East Anglia Offshore Wind

VATTENFALL

SCOTTISHPOWER RENEWABLES

East Anglia THREE

Appendix 15.1

Annex 5

DR1 Light Buoy Deep Water Route Technical Note

Volume 3

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East Anglia THREE Offshore Windfarm

DR1 Light Buoy Deep Water Route Technical Note

APPENDIX 15.1

ANNEX 5

Prepared by:	Anatec Limited
Presented to:	East Anglia THREE Ltd (EATL).
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Anatec	Aberdeen Office	Cambridge Office
Address:	10 Exchange Street, Aberdeen, AB11 6PH, UK	Braemoor, No. 4 The Warren, Witchford, Ely, Cambs, CB6 2HN, UK
Tel:	01224 253700	01353 661200
Fax:	0709 2367306	0709 2367306
Email:	aberdeen@anatec.com	cambs@anatec.com

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A	01 July 2015	Final Version Submitted to Client
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TABLE OF CONTENTS

Table of Figures

Table of Tables

Abbreviations

AIS	-	Automatic Identification System
BWEA	-	British Wind Energy Association
CPA	-	Closest Point of Approach
DWR	-	Deep Water Route
EATL	-	East Anglia THREE Limited
GPS	-	Global Positioning System
IMO	-	International Maritime Organisation
MCA	-	Maritime and Coastguard Agency
NRA	-	Navigational Risk Assessment
nm	-	Nautical Mile
PLA	-	Port of London Authority
SPR	-	Scottish Power Renewables
TSS	-	Traffic Separation Scheme
UHF	-	Ultra High Frequency
VHF	-	Very High Frequency
VTS	-	Vessel Traffic Service

1. Introduction

1.1 Project Description

1. Anatec Ltd have been commissioned by Scottish Power Renewables (SPR) to assess the traffic currently utilising the DR1 Light Buoy Deep Water Route (hereby referred to as DWR) located directly to the west of East Anglia THREE. This purpose of this technical note is to review the separation distance between the shipping using the DWR and the proposed development.
2. This report should be considered in conjunction with the East Anglia THREE Navigation Risk Assessment (NRA) (Anatec 2015) and other supporting documents; and has been undertaken as part of the Environmental Statement for submission as part of the consent application.

1.2 Objectives

3. The objectives of this technical note are as follows:

- Determine the behaviour and characteristics of vessels using the DWR;
- Perform a closest point of approach (CPA) analysis between the DWR traffic and the western boundary of East Anglia THREE.
- Assess the time exposure of DWR vessels to the proposed East Anglia THREE turbine layouts;
- Present details on the effects of the turbines on marine radar use;
- Assess the cumulative radar impact of the East Anglia THREE and East Anglia ONE projects.

1.3 Overview of a Deep Water Route

4. To clarify the DWR is an area designated by the International Maritime Organisation in which the defined limits have been accurately surveyed for under keel clearance including the seabed and any submerged objects; indicating a minimum depth of water. Although there are no specific regulations for navigating with a DWR, if a vessel were to display its 'constrained by draught' lights or day signals the International Convention for the Prevention of Collisions at Sea (COLREGs) would give priority to that vessels movements and positioning within the DWR over other non-constrained vessels. Rule 18(d) of COLREGS states *that 'any vessel other than a vessel not under command or a vessel restricted in its ability to manoeuvre shall, if the circumstances of the case admit, avoid impeding the safe passage of a vessel constrained by her draught, exhibit the signals in Rule 28'.*

2. Site Overview

2.1 Site Boundary

5. A detailed overview of the East Anglia THREE site boundary relative to the DWR is presented in Figure 2.1. The East Anglia ONE site (consented) boundary and the chosen study area in which the analysis has been undertaken are shown below.

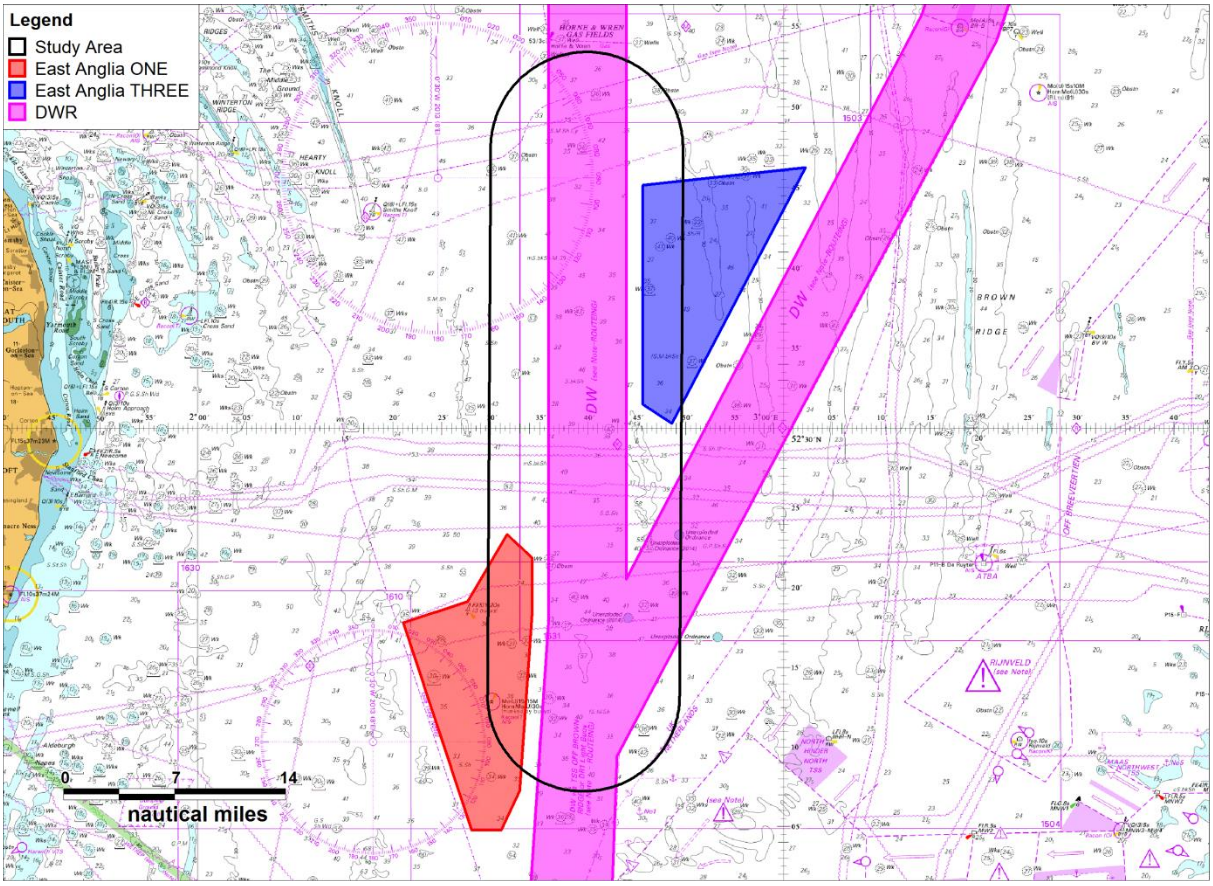

Figure 2.1 East Anglia THREE Site Boundary relative to DWR

6. The study area was chosen to include all traffic to the west of East Anglia THREE using the DWR, and to incorporate the traffic further south, to the east of East Anglia ONE, on the approach to the DR 1 light Buoy DWR and its junction with the Off Brown Ridge DWR.

2.2 Realistic Worst Case Layouts

7. There are two realistic worst case layouts which have been considered for East Anglia THREE within the Navigational Risk Assessment (NRA), a 100% fill

option and a partial fill option. These layouts are presented in Figure 2.2 and Figure 2.3 respectively. Both of these layouts are considered within this assessment. It should be noted that for the purposes of allision and collision risk modelling (undertaken as part of the NRA) all additional structures within the windfarm (HVDC converter stations, HVAC collector stations, accommodation platforms, meteorological masts and Lidar buoys) have been positioned within the windfarm where the greatest risk to shipping and navigation is presented in order to model the worst case. Following completion of the allision and collision risk modelling, East Anglia Offshore Wind Limited (EATL) have made the commitment not to place additional structures on the periphery of the windfarm in proximity to areas of high density shipping in order to reduce the overall allision and collision risk for East Anglia THREE. Therefore the worst case layouts presented below are indicative only and used to assess the worst case from a shipping and navigation perspective.

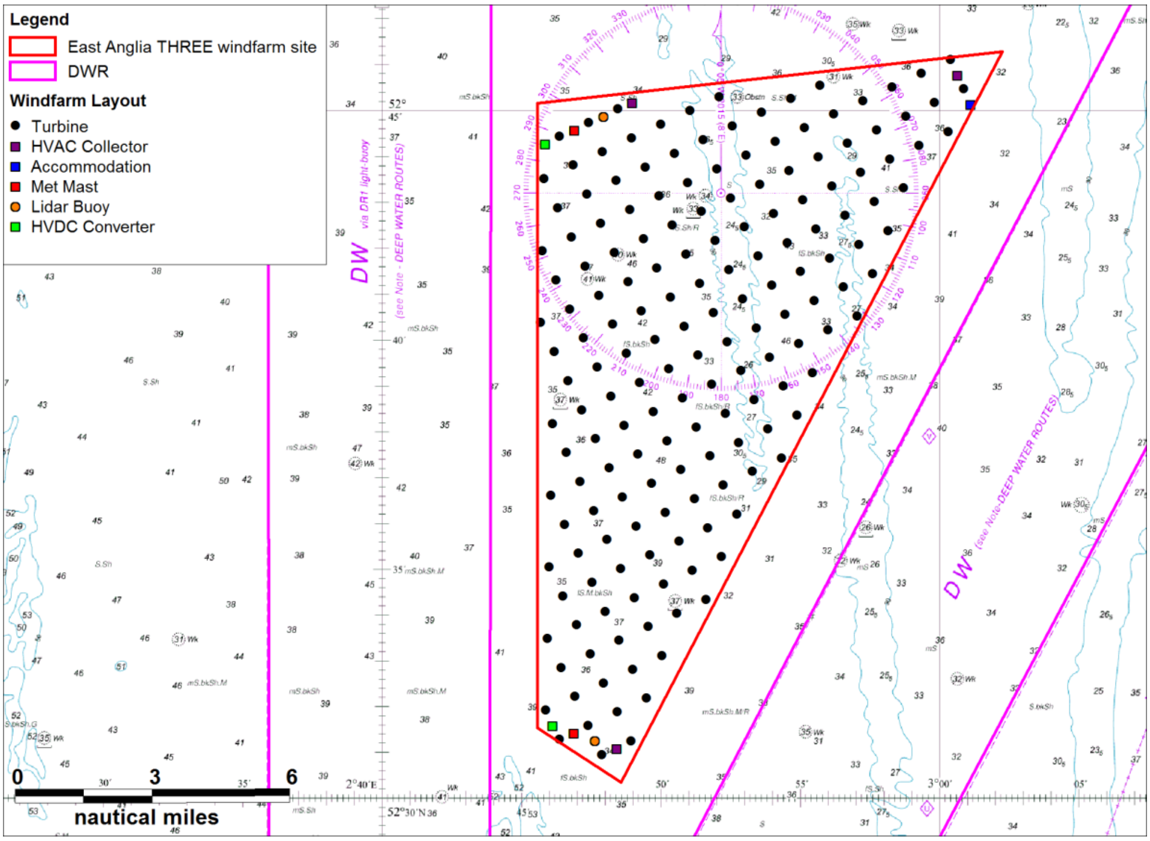

Figure 2.2 East Anglia THREE 100% Fill Turbine Layout – Realistic Worst Case Layout

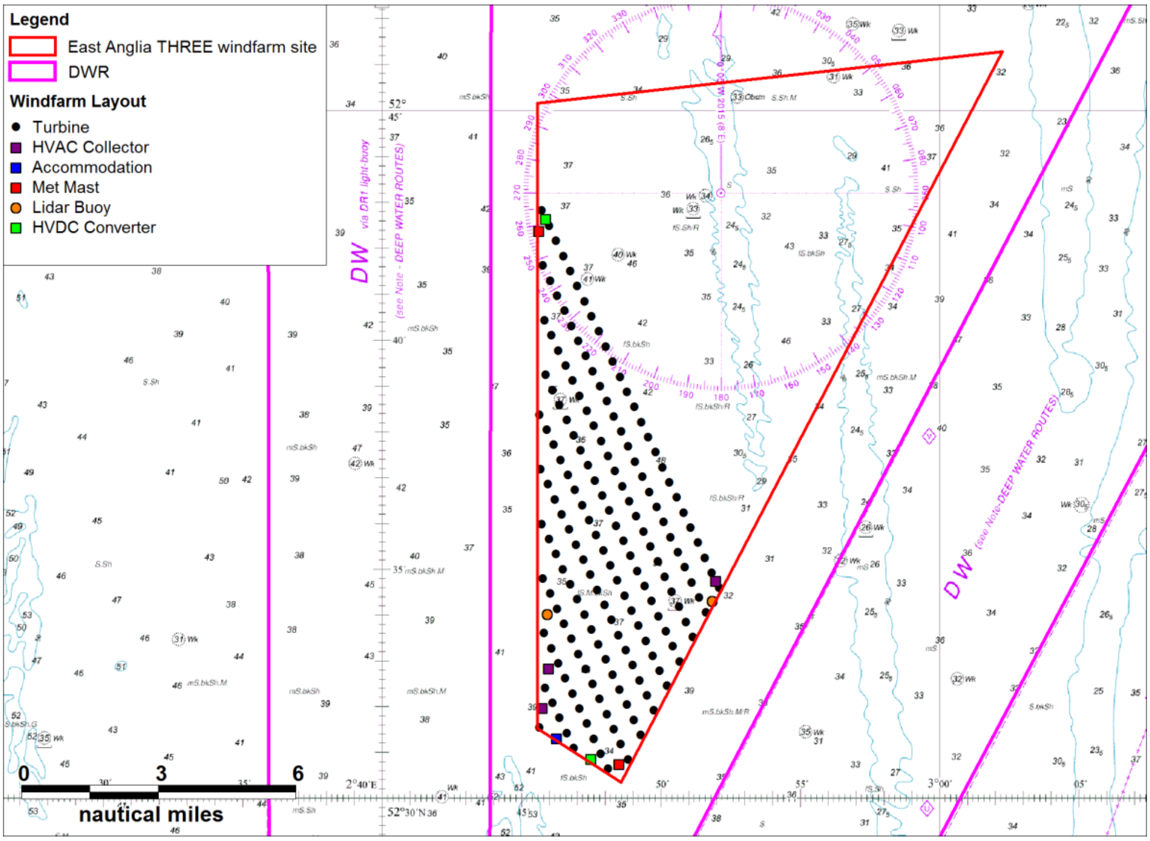

Figure 2.3 East Anglia THREE Partial Fill Turbine Layout – Realistic Worst Case Layout

3. Vessels Utilising DWR

3.1 Introduction

8. In order to assess the activity of vessels utilising the DR1 Light Buoy DWR (west of East Anglia THREE) a total of 40 days of AIS and Radar data has been analysed. The data was recorded from the Northern Viking and Shemarah II survey vessels. The data was then supplemented with further data recorded from shore based receivers to increase comprehensiveness of coverage. It is noted that even with this additional data that the AIS coverage is not fully comprehensive for the southern part of the study area, to the east of East Anglia ONE, and vessels counts may be underrepresented. This is due to the distance of this sea area from the survey vessels, which were centred within East Anglia THREE approximately 27nm north, and the shore based receivers located approximately 40nm west. However the tracks have been included in the analysis to provide an indicative overview of the East Anglia ONE activity.

9. A total of four surveys (each lasting ten days in duration) were performed, details of which are presented in Table 3.1.

Table 3.1 AIS Marine Traffic Survey Details

Survey No	Vessel	Start Date	End Date
1	*Shemarah II*	28/08/2012	06/09/2012
2	*Northern Viking*	12/05/2013	21/05/2013
3	*Northern Viking*	25/07/2013	03/08/2013
4	*Northern Viking*	24/01/2014	02/02/2014

3.2 Vessel Types Utilising the DR1 Light Buoy DWR and its junction with the Off Brown Ridge DWR

10. Vessels that were assessed as using the DR1 Light Buoy DWR within its entirety were used as the basis of the remaining analyses within this report. These tracks are presented in Figure 3.1. It is noted that any track observed to be temporarily using the DWR within the study area has not been included throughout any further analyses. Vessels using the Off Brown Ridge DWR to the east of East Anglia THREE have also been excluded.

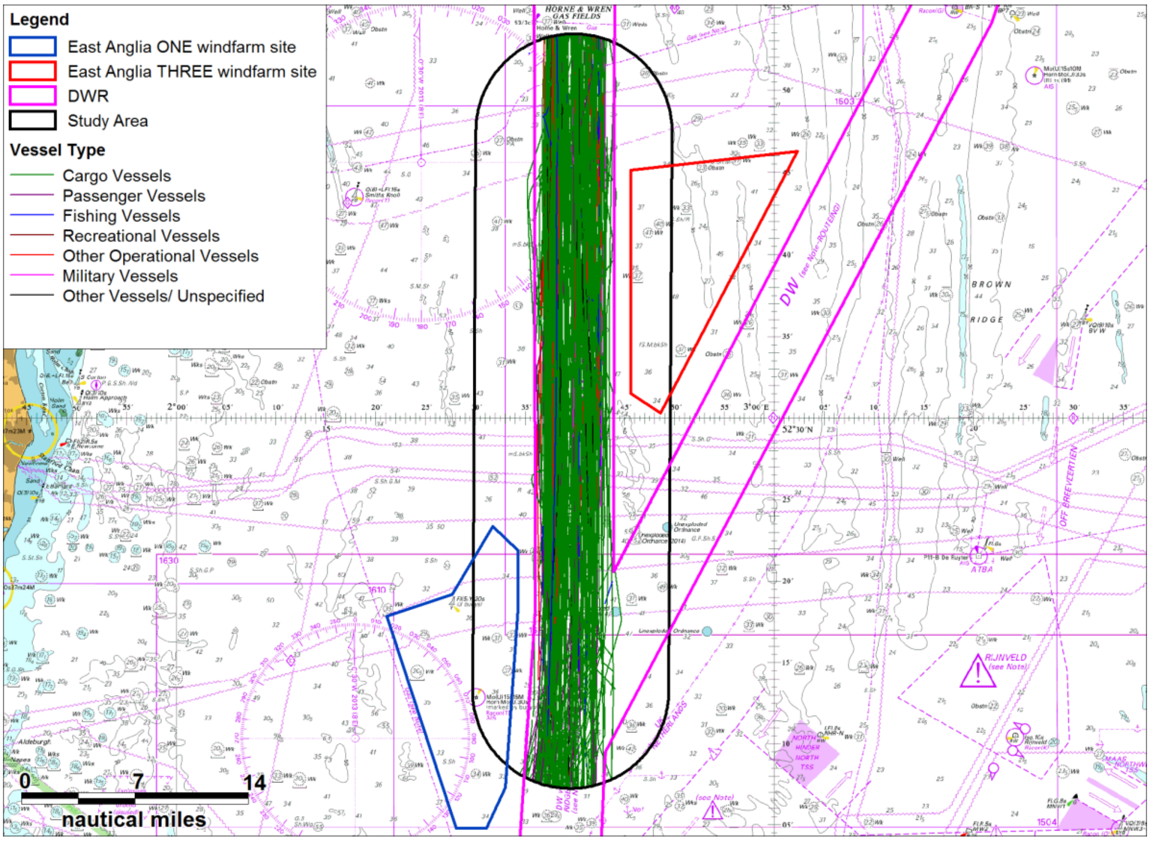

Figure 3.1 Tracks observed using the DWR

11. The vessel type distribution (based on more detailed second level DECC categories (Table 3.2) of vessels using the entirety of the DWR, see Figure 3.1, is presented in Figure 3.2.

