWRs.
21	Rochester – Bergen	< 1	No	No	Commercial traffic route passing between the OWF sites, and crossing the DR1 Lightbuoy DWR.

Route	Main Origin / Terminus	Vessels per Day	Intersects Norfolk Vanguard West	Intersects Norfolk Vanguard East	Comments
22	Great Yarmouth – Davy Field	< 1	Yes	No	Oil and gas route associated with the Davy field. Intersects Norfolk Vanguard West and crosses the DR1 Lightbuoy DWR.
23	The Wash – Hamburg	< 1	No	No	Cargo vessel route passing south of the OWF sites and crossing both DWRs
24	Great Yarmouth – Hamburg	< 1	No	No	Cargo vessel route intersecting Norfolk Vanguard East and crossing both DWRs.

19. Future Case Commercial Vessel Routeing

19.1 *Introduction*

276. This section assesses the potential impacts of Norfolk Vanguard on each of the main routes identified in Section 18. For each route which may deviate, the worst case from a modelling perspective has been presented both when considering Norfolk Vanguard in isolation and cumulatively with other offshore wind farm developments scoped into the cumulative assessment.

277. For the modelling of Norfolk Vanguard in isolation, the 10nm OWF study area used for the previous analysis is considered. Vessels were assumed to deviate at a minimum distance of 1nm from the wind farm structures, with the exception of vessels re-routed into a DWR, in which case it was assumed they would join the existing DWR traffic, as this was the worst case from a vessel to vessel collision point of view.

278. For the modelling of Norfolk Vanguard cumulatively with other offshore wind farm developments, a 25nm buffer of Norfolk Vanguard was considered in order to take into account other offshore wind farms in the region. This larger study area incorporates the proposed Norfolk Boreas and East Anglia Three projects in their entirely, and the East Anglia One North and Scroby Sands sites in part. Array layouts were not considered for developments other than Norfolk Vanguard. Therefore, with the exception of Norfolk Vanguard, vessels were assumed to deviate at a minimum distance of 1nm from the Area for Lease (AfL) boundaries of those offshore wind farm developments scoped into the cumulative assessment. The same protocol regarding re-routeing into DWRs for the modelling of Norfolk Vanguard in isolation was applied for the modelling of Norfolk Vanguard cumulatively with other offshore wind farm developments.

19.2 *Norfolk Vanguard in Isolation Assessment*

19.2.1 Route Deviations

279. The modelled deviations for Norfolk Vanguard in isolation are presented in Figure 19.1[1], relative to a 1nm buffer of the wind turbines. Following this, the results of using the future case routes as inputs to Anatec's AIS Simulator software is presented in Figure 19.2[1]. The simulated AIS has been shown relative to the structure positions that have been used as input to the modelling (see Section 20).

[1] As per Section 20.2.1, the worst case layout presented contains more structures than are currently under consideration within the most up to date Project Design Envelope.

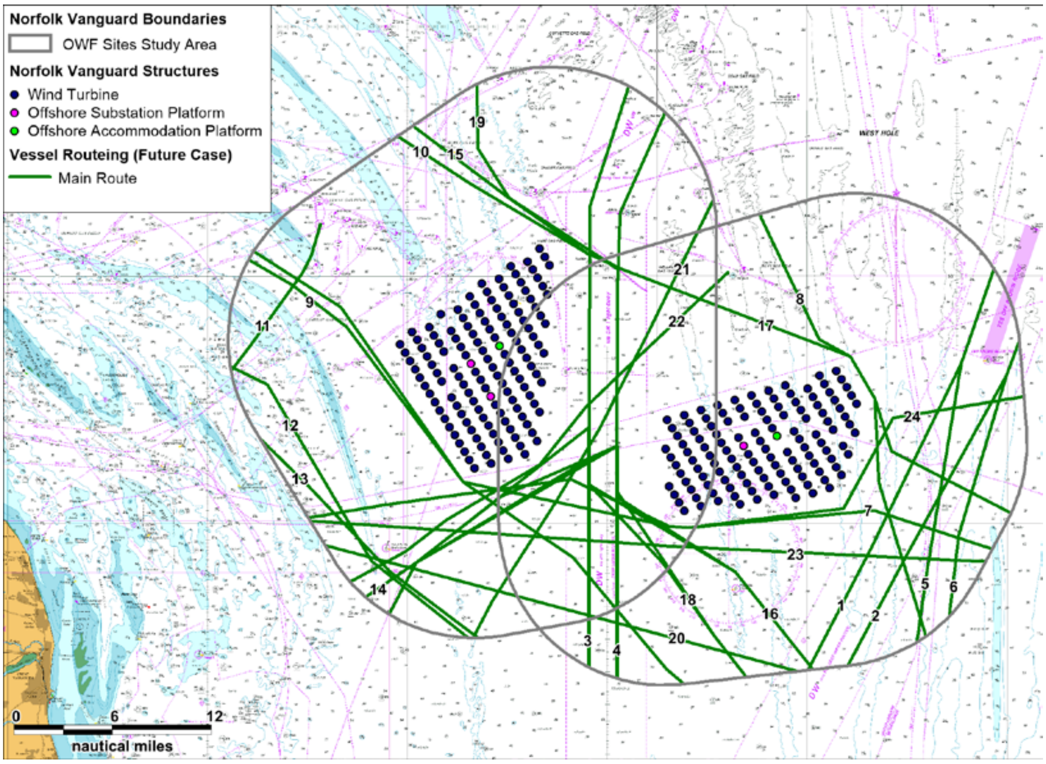

Figure 19.1 Vessel Routeing – Norfolk Vanguard in Isolation Future Case Deviations

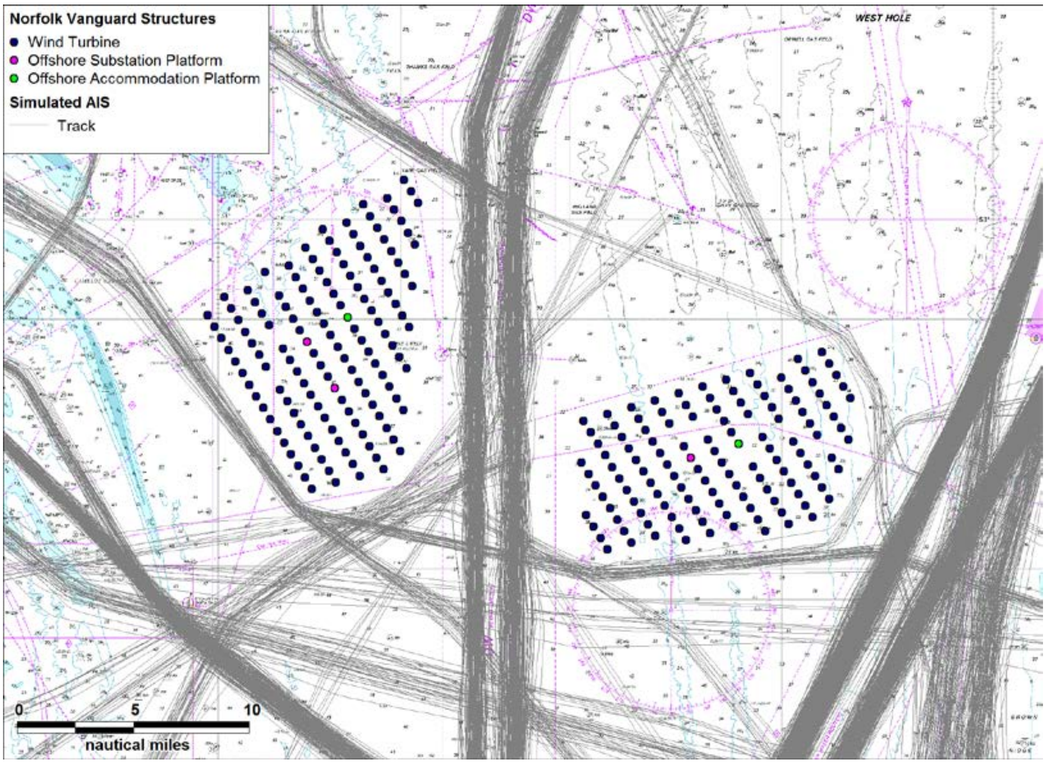

Figure 19.2 Simulated AIS – Norfolk Vanguard in Isolation Future Case

19.2.2 Journey Distance Changes

280. Increased route lengths between the base and future cases are provided in Table 19.1.

Table 19.1 Summary of Norfolk Vanguard in Isolation Route Deviations

Route	Main Origin / Terminus	Vessels per Day	Change in Length (nm)	Change (%)
7	Amsterdam to Immingham	1	3.50	2.0%
	Immingham to Amsterdam		3.50	2.0%
8	Rotterdam to Tees	1	0.77	0.3%
	Tees to Rotterdam		0.77	0.3%
9	Rotterdam to Immingham	1	0.25	0.1%
	Immingham to Rotterdam		0.25	0.1%
10	Antwerp to Immingham	1	1.81	0.9%
	Immingham to Antwerp		1.82	0.9%
14	Northfleet to Jelsa	1	3.56	1.9%
	Jelsa to Northfleet		2.71	1.5%
15	Grangemouth to Antwerp	1	3.99	1.0%
	Antwerp to Grangemouth		1.46	0.4%
16	Tees to Rotterdam	1	4.49	1.7%
	Rotterdam to Tees		4.03	1.5%
17	Grangemouth to Amsterdam	0 to 1	1.16	0.3%
	Amsterdam to Grangemouth		0.96	0.3%
18	Grangemouth to Rotterdam	0 to 1	3.87	1.1%
	Rotterdam to Grangemouth		3.56	1.0%
19	Great Yarmouth to Victor Field	1	11.00	13.8%
	Victor Field to Great Yarmouth		8.90	11.5%
22	Great Yarmouth to Davy Field	0 to 1	0.18	0.4%
	Davy Field to Great Yarmouth		0.18	0.4%
24	Great Yarmouth to Hamburg	0 to 1	3.65	3.3%
	Hamburg to Great Yarmouth		3.65	3.3%

281. It is noted that no deviated route carries more than approximately one vessel per day. Those routes which were found to be transited by more than one vessel per day were either those routes utilising the DR1 Lightbuoy and West Friesland DWRs or the commercial ferry routes to the south-west of the OWF sites study area; these routes are not impeded by the proposed project.

19.3 *Norfolk Vanguard Cumulative Assessment*

19.3.1 Route Deviations

282. The modelled deviations for Norfolk Vanguard cumulatively with other offshore wind farm developments are presented in Figure 19.3[1], relative to a 1nm buffer of the wind turbines within Norfolk Vanguard and a 1nm buffer of the AfL boundary of other developments.

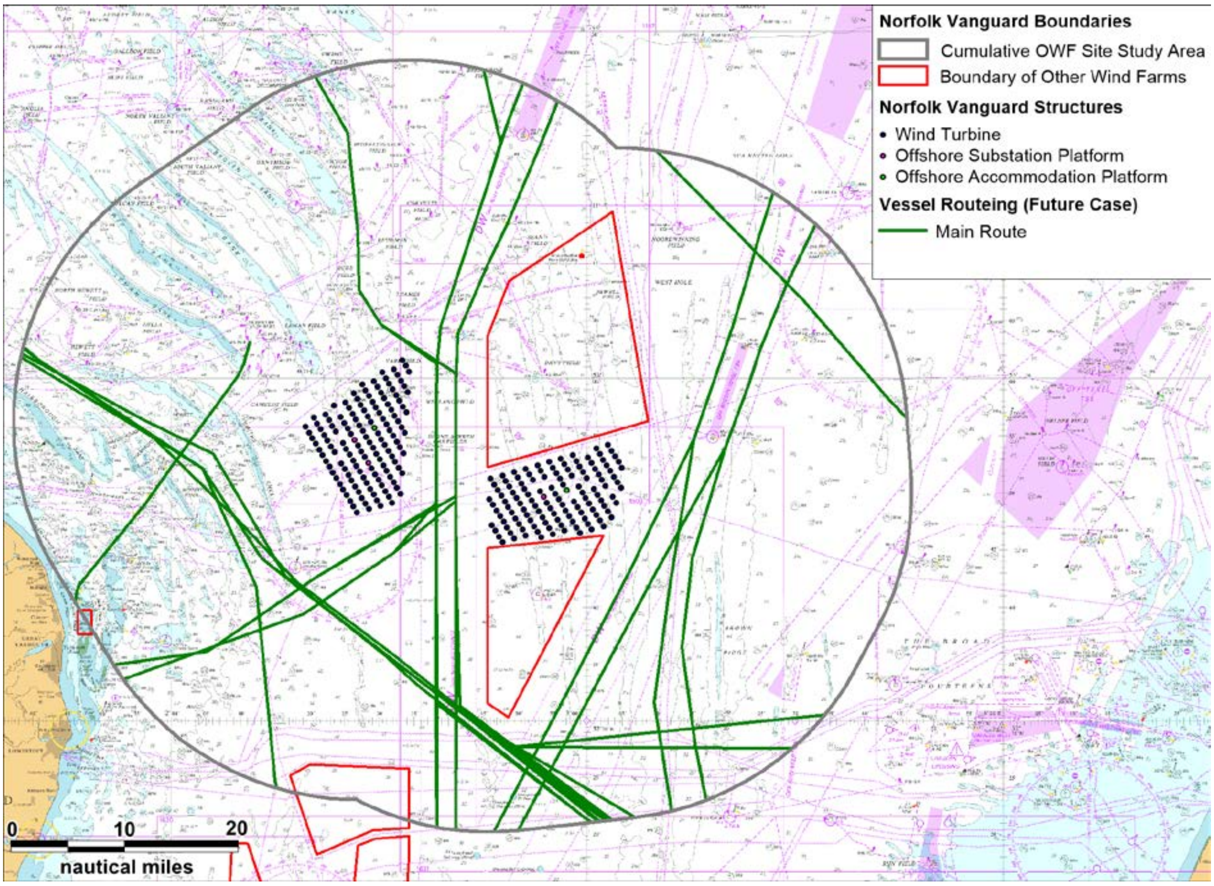

Figure 19.3 Vessel Routeing – Norfolk Vanguard Cumulatively with Other Offshore Wind Farms Future Case Deviations

283. It is noted that the route between Great Yarmouth and the Davy Field (Route 24 in Table 19.1) has been removed for the cumulative assessment since the Davy platform is likely to be decommissioned prior to 2020, and is located within the boundary of a wind farm scoped in on a cumulative basis (Norfolk Boreas).

[1] As per Section 20.2.1, the layout presented contains more structures than are currently under consideration within the most up to date Project Design Envelope.

20. Collision and Allision Risk Modelling Overview

20.1 *Modelling Scenarios*

284. The following sections provide quantitative assessment of the major hazards associated with the development of Norfolk Vanguard. This is divided into a base case and a future case assessment, and includes major hazards associated with:

- Increased vessel to vessel collision risk;
- Additional vessel to structure allision risk;
- Additional fishing vessel to structure allision risk; and
- Additional risk associated with vessels Not Under Command (NUC).

285. The base case assessment used the marine traffic survey data in combination with the consultation responses and other baseline data sources to estimate the current encounter probability, and vessel to vessel collision risk. Conservative assumptions of shipping level increases and route deviations were then made to model future case results.

286. For the future case assessment, the potential growth in shipping movements was considered. Further details are provided in the following sections.

20.1.1 Commercial Shipping Estimated Future Case

287. Given the uncertainty associated with long-term predictions traffic growth including the potential for any major new developments in UK or Transboundary ports, a conservative (i.e., high) potential growth in shipping movements of 10% was estimated over the life of the windfarm. At the request of the CoS, a sensitivity analysis which considers an increase of 20% has also been undertaken.

288. It is noted that the growth rates have been applied to oil and gas routes, despite it being likely that oil and gas traffic will reduce over the lifetime of Norfolk Vanguard.

20.1.2 Commercial Fishing Estimated Future Case

289. The Commercial Fisheries Assessment (Chapter 14 Commercial Fishing) considered the potential changes to the fishing baseline over the life of the proposed project. It is recognised that this is a speculative exercise due to the numerous unpredictable direct and indirect factors which could materially affect fisheries, including the presence of the wind farm.

290. A 10% increase in fishing activity has been assumed; it is considered that this value is conservative.

20.1.3 Recreational Estimated Future Case

291. In terms of recreational vessel activity, there are no major developments known of that would increase the activity of these vessels in the area. Based on the discussion presented, the future level of activity has been assumed to increase by 10% compared to the current levels and is assumed conservative.

20.2 *Layout Assumptions*

20.2.1 Number of Structures

292. Modelling has been undertaken on an indicative worst case layout, based on the worst case parameters presented in the most up to date Project Design Envelope available at the time that modelling commenced. It should therefore be noted that the number of structures modelled now exceeds the maximum number of structures under consideration at the time of writing, as summarised in Table 20.1.

Table 20.1 Modelled Structure Numbers vs Current Project Design Envelope

Structure	Number Modelled	Maximum currently Under Consideration
Wind Turbines	257	200
Offshore Electrical Platforms	3	2
Accommodation Platforms	2	2

293. It is considered unlikely that the reduction in structures would impact on vessel to vessel collision risk, as it has been assumed that displaced vessels will avoid the OWF sites altogether. However, the reduction in the number of structures is considered likely to equal or reduce vessel to structure allision risk, on the basis that the number of potential allision targets is also reduced.

294. It should therefore be considered when viewing Section 21 that the results presented would exceed those of modelling undertaken on the current worst case. The existing modelling results are therefore considered acceptable for use as input to the ES, and remodelling is not considered necessary.

20.2.2 Indicative Layout

295. The indicative layout used for the purposes of the modelling is presented in Figure 20.1. Positions of offshore electrical platforms and accommodation platforms were not available at the time of the modelling, and indicative positions within the wind turbine array were therefore used (as shown in Figure 20.1).

296. It is noted that the significant structures in terms of collision and allision modelling to regular routed traffic are those on the periphery, and layout of additional structures placed within the wind turbine array will therefore have limited effect on the modelling.

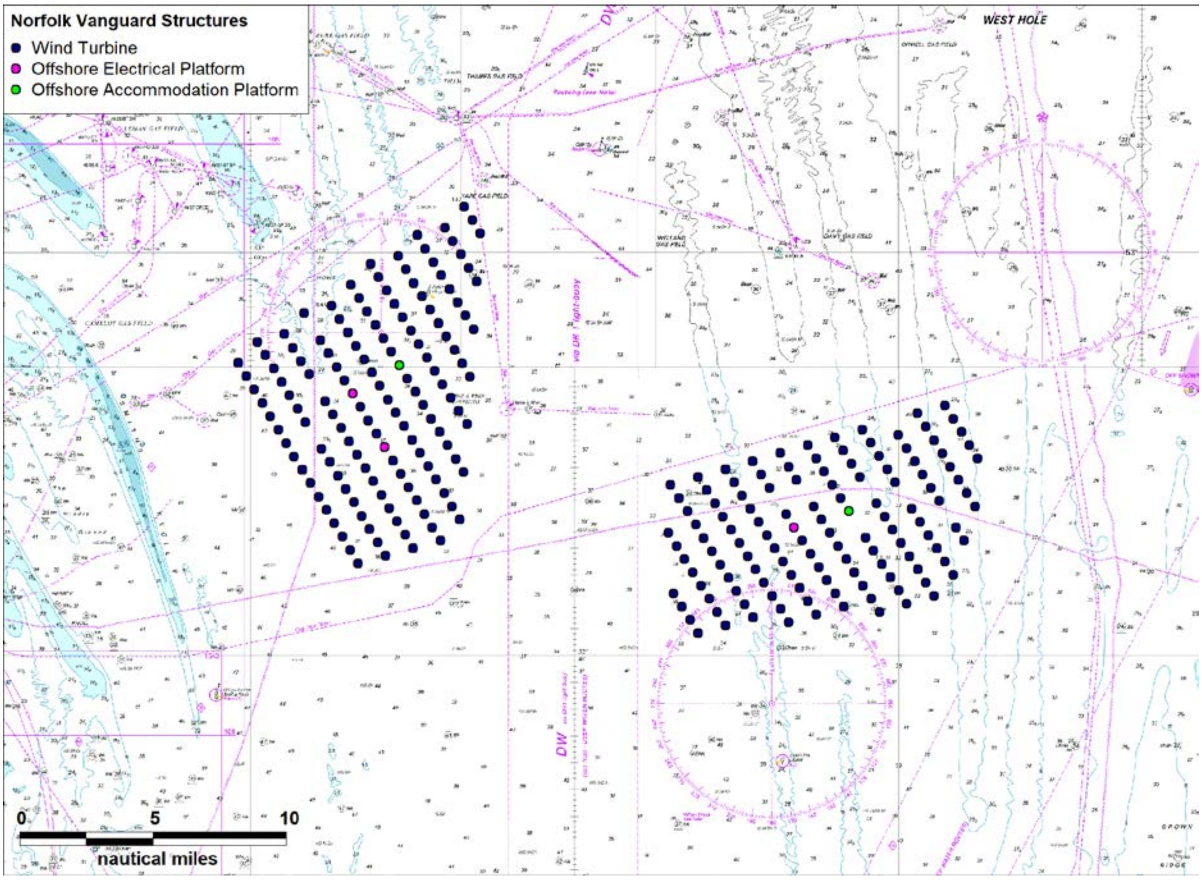

Figure 20.1 Layout used in Future Case Modelling (Positions only, structures not to scale)

20.3 *Modelled Dimensions*

297. The dimensions assumed during the modelling are presented in Table 20.2. The worst case foundation type from a shipping and navigation perspective is floating tension leg platform. Assuming the worst case layout shown in Figure 20.1 (257[1] x 7MW wind turbines), diameters of the floating foundations are estimated at 45m each. As no orientation information was available, the rectangular platforms have been assumed to be oriented with long edges parallel to the DR1 Lightbuoy DWR (noting that as these structures are not on the peripheral, their orientation is unlikely to have a noticeable effect on the modelling process).

[1] Note that maximum number of turbines under consideration has been reduced to 200 as of the time of writing.

298. As per Section 4.3.3, helicopter platforms may be used in place of the accommodation platforms. Precise dimensions of the helicopter platforms are unknown at the time of writing; however they would be smaller than the accommodation platforms.

Table 20.2 Modelling Structure Dimensions

Structure Type	Surface Dimensions	Shape
WTG	45m diameter	Circle
Offshore Electrical Platform	90 x 60m	Rectangle
Offshore Accommodation Platform	90 x 60m	Rectangle

21. Norfolk Vanguard in Isolation Assessment

21.1 *Base Case (Without Wind Farm)*

21.1.1 Encounters

21.1.1.1 Introduction

299. An assessment of current vessel to vessel encounters has been carried out by replaying at high speed the AIS and Radar data collected for the OWF sites. An encounter distance of 1nm has been considered, i.e. two vessels passing within 1nm of each other has been classed as an encounter. This helps to illustrate where existing shipping congestion is highest and therefore where offshore developments, such as windfarms, could potentially increase congestion and therefore also increase the risk of encounters / collisions.

300. It is noted that as not all vessels recorded by radar during the marine traffic surveys could be identified, there were instances of there being doubt as to if an identified encounter was actually a vessel encountering itself. Cases where an encounter was clearly false have been removed; however, cases which could not be confirmed as false have been included in the following analysis.

21.1.1.2 Encounter Overview

301. The tracks from each of the encounters identified within 10nm of Norfolk Vanguard East and West are presented in Figure 21.1 and Figure 21.2 respectively, colour-coded by vessel type. It is noted that where only one transmitted data point from a vessel was recorded within an encounter zone, only the single point has been shown. Otherwise, the track created by joining the points transmitted within the zone has been shown.

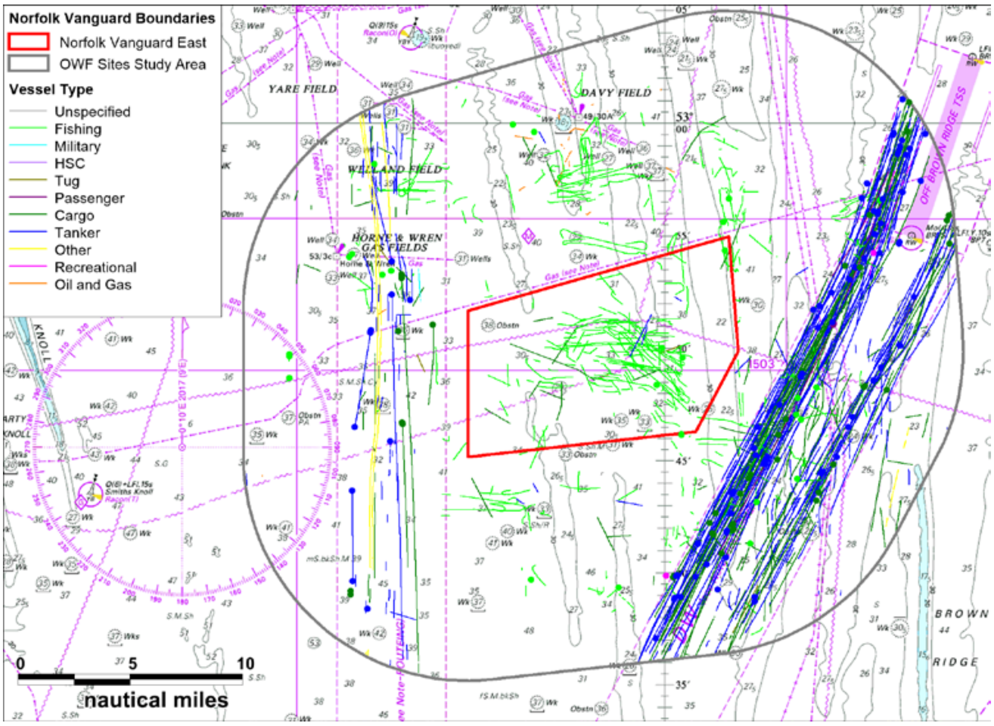

Figure 21.1 Encounter Overview - Norfolk Vanguard East

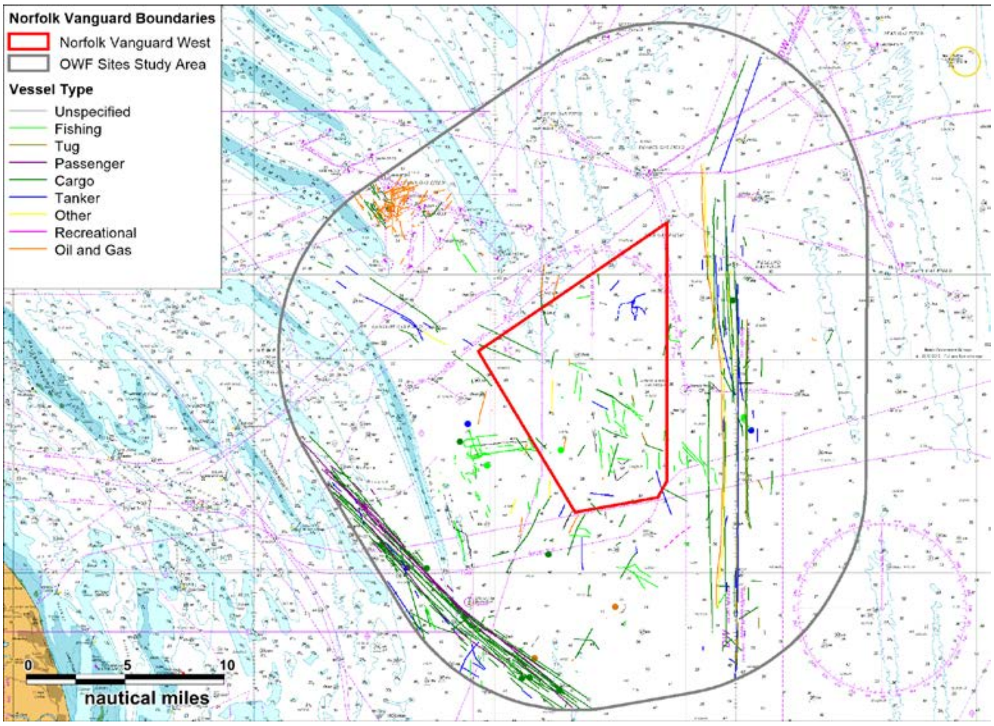

Figure 21.2 Encounter Overview - Norfolk Vanguard West

302. Within the Norfolk Vanguard East study area, the majority of encounters were observed to occur within the West Friesland DWR and TSS, with most of these

involving at least one commercial vessel. Similar encounters were also recorded within the DR1 Lightbuoy DWR. Encounters involving fishing vessels were identified between the two DWRs, including within Norfolk Vanguard East.

303. Within the Norfolk Vanguard West study area, the majority of encounters were identified as occurring on the busy routes south-east of the OWF site running between the UK and Rotterdam (see Section 18 for more details of vessel routeing). As with the Norfolk Vanguard East analysis, a notable number of encounters were also recorded within the DR1 Lightbuoy DWR. As seen in Figure 21.2, encounters between oil and gas vessels were identified at the Leman Field north-west of the OWF sites.

21.1.1.3 Daily Counts

304. The number of encounters recorded per day during the Norfolk Vanguard East marine traffic surveys is presented in Figure 21.3. Following that, the corresponding counts for Norfolk Vanguard West are shown in Figure 21.4.