Table 3.2 Cargo and Passenger Vessel Subtypes (DECC Categories)

Type	Subtypes
Cargo	Bulk Carriers Bulk/Oil Carriers Chemical Tankers Container vessels Liquefied Gas Carriers Oil Tankers General Cargo Specialised Carriers
Passenger	Cruise Vessels Passenger

Type	Subtypes
	Passenger Ferries High Speed Ferries Other High Speed Craft

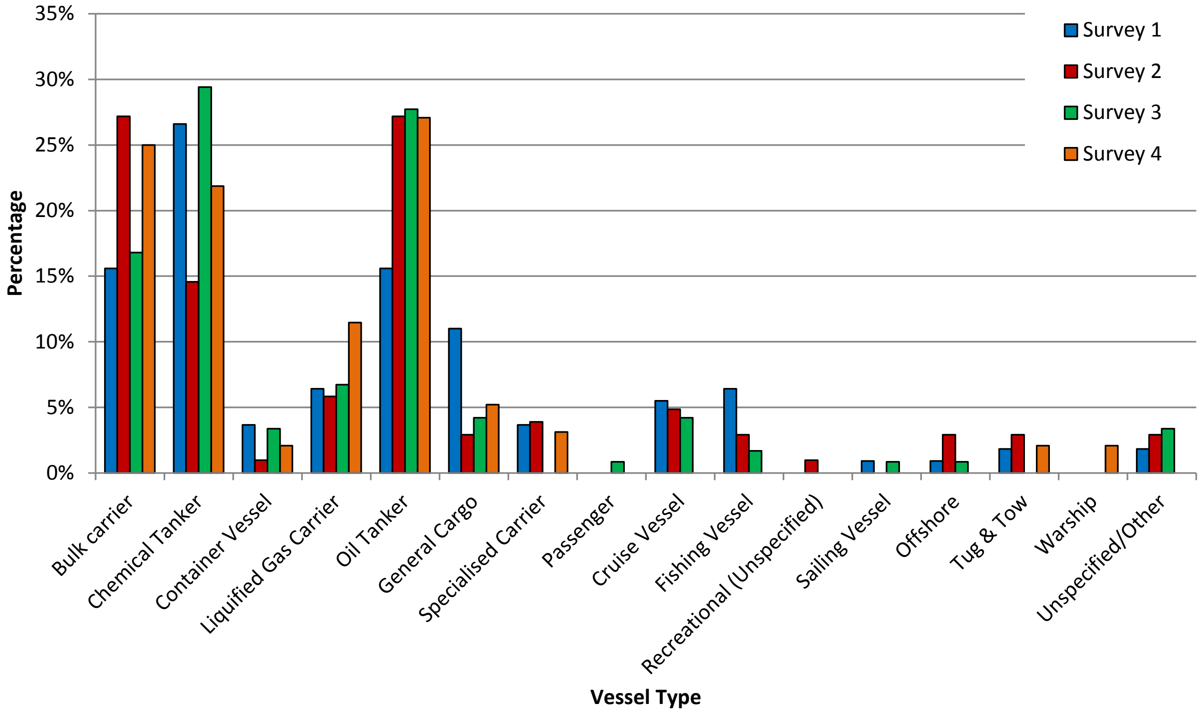

Figure 3.2 Vessel Type Distribution in DWR

12. Throughout all four surveys, the most frequently recorded vessel types using the DWR were:

- Oil tankers (average of 24.4% of marine traffic within DWR throughout all surveys);
- Chemical tankers (average of 23.4% of marine traffic within DWR throughout all surveys) and
- Bulk carriers (average of 20.8% of marine traffic within DWR throughout all surveys).

13. Small numbers of passenger, fishing, recreational and military vessels were also observed using the DWR.

3.3 Vessel Numbers on DWR

14. Figure 3.3 presents the number of unique vessels per day recorded in the

DWR in each survey period.

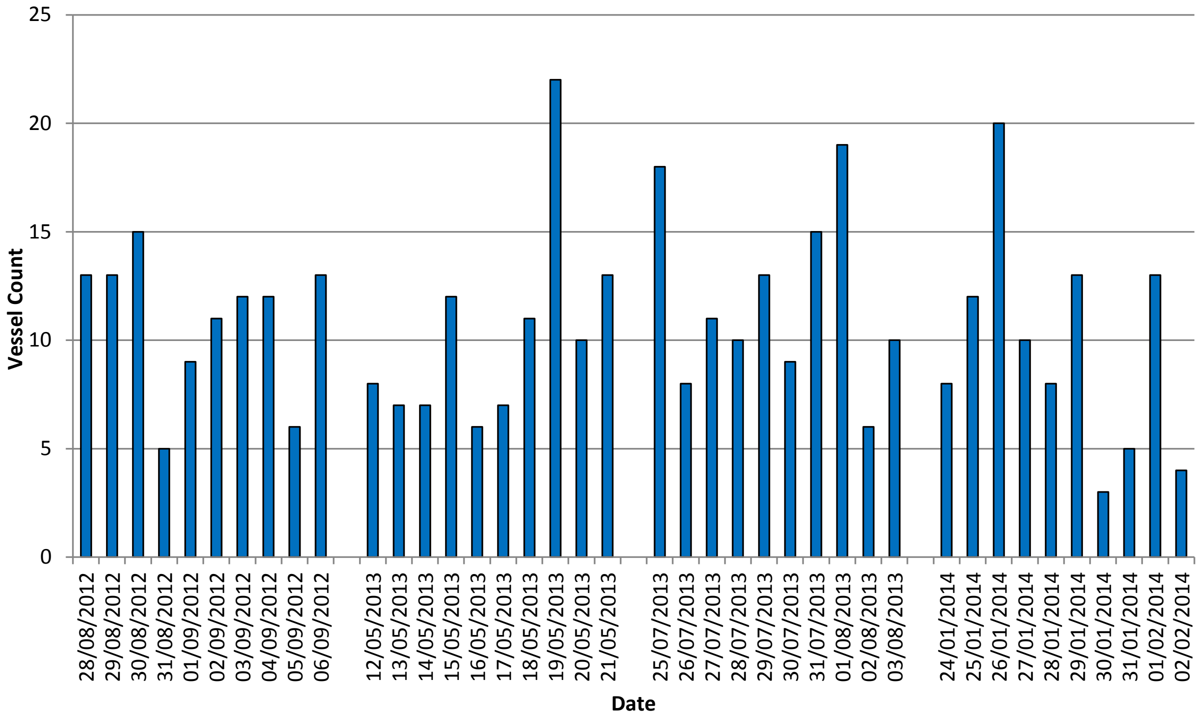

Figure 3.3 Vessel Numbers in DWR

15. The busiest day recorded during the four surveys was the 19th May 2013, when 22 vessels were recorded in the DWR. The quietest day was the 30th January 2014 when THREE vessels were recorded. An average of 11 vessels per day used the DWR.

16. Plots of the busiest day, an average day (in terms of DWR vessel use) and the quietest day are presented in Figure 3.4, Figure 3.5 and Figure 3.6 respectively.

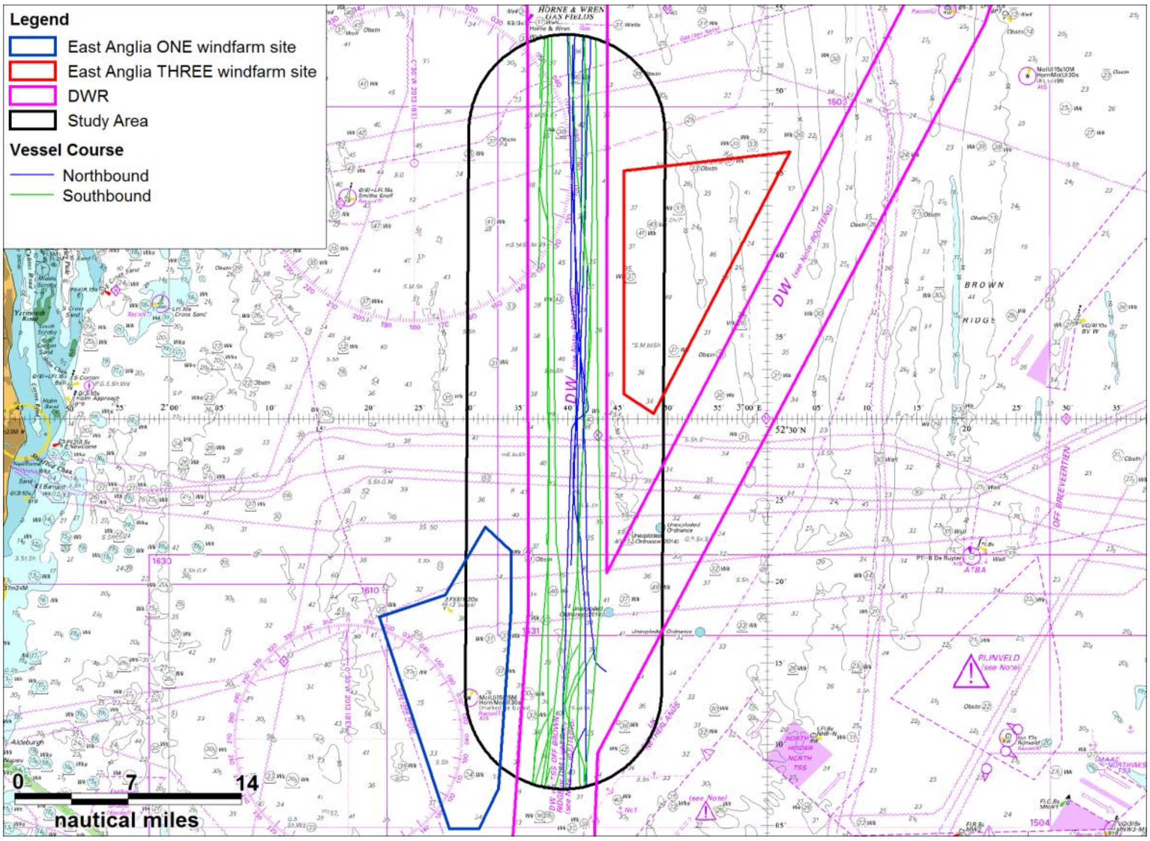

Figure 3.4 Busiest Day – 19th May 2013

17. A total of 22 unique vessels were recorded on the busiest day (19th May 2013). The most frequently recorded vessel types on the busiest day were: Bulk carriers (eight vessels), chemical tankers (three vessels) and cruise vessels (three vessels). Other vessel types recorded on the busiest day include: Liquefied gas carriers, oil tankers, general cargo vessels, fishing vessels and offshore support vessels. Throughout the busiest day the majority of vessels (68.2%) were recorded transiting southbound within the DWR. The remaining 31.8% were recorded transiting northbound. It should be noted that four of the southbound vessel transits were recorded on the eastern extent of the DWR.

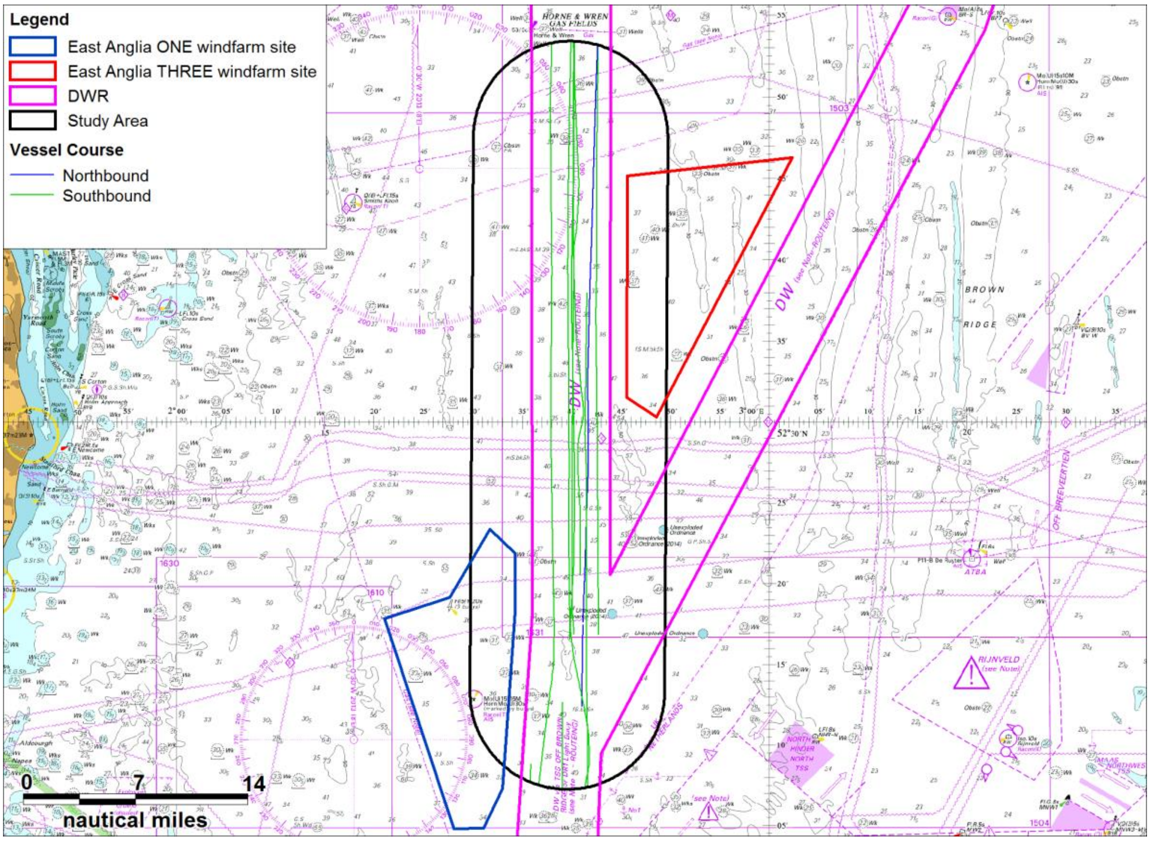

Figure 3.5 Average Day – 18th May 2013

18. A total of 11 unique vessels were recorded within the DWR on the 18th May 2013, thus representing the average number of vessels per day recorded throughout the entire 40 day survey period. The most frequently recorded vessel types were: Oil tankers (six vessels) and bulk carriers (two vessels). Other vessel types recorded on this day include: chemical tankers, liquefied gas carriers and fishing vessels. The majority of vessels (81.8%) were recorded transiting southbound within the DWR. The remaining 18.2% were recorded transiting northbound. It should be noted that two of the southbound vessel transits were recorded on the eastern extent of the DWR.

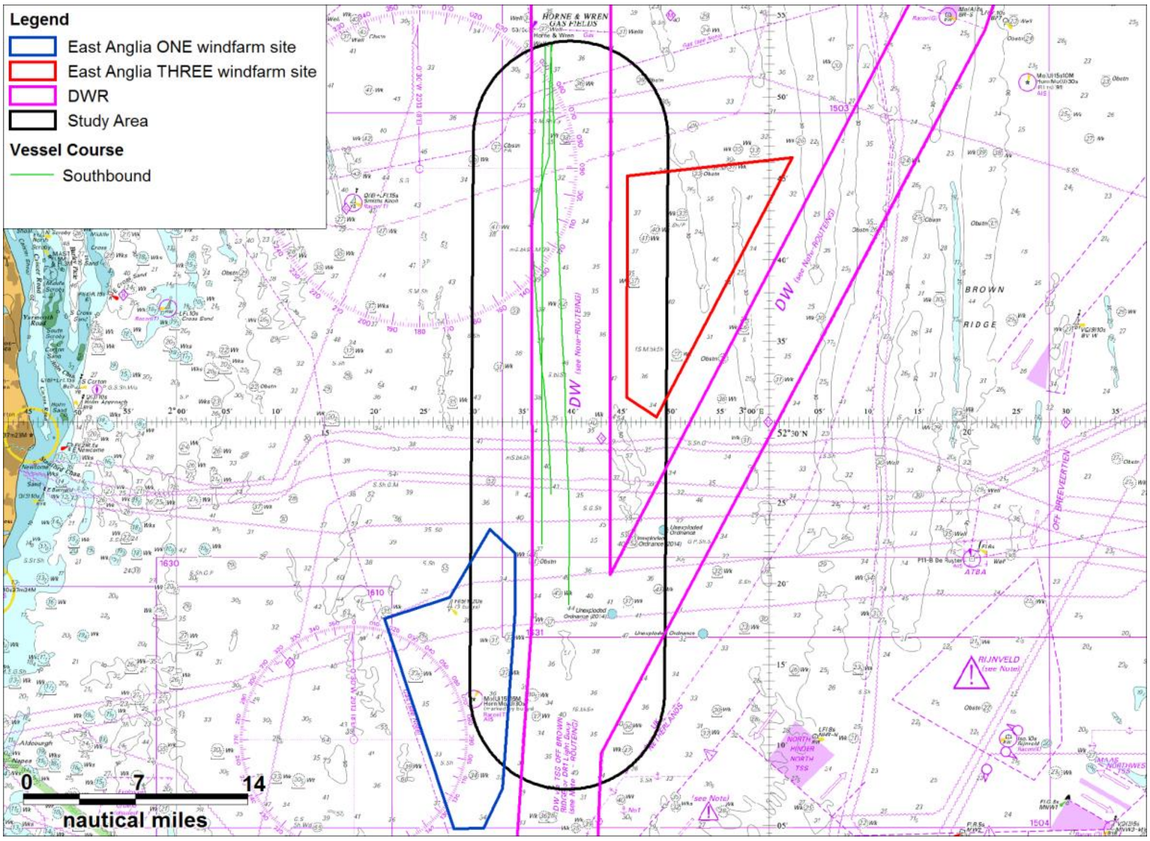

Figure 3.6 Quietest Day – 30th January 2014

19. Three vessels were recorded on the quietest day (30th January 2014) throughout the survey period: one bulk carrier, one liquefied gas carrier and one oil tanker. Throughout the quietest day all vessels were recorded transiting southbound within the DWR.