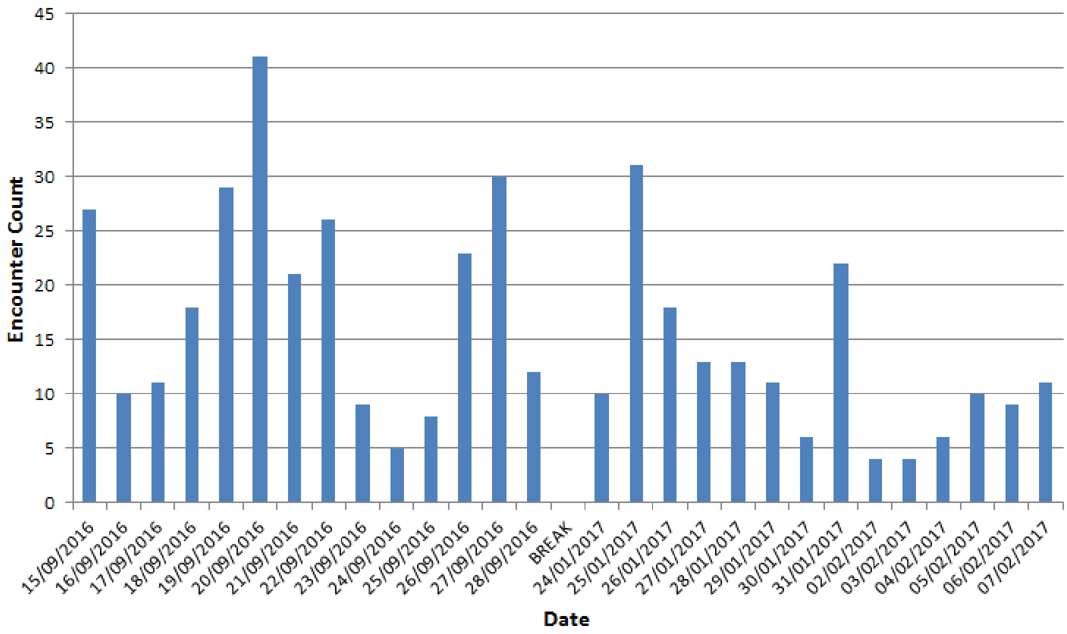

Figure 21.3 Daily Encounter Count - Norfolk Vanguard East

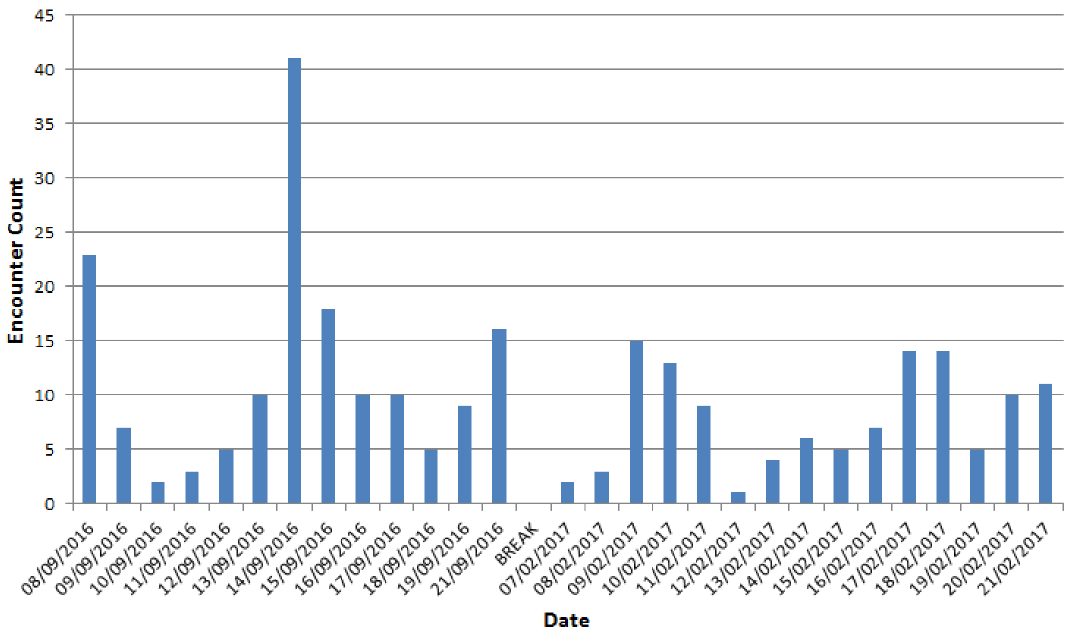

Figure 21.4 Daily Encounter Count - Norfolk Vanguard West

305. An average of 15 encounters per day were recorded during the surveys for Norfolk Vanguard East. The most encounters recorded during a single day was 41, on the 20th September 2016. Encounter numbers totalled 438 over the 28 day period.

306. For Norfolk Vanguard West, an average of ten encounters per day was recorded within the study area. The reduction when compared to Norfolk Vanguard East is due to the number of encounters occurring in the West Friesland DWR, which are not captured within the analysis of the Norfolk Vanguard West site. The most encounters recorded on a single day was 41, on the 14 September 2016. The high encounter count on this day when compared to the rest of the study period was due to an above average fishing vessel presence within the immediate vicinity of Norfolk Vanguard West.

21.1.1.4 Type Distribution

307. The vessel type distribution of encounters within the study area is presented in Figure 21.5. All vessels classed as "unspecified" were recorded by radar, and unable to be visually identified. It is considered likely that most of these are fishing or recreational vessels.

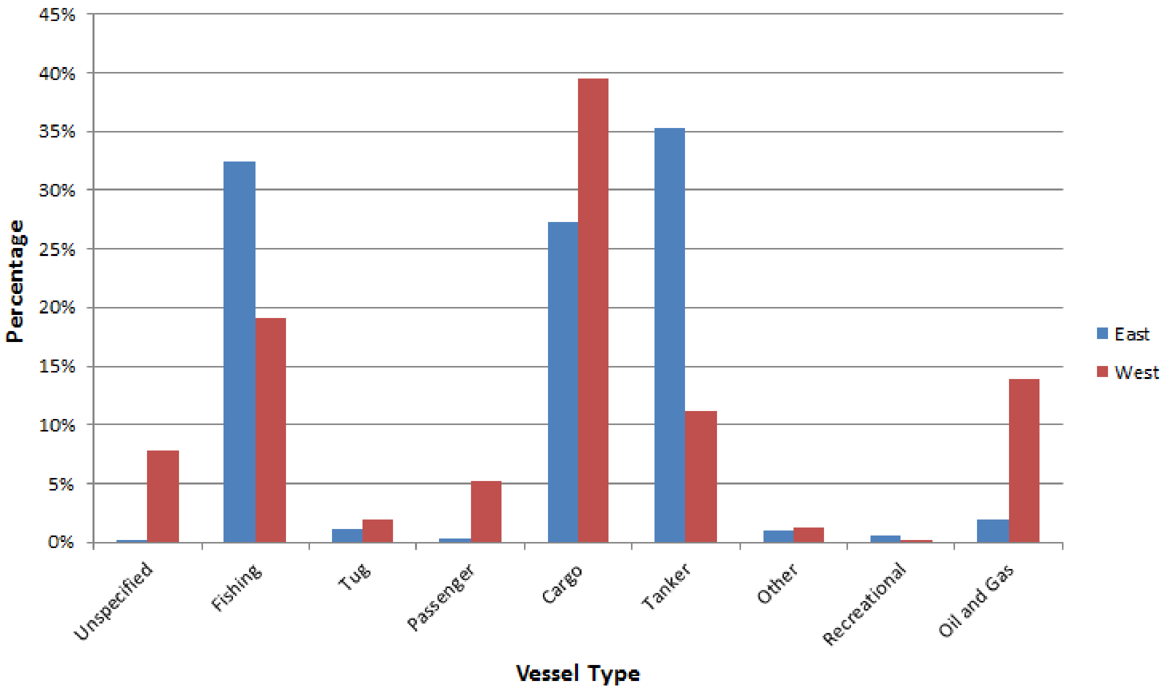

Figure 21.5 Encounters – Vessel Type Distribution

308. The majority of vessels involved in an encounter were observed to be commercial, with 62% of involved vessels being either cargo or tanker for Norfolk Vanguard East, and 51% for Norfolk Vanguard West. Fishing vessel encounters were also observed to be common, with 32% of all vessels involved in an encounter in the Norfolk Vanguard East analysis being a fishing vessel, dropping to 19% for the West analysis. Encounters at the Leman Field resulted in 14% of vessels involved in an encounter in the Norfolk Vanguard West analysis being associated with the oil and gas industry.

21.1.1.5 Encounter Density

309. The results of the encounters analysis were used to estimate the encounter density within the vicinity of the OWF sites. The resultant density grids for Norfolk Vanguard East and West are presented in Figure 21.6 and Figure 21.7 respectively. The same density brackets have been used in both figures to allow direct comparison.

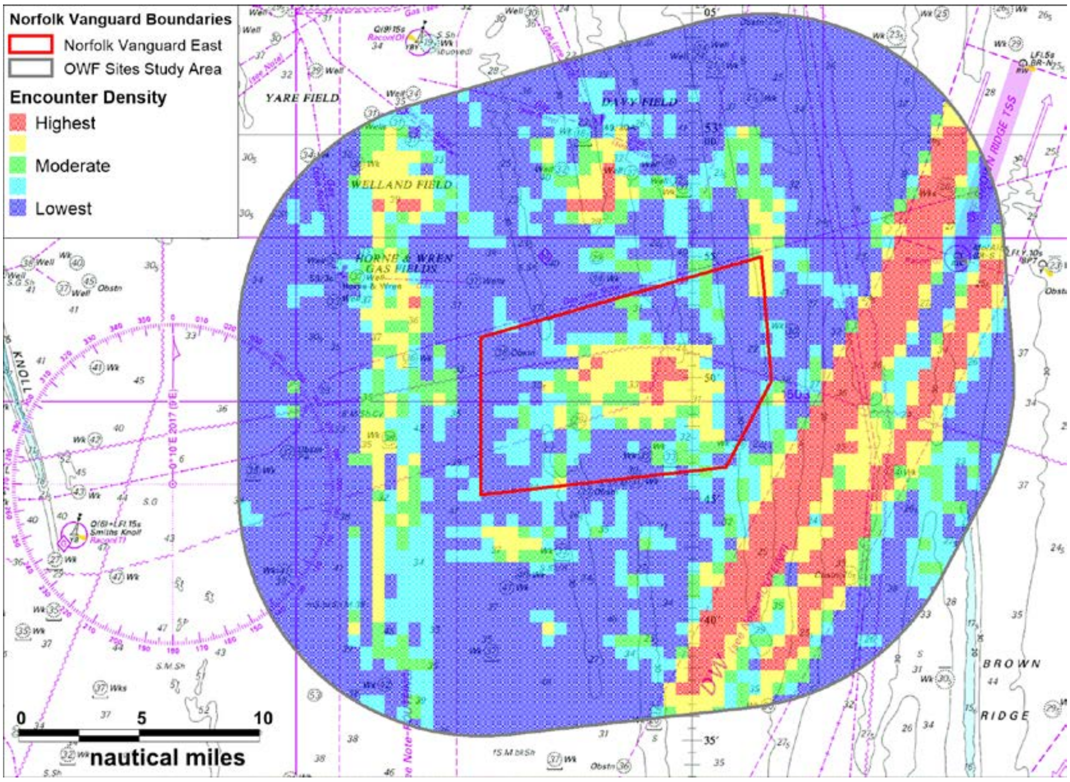

Figure 21.6 Estimated Encounter Density – Norfolk Vanguard East

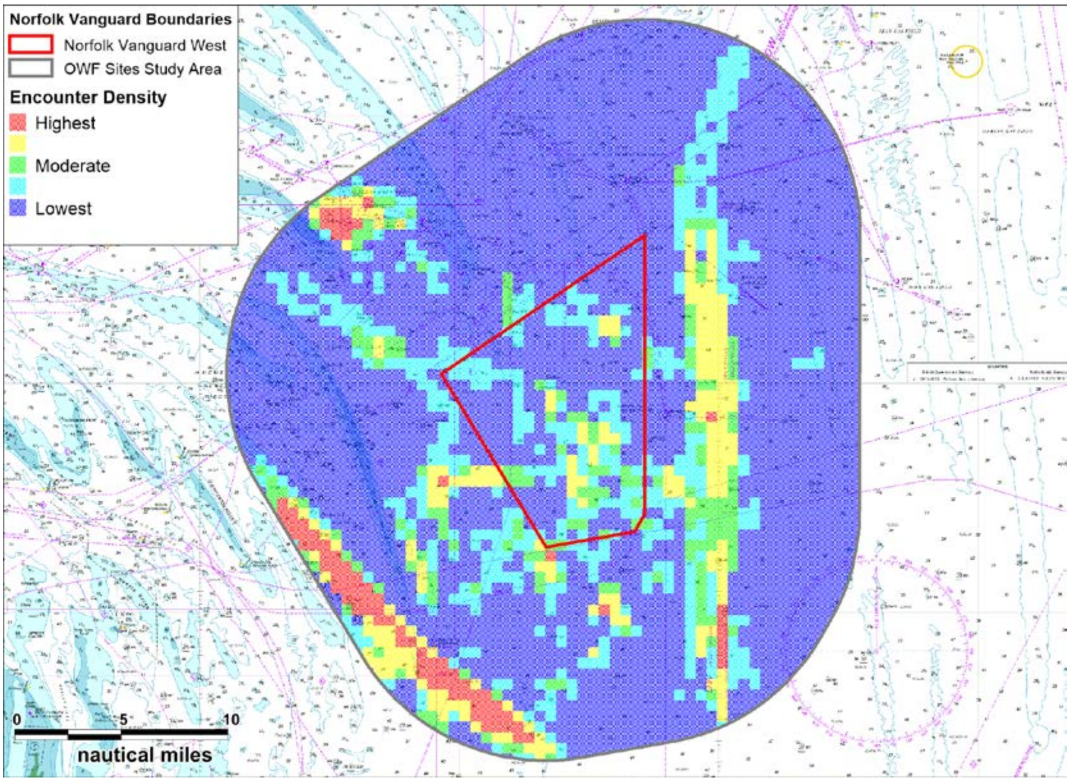

Figure 21.7 Estimated Encounter Density – Norfolk Vanguard West

310. The most significant area in terms of encounters was identified as being the West Friesland DWR, with most encounters within the DWR involving at least one commercial vessel. The area south-west of Norfolk Vanguard West was also identified as being significant; due to encounters involving vessels on the busy routes running between Rotterdam and the UK (see Section 18 for more details of vessel routeing).

21.1.2 Vessel to Vessel Collisions

311. The baseline routeing and encounter levels in the area were used as input to the vessel to vessel collision model within Anatec's CollRisk model suite to estimate the base case vessel to vessel collision risk within the vicinity of Norfolk Vanguard. The results are presented as a density grid in Figure 21.8.

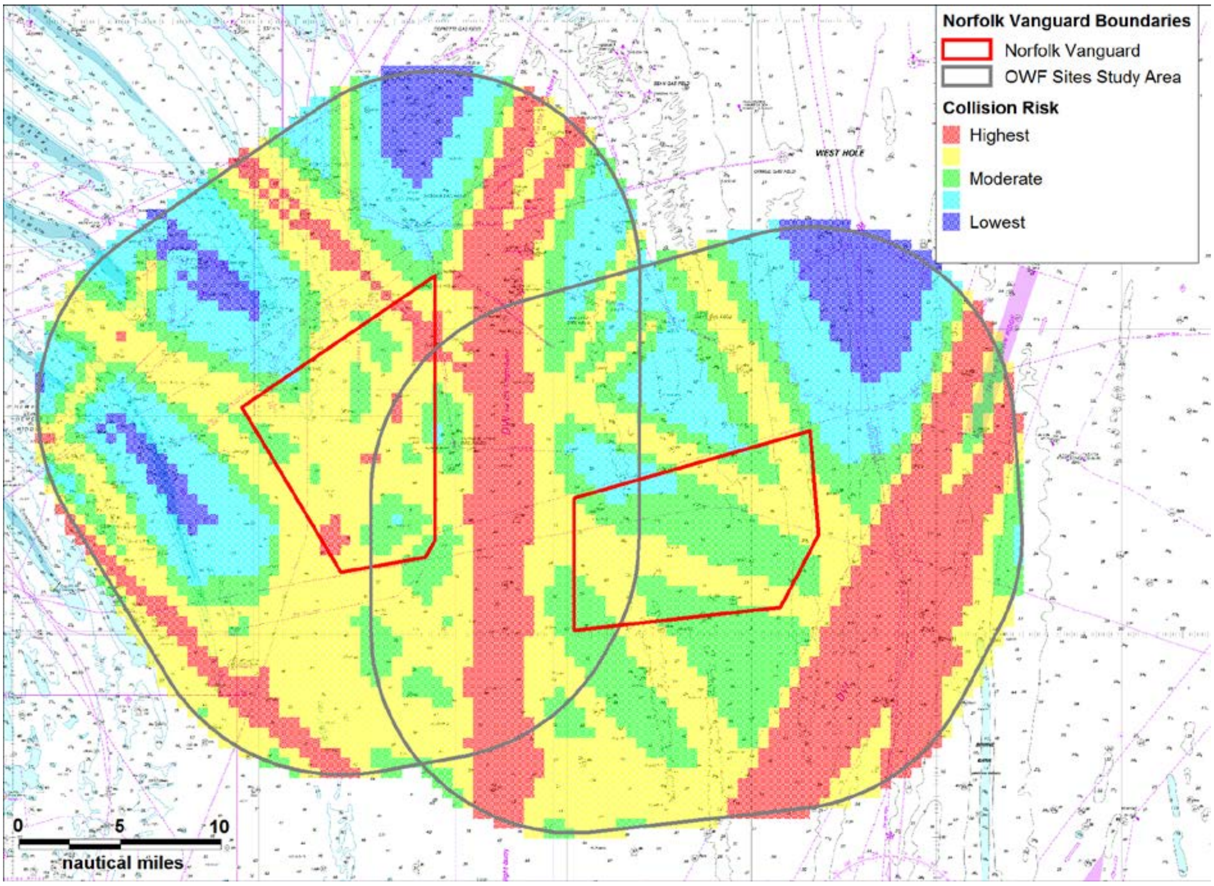

Figure 21.8 Vessel to Vessel Collision Risk – Base Case

312. At base case levels, it is anticipated that a vessel will be involved in a collision once every 14 to 15 years, with the majority of the risk occurring within the West Friesland

DWR (approximately 84%). Other high risk areas were observed to be the DR1 Lightbuoy DWR, and the area south-west of Norfolk Vanguard West, caused by busy routes between the UK and Rotterdam (which includes commercial ferries operated by DFDS and P&O).

313. It is emphasised that the model is calibrated based on major incident data at sea which allows for benchmarking but does not cover all incidents, such as minor impacts. Other incident data, which includes minor incidents, is presented in Section 11.

21.2 *Future Case (with Wind Farm)*

21.2.1 Vessel to Vessel Collisions

314. The revised routeing pattern shown in section 19.2 was used as input to the vessel to vessel collision model within Anatec's CollRisk model suite to estimate the potential rise in vessel to vessel collisions as a result of the proposed project. The results are compared with the base case in Table 21.1.

Table 21.1 Vessel to Vessel Collision Rate Increases

Scenario	Annual Frequency		Return Period (Years)		Increase from Base Case (No Traffic Growth)	
	Without Wind Farm	With Wind Farm	Without Wind Farm	With Wind Farm	Without Wind Farm	With Wind Farm
No Traffic Increase	6.88×10^{-2}	6.94×10^{-2}	14.5	14.4	n/a	1%
10% Increase	8.33×10^{-2}	8.40×10^{-2}	12.0	11.9	21%	22%
20% Increase	9.90×10^{-2}	9.98×10^{-2}	10.1	10.0	44%	45%

315. Assuming no growth in traffic, it is estimated that the vessel to vessel collision risk will rise by approximately 1% as a result of the construction of the proposed project. As discussed in Section 21.1.2, most of the base case risk is within the West Friesland DWR, and as shown in Section 19.2, it is expected that most re-routed traffic will either deviate through the DR1 Lightbuoy DWR, or pass either north or south of the OWF sites. The risk within the West Friesland DWR was therefore largely unaffected by the modelled route deviations, resulting in only a minor increase of the overall risk. This is illustrated in Figure 21.9, which shows the change in vessel to vessel collision

risk between the base case, and the future case (assuming no growth in traffic), in the form of a density grid.

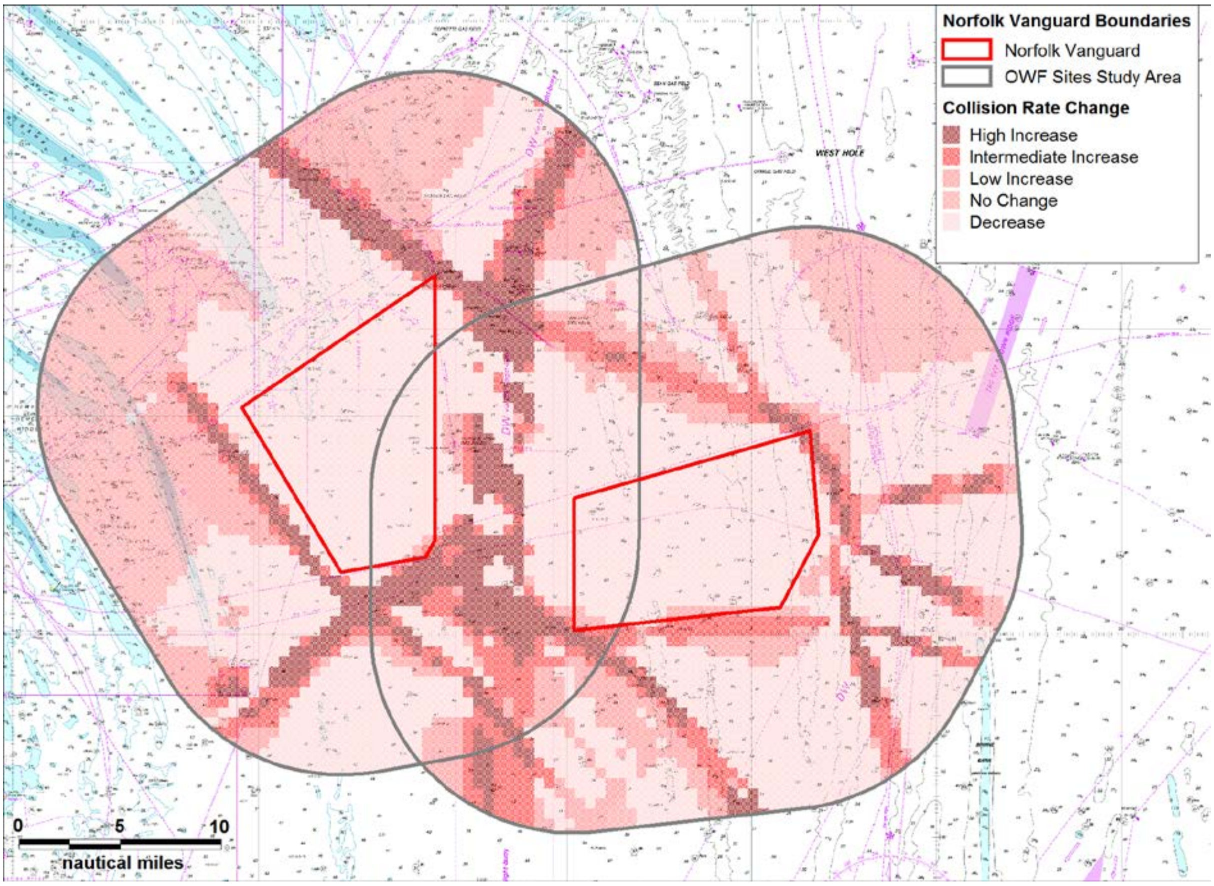

Figure 21.9 Change in Vessel to Vessel Collision

316. Assuming a 10% growth in commercial traffic, the vessel to vessel collision risk rises by approximately 22%; regardless of any re routeing within the area. This can be attributed to the fact that a collision will involve two vessels, and therefore increasing the levels of traffic by 10% would be expected to incur an increase in the number of vessel to vessel collisions in the vicinity of 20%.

317. Likewise, a 20% growth in commercial traffic results in the vessel to vessel collision risk rising by approximately 45%; regardless of any re routeing within the area.

318. Collision modelling is assessed further in Chapter 15 Shipping and Navigation.

21.2.2 Vessel Allision with Structure

21.2.2.1 Powered Vessel Allision

319. Based on the vessel routeing identified for the area, the anticipated change in routeing due to the proposed project, and assumptions that effective mitigation measures are in place, the frequency of an errant vessel under power deviating from its route to the extent that it comes into proximity with a structure is not considered to be a probable outcome.

320. From consultation with the shipping industry it is also assumed that merchant vessels would not navigate between wind turbine rows due to the restricted sea room and would be directed by the navigational aids in the area.

321. The deviated routes presented in Section 21 were used as input to the powered allision function of Anatec's CollRisk modelling suite. This model estimates the likelihood that a vessel will allide with one of the wind farm structures whilst under power. It is noted that the model does not take account for the possibility of one structure shielding another.

322. The results are presented in Table 21.2.

Table 21.2 Vessel to Structure Allision Rates – Powered Case

Scenario	Annual Frequency	Return Period (Years)
Base Case	0	n/a
Future Case (0% Increase)	3.50×10^{-4}	2,860
Future Case (10% Increase)	3.86×10^{-4}	2,590

323. The annual powered allision frequency per structure is presented in Figure 21.10[1] for the 0% increase in traffic growth case. It is noted that the difference in the distribution of the allision risk between the two traffic growth scenarios was not considered significant.

[1] As per Section 20.2.1, the layout presented contains more structures than are currently under consideration within the most up to date Project Design Envelope.

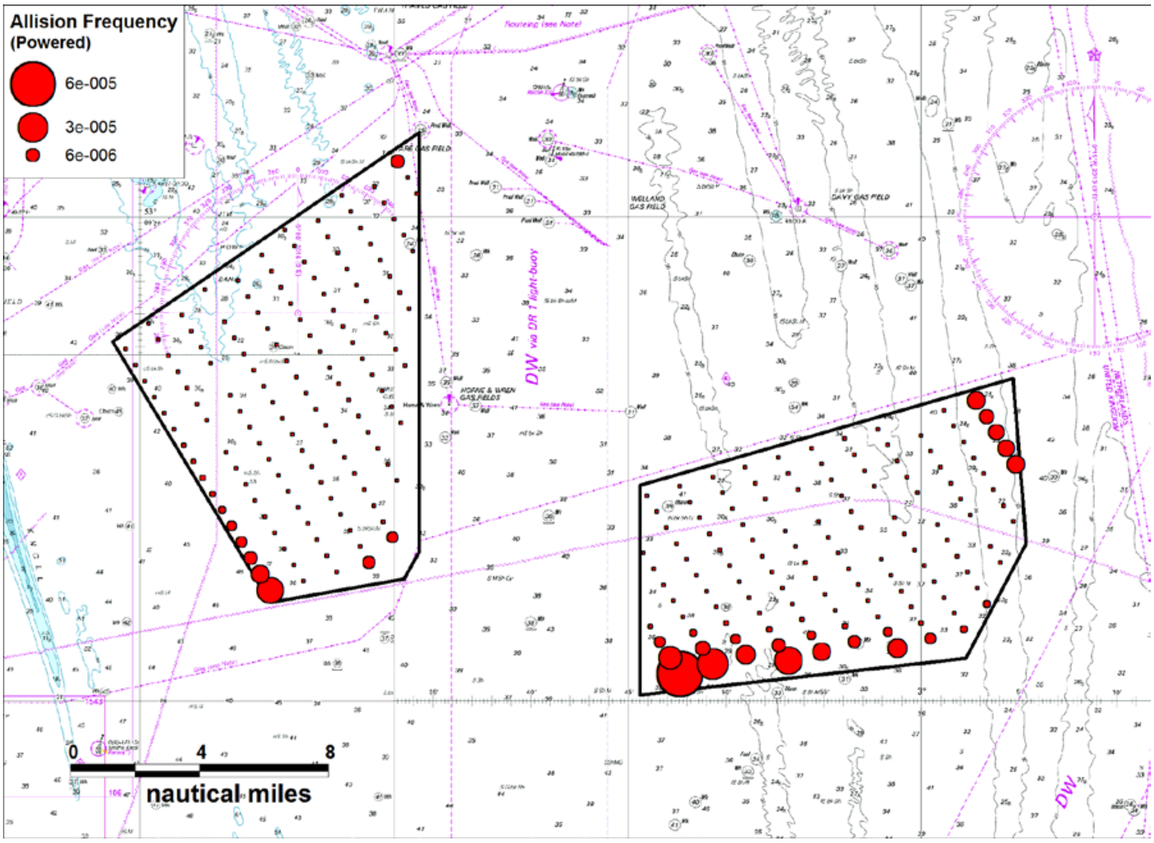

Figure 21.10 Powered Allision Frequency – Future Case

324. It can be seen that the majority of the powered allision risk is associated with periphery wind turbines, particularly on the southern and north-east boundaries of Norfolk Vanguard East, and the western boundary of Norfolk Vanguard West. This is due to the routes previously passing through the OWF sites that have been assumed to deviate either north or south of the OWF sites (see Section 19 for more details). The vessels within the DWRs did not contribute significantly to the overall risk, due to the separation distance between the corresponding routes and the wind farm structures.

21.2.2.2 Drifting Vessel Allision

325. The deviated routes presented in Section 19 were used as input to the NUC allision function of Anatec's CollRisk modelling suite. This model is based on the premise that propulsion on a vessel must fail before a vessel would drift. The model takes account of the type and size of the vessel, number of engines and average time to repair in different conditions.

326. The exposure times for a drifting scenario are based on the vessel-hours spent in proximity to the proposed wind farms (up to 10nm from perimeter). These have been estimated based on the traffic levels, speeds and revised routeing pattern. The

exposure is divided by vessel type and size to ensure these factors, which based on analysis of historical accident data have been shown to influence accident rates, are taken into account within the modelling.

327. Using this information, the overall rate of breakdown within the area surrounding the wind farm was estimated. The probability of a vessel drifting towards a structure and the drift speed are dependent on the prevailing wind, wave and tide conditions at the time of the accident.

328. The following drift scenarios were modelled:

- Wind;
- Peak spring flood tide; and
- Peak spring ebb tide.

329. The probability of vessel recovery from drift is estimated based on the speed of drift and hence the time available before reaching the windfarm structure. Vessels that do not recover within this time are assumed to allide.

330. After modelling each of the drift scenarios it was established that the ebb tide-dominated drift produced the worst case results. The results are presented in Table 21.3.

Table 21.3 Vessel to Structure Allision Rates – NUC Case

Scenario	Annual Frequency	Return Period (years)
Base Case	0	n/a
Future Case (0% Increase)	9.42×10^{-4}	1,060
Future Case (10% Increase)	1.04×10^{-3}	960

331. The annual drifting allision frequency per structure is presented in Figure 21.11[1] for the 0% increase in traffic growth case. As with the powered allision modelling, the difference in the distribution of the allision risk between the two traffic growth scenarios was not considered significant.

[1] As per Section 20.2.1, the layout presented contains more structures than are currently under consideration within the most up to date Project Design Envelope.