3.4 Course of Vessels Utilising DWR

20. The tracks of vessels using the DR1 Light Buoy DWR, directly to the west of East Anglia THREE, are presented colour-coded by course in Figure 3.7 (southbound) and Figure 3.8 (northbound).

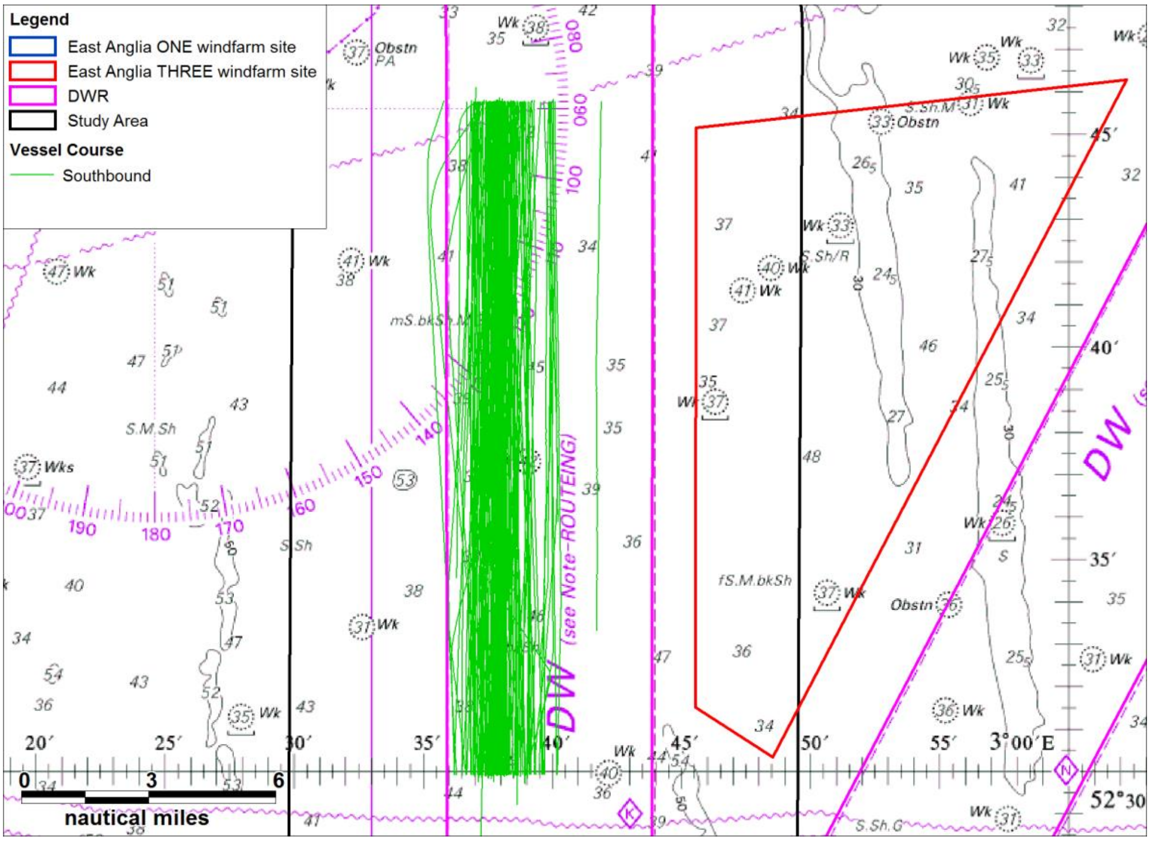

Figure 3.7 DWR Southbound Tracks

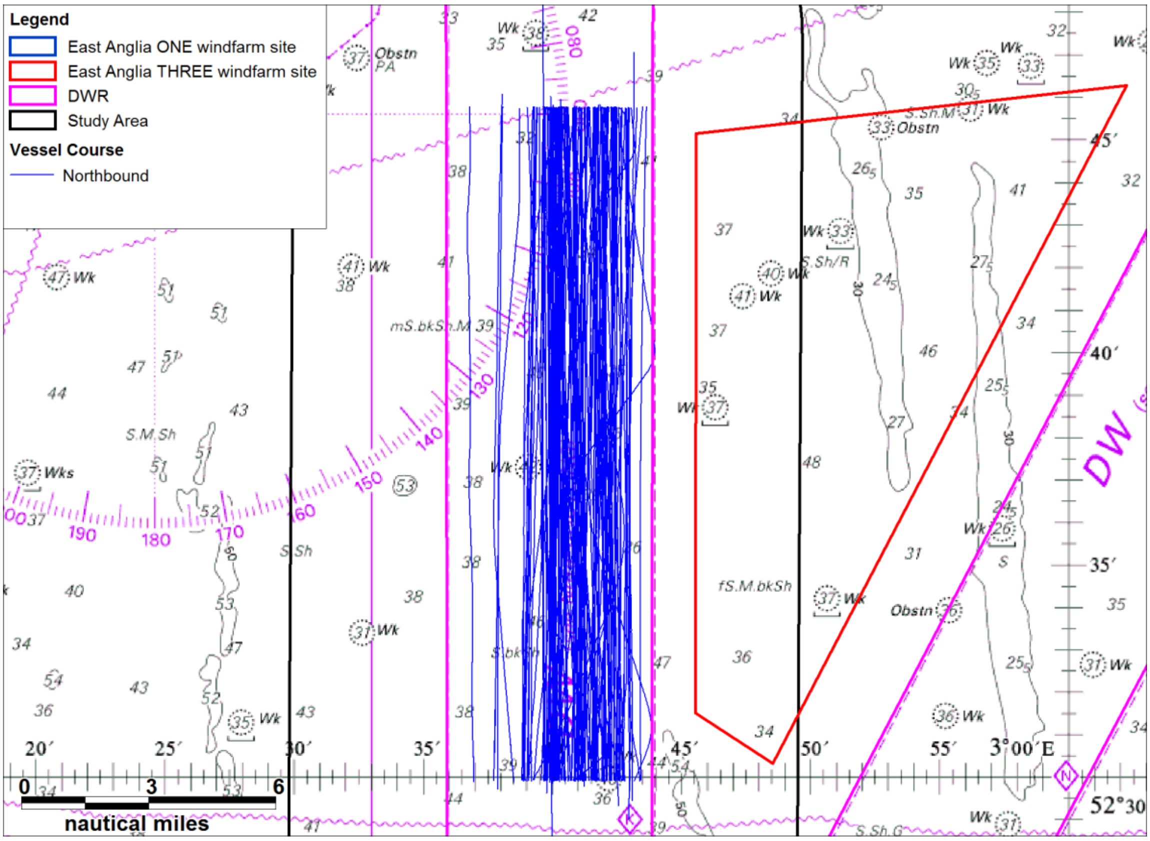

Figure 3.8 DWR Northbound Tracks

21. It is seen that, in general, southbound vessels used the western part of the DWR, and northbound vessels used the eastern part. However, a number of chemical tankers were recorded deviating from this pattern whilst undertaking U-turns within the DWR (as detailed in Figure 4.1). These vessels have been excluded from subsequent analysis due to the unusual nature of their transit. Although no specific traffic separation is in place the traffic does tend to follow good navigational practice, and the positioning of traffic corresponds to the Off Botney Ground Traffic Separation Scheme (TSS) to the north of the DWR. It is considered good navigational practise to adhere to this separation pattern in order to limit the likelihood of head on encounters between vessels using the DWR.

3.5 Draught of Vessels Utilising DWR

22. The tracks of vessels using the DR1 Light Buoy DWR, directly to the west of East Anglia THREE, are presented colour-coded by course in Figure 3.9. Following this, the vessel draught distribution of vessels recorded using the DWR route throughout each survey period is illustrated in Figure 3.10.

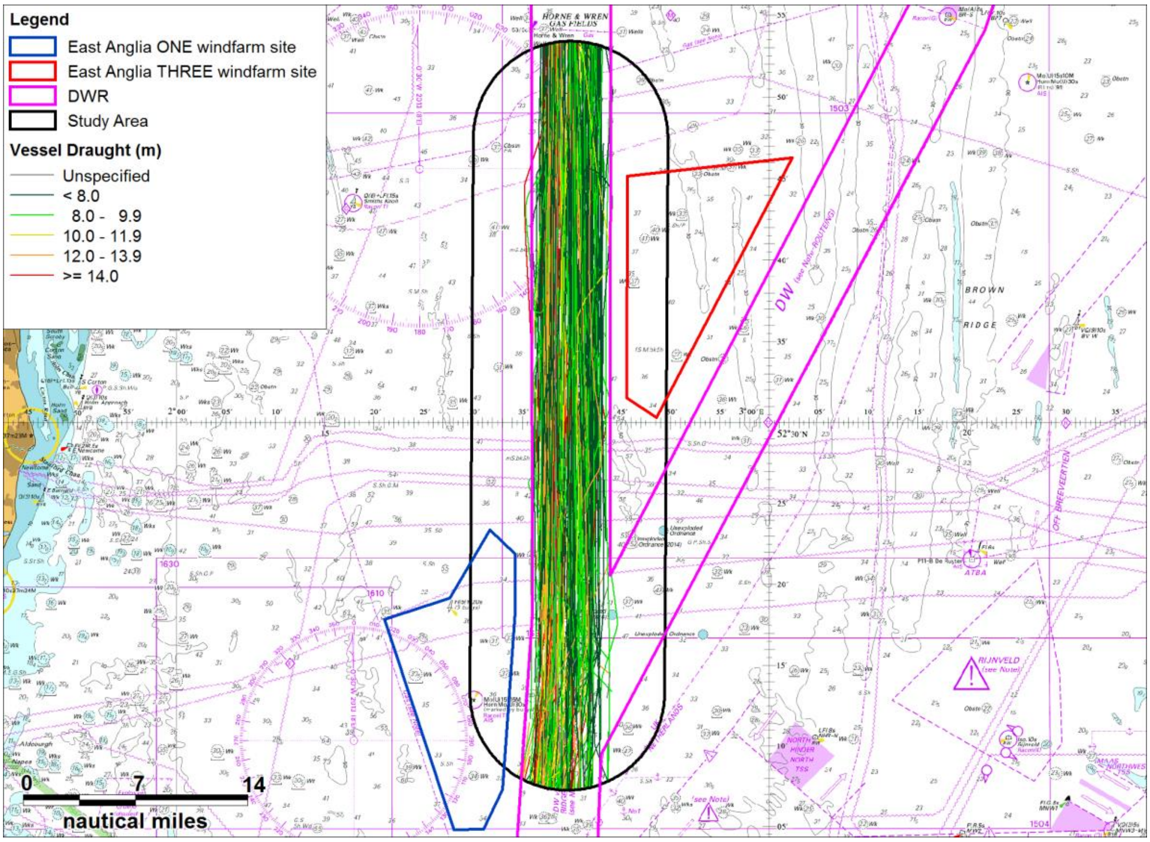

Figure 3.9 DWR Tracks by Draught

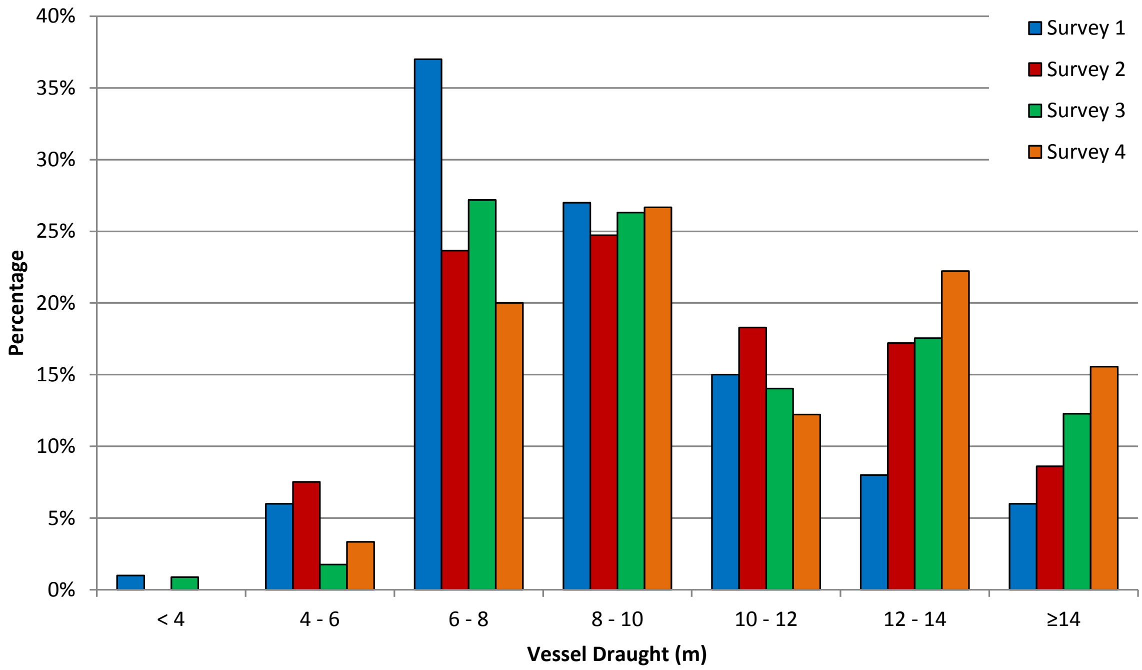

Figure 3.10 Vessel Draught Distribution in DWR

23. The average draught of vessels recorded using the DWR were 8.1m (Survey 1), 9.1m (Surveys 2 and 3) and 10.0m (Survey 4). Throughout all survey periods, the vast majority of vessels using the DWR had draughts greater than or equal to 6m. The deepest draught vessel recorded throughout the entire survey period was the oil tanker *Saiq*, with a draught of 21.2m, bound for Ningbo (China).

3.6 90th Percentile Lanes

24. As part of the East Anglia THREE NRA (Anatec 2015), 90th percentile shipping lanes were produced based on the marine traffic surveys. These are presented in Figure 3.11. Average vessel numbers per day have been included in the figure, estimated using the marine traffic survey data.

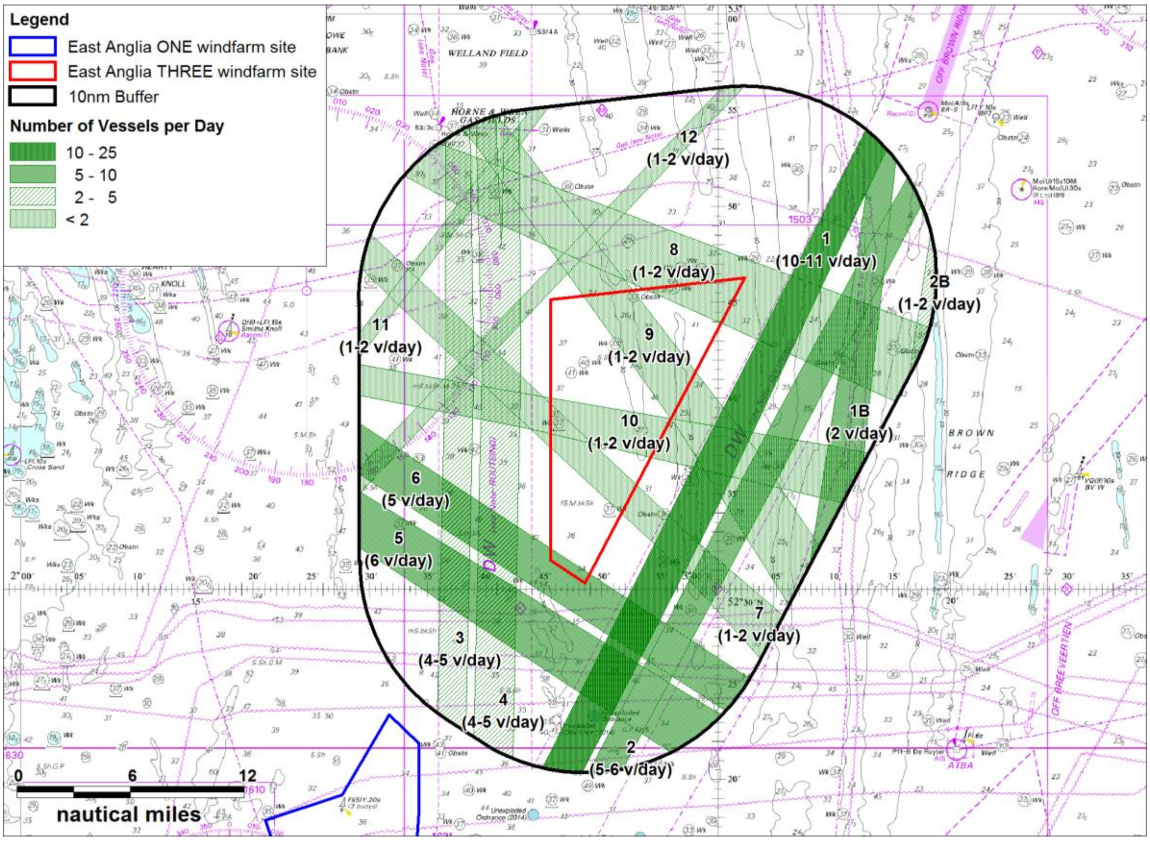

Figure 3.11 90th Percentile Shipping Lanes – Base Case

25. The NRA concluded that on average, approximately four to five vessels per day were observed using each of the northbound and southbound routes within the DR1 Light Buoy DWR, giving a total of approximately 10 vessels per day. It is also noted that the Off Brown Ridge DWR to the east of East Anglia THREE is busier than the western DWR, with approximately 17 vessels a day using this route.

4. CPA Analysis

4.1 CPA to East Anglia THREE

26. A CPA analysis was performed on the 40 days of AIS data in order to determine the passing distances of north and southbound traffic to East Anglia THREE within the DR1 Light Buoy DWR. Tracks seen entering the East Anglia THREE boundary have been excluded from this analysis so as to not affect the results. Some tracks were noted to change direction (northbound to southbound or vice versa) whilst in the DWR, illustrated in Figure 4.1. Due to the unusual nature of their transit, these vessels have been excluded from subsequent analysis.

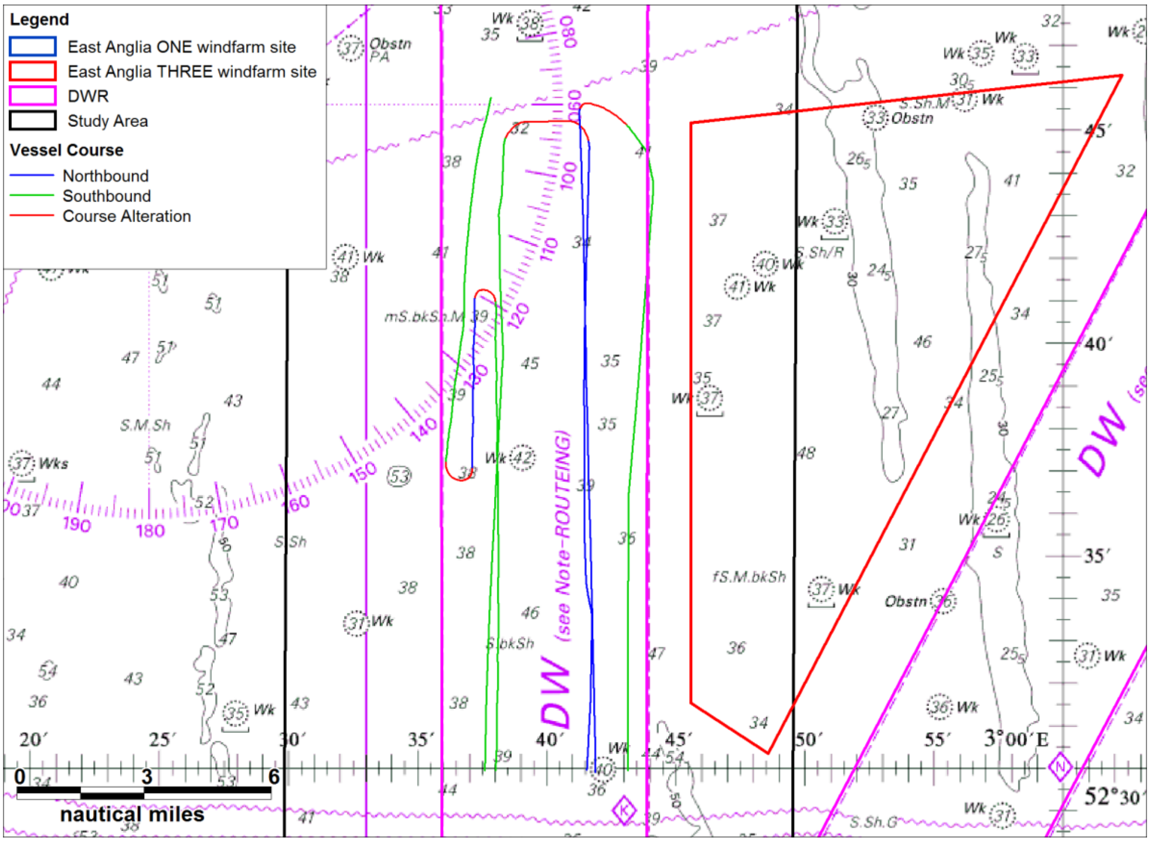

Figure 4.1 Example of Vessel U-turns within DWR

27. The results of the CPA analysis are presented in Figure 4.2.

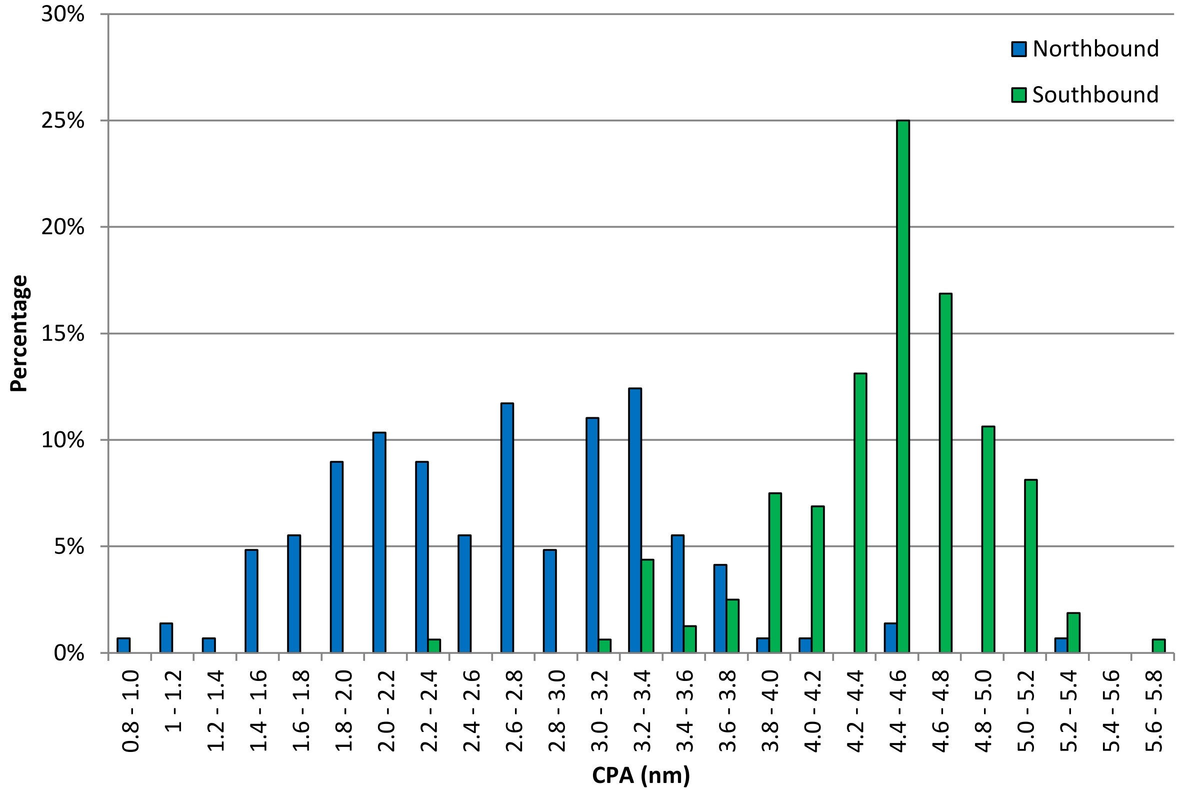

Figure 4.2 CPA Analysis Results

28. It is seen that while overall vessel numbers were similar, southbound traffic tended to be more dense, with approximately 90.6% of tracks having a CPA of between 3.8nm and 5.2nm (1.4nm wide) from East Anglia THREE. The northbound traffic was more spread out, with a similar percentage (93.8%) seen over a larger range of 1.4nm to 3.8nm (2.4nm).

29. The mean passing distances within the DWR, in addition to a summary of the CPA breakdown are presented in Table 4.1.

Table 4.1 CPA Breakdown

	No of Vessels per Day	Mean CPA to East Anglia THREE Site Boundary (nm)	% within 2.0nm	% within 1.5nm	% within 1.0nm
Northbound	4 -5	2.6	22.1	4.8	0.7
Southbound	4 - 5	4.4	0.0	0.0	0.0

30. It is seen that only 0.7% of traffic was seen within 1nm of East Anglia THREE

in the northbound case with no traffic recorded within 1nmin the southbound case. A total of 4.8% of northbound tracks passed within 1.5nm, rising to 22.1% within 2nm.

4.2 DWR Congestion

31. The congestion levels within the DR1 Light Buoy DWR over the 40 day survey period were assessed by determining the proportion of time that more than one vessel was observed to be using the DWR. The results of this analysis are presented in Figure 4.3. It is noted that only vessels using the entirety of the DWR have been included in this analysis (see Figure 3.1 for vessel tracks).

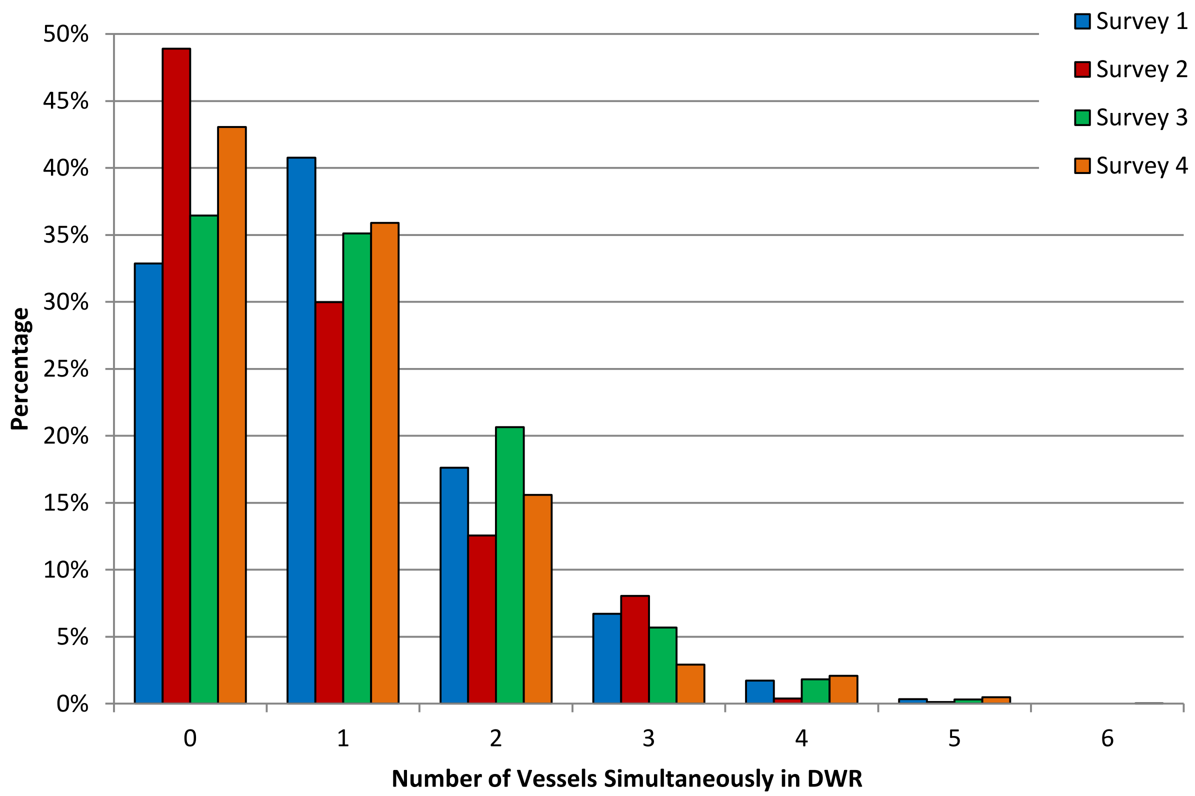

Figure 4.3 Distribution of Traffic Levels in DWR

32. The overall trend of traffic levels within the DWR was consistent throughout all four surveys, with low levels of traffic (less than three vessels) using the DWR at any one time accounting for an average of 98.2% throughout all of the surveyed periods. Less than three vessels is conservatively considered as a low level of traffic due to the width of the DWR (approximately 4.8nm).

33. The results are summarised in Table 4.2.

Table 4.2 DWR Congestion Levels Summary

Number of vessels	Survey 1	Survey 2	Survey 3	Survey 4
0	32.9%	48.9%	36.4%	43.0%
1	40.8%	30.0%	35.1%	35.9%
2	17.6%	12.6%	20.6%	15.6%
>= 3	8.7%	8.5%	7.9%	5.5%

34. The maximum number of vessels recorded as being simultaneously within the DWR was six, occurring on the 26th January 2014 at 20:45. A snapshot of the activity is presented in Figure 4.4. It should be noted that the circular dot represents the location of each vessel at 20:45. The associated arrow indicates the course of the vessel at this time.

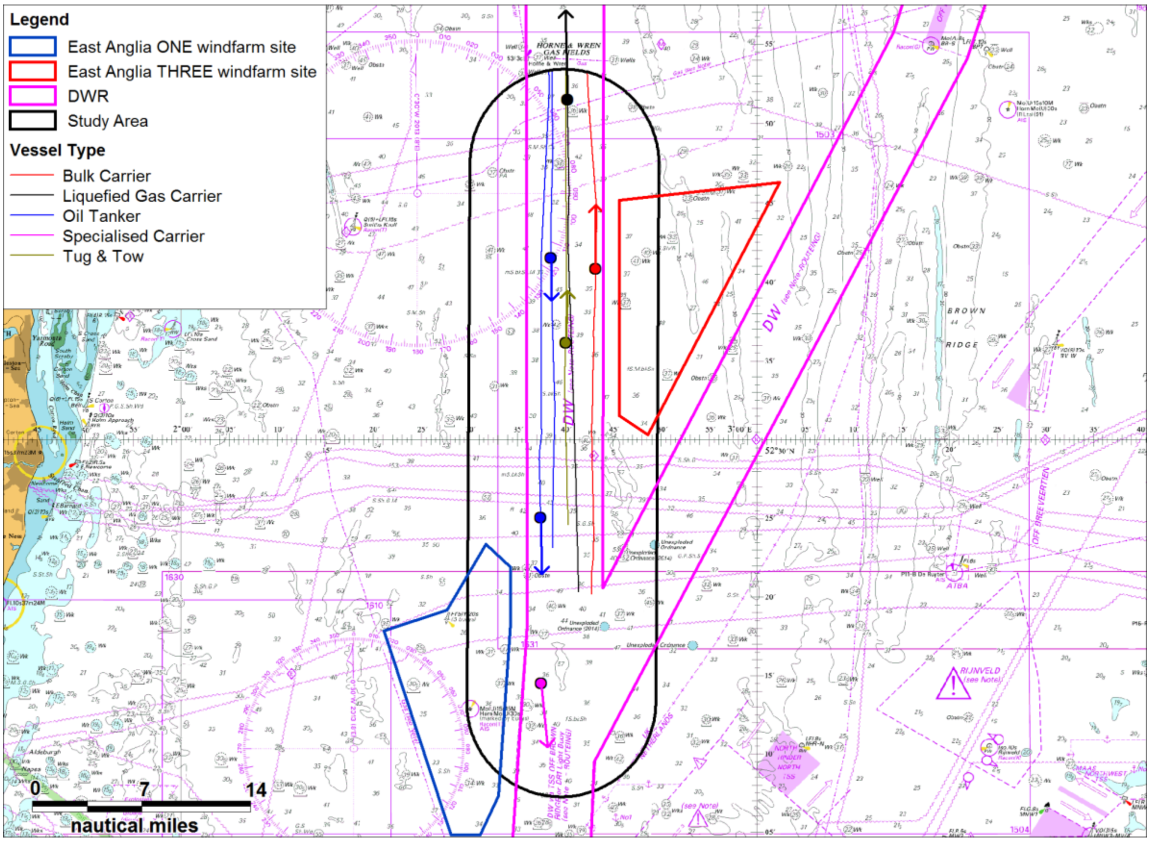

Figure 4.4 Example of Busy DWR Activity – 20:45 26th January 2014

35. A more typical example of DWR use is presented in Figure 4.5. The figure shows a snapshot taken on the 26th January 2014 at 00:30, when two vessels were within the DWR, one northbound and one southbound. At the same

moment a further two vessels were within the Off Brown Ridge DWR and one vessel was recorded crossing the DWR (westbound).

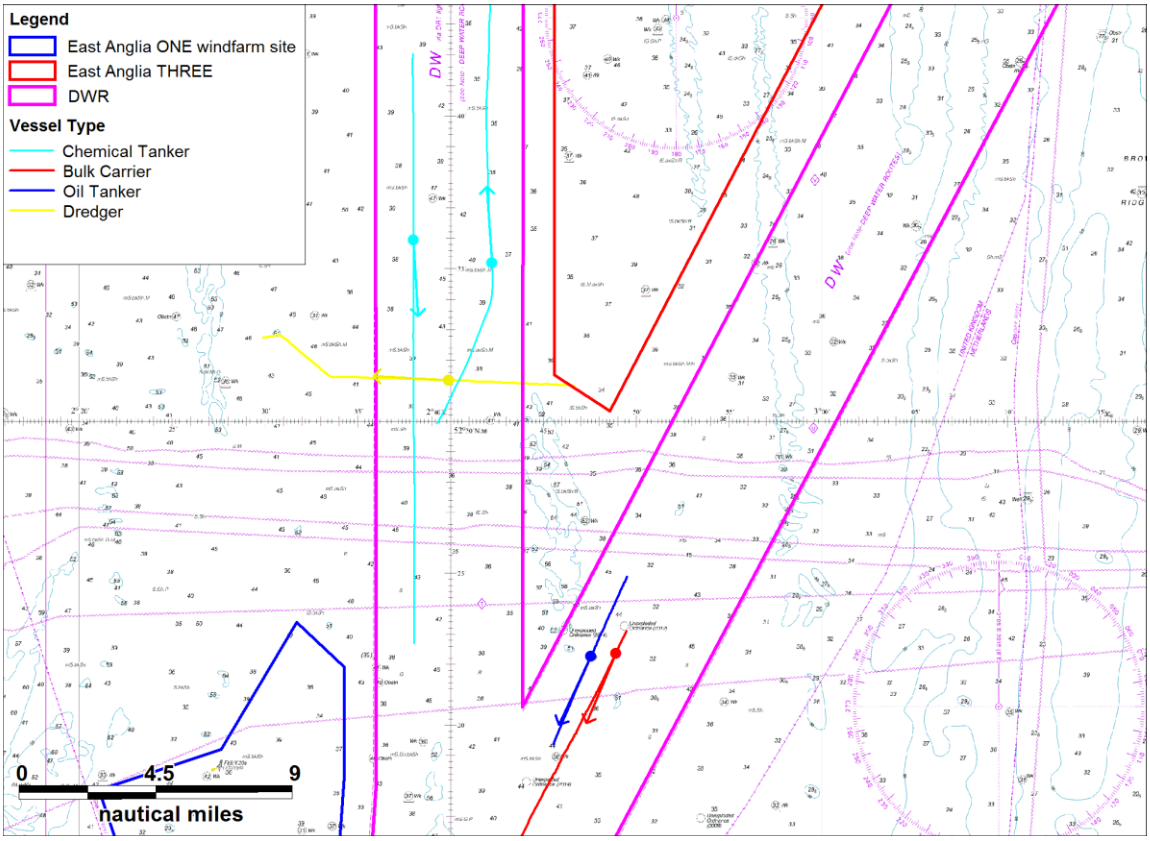

Figure 4.5 Example of Typical DWR Activity – 00:30 26th January 2014

5. Encounters

5.1 Introduction

36. An encounter analysis was performed on the 40 days of data (AIS and radar) recorded during the four marine traffic surveys in order to assess the current vessel interactions within the DWR. The encounter analysis was carried out for all marine traffic within the study area inclusive of vessels crossing the DR1 Light Buoy DWR, within the Off Brown Ridge DWR and within the junction of these DWRs. As the analysis has been carried out on existing AIS data, pre-construction of East Anglia THREE, no degree of vessel re-routeing has been assumed throughout the encounters analysis.