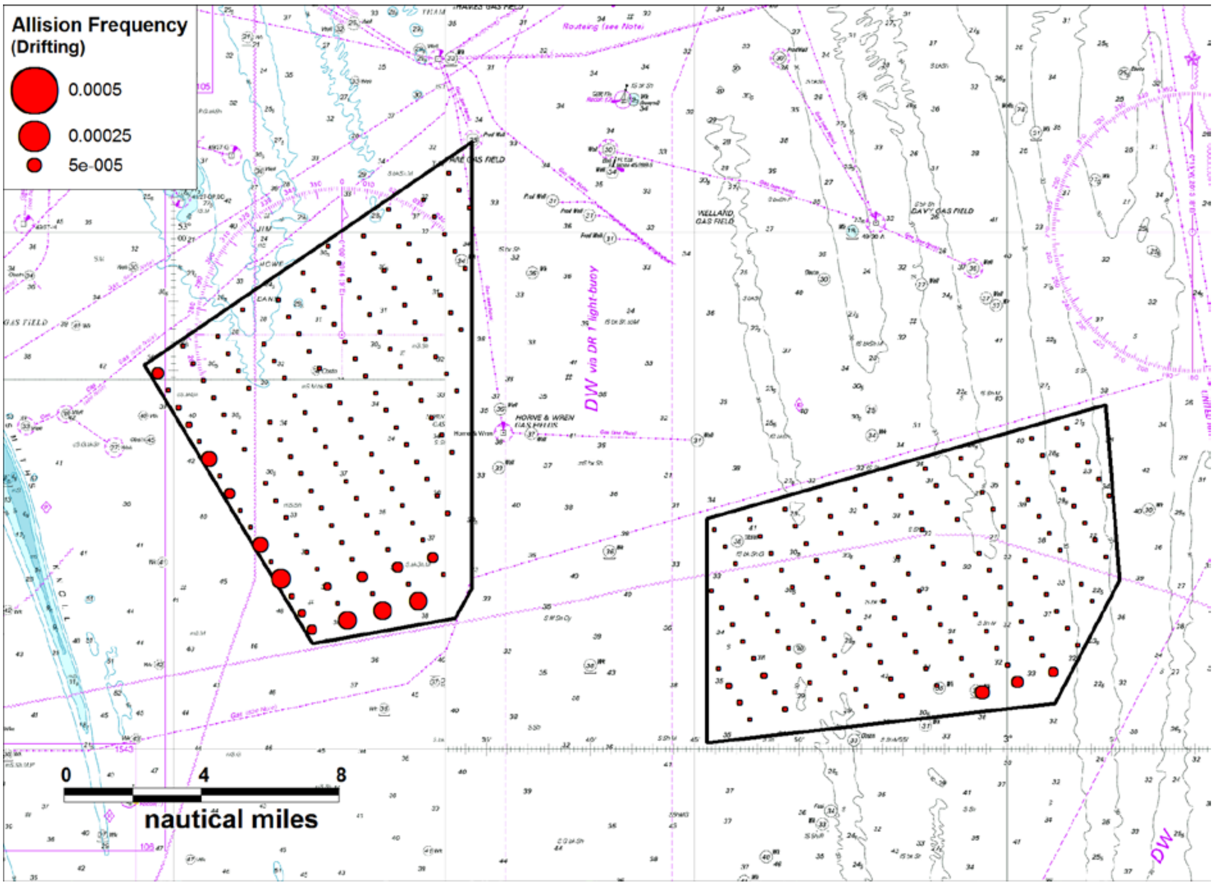

Figure 21.11 Drifting (NUC) Allision Frequency – Future Case

332. It can be seen that the highest risk was observed to be on the southern and western boundaries of Norfolk Vanguard West. This was due to the prevalent tidal direction being 356°, meaning that the model assumed vessels would drift north upon engine failure and includes the potential for vessels to drift into the array.

21.2.3 Fishing Vessel Allision

333. Anatec's CollRisk fishing vessel risk model has been calibrated using fishing vessel activity data along with offshore installation operating experience in the UK (oil and gas) and the experience of allisions between fishing vessels and UKCS offshore installations (published by the Health and Safety Executive (HSE)).

334. The two main inputs to the model are the fishing vessel density for the area and the structure details including the number and dimensions of the structures. The fishing vessel density in the area of the OWF sites was based upon fishing vessel sightings data (2005 to 2009).

335. Using site-specific data as input to the model to the annual fishing vessel allision frequency, based upon the density of fishing activity and the maximum number of wind farm structures in situ, the fishing vessel to structure allision return period was estimated for both layouts. The results are presented in Table 21.4.

Table 21.4 Fishing Vessel to Structure Allision Rate

Number of Structures[1]	Annual Frequency		Return Period (years)	
	0% Increase	10% Increase	0% Increase	10% Increase
• 257 wind turbines; • 3 offshore electrical platforms; and • 2 offshore accommodation platforms	2.91×10^{-1}	3.20×10^{-1}	3.4	3.1

336. The estimated allision frequencies are high and reflect the maximum target area assumed for all the structures based on the installation of floating foundations. It also assumes the fishing vessel density following the proposed project would remain the same as the current levels, as defined within the baseline assessment.

337. In terms of the consequences of these impacts it is expected that the majority will be relatively minor during fishing itself and there will be low levels of risk to crew and of pollution.

21.3 *Risk Results Summary*

338. The results of the modelling are summarised in Table 21.5.

Table 21.5 Summary of Annual Collision and Allision Frequency Results

	Base Case (Return Period)	Future Case (Return Period)		
		0% Increase	10% Increase	20% Increase
Vessel to Vessel	6.88×10^{-2} (15 years)	6.94×10^{-2} (14 years)	8.40×10^{-2} (12 years)	9.98×10^{-2} (10 years)
Powered Allision	n/a	3.50×10^{-4} (2,860 years)	3.86×10^{-4} (2,590 years)	n/a
Drifting Allision	n/a	9.42×10^{-4} (1,060 years)	1.04×10^{-3} (960 years)	n/a
Fishing Allision	n/a	2.91×10^{-1} (3.4 years)	3.20×10^{-1} (3.1 years)	n/a

[1] Note that number of structures has been reduced from those modelled to maximum of 200 wind turbines, two offshore electrical platforms, and two accommodation platforms as of the time of writing.

	Base Case (Return Period)	Future Case (Return Period)		
		0% Increase	10% Increase	20% Increase
Total	**6.88 x 10^{-2} (15 years)**	**3.62 x 10^{-1} (2.8 years)**	**4.05 x 10^{-1} (2.5 years)**	n/a

339. Overall the collision and allision risk is estimated to increase due to the proposed project from one in every 15 years (base case) to one in every 2.8 years (future case with 0% increase in level of traffic), one in every 2.5 years (future case with 10% increase in level of traffic). The increases from the base case are largely due to the fishing vessel to structure allision risk.

340. Vessel to structure allision rates were not modelled in the 20% increase in traffic scenario, however vessel to vessel collision rates were estimated to rise by 45%. As previously discussed, this was due to the increase in traffic, rather than the deviations arising from the presence of the OWF sites.

21.4 *Consequences*

341. The probable outcomes for the majority of hazards are expected to be minor. However, the worst case outcomes could be severe, including events with potentially multiple fatalities.

342. An allision involving a larger vessel is likely to result in the collapse of a wind turbine with limited damage to the vessel. Breach of a vessel's fuel tank is considered unlikely and in the case of vessels carrying hazardous cargoes, e.g., tanker or gas carrier, the additional safety features associated with these vessels would further mitigate the risk of pollution (for example double hulls). Similarly, in a drifting allision the proposed wind farm structures are likely to absorb the majority of the impact energy, with some energy also being retained by the vessel in terms of rotational movement (glancing blow).

343. In terms of smaller vessels such as fishing and recreational craft, the worst case scenario would be risk of vessel damage leading to foundering of the vessel and Potential Loss of Life (PLL).

344. A quantitative assessment of the potential consequences of collision / allision for each of the scenarios is presented in Section 21.2. This applies the site-specific collision / allision frequency results presented above with estimated outcomes in terms of fatalities on-board and oil pollution from the vessel based on research into historical collision incidents (MAIB, Internal Tanker Owners Pollution Federation (ITOPF), etc.).

345. The overall increase in PLL estimated due to the proposed project is 2.48 x 10^{-3} fatalities per year (base case), which equates to one additional fatality in 404 years. This is a very small change in comparison to MAIB statistics which indicate an average of 29 fatalities per year in UK territorial waters.

346. In terms of individual risk to people, the incremental increase for commercial vessels (in the region of 10^{-8}) is very low compared to the background risk level for the UK sea transport industry of 2.9 x 10^{-4} per year.

347. Similarly, for fishing vessels, whilst the change in individual risk attributed to the proposed project is higher than for commercial vessels (in the region of 10^{-4}), it is relatively low compared to the background risk level for the UK sea fishing industry of 1.2 x 10^{-3} per year.

348. The overall increase in oil spilled due to the Norfolk Vanguard project is 0.84 tonnes of oil per year (base case). From research undertaken as part of the DfT MEHRA project (DfT, 2005) the average annual tonnes of oil spilled in the waters around the British Isles due to marine accidents in the 10-year period from 1989 to 1998 was 16,111. Therefore, the overall increase in pollution estimated for Norfolk Vanguard is very low compared to the historical average pollution quantities from marine accidents in the UK waters.

349. Therefore, the incremental increase in risk to both people and the environment caused by the proposed project is estimated to be low.

350. Impacts associated with allision modelling are considered within Chapter 15 Shipping and Navigation.

22. Norfolk Vanguard Cumulative Effect Assessment

22.1 *Base Case (Without Wind Farm)*

22.1.1 Vessel to Vessel Collisions

351. The baseline routeing and encounter levels in the area were used as input to the vessel to vessel collision model within Anatec's CollRisk model suite to estimate the base case vessel to vessel collision risk within the larger study area used in the cumulative assessment (see section 19.1). The results are presented as a density grid in Figure 22.1.

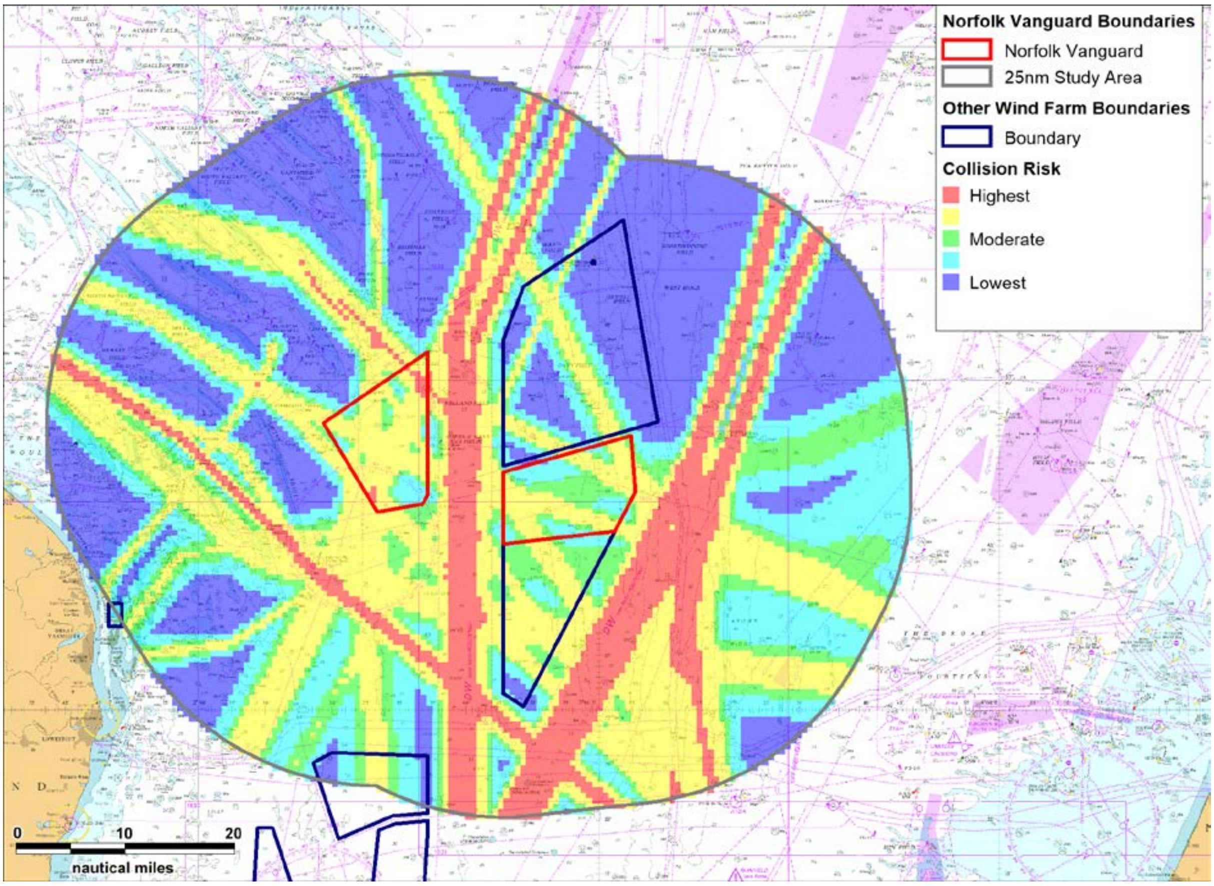

Figure 22.1 Vessel to Vessel Collision Risk – Cumulative Base Case

352. At base case levels it is anticipated that a vessel will be involved in a collision once every six years within 25nm of the OWF sites. As with the assessment of Norfolk Vanguard in isolation, the majority of the risk occurs within the West Friesland DWR, with the DR1 Lightbuoy DWR and the area south-west of Norfolk Vanguard West

(caused by routes passing between the East Anglia Three and East Anglia One North sites) also observed to be high risk areas.

22.2 *Future Case (With Wind Farm)*

353. The revised routeing pattern shown in Section 19 was used as input to the vessel to vessel collision model within Anatec's CollRisk model suite to estimate the potential rise in vessel to vessel collisions as a result of the proposed project on a cumulative basis with other offshore wind farm developments. The results are presented as a density grid in Figure 22.2. It is noted that the results presented assume no growth in traffic.

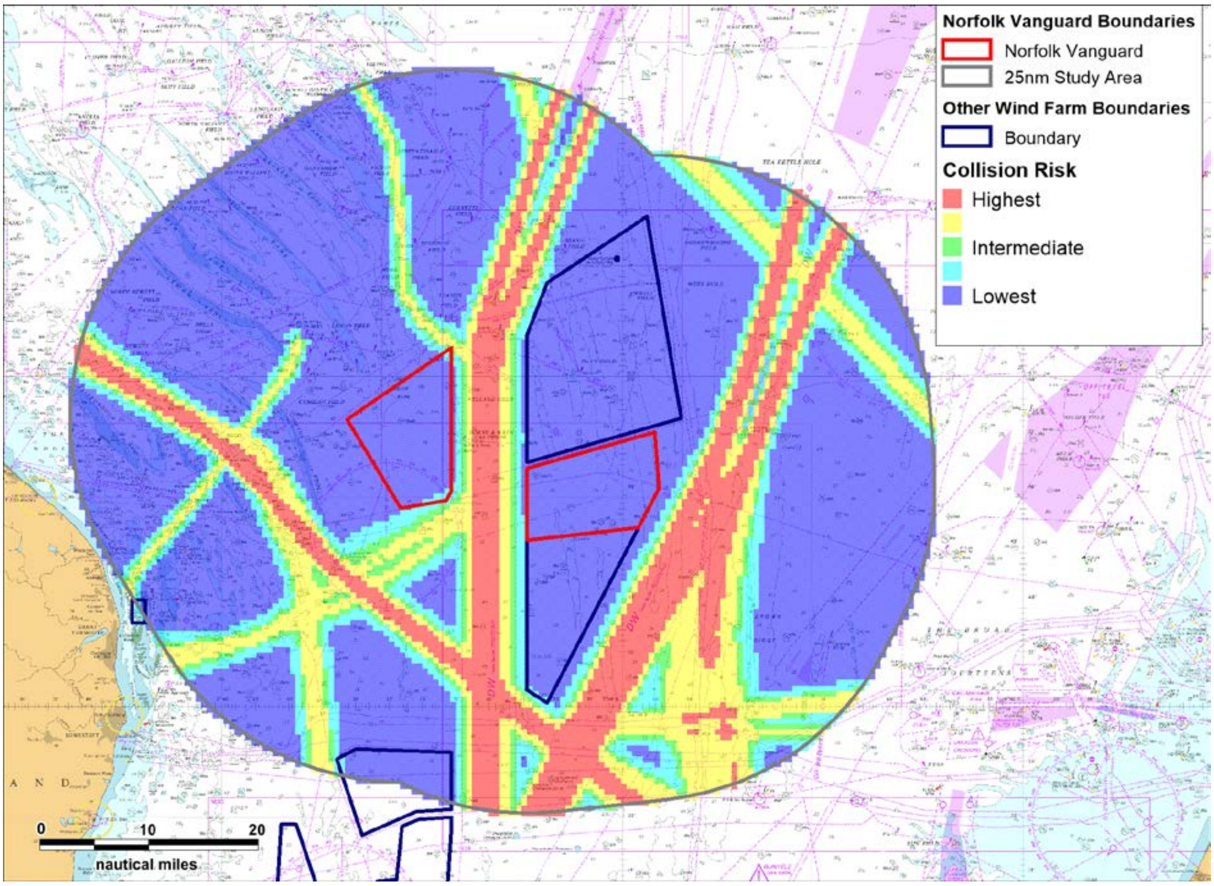

Figure 22.2 Vessel to Vessel Collision Risk – Cumulative Future Case

354. Based on the cumulative assessment, it is anticipated that a vessel will be involved in a collision once every six years. Areas where the risk was highest were similar to the base case, with the majority of the collision risk estimated to be within the West Friesland DWR. The results are compared with the base case in Table 22.1.

Table 22.1 Vessel to Vessel Collision Rate Increases – Cumulative Case

Scenario	Annual Frequency		Return Period (Years)		Increase from Base Case (No Traffic Growth)	
	Without Wind Farm	With Wind Farm	Without Wind Farm	With Wind Farm	Without Wind Farm	With Wind Farm
No Traffic Increase	1.60×10^{-1}	1.69×10^{-1}	6.2	5.9	n/a	6%

355. Based on the cumulative assessment, it was estimated that the collision risk will rise by approximately 6% within 25nm of the OWF sites. This is largely due to the traffic deviated south of the OWF sites between East Anglia Three and East Anglia One North, however a rise in collision rates was also observed in the DR1 Lightbuoy DWR, again due to additional deviated traffic. These areas are illustrated in Figure 22.3, which shows the change in collision risk between the base case and the cumulative case.

356. It is noted that a minor reduction in collision risk within the West Friesland DWR was estimated. This is due to a decrease of vessel encounters between vessels using the DWR and vessels on routes that previously crossed the DWR, which were no longer predicted to do so on a cumulative basis.

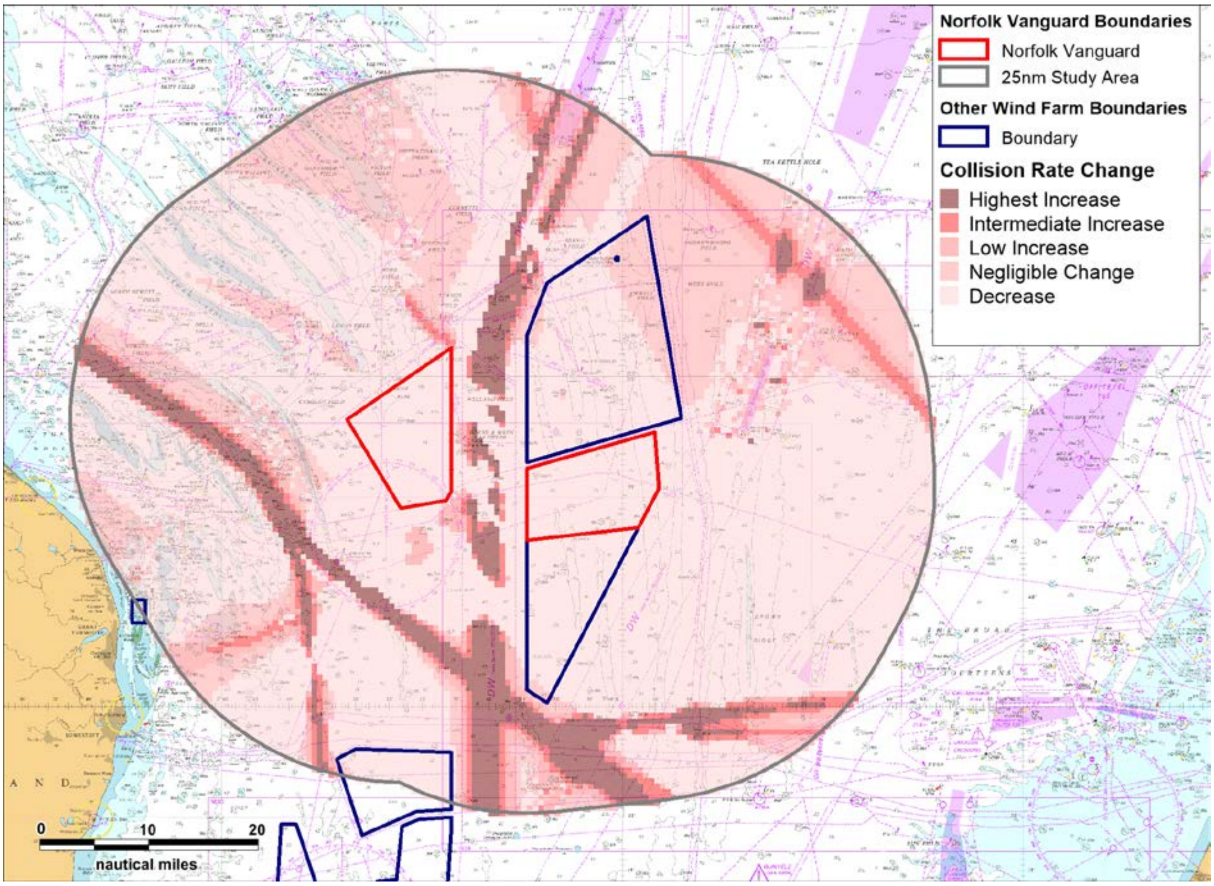

Figure 22.3 Change in Vessel to Vessel Collision – Cumulative

23. Communication and Position Fixing

23.1 *Introduction*

357. The following section summarises the potential impacts from the Norfolk Vanguard Development upon communication and position fixing devices used by vessels within the vicinity.

23.2 *Very High Frequency (VHF) Communications (including Digital Selective Calling (DSC))*

358. As part of the 2004 SAR provider (MCA and QinetiQ, 2004) trials at North Hoyle wind farm, tests were undertaken to evaluate the operational use of typical small vessel Very High Frequency (VHF) transceivers when operated close to wind farm structures.

359. The wind farm structures had no noticeable effect on voice communications within the wind farm or ashore. It was noted that if small craft vessel to vessel and vessel to shore communications were not affected significantly by the presence of wind turbines, then it is reasonable to assume that larger vessels with higher powered and more efficient systems would also be unaffected.

360. During this trial a number of mobile telephone calls were made from ashore, within the wind farm, and on its seawards side. No effects were recorded using any system provider (MCA and QinetiQ, 2004).

361. Furthermore, as part of the SAR trials carried out at North Hoyle wind farm in 2005, radio checks were undertaken between the Sea King helicopter and both Holyhead and Liverpool coastguards. The aircraft was positioned to the seaward side of the wind farm and communications were reported as very clear, with no apparent degradation of performance. Communications with the service vessel located within the wind farm were also fully satisfactory throughout the trial (MCA, 2005).

362. Following consideration of these independent reports, Norfolk Vanguard is anticipated to have no significant impact upon VHF communications as demonstrated at other operational sites.

23.3 *VHF Direction Finding*

363. During the 2004 trials at North Hoyle wind farm, the VHF direction equipment carried in the trial boats did not function correctly when very close to wind turbines

(within approximately 50 m). This is deemed to be a relatively small scale impact due to the limited use of VHF direction finding equipment and will not impact operational or SAR activities, especially as the effect is now recognised by the MCA (MCA and QinetiQ, 2004).

364. Throughout the 2005 SAR trials carried out at North Hoyle wind farm, the Sea King radio homer system was tested. The sea king radio homer system utilises the lateral displacement of a vertical bar on an instrument to indicate the sense of a target relative to the aircraft heading. With the aircraft and the target vessel within the wind farm, at a range of approximately 1nm, the homer system operated as expected with no apparent degradation.

23.4 *Automatic Identification System (AIS)*

365. In theory there could be interference when there is a structure located between the transmitting and receiving antennas (i.e. blocking line of sight) of the AIS. This was not evident in the trials carried out at the North Hoyle offshore wind farm site and no significant impact is anticipated for any AIS signals being transmitted and received within the OWF sites (MCA and QinetiQ, 2004).

23.5 *Navtex Systems*

366. The Navigational Telex (NAVTEX) system is used for the automatic broadcast of localised Maritime Safety Information (MSI) and either prints it out in hard copy or displays it on an LCD screen, depending on the model.

367. There are two NAVTEX frequencies. All transmissions on NAVTEX 518 Kilohertz (kHz), the international channel, are in English. NAVTEX 518 kHz provides the mariner (both recreational and commercial) with weather forecasts, severe weather warnings and navigation warnings such as obstructions or buoys off station. Depending on the users’ location other information options may be available such as ice warnings for high latitude sailing.

368. The 490 kHz national NAVTEX service may be transmitted in the local language. In the UK full use is made of this second frequency including useful information for smaller craft, such as the inshore waters forecast and actual weather observations from weather stations around the coast.

369. Although no specific trials have been undertaken, no significant effect has been noted at operational sites and therefore no effects are expected to arise from Norfolk Vanguard.

23.6 *Global Positioning System (GPS)*

370. Global Positioning System (GPS) is a satellite based navigational system. GPS trials were also undertaken throughout the 2004 trials at North Hoyle wind farm and stated that "no problems with basic GPS reception or positional accuracy were reported during the trials".

371. The additional tests showed that "even with a very close proximity of a wind turbine to the GPS antenna, there were always enough satellites elsewhere in the sky to cover for any that might be shadowed by the wind turbine tower" (MCA and QinetiQ, 2004).

372. Therefore, there are not expected to be any significant impacts associated with the use of GPS systems within or in proximity to Norfolk Vanguard.

23.7 *Electromagnetic Interference (from Wind Turbines or Cables) on Navigation Equipment*

373. A compass, magnetic compass or mariner's compass is a navigational instrument for determining direction relative to the earth's magnetic poles. It consists of a magnetised pointer (usually marked on the north end) free to align itself with the earth's magnetic field. A compass can be used to calculate heading, used with a sextant to calculate latitude, and with a marine chronometer to calculate longitude.

374. Like any magnetic device, compasses are affected by nearby ferrous materials as well as by strong local electromagnetic forces, such as magnetic fields emitted from power cables. As the compass still serves as an essential means of navigation in the advent of power loss or a secondary source, it should not be allowed to be affected to the extent that safe navigation is prohibited. The important factors that affect the resultant deviation are:

- Water and burial depth;
- Current (whether alternating or direct) running through the cables;
- Spacing or separation of the two cables in a pair (balanced monopole and Bipolar designs); and / or
- Cable route alignment relative to the earth's magnetic field.

375. Norfolk Vanguard export and array cables could be either alternating current (AC) or direct current (DC), with studies indicating that AC does not emit an electromagnetic field significant enough to impact marine magnetic compasses (OSPAR, 2008).

376. It is noted that should any DC cables be used they may cause electromagnetic interference for vessels using magnetic compasses. However, effects on larger vessels

using inertial navigation systems and GPS as their main navigational system are expected to be limited. Smaller craft which may only carry a magnetic compass and operate within near shore waters are likely to experience the highest effects but only for the period where they are directly above an unbundled DC cable.

377. No problems with respect to magnetic compasses have been reported to date in any of the trials carried out (inclusive of SAR helicopters). However, small vessels with simple magnetic steering and hand bearing compasses should be wary of using these close to wind turbines as with any structure in which there is a large amount of ferrous material (MCA and QinetiQ, 2004).

23.8 *Impact on Marine Radar Systems*

378. The 2004 MCA North Hoyle wind farm trials identified areas of concern with regard to the potential impact on marine and shore based Radar systems. This is due to the large vertical extent of the wind turbines returning Radar responses strong enough to produce interfering side lobes, multiple and reflected echoes (ghosts). This has also been raised as a major concern by the maritime industry with further evidence of the problems being identified by the Port of London Authority (PLA) around the Kentish Flats offshore wind farm in the Thames Estuary. Based on the results of the North Hoyle trial, the MCA produced a wind farm / shipping route template to give guidance on the distances which should be established between shipping routes and offshore wind farms.

379. A second trial was conducted at Kentish Flats between 30 April 2006 and 27 June 2006 on behalf of the British Wind Energy Association (BWEA, 2007). The project steering group had members from the BEIS, the MCA and the PLA. This trial was conducted in pilotage waters and in an area covered by the PLA Vessel Traffic Services (VTS). It therefore had the benefit of pilot advice and experience but was also able to assess the impact of the generated effects on VTS Radars.

380. The trial concluded that:

- The phenomena referred to above detected on marine Radar displays in the vicinity of wind farms can be produced by other strong echoes close to the observing vessel although not necessarily to the same extent;
- Reflections and distortions by vessels’ structures and fittings created many of the effects and the effects vary from vessel to vessel and Radar to Radar;
- VTS scanners static Radars can be subject to similar phenomena as above if passing vessels provide a suitable reflecting surface but the effect did not seem to present a significant problem for the PLA VTS; and

- Small vessels operating in or near the wind farm would be detectable by Radars located on vessels operating near the OWF sites but would be less detectable when the vessel was operating within the OWF sites.

381. Throughout the 2005 MCA SAR helicopter trials at the North Hoyle wind farm, side lobe returns were found to extend approximately 100m to either side of each wind turbine, with side lobe depth estimated at less than 50m. The Radar target, which was moving between the wind turbines within the wind farm, was tracked from an aircraft positioned in the 50-foot hover position between 0.25 to 0.5nm clear of the wind farm boundary. The target could be tracked to a distance of approximately 100 m from each wind turbine. Beyond this point the target could be recognised at a slightly closer range to the wind turbine, but only if it had been previously identified at a greater separation and Radar processing continuously adjusted (MCA, 2005).

382. Theoretical modelling of the composite effects of the development of the Atlantic Array offshore wind farm on marine Radar systems was carried out by Ledwood Technology in October 2011 (Atlantic Array, 2012). The main outcomes of the modelling were as follows:

- “Multipath effects (false targets) were detected under all modelled parameters. The main effects noticed were stretching of targets in azimuth and appearance of more ghost targets due to multipath energy arriving through the side lobes. However, it was concluded that there was a significant amount of clear space amongst the returns to ensure recognition of vessels moving amongst the wind farm structures and safe navigation.
- Even in the worst case with Radar operator settings set artificially bad there is significant clear space around each wind turbine that does not contain any multipath or side lobe ambiguities to ensure safe navigation and allow differentiation between false and real (both static and moving) targets.
- Overall it can be concluded that the amount of shadowing observed was very little. However, it should be noted that this was modelled on lattice-type base structures which are sufficiently sparse to allow Radar energy to pass through. The lower the density of structures the easier it is to interpret the Radar returns and fewer multipath ambiguities are present.
- In dense, target rich environments S-Band Radar scanners suffer more severely from multipath effects in comparison to X-Band scanners.
- It is important for passing vessels to keep a reasonable separation distance between the wind farm structures in order to minimise the effect of multipath and other ambiguities.
- The potential Radar interference is mainly a problem during periods of reduced visibility when mariners may not be able to visually confirm the presence of other

vessels in the vicinity (i.e. those without AIS installed which are usually fishing and recreational craft)".