37. An encounter is classed as a vessel entering another vessel's "domain". As a definition, a vessel's domain represents the distance at which the Master or watch officer of the vessel considers a safe distance to pass another vessel. This will vary based on a number of factors including:

- Vessel Characteristics
  - Physical Characteristics (length, width, draught, block coefficient, ship type, cargo, etc.);
  - Vessel Dynamics (speed, course, etc.);
  - Manoeuvrability (engine configuration, rudder type, etc.); and
  - Human Factors (crew competency, complacency, nationality, familiarity with the particular sea area, etc.).

- Environmental Characteristics
  - Hydrodynamic Factors (wave height, current, water depth, etc.);
  - Meteorological Factors (wind speed, visibility, etc.); and
  - Area Characteristics (open sea / narrow channel, seabed type, proximity of hazards, traffic density, etc.).

38. Head-on, crossing and overtaking encounters have been considered separately due to the differing level of risk associated with these encounter types, for example, head-on encounters at a given distance may be considered more hazardous than crossing encounters at a similar distance. For the purposes of this assessment the following definitions of the encounter types have been applied:

- Head-on: two vessels on reciprocal or nearly reciprocal courses (3° either side of head-on);
- Overtaking: one vessel coming up with another vessel with a course difference of less than 45°; and
- Crossing: all other encounters.

39. Domain radii of 1.0nm, 0.75nm, and 0.5nm have been assessed in the following analysis. Encounters have also been defined by DWR use and classified as either:

- Involving DWR vessel; or
- Not Involving DWR vessel.

40. If the encounter involved at least one vessel transiting north / south within the DWR (tracks of these vessels illustrated in Figure 3.1) at the time of the encounter it has been classified as a "involving DWR vessel" encounter. Therefore a "involving DWR vessel" encounter is inclusive of a north / south bound vessel within the DR1 Light Buoy DWR encountering another north / south bound vessel within the DWR or encountering a crossing (east / west bound) vessel.

41. A "not involving DWR vessel" encounter has been classified as an encounter event which does not involve a vessel transiting north / south within the DR1 Light Buoy DWR. Therefore a "not involving DWR vessel" encounter is not related to the direct use of the DR1 Light Buoy DWR and instead is inclusive of crossing (east / west bound) traffic encountering other crossing (east / west bound) traffic.

5.2 Encounter Types

5.2.1 Crossing Encounters

42. A plot showing the number of crossing encounters recorded over the 40 days within the study area is presented in Figure 5.1.

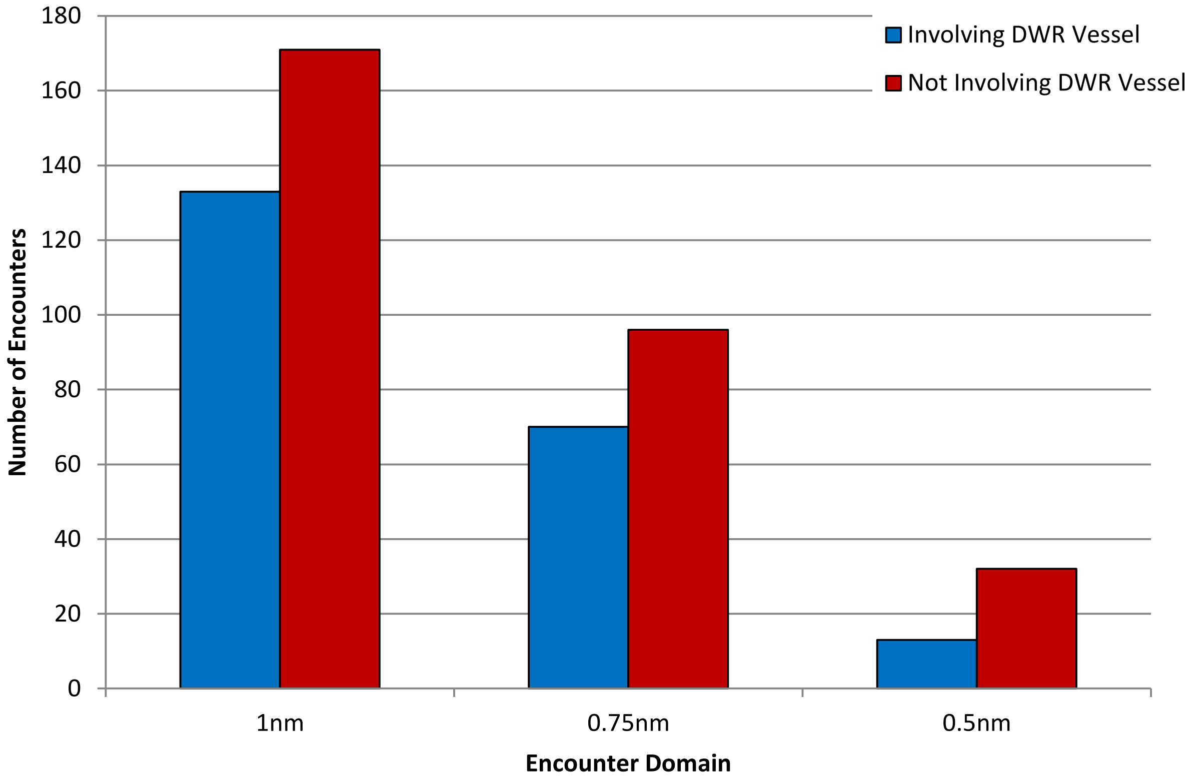

Figure 5.1 Number of Crossing Encounters in Study Area

43. The majority of vessel encounters (60%) were crossing encounters. More than 300 (approximately eight per day) crossing encounters were recorded within the study area (see Figure 2.1 for details of the study area) over the 40 days assuming a 1nm domain radius. Of these, 133 (approximately three per day) involved at least one vessel using the DWR at the time of the encounter.

5.2.2 Overtaking Encounters

44. The number of overtaking encounters is presented in Figure 5.2.

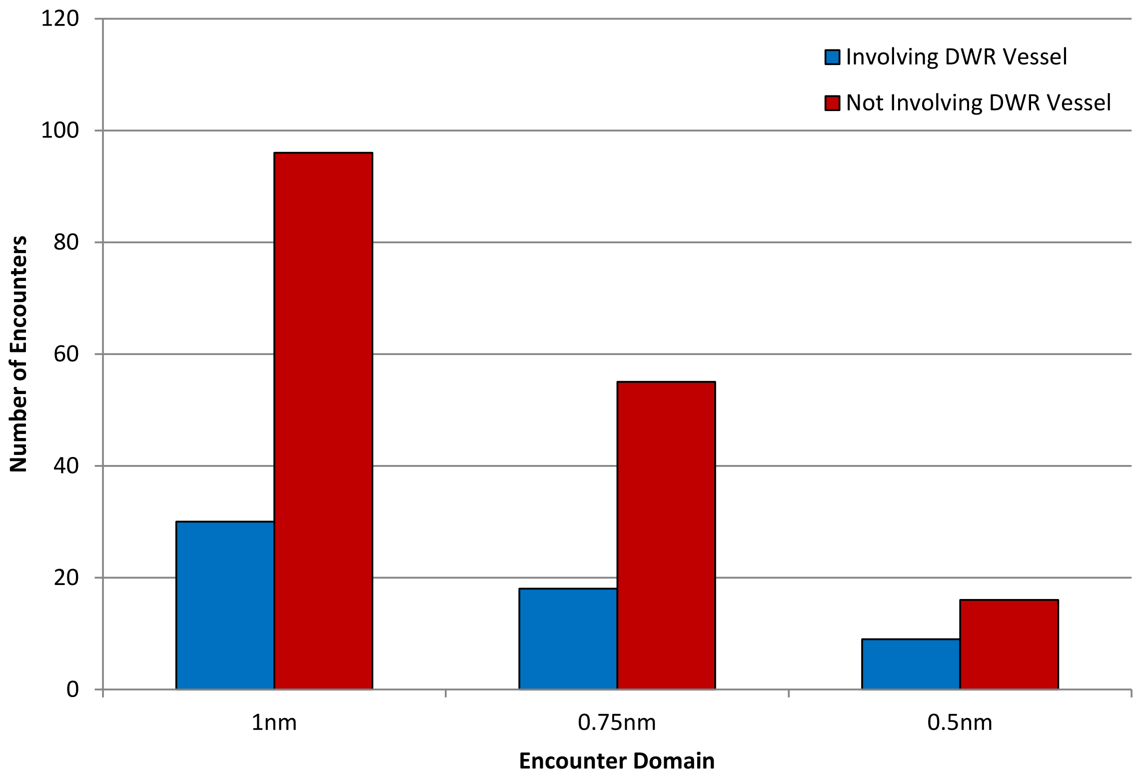

Figure 5.2 Number of Overtaking Encounters in Study Area

45. Approximately one quarter of vessel encounters observed were overtaking encounters. This corresponded to three per day in the 1nm analysis, one of which involved a DWR vessel. It was noted that there was a significant disparity between the number of overtaking encounters involving a vessel using the DWR compared to those occurring out with the DWR in the 1nm and 0.75nm analysis. This suggests that vessels are less likely to attempt overtaking manoeuvres whilst utilizing the DWR.

5.2.3 Head-On Encounters

46. The results of the head-on analysis are presented in Figure 5.3.

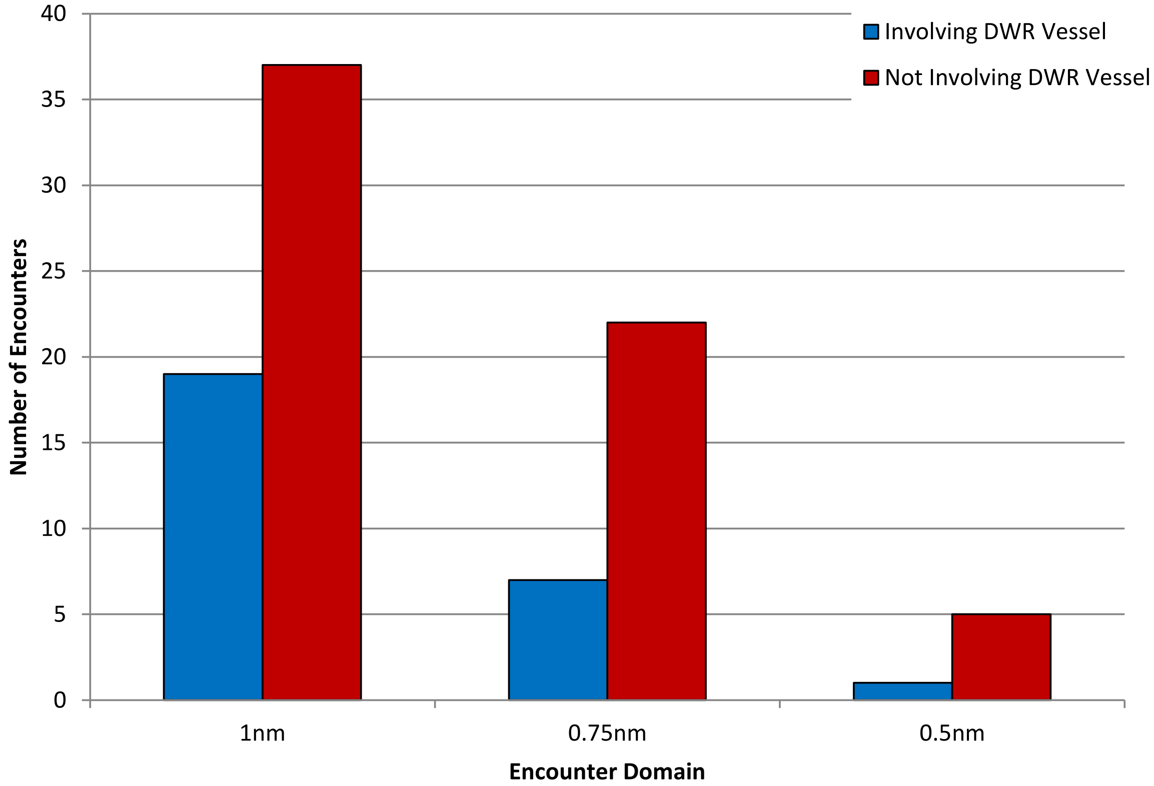

Figure 5.3 Number of Head-On Encounters in Study Area

47. Head-on encounters were the least most regularly occurring type, making up approximately 12% of the total in the 1nm analysis, and falling to 8% in the 0.5nm analysis. A head on encounter involving a DWR vessel was estimated to occur once every two days in the 1nm analysis, once every six days in the 0.75nm analysis, and once every 40 days in the 0.5nm analysis. This suggests that head-on encounters at lower domain radii are avoided by vessels where possible. As with the overtaking analysis, it was noted that head-on encounters not involving a DWR vessel (i.e. an east / west bound crossing vessel encountering another east / west bound crossing vessel) were more common, with approximately one such incident recorded per day over the course of the 40 day period in the 1nm analysis.

5.3 Encounter Density

48. This section presents the density of recorded encounters within the study area. As previously discussed, AIS coverage was not comprehensive in the southern section of the study area to the east of East Anglia One, which should be taken into consideration when viewing the following figures. It is also noted that the following figures only take into account encounters involving at least one vessel using the DWR at the time of encounter. Therefore a proportion of

vessel encounters recorded involve vessels crossing the DWR, rather than transiting within it. These encounters have been included in order to fully assess the interaction of DWR vessel traffic with the surrounding / crossing vessel traffic.

49. The vessel tracks of encounters occurring within a 1.0nm domain radius are presented in Figure 5.4. Following this the 1.0nm domain radius encounters are presented as a heat map in Figure 5.5.