383. Based on the trials carried out to date, the onset range from the wind turbines of false returns is approximately 1.5nm, with progressive deterioration in the Radar display as the range closes. If interfering echoes develop, the requirements of the COLREGS Rule 6 Safe speed are particularly applicable and must be observed with due regard to the prevailing circumstances. In restricted visibility, Rule 19 Conduct of vessels in restricted visibility applies and compliance with Rule 6 becomes especially relevant. In such conditions mariners are required, under Rule 5 Lookout to take into account information from other sources which may include sound signals and VHF information, for example from a VTS, or AIS (MCA, 2016).

384. It is noted that upon development of Norfolk Vanguard, commercial vessels are likely to pass over 1nm from the OWF site study area, and thereby potentially be subject to a minor level of Radar interference. There is sufficient sea room around the proposed wind farm for vessels to increase their clearance further if they consider it necessary to greater than 2nm and out with the potential range of Radar interference.

385. Figure 23.1 and Figure 23.2 presents a visual representation of the identified impacts.

386. Experienced mariners should be able to suppress the observed problems to an extent and for short periods (a few sweeps) by careful adjustment of the receiver amplification (gain), sea clutter and range settings of the Radar. However, there is a consequential risk of losing targets with a small Radar cross section, which may include buoys or small craft, particularly yachts or Glass Reinforced Plastic (GRP) constructed craft, therefore due care is needed in making such adjustments. The Kentish Flats study observed that the use of an easily identifiable reference target (a small buoy) can help the operator select the optimum Radar settings.

387. The performance of a vessel's ARPA could also be affected when tracking targets in or near Norfolk Vanguard. However, although greater vigilance is required, it appears that during the Kentish Flats trials, false targets were quickly identified as such by the mariners and then by the equipment itself.

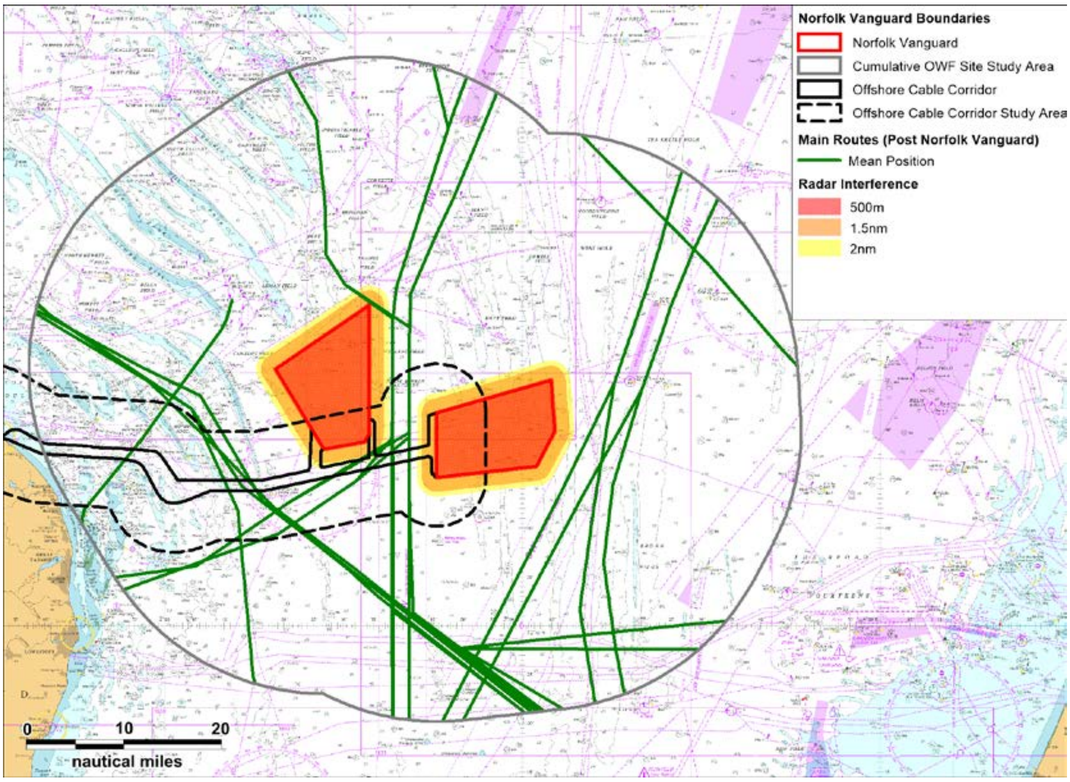

Figure 23.1 Norfolk Vanguard Radar Interference within 25nm

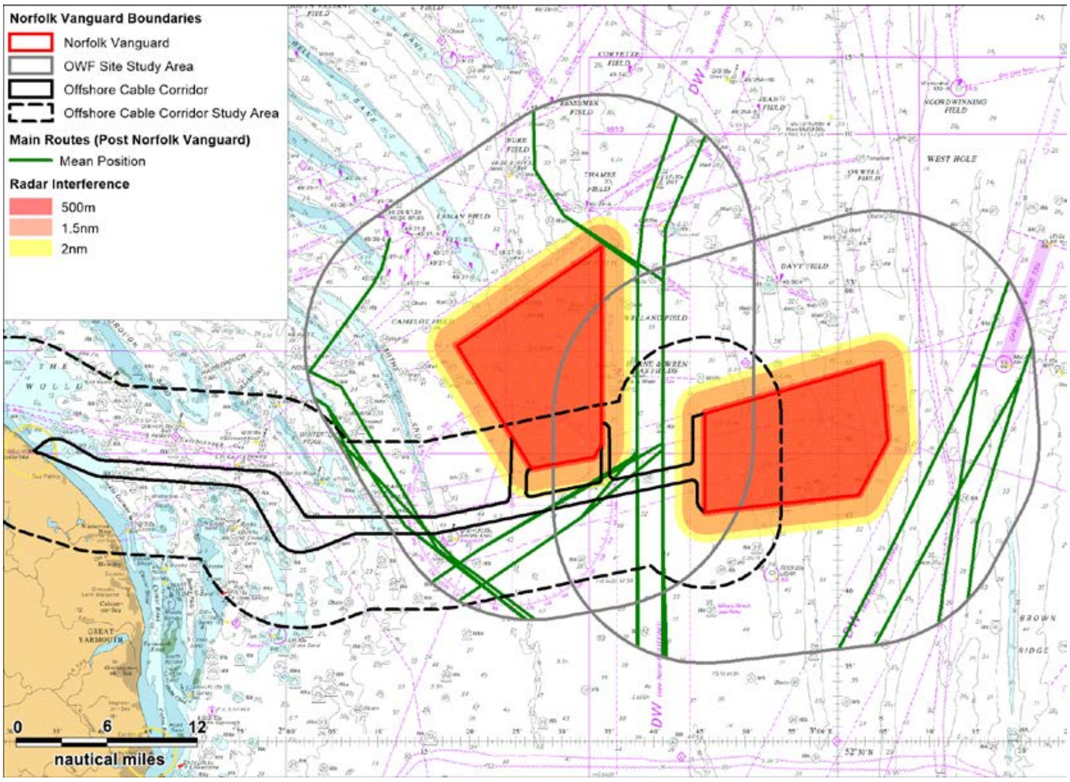

Figure 23.2 Norfolk Vanguard Radar Interference within 10nm

388. The evidence from mariners operating in the vicinity of existing wind farms is that they quickly learn to work with and around the effects. The MCA has produced guidance to mariners operating in the vicinity of UK Offshore Renewable Energy Installations (OREIs) which highlights Radar issues amongst others to be taken into account when planning and undertaking voyages in the vicinity of renewable energy installations off the UK coast (MCA, 2016).

389. AIS information can also be used to verify the targets of larger vessels (generally vessels above 300 tonnes) and fishing vessels of 18 m length and over which are required to carry AIS. Since May 2014 the carriage requirements of AIS for fishing vessels require all fishing vessels of 15 m length and over to carry AIS. It is noted that no fishing vessels less than 15m in length were recorded within the OWF sites during the marine traffic surveys, however it should be considered that lengths could not be specified for 3% of fishing vessels. Furthermore, an increasing number of small fishing vessels (currently not required to carry AIS) and recreational craft are voluntarily utilising Class B AIS units thus enabling verification of these small craft when in proximity to a wind farm.

23.8.1 Increased Wind Turbine Size

390. Following analysis of Radar interference studies and general Radar principles the following impacts associated with the use of the large wind turbines (maximum hub height of 198.5 m and rotor tip of 350 m LAT) which could be used in Norfolk Vanguard have been identified. This is specifically to identify potential impacts with the increasing size of wind turbines due to the operation of marine Radar beam widths and does not consider impacts associated with the total number of wind turbines or amount of exposure for transiting vessels passing within 2nm.

391. Figure 23.3 shows an example of how Radar range is determined – the curve of the earth plus the sum of the scanner and target height. A higher target height (point B in Figure 23.3) will result in a greater range of detection (point C) of the target, especially for larger vessels with a higher antenna (point A). However, the increased distance would result in a weaker Radar return and therefore the effects recorded whilst operating in close proximity to a wind farm (e.g. interfering side lobes, multiple and reflected echoes), are not likely to occur at this increased range. Therefore, the increased range of detection of larger wind turbines will not impact on a vessels' ability to navigate safely.

392. Increased wind turbine size would mean that small craft transiting within Norfolk Vanguard would be able to identify wind turbine targets at a greater distance,

especially if they are not in rows. Consequently, Norfolk Vanguard, ahead of the vessel, would be clear on the Radar screen.

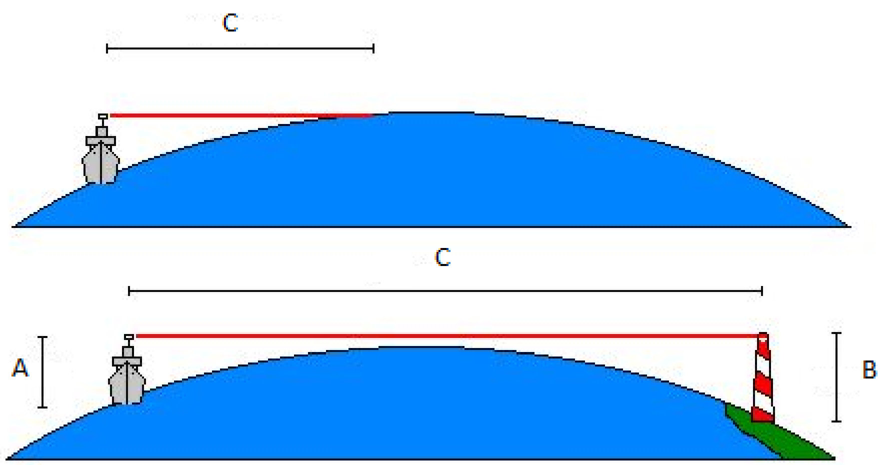

Figure 23.3 Determining Radar range

23.8.2 Increased Target Returns

393. Beam width is the angular width, horizontal or vertical, of the path taken by the Radar pulse. Horizontal beam width ranges from 0.75 to 5°, and vertical beam width from 20 to 25°. How well an object reflects energy back towards the Radar depends on its size, shape and aspect angle.

394. The larger wind turbines (either in height or width) will return a greater target size or stronger false targets. However, there is a limit to which the vertical beam width would be affected (20 to 25°) dependant on the distance from the target. Therefore, the increased wind turbine height at the Norfolk Vanguard will not create any effects in addition to those already identified from existing operational wind farms (e.g. interfering side lobes, multiple and reflected echoes).

395. The most likely occurrence will be a greater target return due to increased width of wind turbines and foundations resulting in similar effects to those previously described (e.g. interfering side lobes, multiple and reflected echoes). Again, when taking into consideration the potential options available to marine users (e.g. reducing gain to remove false returns) and feedback from trials carried out to date that the effects of increased returns can be managed effectively, this effect is expected to be negligible and not further impact on navigational safety.

23.9 *Structures and Wind Turbines Affecting Sonar Systems*

396. No evidence has been found to date with regard to existing wind farms to suggest that they produce any kind of sonar interference which is detrimental to the fishing industry, or to military systems. No impact is therefore anticipated for Norfolk Vanguard and offshore cable corridor.

23.10 *Noise Impact*

397. The concern which must be addressed under MGN 543 is whether acoustic noise from the wind farm could mask prescribed sound signals.

398. The sound level from a wind farm at a distance of 350 m has been predicted to be 51 (decibels) dB to 54 dB (A). Furthermore, recent predictions of noise levels have been carried out throughout the consenting process of the Atlantic Array offshore wind farm. Modelling shows that the highest predicted level due to operational wind turbine noise (for a 125m tall eight megawatt (MW) wind turbines) is around 60 dB (Atlantic Array Offshore Wind Farm, 2012).

399. A vessel's whistle for a vessel of 7m should generate in the order of 138 dB and be audible at a range of 1.5nm (IMO, 1972/77); hence this should be heard above the background noise of the wind turbines. Similarly, foghorns will also be audible over the background noise of the project.

400. There are therefore no indications that the sound level of the wind farm will have a significant influence on marine safety.

23.11 *Underwater Noise*

401. Underwater noise radiated from 110 m tall, 2MW capacity wind turbines during the operation of the Horns Rev offshore wind farm (Denmark) was measured in November 2005. The maximum levels recorded at 100m from the wind turbines were a sound pressure of 122 dB re 1µ pascals (Pa) (ITAP, 2006).

402. During the operational phase of Norfolk Vanguard, the subsea noise levels generated by wind turbines are not anticipated to have any significant impact on sonar systems as they are designed to work in pre-existing noisy environments.

23.12 *Effects on Communication and Position Fixing*

403. Table 23.1 summarises the impacts of Norfolk Vanguard on communication and position fixing equipment.

Table 23.1 Summary of Effects on Communication and Position Fixing Equipment

Topic		Sensitivity	Screen in/out – Isolation	Screen in/out - Cumulative
Type	**Specific**			
Communication	VHF	No anticipated impacts. Not impacted by layout design.	Screened out	Screened out
	VHF direction finding	No anticipated impacts. Not impacted by layout design.	Screened out	Screened out
	AIS	No anticipated impacts. Not impacted by layout design.	Screened out	Screened out
	NAVTEX	No anticipated impacts. Not impacted by layout design.	Screened out	Screened out
	GPS	No anticipated impacts. Not impacted by layout design.	Screened out	Screened out
EMF	Cables	No anticipated impacts.	Screened out	Screened out
	Wind turbines	No anticipated impacts. Not impacted by layout design.	Screened out	Screened out
Marine Radar	Use of marine Radar	Vessels have sufficient sea room to distance themselves from Norfolk Vanguard, in line with the shipping template, to mitigate any effects. There are not anticipated to be any impacts with floating foundations given the slow speed at which they would move within their excursion area. Cumulatively, vessels within the navigational corridor could be sensitive but have the ability to distance themselves further from the boundary or to make manual adjustments to mitigate any temporary	Screened out	Screened out

Topic		Sensitivity	Screen in/out – Isolation	Screen in/out - Cumulative
Type	**Specific**			
		impacts.		
Noise	Wind turbine generated noise	No anticipated impacts. Not impact by layout design.	Screened out	Screened out
	SONAR	No anticipated impacts. Not impact by layout design.	Screened out	Screened out

23.13 *Effects on Visual Collision / Allision Avoidance*

23.13.1 Visual Impact (Other Vessels)

404. Consideration has been given to the alignment of wind turbines within the array with regards to visual navigation. Based on the alignment, number of wind turbines and minimum spacing (200 wind turbines, 680m) it is not considered there would be any significant effects associated with visual "blind spots" between vessels on the main commercial shipping routes in the area, this also includes small craft navigating within the array.

405. During the survey periods, recreational activity was recorded during the summer and winter for Norfolk Vanguard West and summer only for Norfolk Vanguard East, with fishing identified all year round in the general area. In the event of a small vessel emerging from the windfarm towards shipping traffic, the vessel should be visible for the vast majority of the time, due to the size of the wind turbines and the spacing between them.

23.13.2 Visual Impact (Navigational Aids and / or Landmarks)

406. Norfolk Vanguard itself would form a significant aid to navigation, which would be very visible to shipping with lights on significant peripheral structures as well as selected intermediate structures in accordance with TH requirements (see section 26.1). It is therefore considered that, provided suitable marking and lighting would be developed at Norfolk Vanguard, it would not degrade the ability of vessels to navigate in the area through visual impairment.

407. It is also noted that the windfarm does not impact on any other pre-established navigational aids (as per section 8.2).

408. Both effects are assessed further in Chapter 15 Shipping and Navigation.

24. Hazard Log

24.1 *Introduction*

409. This section summarises the Hazard Log which has been created for Norfolk Vanguard as per the methodology (MCA, 2015) to detail the impacts upon shipping and navigation that may arise from the construction, operation, and decommissioning of the proposed project. The full log is presented in Appendix C, which provides a list of the identified impacts, and ranks each in terms of significance (assuming the embedded mitigation measures described in Section 26 will be in place). Where necessary, the log also summarises any recommended additional mitigation measures.

24.2 *Consultation*

410. In order to satisfy the consultation requirement, the initial draft of the Hazard Log was distributed to stakeholders identified as being relevant to shipping and navigation. A summary of the distribution list, and any response received is presented in Table 24.1. All responses were taken into consideration when producing the final version of the log. It is noted that a hazard workshop was not undertaken, due to lack of interest in attendance in person from the invitees. This was done in agreement within the MCA and used the hazard log undertaken for the previous East Anglia Four as a basis.

Table 24.1 Hazard Log Consultation

Stakeholder	Comments
MCA	n/a
TH	Responded with no comments.
DfT	Responded with no comments.
CoS	See table 5.1
CA	Responded with no comments.
RYA	Responded with no comments.
BMAPA	n/a
RNLI	n/a
Rijkswaterstaat	n/a
NFFO	n/a
VisNed	See table 5.1
Brown and May	Responded with no comments.
ABP	Responded with no comments.
Peel Ports – Great Yarmouth Harbour Office	Responded with no comments.

Stakeholder	Comments
BP Shipping Ltd	See table 5.1
Ostensjo Rederi AS	n/a
Boston Putford Offshore Safety	Responded with no comments.
DFDS A/S	n/a
P&O	See table 5.1

24.3 *Results*

411. Based on a review of the baseline assessment, the impacts arising as a result of the proposed project were identified, and subsequently included in the Hazard Log distributed to stakeholders. It is noted that in some cases it was considered necessary to treat impacts separately by project phase (i.e., construction, operation, decommissioning) or receptor. The impacts are listed below:

- Deviation of commercial vessel routeing (C,O,D);
- Powered or NUC allision of a commercial vessel with wind farm structure (C, D);
- Powered allision of a commercial vessel with wind farm structure (O);
- NUC allision of a commercial vessel with wind farm structure (O);
- Collision involving a commercial vessel (C,O,D);
- Snagging of a commercial vessel anchor on wind farm infrastructure (C,O,D);
- Unauthorised mooring to and / or deliberate damage to device (C,O,D);
- Unauthorised access to and / or deliberate damage to device (C,O,D);
- Mooring for access to structure in an emergency situation (C,O,D);
- Restricted emergency response within the OWF sites in an emergency situation (C,O,D);
- Allision of a fishing vessel with wind farm structure (C,O,D);
- Snagging of a fishing vessels gear or anchor on infrastructure within OWF sites (C,O,D);
- Snagging of a fishing vessels gear or anchor on subsea cables (C,O,D);
- Deviation of fishing vessel activity (C,O,D);
- Allision of a wind farm support vessel with wind farm structure (C,O,D);
- Person overboard from a wind farm support vessel (C,O,D);
- Displacement of oil and gas vessel activity (C,O,D);
- Displacement of recreational vessel activity (C,O,D);
- Allision of a recreational vessel with wind farm structure (C,O,D);
- Collision involving a recreational vessel (O,D); and
- Deliberate allision between a vessel and wind farm structure (C,O,D).

25. Cumulative Effects

25.1 *Introduction*

412. Cumulative effects have been considered for the proposed project including impacts on shipping and navigation arising from other proposed offshore wind projects and any impacts arising from other marine activities or users in the sea.

413. Projects and proposed projects were screen into the assessment only where there was potential overlap between activities and receptors identified.

414. Vessel transits were considered in detail as part of the baseline for the NRA and therefore vessel traffic associated with marine aggregates dredging, oil and gas support, commercial fishing, recreational activity and MOD movements are effectively screened out of the cumulative assessment.

25.2 *Cumulative Screening*

415. Table 25.1 summarises the projects and proposed projects where a cumulative activity has been identified.

416. Cumulative impacts have been considered for shipping and navigation receptors, including other offshore developments, as well as activities associated with other marine operations. However, it should be noted that fishing, recreational, and marine aggregate dredging transits have been considered as part of the baseline assessment and are therefore not included in Table 25.1

417. Cumulative impacts are considered within a 10nm buffer around the OWF sites but this area is extended where applicable to encompass vessel routeing. This includes consideration of transboundary offshore wind farm projects and shipping routes. However, for a cumulative or transboundary wind farm to be considered in the cumulative routeing assessment, a vessel route needs to be impacted (route through or in proximity to) by both the screened wind farm and the proposed project.

Table 25.1 Cumulative Screening

Project	Country	Offshore Status	Closest Distance to Norfolk Vanguard (nm)
Doggerbank Creyke Beck A	UK	Consented	99.33
Doggerbank Creyke Beck B	UK	Consented	111.94

Project	Country	Offshore Status	Closest Distance to Norfolk Vanguard (nm)
Doggerbank Teesside A	UK	Consented	115.13
Doggerbank Teesside B	UK	Consented	108.34
Dudgeon	UK	Under construction	35.84
East Anglia One	UK	Consented	26.28
East Anglia One North	UK	Pre-planning application	20.59
East Anglia Three	UK	Consent application submitted	0.00
East Anglia Two	UK	Pre-planning application	30.45
Galloper	UK	Under construction	50.28
Greater Gabbard	UK	Operational	52.01
Gunfleet Sands Demo	UK	Operational	79.80
Gunfleet Sands I	UK	Operational	76.99
Gunfleet Sands II	UK	Operational	76.22
Hornsea Project Four	UK	Pre-planning application	62.11
Hornsea Project One	UK	Under construction	51.04
Hornsea Project Three	UK	Pre-planning application	39.61
Hornsea Project Two	UK	Consented	58.00
Humber Gateway	UK	Operational	82.69
Inner Dowsing	UK	Operational	68.33
Kentish Flats 1	UK	Operational	93.77
Kentish Flats 2	UK	Operational	94.36
Lincs	UK	Operational	66.09
London Array 1	UK	Operational	74.55
Lynn	UK	Operational	67.35
Norfolk Boreas	UK	Pre-planning application	0.52
Norfolk Vanguard	UK	Pre-planning application	n/a
Race Bank	UK	Under construction	53.47
Scroby Sands	UK	Operational	24.19
Sheringham Shoal	UK	Operational	40.72

Project	Country	Offshore Status	Closest Distance to Norfolk Vanguard (nm)
Thanet	UK	Operational	85.85
Thanet Extension	UK	Pre-planning application	TBC
Triton Knoll	UK	Consented	54.36
Westermost Rough	UK	Operational	91.49
Belwind	Belgium	Operational	62.87
Belwind Alstom Haliade Demonstration	Belgium	Operational	63.85
Mermaid	Belgium	Consented	60.84
Nobelwind	Belgium	Consented	62.52
Norther	Belgium	Consented	71.39
Northwester 2	Belgium	Consented	62.03
Northwind	Belgium	Operational	66.74
Poseidon P60 – Mermaid	Belgium	Concept / early planning	62.90
Rentel	Belgium	Pre-construction	68.43
Seastar	Belgium	Consented	65.42
Thornton Bank phase I	Belgium	Operational	72.38
Thornton Bank phase II	Belgium	Operational	70.91
Thornton Bank phase III	Belgium	Operational	71.97
Borssele Site I	Netherlands	Consented	58.11
Borssele Site II	Netherlands	Consented	63.65
Borssele Site III	Netherlands	Consented	61.76
Borssele Site IV	Netherlands	Consented	58.62
Egmond aan Zee	Netherlands	Operational	47.56
Eneco Luchterduinen	Netherlands	Operational	45.63
Hollandse Kust Noord Holland I (Tender 2019)	Netherlands	Concept / early planning	40.07
Hollandse Kust Noord Holland II (Tender 2019)	Netherlands	Concept / early planning	40.07
Hollandse Kust Zuid Holland I (Tender 2017)	Netherlands	Concept / early planning	40.79
Hollandse Kust Zuid Holland II (Tender 2017)	Netherlands	Concept / early planning	40.79
Hollandse Kust Zuid Holland III (Tender 2018)	Netherlands	Concept / early planning	40.79

Project	Country	Offshore Status	Closest Distance to Norfolk Vanguard (nm)
Hollandse Kust Zuid Holland IIII (Tender 2018)	Netherlands	Concept / early planning	40.79
IJmuiden Wind Farm Zone	Netherlands	Development zone	8.82
Irene Vorrink	Netherlands	Operational	90.90
Leeghwater – Wind Turbine Demonstration Facility	Netherlands	Consented	59.36
Nord-Holland boven Noordzeekanaal Potentiele Zoekgebieden	Netherlands	Development zone	44.75
Prinses Amaliawindpark	Netherlands	Operational	42.55
Voorde Hollandse kust Zoekgebieden	Netherlands	Development zone	21.31
Westermeerwind	Netherlands	Operational	90.60
Windpark Fryslân	Netherlands	Consent application submitted	77.62
Zuid-en Noord-Holland onder het Noordzeekanaal Potentiele Zoekgebieden	Netherlands	Development zone	47.89

25.3 *Increased Deviations Associated with Offshore Wind Farm Projects (including Transboundary)*

418. A full assessment of cumulative vessel routeing is provided in Section 19.3. The results of this assessment were used as input to Anatec's CollRisk software to assess the vessel to vessel collision rates. The results of this assessment are presented in Section 22.

26. Embedded Mitigation Measures

419. As well as compliance with MGN 543 the following list notes measures including standard industry practices that are considered embedded mitigation.

- Cable Burial Risk Assessment undertaken pre-construction, including consideration of under keel clearance. All subsea cables will be suitably protected based on risk assessment, and the protection will be monitored and maintained as appropriate.
- Compliance from all vessels associated with the proposed project with international maritime regulations as adopted by the relevant flag state (most notably International Convention for the Prevention of Collision at Sea (COLREGS) (IMO, 1972) and International Convention for the Safety of Life at Sea (SOLAS) (IMO, 1974)).
- Final site design to include consideration of lighting and marking. Suitable lighting and marking of the OWF sites complying with IALA Recommendations O-139 (IALA, 2013), to be finalised in consultation with TH and the MCA.
- Site design to ensure no outlying or extreme peripheral turbines and regular edges either side of the DWR.
- Continued dialogue with the developers of East Anglia Three;
- Foundations to be considered post consent to ensure they do not impact on vessels transiting within the array (under keel clearance issues). The RYA request a minimum of 4m under keel clearance and the Norfolk Vanguard OWF sites are expected to achieve this.
- An ERCoP will be developed and implemented for the construction, operational & maintenance and decommissioning phases. The ERCoP is based on the standard MCA template and would consider the potential for self-help capability as part of the ongoing process.
- Floating foundation mooring lines will be independently verified by a third party and meet required ISO standards.
- Information relevant to the proposed project will be promulgated via Notice to Mariners and other appropriate media including provision of information for use in fish plotters (where available).
- Marine traffic coordination to manage Norfolk Vanguard construction and operation vessels.

- MGN 372 (MCA, 2008), COLREGs (IMO, 1972) and SOLAS (IMO, 1974) which set out rules and regulations for third party vessels operating in the area including advice on navigating in proximity to a wind farm.
- Structures and all cables (offshore export and array) will be clearly marked on appropriately scaled nautical charts and electronic charts.
- Suitable lighting and marking of the OWF sites complying with IALA Recommendations O-139 (IALA, 2013), to be finalised in consultation with TH and the MCA (see section 25.1).
- The proposed project to be constructed in accordance with MGN 543 where applicable (MCA, 2016).
- Use of guard vessel during the deployment of safety zones, and during any other key construction periods.
- Wind turbines will have at least 22m clearance above Mean High Water Spring (MHWS).

420. The application for safety zones is also considered a required mitigation. The safety zones that may be applied for are summarised in Table 26.1.

Table 26.1 Summary of Safety Zones

Type of Safety Zone	Area Covered
Construction	Typically, up to 500m around structures under construction. This should be evidenced by the presence of a jack-up rig or other large construction vessel.
Construction (pre-commissioning)	Typically, up to 50m around wind turbines where construction has finished but some work is on-going e.g. wind turbine incomplete or in the process of being commissioned.
Operation	Potentially up to 500m around permanently manned platforms.
Major Maintenance	Typically, up to 500m when major maintenance is in progress. This should be evidenced by the presence of a jack-up rig or other large construction vessel.
Decommissioning	Typically, up to 500m at the end of the working life of a wind farm when it is being decommissioned. This should be evidenced by the presence of a jack-up rig or other large construction vessel.

26.1 *Marine Navigational Markings*

421. Throughout the life of the project marine navigational marking would be provided in accordance with the TH requirements, which will comply with IALA Recommendation O-139 on the Marking of Offshore Wind Farms (IALA, 2013) and the additional requirements of MCA MGN 543 (MCA, 2016).

422. Aviation lighting would be as per Civil Aviation Authority (CAA) requirements; however, it is likely that specific requirements will be made with regards to flash sequences and Search and Rescue (SAR) lighting. It is noted that SAR lighting falls under the MCA's remit.

423. All navigational aids will be suitably monitored and maintained to ensure the relevant IALA availability targets are met.

26.1.1 Construction and Decommissioning

424. During the construction / decommissioning of an offshore windfarm, working areas would be established and marked by a buoyed construction or decommissioning area as per TH requirements. In addition to this, where advised by TH, additional temporary marking would be applied including temporary lighting.

26.1.2 Operational Phase

425. The markings for the proposed project would be agreed in consultation with TH once the final wind turbine layout has been selected however the following sections summarise likely scenarios.