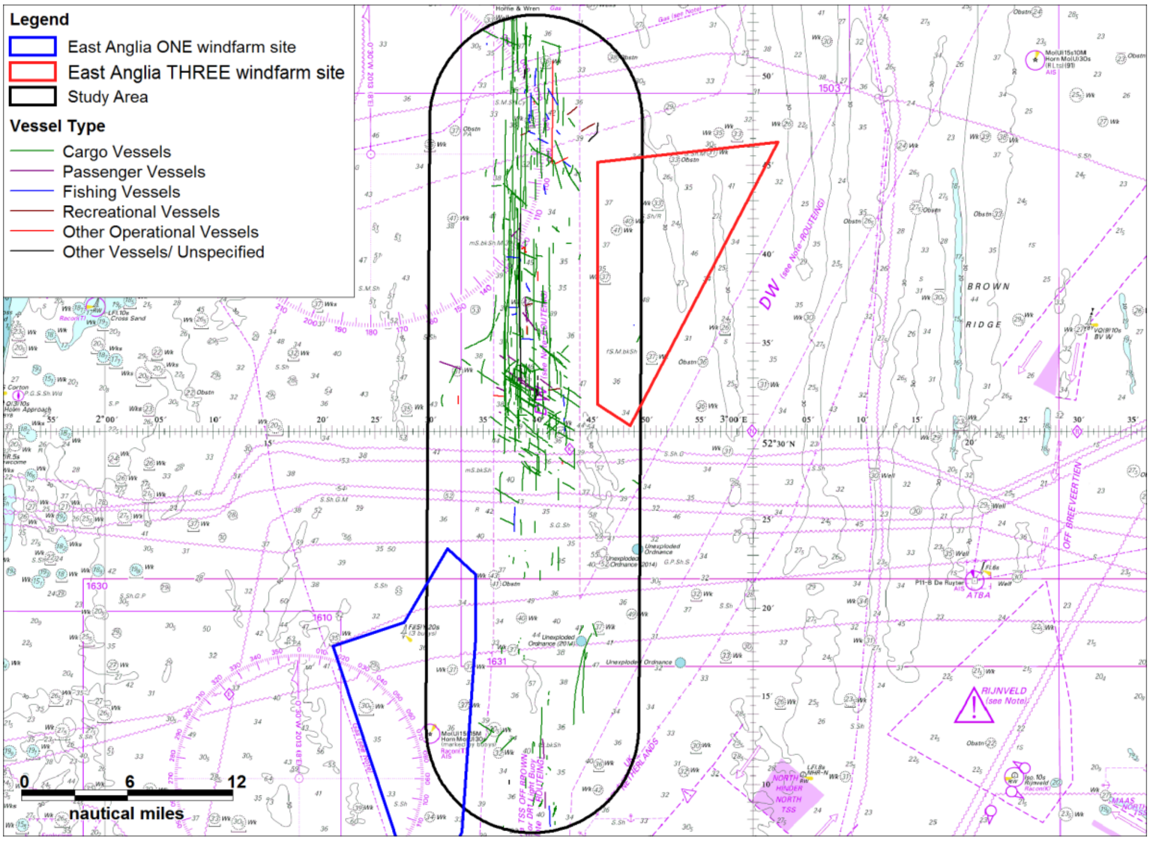

Figure 5.4 Encounter Tracks – 1.0nm Domain Radius

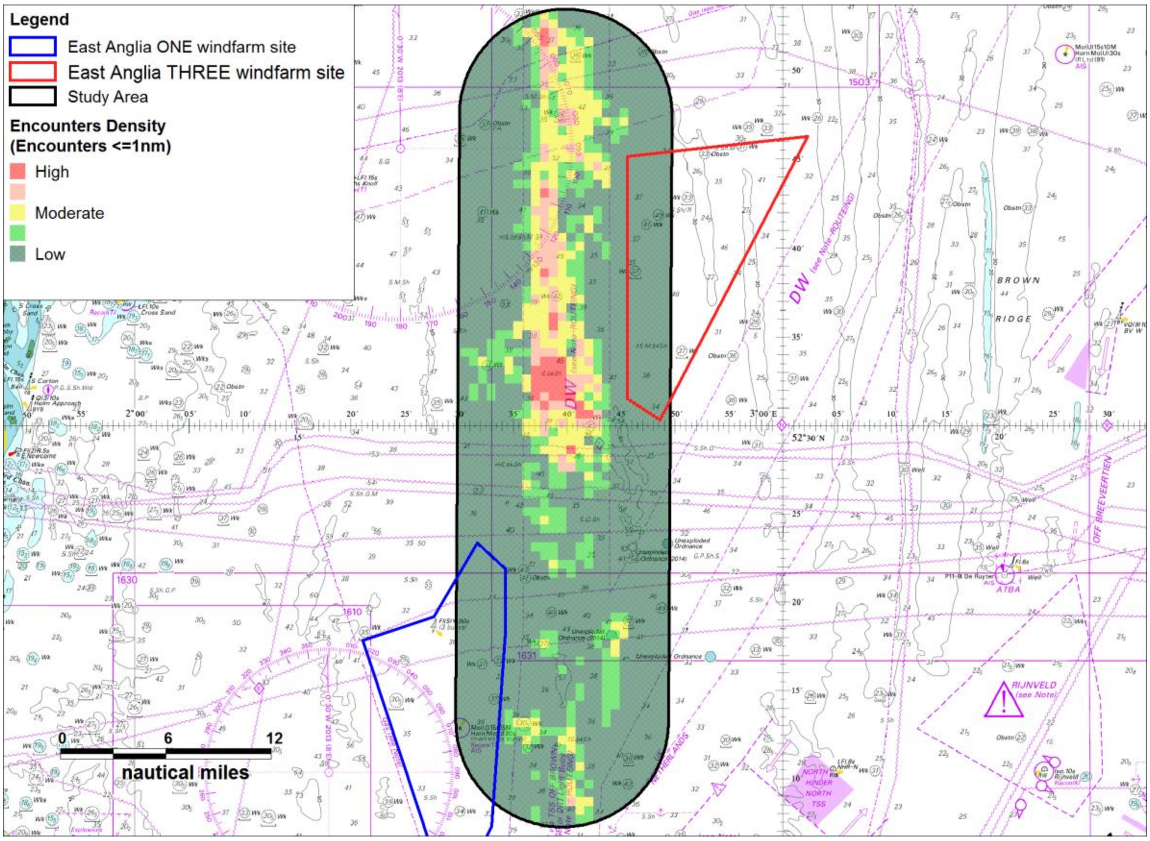

Figure 5.5 Encounter Density – 1.0nm Domain Radius

50. The most significant area of encounter density (assuming a 1.0nm encounter distance) was recorded approximately 2nm west of the southern boundary of East Anglia THREE. This corresponds to the east / west crossing point of main routes 5 and 6 (as per Figure 3.11) crossing the DR1 Light Buoy DWR. Moderate density was also recorded in the entirety of the section of DWR to the west and north west of East Anglia THREE.

51. The vessel tracks of encounters occurring within a 0.75nm domain radius are presented in Figure 5.6. Following this the 0.75nm domain radius encounters are presented as a heat map in Figure 5.7.

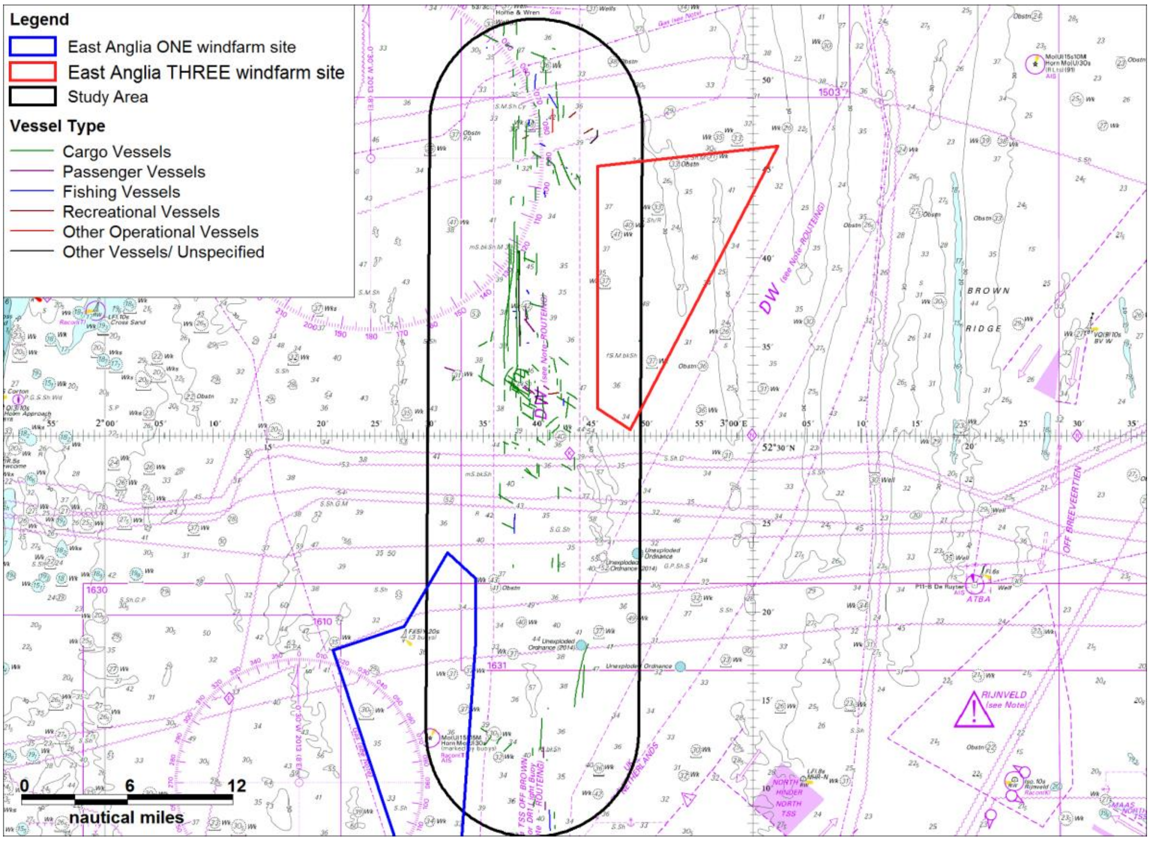

Figure 5.6 Encounter Tracks - 0.75nm Domain Radius

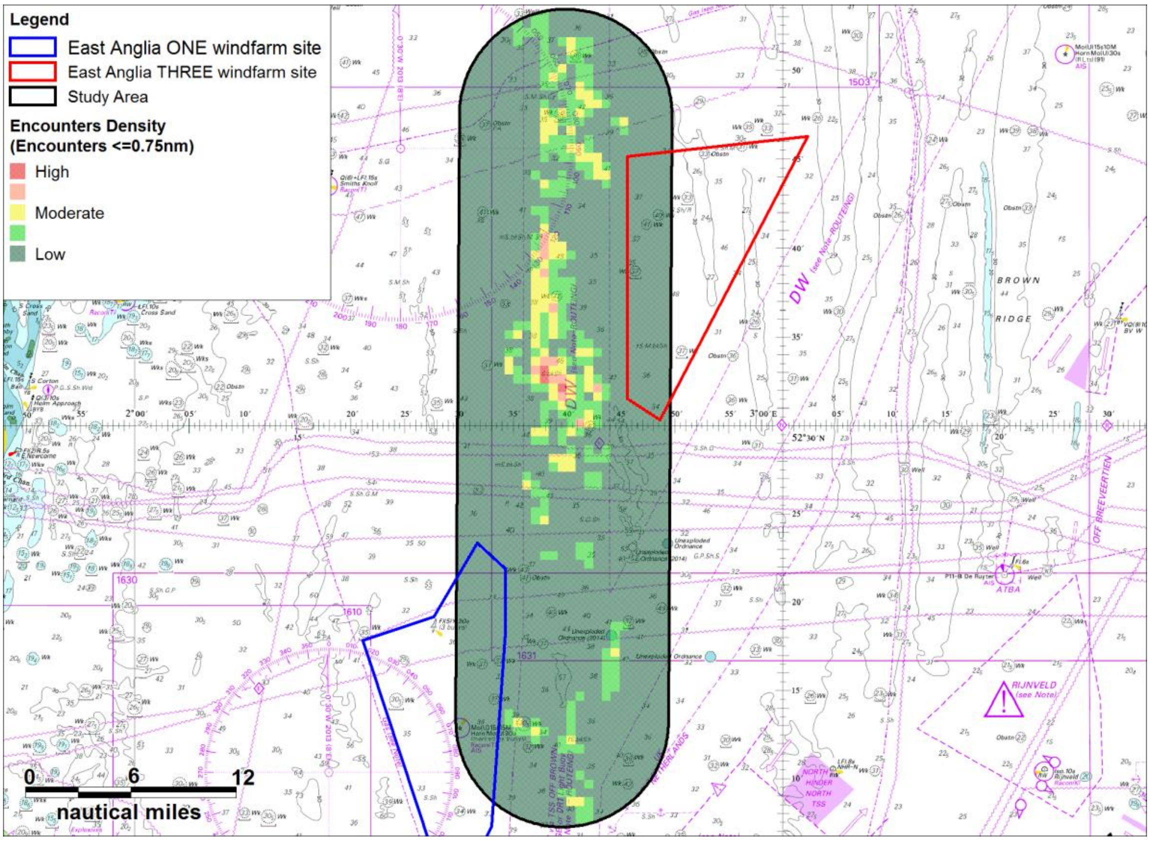

Figure 5.7 Encounter Density – 0.75nm Domain Radius

52. The 0.75nm encounter density analysis showed an overall reduction in encounter density within the study area. The most significant area of density remained unchanged from the 1nm case, however the distance to the nearest "high" density cell from the East Anglia THREE boundary rose from 2nm to 3nm.

53. The vessel tracks of encounters occurring within a 0.5nm domain radius are presented in Figure 5.8. Following this the 0.5nm domain radius encounters are presented as a heat map in Figure 5.9.

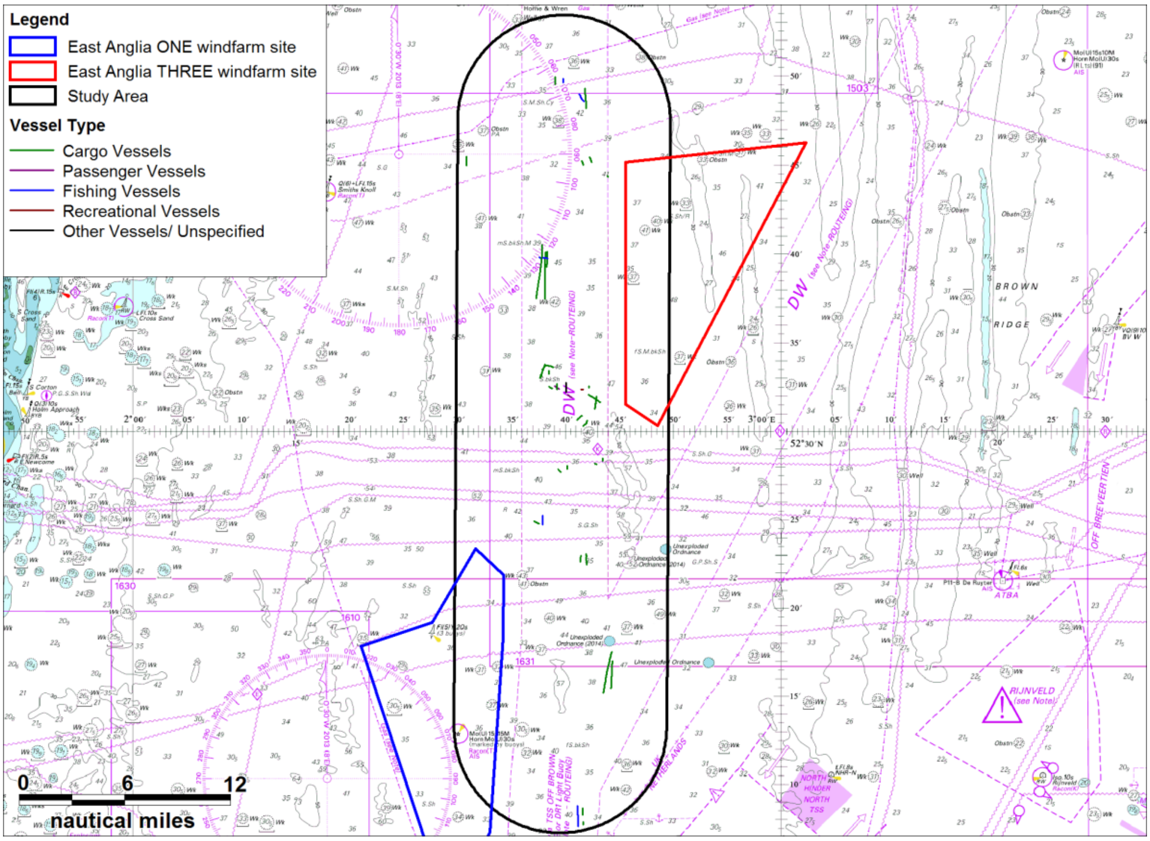

Figure 5.8 Encounter Tracks – 0.5nm Domain Radius

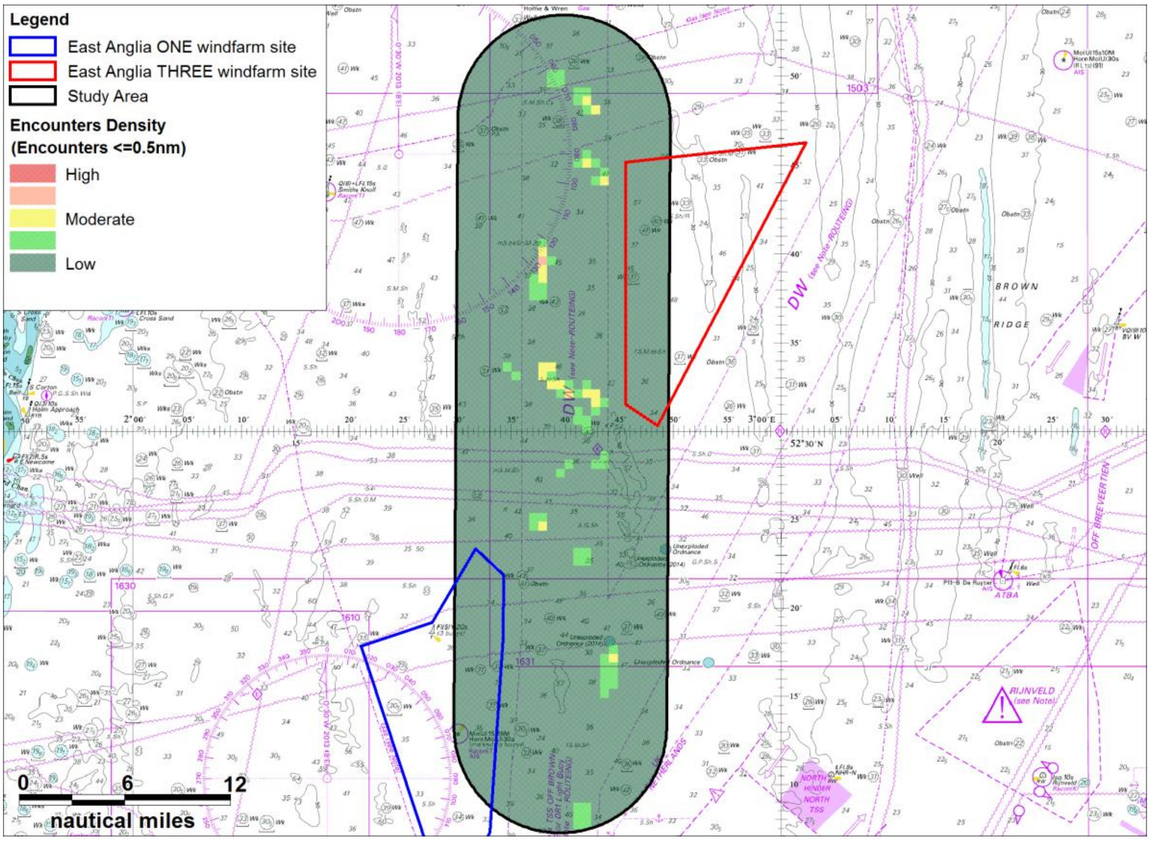

Figure 5.9 Encounter Density – 0.5nm Domain Radius

54. It is seen that a 0.5nm domain for the encounter analysis produced a significant reduction in encounter density compared to both the 1.0nm and 0.75nm cases. This suggests that in most cases vessels will maintain a distance of greater than 0.5nm from each other in this area.

6. Exposure Time

55. The exposure time of main routes within the DR1 Light Buoy DWR to the proposed East Anglia THREE layouts has been calculated using a time exposure model. The time exposure model calculates the overall time, given a prescribed transit speed, and distance a given route passes in proximity to structures within a wind farm. This analysis has been carried out in order to assess the overall duration that each main route within the DWR spends in proximity to wind farm structures.