26.1.3 Marking of Individual Structures

426. As per IALA Recommendations O-139 (IALA 2013), each structure within the wind farm will be painted yellow from the level of HAT to 15m above HAT. Each structure will also be clearly marked with a unique alphanumeric identifier, which will be clearly visible in all directions. The identifications characteristics will each be illuminated by a low-intensity light, so that the sign is visible from a vessel thus enabling the structure to be identified at a suitable distance to avoid a collision with it. This will be such that under normal conditions of visibility and all known tidal conditions, they are clearly readable by an observer (with naked eye), stationed three metres above sea levels, and at a distance of at least 150m from the wind turbine. The light will be either hooded or baffled so as to avoid unnecessary light pollution or confusion with navigation marks.

26.1.4 Proposed Markings

427. The markings for the proposed project would be agreed in consultation with TH once the final wind turbine layout has been selected and would be in line with IALA Recommendation O-139. As per the IALA guidance and in consultation with TH, it will be ensured that:

- All corner wind turbines, will be marked as Significant Peripheral Structures (SPSs). Where necessary, to satisfy the spacing requirements between SPSs, additional periphery structures may also be marked as SPSs. Depending on spacing, further intermediate wind turbines on each of the boundaries may be marked as Intermediate Peripheral Structures (IPSs).
- In all the layouts, wind turbines designated as SPSs are to exhibit flashing yellow five second (flash yellow every five seconds) lights of at least 5nm nominal range and omnidirectional fog signals as appropriate / where prescribed by TH. Wind turbines designated as IPSs are to exhibit flash yellow every 2.5 seconds lights of at least 2nm nominal range.
- All the lights are to be visible to shipping through 360 degrees and if more than one lantern is required on a wind turbine meet the all-round visibility requirement, then all the lanterns on that a wind turbine should be synchronised.
- All the lights are to be exhibited at the same height at least 6m above HAT and below the arc of the lowest wind turbine blades.
- All the lights are to be exhibited at least at night and when the visibility is reduced to 2nm or less. Fog signals will be fitted to select structures as necessary and in consultation with TH, and are to be sounded at least when the visibility is 2nm or less.
- Aviation lighting will be as per Civil Aviation Authority (CAA) requirements, however will likely be synchronised Morse "W" at the request of TH.
- All lighting of the proposed project will be considered cumulatively with existing aids to navigation to avoid the potential for light confusion to passing traffic.

428. Consideration will also be given to the use of marking via AIS, or other electronic means (e.g., Racon), however this will be agreed in consultation with TH.

27. Next Steps – EIA and Additional Mitigations

429. The requirement for an EIA is set out in the Infrastructure Planning EIA Regulations 2009 which implement EC directive 85/337/EEC as amended by Directive 97/11/EC as detailed within Chapter 3 Policy and Legislative Context of the Environmental Statement.

430. Following identification of both future case impacts and the outcomes of the Formal Safety Assessment an impact assessment in line with EIA guidance has been undertaken. The impact assessment screens the identified impacts from the NRA with effective pathways.

431. The EIA requires compiling and reviewing available data. For shipping and navigation this includes the marine traffic surveys, base case assessment and Navigational Risk Assessment. The likely and significant effects of the proposed project during the construction, operation and decommissioning stages of the project are assessed and feedback provided to the design and engineering teams to mitigate or modify the proposed project in order to avoid, prevent, reduce and, where possible, offset any significant adverse effects on the environment. Following this is the identification of any residual effects and any further mitigation measures that may be required.

28. Future Monitoring

28.1 *Safety Management System (SMS)and Emergency Response Planning*

432. Health and safety documentation, including a policy statement, SMS and emergency response plans would be in place for the project post consent and prior to construction. This would be continually updated throughout the development process. The following sections provide an overview of documentation and how it would be maintained and reviewed with reference where required to specific marine documentation.

433. Monitoring, reviewing and auditing would be carried out on all procedures and activities and feedback actively sought. Any designated person, managers and supervisors are to maintain continuous monitoring of all marine operations and determine if all required procedures and processes are being correctly implemented.

28.2 *Future Monitoring of Marine Traffic*

434. The Development Consent Order is expected to include the requirement for construction traffic monitoring by AIS, including continual collection of data from a suitable location at the OWF sites with an assessment of a minimum of 28 days submitted to the MCA annually. This is likely to continue through to the first year of operation to ensure mitigations put in place are effective.

28.3 *Tensioned Leg Floating Platforms*

435. Mooring lines associated with floating foundations will have a monitoring system in place to ensure any significant movement is identified as early as possible. Mooring lines shall also be independently verified.

28.4 *Subsea Cables*

436. The subsea cable routes will be subject to periodic inspection to monitor the cable protection, including burial depths. Array cables will be reburied every five years.

28.5 *Hydrographic Surveys*

437. As required by MGN 543, detailed and accurate hydrographic surveys will be undertaken periodically at agreed intervals.

28.6 *Decommissioning Plan*

438. A decommissioning plan will be developed. With regards to impacts on shipping and navigation this will also include consideration of the scenario where on decommissioning and on completion of removal operations, an obstruction is left on site (attributable to the windfarm) which is considered to be a danger to navigation and which it has not proved possible to remove. Such an obstruction may require marking until such time as it is either removed or no longer considered a danger to navigation, the continuing cost of which would need to be met by the operator.

29. Summary

29.1 *Marine Traffic*

439. Four 14 day marine traffic surveys were undertaken for Norfolk Vanguard, two within each OWF site, with periods chosen to cover seasonal variations. Based on the survey data recorded during summer it was estimated that 69 unique vessels per day passed within 10nm of Norfolk Vanguard East, and 46 within 10nm of Norfolk Vanguard West. During winter, this fell to 63 unique vessels per day for Norfolk Vanguard East, and 39 for Norfolk Vanguard West.

440. The majority of vessels recorded during the surveys were commercial (either cargo or tanker), which was due to the presence of the DR1 Lightbuoy DWR running between the OWF sites, and the West Friesland DWR passing east of Norfolk Vanguard East. It was estimated that 10 to 12 vessels per day used the DR1 Lightbuoy DWR, and 28 to 29 used the West Friesland DWR. Twelve routes were observed to intersect one or both of the OWF sites, however none of these were used by more than one vessel per day.

441. The majority of fishing activity recorded in the vicinity of the OWF sites was from beam trawlers, however demersal trawlers, pelagic trawlers, and seiners were also observed to be actively fishing in the area. Similarly, the majority of fishing recorded in the vicinity of the cable corridor was from beam trawlers. Coastal activity was largely from fishing vessels in transit, however some potting activity was recorded near the landfall site.

442. With the exception of a tanker to tanker manoeuvre recorded within Norfolk Vanguard West, no anchoring was recorded within the vicinity of the OWF sites. One cargo vessel and one tanker were recorded within the area of interest surrounding the offshore cable corridor.

29.2 *Allision / Collision Modelling*

443. It was estimated that the construction of the proposed project would raise current vessel to vessel collision rates by approximately 1% (assuming no growth in traffic). Increases in traffic of 10% and 20% raised the collision risk by 22% and 45% respectively, however this was shown to be mainly due to the increased vessel numbers rather than route deviations caused by the OWF sites (modelling 10% and 20% increases without the wind farm increased the collision risk by 21% and 44%).

444. It was estimated that a vessel would allide with a wind farm structure under power once every 2,860 years assuming no growth in traffic. An allision from an NUC vessel was estimated to occur once every 1,060 years. It was estimated that an allision between a fishing vessel and a wind farm structure would occur once every three years, however it is noted that this assumes fishing levels will remain unchanged following construction of the proposed project.

29.3 *Hazard Log*

445. A hazard log was drafted by Anatec to detail all hazard identified following a review of the baseline assessment. Each hazard was ranked in terms of significance, and further mitigation proposed where required. The initial draft was distributed to the relevant shipping and navigation stakeholders, and any responses were taken into consideration in the final version. The final log was then used to inform the significance rankings used within the FSA in the ES, in addition to the modelling results and expert opinion.

29.4 *Emergency Response*

446. Under national and international law, the operators of the proposed project would be required to comply with existing emergency response requirements as well as giving consideration to other response groups within the area. Owing to the increased level of activity in and around the proposed project there are expected to be some increased demands on search and rescue facilities within the area. The proposed project could also increase traffic and activity to a level that self-help emergency response would be required and consideration in the ERCoP should be given to what resources would be required to provide a level of response that would ensure that response time and resources aren't impacted.

29.5 *Cumulative Impacts*

447. The cumulative impact of the proposed project upon vessel routeing when considered with other Southern North Sea wind farms was raised as a key issue during consultation. For this reason, vessel routeing patterns were predicted on a cumulative basis, and subsequently used to model the corresponding rise in collision rates. This cumulative assessment estimated that the frequency of a vessel to vessel collision will rise by approximately 6% within 25nm of the OWF sites (assuming no growth in traffic).

448. No further cumulative modelling was undertaken, however each impact identified in the hazard log has been assessed for the potential for cumulative impact in the ES.

29.6 *Impacts carried forward to the EIA*

449. Following consideration of the results of the NRA including baseline data, consultation, the hazard log, and modelling results, the NRA has identified the following receptors for consideration in the EIA:

- Commercial Vessel Routeing;
- Commercial Vessel Safe Navigation;
- Fishing Vessel Safe Navigation;
- Recreational Craft;
- Wind Farm Vessels;
- Oil and Gas Vessels; and
- Emergency Response.

450. Based on the receptors listed above, the following impacts have been assessed within the ES. Each of the below impacts have also been assessed within the ES for the potential for cumulative impact when considered with other projects or developments.

- Commercial routeing displacement / deviation;
- Displacement of fishing activity;
- Displacement if recreational vessel activity;
- Increase in vessel to vessel collision risk;
- Increase in in vessel to structure allision risk;
- Anchor snagging risk (cables and other subsea infrastructure); and
- Diminishment of emergency response capacity.

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31. Appendix A: Consequences Assessment

31.1 *Introduction*

451. This appendix presents an assessment of the consequences of collision and allision incidents, in terms of people and the environment, due to the impact of Norfolk Vanguard.

452. The significance of the impact of Norfolk Vanguard is also assessed based upon risk evaluation criteria and comparison with historical accident data in UK waters[1].

453. The consequences assessment uses as input the allision and collision modelling results calculated for Norfolk Vanguard (see Section 21). As discussed in Section 20.2.1, the layout used within this modelling assumed a larger number of structures than the current (as of the time writing) maximum under consideration. It should therefore be considered when viewing the consequences results that they may exceed those that would be obtained assuming the current worst case parameters.

31.2 *Risk Evaluation Criteria*

31.2.1 Risk to People

454. With regard to the assessment of risk to people, two measures are considered, namely:

- Individual risk; and
- Societal risk.

31.2.1.1 Individual Risk (per Year)

455. This measure considers whether the risk from an accident to a particular individual changes significantly due to the presence of Norfolk Vanguard. Individual risk considers not only the frequency of the accident and the consequence (likelihood of death), but also the individual's fractional exposure to that risk, i.e. the probability of the individual being in the given location at the time of the accident.

456. The purpose of estimating the individual risk is to ensure that individuals who may be affected by the presence of Norfolk Vanguard are not exposed to excessive risks. This is achieved by considering the significance of the change in individual risk resulting from the presence of the OWF sites relative to the background individual risk levels.

[1] In this context, UK waters refers to the UK Exclusive Economic Zone and UK territorial waters refers to waters within the 12nm limit.

457. Annual individual risk levels to crew (i.e. the annual fatality risk of an average crew member) for different vessel types are presented in Figure 31.1 (IMO, 2001). This figure also highlights the risk acceptance criteria as suggested in IMO Maritime Safety Committee (MSC) 72/16.

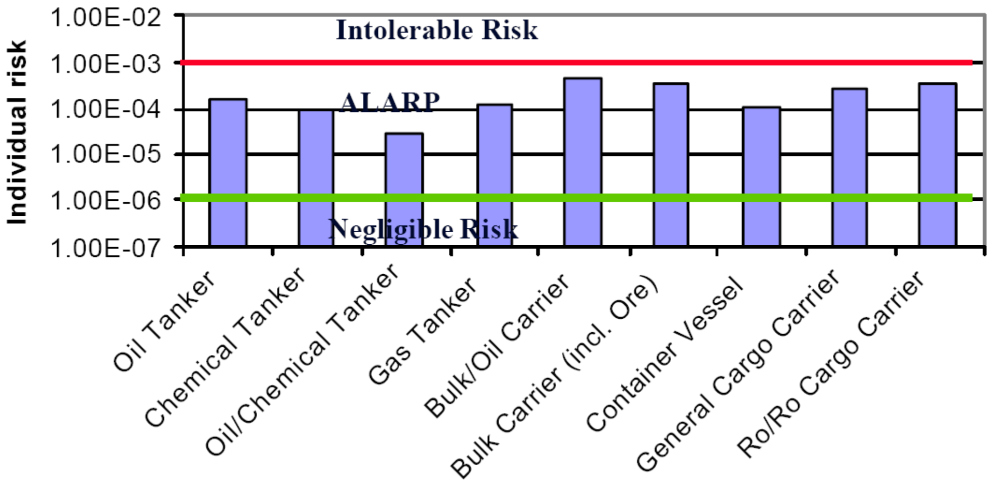

Figure 31.1 Individual Risk Levels and Acceptance Criteria per Vessel Type

458. Typical bounds defining the ALARP regions for decision making within shipping are presented in Table 31.1.

Table 31.1 Individual Risk ALARP Criteria

Individual	Lower Bound for ALARP	Upper Bound for ALARP
To crew member	10^{-6}	10^{-3}
To passenger	10^{-6}	10^{-4}
Third party	10^{-6}	10^{-4}
New vessel target	10^{-6}	Above values reduced by one order of magnitude

459. On a UK basis, the MCA website presents individual risks for various UK industries based upon HSE data from 1987 to 1991. The risks for different industries are presented in Figure 31.2.

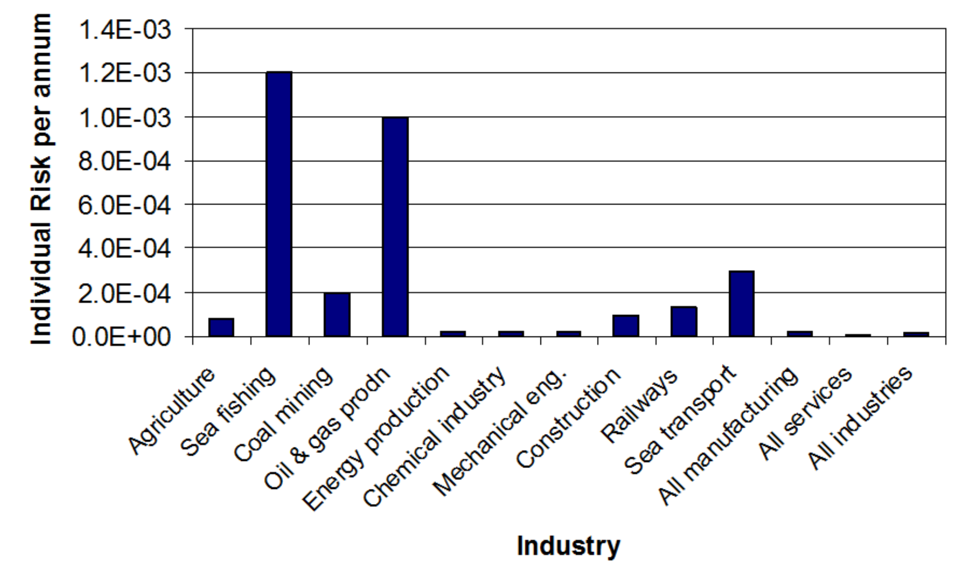

Figure 31.2 Individual Risk per Year for Various UK Industries

460. The individual risk for sea transport of 2.9 x 10^{-4} per year is consistent with the worldwide data presented in Figure 31.1, whilst the individual risk for sea fishing of 1.2 x 10^{-3} per year is the highest across all of the industries included.

31.2.1.2 Societal Risk

461. Societal risk is used to estimate risks of accidents affecting many persons, e.g. catastrophes, and acknowledging risk averse or neutral attitudes. Societal risk includes the risk to every person, even if a person is only exposed on one brief occasion to that risk. For assessing the risk to a large number of affected people, societal risk is desirable because individual risk is insufficient in evaluating risks imposed on large numbers of people.

462. Within this assessment societal risk (navigational based) can be assessed for the OWF sites study area, giving account to the change in risk associated with each accident scenario caused by the installation of the wind farm structures. Societal risk may be expressed as:

- Annual fatality rate where frequency and fatality are combined into a convenient one-dimensional measure of societal risk. This is also known as Potential Loss of Life (PLL); and
- FN-diagrams showing explicitly the relationship between the cumulative frequency of an accident and the number of fatalities in a multi-dimensional diagram.

463. When assessing societal risk this study focuses on PLL, which takes into account the number of people likely to be involved in an incident (which is higher for passenger ferries, for example), and assesses the significance of the change in risk compared to background risk levels for the UK.

31.2.2 Risk to Environment

464. For risk to the environment the key criteria considered in terms of the effect of Norfolk Vanguard is the potential amount of oil spilled from a vessel involved in an incident.

465. It is recognised there will be other potential pollution (e.g. hazardous containerised cargoes) but oil is considered the most likely pollutant and the extent of predicted oil spills will provide an indication of the significance of pollution risk due to Norfolk Vanguard compared to background pollution risk levels for the UK.

31.3 *MAIB Incident Analysis*

31.3.1 All Incidents

466. All UK-flagged commercial vessels are required to report accidents to the MAIB. Non-UK vessels do not have to report unless they are in a UK port or are within 12nm territorial waters and carrying passengers to a UK port. There are no requirements for non-commercial recreational craft to report accidents to the MAIB; however, the MAIB will record details of significant accidents of which they are notified by bodies such as the Coastguard, or by monitoring news and other information sources for relevant accidents to MAIB. Therefore, while there may be a degree of under-reporting of accidents with minor consequences, those resulting in more serious consequences, including fatalities, are likely to be reported.

467. Only incidents occurring in UK waters have been considered within this assessment for which MAIB data is most comprehensive. It is also noted that incidents occurring in ports / harbours and rivers / canals have been excluded from the data set as the causes and consequences may differ from an accident occurring offshore, which is the data set most relevant to Norfolk Vanguard.

468. Taking into account these criteria, a total of 13,374 accidents, injuries and hazardous incidents were reported to the MAIB between 1 January 1994 and 31 December 2014 involving 15,212 vessels (some incidents such as collisions involved more than one vessel).

469. The locations[1] of incidents reported in the vicinity of the UK are presented in Figure 31.3, colour-coded by type. It can be seen that most incidents occurred within coastal waters.

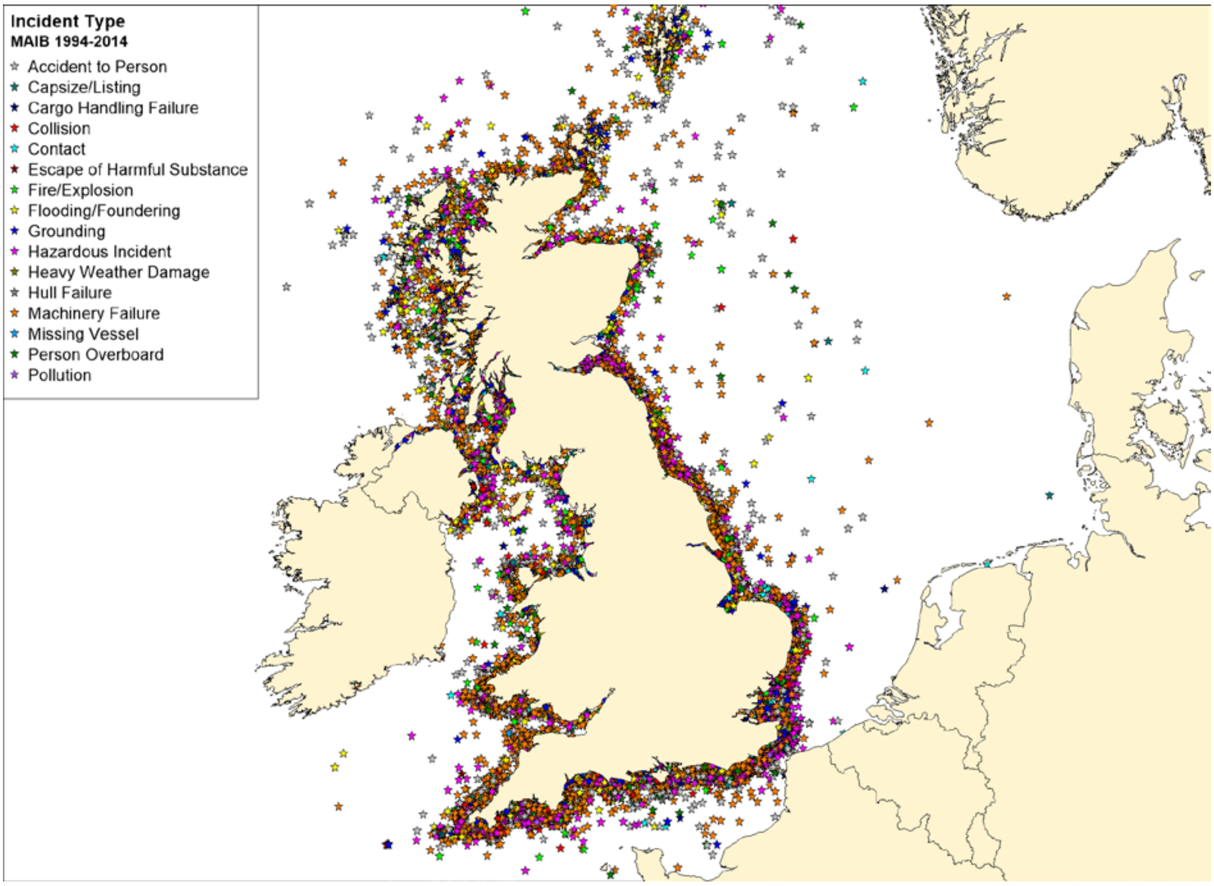

Figure 31.3 Incident Locations by Type (MAIB 1994 to 2014)

470. The distribution of incidents by year is presented in Figure 31.4.

[1] MAIB aim for 97% accuracy in reporting the locations of incidents.

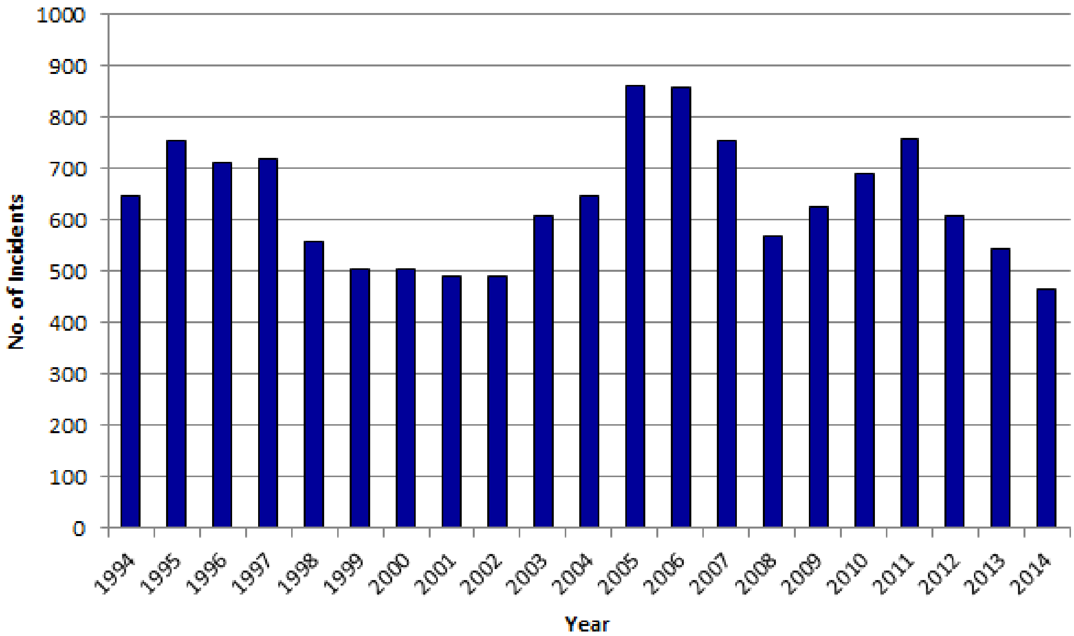

Figure 31.4 Incidents per Year (MAIB 1994 to 2014)

471. The average number of incidents per year was 637. There has been a fluctuating trend in incidents but the overall trend has been downward over the 21 year period.

472. The distribution of incidents by incident type is presented in Figure 31.5.

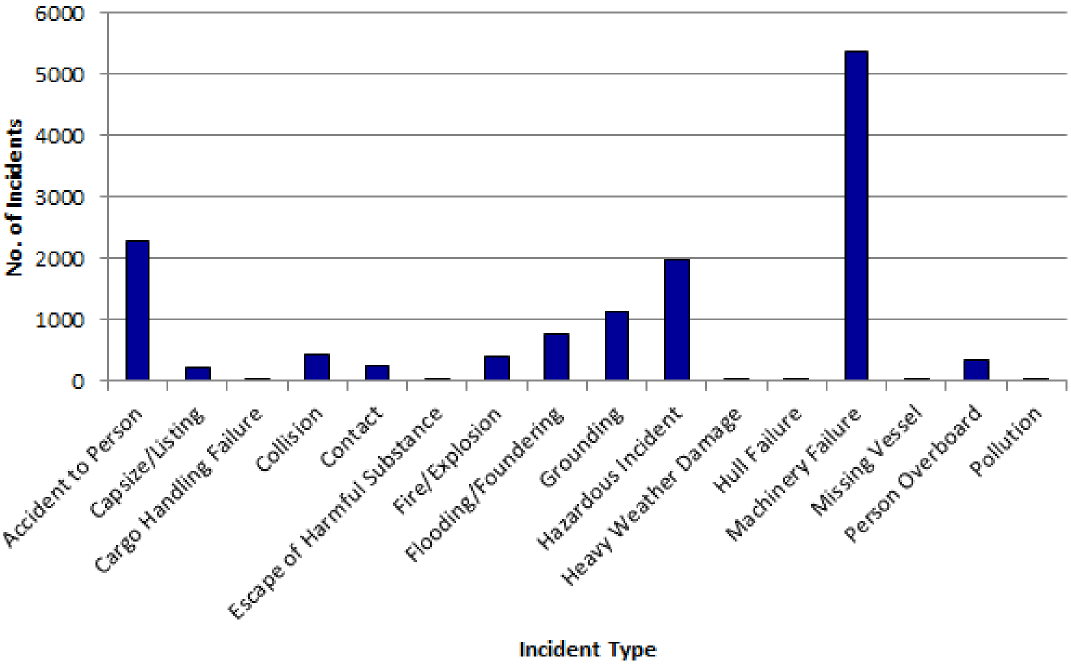

Figure 31.5 MAIB Incidents by Incident Type (MAIB 1994 to 2014)

473. The most common incident types were "Machinery Failure" (40%), "Accident to Person"[1] (17%) and "Hazardous Incident" (15%). "Collisions" and "Contacts" represented 3% and 2% of total incidents respectively.

474. The distribution of vessel type categories involved in incidents is presented in Figure 31.6.

[1] Where the incident is an accident to a vessel, e.g. collision or machinery failure, it would be reported under this vessel accident category.

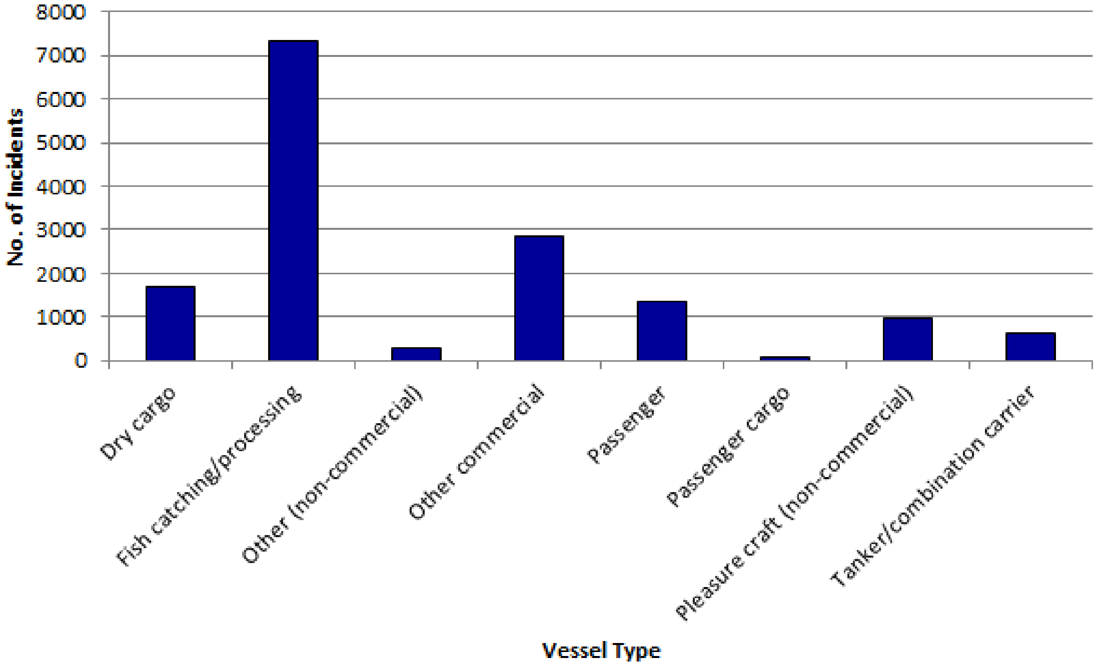

Figure 31.6 Incidents by Casualty Type (MAIB 1994 to 2014)

475. The most common casualty types were fishing vessels (48%), other commercial vessels (17%) (which includes offshore industry vessels, tugs, workboats and pilot vessels) and dry cargo vessels (11%).

476. The total number of fatalities reported in the MAIB incidents from 1994 to 2014 was 428. The average number of fatalities per year was approximately 20.

477. The distribution of fatalities in UK waters by vessel type and person is presented in Figure 31.7.

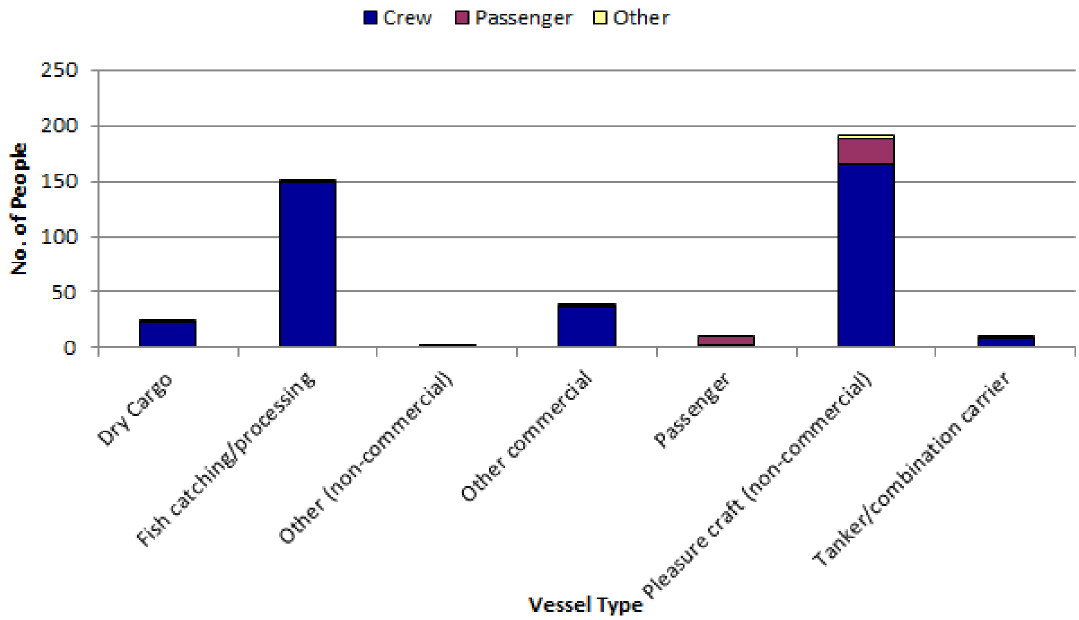

Figure 31.7 Fatalities by Vessel Type for Incidents (MAIB 1994 to 2014)

478. The majority of fatalities occurred to crew members of pleasure craft and fishing vessels.

31.3.2 Collision Incidents

479. The MAIB define a collision incident as when "a vessel hits another vessel that is floating freely or is anchored (as opposed to being tied up alongside)."

480. A total of 447 collision incidents were reported to the MAIB in UK waters between 1 January 1994 and 31 December 2014 involving 889 vessels (in a handful of cases the other vessel involved was not logged).

481. The locations of collision incidents reported in the vicinity of the UK are presented in Figure 31.8, colour coded by vessel type.

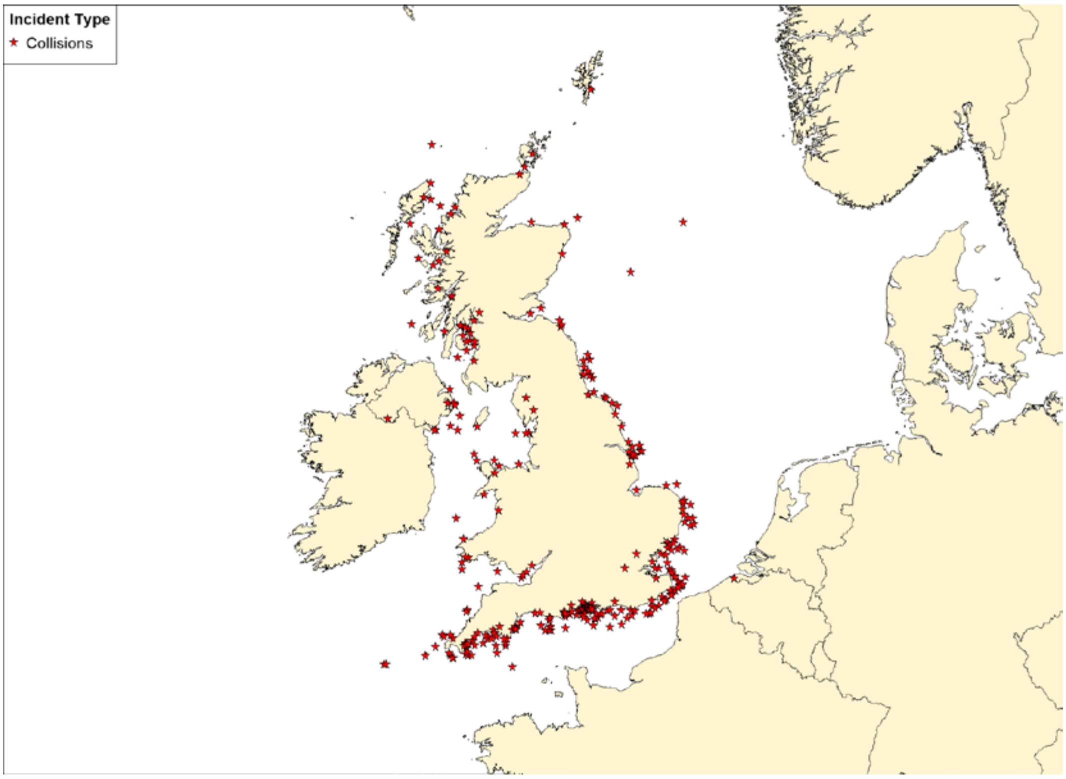

Figure 31.8 Collision Incident Locations (MAIB 1994 to 2014)

482. The number of vessels involved in collisions by year is presented in Figure 31.9.

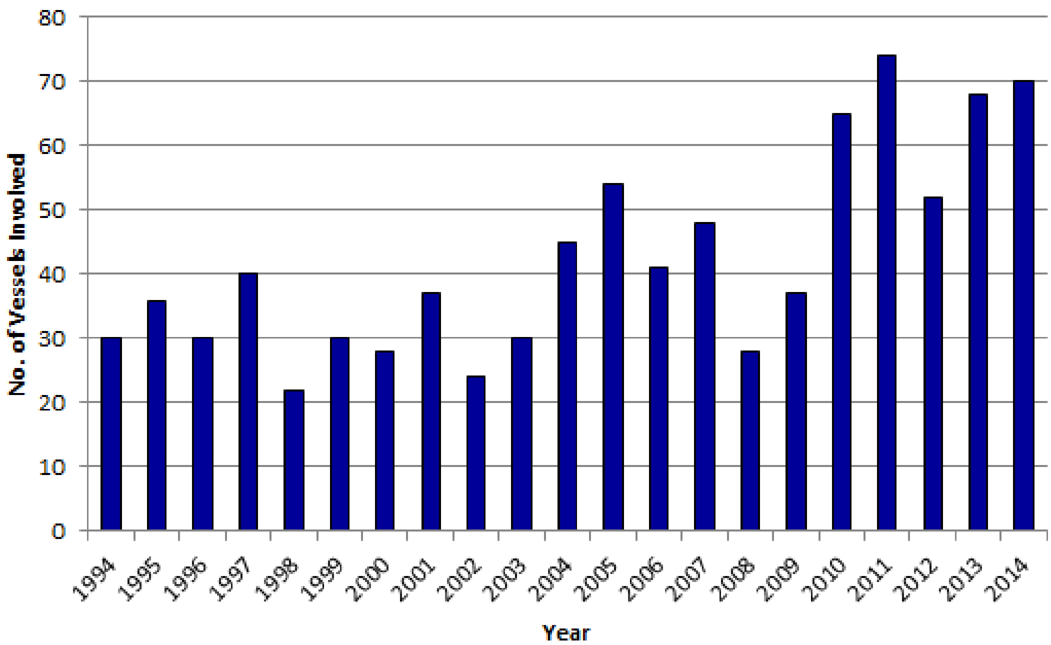

Figure 31.9 Vessels Involved in Collision Incidents per Year (MAIB 1994 to 2014)

483. The average number of vessels involved in collision incidents per year was 42. There has been an overall increasing trend in collisions reported over the study period, which may be due to better reporting of less serious incidents in recent years.

484. The distribution of collisions by casualty type is presented in Figure 31.10.

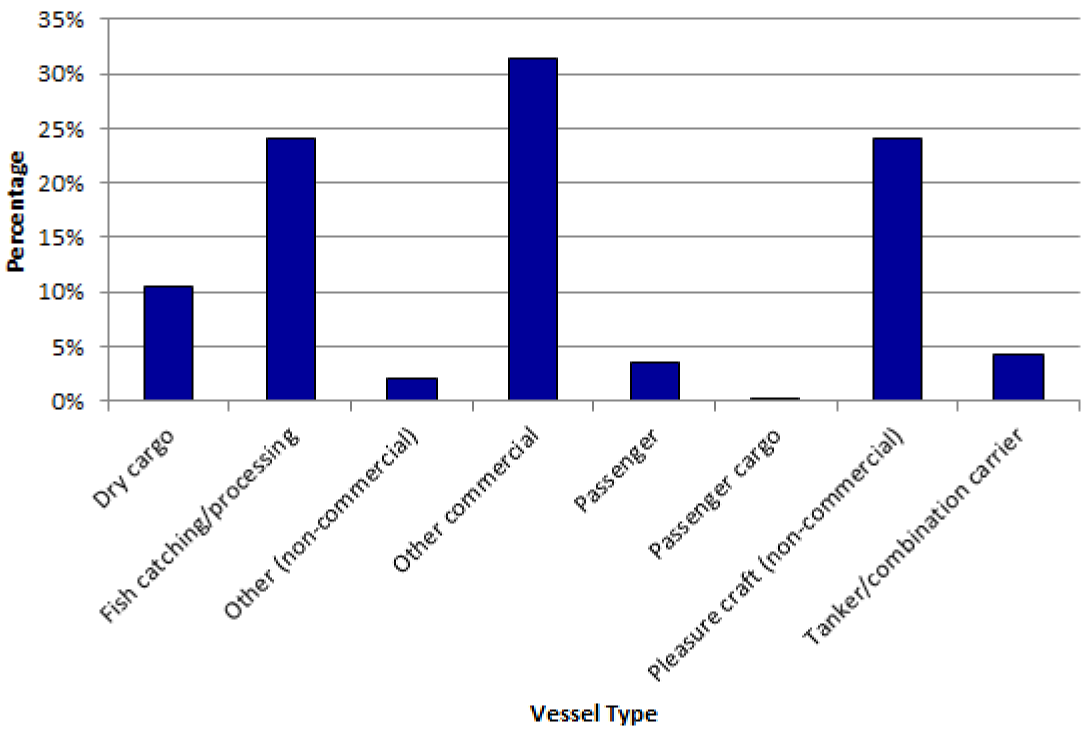

Figure 31.10 Collision Incidents by Casualty Type (MAIB 1994 to 2014)

485. The most common casualty types involved in collision incidents were other commercial vessels (31%), fishing vessels (24%), non-commercial pleasure craft (24%) and dry cargo vessels (10%).

486. There were four fatalities resulting from collision incidents in UK waters (excluding ports etc.) reported between 1994 and 2014. Details of these four incidents (each of which involved one fatality) reported by the MAIB are provided in Table 31.2. In each case the first vessel mentioned suffered the loss.

487.

Table 31.2 Summary of Fatal Collision Incidents (MAIB 1994 to 2014)

Date	Description
October 2001	Dry cargo vessel collision with chemical tanker. English waters, good visibility, moderate sea state.
August 2002	Pleasure craft collision with another pleasure craft. English waters, good visibility, calm sea state.
July 2005	Pleasure power boat collision with another pleasure power boat. English waters, good visibility, calm sea state.
August 2010	Fishing vessel collision with Ro Ro passenger vessel. Scottish waters, good visibility, calm sea state.

488. A more detailed description of the four incidents which resulted in multiple fatalities is provided below:

- **Collision between a dry cargo vessel and chemical tanker in the south-west traffic lane of the Dover Strait TSS to the south-east of Hastings.** Although the weather and visibility were good, both watch keepers were too late to take effective avoiding action. The collision resulted in the sinking of the dry cargo vessel from which five out of six crew members were rescued.
- **Collision between two speed boats.** Incident resulted in one fatality and one injury. Visibility was good and the weather was calm. Police were called to the scene and both drivers were arrested.
- **Collision between two power boats near Castle Point, St. Mawes.** Incident occurred during the night with both vessels unlit whilst transiting through the area. Both helmsmen had consumed alcohol prior to the incident which is suspected to have caused reduced peripheral vision, deterioration of judgment and slower reaction times, resulting in the collision, in which one of the helmsman died.
- **Collision between an Italian registered Ro Ro passenger ferry and a UK registered fishing vessel approximately 4nm off St Abb's Head.** Incident resulted in the fishing vessel sinking, and although the skipper was recovered from the sea, the remaining crew member was lost, despite an extensive search by the rescue services and a large number of local fishing vessels.

31.3.3 Contact Incidents

489. The MAIB define a contact incident as "a vessel hits an object that is immobile and is not subject to the collision regulations, e.g. buoy, post, dock (too hard), etc. Also, another vessel if it is tied up alongside. Also floating logs, containers etc."

490. A total of 262 contact incidents were reported to the MAIB between 1 January 1994 and 31 December 2014 involving 294 vessels (a small number of incidents involved a moving vessel contacting a stationary vessel).

491. The locations of contact incidents reported in the vicinity of the UK are presented in Figure 31.11.

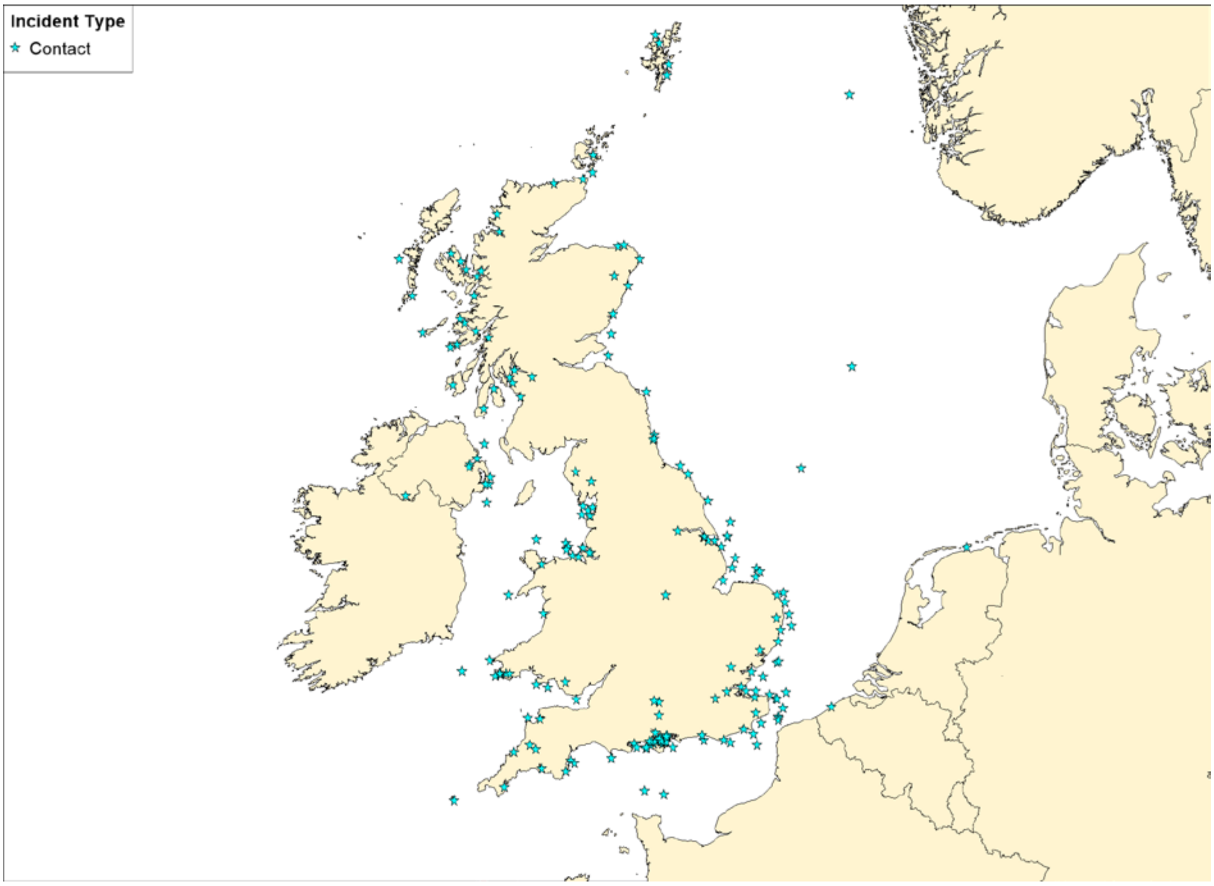

Figure 31.11 Contact Incident Locations (MAIB 1994 to 2014)

492. The distribution of contact incidents by year is presented in Figure 31.12.

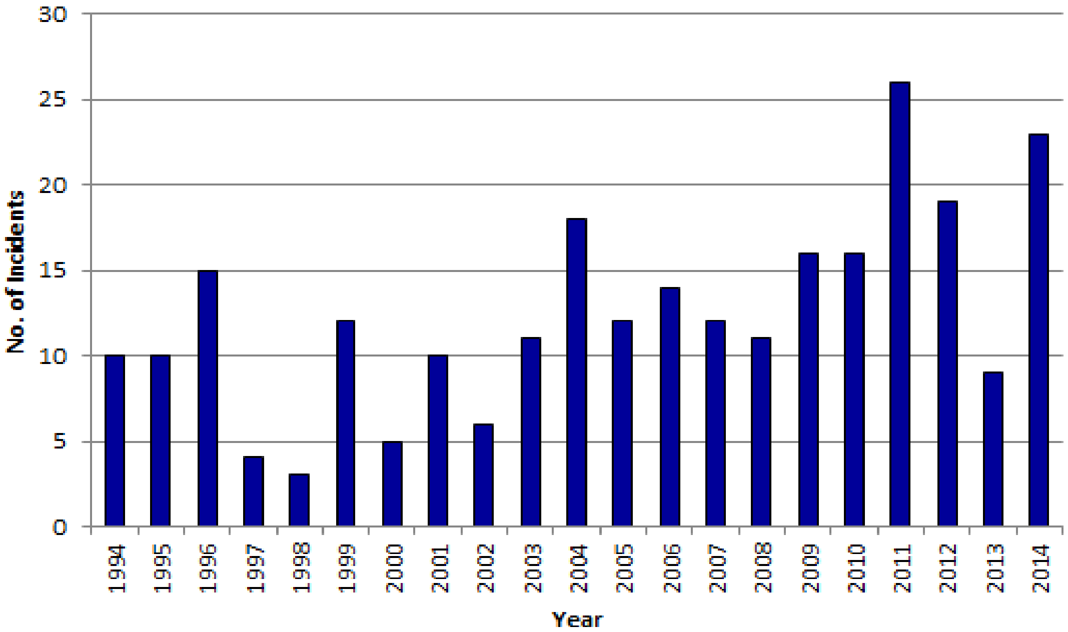

Figure 31.12 Contact Incidents per Year (MAIB 1994 to 2005)

493. The average number of contact incidents per year was 13. As with collision incidents there has been an overall increasing trend in contacts reported over the study period, which may be due to better reporting of less serious incidents in recent years.

494. The distribution of vessel types involved in contact incidents is presented in Figure 31.13.

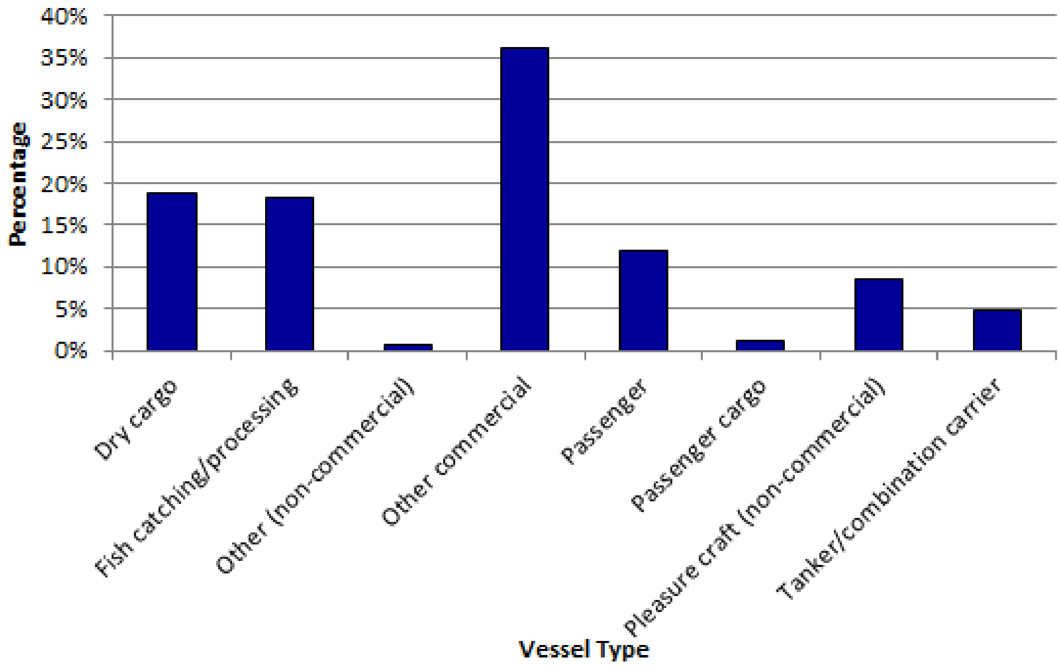

Figure 31.13 Contact Incidents by Casualty Type (1994 to 2014)

495. The most common casualty types involved in contact incidents were other commercial vessels (36%), dry cargo vessels (22%) and fishing vessels (18%).

496. There were no fatalities in any of the contact incidents recorded by the MAIB when excluding incidents occurring in ports and harbours.

31.4 *Fatality Risk*

31.4.1 Overview

497. This section uses the MAIB incident data reported in section 31.3 along with information on average manning levels per vessel type to estimate the probability of fatality in a marine incident associated with Norfolk Vanguard.

498. The wind farm structures are assessed to have the potential to affect the following incidents:

- Vessel to vessel collision;
- Powered vessel allision with wind farm structure;
- Drifting vessel allision with wind farm structure; and
- Fishing vessel allision with wind farm structure.

499. Of these incidents, only vessel to vessel collisions match the MAIB definition of collisions and hence the fatality analysis presented in section 31.3.2 is considered to be directly applicable to these types of incidents.

500. The other scenarios of powered and drifting vessel to structure allision and fishing vessel to structure allision are technically contacts, i.e. the vessel hits an immobile object in the form of a wind turbine or other wind farm structure. From section 31.3.3 it can be seen that none of the 262 contact incidents reported by the MAIB out with ports and harbours between 1994 and 2014 resulted in fatalities.

501. However, as the mechanics involved in a vessel contacting a wind farm structure may differ in severity from hitting, for example, a buoy, quayside or moored vessel, the MAIB collision fatality risk rate has also been conservatively applied for these incidents.

31.4.2 Fatality Probability

502. To assess the fatality risk for personnel on-board a vessel (crew, passenger or other) the number of persons involved in the incident needs to be estimated. From analysis of the MAIB incident data, the average commercial passenger vessel had approximately 193 people of board (POB) (total number of crew and passengers). For commercial cargo / freight vessels, fishing vessels and pleasure craft, the average POB was approximately 14, 3.3 and 6.4 respectively.

503. It is recognised that these numbers can be substantially higher or lower on an individual vessel basis, depending upon size, subtype, etc. but applying reasonable averages is considered sufficient for this analysis

504. Using the average number of persons carried along with the vessel type information involved in collisions reported by the MAIB (see section 31.3.2), gives an estimated 12,966 personnel on-board the vessels involved in the collisions.

505. Based on four fatalities, the overall fatality probability in a collision for any individual on-board is approximately 3.08×10^{-4} per collision (0.031%).

506. It is considered inappropriate to apply this rate uniformly as the statistics clearly show that the probability of fatalities is higher on smaller craft, such as fishing vessels and recreational vessels. Therefore, the fatality probability has been subdivided into three categories of vessel as presented in Table 31.3.

Table 31.3 Fatality Probability per Incident per Vessel Category (MAIB 1994 to 2014)

Vessel Category	Sub Categories	Fatalities	People Involved	Fatality Probability
Commercial	Dry cargo, passenger, tanker, etc.	1	9,718	1.0×10^{-4}
Fishing	Trawler, potter, dredger, etc.	1	708	1.4×10^{-3}
Recreational	Yacht, small commercial motor vessel, etc.	2	2,540	7.9×10^{-4}

507. It can be seen that the risk is approximately one order of magnitude higher for people on-board small craft compared to larger commercial vessels.

31.4.3 Fatality Risk due to Norfolk Vanguard

508. The base case and future case annual collision and allision frequency levels without and with the wind farm are summarised in Table 31.4 where the future case traffic growth is assumed to be 10% (see section 20).

Table 31.4 Summary of Annual Collision and Allision Frequency Results

Collision / Allision Scenario	Base Case			Future Case		
	Without	With	Change	Without	With	Change
Vessel to vessel collision	6.88×10^{-2}	6.94×10^{-2}	5.91×10^{-4}	8.33×10^{-2}	8.40×10^{-2}	7.14×10^{-4}
Powered allision	n/a	3.50×10^{-4}	3.50×10^{-4}	n/a	3.86×10^{-4}	3.86×10^{-4}
Drifting allision	n/a	9.42×10^{-4}	9.42×10^{-4}	n/a	1.04×10^{-3}	1.04×10^{-3}
Fishing allision	n/a	2.91×10^{-1}	2.91×10^{-1}	n/a	3.20×10^{-1}	3.20×10^{-1}
Total	**6.88×10^{-2}**	**3.62×10^{-1}**	**2.93×10^{-1}**	**8.33×10^{-2}**	**4.05×10^{-1}**	**3.22×10^{-1}**

509. For the local vessels operating in the area of Norfolk Vanguard, the average POB has been estimated as shown in Table 31.5.

Table 31.5 Vessel Types, Incidents and Average POB

Vessel Type	Collision / Allision Incidents	Average POB
Cargo / freight	Vessel to vessel collision, powered allision and drifting allision.	15
Tanker	Vessel to vessel collision, powered allision and drifting allision.	20
Ferry	Vessel to vessel collision, powered allision and drifting allision.	1,000
Fishing	Vessel to vessel collision and fishing allision.	3
Recreational	Vessel to vessel collision.	4

510. From the detailed results of the collision and allision frequency modelling, the distribution of the predicted change in annual collision and allision frequency by vessel type due to Norfolk Vanguard for the base and future cases are presented in Figure 31.14. For clarity, the same distribution is presented in Figure 31.15 with the proportion of the change in annual collision frequency attributed to fishing vessels excluded.

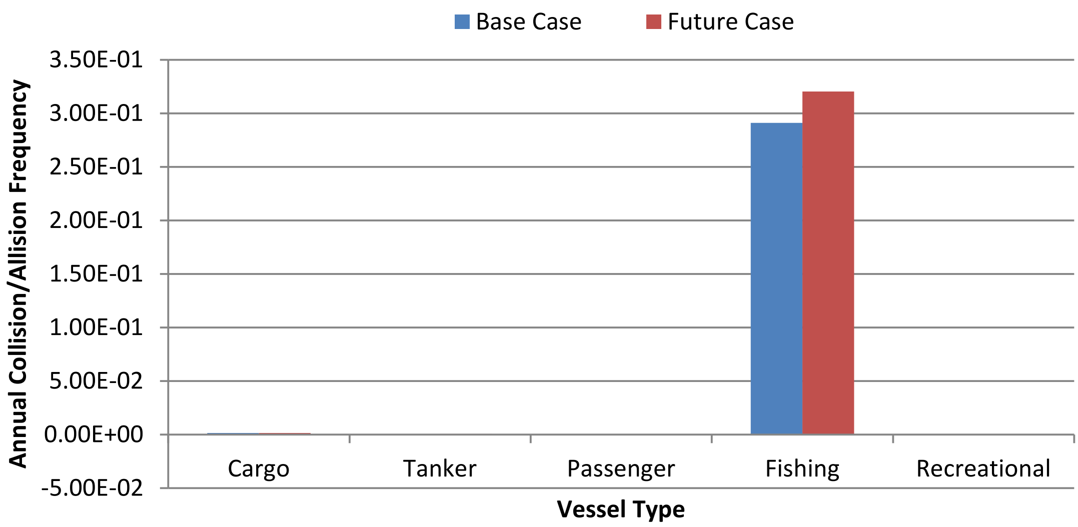

Figure 31.14 Change in Annual Collision and Allision Frequency by Vessel Type

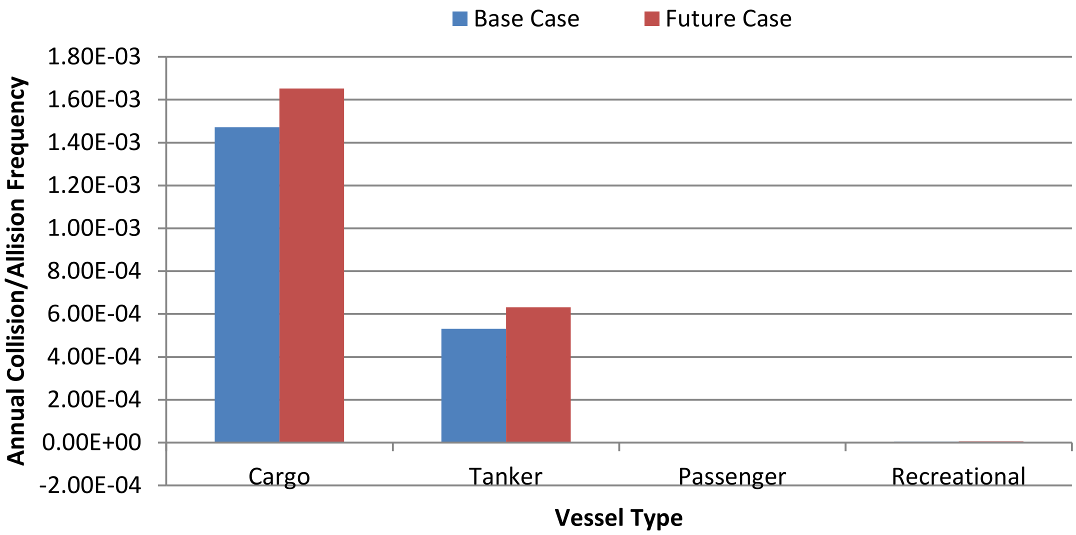

Figure 31.15 Change in Annual Collision and Allision Frequency by Vessel Type (Excluding Fishing Vessels)

511. It can be seen that the change in annual collision frequency is dominated by fishing vessels. The change in frequency is lowest for passenger vessels and recreational vessels. The change in frequency is negative for passenger vessels; this is due to the deviation of a number of routes which previously crossed the DR1 Lightbuoy DWR but which now join the DWR. This results in a reduction in the frequency of crossing collisions involving passenger vessels and consequently a reduction in the overall collision frequency for passenger vessels. With the number of routes containing passenger vessels relatively low, this change is therefore reflected in the total annual collision frequency for passenger vessels.

512. Combining the annual collision and allision frequency (Table 31.4) the estimated POB each vessel type (Table 31.5) and the estimated fatality probability for each vessel category (Table 31.3), the annual increase in PLL due to the impact of Norfolk Vanguard is shown in Table 31.6.