6.1 100% Fill Turbine Layout

56. A passing distance assessment was carried out in order to determine the closest passing distance of a vessel within the DWR to a turbine in the100% fill layout. Four routes were considered, the mean route positions of the northbound and southbound lanes in the DWR (based on the AIS data), and the far eastern and western limits of the DWR. These routes relative to the East Anglia THREE 100% fill layout are presented in Figure 6.1.

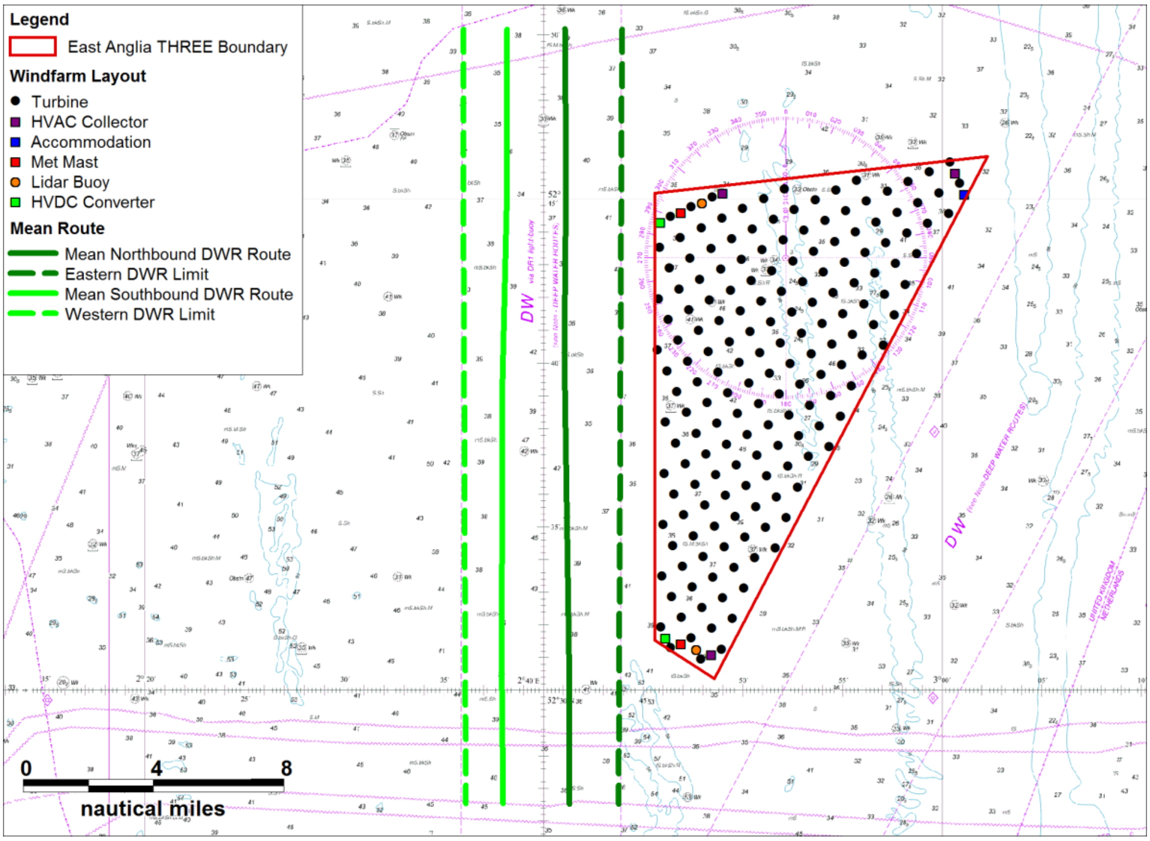

Figure 6.1 Routes considered in Exposure Time Analysis – 100% Fill

57. The routes were considered from 5nm either side of the north and south

extremities of the East Anglia THREE site boundary. For the purposes of the time exposure model, it was assumed that vessels using these routes were travelling at 15 knots, as this was the average speed of vessels using the DWR within the AIS data.

58. The results of the time exposure analysis are presented in Figure 6.2. These results are based on the 100% fill turbine layout of East Anglia THREE. It should be considered when viewing this figure that the mean northbound DWR route and eastern DWR limit timelines are based on a vessel travelling south to north, and the mean southbound DWR route and western DWR limit timelines are based on a vessel travelling north to south.

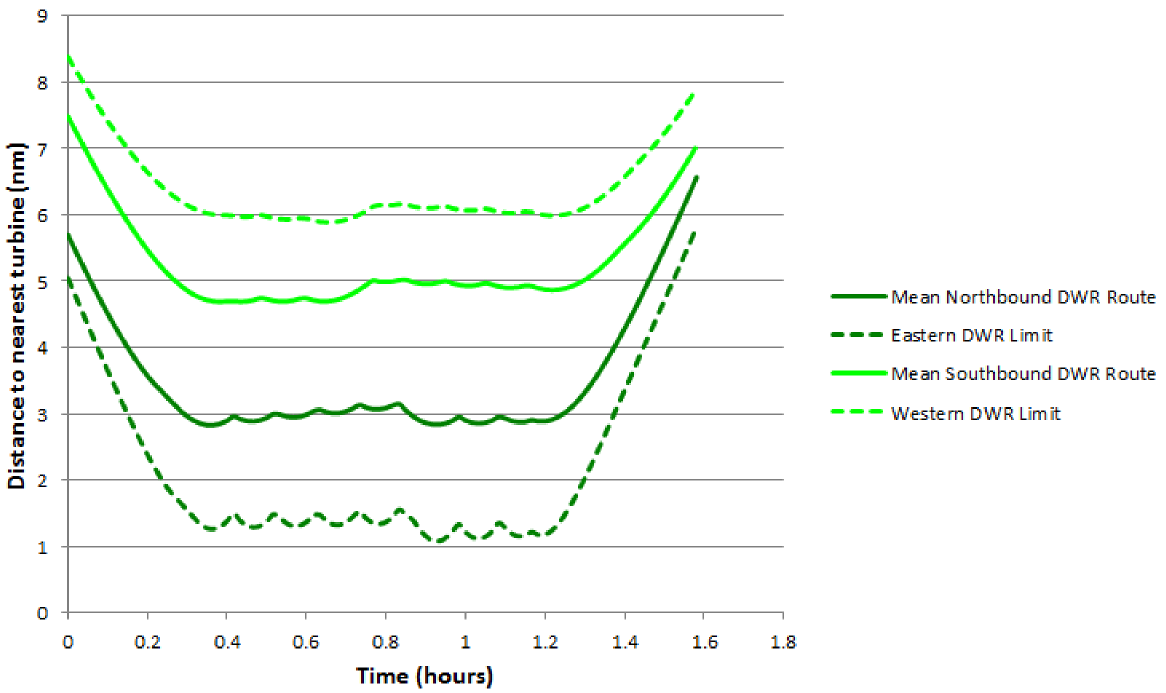

Figure 6.2 Time Exposure Analysis Results – 100% Fill

59. The analysis showed that a vessel travelling on the eastern limit of the DWR would not be expected to come within 1nm of an East Anglia THREE turbine, while a vessel taking the mean passage down the centre of the northbound DWR route would typically remain approximately 3nm from a turbine at any one time.

60. This suggests that in periods of heavy congestion within the DWR, even if a vessel must use the very eastern extreme of the DWR, a separation distance of 1nm from the turbines is still expected to be maintained. Furthermore, it is anticipated that the 1nm clearance from the turbines allows sufficient sea room for collision avoidance action to be taken should a crossing vessel enter the

DWR (heading west and passing the south of East Anglia THREE) and meaning that the north bound vessel would be the give way vessel under COLREGs (options could including following safe speed principles and re or clear alterations of course). Either of these options should be the adequate means of mitigating the risk of collision in this scenario. The most likely vessel to exit the western boundary of the wind farm into the DWR would be a small craft such as a recreational vessel or a works vessel associated with the windfarm. COLREGs would also apply in this instance but as noted in the NRA, works vessel associated with the site would be controlled and prevented from increasing risk to vessels within the DWR.

61. In total, a vessel using the eastern DWR limit would spend 56 minutes within 1.5nm of the turbines, assuming a speed of 15 knots.

62. It is noted that the current 1nm separation distance is being maintained before any turbines have been installed. Once construction is complete vessels may choose to pass further from the site. If vessels were to choose to pass greater than 1nm from the East Anglia THREE site, the available sea room and hence overall safety margin for collision avoidance manoeuvring would increase.

6.2 Partial Fill Turbine Layout

63. The analysis was repeated assuming the partial fill turbine layout. The considered routes relative to the East Anglia THREE partial fill layout are presented in Figure 6.3, and the results of the analysis are presented in Figure 6.4.

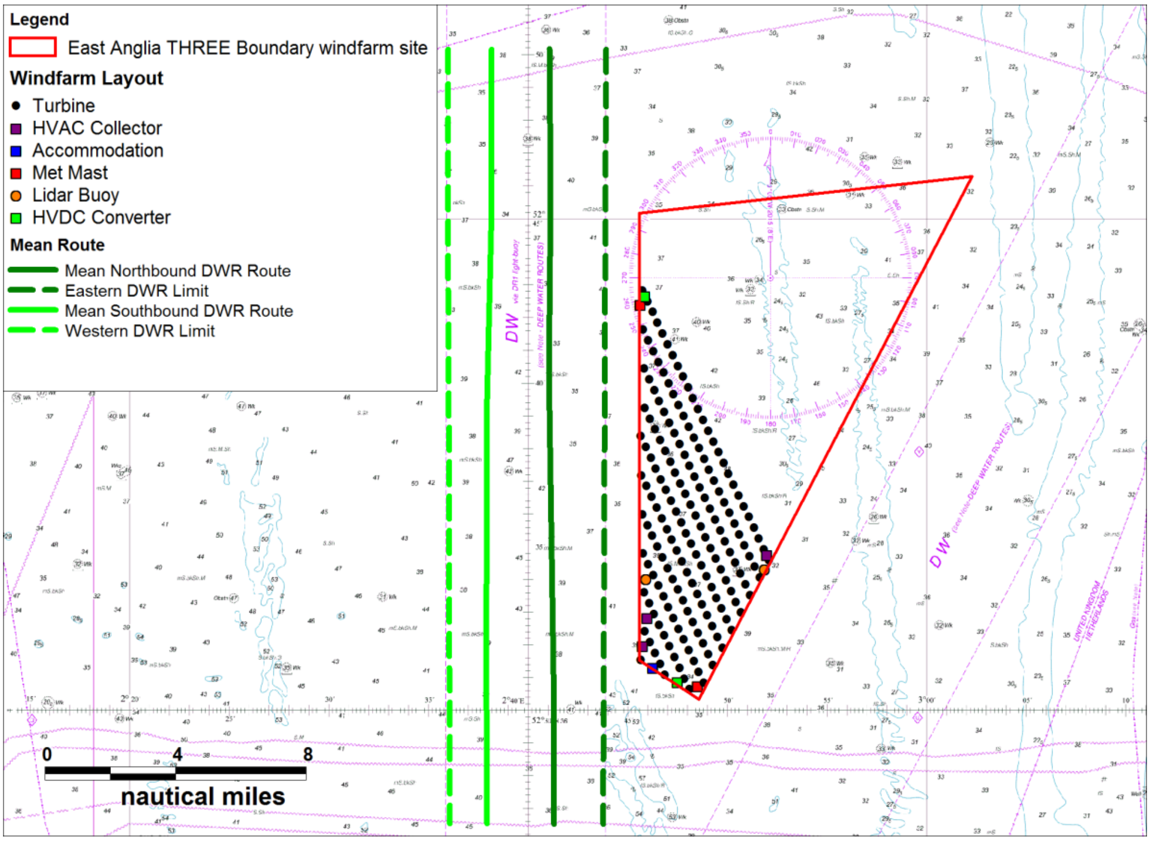

Figure 6.3 Routes considered in Exposure Time Analysis – Partial Fill

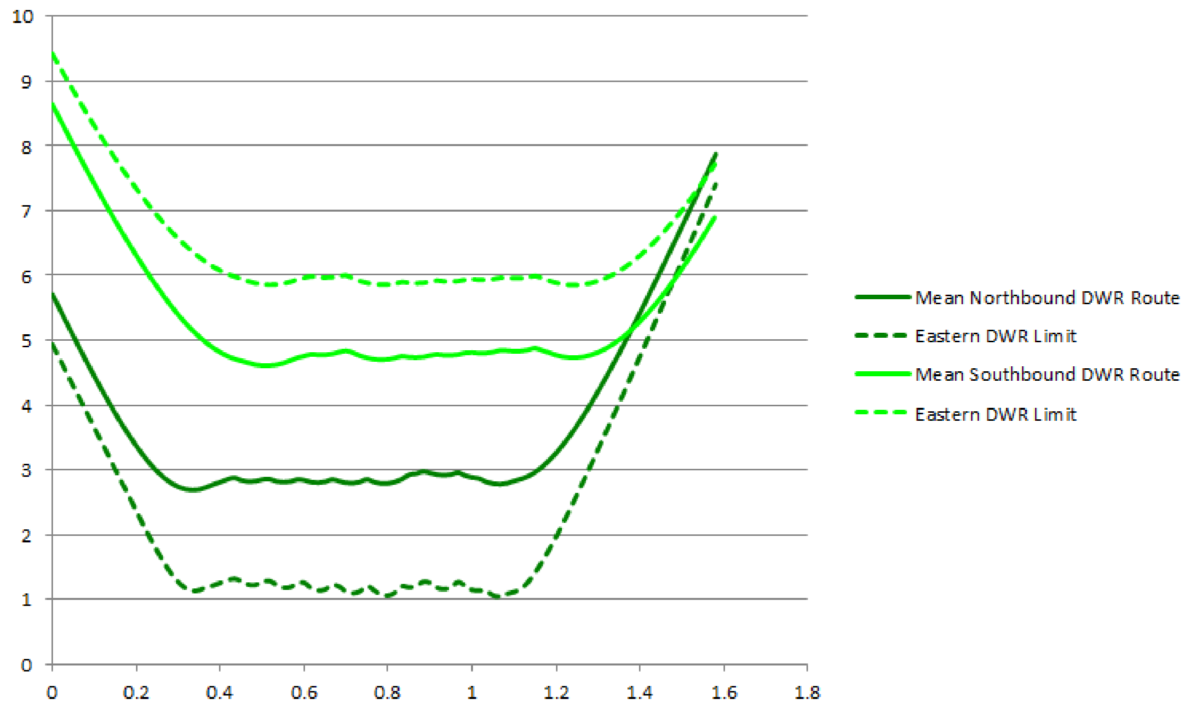

Figure 6.4 Time Exposure Analysis Results – Partial Fill

64. As with the 100% fill scenario analysis, the results of the partial fill analysis showed that a vessel using the extreme eastern side of the DWR should always maintain a separation distance of at least 1nm from the nearest turbine.

65. A vessel using the eastern DWR limit travelling at 15 knots would spend 52 minutes within 1.5nm of the turbines in the partial layout scenario.

7. Radar Effects

7.1 Introduction

66. In 2004 the MCA conducted trials within and close to the North Hoyle windfarm off North Wales to determine any impact of wind turbines on marine communications and navigations systems.

67. The trials indicated that there is minimal impact on VHF radio, GPS receivers, cellular telephones and AIS. UHF and other microwave systems suffered from the normal masking effect when turbines were in the line of the transmissions (MCA, 2004).

68. This trial identified areas of concern with regard to the potential impact on vessel borne and shore based radar systems. This is due to the large vertical extent of the wind turbine generators returning radar responses strong enough to produce interfering side lobe, 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 around the Kentish Flats offshore Windfarm in the Thames Estuary and by Trinity House in other locations. Based on the results of the North Hoyle trial, the MCA produced the shipping route template a non-prescriptive tool used to give guidance on the distances which should be established between shipping routes and offshore wind farms.

69. A second trial was conducted at Kentish Flats on behalf of British Wind Energy Association. The project steering group had members from BERR, the MCA and the Port of London Authority (PLA). The trial took place between 30 April and 27 June 2006. This trial was conducted in Pilotage waters and in an area covered by the PLA VTS at distances of one nautical mile and more from the windfarm. 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 (MCA, 2007).

70. The trial concluded that:

- The phenomena referred to above detected on marine radar displays in the vicinity of windfarms could be produced by other strong echoes close to the observing vessel although not necessarily to the same extent;
- Reflections and distortions by conventional ships structures and fittings created many of the effects and that the effects vary from vessel to vessel and radar to radar;
- VTS scanners static radars could 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 near the windfarm were usually detectable by radar on ships' operating near the array but were less detectable when the small vessel was operating within the array.

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

72. 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 (Ledwood, 2011). A variety of wind farm layouts and operator settings were modelled. 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 incorrectly there is significant clear space around each 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.

73. Based on the trials carried out to date the onset range from the turbines of false returns is about 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.

74. Full details of radar impacts are provided with the NRA.

7.1 Ghosting

75. Ghosting may be caused by reflections from large structures such as port buildings, oil and gas platforms, large vessels, wind turbines, or from reflectors on the observing vessel’s own structure. Operationally, in terms of persistence and severity, the most significant impact is the ghosting due to reflections from the vessel’s structure. At any time, ghosting due to reflections from vessel structures could occur at all bearings, between ranges R_1 and R_2, where:

- R_1 = distance between radar vessel and closest turbine
- R_2 = distance between radar vessel and furthest turbine

76. This is illustrated in Figure 6.1. Ghost images are more likely to appear abaft the observing vessel’s beam than ahead, due to installation regulations on where radars are placed relative to vessel structures However, items such as badly placed containers, cranes, derricks, antennae, etc., could cause ghosting forward of the vessel’s beam

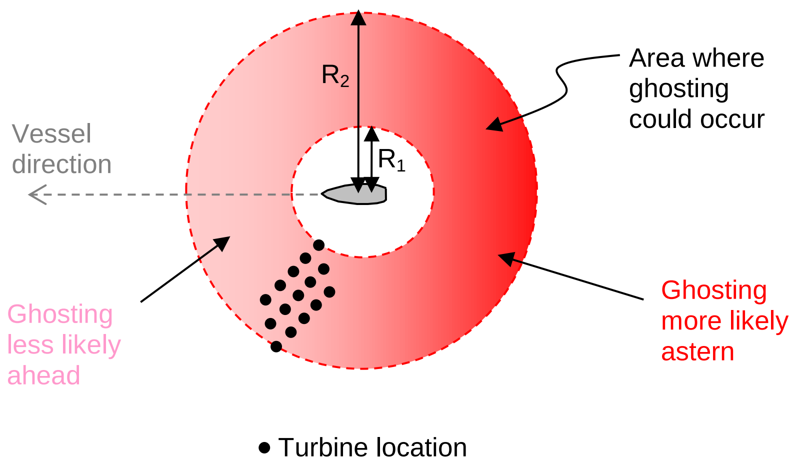

Figure 7.1 Wind Farm Ghosting

77. The impacts can potentially be mitigated through gain control, but this may also

reduce the probability of detection of vessels or structures. Mitigation can also be through ensuring separation of the ghost targets with other objects.