Table 31.6 Estimated Annual Increase in PLL

Case	PLL	
	Annual Increase	**Return Period**
Base Case	2.48×10^{-3}	404 years
Future Case	2.72×10^{-3}	367 years

513. The estimated incremental increases in PLL due to Norfolk Vanguard, distributed by vessel type for the base case and future case are presented in Figure 31.16. For clarity, the same distribution is presented in Figure 31.17 with the proportion of the change annual collision frequency attributed to fishing vessels excluded.

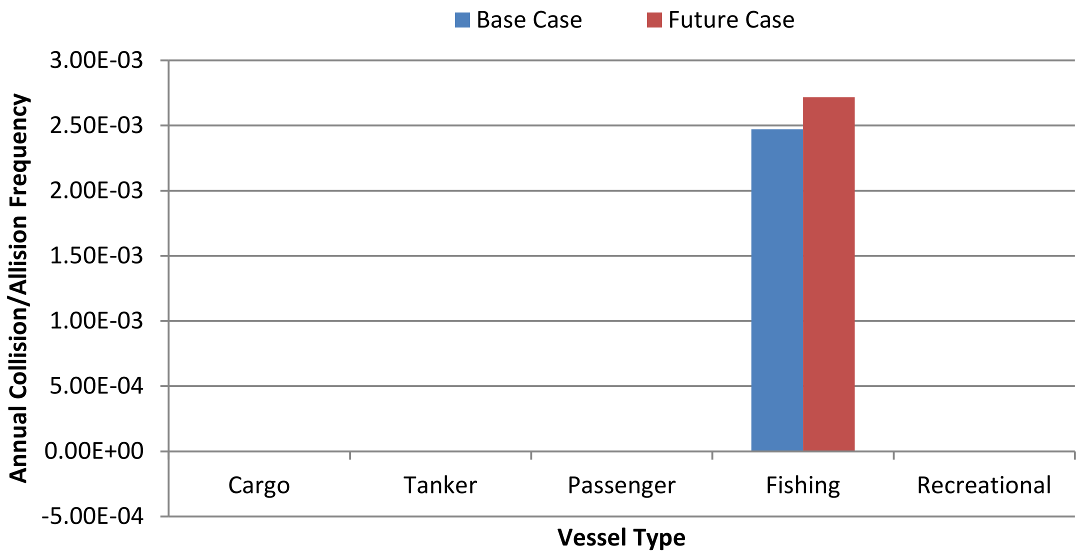

Figure 31.16 Estimated Change in Annual PLL by Vessel Type

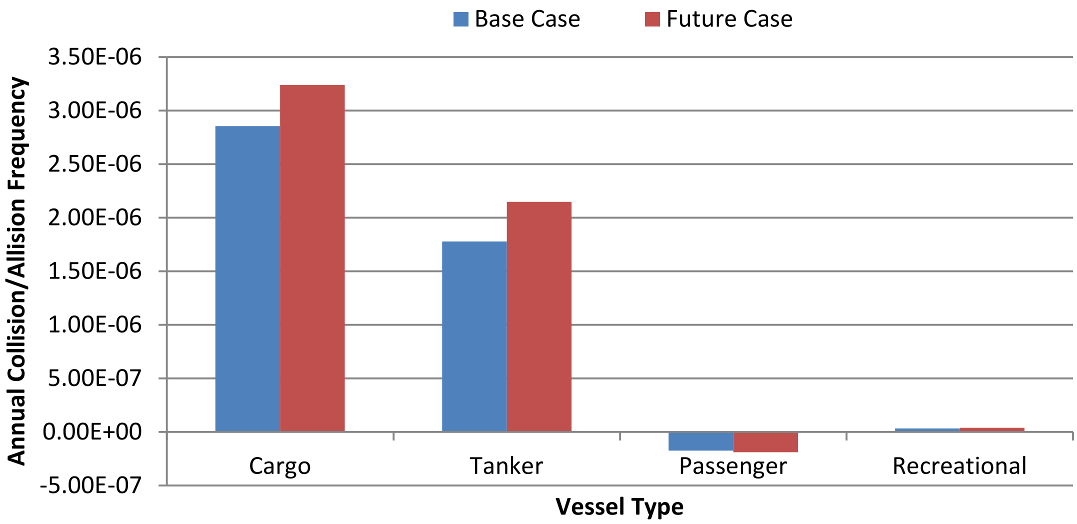

Figure 31.17 Estimated Change in Annual PLL by Vessel Type (Excluding Fishing Vessels)

514. As with the change in annual collision frequency, it can be seen that the change in annual PLL is dominated by fishing vessels, which historically have a higher fatality probability than commercial vessels.

515. Converting the PLL to individual risk based upon the average number of people exposed by vessel type, the results are presented in Figure 31.18 (this calculation assumes that the risk is shared between ten vessels of each type, which is considered to be conservative based upon the number of different vessels operating in the vicinity of Norfolk Vanguard). For clarity, the same changes in individual risk are presented in Figure 31.19 with the proportion of the individual risk attributed to fishing vessels excluded.

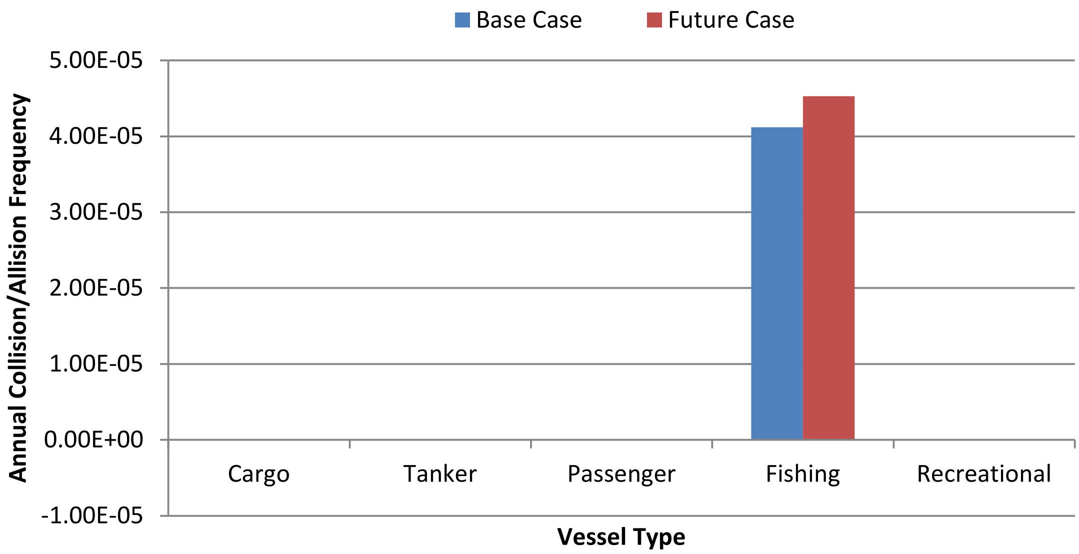

Figure 31.18 Estimated Change in Individual Risk by Vessel Type

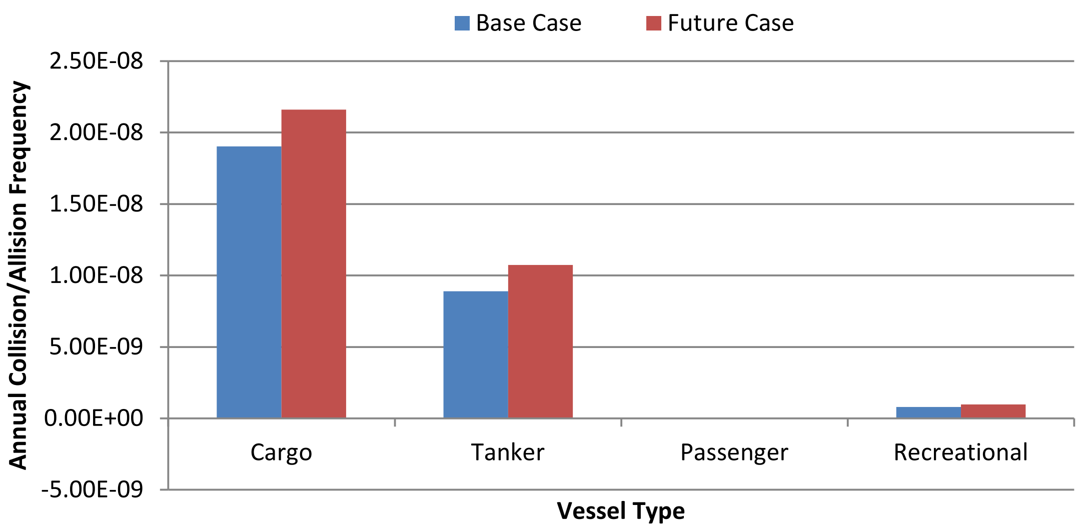

Figure 31.19 Estimated Change in Individual Risk by Vessel Type (Excluding Fishing Vessels)

516. It can be seen that the individual risk is highest for people on fishing vessels, which is related to the higher fatality probability in the event of an incident for fishing vessels.

31.4.4 Significance of Increase in Fatality Risk due to Norfolk Vanguard

517. The overall increase in PLL estimated due to Norfolk Vanguard is 2.48×10^{-3} fatalities per year (base case), which equates to one additional fatality in 404 years. This is very low compared to the MAIB statistics which indicate an average of 20 fatalities per year in UK territorial waters, excluding ports / harbours and rivers / canals.

518. In terms of individual risk to people, the incremental increase for commercial vessels (approximately 2.79×10^{-8} for the base case) is very low compared to the background risk level for the UK sea transport industry of 2.9×10^{-4} per year.

519. Similarly, for fishing vessels, whilst the change in individual risk attributed to Norfolk Vanguard is significantly higher than for commercial vessels (approximately 4.12×10^{-5} for the base case), it is low compared to the background risk level for the UK sea fishing industry of 1.2×10^{-3} per year.

31.5 *Pollution Risk*

31.5.1 Historical Analysis

520. The pollution consequences of a collision in terms of oil spill depend upon the following:

- Spill probability (i.e. likelihood of outflow following an accident); and
- Spill size (amount of oil).

521. Two types of oil spill are considered:

- Fuel oil spills from bunkers (all vessel types); and
- Cargo oil spills (laden tankers only).

522. The research undertaken as part of the DfT's MEHRAs project (DfT, 2001) has been used as it was comprehensive and based on worldwide marine spill data analysis.

523. From this research, the overall probability of a spill per accident was calculated based upon historical accident data for each accident type as presented in Figure 31.20.

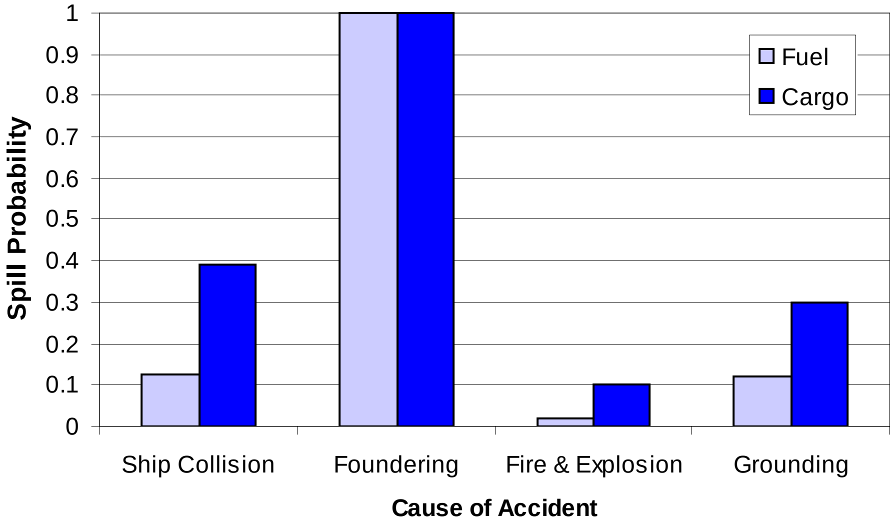

Figure 31.20 Probability of an Oil Spill Resulting from an Accident

524. Therefore, it was estimated that 13% of vessel collisions result in a fuel oil spill and 39% of collisions involving a laden tanker result in a cargo oil spill.

525. In the event of a bunker spill, the potential outflow of oil depends upon the bunker capacity of the vessel. Historical bunker spills from vessels have generally been limited to a size below 50% of the bunker capacity, and in most incidents much lower. For the types and sizes of vessels exposed to the OWF sites, an average spill size of 100 tonnes of fuel oil is considered to be a conservative assumption.

526. For cargo spills from laden tankers, the spill size can vary significantly. International Tanker Owners Pollution Federation Limited (ITOPF) report the following spill size distribution for tanker collisions between 1974 and 2004:

- 31% of spills below seven tonnes;
- 52% of spills between seven and 700 tonnes; and
- 17% of spills greater than 700 tonnes.

527. Based on this data and the tankers transiting the area in proximity to the OWF sites, an average spill size of 400 tonnes is considered conservative.

528. For fishing vessel collisions, comprehensive statistical data is not available. Consequently, it is conservatively assumed that 50% of all collisions involving fishing vessels will lead to an oil spill with the quantity spilled being an average of five tonnes. Similarly, for recreational vessels, due to a lack of data, 50% of collisions are assumed to lead to a spill with an average size of one tonne.

31.5.2 Pollution Risk due to Norfolk Vanguard

529. Applying the probabilities outlined in section 31.5.1 to the annual collision and allision frequency by vessel type and the average spill size per vessel, the estimated annual amount of oil spilled due to the impact of Norfolk Vanguard is shown in Table 31.7.

Table 31.7 Estimated Annual Increase in Amount of Oil Spilled

Case	**Estimated Tonnes of Oil Spilled per Year**
Base Case	0.83
Future Case	0.92

530. The estimated increases in tonnes of oil spilled distributed by vessel type for the base case and future case are presented in Figure 31.21.

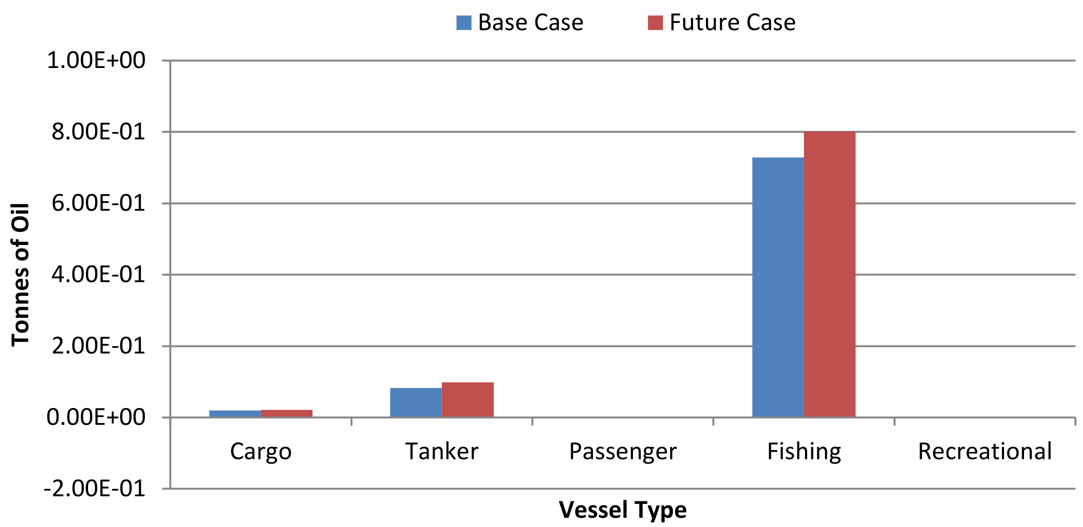

Figure 31.21 Estimated Change in Pollution by Vessel Type

531. It can be seen that fishing vessels contribute the majority of the overall risk of oil spills despite tankers having the potential to spill both fuel and cargo oils, with this being due to fishing vessels being assessed to have a higher frequency of spill incidents. However, tankers do make up a greater proportion of the overall risk of oil spills than they do with regards to the fatality risk (see Section 31.4).

31.5.3 Significance of Increase in Pollution Risk due to Norfolk Vanguard

532. To assess the significance of the increased pollution risk from marine vessels caused by Norfolk Vanguard, historical oil spill data for the UK has been used as a benchmark.

533. From the MEHRAs research (DfT, 2001), the average annual tonnes of oil spilled in the waters around the British Isles due to marine accidents in the ten year period from 1989 to 1998 was 16,111. This is based upon a total of 146 reported oil pollution incidents of greater than one tonne (smaller spills are excluded as are incidents which occurred within port and harbour areas or as a result of operational errors or equipment failure). Commercial vessel spills accounted for approximately 99% of the total while fishing vessel incidents accounted for less than 1%.

534. The overall increase in pollution estimated due to Norfolk Vanguard of 0.83 tonnes for the base case is very low compared to the historical average pollution quantities from marine accidents in UK waters (approximately 0.001%).

31.6 *Conclusions of Consequences Assessment*

535. The quantitative assessment of the fatality and pollution risk associated with the proposed project indicates that fishing vessels contribute the greatest collision and allision risk.

536. Overall, the impact of the wind farm on people and the environment is relatively low compared to the existing background risk levels in UK waters. However, it should be noted that this is the localised impact of a single project and there will be additional maritime risks associated with other offshore wind farm projects in the southern North Sea and the UK as a whole.

32. Appendix B: MGN 543 Compliance Checklist

<table>
<tr><th>Issue</th><th>Compliant (Yes/No)</th><th>Reference notes/remarks</th></tr>
<tr><td colspan="3">Annex 1: Considerations on Site Position, Structures and Safety Zones</td></tr>
<tr><td colspan="3">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 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.</td></tr>
<tr><td colspan="3">2. Traffic Survey. Includes the following:</td></tr>
<tr><td>All vessel types</td><td>✓</td><td>Section 12 OWF Sites Marine Traffic Surveys

All vessel types are considered for both OWF sites, with sections 12.2.3 and 12.3.3 providing specific breakdowns by vessel type for Norfolk Vanguard East and Norfolk Vanguard West respectively, and sections 13 and 14 providing details specific to fishing and recreational vessels respectively.

Section 15 Offshore Cable Corridor Marine Traffic Survey

All vessel types are considered for the offshore cable corridor, with section 15.5 providing specific breakdowns by vessel type.</td></tr>
<tr><td>At least 28 days duration, within either 12 or 24 months prior to submission of the Environmental Statement</td><td>✓</td><td>Section 12 OWF Sites Marine Traffic Surveys

Twenty-eight days of AIS and Radar data was recorded for both OWF sites across September 2016 and January and February 2017.

Section 15 Offshore Cable Corridor Marine Traffic Survey

Twenty-eight days of AIS data was recorded for the offshore cable corridor across September 2016 and February 2017.</td></tr>
<tr><td>Multiple data sources</td><td>✓</td><td>Section 12 OWF Sites Marine Traffic Surveys

The marine traffic surveys for the</td></tr>
</table>

Issue	Compliant (Yes/No)	Reference notes/remarks
		OWF sites included both AIS and Radar data.
Seasonal variations	✓	**Section 12 OWF Sites Marine Traffic Surveys** Marine traffic surveys were carried out in summer (September 2016) and winter (January/February 2017) periods to take account of seasonal variations in traffic patterns. **Section 15 Offshore Cable Corridor Marine Traffic Survey** Marine traffic surveys were carried out in summer (September 2016) and winter (January/February 2017) periods to take account of seasonal variations in traffic patterns.
MCA consultation	✓	**Section 5 Consultation** Table 5.1 includes issues raised by the MCA relevant to shipping and navigation during consultation for the proposed project. **Section 23 Hazard Log** The MCA were among the stakeholders to receive the initial draft of the Hazard Log for comment.
General Lighthouse Authority (TH) consultation	✓	**Section 5 Consultation** Table 5.1 includes issues raised by TH relevant to shipping and navigation during consultation for the proposed project. **Section 23 Hazard Log** TH were among the stakeholders to receive the initial draft of the Hazard Log for comment.
CoS consultation	✓	**Section 5 Consultation** Table 5.1 includes issues raised by the CoS relevant to shipping and navigation during consultation for the proposed project. **Section 23 Hazard Log** The CoS were among the stakeholders to receive the initial

Issue	Compliant (Yes/No)	Reference notes/remarks
		draft of the Hazard Log for comment.
Recreational and fishing vessel organisations consultations	✓	**Section 5 Consultation** Table 5.1 includes issues raised by the RYA and CA relevant to shipping and navigation during consultation for the proposed project. **Section 23 Hazard Log** The RYA and CA were among the stakeholders to receive the initial draft of the Hazard Log for comment.
Port and navigation authorities consultation, as appropriate	✓	**Section 23 Hazard Log** ABP and Peel Ports were among the stakeholders to receive the initial draft of the Hazard Log for comment.
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 12 OWF Sites Marine Traffic Surveys** Summarises the results of the marine traffic surveys, including commercial and non-commercial traffic, with sections 13 and 14 providing details specific to fishing and recreational vessels respectively. **Chapter 15 Shipping and Navigation (within ES)** Sections 14.6 and 14.7 provide a formal safety assessment of the individual and cumulative effects respectively of the proposed project, with impacts presented by shipping and navigation receptor.
ii. Numbers, types and sizes of vessels presently using such areas.	✓	**Section 12 OWF Sites Marine Traffic Surveys** Summarises the results of the marine traffic surveys for the OWF sites, including specific breakdowns by vessel numbers, types and sizes. Additionally, sections 13 and 14 provide an overview of fishing and recreational vessel activity.

Issue	Compliant (Yes/No)	Reference notes/remarks
		Section 15 Offshore Cable Corridor Marine Traffic Survey Summarises the results of the marine traffic survey for the offshore cable corridor, including specific breakdowns by vessel numbers, types and sizes. Additionally, sections 15.7 and 15.8 provide an overview of recreational and fishing vessel activity. **Chapter 15 Shipping and Navigation (within ES)** Sections 14.6 and 14.7 provide a formal safety assessment of the individual and cumulative effects respectively of the proposed project, with impacts presented by shipping and navigation receptor.
iii. Non-transit uses of the areas, e.g. fishing, day cruising of leisure craft, racing, aggregate dredging, etc.	✓	**Section 8 Existing Environment** Section 8.7 provides an overview of aggregate dredging activity in the southern North Sea based on BMAPA transit routes. **Section 13 OWF Sites Fishing Vessel Activity** Provides an overview of fishing vessel activity for the OWF sites based on marine traffic survey data. **Section 14 OWF Sites Recreational Vessel Activity** Provides an overview of recreational vessel activity in the southern North Sea based upon RYA cruising routes in addition to marine traffic survey data. **Section 15 Offshore able Corridor Marine Traffic Survey** Sections 15.7 and 15.8 provide an overview of recreational and fishing vessel activity for the offshore cable corridor. **Chapter 15 Shipping and Navigation (within ES)** Sections 14.6 and 14.7 provide a formal safety assessment of the

Issue	Compliant (Yes/No)	Reference notes/remarks
		individual and cumulative effects respectively of the proposed project, with impacts presented by shipping and navigation receptor. It is noted that commercial fishing displacement is considered in Chapter 14 Commercial Fisheries.
iv. Whether these areas contain transit routes used by coastal or deep draught vessels on passage.	✓	**Section 17 Base Case Routeing Analysis** Provides an overview of the current vessel routeing in the vicinity of the proposed project. **Section 18 Future Case Commercial Vessel Routeing** Sections 18.2 and 18.3 consider the individual and cumulative effects on vessel routeing of the proposed project respectively.
v. Alignment and proximity of the site relative to adjacent shipping lanes.	✓	**Section 8 Existing Environment** Section 8.1 provides an overview of IMO routeing measures used by deep draught vessels located within the vicinity of the proposed project. **Section 17 Base Case Routeing Analysis** Provides an overview of the current vessel routeing in the vicinity of the proposed project. **Section 20 Norfolk Vanguard in Isolation Assessment** Considers the effects on vessel routeing of the proposed project in isolation. **Section 21 Norfolk Vanguard Cumulative Effect Assessment** Considers the cumulative effect on vessel routeing of the proposed project.
vi. Whether the nearby area contains prescribed routeing schemes or precautionary areas.	✓	**Section 8 Existing Environment** Section 8.1 provides an overview of IMO routeing measures used by deep draught vessels located within the vicinity of the proposed project.
vii. Whether the site lies on or near a prescribed or conventionally accepted separation zone between	✓	**Section 8 Existing Environment** Section 8.1 provides an overview

Issue	Compliant (Yes/No)	Reference notes/remarks
two opposing routes		of IMO routeing measures used by deep draught vessels located within the vicinity of the proposed project.
viii. Proximity of the site to areas used for anchorage, safe haven, port approaches and pilot boarding or landing areas.	✓	**Section 8 Existing Environment** Section 8.3 provides an overview of preferred anchorage areas within the vicinity of the proposed project. Additionally, section 8.4 provides an overview of ports within the vicinity of the proposed project.
ix. Whether the site lies within the jurisdiction of a port and/or navigation authority.	✓	**Section 8 Existing Environment** Section 8.4 provides an overview of ports within the vicinity of the proposed project. It us noted that Norfolk Vanguard does not lie within the jurisdiction of a port and/or navigation authority.
x. Proximity of the site to existing fishing grounds, or to routes used by fishing vessels to such grounds.	✓	**Section 13 OWF Sites Fishing Vessel Activity** Provides an overview of fishing vessel activity for the OWF sites based on marine traffic survey data. **Section 20 Norfolk Vanguard in Isolation Assessment** Considers the effects on fishing vessels of the proposed project in isolation. It is noted that commercial fishing displacement is considered in Chapter 14 Commercial Fisheries. **Section 21 Norfolk Vanguard Cumulative Effect Assessment** Considers the cumulative effect on fishing vessels of the proposed project.
xi. Proximity of the site to offshore firing/bombing ranges and areas used for any marine military purposes.	✓	**Section 8 Existing Environment** Section 8 provides an overview of military exercise areas within the vicinity of the proposed project.
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	✓	**Section 8 Existing Environment** Sections 8.6, 8.7, 8.10 and 8.11 provide an overview of the oil and gas infrastructure, aggregate dredging areas, MEHRAs and charted wrecks within the vicinity

Issue	Compliant (Yes/No)	Reference notes/remarks
exploration/exploitation sites.		of the proposed project respectively.
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 8 Existing Environment** Section 8.8 provides an overview of operational wind farm projects (both UK and non-UK) within the vicinity of the proposed project. **Section 24 Cumulative Effects** Table 24.1 summarises the offshore wind farm developments screened into the cumulative assessment.
xiv. Proximity of the site relative to any designated areas for the disposal of dredging spoil or other dumping ground.	✓	n/a
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 8.2 Existing Environment** Section 8.2 provides an overview of existing aids to navigation within the vicinity of the proposed project.
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 18 Future Case Commercial Vessel Routeing** Sections 18.2 and 18.3 consider the individual and cumulative effects on vessel routeing of the proposed project.
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 11 Maritime Incidents** Sections 11.2 and 11.3 present analysis of the incidents reported by the MAIB and RNLI respectively. Additionally, section 11.4 summarises historical collision and allision incidents within UK waters.
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	✓	**Section 4 Project Description** Summarises the proposed project, including details on the number of structures. **Section 19 Collision and Allision Risk Modelling Overview** Assesses the impact of Norfolk Vanguard on vessel to vessel

Issue	Compliant (Yes/No)	Reference notes/remarks
fishing, anchoring and emergency response.		collisions, vessel to structure allision (powered and NUC vessels), fishing vessel to structure allision and recreational vessel allisions. **Appendix A Consequences Assessment** Provides an assessment of the consequences of collision and allision incidents, in terms of people and the environment, due to the impact of the proposed project.
b. Clearances of wind turbine blades above the sea surface are not less than 22m above MHWS.	✓	**Section 4 Project Description** The minimum rotor blade clearance above MHWS is 22m, for any of the wind turbine size selected.
c. Underwater devices: Changes to charted depth; Maximum height above seabed; and UKC.	✓	**Section 25 Embedded Mitigation Measures** A Cable Burial Management Plan will be undertaken post consent, which will include full consideration of issues relating to under keel clearance.
d. The burial depth of cabling and changes to charted depths associated with any protection measures.	✓	**Section 25 Embedded Mitigation Measures** A Cable Burial Management Plan will be undertaken post consent.
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:		

Issue	Compliant (Yes/No)	Reference notes/remarks
a. Navigation within or close to the site would be safe: by all vessels, or by specified vessel types, operations and/or sizes; in specified directions or areas; and in specified tidal, weather or other conditions.	✓	**Section 5 Consultation** Table 5.1 includes issues raised by marine and navigation stakeholders during consultation for the proposed project. **Section 20 Norfolk Vanguard in Isolation Assessment** Assesses the individual effect of the proposed project on vessel movement using a number of collision and allision models which take into account tidal and weather conditions. **Section 21 Norfolk Vanguard Cumulative Effect Assessment** Assesses the cumulative effect of the proposed project on vessel movement using a number of collision and allision models which take into account tidal and weather conditions. **Section 22 Communication and Position Fixing** Summarises the potential impacts on navigation of the different communications and position fixing devices used in and around offshore wind farms.
b. Navigation in and/or near the site should be: Prohibited by specified vessel types, operations and/or sizes; Prohibited in respect of specific activities; Prohibited in all areas or directions, or Prohibited in specific areas or directions, or Prohibited specified tidal or weather conditions, or simply Recommended to be avoided.	✓	**Section 20 Norfolk Vanguard in Isolation Assessment and** Assesses the individual effect of the proposed project on vessel movement using a number of collision and allision models which take into account tidal and weather conditions. **Section 21 Norfolk Vanguard Cumulative Effect Assessment** Assesses the cumulative effect of the proposed project on vessel movement using a number of collision and allision models which take into account tidal and weather conditions. **Section 22 Communication and Position Fixing**

Issue	Compliant (Yes/No)	Reference notes/remarks
		Summarises the potential impacts on navigation of the different communications and position fixing devices used in and around offshore wind farms. **Section 25 Embedded Mitigation Measures** Table 25.1 summarises the application and use of safety zones during construction, operation, major maintenance and decommissioning phases.
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	✓	**Chapter 15 Shipping and Navigation (within ES)** Sections 14.6 and 14.7 provide a formal safety assessment of the individual and cumulative effects respectively of the proposed project, including the potential for diminishing emergency response resources.
d. 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 25 Embedded Mitigation Measures** Table 25.1 summarises the application and use of safety zones during construction, operation, major maintenance and decommissioning phases.
Annex 2: Navigation, Collision Avoidance and Communications		
1. 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 water which do not exist at low water conditions, and vice versa.	✓	**Section 9 MetOcean Data** Provides an overview of tidal current data within the vicinity of the proposed project. **Section 12 OWF Sites Marine Traffic Surveys** Summarises the results of the marine traffic surveys for the OWF sites, with the study periods used accounting for a range of tidal conditions. **Section 20 Norfolk Vanguard in Isolation Assessment** The drifting vessel allision model

Issue	Compliant (Yes/No)	Reference notes/remarks
		takes into account tidal conditions.
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 9 MetOcean Data** Provides an overview of tidal current data within the vicinity of the proposed project. **Section 12 OWF Sites Marine Traffic Surveys** Summarises the results of the marine traffic surveys for the OWF sites, with the study periods used accounting for a range of tidal conditions. **Section 20 Norfolk Vanguard in Isolation Assessment** The drifting vessel allision model takes into account tidal conditions. **Chapter 15 Shipping and Navigation (within ES)** Sections 14.6 and 14.7 provide a formal safety assessment of the individual and cumulative effects respectively of the proposed project, including the potential for vessel to structure allision.
c. The maximum rate tidal stream runs parallel to the major axis of the proposed site layout, and, if so, its effect.	✓	**Section 9 MetOcean Data** Provides an overview of tidal current data within the vicinity of the proposed project.
d. The set is across the major axis of the layout at any time, and, if so, at what rate.	✓	**Section 9 MetOcean Data** Provides an overview of tidal current data within the vicinity of the proposed project.
e. In general, whether engine failure or other circumstance could cause vessels to be set into danger by the tidal stream.	✓	**Section 9 MetOcean Data** Provides an overview of tidal current data within the vicinity of the proposed project. **Section 20 Norfolk Vanguard in Isolation Assessment** The drifting vessel allision model takes into account tidal conditions. **Chapter 15 Shipping and Navigation (within ES)** Sections 14.6 and 14.7 provide a formal safety assessment of the individual and cumulative effects respectively of the proposed

Issue	Compliant (Yes/No)	Reference notes/remarks
		project, including the potential for vessel to structure allision.
f. The structures themselves could cause changes in the set and rate of the tidal stream.	✓	No such effect was found.
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 25 Embedded Mitigation Measures** A Cable Burial Management Plan will be undertaken post consent to ensure subsea cables are suitably protected.
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 9 MetOcean Data** Provides an overview the of weather conditions within the vicinity of the proposed project. **Chapter 15 Shipping and Navigation (within ES)** Sections 14.6 and 14.7 provide a formal safety assessment of the individual and cumulative effects respectively of the proposed project.
b. The structures could create problems in the area for vessels under sail, such as wind masking, turbulence or sheer.	✓	**Section 14 OWF Sites Recreational Activity** Section 14.5 discusses the potential vessels under sail to be affected by wind shear, masking and turbulence.
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 20 Norfolk Vanguard in Isolation Assessment** The drifting vessel allision model assesses whether vessels could drift into danger.
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 4 Project Description** The turbines will maintain at least one line of orientation, with minimum spacing of four rotor diameters length (680m).
b. The MCA's Navigation Safety Branch and Maritime Operations branch will be consulted on the layout design and agreement will	✓	**Section 5 Consultation** Table 5.1 includes issues raised by the MCA in relation to the layout design.

Issue	Compliant (Yes/No)	Reference notes/remarks
be sought.		
c. The layout design has been or will be determined with due regard to safety of navigation and Search and Rescue.	✓	**Section 4 Project Description** The turbines will maintain at least one line of orientation, with minimum spacing of four rotor diameters length (680m).
d.i. The structures could block or hinder the view of other vessels under way on any route.	✓	**Section 18 Future Case Commercial Vessel Routeing** Sections 18.2 and 18.3 consider the individual and cumulative effects on vessel routeing of the proposed project respectively.
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 8 Existing Environment** Section 8.2 provides an overview of existing aids to navigation within the vicinity of the proposed project.
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 Global Maritime Distress and Safety System (GMDSS) and AIS, whether vessel borne, ashore or fitted to any of the proposed structures, to: Vessels operating at a safe navigational distance; 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; and Vessels by the nature of their work necessarily operating within the OREI.	✓	**Section 22 Communication and Position Fixing** Summarises the potential impacts on navigation of the different communications and position fixing devices used in and around offshore wind farms.
b. The structures could produce radar reflections, blind spots, shadow areas or other adverse effects: • Vessel to vessel;	✓	**Section 22 Communication and Position Fixing** Section 22.9 discusses Radar interference and related impacts.

Issue	Compliant (Yes/No)	Reference notes/remarks
• Vessel to shore; • VTS radar to vessel; • Racon to/from vessel.		
c. The structures and generators might produce sonar interference affecting fishing, industrial or military systems used in the area.	✓	**Section 22 Communication and Position Fixing** Section 22.9 discusses sonar interference and related impacts.
d. The site might produce acoustic noise which could mask prescribed sound signals.	✓	**Section 22 Communication and Position Fixing** Section 22.10 discusses noise and related impacts.
e. Generators and the seabed cabling within the site and onshore might produce electro-magnetic fields affecting compasses and other navigation systems.	✓	**Section 22 Communication and Position Fixing** Section 22.7 discusses electromagnetic and related impacts.
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 25 Embedded Mitigation Measures** Sections 25.1 discusses the marking of the proposed project across each of the construction, operation and maintenance and decommissioning phases.
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 25 Embedded Mitigation Measures** Sections 25.1 discusses the marking of the proposed project across each of the construction, operation and maintenance and decommissioning phases.
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.	✓	n/a
d. If the site would be marked by additional electronic means e.g. Racons	✓	**Section 25 Embedded Mitigation Measures** Section 25.1 discusses the marking of the proposed project across each of the construction, operation and maintenance and decommissioning

Issue	Compliant (Yes/No)	Reference notes/remarks
		phases.
e. If the site would be marked by an AIS transceiver, and if so, the data it would transmit.	✓	**Section 25 Embedded Mitigation Measures** Section 25.1 discusses the marking of the proposed project across each of the construction, operation and maintenance and decommissioning phases.
f. If the site would be fitted with audible hazard warning in accordance with IALA recommendations	✓	**Section 25 Embedded Mitigation Measures** Sections 25.1 discusses the marking of the proposed project across each of the construction, operation and maintenance and decommissioning phases.
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 25 Embedded Mitigation Measures** Aviation lighting will be as per CAA requirements, but will likely be synchronised Morse 'W' at the request of TH.
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 25 Embedded Mitigation Measures** The markings for the proposed project would be agreed in consultation with TH once the final wind turbine layout has been selected and would be in line with IALA Recommendation O-139.
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 25 Embedded Mitigation Measures** Section 25.1 discusses the marking of the proposed project across each of the construction, operation and maintenance and decommissioning phases, including the requirement to meet IALAs availability targets.
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 25 Embedded Mitigation Measures** Section 25.1 discusses the marking of the proposed project across each of the construction, operation and maintenance and decommissioning phases, including the requirement to meet IALAs availability targets.
k. The ID marking will conform to	✓	**Section 25 Embedded Mitigation**

Issue	Compliant (Yes/No)	Reference notes/remarks
a spreadsheet layout, sequential, aligned with SAR lanes and avoid the letters O and I.		**Measures** The markings for the proposed project would be agreed in consultation with TH once the final wind turbine layout has been selected and would be in line with IALA Recommendation O-139.
l. Working lights will not interfere with AtoN or create confusion for the Mariner navigating in or near the OREI.	✓	**Section 25 Embedded Mitigation Measures** Section 25.1 discusses the marking of the proposed project across each of the construction, operation and maintenance and decommissioning phases.
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 environment 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).	✓	Will be provided by the Applicant.
ii. Post-construction: cable route(s).	✓	Will be provided by the Applicant.
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.	✓	Will be provided by the Applicant.
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 wind turbine boundaries.	✓	**Section 16 DWR Analysis** Section 16.3 considers the separation of the OWF sites from the DR1 Lightbuoy DWR, with the assessment undertaken at a cumulative level.
b. The width of a corridor between sites or OREIs to allow safe passage of shipping.	✓	**Section 16 DWR Analysis** Section 16.3 considers the width of the corridor between the OWF sites against the relevant MCA guidance.
Annex 4: Safety and mitigation measures recommended for OREI construction, operation and decommissioning		

Issue	Compliant (Yes/No)	Reference notes/remarks
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. These will be consistent with international standards contained in, for example, the Safety of Life at Sea (SOLAS) Convention - Chapter V, IMO Resolution A.572 and Resolution A.671 and could include any or all of the following:		
i. Promulgation of Information and warnings through notices to mariners and other appropriate MSI dissemination methods.	✓	**Section 25 Embedded Mitigation Measures** Information relevant to the proposed project will be promulgated via Notice to Mariners and other appropriate media (e.g. KIS-ORCA).
ii. Continuous watch by multi-channel VHF, including DSC.	✓	**Section 22 Communication and Position Fixing** Screen out based on lessons learned at existing developments.
iii. Safety zones of appropriate configuration, extent and application to specified vessels	✓	**Section 25 Embedded Mitigation Measures** Table 25.1 summarises the application and use of safety zones during construction, operation, major maintenance and decommissioning phases.
iv. Designation of the site as an area to be avoided (ATBA).	✓	n/a
v. Provision of AtoN as determined by the GLA	✓	**Section 25 Embedded Mitigation Measures** Aids to navigation would be installed (both permanent and temporary) as per TH requirements.
vi. Implementation of routeing measures within or near to the proposed project.	✓	n/a
vii. Monitoring by Radar, AIS, CCTV or other agreed means	✓	**Section 27 Future Monitoring** AIS data would be continuously collected from a suitable location at the OWF sites with an assessment of a minimum of 28 days submitted to the MCA annually.
viii. Appropriate means for OREI operators to notify, and provide evidence of, the infringement of safety zones.	✓	n/a
ix. Creation of an ERCoP with the MCA's SAR Branch for the	✓	**Section 25 Embedded Mitigation**

Issue	Compliant (Yes/No)	Reference notes/remarks
construction phase onwards.		**Measures** An ERCoP would be developed and implemented with the MCA for the construction, operation and maintenance and decommissioning phases.
x. Use of guard vessels, where appropriate	✓	**Section 25 Embedded Mitigation Measures** Guard vessels would be present during the deployment of safety zones, and during any other key construction periods.
xi. Any other measures and procedures considered appropriate in consultation with other stakeholders.	✓	n/a
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 Search and Rescue 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 25 Embedded Mitigation Measures** An ERCoP would be developed and implemented with the MCA for the construction, operation and maintenance and decommissioning phases.
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 25 Embedded Mitigation Measures** The Applicant will consider guidance within MGN 543.

33. Appendix C: Hazard Log

The hazard log distributed to stakeholders, as described in Section 24, is presented below. The log presents the initial set of impacts relevant to shipping and navigation receptors that were identified following a review of the baseline assessment. Each impact has been assigned a "Frequency of Occurrence" ranking and "Severity of Consequence" ranking, which has been used to define the impacts significance, as per the FSA process. The definitions used for "Frequency of Occurrence" and "Severity of Consequence" are presented in Table 33.1 and Table 33.2 respectively.

Table 33.1 Frequency of Occurrence

Rank	Description	Definition
1	**Negligible**	< 1 occurrence per 10,000 years
2	**Extremely Unlikely**	1 per 100 – 10,000 years
3	**Remote**	1 per 10 – 100 years
4	**Reasonably Probable**	1 per 1 – 10 years
5	**Frequent**	Yearly

Table 33.2 Severity of Consequence

Rank	Magnitude	Definition
1	**Negligible**	No injury to persons No significant damage to infrastructure or vessel No significant environmental impacts No significant business(safety), operation or reputation impacts
2	**Minor**	Slight injury(s) to person Minor damage to infrastructure or vessel Tier 1 pollution assistance (marine pollution) Minor business(safety), operation or reputation impacts
3	**Moderate**	Multiple moderate or single serious injury to persons Moderate damage to infrastructure or vessel Tier 2 pollution assistance (marine pollution) Considerable business(safety), operation or reputation impacts
4	**Serious**	Serious injury or single fatality Major damage to infrastructure or vessel Tier 2 pollution assistance (marine pollution) Major national business(safety), operation or reputation impacts

Rank	Magnitude	Definition
5	**Major**	More than one fatality Extensive damage to infrastructure or vessel (> £100M) Tier 3 pollution assistance (marine pollution) Major international business, operation or reputation impacts (> £10M)

537. The severity of consequences is then assessed against the frequency of occurrence to provide the level of tolerability of the impact. This tolerability matrix is shown in Table 33.3. The tolerability of the impact is defined as **Broadly Acceptable** (low risk), **Tolerable** (intermediate risk) or **Unacceptable** (high risk).

Table 33.3 Tolerability Matrix and Risk Rankings

Frequency						
	Frequent	Tolerable	Tolerable	Unacceptable	Unacceptable	Unacceptable
	Reasonably Probable	Broadly Acceptable	Tolerable	Tolerable	Unacceptable	Unacceptable
	Remote	Broadly Acceptable	Broadly Acceptable	Tolerable	Tolerable	Unacceptable
	Extremely Unlikely	Broadly Acceptable	Broadly Acceptable	Broadly Acceptable	Tolerable	Tolerable
	Negligible	Broadly Acceptable	Broadly Acceptable	Broadly Acceptable	Broadly Acceptable	Tolerable
		Negligible	**Minor**	**Moderate**	**Serious**	**Major**
		Severity				

	Broadly Acceptable	Risk ALARP with no additional mitigations or monitoring required above embedded mitigations.
	Tolerable	Risk acceptable but may require additional mitigation measures and monitoring in place to control and reduce to ALARP.
	Unacceptable	Significant risk mitigation or design modification required to reduce to ALARP.

538. Once identified the impact will then be assessed to ensure it is ALARP. Further risk control measures may be required to further mitigate the impact and bring it within ALARP regions.

539. The Hazard Log is presented in Table 33.4.

Table 33.4 Hazard Log

Phase (C, O, D)	Impact	Receptor	Hazard Title	Hazard Detail	Possible Causes	Embedded Mitigation	Most Likely Consequence	Realistic Worst Case Consequence	Most Likely – Consequences – People	Most Likely – Consequences – Environment	Most Likely – Consequences – Property	Most Likely – Consequences – Business	Most Likely – Consequences – Average	Most Likely – Frequency	Most Likely – Risk	Most Likely – Risk rating	Worst Case – Consequences – People	Worst Case – Consequences – Environment	Worst Case – Consequences – Property	Worst Case – Consequences – Business	Worst Case – Consequences – Average	Worst Case – Frequency	Worst Case – Risk	Worst Case – Risk rating	Other Potential Risk Reduction Measures?	Remarks / Questions
Commercial Vessels																										
C, O, D	Deviation	Commercial Vessels	Activities within the Norfolk Vanguard site and offshore export cable route could cause commercial vessels to be deviated.	Established vessel routes are displaced, leading to increased journey time and potentially disruption to timetabled services	Location of site in proximity to shipping routes.	Promulgation of Information. Consultation with vessel operators.	Increased journey time and distance.	Increased journey time and distance affecting operational schedules.	1	1	1	1	1	3	3	Broadly Acceptable	1	1	1	3	3	2	3	Broadly Acceptable		
C, D	Allision (powered and NUC)	Commercial Vessels	Presence of infrastructure within the Norfolk Vanguard array area may cause increased allision risk for commercial vessels (including vessels NUC)	During the construction and decommissioning stages, there could be an increased risk of vessels alliding with the wind turbines due to the fact that navigational aids (e.g. lights and markings) may not all be present.	Presence of newly installed infrastructure within the Norfolk Vanguard array area poses an allision risk to vessels. The risk could be associated with lack of or failure of navigational marking, human error, adverse weather, navigational error.	Buoyed construction areas, safety zones, temporary navigational marks, Marine Coordination, monitoring by AIS, promulgation of information	Near miss or entrance into safety zone by third party vessel.	Vessel allides with a newly installed structure.	3	1	3	4	2.8	1	2.8	Broadly Acceptable	5	5	5	5	5	1	5	Tolerable		
O	Allision (powered)	Commercial Vessels	Presence of infrastructure located within the Norfolk Vanguard array area may increase vessel to structure allision risk external to the array for commercial vessels.	Oil Tanker	Presence of infrastructure within the Norfolk Vanguard array area poses an allision risk to vessels. The risk could be associated with lack of or failure of navigational marking, human error, adverse weather, navigational error.	Compliance with international and flag state regulations, MGN 372, MGN 543, promulgation of information, Marine Coordination, monitoring by AIS, permanent aids to navigation, marine pollution contingency planning, IALA 0-139	Near miss of structure by third party vessel on the periphery of the site.	Allision with structure by third party vessel on the periphery of the site.	2	1	3	4	2.5	2	5.0	Broadly Acceptable	5	5	5	5	5	1	5	Tolerable	Consideration for adverse weather routeing	
				General Cargo					3	1	3	4	2.8	2	5.5	Broadly Acceptable	5	3	5	4	4.3	1	4.3	Broadly Acceptable		
				Passenger					4	1	3	4	3	2	6	Broadly Acceptable	5	3	5	5	4.5	1	4.5	Broadly Acceptable		
				Gas Carrier					3	1	3	4	2.8	2	5.5	Broadly Acceptable	5	4	5	5	4.8	1	4.8	Broadly Acceptable		
				Coaster					3	1	3	3	2.5	2	5	Broadly Acceptable	5	5	5	5	5	1	5	Tolerable		

O	Allision (NUC)	Commercial Vessels	Presence of infrastructure within the Norfolk Vanguard array area may increase vessel to structure allision risk external to the array for NUC vessels in an emergency situation (including machinery related problems or navigational system errors).	Oil Tanker	Presence of infrastructure within Norfolk Vanguard array areas poses an allision risk to vessels NUC caused by engine failure; navigational equipment failure, machinery failure; steering gear failure	Compliance with international and flag state regulations, MGN 372, MGN 543, promulgation of information, Marine Coordination, monitoring by AIS, permanent aids to navigation, marine pollution contingency planning.	Vessel NUC is on a closing point of approach with a structure but no allision occurs due to the vessel regaining power or other evasive action.	NUC vessel is on a closing point of approach with a structure and an allision occurs potentially resulting in pollution.	2	1	2	4	2.3	2	4.5	Broadly Acceptable	5	5	5	5	5	1	5	Tolerable	Consideration for self help and advanced emergency response capabilities.	
				General Cargo					3	1	3	4	2.8	2	5.5	Broadly Acceptable	5	3	5	4	4.3	1	4.3	Broadly Acceptable		
				Passenger					2	1	2	4	2.3	2	4.5	Broadly Acceptable	5	3	5	4	4.3	1	4.3	Broadly Acceptable		
				Gas Carrier					2	1	2	4	2.3	2	4.5	Broadly Acceptable	5	4	5	5	4.8	1	4.8	Broadly Acceptable		
				Coaster					2	1	2	2	1.8	2	3.5	Broadly Acceptable	5	5	5	5	5	1	5	Tolerable		
C, O, D	Collision	Commercial Vessels	Activities within the Norfolk Vanguard array area and offshore export cable route cause commercial vessels to be deviated, increasing encounters and thus the risk of vessel to vessel collision including with project vessels.	Displaced traffic increases congestion outside of the array area. This can lead to an increase in vessel-to-vessel encounters and potentially collisions.	Presence of construction, operation or decommissioning activities including buoyed construction areas and safety zones will cause commercial vessels to be deviated creating new areas of high density traffic or congestion points for third party vessels and thus increasing risk of collision. This impact could also include causes associated with navigational error, human error or adverse weather	Compliance with international and flag state regulations, MGN 372, promulgation of information	Increased encounters and therefore more collision avoidance action required by vessels as per COLREGS but does not result in a collision	Vessel to vessel collision resulting in major injury to persons and major damage to vessel	3	2	4	3	3	1	3	Broadly Acceptable	5	5	5	5	5	1	5	Tolerable	Site design giving consideration to navigation, consideration for self help and advanced emergency response capabilities, consideration for adverse weather routes	
C, O, D	Snagging	Commercial Vessels	Presence of cables and other subsea infrastructure will present an anchor snagging risk for commercial vessels	Vessel drops anchor over subsea equipment or a nearby vessel drags anchor over a subsea cable. Vessel may drop anchor over cable(s) in an emergency, i.e. machinery failure.	Presence of installed cables could pose a risk to vessels anchoring. This could be associated with human error, navigational equipment error or adverse weather.	Cable burial risk assessment, compliance with international and flag state regulations, promulgation of information (charting)	A vessel anchors on an area of buried / protected cable or floating foundation mooring but no interaction occurs	A vessel anchors on an area of exposed or partially buried cable or subsea structure resulting in damage to the cable and/or anchor.	1	2	3	3	2.3	1	2.3	Broadly Acceptable	5	4	5	4	4.5	1	4.5	Broadly Acceptable		Increased from EA4 hazard workshop given the introduction of floating foundations into the Project Design Statement
Emergency Response																										
C, O, D	Access	Third Party	Unauthorised mooring to and/or deliberate damage to device	Vessels moor to the structure without the authority to do so and/or with the intention to cause damage to the device	Act of Protest or Vandalism	ERCoP	Potential for considerable operational impacts but unlikely to result in injury	Could result in serious injury to person, damage to property and operational impacts	1	1	1	3	1.5	1	1.5	Broadly Acceptable	4	1	2	3	2.5	1	2.5	Broadly Acceptable		
C, O, D	Access	Third Party	Unauthorised access to and/or deliberate damage to device	People access the structure without the authority to do so and/or with the intention to cause damage to the device	Act of Protest or Vandalism	ERCoP	Potential for considerable operational impacts but unlikely to result in injury	Could result in serious injury to person, damage to property and operational impacts	1	1	1	3	1.5	1	1.5	Broadly Acceptable	4	1	2	3	2.5	1	2.5	Broadly Acceptable		
C, O, D	Access	Third Party	Access to structure in an emergency situation	During emergency situations, a vessel may have to moor/secures itself to a wind farm structure	Emergency response incident	MGN 543	Moderate potential for damage to a structure but limited potential for a minor injury and potential operational impacts	Person becomes stranded and unable to be recovered resulting in injury, moderate damage to structure and potential operational impacts	1	1	2	1	1.3	1	1.3	Broadly Acceptab	4	1	2	2	2.3	1	2.3	Broadly Acceptab		

C, O, D	SAR	Third Party	Restricted emergency response in the array in an emergency situation	Access to the wind farm for search and rescue operations or other emergency may be affected by the presence of the wind farm structures	Restricted sea room and air space, Ineffective industry wide Emergency Response	MGN 543, SOLAS and ERCoP	Restricted but not ineffective emergency response capability	Loss of life due to restricted emergency response access	2	1	1	3	1.8	3	5.3	Broadly Acceptabl	5	1	4	5	3.8	2	7.5	Broadly Acceptabl		
Fishing vessels																										
C, O, D	Allision	Commercial Fishing Vessels (in transit/mobile gear)	Presence of Norfolk Vanguard array area may increase vessel to structure allision risk for commercial fishing vessels.	Fishing vessel allides with wind farm structure whilst fishing in the area or in transit.	Human error, adverse weather, emergency scenario, uncharted cables/equipment on seabed; navigational equipment failure, engine failure/blackout, Dragged anchor, Sediment transport exposing and lifting cables	Compliance with international and flag state regulations, MGN 372, promulgation of information, Marine Coordination, monitoring by AIS, permanent aids to navigation, marine pollution contingency planning.	Commercial fishing vessel allides with a structure.	Vessel allides with structure resulting in the potential major consequence for persons and moderate damage to vessel and infrastructure.	3	1	2	2	2	2	4	Broadly Acceptable	5	2	3	4	3.5	1	3.5	Broadly Acceptable		
C, O, D	Snagging	Commercial Fishing Vessels (mobile gear)	Presence of cables and other subsea infrastructure within the array (including foundations and mooring lines) will present an increased gear snagging risk for commercial fishing vessels.	There is the potential for fishing gear to interact with the subsea infrastructure within the array (including the array cables).	Presence of partially installed or installed cables and structures could pose a risk to vessels fishing in proximity or near to current areas of operation. This could be associated with human error or navigational equipment error.	Cable burial risk assessment, compliance with international and flag state regulations, use of guard vessels or temporary marks, promulgation of information (charting and KISORCA).	A vessel fishes (trawls) close to an area of exposed cable or subsea structure but no snagging interaction occurs.	A vessel fishes (trawls) on an area of exposed or partially buried cable or subsea structure. This results in damage to the cable, gear or foundering of vessel.	1	1	2	2	1.5	3	4.5	Broadly Acceptable	5	2	5	4	4	3	12	Tolerable	Chart Markings; of abandoned gear/dropped objects.	Increased from EA4 hazard workshop given the introduction of floating foundations into the Project Design Statement
C, O, D	Snagging	Commercial Fishing Vessels (mobile gear)	Presence of offshore export cables will present an increased gear snagging risk for commercial fishing vessels.	Fishing vessel drags gear over offshore export cable, e.g. scallop dredger or trawler	Uncharted obstruction on seabed, Lack of Awareness; sediment transport exposing / lifting cables; Human error	Cable burial risk assessment, compliance with international and flag state regulations, use of guard vessels or temporary marks, promulgation of information (charting and KISORCA).	A vessel fishes (trawls) close to an area of partially installed or exposed cable but no snagging interaction occurs.	A vessel fishes (trawls) on an area of exposed or partially buried cable. This results in damage to the cable, gear or foundering of vessel.	1	1	2	2	1.5	3	4.5	Broadly Acceptable	5	2	5	5	4.3	3	13	Tolerable	Chart Markings; of abandoned gear/dropped objects.	Increased from EA4 hazard workshop given the introduction of floating foundations into the Project Design Statement
C, O, D	Displacement	Commercial Fishing Vessels (mobile gear)	Activities within the Norfolk Vanguard site and offshore export cable route could cause fishing vessels to be deviated.	Established vessel routes and fishing areas area displaced	Location of site in proximity to fishing vessel routes and grounds, plus the use of floating foundations.	Promulgation of Information. Consultation with fishing vessels operators,	Increased distance to fishing grounds	Exclusion from fishing grounds	1	1	1	1	1	3	3	Broadly Acceptable	1	1	1	5	2	3	6	Broadly Acceptable		Increased from EA4 hazard workshop given the introduction of floating foundations into the Project Design Statement
Wind Farm Support																										
C, O, D	Allision	Wind Farm Construction, Operational or Maintenance Vessels	Support vessel allision with wind farm structure	Vessels will be working in proximity to the structures, e.g., during construction and maintenance. Misjudgement, weather or equipment failure could lead to an allision	Poor Visibility; Manoeuvring error; Machinery Failure; Lack of Passage Planning; Lack of experience; Lack of awareness; Human error; Fatigue; Engine Failure/ Blackout; Bad weather.	Compliance with international and flag state regulations, IALA 0-139, MGN 543, MGN 372, standard template ERCoP, standard marine practices such as notice to mariners	Minor damage to vessel and potential for minor injury	High speed impact that results in major damage to vessels and consequences for personnel. Could also lead to major damage to vessel.	2	1	2	2	1.8	4	7	Broadly Acceptable	5	2	4	4	3.8	2	7.5	Broadly Acceptable		
C, O, D	Man Overboard	Wind Farm Construction, Operational or Maintenance Vessels	Man Overboard	Man overboard scenario within the wind farm from either a wind farm work craft or a third party vessel.	Recovery of person/s from the water during man overboard incident	MGN 543, SOLAS and ERCoP	Man overboard from support /wind farm operational vessels within the wind farm resulting in no injury	Multiple persons in the water from a large vessel with the potential for serious injury to persons from an inability to adequately undertake SAR.	1	1	1	1	1	1	1	Broadly Acceptable	4	1	4	1	2.5	1	2.5	Broadly Acceptable		
Oil and Gas																										
C, O, D	Displacement	Oil and Gas Support Vessels	Displacement of oil and gas vessels working within or around the array area	Oil and gas vessels working within or near the sites are displaced	Location of site in proximity to oil and gas assets and routes.	Promulgation of Information. Consultation with vessel operators.	Increased journey time and distance.	Oil and gas vessels unable to access their required destination	1	1	1	1	1	2	2	Broadly Acceptable	1	1	1	3	1.5	2	3	Broadly Acceptable		
Recreation																										
C, O, D	Deviation	Recreational Vessels (2.5 to 24 m)	Activities within the Norfolk Vanguard site and offshore export cable route could cause recreational vessels to be displaced.	Established vessel routes and fishing areas area displaced	Location of Norfolk Vanguard in proximity to known recreational routes.	Promulgation of Information. Consultation with fishing recreational stakeholders	Increased distance and time	Increased journey time and distance affecting passage planning	1	1	1	1	1	2	2	Broadly Acceptable	2	1	1	1	1.3	1	1.3	Broadly Acceptable		

C, O, D	Allisions	Recreational Vessels (2.5 to 24m)	Presence of infrastructure within the Norfolk Vanguard array area may cause increased allision risk for recreational vessels.	Recreational vessel allides with wind turbine or offshore substation platform.	Human error, adverse weather/poor visibility, Aid to Navigation failure, communication or navigational equipment failure Fatigue	Compliance with international and flag state regulations, MGN 372, MGN 543 promulgation of information, Marine Coordination, monitoring by AIS, permanent aids to navigation, RYA guidance	Near miss by recreational vessel.	Vessel allides with a structure	2	1	2	2	1.8	2	3.5	Broadly Acceptable	5	1	2	2	2.5	1	2.5	Broadly Acceptable		
O, D	Collision	Recreational Vessels (2.5 to 24m)	Presence of infrastructure within the Norfolk Vanguard array area may cause recreational vessels to be deviated, increasing encounters and thus the risk of a vessel to vessel collision internally within the array.	Recreational vessels collides with another vessel (most likely fishing or other small craft within wind farm array)	Human error, adverse weather/poor visibility, Aid to Navigation failure, communication or navigational equipment failure Fatigue, visual confusion associated with the wind turbine alignment, reduced detection of vessels by Radar	Compliance with international and flag state regulations, MGN 372, MGN 543, promulgation of information, Marine Coordination, monitoring by AIS, permanent aids to navigation.	Near miss between a recreational vessel and another vessel internally within the array.	Collision between a recreational vessel and another vessel internally within the array.	2	1	2	2	1.8	1	1.8	Broadly Acceptable	5	1	4	2	3	1	3	Broadly Acceptable		
Deliberate Act of Allision																										
C, O , D	Allision	All Vessels	Presence of infrastructure creates a target for deliberate allision	Vessel deliberately allides with a structure due to vandalism or terrorism	Deliberate Act	Marine Coordination (site monitoring)	Allision between a vessel and wind farm structures, resulting in some loss of life	Allision between a passenger vessel and wind farm structures, resulting in significant loss of life	4	1	2	2	2.3	1	2.3	Broadly Acceptable	5	1	3	3	3	1	3	Broadly Acceptable		