- ensuring separation from other vessels is not practical.
- ensuring separation from other wind farms is practical, with a separation distance based on the maximum range at which ghosting is likely to be observed and the separation between vessels and turbines. This topic is being researched by NOREL, as also are representative wind farm separation distances together with navigation channel widths through individual wind farms.

Figure 7.2 **Illustration of typical ghosting produced on a passing vessel one n.m. from the wind farm boundary**

7.2 Radar Impact – East Anglia THREE

78. Radar interference is most likely to cause an impact on passing traffic during periods of poor visibility, where visual confirmation of non AIS vessels is not possible (in most cases vessels without AIS are likely to be fishing (of less than 15m in length) or recreational vessels).

79. Figure 7.3 and Figure 7.4 present the future case 90th percentiles relative to the East Anglia THREE turbine locations, based on the partial fill and 100% fill layouts with 500m, 1.5nm and 2nm buffers applied around each turbine location in order to illustrate potential radar interference. As noted in the previous section on CPAs only 4.8% of vessels on the northbound route (closest to East Anglia THREE), passed within 1.5nm, which is the distance at which, based on trials, is the onset range from the turbines of false returns start

with progressive deterioration in the radar display as the range close.

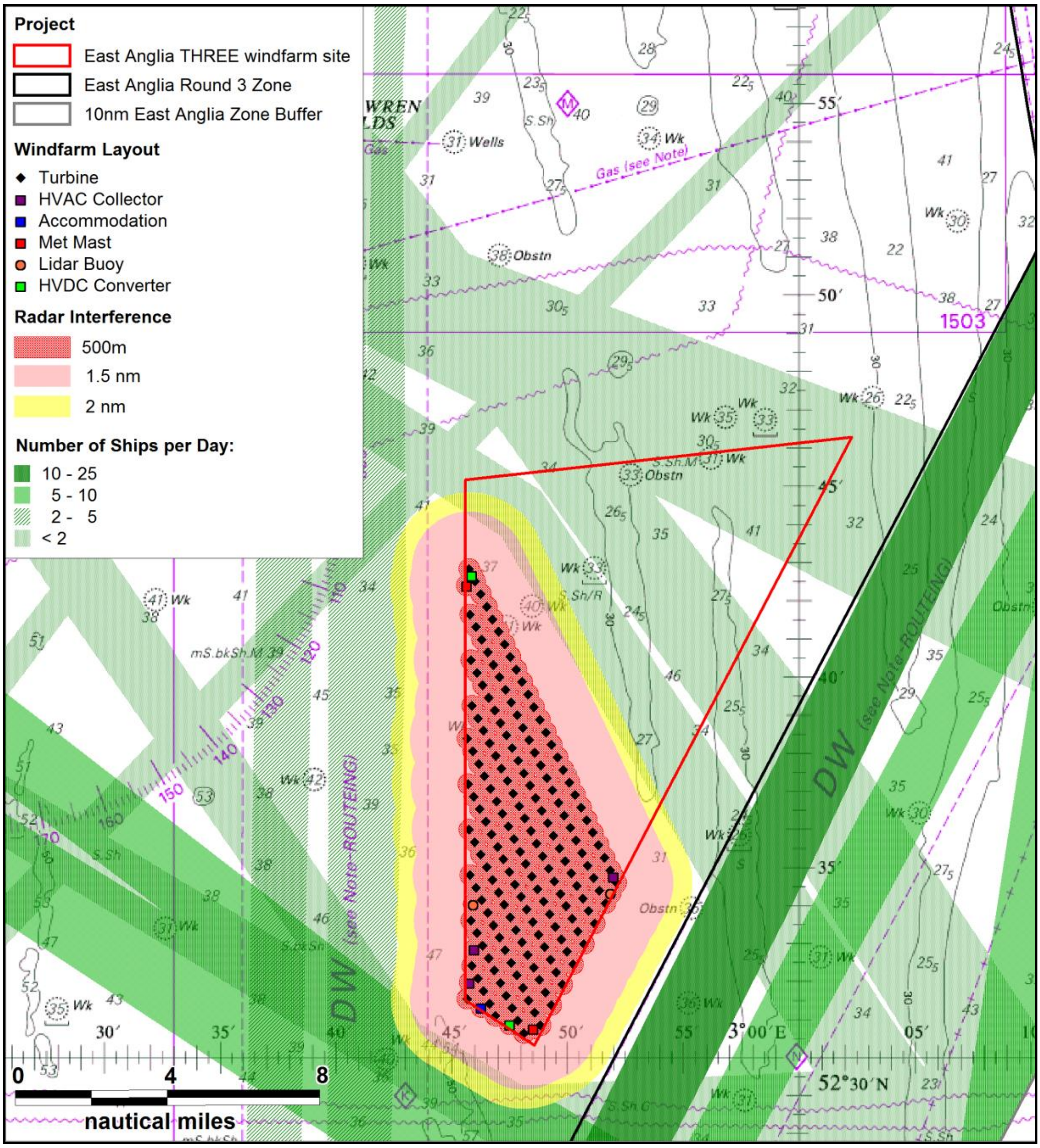

Figure 7.3 Partial Fill Layout and Indicative Radar Buffer Zones

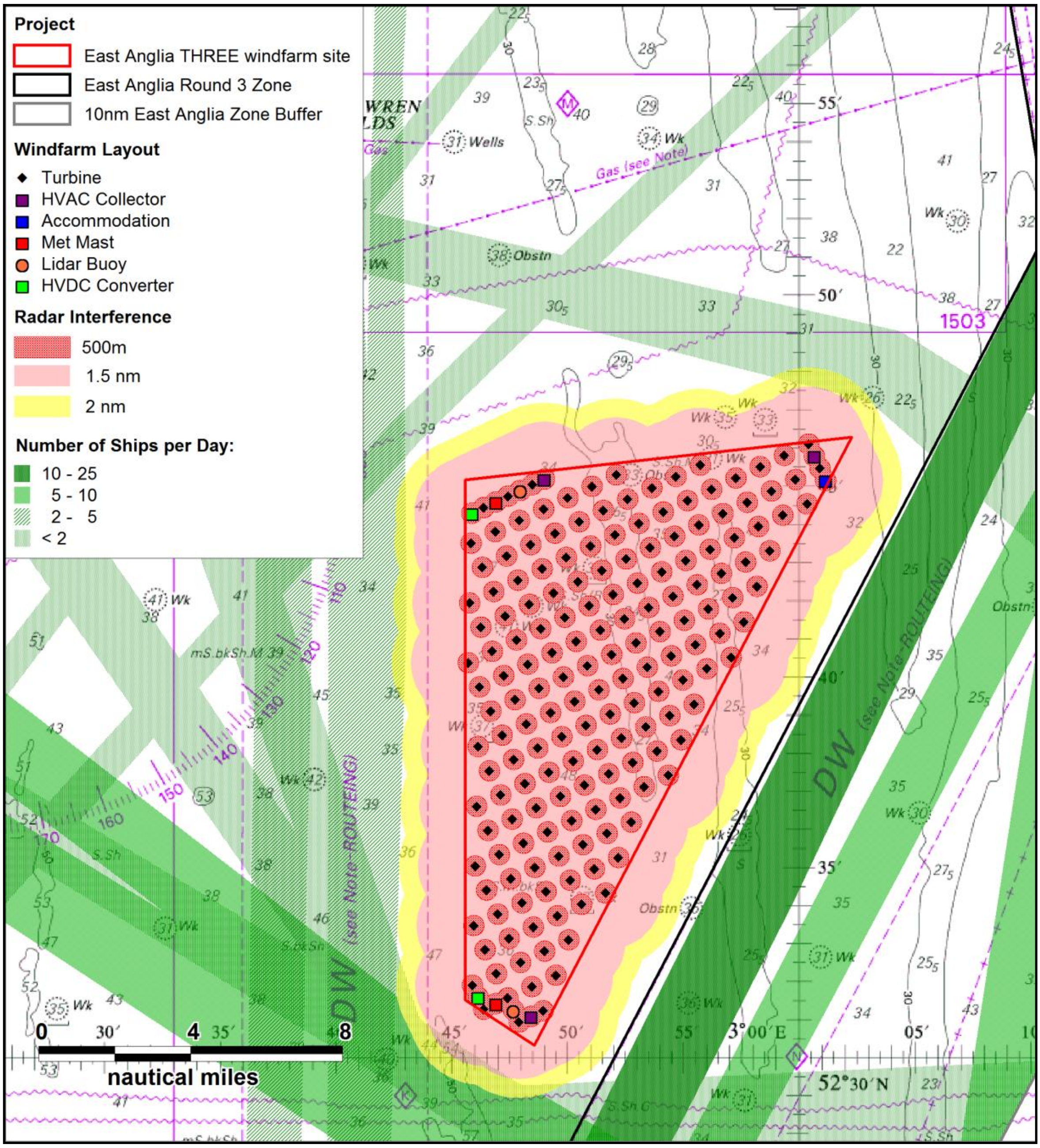

Figure 7.4 100% Fill Layout and Indicative Radar Buffer Zones

7.3 Cumulative Radar Impact

80. The potential radar impact of the East Anglia THREE turbines on passing traffic has also been considered cumulatively with the same impact from the East Anglia ONE turbines. East Anglia ONE was consented in 2014 and has the same 1nm buffer as proposed at East Anglia THREE. This ensure that vessels entering the DWR are assured that the clearance between the DWR

and turbines, either to the east or west, does not change, preventing any confusion. Based on the encounters, width of DWR (4.8nm) and level of traffic within the DWR including its preference to maintain north/south directional routes it is concluded that there are not any issues with the cumulative development for vessels constrained by their draught, who as per section 1.3, can ensure that their passage is not impeded should they wish to take a more central line within the channel. Figure 7.5 presents the future case 90th percentiles relative to the East Anglia ONE and East Anglia THREE turbine locations, based on the 100% fill layouts with 500m, 1.5nm and 2nm buffers applied around each turbine location in order to illustrate potential radar interference.

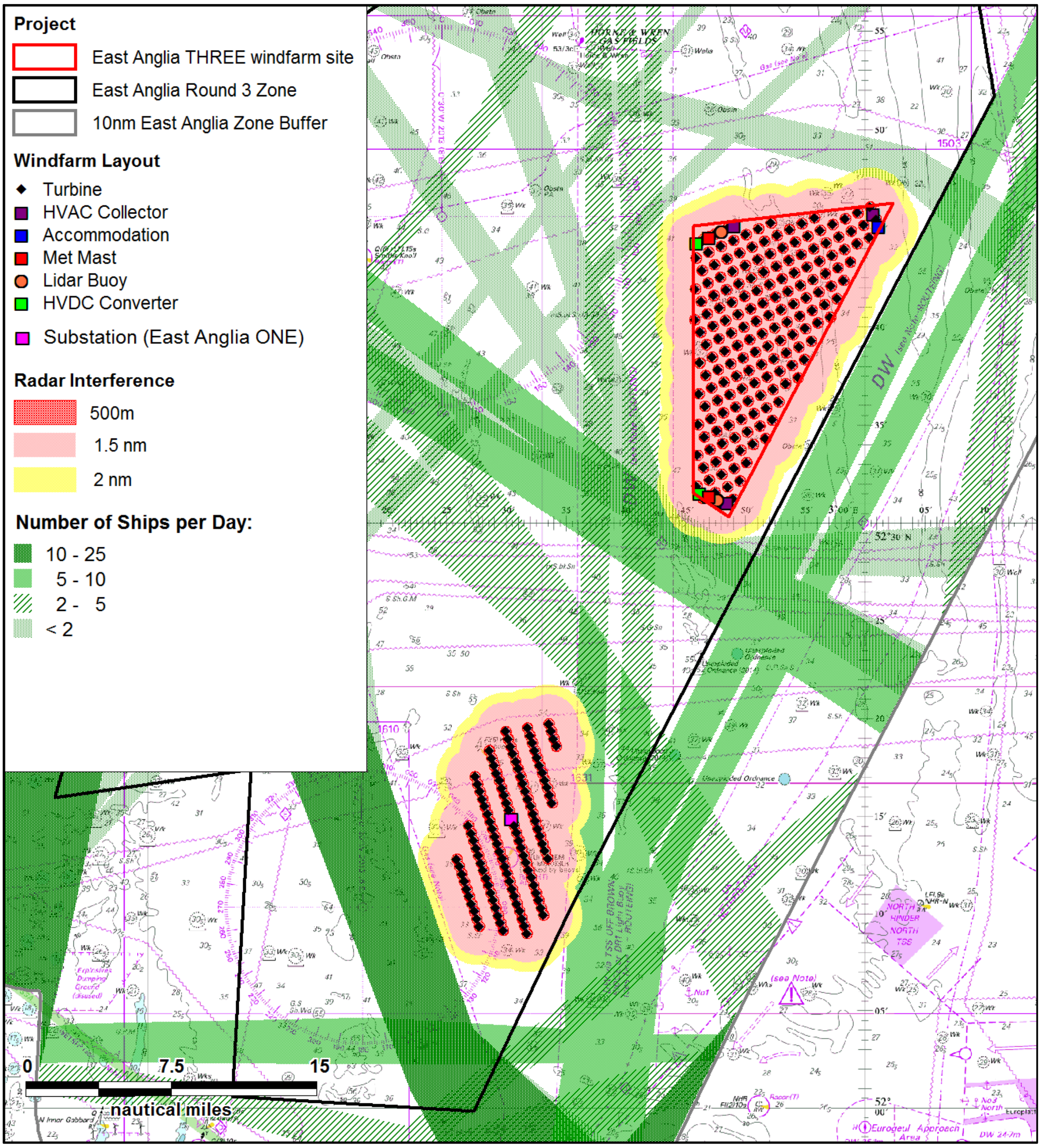

Figure 7.5 Cumulative (East Anglia ONE and East Anglia THREE) 100% Fill Layout and Indicative Radar Buffer Zones

8. Conclusions

81. A total of 40 days of AIS and radar data recorded between 2012 and 2014 (from dedicated marine traffic surveys undertaken as part of the East Anglia THREE NRA) was used to assess the vessel activity occurring within the DR-1 Light Buoy DWR located to the west of the East Anglia THREE site.

82. The AIS and radar data showed that the most frequently recorded vessel types utilising the DWR were oil tankers, chemical tankers and bulk carriers. The average draught of vessels recorded using the DWR were 8.1m (Survey 1), 9.1m (Surveys 2 and 3) and 10.0m (Survey 4). Throughout all survey periods, the vast majority of vessels using the DWR had draughts greater than or equal to 6m.

83. The AIS and radar data showed that northbound traffic tended to remain in the eastern half of the DWR, and southbound traffic in the western half as per standard marine practice. Between four and five vessels a day were recorded transiting both north and south bound.

84. A CPA analysis showed that 0.7% of northbound traffic and no southbound traffic came within 1.0nm of East Anglia THREE. It also showed that 4.8% of northbound traffic came within 1.5nm and 22.1% of northbound traffic passed within 2.0nm of the site. For an average of 98.2% throughout all of the surveyed time, no more than three vessels were recorded to use the DWR at any one time.

85. An analysis of vessel encounters, involving at least one vessel using the DWR, showed that assuming a 1.0nm encounter domain approximately 73.1% of encounters were “crossing”, 16.5% of encounters were “overtaking” encounters and a further 10.4% were “head-on” encounters. Assuming a 0.5nm encounter domain approximately 56.5% of encounters were “crossing”, 39.1% were “overtaking” encounters and a further 4.3% were “head-on” encounters, noting the preference for maintaining a direction of transit within the DWR. The encounters analysis considered crossing traffic interacting with DWR traffic which is likely to continue post construction.

86. It was considered likely that a separation distance of at least 1.0nm between passing traffic and the nearest East Anglia THREE turbine (in both 100% and partial fill cases) could safely be maintained in the vast majority of cases.

87. As noted in the previous section on CPAs only 4.8% of vessels on the northbound route (closest to East Anglia THREE), passed within 1.5nm, which is the distance at which, based on trials, is the onset range from the turbines of false returns start with progressive deterioration in the radar display as the range closes. However the width of the DWR is considered adequate enough to accommodate any resulting vessel manoeuvres (from the 5.4% of traffic that may experience radar issues), even when considered alongside the impact of traffic affected by similar issues from East Anglia ONE. It was also noted that

maintaining the 1.0nm buffer already agreed at East Anglia ONE ensured that mariners would not become confused by varying buffer widths within the same DWR.

88. On the basis of the technical note, the conclusions above in section 81 to 88 and following consultation with the MCA in August 2015 the risk of having a one nm buffer is deemed as ALARP/Tolerable.

89. The following mitigations enable the risk to be deemed as ALARP / Tolerable:

- That the windfarm is charted;
- The windfarm will follow the guidance of MGN371 and include sign off with the MMO in conjunction with the MCA and THLS;
- Marking is as per IALA 0139 and requires approval of Trinity House; and
- The traffic assessment within this technical note.

9. References

- (Anatec, 2015). Navigation Risk Assessment East Anglia THREE Offshore Windfarm. Anatec: Aberdeen.
- (Ledwood 2011). Investigation into the effects of proposed Atlantic Array wind farms on radar returns. Ledwood Technology. 2011.
- (MCA, 2004). Results of the electromagnetic investigation and assessments of marine radar, communications and positioning systems undertaken at North Hoyle wind farm. QinetiQ and the MCA. 2004.
- (MCA, 2005). Offshore Wind Farm Helicopter Search and Rescue Trials Undertaken at the North Hoyle Wind Farm. MCA. 2005.
- (MCA, 2007). Investigation of Technical and Operational Effects on Marine Radar Close to Kentish Flats Offshore Wind Farm. 2007.

Appendix 15.1 (f) ends here